Decision Support Systems 56 (2013) 406–418

Contents lists available at ScienceDirect

Decision Support Systems

journal homepage: www.elsevier.com/locate/dss

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

Ming Lei [a], Xinna Zhao [a], Honghui Deng [b,*], Keah-Choon Tan [b]

[a] Guanghua School of Management, Peking University, China
[b] Lee Business School, University of Nevada Las Vegas, United States

ARTICLE INFO

Available online 6 November 2012

Keywords:
Mechanism design
Foreign direct investment
Malmquist index
Data envelopment analysis
Sustainable development

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

* Corresponding author. Tel.: +1 702 3538870; fax: +1 702 8958020.
E-mail addresses: leiming@gsm.pku.edu.cn (M. Lei), zhaoxinna@pku.edu.cn (X. Zhao), honghui.deng@unlv.edu (H. Deng), kctan@unlv.edu (K.-C. Tan).

0167-9236/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.dss.2012.10.053

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:

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

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

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

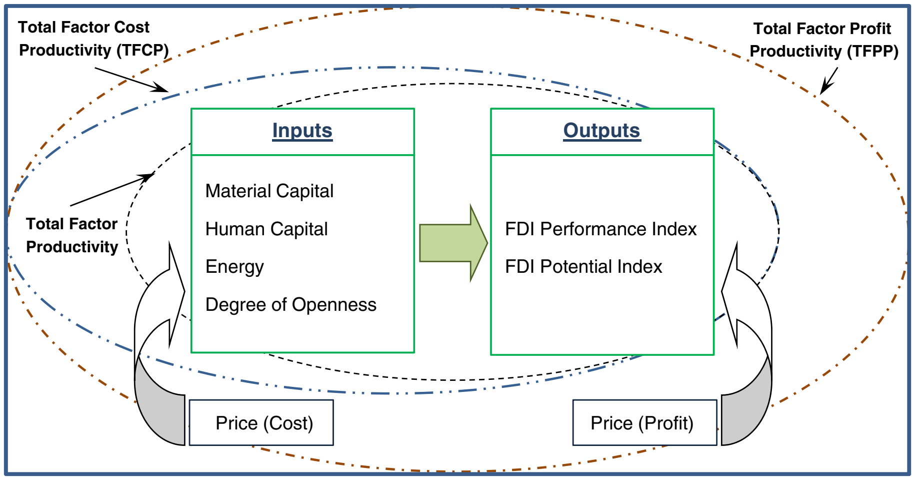

Fig. 1. FDI efficiency model.

with price influence between period t and period $t+1$. When OEC>1, it shows that there is an improvement to the frontier in period $t+1$, but if OEC<1, it indicates that the DMU is further away from the frontier in period $t+1$. When OEC=1, there is no change in period $t+1$ compares to period t. Part ② indicates that TC is similar to the frontier-shift components of traditional MPI. The index measures the shift of efficient isoquant between period t and period $t+1$. If TC>1, it indicates that the frontier shifts toward more outputs in period $t+1$ from period t. If TC=1, there is no change in period $t+1$ compares to period t. If TC<1, there is a regress of the frontier shifting toward fewer outputs in period $t+1$ compares to period t.

3.2. The second stage of FDI attractiveness model decomposition

The catching-up component of the new MPI is OEC. It can be decomposed into the product of technical efficiency changes (TEC) as in the traditional MPI, cost efficiency changes (CEC) of cost influence by inputs, and profit efficiency changes (PEC) of profit influence from outputs.

In the first stage, we obtain the OEC with price influence and TC over the time. In the second stage, we further decompose the catching-up component of the new MPI according to the traditional technical efficiency concept by decomposing it into a scale efficiency component and a pure technical efficiency component.

$$\mathrm{OEC} = \mathrm{TEC}\cdot\mathrm{CEC}\cdot\mathrm{PEC}$$
$$= \underbrace{\frac{D^t\left(x^t,y^t\right)}{D^{t+1}\left(x^{t+1},y^{t+1}\right)}}_{③}\cdot\underbrace{\frac{\overline{D}^t\left(x^t,p_i^t,y^t\right)/D^t\left(x^t,y^t\right)}{\overline{D}t+1\left(x^{t+1},p_i^{t+1},y^{t+1}\right)/D^{t+1}\left(x^{t+1},y^{t+1}\right)}}_{④}$$
$$\cdot\underbrace{\frac{\overline{\overline{D}}^t\left(x^t,p_i^t,y^t,p_o^t\right)/\overline{D}^t\left(x^t,p_i^t,y^t\right)}{\overline{\overline{D}}^{t+1}\left(x^{t+1},p_i^{t+1},y^{t+1},p_o^{t+1}\right)/\overline{D}^{t+1}\left(x^{t+1},p_i^{t+1},y^{t+1}\right)}}_{⑤}. \quad (4)$$

Part ① in Formula (3) decomposes into Formula (4) above. Part ③ in Formula (4) is the TEC proposed by the traditional MPI as catching-up component. Similarly, part ④ is the CEC and part ⑤ is PEC. This index shows the DMU's catching-up effect on optimal production isoquant with price influence. Similar to the traditional MPI, TEC can be further decomposed into pure technical efficiency changes (PTC) and scale efficiency changes (SEC).

In words, the new MPI can be decomposed into Formula (5) below. When M_p is greater than 1, it suggests progress; less than 1 suggests regressions; and equals to 1 indicates stable productivity.

$$\begin{aligned} M_p &= \text{overall efficiency changes(OEC)} \times \text{technology changes(TC)} \\ &= \text{technical efficiency changes (TEC)} \\ &\quad \times \text{cost efficiency changes (CEC)} \times \text{profit efficiency changes (PEC)} \\ &\quad \times \text{technical changes (TC)} \\ &= \text{pure technical efficiency changes (PTC)} \\ &\quad \times \text{scale efficiency changes (SEC)} \times \text{cost efficiency changes (CEC)} \\ &\quad \times \text{profit efficiency changes (PEC)} \times \text{technical changes (TC)} \\ &= M \times \text{cost efficiency changes (CEC)} \\ &\quad \times \text{profit efficiency changes (PEC)}. \end{aligned} \quad (5)$$

3.3. Computation of the FDI attractiveness model decomposition

We compute and decompose the new MPI between consecutive periods based on the components that are reciprocal of overall efficiency. We use the classical Charnes, Cooper and Rhodes' (CCR) model to solve the distance functions [10]. There are n DMUs ($j=1,\ldots,n$) over t periods ($t=1,\ldots,T$) in the model. Using period t as benchmark, DMUs produce s outputs ($i=1,\ldots,s$) using m inputs ($i=1,\ldots,m$). Also, we define p_i ($i=1,\ldots,r$) as the price of inputs and p_o ($o=1,\ldots,q$) as the price of outputs between two consecutive periods. Hence, the distance function of DMU j in period t is,

$$\overline{ME} = \max\frac{{p_o}^T\cdot y^*}{{p_o}^T\cdot y} \qquad st\begin{cases} {p_i}^T\cdot x^*\le C={p_i}^T\cdot x \\ \sum_{i=1}^{N} x_i\lambda_i\le x^* \\ \sum_{i=1}^{N} y_i\lambda_i\ge y^* \\ \lambda_i, x^*, y^*\ge 0 \end{cases} .(6)$$

In the $\overline{ME}$ model above, ${p_o}^T$ is the transposition of output price vector p_o. The denominator of target expression, ${p_o}^T\cdot y$, is the DMU's real profit, and the numerator, ${p_o}^T\cdot y^*$, is the theoretical profit with optimal output structure. The target expression is the efficiency degree of theoretical revenue compares to the DMU's real profit.

We can obtain the constant returns-to-scale case of overall efficiency changes if we solve the model above for each DMU. However, for the variable returns-to-scale case, we only need to add the restriction $\sum_{j=1}^{n}\lambda_j=1$ in the model. Essentially, all the distance functions can be computed based on the model in Eq. (6) above by changing period t and period $t+1$ separately.

According to [20], $D^t(x^t, y^t)$ is reciprocal to technical efficiency (TE). We notate the efficiency of DMU at period t as,

$$TE^t\left(x^t, y^t\right) = \min\left\{\rho : \left(x^t, y^t\right) \in S^t\right\} = D_t\left(x^t, y^t\right)^{-1}. \quad (7)$$

Similar to Eq. (7), we notate overall efficiency (OE) at period t under the influence of price as,

$$OE^t\left(x^t, p_i^t, y^t, p_o^t\right) = \overline{\overline{D}}_t\left(x^t, p_i^t, y^t, p_o^t\right)^{-1}. \quad (8)$$

This measures the optimal feasible production allocation to the observed value. If the index is less than 1, it indicates that allocation of inputs and outputs is suboptimal in period t due to the impact of technical efficiency and/or price influence. The first impact factors can be measured by Eq. (7) and the second factors can be measured by CEC and PEC at period t, which we can notate as,

$$CE^t\left(x^t, p_i^t, y^t\right) = \bar{D}^t\left(x^t, p_i^t, y^t\right) / D^t\left(x^t, y^t\right). \quad (9)$$

$$PE^t\left(x^t, p_i^t, y^t, p_o^t\right) = \overline{\overline{D}}^t\left(x^t, p_i^t, y^t, p_o^t\right) / \bar{D}^t\left(x^t, p_i^t, y^t\right). \quad (10)$$

$$\text{If} CE^t = 1 \text{ and} PE^t = 1 \Leftrightarrow OE^t\left(x^t, z^{t-1}, y^{dt}, y^{ut}, z^t\right) = TE^t\left(x^t, z^{t-1}, y^t, z^t\right)$$
$$\Leftrightarrow \text{new MPI} = \text{traditional MPI}. \quad (11)$$

Basically, in some special cases, Formulas (9), (10), and (11) show that the new MPI equals the traditional MPI. Thus, the new MPI is a more general index than the traditional MPI.

4. Data and research setting

Using data from 1997 to 2008, we analyze the FDI attractiveness of 30 provinces in China, except Xizang. We select this research period because Chongqing was reclassified as the fourth municipality in China in 1997. With the exception of human capital stock, data for this study was obtained from the *New China of 60 Year of Data Collection and Statistics Yearbook of Provinces* published by China's National Bureau of Statistics [13]. We normalized the data using 1996 as the base year, and replaced some missing data for Hunan province and Hainan province with averages of their adjacent provinces.

4.1. Research setting

Since 1978, China has encouraged economic globalization and gradually abolished its trade restrictions step by step. An influx of international capital began to flow into China, especially after its admittance into the World Trade Organization in 2001. China becomes a popular supply source and major potential market for multinational corporations. With its vast territory and a population of over 1.3 billion, China has a much diversified market that consists of 30 provinces. However, we can classify the Chinese market into eastern, western, and central regions (Fig. 3). Both the eastern and western regions consist of eleven provinces each, whereas the central region covers eight provinces. Our research focus is in the central region, except Xizang.

The eastern region is a developed area in China compared to the other regions. Provinces in the eastern region have unique competitive advantages such as developed infrastructure and economy, advanced manufacturing and information technology, mature market, and a long history of FDI by multinational corporations. Besides being more diverse, these provinces also enjoy higher FDI spillover effects. For example, Jiangsu, Fujian, and Zhejiang in the eastern region actively promote private economy, whereas Liaoning and Hebei are typical manufacturing provinces. The western region is primarily an undeveloped area in China. Government policy to "develop the west" plays an important role in promoting FDI in this region. However, western provinces have their own competitive advantages such as low cost, low environment threshold, resource richness, and industry incubation convenience. For example, Xinjiang and Inner Mongolia are new provinces with ample resources, whereas Ningxia is a low carbon province. The central region lies between the eastern and western regions. The economy and infrastructure of this region is affected by its neighbors. For example, since Jiangxi borders on the eastern provinces of Guangzhou, Fujian and Zhejiang, it enjoys FDI spillover effects from these eastern provinces. Due to its special classification, central region is less restricted by macro adjustment imposed by the Chinese government. Thus, central provinces enjoy liberal regulation advantage.

We identify four inputs—average material capital stock, average human capital stock, average energy consumption situation, and export proportion index—to develop a sustainable development strategy based on the proposed FDI attractiveness model. The two outputs are FDI performance index and FDI potential index. We introduce price influence factors of costs as fixed asset price index, average real wage index, fuel retail price index, GDP deflator, and export price index. The price influence factors of profits are purchasing price indices for raw materials, fuels and power index (PPI), and GDP deflator. For uniformity, we convert all data in U.S. dollar to RMB using the exchange rate of the year that data was obtained.

4.2. Inputs and outputs

Average Material Capital Stock: We calculate each provincial material capital stock using the perpetual inventory method, $K_{it} = K_{it-1}(1 - \delta_{it}) + I_{it}$ [41]. First, we assume that total fixed capital stock is the sum of investments in those years. Second, total fixed capital stock in 1952 is tenfold equivalent of the material capital stock in 1951. Third, we assume that depreciation is 9.732% [27]. Lastly, we

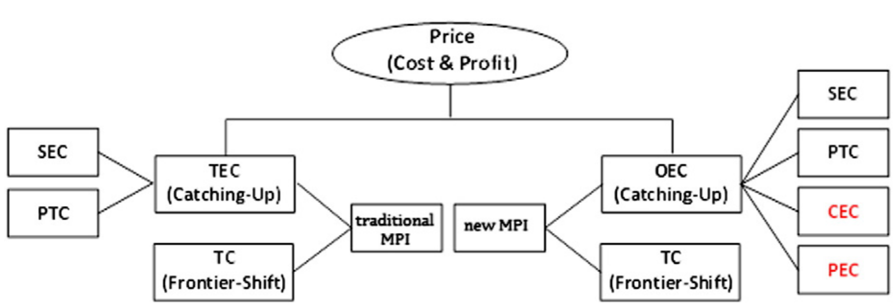

Fig. 2. The evolution of FDI attractiveness model decomposition.

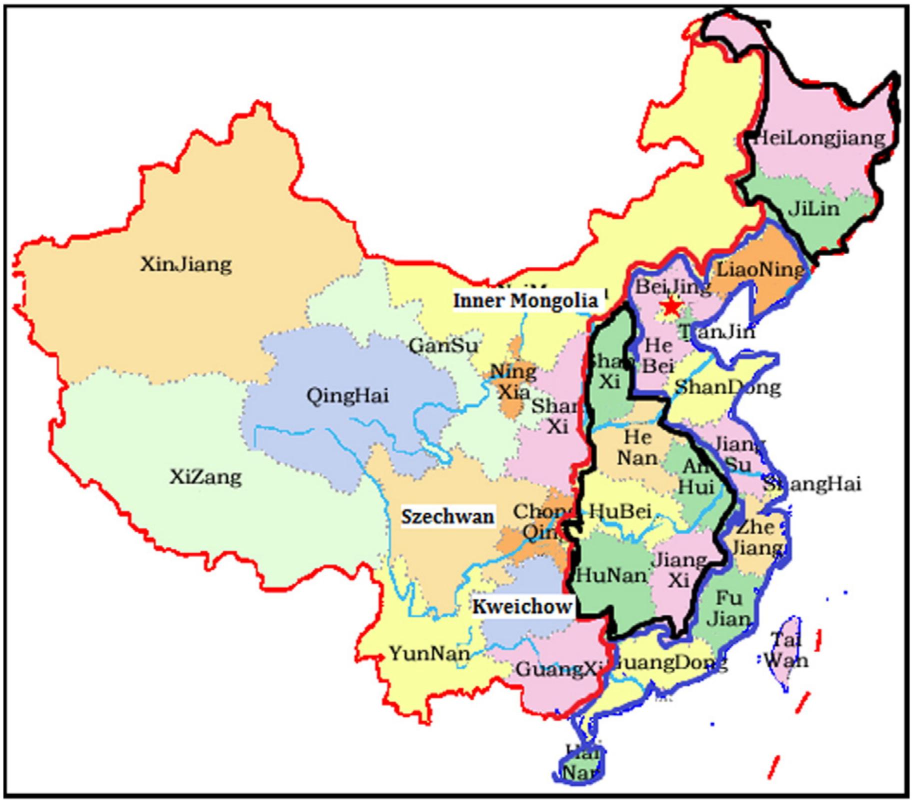

Fig. 3. The three regions and Thirty provinces in China.

compute the average material capital stock of each province by dividing the provincial material capital stock with population of the province.

Average material capital stock reflects the material standard of each province. We use averages for all input–output factors because averages remove the bias of population size of each province and it allows us to consider only the influence of the factors of interest on FDI. In the calculation of the input–output factors, we use quantity as unit. In other words, we get rid of the price effect in our primary calculation.

Average Human Capital Stock: Educated and skilled labor is an incentive to attract FDI in the global market. We calculate this input factor by using the method proposed by Zhao and Zhang [42]. First, we number the years of education as follows: illiterate labor = 3, primary school = 6, secondary school = 9, high school = 12, and college or above = 16. Using this information, we arrive at the formula, average human capital stock = the proportion of illiterate labor × 3 + the proportion of primary school educated labor × 6 + the proportion of secondary school educated labor × 9 + the proportion of high school educated labor × 12 + the proportion of college educated labor or above × 16. The source of this data is the *China Population and Employment Statistics Yearbook of 1998–2009* [12].

Average Energy Consumption Situation: This variable denotes the cost and availability of substitute energy. It is an important factor affecting FDI. We compute the average index as the ratio of total energy consumption to population.

Export Proportion Index: The degree of market openness is directly related to the level of FDI attractiveness in that market. Hence, the degree of openness of the local market is the basis of attracting FDI. To measure degrees of market openness, we use the export proportion index which is the ratio of total export to local GDP.

FDI Performance Index: The United Nations Conference on Trade and Development (UNCTAD) defines the FDI performance index and FDI potential index in its World Investment Report [39]. These two indices have been used to evaluate the FDI situation of some countries [40]. The FDI performance index is the ratio of the FDI in a nation to the global FDI divided by the ratio of a nation's GDP to the global GDP. We use UNCTAD's definition of FDI performance index to define the provincial FDI performance index as the ratio of local FDI to total FDI in China divides by the ratio of local GDP to GDP in China. We also get rid of price effect in this index. To simplify the calculation, we omit the two denominators, national FDI and national GDP, since their effect on all the provinces is similar. Thus, the FDI performance index can be simplified as the local FDI in 1996 constant dollars to local GDP.

FDI Potential Index: Similar to the FDI performance index, we use UNCTAD's definition to define the FDI potential index as $V = \frac{V_i - V_{min}}{V_{max} - V_{min}}$, where V is the average local inputs.

4.3. Price influence factors

Fix Asset Price Index: In measuring productivity, material capital stock contributes to productivity as an input factor that can be increased by fixed asset investment. We use fixed asset price index as the cost of material capital.

Average Real Wage Index: This index reflects the price of local human capital.

Fuel Retail Price Index: This index measures the local energy price level. Since data on electricity consumption is not readily available, we use fuel retail price index to measure energy.

Export Price Index: This index is an important factor that accounts for inflation and reflects the main price level of Chinese exporters.

GDP Deflator: This index exhibits the price level of local GDP. GDP deflator is a broader indicator to measure operation than inflation rate because the commodities being measured in an economic operation is not only consumption goods, but also include investment goods, and import and export goods.

PPI: This index measures the purchasing power of FDI and reflects the price level of FDI.

5. Empirical results — FDI attractiveness in China

We analyze the inter-temporal empirical data using MPI. To compute the overall efficiency, we analyze the local FDI attractiveness starting from 1997. First, we find the bottleneck of FDI decomposed efficiency to promote or constrain the whole efficiency. Second, we identify the peak and trough year as well as their patterns to adjust the FDI strategy. Next, we analyze FDI attractiveness of each province according to the regionalization from a diachronic angle. We purposely seek to identify the characteristics of FDI in each province. In line with the local condition, we plan to provide strategy references to policy makers to improve their performance on attracting FDI and to foreign investors to help them select investment destinations in China.

5.1. National and provincial FDI attractiveness in China

First, we analyze China's aggregated national FDI attractiveness (i.e., TFPP) from 1997 to 2008. The results are shown in Fig. 4. From a diachronic angle, China's FDI attractiveness was universally low and was effective only from 2000 to 2002 and 2005 to 2006. Fig. 4 shows that TFPP reaches its peak in 2002 but falls almost vertically to the bottom in 2003. The abrupt oscillation is due solely to technology changes. This phenomenon shows that technology change can drive greater improvement in TFPP than to technical efficiency. In other words, the improvement of inputs and outputs factors and the development of technology are more appealing to improve China's aggregated FDI attractiveness. However, technical efficiency changes affect TFPP via scale efficiency changes, which mean factors' scale and price level of outputs influence FDI attractiveness simultaneously. Pure technical efficiency changes are relatively stable although cost efficiency changes gradually strengthen within a couple of years.

In sub-regions of China, TFPPs in the West exhibit the greatest variation followed by Central China, and those in the East are the most stable (Fig. 5). In these sub-regions, technology changes have low efficiency except in Inner Mongolia. Similarly, TFPPs have low efficiency except in Yunnan, Szechwan, and Inner Mongolia. This observation indicates that qualitative ascendance and technology development are bottlenecks of FDI attractiveness. The influences of output price and factor scale are prominent, especially in the West and Central China. Overall, however, the factor combination and input price influences tend to be stable.

Inner Mongolia, Szechwan and Yunnan with TFPPs > 1 are in the frontend of the western region. Their high TFPPs suggest that macro-environment and situations of FDI attractiveness satisfy the comprehensive efficiency and provide immerse benefits to economic and social development. The higher performance is a result of the policy support in "developing the west" campaign. While some inefficient provinces (TFPP < .8) are also located in the western region, such as Qinghai and Gansu, the lower performance indicates that policy support is just one side of economic development. What is more important is how to produce the best possible result by combining the unique characteristics of a region with policy support from the government.

We consider pure technical efficiency changes in traditional estimation ways. In other words, we consider performance without price influence under variable return to scale. Hence, each province is efficient during the research period from 1997 to 2008. This efficient phenomenon indicates that regional disparity is not the key variable that limits pure efficiency changes, thus proving proportionality of micro-control. While considering scale efficiency changes, we found that Qinghai, Ningxia, and Inner Mongolia are the top three most efficient provinces. Half of the 30 provinces are scale efficient, including most eastern provinces. Meanwhile, Gansu, Yunnan, and Kweichow from the western region are the most inefficient three provinces.

We introduce price influences—CEC and PEC in the traditional estimation ways. As a whole, the CEC of each province tends to be 1. It means most provinces are efficient or tend to be efficient and that price influence of inputs is small. Although PECs in eastern region are stable and efficient, those in central region and western region fluctuate sharply, particularly in western region. The fluctuation indicates that when we combine long-term and short-term FDI, local price level in western region affects FDI performance and potential sharply. In particular, in Qinghai, price influence leads to inefficient directly. On the contrary, high FDI attractiveness in Yunnan and Szechwan are due to promotion of PEC.

In conclusion, technology change promotes FDI attractiveness. That is, we should favor attracting FDI into high technology industries. Local price level influence plays a more important role in recent years. Above all, Hebei, Tianjin and Shanghai in the eastern region, Jilin and Anhui in central region, and Szechwan, Yunnan and Chongqing in western region are preferred provinces to attract FDI.

5.2. Regional FDI attractiveness

Using provincial division in China, we analyze the FDI attractiveness for the eastern, central, western regions in China. Based on the strength of decomposed efficiency indices, we classify the TFPPs of

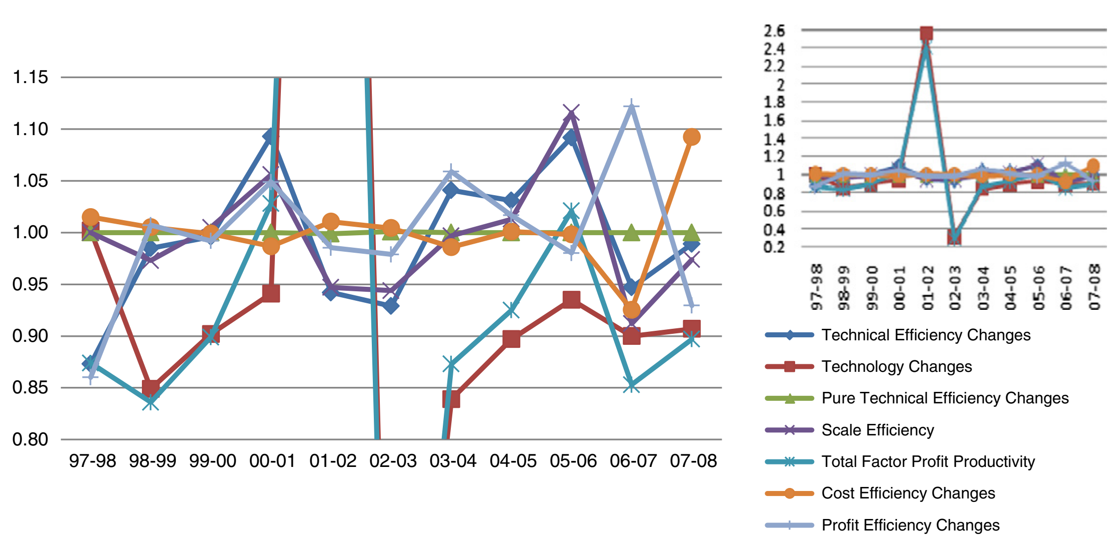

Fig. 4. National FDI attractiveness in China from 1997 to 2008.

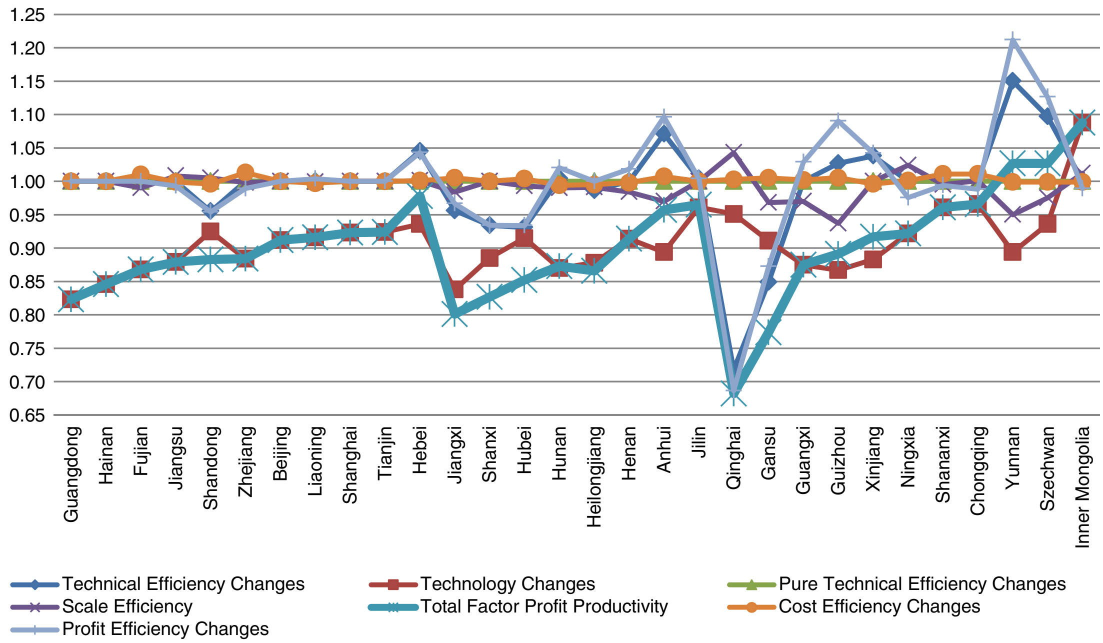

Fig. 5. Provincial FDI attractiveness in China.

30 provinces into four types—technology changes type (TCT), scale efficiency changes type (SECT), cost efficiency changes type (CECT), and profit efficiency changes type (PECT) as shown in Table 1. The decomposed efficiency indices such as TC in the first type, SEC in the second type, CEC in the third type, and PEC in the fourth type are the main strengths for improving FDI attractiveness of each province.

Overall, there are eleven provinces in the eastern region spreading across the four TFPP types in Table 1. It reflects diversity when compared to the central and western regions. The richness in the eastern region indicates huge potential for FDI. We examined the data and found that FDI attractiveness in eastern provinces are relatively stable due to the unique characteristics of eastern provinces such as developed economy, advantage technology, mature market, and long history of attracting FDI at an early stage. These characteristics formed a mature and well-developed model. Thus, from the diachronic approach, we found that pure technical changes in the eastern region are about one. This means that allocations of inputs and outputs without price influence in eastern provinces are similar to the national level in China. PTCs are all efficient.

As expected in each province, TFPPs in Beijing, Shanghai, Tianjin, Guangdong, and Hainan are all decided by their technology changes. In other words, FDI attractiveness in these provinces is decided by utilization of factors, so we define them as TCT. These provinces are among the pioneer regions that opened their markets to foreign investors, and with a relatively opened market they enjoyed a matured market though they cannot improve much more. Hence, these provinces should choose to attract FDI for knowledge-intensive industry since this sector has high FDI spillover effects. When compared to the western and central regions, the manufacturing and information technology, regime, and management expertise in these provinces are more advanced. While pursuing the advantages, one should pay more attention to quality in these provinces. One in particular is that there is run-in period in application of new technology and management training. It may yield adverse effects on technical change. This is the only issue affecting the total factor profit fluctuation. So technology change determines FDI attractiveness in developed areas and mature macro-environments. For investors, stable performance environments are suitable for developing knowledge-intensive industry. Above all, these five provinces have a win–win chance for decision makers or investors.

Shandong and Jiangsu belong to SECT (Table 1). These two provinces are clearly affected by technology changes. However, scale efficiency change is the main factor affecting FDI attractiveness, especially in inefficiency years (meaning TFPP is inefficient these years). Promotion of scale efficiency change is the key to increasing FDI attractiveness. Therefore, government agencies should focus on developing promotional campaigns that increase the effect of scale efficiency change is these provinces. For example, agencies should focus on industrial restructuring, regional economic circle development, and intensive economic development.

Fujian and Zhejiang are grouped in CECT (Table 1). Table 1 indicates that besides technology changes, the influence of local price levels on inputs is the main factor affecting provincial FDI attractiveness, especially in the last two years when these two provinces controlled price levels to promote FDI attractiveness. These two provinces should focus on cost leadership strategy to develop their industry. This cost leadership strategy is decided by the special private individual economy model in the two provinces because Fujian and Zhejiang are typical provinces in China which promote private individual economy. Especially Zhejiang, both of the GDP and Gross Sales of private industries are the best among all the provinces in

Table 1
Total factor profit productivity types.

Types	East	Center	West
Technology Changes Type	Guangdong, Hainan, Beijing, Shanghai, and Tianjin		
Scale Efficiency Changes Type	Jiangsu and Shandong		Qinghai, Ningxia, Chongqing, Xinjiang, Yunnan, and Szechwan
Cost Efficient Changes Type	Fujian and Zhejiang		
Profit Efficiency Changes Type	Liaoning and Hebei	All the 8 provinces	Shaanxi, Gansu, Inner Mongolia, Guangxi, and Kweichow

China by the end of 2009. In contrast, Liaoning and Hebei are grouped in PECT (Table 1) which represent the output price influence on FDI attractiveness in these provinces, since Liaoning and Hebei are the typical manufacturing provinces in China. Thus, profit efficiency changes for Liaoning and Hebei are important factor to improve their FDI attractiveness. The key issues to improve FDI attractiveness are rational development of outputs' price sensitive industry, for example, resource industry and manufacture industry.

In summary, the diversity of TFPP types in eastern provinces reflects their advantages in attracting FDI. Nearly half of the eastern provinces belong to TCT due to the advantage of economic background. For groups of similar province type, such as Fujian and Zhejiang, Liaoning and Hebei, they can extend beyond its provincial boundary to develop a cross-province economic circle. This strategy not only provides full benefit to the type advantages, but also achieves economies of scale.

Table 1 shows that eastern provinces have four types of TFPPs, whereas western provinces have two types of TFPPs. Further, there are SECT and PECT in western provinces. Similar with eastern provinces, the pure technical changes in western provinces are near one from a diachronic approach. In other words, the allocation efficiency of inputs and outputs is efficient if we do not consider local price influence. The FDI attractiveness fluctuation range of western provinces is relatively larger. The whole performances of advantage provinces in the west exceed those of the east. For one thing, most of western provinces belong to undeveloped area in China, thus, a little improvement can increase the efficiency observably. For another thing, the policies support of "Develop the West" plays an important role in promoting FDI attractiveness.

In particular, objective factors such as lower cost and lower energy deter foreign investors from investing in labor-intensive industry or low-technology industry. So, most provinces in the west are SECT, such as Qinghai, Xinjiang, Ningxia, Chongqing, Yunnan, and Szechwan. Compared to the East, the scale efficiency changes of the west promotion are more obvious, especially in low technology change years. Because these provinces were opened to foreign investment late, they are still in scale increasing stage. However, Gansu, Guangxi, Kweichow, Shaanxi, and Inner Mongolia belong to PECT. It indicates they are more sensitive to outputs' local price influence. Inner Mongolia is the most efficient province in China. From a diachronic approach, we found Inner Mongolia gradually transits to exactly TCT from 2004. In other words, all decomposing efficiencies except technology changes are equal to one. Its FDI attractiveness is promoted by technology changes alone. Furthermore, except that in 2008, Inner Mongolia's FDI attractiveness in other years are greater than one. Inner Mongolia is efficient for multiple reasons. Its location is convenient for attracting FDI, and it has many energy resources. . The Chinese government has promoted its development vigorously. Above all, Inner Mongolia's technical change is high. Therefore, Inner Mongolia is a new paradise for FDI.

Eight provinces in central region are geographically between eastern region and western region. So its characteristics are uniqueness. All of them belong to PECT. Central provinces don't have the economic background and government support as eastern provinces, their economic development depend on self-control and macro influence in the market. The local price influence is bigger, especially that of the outputs' local price level. Due to the unique TFPP type, the profit efficiency change is the main factor in improving FDI attractiveness. Overall, output price sensitive industry is suitable for attracting FDI in central region. While similar to the eastern and western regions, pure technical efficiency changes in central provinces are near 1 from a diachronic approach.

In conclusion, technology change is the bottleneck of FDI attractiveness. Each province belongs to different types according to their own characteristics. For investors, we suggest they select location of investment according to the industry characteristics. For decision makers, we advise they should exercise macro control over inputs and outputs in order to promote the provinces to be TCT, and then continue to improve the quality of inputs in order to increase FDI attractiveness furthermore.

6. Empirical results — factor analysis of FDI attractiveness

Still based on China data, we analyze FDI attractiveness from 1997 to 2008 using new MPI. We conclude the total factor profit productivity is affected by allocation of factors and quality improvement of factors. In other words, both technical efficiency changes and technology changes affect FDI attractiveness. However, how is the index influenced by definite factors? Now we restore the index's effects into definite factors using output-oriented CCR model. Then, we observe how definite factors affect the whole performance under different local price levels. We conclude that the FDI attractiveness of most provinces reached their peak in 2002, but retreated to the bottom in 2003. However, these indices stabilized in the last five years from 2003 to 2008 (Fig. 6).

Next, we used the 2002, 2003, and 2004–2008 data to compute the efficiency scores and slacks of each input variable to determine the strengths and potential market of each province. The column labeled "Score" in Table 2 shows the efficiency score of each province. The column labeled "Potential" indicates the potential market or potential strength of each province. The column labeled "E" shows the slacks of energy capital, and the column labeled "M" shows the material capital. Smaller slack suggests higher strength for the province. In eastern provinces, the scores are higher than any others. However, the fluctuation of score is relatively stable despite different local price levels.

In conclusion, the FDI attractiveness in most eastern provinces is efficient, and the number of efficient provinces has been increasing in this region. For those relatively inefficient provinces, returns to scale tend to increase. It implies there is a potential market for more unused inputs. Meanwhile, there is also redundancy in inputs. On one hand, the potential market supplies the new opportunities for investors. On the other hand, the redundancy phenomenon is alarming for decision makers. Analyzing the data, we found that regardless of time issue, a potential market existed in the eastern region at some degree. However, in recent years, the potential market is disappearing gradually. Because abundant FDI exists in the east, the inputs utility nears its saturation point, which demonstrates that the east needs more inputs. Inefficient provinces have a lot of input redundancy, especially recently. During the stable period, the energy consumption is worst because of energy saving policies and emission reductions in the eastern region. Series of policies are published to control the energy consumption. Overall, material capital and energy consumption lead to the diversity between the provinces on the non-productive frontier and the provinces on the productive frontier. However, during the whole research period, degree of openness and human capital are the bottlenecks of improving productivity.

Most provinces are efficient. Shandong and Hebei are relatively inefficient during the period of study. Tianjin and Fujian are inefficient in 2003. Jiangsu is inefficient in the peak year while others are efficient this year. It implies that the FDI attractiveness of these provinces can be improved in some degree considering the local price level. As we analyzed above, a potential market exists in inefficient provinces during the middle research period, especially in Hebei and Shandong. Their potential markets are 24.4% and 22.5% respectively. Similarly, the advantage vanishes at the stable stage in recent years. The redundancy phenomenon of material capital highlights are 29.73% and 20.77% for Hebei and Shandong respectively. The low efficiencies in Hebei and Shandong are due to material capital redundancy. When compared to the peak and trough performance in 2002 and 2003 respectively, energy consumption redundancy during the period 2004 to 2008 in Hebei was under controlled at the third stage. Material capital and energy consumption are redundant in Jiangsu, Tianjin and Fujian during these years. However, they also appeared under control in recent years to become more efficient. The developing

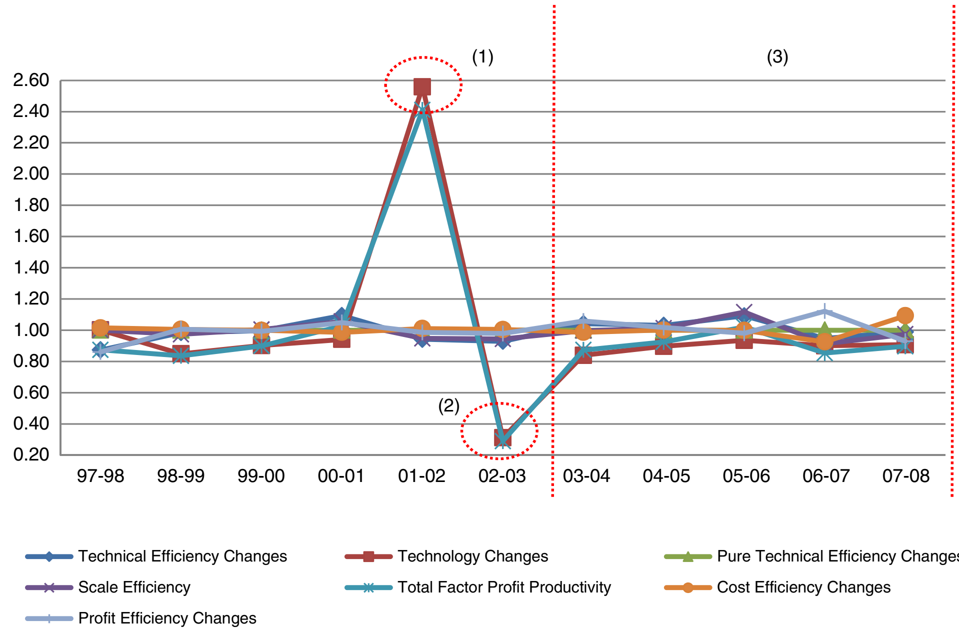

Fig. 6. 1997–2008 FDI attractiveness in special steps.

model in the eastern provinces focuses on the macro situation of energy saving and emission reduction. Meanwhile, the absence of inputs is the key limit of FDI attractiveness promotion.

Recently, FDI attractiveness among western provinces is diverse and scattered. The efficient provinces increase gradually in recent years. However, the degree of openness becomes the bottleneck of FDI attractiveness. As in the east, returns to scale of lower efficiency provinces tend to increase. The redundancy of energy consumption is terrible in the peak year and the trough year. Although it changes for the better in recent years, it falls unavoidably into the developing model of "Govern after the Waste". Because of the location, environment, and technology limitations, FDI investors prefer to invest in labor intensive industry and energy consumption industry, which leads to the large use of energy. With economic development and the policy of low carbon economy, the redundancy of energy is better-controlled. However, as in the eastern region, the redundancy of material capital is still obvious, as demonstrated in Table 3. During the middle research period, a potential market exists in the lower efficient provinces in the west. But with the FDI pouring into the market, the potential is decreasing gradually. So the central government published a new round of policies to develop the west in 2010 in order to adjust the industry structure. Therefore, policy supports directional change.

Chongqing is the only efficient province during the entire study period. It is a good example for other provinces and undeveloped areas in other country. Inner Mongolia, Guangxi, and Qinghai are on the productive frontier at two stages. FDI attractiveness in Shaanxi develops quickly. The supporting policies of "develop the west" promoted performance and the characteristics of western provinces, such as low cost, low environment threshold, rich in resources, are convenient for the industry incubation. Besides that, their economic background is relatively low, and relatively inputs are large. As demonstrated in Table 3, Inner Mongolia is a new province with good resources. However, the redundancy of energy consumption is terrible at the early period of attracting FDI with 41.22%. It demonstrates that Inner Mongolia exchanged environment for economic profit after 2002 to attract FDI. Therefore, after 2003, Inner Mongolia reaches the productive frontier. FDI attractiveness in Qinghai has decreased in recent years. Except degree of openness, all the inputs are redundant. Worse yet, no potential market exists in these provinces. It proves FDI industry structure in Qinghai needs to be adjusted as soon as possible. Ningxia is on the productive frontier with its

Table 2
Inputs decomposition in eastern provinces of China.

2002 Percent					2003 Percent					2004–2008 Percent		
Province	Score RTS+	Potential	E	M	Province	Score RTS+	Potential	E	M	Province	Score RTS+	E
Beijing	1				Beijing	1				Beijing	1	
Liaoning	1				Liaoning	1				Liaoning	1	
Shanghai	1				Shanghai	1				Shanghai	1	
Zhejiang	1				Zhejiang	1				Zhejiang	1	
Guangdong	1				Guangdong	1				Guangdong	1	
Hainan	1				Hainan	1				Hainan	1	
Fujian	1				Jiangsu	1				Jiangsu	1	
Tianjin	1				Tianjin	0.977	2.31	16.69		Tianjin	1	
Jiangsu	0.976	2.38		13.44	Fujian	0.915	8.46	0.61		Fujian	1	
Shandong	0.834	16.6			Shandong	0.775	22.5		9.20	Shandong	0.792	20.77
Hebei	0.709	29.1	12.79	1.64	Hebei	0.756	24.4	16.09	6.63	Hebei	0.703	29.73

Table 3
Inputs decomposition in western provinces of China.

2002 Percent						2003 Percent					
Province	Score RTS+	Potential	H	E	M	Province	Score RTS+	Potential	H	E	M
Chongqing	1					Chongqing	1				
Qinghai	1					Qinghai	1				
Guangxi	1					Inner Mongolia	1				
Shaanxi	0.964	3.64				Ningxia	0.868	13.22		38.13	
Inner Mongolia	0.952	4.8		41.22		Shaanxi	0.743	25.71			8.24
Ningxia	0.947	5.25		7.03		Xinjiang	0.726	27.44		17.22	4.13
Xinjiang	0.821	17.9		12.29	8.42	Guangxi	0.689	31.09	10.97		
Kweichow	0.665	33.5	19.98	20.63		Kweichow	0.541	45.94	10.98	29.85	
Szechwan	0.581	41.9				Szechwan	0.436	56.37			1.51
Gansu	0.444	55.6		2.53		Gansu	0.368	63.23		13.34	
Yunnan	0.373	62.7				Yunnan	0.204	79.56			2.43
2004–2008 Percent											
Province	Score RTS+	Potential	H	E	M	Province	Score RTS+	Potential	H	E	M
Chongqing	1					Qinghai	0.879		14.05	12.05	12.09
Guangxi	1					Xinjiang	0.719				28.15
Inner Mongolia	1					Kweichow	0.599	27.3			40.07
Shaanxi	1					Szechwan	0.484				51.62
Ningxia	1					Gansu	0.398				60.22
						Yunnan	0.390	2.13	10.94		60.97

excellent control of energy consumption. Ningxia is a low carbon province. Although Shaanxi is out of the productive frontier, it has a potential market and the redundancy is better. Only material capital is redundant in the trough year, about 8.4% in recent years, Shaanxi seizes the chance of potential market and reaches the productivity frontier. At last, Shaanxi is another efficient province.

Similar to Shaanxi at early period, Szechwan's material capital decreases after year 2002. However, a larger potential market exists in Szechwan during the middle period compared with that of Shaanxi. The potential percentages are 41.9% in 2002 and 56.37% in 2003. Furthermore, the redundancy factor in material capital is about 1.5% in the trough year. However, Szechwan's FDI attractiveness is still at the third from bottom. Also located in the bottom are Yunnan, Gansu, and Kweichow. Worse than that, potential markets in the middle period disappear in recent years, which results in low FDI attractiveness in those provinces. Besides that, abundant redundancy of material capital, about 40%–60%, is the key of this decline. Although Yunnan and Kweichow are located at the bottom, potential markets there did not disappear in recent years, especially in Kweichow. For those provinces, on one hand, we suggest investors should seize the good chance. On the other hand, the decision makers should hold the advantage, imitate Shaanxi and learn Szechwan's lesson in order to improve their FDI attractiveness.

Scores in central provinces ranged between those of eastern and western provinces due to their special location. Similarly, returns to scale of lower FDI provinces tend to increase. The degree of openness is the bottleneck of FDI and material capital is terribly redundant (Table 4). The efficiency span is relatively larger than that of eastern region. With development, the efficiency fluctuation among provinces grows smaller. However, from a diachronic approach in each province, the ascending speed is quicker and the fluctuation range is larger.

Since Jiangxi borders on Guangzhou, Fujian and Zhejiang, its FDI is positively affected by these three neighboring provinces. Meanwhile, Guangdong, Fujian, and Zhejiang are located on or near the productive frontier, especially at the stable period from 2004 to 2008. So, Jiangxi is the only efficient province in the central region. Compared to other provinces, Henan is affected by national low FDI

Table 4
Inputs decomposition in central provinces of China.

2002 Percent						2003 Percent					
Province	Score RTS+	Potential	H	E	M	Province	Score RTS+	Potential	H	E	M
Jiangxi	1					Jiangxi	1				
Henan	1					Heilongjiang	0.969	3.05			9.16
Heilongjiang	1					Henan	0.787	21.25	12.62	37.96	12.11
Jilin	0.764	23.6		0.81		Hubei	0.693	30.7			22.51
Hubei	0.710	29.0		1.38	15.21	Shanxi	0.691	30.92		43.84	
Shanxi	0.676	32.4		30.17		Jilin	0.685	31.46			
Hunan	0.649	35.1			5.14	Hunan	0.655	34.52		12.5	9.17
Anhui	0.246	75.4	1.7	0.55		Anhui	0.286	71.41			
2004–2008 Percent											
Province	Score RTS+	Potential	H	E	M	Province	Score RTS+	Potential	H	E	M
Jiangxi	1					Anhui	0.784	25.4			21.62
Henan	1					Hunan	0.779	4.03		0.07	22.14
Heilongjiang	0.968	14.4			3.19	Shanxi	0.673		0.47		32.74
Jilin	0.936			17.06	6.37	Hubei	0.594		3.96	9.32	40.64

attractiveness during the stable period. The inputs' redundancy phenomenon is terrible. In particular, the redundancy of energy consumption is 38%. Fortunately, Henan has improved in recent years and has returned to the productive frontier during the stable period. However, Heilongjiang has regressed, falling from the productive frontier to the second area after the peak year and never recovers. Luckily, the potential market percent increases gradually and material capital is the only redundant factor. Therefore, it decreases gradually. So either for the investors, or for the decision makers, it's a good chance. Hubei also exhibits this redundancy phenomenon. Furthermore, the situation is more severe because there is no potential market. So Hubei is the last in terms of efficiency in the central region. FDI promotions in Anhui and Hunan to take advantage of potential market and to increase energy consumption cannot be ignored. In recent years, Anhui, Heilongjiang, and Hunan show some potential market, but the key is how to seize the opportunity to solve the current problems quickly.

In summary, the promotion experience in the eastern, central, and western provinces shows that how to catch the potential market is a crucial issue. On the other hand controlling the redundancy of energy consumption is a key of vital importance as well. Furthermore, control of material capital redundancy is a national problem that needs to be solved urgently. From the analysis above, for the investors, we suggest that holding the existing potential market and combining with the characteristics of FDI industry in order to get more profit are of paramount importance. For the decision makers, we advise they should base on local conditions to macro control and guide the FDI industry structure in order to improve the province's efficiency.

7. Managerial insight and policy guidance

Based on the results of our research, we provide the following managerial insight and policy guidance for investors and policy makers to improve FDI attractiveness. First, savvy investors, guided by a sustainable development strategy, should choose provinces with good development environment for their investments. The short-term goal of immediate profit should be discounted but instead focus on factors' redundancy and overall productivity. For policy makers, both FDI performance index and FDI potential index should be considered in their mechanism design to encourage FDI. Rules and regulation imposed should exert FDI spillover effects and avoid exchanging environment for short-term economic gain at the expense of long-term FDI potential.

Second, investors should seize the opportunity to take advantage of provinces with potential market. This means not only shifting focus to the central and western regions, but also increasing the amount of investment. For policy makers, they should enhance the conditions to attract FDI. During the promotion of the "West Development Policy", new development patterns should be considered and government should emphasize development of knowledge-intensive industries.

Third, investors should shift their investments to areas with high-technology, advanced manufacturing and information technology, energy saving, new energy, and modern service industries to exploit the macro policy support. Therefore they could continue developing towards the goal of technology change. For policy makers, we advise that each province should exert their competitive advantages and reinforce their mechanism design to increase FDI attractiveness. Besides that, they should find a breakthrough to solve their limitations in factor inputs and adjust their industrial structure accordingly. Meanwhile, the government should encourage neighboring regions and provinces to optimize their input factors across geographical boundaries. Along this concept, local government can set up economic circles and policies to ensure factor inputs flow freely among investors and provinces. Within the economic circles, policy makers should learn from successful provinces with high FDI. Meanwhile, they can revise their trade practices, import and export restrictions, and domestic technological progress to be more conducive to FDI.

Last but not least, improving energy efficiency of input factors and reducing environmental pollution are important factors in creating mechanism design to increase FDI. Therefore, energy efficiency must be improved in order to minimize energy consumption of FDI resource inputs and to achieve the goal of energy-saving and emission-reduction. The lack of human capital is another key challenge that restricts the overall efficiency of FDI attractiveness. On one hand, the Chinese government should conduct a series of measures to accumulate human capital resource, adjust industrial structure, and promote progress in science and technology. These measures help to decrease pressure on the environment. On the other hand, investors should also promote low-carbon strategy by observing the macro orientation of energy-saving and emission-reduction to enhance corporate image and gain potential market, which in the long-term is a win–win situation.

8. Summary and conclusions

In this study, we combine different price levels, and inject input cost efficiency and output profit efficiency into the traditional DEA method. In addition, this paper identifies the influence of each study unit's macro environment on FDI attractiveness. Next, we use the model to analyze data from China's 30 provinces from 1997 to 2008. Major conclusions of our study are:

First, FDI attractiveness is led by technological progress, which means that enhancement of the quality of input factors, is the key issue to attracting FDI. After 2008, technological progress shows a negative effect on entire efficiency. The price influence on technological progress was absent in the beginning. However, it showed up as a negative effect later and then became a significant efficiency in the last two years. The price effects result in a great influence on product structure, which is more significant within recent years. The provinces with low efficiency lie in the increases on returns to scale. The degree of openness is now the bottleneck of FDI attractiveness in China. While the waste of energy factors has been under control, however, the problem of material capital factors waste demands prompt solution.

Second, there is variation in FDI attractiveness among the eastern provinces that suit the development of various types of industries, which means that the eastern provinces have great potential development space. Since the east is more developed compared to other regions of China, FDI attraction begins early and has grown gradually. Therefore, the factor of price is rather smooth for the provinces' FDI attraction. Most of these provinces have higher attractive performance. Hebei province and Shandong province are bottlenecks of the eastern region which give them more room to improve the overall efficiency of input factors. However, the advantage of potential market has vanished for the eastern provinces.

Third, FDI attractiveness of western provinces shows duality, which means there is a large potential market for the west. The performance gap between the provinces is also great, some of the provinces face the danger of "waste first, treatment later." The price advantage is gradually disappearing. However, in recent years, with policy support, low barriers to entry and low base of FDI, these provinces have a trend of catching-up the east.

Fourth, FDI performance of central provinces shows similar trends as the eight provinces are profit efficiency changes dominate, which means that the price factor could not be ignored. Because these areas lie in central regions and they are less influenced by the government's macro adjustment, they have their own unique advantages of market regulation. There are potential markets in Heilongjiang province, Anhui province, and Hunan province.

Guided by a sustainable development strategy, this paper considers price level influence on input–output factors. Using economic data from the 30 provinces in China, we analyze the FDI attractiveness to provide insight for foreign investors and policy makers of developing countries. However, since we focused on FDI for the host country, we have ignored investment efficient analysis like investor's return on investment. For future studies, the lagging effect of overall FDI should be taken into account. The extended dynamic model is worth further exploration.

Abbreviations

A	FDI Performance Index
CCR	Charnes, Cooper and Rhodes' model
CEC	Cost Efficiency Changes
CECT	Cost Efficiency Changes Type
DMU	Decision-Making Unit
E	Energy Capital
FDI	Foreign Direct Investment
H	Human Capital
M	Material Capital
O	Degrees of Market Openness
OEC	Overall Technical Efficiency Changes
P	FDI Potential Index
PEC	Profit Efficiency Changes
PECT	Profit Efficiency Changes Type
PPI	Purchasing Price Indices
PTC	Pure Efficiency Changes
SEC	Scale Efficiency Changes
SECT	Scale Efficiency Changes Type
TC	Technology Changes
TCT	Technology Changes Type
TE	Technical Efficiency
TEC	Technical Efficiency Changes
TFP	Total Factor Productivity
TFPP	Total Factor Profit Productivity
TFRP	Total Factor Return Productivity
UNCTD	United Nations Conference on Trade and Development

Acknowledgment

The authors would like to thank the Editor and two anonymous reviewers whose constructive and insightful comments have improved the quality of this research. The Corresponding Author, Dr. Deng, would like to dedicate this research to Dr. William W. Cooper. who has passed away on June 2012. Dr. Cooper was a great mentor supporter of his Ph.D. study at the University of Texas at Austin. Dr. Cooper's knowledge and guidance have inspired many to excel in research.

References

[1] Laura Alfaro, Areendam Chanda, Sebnem Kalemli-Ozcan, Selin Sayek, FDI and economic growth: the role of local financial markets, Journal of International Economics 64 (2004) 89–112.
[2] Arnold J. Matthias, Beata S. Javorcik, Gifted kids or pushy parents? Foreign direct investment and plant productivity in Indonesia, Journal of International Economics 79 (2009) 42–53.
[3] Natália Barbosa, Vasco Eiriz, Linking corporate productivity to foreign direct investment: an empirical assessment, International Business Review 18 (2009) 1–13.
[4] N. Balasubramanyam, David Sapsford, Does India need a lot more FDI? Economic and Political Weekly 42 (17) (2007) 1549–1555.
[5] Salvador Barrios, Holger Grög, Eric Strobl, Foreign direct investment, competition and industrial development in the host country, European Economic Review 49 (2005) 1761–1784.
[6] Roberto Basile, Davide Castellani, Antonello Zanfei, Location choices of multinational firms in Europe: the role of EU cohesion policy, Journal of International Economics 74 (2008) 328–340.
[7] Jelle Brouwer, Richard Paap, Viaene Jean-Marie, The trade and FDI effects of EMU enlargement, Journal of International Money and Finance 27 (2008) 188–208.
[8] R.E. Caves, Multinational Enterprise and Economic Analysis, Cambridge University Press, Cambridge, 1982.
[9] R.E. Caves, Multinational Enterprise and Economic Analysis, 2nd ed. Cambridge University Press, Cambridge, 1996.
[10] A. Charnes, W.W. Cooper, E. Rhodes, Measuring the efficiency of decision making units, European Journal of Operations Research 2 (1978) 429–435.
[11] Leonard K. Cheng, K. Kwan Yun, What are the determinants of the location of foreign direct investment? The Chinese experience, Journal of International Economics 51 (2000) 379–400.
[12] China's National Bureau of Statistics, China Population and Employment Statistics Yearbook, China Statistics Press, Beijing, 1998–2009.
[13] China's National Bureau of Statistics, New China of 60 Year of Data Collection and Statistics Yearbook of Provinces, China Statistics Press, Beijing, 2010.
[14] Yen-Chun Chou, Benjamin B.M. Shao, Winston T. Lin, Performance Evaluation of Production of IT Capital Goods across OECD Countries: A Stochastic Frontier Approach to Malmquist Index, Decision Support Systems 54 (1) (2012) 173–184.
[15] Paola Criscuolo, Rajneesh Narula, A novel approach to national technological accumulation and absorptive capacity: aggregating Cohen and Levinthal, European Journal of Development Research 20 (1) (2008) 56–73.
[16] Stephane Dees, Foreign direct investment in China: determinants and effects, Economics of Planning 31 (2–3) (1998) 175–194.
[17] Shengliang Deng, Yuan Li, Jinxian Chen, Evaluating foreign investment environment in China: a systematic approach, European Journal of Operational Research 100 (1997) 16–26.
[18] X. Fan, P.M. Dickie, The contribution of foreign direct investment to growth and stability, a post-crisis ASEAN-5 review, ASEAN Economic Bulletin 17 (3) (2000) 312–323.
[19] R. Färe, S. Grosskopf, S. Norris, Z. Zhang, Productivity growth, technical progress, and efficiency change in industrialized countries, American Economic Review 84 (1) (1994) 66–83.
[20] J.M. Farrell, The measurement of productive efficiency, Journal of the Royal Statistical Society 120 (1957) 253–290.
[21] Chiara Franco, Exports and FDI motivations: empirical evidence from U.S. foreign subsidiaries, International Business Review (2012), http://dx.doi.org/10.1016/j.ibusrev.2012.02.002.
[22] Xiaolan Fu, Christian Helmers, Jiang Zhang, The two faces of foreign management capabilities: FDI and productive efficiency in the UK retail sector, International Business Review 21 (2012) 71–88.
[23] Xiaolan Fu, Yundan Gong, International and intranational technological spillovers and productivity growth in China, Asian Economic Papers 8 (2) (2009) 1–23.
[24] Yue He, He Zhenglin, Ma Haixia, Appraisal of the efficiency in absorbing FDI in China based on GMDH and DEA, (in Chinese), East China Economic Management 22 (8) (2008) 42–49.
[25] Yichao Hu, Lei Ming, Appraisal and analysis of the efficiency in absorbing FDI in China, (in Chinese), Institute of Quantitative & Technical Economics 5 (2006) 64–73.
[26] Kuosmanen Timo, Neil Bijsterbosch, Rob Dellink, Environmental cost–benefit analysis of alternative timing strategies in greenhouse gas abatement: a data envelopment analysis approach, Ecological Economics 68 (2009) 1633–1642.
[27] Hui Lei, Calculating the capital of China and a review of investment efficiency, (in Chinese), Economist 6 (2009) 75–83.
[28] Nikolaos Maniadakis, Emmanuel Thanassoulis, A cost Malmquist productivity index, European Journal of Operational Research 154 (2004) 396–409.
[29] Farrokh Nourzad, Openness and the efficiency of FDI: a panel stochastic production frontier study, International Advances in Economic Research 14 (1) (2008) 25–35.
[30] Giovanni Pica, José V.R. Mora, Who's afraid of a globalized world? Foreign direct investments, local knowledge and allocation of talents, Journal of International Economics 85 (2011) 86–101.
[31] M.C.A.S. Portela, Emmanuel Thanassoulis, Developing a decomposable measure of profit efficiency using DEA, Journal of the Operational Research Society 58 (2007) 481–490.
[32] Banga Rashmi, Impact of Japanese and US FDI on productivity growth: a firm-level analysis, Economic and Political Weekly 39 (5) (2004) 453–460.
[33] Bahar Bayraktar Saglam, Sayek Selin, MNEs and wages: the role of productivity spillovers and imperfect labor markets, Economic Modelling 28 (2011) 2736–2742.
[34] Toshiyuki Sueyoshi, Beyond economics for guiding large public policy issues: lessons from the Bell System Divestiture and the California Electricity Crisis, Decision Support Systems 48 (2010) 457–469.
[35] Ling Sun, Lilyan E. Fulginiti, Yo-Chan Chen, Taiwanese industry competitiveness when outward FDI is defensive, Journal of Asian Economics 21 (2010) 365–377.
[36] Suyanto, Ruhul A. Salim, Harry Bloch, Does foreign direct investment lead to productivity spillovers? Firm level evidence from Indonesia, World Development 37 (12) (2009) 1861–1876.
[37] Kiyoyasu Tanaka, Vertical foreign direct investment: evidence from Japanese and U.S. multinational enterprises, Japan and the World Economy 23 (2011) 97–111.
[38] K.M. Tomlin, Japanese FDI into U.S. service industries: exchange rate changes and services tradability, Japan and the World Economy 20 (2007) 521–541.
[39] UNCTAD, World Investment Report 2002: Transnational Corporations and Export Competitiveness, United Nations Publication, New York and Geneva, 2002.
[40] UNCTAD, World Investment Report 2010: Investing in a Low-Carbon Economy, United Nations Publication, New York and Geneva, 2010.
[41] Jun Zhang, Zhang Yuan, Recalculating the capital of China and a review of Li and Tang's article, Statistical Research 7 (2003) 35–43 (in Chinese).
[42] Qiwei Zhao, Zhang Cheng, Foreign direct investment and China's technical efficiency improvement: an empirical analysis based on stochastic frontiers production model, (in Chinese), World Economy Study 6 (2009) 61–67.
[43] Dan Zhu, A hybrid approach for efficient ensembles, Decision Support Systems 48 (2010) 480–487.

Ming Lei is a Professor in the Guanghua School of Management, Beijing University. He received his Ph.D. in Department of Automatic Control Engineering, Huazhong University of Science and Technology. His research focuses on Operations Research, Low Carbon Economics, Information Systems and Management Science. Prof. Lei's research has appeared in the *Bulletin of the International Statistical Institute*, *Journal of Systems Science* & *Systems Engineering*, and *International Journal of Social Economics* among others. He also authored six books such as: *Green accounting of China* (*in Chinese*), *Integrated analysis of China's natural resources–economy–environment* (*in Chinese*), and *Scientific development and harmonious society construction development* (*in Chinese*). Prof. Lei has served as a member of several professional organization committees such as the Council of Chinese Environmental Science Society, Chinese Environmental and Culture Society, Chinese Input–output Society, Chinese National Accounting Society, Chinese Energy Society, Chinese Regional Science Association, Editorial Broad of Economy Science, respectively. He has also been a Senior Expert of Chinese National Green GDP Accounting Project and a Senior Member of International Sustainable Energy Association (ISEA) and won the "China's Green Figure" award in 2006.

Xinna Zhao is a Ph.D. candidate in management at Guanghua School of Management, Peking University. Her research focuses mainly on Operations Research/Management, Information Systems, Management Science, Low Carbon Economy and Green Management. Zhao's research has appeared in the *Economic Science* (*in Chinese*), *the Journal of Quantitative* & *Technical Economics* (*in Chinese*), and *Chinese Journal of Management Science* (*in Chinese*) among others.

Honghui Deng is an Associate Professor in the Lee School of Business, University of Nevada Las Vegas. He received his Ph.D. in Red McCombs School of Business, the University of Texas at Austin. His research focuses mainly on Operations Research/Management, Economics, Information Systems, Management Science, and Risk Management with both methodology and empirical studies. Dr. Deng's research has appeared in *Decision Sciences*, *European Journal of Operational Research*, *Journal of Productivity Analysis*, and *Socio-Economic Planning Sciences* among others. He also co-authored two books such as: *Handbook on Data Envelopment Analysis* (Kluwer Academic Publishers 2011.) Dr. Deng has served as a member of several professional organization committees such as the China Summer Workshop on Information Management (CSWIM), the Workshop on E-Business (WEB) and the Annual Conference of the Academy of Innovation and Entrepreneurship (AIE). He is currently also working as a Fellow of the Institute of Innovation, Creativity and Capital (IC2) of the University of Texas at Austin.

Keah-Choon Tan is Interim Associate Dean and Professor of Operations Management in the Lee Business School at the University of Nevada Las Vegas. He received his Ph.D. in Production and Operations Management from Michigan State University. He has published articles in the areas of supply chain management, quality and operations scheduling in a number of reputable academic journals. Additionally, he has coauthored a supply chain management textbook, currently in its third edition. He has also served as the Editor and Co-guest Editor of journals, and won research grants and teaching awards, including the UNLV Foundation Distinguished Teaching Award.