sustainability

MDPI

Article

Does Foreign Direct Investment Affect Green Growth? Evidence from China's Experience

Shujing Yue *, Yang Yang and Yaoyu Hu

School of Economics & Management, Southeast University, 2 Si Pai Lou, Nanjing 210000, China; 220151825@seu.edu.cn (Y.Y.); 220131729@seu.edu.cn (Y.H.)

* Correspondence: yueshujing@seu.edu.cn or yue_shujing@126.com; Tel.: +86-25-5209-0700; Fax: +86-25-5209-0702

Academic Editors: Yongrok Choi, Malin Song and Seunghwan Myeong

Received: 29 October 2015; Accepted: 2 February 2016; Published: 16 February 2016

Abstract: Foreign Direct Investment (FDI) not only affects the economic growth but also affects the environmental protection of the host country. With China's background of pursuing green growth, we need to consider the performance of FDI from the economic and environmental benefit aspects. On this basis, using slacks-based measure directional distance function (SBMDDF) to build up green growth efficiency, economic efficiency and environmental efficiency indexes, empirical research on FDI in 104 Chinese cities from 2004 to 2011 has shown that: (1) Different cities have differences in their green growth efficiency. Shenzhen city is always efficient in green economic growth. (2) Overall, FDI is positive on Chinese cities' green growth. (3) When the green growth efficiency is broken down into economic efficiency and environmental efficiency, FDI promotes China's economic green growth through both environmental benefits and economic benefits. (4) The effect of FDI differs in different sectors. FDI in the emission-intensive sector promotes green efficiency mainly through the improvement of economic efficiency. FDI in the non-emission-intensive sector promotes economic efficiency, environmental efficiency and green efficiency.

Keywords: green efficiency; FDI; economic growth; environmental pollution; China

---

1. Introduction

In the past 30 years, China has maintained a sustained and stable economic growth. The rapid growth of China's economy has benefitted from the promotion of many factors, and Foreign Direct Investment (FDI) is one of them. Since the early 1990s China has seen large inflows of FDI and has become one of the biggest recipients of FDI among the developing countries. According to the *China City Statistical Yearbook*, in 2014, the amount of FDI that China introduced has reached 11.9562 trillion dollars, which is 34 times that of the amount 1990.

With rapid economic growth, the inefficient use of resources, increasing environmental pollution, as well as the large range and frequent appearance of smog and thick haze in recent years have prompted the Chinese government to transfer from the original model of economic growth, which involves high pollution, high energy consumption and high emissions, to a low pollution, low energy consumption and low emissions economic growth model. These requirements may have negative impacts on the current economic growth. Therefore, China's economy is facing the following question: "Economic growth first, or environmental protection first?"

Considering that China is in the developing stage, on the one hand, it needs continued economic growth because most of the problems which are currently faced by China rely on economic growth to be solved. On the other hand, China also needs a suitable and sustainable ecological environment because large forests, clear streams, and clean air are not only ecological barriers of economic growth, but also the basis of China's sustainable economic development. Therefore, taking into account both economic growth and environmental protection, which is also called "green growth", it has become China's actual choice.

FDI can not only have an impact on the economic growth of the host country, but can also exert an influence on the environment of the host country. Thus, FDI would have an impact on green growth concerning both economic growth and environmental pollution. From the background of green growth, when evaluating the impact of FDI on China's economy, we should not just evaluate the impact of FDI on traditional economic growth, but also consider the impact of FDI on energy consumption and environmental pollution.

The impact of FDI on China's green growth will directly influence the adjustment of China's FDI policy. If FDI is negative for China's green growth, the Chinese government should not continue to give more incentives and preferential policies to foreign investment, but should focus on improving the efficiency of domestic capital use. If FDI is positive for China's green growth, the Chinese government should continue to introduce and attract foreign investments through fiscal and financial instruments. Furthermore, behind the influence of FDI on China's green growth, if we can judge the main effects of FDI, whether on economic growth or on environmental pollution, and we can implement targeted policies, making best use of the advantages and bypassing the disadvantages, absorbing the positive spillover effects of FDI and reducing its negative effects.

Most literature explores the economic impacts of FDI and the environmental impacts of FDI on the host country, respectively. However, literature research on the impact of FDI on the host country's economy and environment in comprehensive ways is scarce. This paper takes 104 cities in China as research objectives, builds a comprehensive index reflecting the economic and environmental effects of FDI, and explores the economic effects and environmental effects of FDI on the host country, respectively. This paper will make three main contributions to the studies on China's green growth. First, this paper analyzes the green growth of China at the city level by using an SBM-DDF (slacks-based measure directional distance function) model. Second, through breaking down the green growth efficiency into economic efficiency and environmental efficiency, this paper explores the effects of FDI on green growth, economic growth and environmental pollution, respectively. Third, this paper proposes effective countermeasures to improve the effect of FDI on China's green economic growth.

The remainder of this paper is organized as follows: Section 2 briefly reviews the previous studies. Section 3 calculates the green efficiency of Chinese cities. Section 4 establishes the econometric model and presents the empirical findings. Section 5 concludes with some policy suggestions.

2. Literature Overview

Different from the present research which studies the impact of FDI on the host country's economy and environment separately, our paper focuses on the comprehensive impact of FDI to the host country's economic growth and environmental protection under a unified framework. Our paper is particularly related to two strands of literature.

The first strand focuses on the relationship between FDI and economic growth. As for FDI and economic growth, empirical studies provide a blurred picture of this relationship with some studies reporting positive effects and others reporting negative effects of FDI on economic growth. On the one hand, FDI has the following three important effects on the growth of the host country: providing a source of external capital, creating new job opportunities, and easing the transfer of technology and managerial skills [1,2]. Performing both cross-section and panel data analysis on a dataset covering 90 countries, Johnson [3] finds indications that FDI enhances economic growth in developing economies but not in developed economics. As for China, Cheung and Lin [4] found positive effects of FDI on the number of domestic patent applications in China, using provincial data from 1995 to 2000. Yao [5] focused on the effect of FDI on economic performance, using a panel data set encompassing 28 Chinese provinces over the period 1978–2000. The results of this study showed that FDI had a strong and positive effect on economic growth. Tang *et al.* [6] investigated the causal link between FDI and economic growth in China for the period of 1988–2003 using a multivariate Vector Auto-regression (VAR) system, and found single-directional causality from FDI to GDP in China. Hong [7] employed Generalized Method of Moments (GMM) to evaluate the effect of FDI on economic growth in China, and found that FDI exerted a positive impact on the economic growth during the period of 1994–2010.

On the other hand, FDI may have negative effects on economic growth by crowding out domestic investment, increasing external vulnerability, and causing dependence [8,9]. Carkovic and Levine [10] used a panel dataset covering 72 developed and developing countries and concluded that there is no robust link running from inward FDI to the host country's economic growth. Herzer *et al.* [11] challenged the belief that FDI has a positive impact on economic growth in developing countries. This paper used co-integration techniques for 28 countries and suggested that there is no causal relation between the FDI and GDP growth rate. Yalta [12] investigated the causal relationship between foreign direct investment and gross domestic product in China for the 1982–2008 period, and showed that a statistically significant relationship between FDI and GDP growth did not exist. Lian and Ma [13] also found that FDI did not lead to economic growth in the western region of China using time-series data from 1986 to 2010.

The second strand of research is concerned with the nexus between environmental degradation and FDI inflows. This issue has received much less attention from academic researchers compared with the extensive literature investigating the relationship between economic growth and FDI inflows. Economic theory is ambiguous concerning whether FDI is positive or negative to environmental pollution, because there are two different possible outcomes associated with FDI inflows.

One possibility is that countries experiencing increased FDI inflows obtain low environmental efficiency as the foreign investors choose the low-regulation countries and the scale of heavy industrial production increases. This is a pollution haven effect [14]. Xing and Kolstad [15] explore how the laxity of environmental regulations in a host country attracts FDIs and influences the location of heavily polluting industries, and find that lax environmental regulation in a host country is a significant determinant of FDI from the US. He [16] constructs a simultaneous model using a panel of data from China's 29 provinces to study the FDI-emission nexus in China, and the results show that with a 1% increase in FDI, industrial emissions will increase by 0.099%. Baek and Koo [17] apply integration analysis and a vector error-correction model to explore the short-run and long-run relationship between FDI and the environment in China and India, and the estimates are also consistent with the pollution haven effect.

Conversely, it is possible that FDI improves environmental efficiency in host countries because such new capital helps to modernize the capital stock [18]. Foreign companies employ better management practices and up-to-date technologies that result in a relatively clean environment in the host countries [19]. List and Co [20] suggest that FDI helps promote the energy efficiency of the host countries and decrease pollution emissions. Tamazian *et al.* [21] find that the increase in FDI inflows is associated with lower levels of CO_2 emissions, because FDI inflows encourage Research & Development (R&D) investments, possibly leading to higher technological energy-related efficiency, and therefore lower emissions. Wang and Yanhong [22] find foreign firms are significantly more energy efficient and use cleaner types of energy than the domestic-owned firms in a study examining firm level pollution discharge in more than 1000 firms in China. Zheng *et al.* [23] test the hypothesis concerning the relationship between FDI and ambient air pollution across major Chinese cities, and find cities featuring higher per-capita FDI flows have lower pollution levels. By using panel data on manufacturing FDI from a large sample of highly heterogeneous countries between 1995 and 2008, Natalia [24] investigates the existence and the conditionality of the controversial FDI-induced effects on industrial emissions, and the paper finds that FDI is associated with pollution reduction in countries with a low to average capital-to-labor ratio but not too-lax environmental regulations.

In summary, the existing literature has intensively studied the effects of FDI on a country's economic development and environmental pollution respectively, but comprehensive measurements of the effects of FDI on both economic growth and environmental pollution in the literature are lacking. Therefore, this paper attempts to measure the comprehensive effects (including both economic effects and environmental effects) of FDI on host countries and make an empirical study on these effects of FDI on China's 104 cities.

3. Measurements of the Green Efficiency of Urban Growth

3.1. Comprehensive Measurements of FDI Externalities: Green Growth Efficiency

Green growth efficiency is an index reflecting FDI's comprehensive externalities. Considering energy consumption and environmental pollution, the essence of green growth efficiency is "green + growth". No matter the strengthening of green degree, or the strengthening of growth ability, they will reflect on the increase of green growth efficiency. Therefore, the green growth efficiency is an appropriate indicator to analyze dilemmas faced by China in economic growth and environmental protection. We will make green growth efficiency the comprehensive measure of FDI economic and environmental effects: On the premise of other conditions unchanged, the value of FDI inflows is given such that if FDI helps gain more (or less) GDP and less environmental pollution (or higher), then the green growth efficiency will be improved higher (or lower). Additionally, the greater (or lesser) GDP reflects the positive (or negative) effects of FDI on economic growth. The lesser (or greater) pollution of the environment reflects the positive (or negative) effects of FDI on the environment. The green growth efficiency embodies the comprehensive measurements of FDI's effects on the economy and the environment.

Data Envelopment Analysis (DEA), using a non-parametric linear programming method for estimating a production frontier with multiple inputs and outputs, is the main way to evaluate and analyze the efficiency. Since Charnes, Cooper and Rhodes [25] first invented DEA, this method has been widely used because there is no need to set any prior functions or parameter weights. With the worsening of environmental pollution, undesirable outputs such as pollution emissions should be considered in the DEA. Traditional DEA usually assumes that producing more output relative to less input resources is a criterion of efficiency. In the presence of undesirable output, however, technologies with more desirable output and less undesirable output relative to less input resources should be recognized as efficient. For this purpose Hailu and Veeman [26] used undesirable outputs as input factors to calculate environmental efficiency. Scheel [27] even used the reciprocal transformation method in calculation. However, these methods are not consistent with the actual production process, and a deviation exists. Seiford and Zhu [28] transformed undesirable outputs into positive inputs through vector transformation. Fare *et al.* [29] established an output-oriented distance function to evaluate the environmental efficiency.

However, many studies have adopted radial and oriented DEA for analysis. When the slack variables exist, radical DEA will lead to biased results. Oriented DEA ignores aspects of inputs or outputs and also leads to inaccurate results. To overcome these problems, Fare *et al.* [29] and Fukuyama and Weber [30] developed the slacks-based measure directional distance function (SBMDDF) which is based on the SBM model dealing with the undesirable outputs of Tone [31].

We use SBMDDF to evaluate green growth efficiency. We assume each city is a decision-making unit to construct a green production frontier. Suppose that each city has three factors: inputs, good (desirable) outputs and bad (undesirable) outputs, as represented by three vectors of $x = (x_1, x_2 x_3 \ldots x_N) \in R_N^+$, $y = (y_1, y_2 y_3 \ldots y_M) \in R_M^+$, $(b = (b_1, b_2, b_3 \ldots b_I) \in R_I^+$. In different times (t is equal to 1, . . . ,T), the input and output of K city is $(x^{k.t}, y^{k.t}, b^{k.t})$. By imposing the assumption that desirable output and undesirable output are together weakly disposable, the production possibility set (P) is defined by:

$$P^t\left(x^t\right) = \left\{ \left(y^t, b^t\right) : \sum_{k=1}^{K} z_k^t y_{km}^t \geqslant y_{km}^t, \forall m; \sum_{k=1}^{K} z_k^t b_{ki}^t \leqslant b_{ki}^t, \forall i; \sum_{k=1}^{K} z_k^t x_{kn}^t \leqslant x_{kn}^t, \forall n; z_k^t \geqslant 0, \forall k \right\}$$

where z is the intensity vector, and the three inequalities in the P function stand for when, respectively, the actual desirable output levels are below the frontier desirable output level, the actual undesirable output is greater than the frontier undesirable output level, and the actual input level is greater than the frontier input level.

According to Fukuyama and Weber [30] and Tone *et al.* [31], the SBMDDF under the consideration of energy and environment can be expressed as:

$$S_v^t\left(x^{t,k'},y^{t,k'},b^{t,k'},g^x,g^y,g^b\right)=\max_{s^x,s^y,s^b}\frac{\frac{1}{N}\sum_{n=1}^{N}\frac{s_n^x}{g_n^x}+\frac{1}{M+I}\left(\sum_{m=1}^{M}\frac{s_m^y}{g_m^y}+\sum_{i=1}^{I}\frac{s_i^b}{g_i^b}\right)}{2}$$
$$\text{s.t.}\sum_{k=1}^{K}z_k^t x_{kn}^t+s_n^x=x_{k'n}^t,\forall \text{n};\sum_{k=1}^{K}z_k^t y_{km}^t-s_m^y=y_{k'm}^t,\forall m;\sum_{k=1}^{K}z_k^t b_{ki}^t+s_i^b=b_{k'i}^t,\forall i;$$
$$z_k^t\geqslant 0,\forall k;s_n^x\geqslant 0,\forall n;s_m^y\geqslant 0,\forall m;s_i^b\geqslant 0,\forall i \quad (1)$$

The vector $(x^{t,k'},y^{t,k'},b^{t,k'})$ indicates the kth Decision Making Unit's input, good output and bad output vector. Vector (s_n^x,s_m^y,s_i^b) is the positive directional vector that contracts inputs, contracts bad outputs and expands good outputs, and (g^x,g^y,g^b) is the direction vector. The objective is to maximize the sum of the average input inefficiency, average good output inefficiency, and average bad output inefficiency. This model gives the results of inefficiency for green growth. A smaller value shows that the efficiency of green growth is higher, while a greater value shows that the efficiency of green growth is lower. In the following analysis, we will adopt green growth inefficiency.

Based on 104 cities in China, we calculate the green growth inefficiency for each city from 2004 to 2011. The choice of China's civic level data during 2004–2011 to carry out our analysis is due to the following considerations. Firstly, China's nation-wide unified statistical system assures our comparable empirical study, and avoids the generally encountered critiques as data-incoherent problems by those international experience studies. Secondly, the *China City Statistical Yearbook* did not give urban energy consumption data before 2004, and the updated official data has not been released. Thirdly, given the increase in the FDI flow to China and the escalation of environmental degradation, focusing our analysis in the period will allow us to study the principal influence of FDI on both China's economic and environmental situation.

Green inefficiency is affected by economic and environmental factors, so we should consider environmental input-output as well as economic input-output. This study constructed an indicator system for green growth inefficiency evaluation (see Table 1) using the following input and output indicators. The input factors mainly include capital, labor and energy. We chose the total investment in fixed assets as the capital input. The number of persons employed in various units at year-end was selected as the labor input. We chose the industrial coal consumption as the energy input. We chose the gross regional product as the desirable output, and industrial sulfur dioxide emissions as undesirable output (among the available statistic data describing China's environmental situation, sulfur dioxide emission is the environmental index having the longest time dimension without interruptions). Data used in this paper is from the official statistical yearbooks.

Table 1. Input and output indicators.

Variable Category	Variable Name	Description	Units
Inputs	Capital	total investment in fixed assets	10,000 yuan
	Labor	persons employed in various units at year-end	10,000 persons
	Energy	industrial coal consumption	10,000 t
Desirable outputs	GDP	gross regional product	100 million yuan
Undesirable outputs	SO_2	Industrial sulfur dioxide	10^8 m^3

According to Equation (1), we can break the green growth inefficiency into input (capital, labor, energy) inefficiency, desirable output (GDP) inefficiency, and undesirable output (sulfur dioxide) inefficiency. To conveniently analyze the different effects of FDI on green economic growth, we call the sum of capital, labor and GDP inefficiencies economic inefficiencies (traditional growth inefficiencies), and the sum of energy and sulfur dioxide inefficiencies as environmental inefficiencies. These two inefficiencies are added together to make up green growth inefficiencies.

Economic inefficiency is made up of capital, labor and GDP inefficiencies.

$$\text{ECOINEF} = \frac{1}{2 \times 3}\left(\frac{s_n^l}{g_n^l} + \frac{s_n^k}{g_n^k}\right) + \frac{1}{2 \times (1+1)}\frac{s_m^{gdp}}{g_m^{gdp}} \tag{2}$$

Environmental inefficiency is the total inefficiency of energy and sulfur dioxide inefficiencies

$$\text{ENVIRINEF} = \frac{1}{2 \times 3}\left(\frac{s_n^e}{g_n^e}\right) + \frac{1}{2 \times (1+1)}\frac{s_i^{so2}}{g_i^{so2}} \tag{3}$$

Green inefficiency is equal to the sum of economic inefficiency and environmental inefficiency.

$$\text{GREENINEFF} = \text{ECOINEF} + \text{ENVIRINEF} \tag{4}$$

In the following analysis, we respectively make green growth inefficiency, economic inefficiency and environmental inefficiency dependent variables, and analyze the effects of FDI on China's green economic growth, traditional economic growth and environmental pollution.

3.2. Calculation Results and Analysis

According to the selection of the index variables and the measure of the model described above, the green growth inefficiencies of different cities in different years are shown in Table 2.

Due to space limitation, we chose the capital city of each province as samples, and analyzed the green growth efficiency from the economic and environmental comprehensive aspects. We divided the cities into three regions (eastern, middle and western) according to geographical locations. As we can see from Table 2, the average value of China's green inefficiency is 0.49 from 2004 to 2011; economic inefficiency and environmental inefficiency are respectively separated as 0.16 and 0.33. This indicates that the main cause of green growth inefficiency is from the inefficiency of the environment. In the process of China's rapid economic growth, there are many phenomena of irrational uses of resources and energy, as well as the destruction and deterioration of the natural environment, which results in low efficiency of the environment.

From the perspective of different regions, the average value of the eastern, middle and western regions' green growth inefficiencies from 2004 to 2011 are 0.37, 0.46 and 0.61, respectively. The average values of economic inefficiencies are 0.17, 0.11 and 0.28, and the average values of the environment inefficiencies are as high as 0.26, 0.29 and 0.33. On the one hand, it shows that there is a gap between the green growth of the eastern, middle and western regions. On the other hand, the eastern, middle and western regions' green growth shows the same situation, and it is obvious that the environmental inefficiency is always higher than economic inefficiency in the eastern, middle and western regions.

There are significant differences in the inefficiency of green growth between different cities even in the same region. In the eastern region, the green growth inefficiency values of Shenzhen, Guangzhou, Shanghai, Hangzhou and other cities are relatively lower than the average value. Among them, the green growth inefficiency value of Shenzhen is zero, and the economic inefficiency value and environmental inefficiency values are also zero. This shows that Shenzhen is one of China's best green growth cities. Tianjin, Fuzhou and Nanjing are also in the eastern region, but their green inefficiency values are relative high. The green growth inefficiency average value of Tianjin and Fuzhou is 0.50, Nanjing's green growth inefficiency average value is as high as 0.47. These cities' high inefficiency is mainly due to the low efficiency of the environment (see Table 2). In the middle region, the average value of green growth inefficiency is as high as 0.65, which is higher than the eastern region. Taiyuan, as a typical resourceful city in the middle region has higher green growth inefficiency than other cities in the same region. Taiyuan's leading industry is coal mining which inevitably destroys the local environment, resulting in high environmental inefficiency and poor green growth efficiency. In the western region, most cities' green growth inefficiencies are generally high, and about 80% of the cities' green development inefficiency values were higher than 0.5 in 2011. This indicates that under the economic and environmental double-win assessment criteria, there is a large gap between western cities, eastern cities and middle cities.

Table 2. Green growth inefficiency of typical cities from 2004 to 2011.

Category	City	2004			2011			Average Value		
		ECO INEF	ENVIR INEF	GREEN INEFF	ECO INEF	ENVIR INEF	GREEN INEFF	ECO INEF	ENVIR INEF	GREEN INEFF
Eastern Region	Beijing	0.21	0.23	0.44	0.16	0.28	0.44	0.17	0.19	0.36
	Tianjin	0.11	0.34	0.45	0.35	0.35	0.70	0.15	0.35	0.50
	Shenyang	0.10	0.13	0.23	0.10	0.30	0.40	0.12	0.27	0.39
	Shanghai	0.05	0.29	0.35	0.07	0.37	0.43	0.07	0.30	0.37
	Nanjing	0.11	0.34	0.44	0.11	0.39	0.50	0.11	0.35	0.47
	Hangzhou	0.03	0.10	0.14	0.21	0.33	0.54	0.12	0.29	0.42
	Fuzhou	0.05	0.23	0.28	0.23	0.39	0.61	0.17	0.33	0.50
	Guangzhou	0.03	0.28	0.31	0.07	0.33	0.40	0.04	0.25	0.29
	Shenzhen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Average	0.08	0.22	0.29	0.14	0.30	0.45	0.11	0.26	0.37
Middle Region	Taiyuan	0.30	0.34	0.64	0.25	0.40	0.64	0.29	0.36	0.65
	Changchun	0.04	0.16	0.21	0.12	0.39	0.51	0.14	0.32	0.46
	Harbin	0.11	0.25	0.36	0.20	0.38	0.58	0.20	0.29	0.49
	Hefei	0.14	0.30	0.45	0.17	0.37	0.54	0.15	0.31	0.47
	Nanchang	0.12	0.25	0.37	0.23	0.33	0.56	0.17	0.26	0.43
	Zhengzhou	0.11	0.35	0.46	0.15	0.39	0.54	0.16	0.36	0.52
	Wuhan	0.11	0.32	0.44	0.16	0.35	0.51	0.20	0.30	0.50
	Changsha	0.00	0.00	0.00	0.10	0.16	0.26	0.04	0.08	0.12
	Shijiazhuang	0.09	0.37	0.45	0.11	0.38	0.49	0.14	0.37	0.51
	Average	0.11	0.26	0.38	0.17	0.35	0.51	0.17	0.29	0.46
Western Region	huhehot	0.17	0.36	0.53	0.03	0.31	0.34	0.10	0.35	0.44
	Nanning	0.14	0.33	0.47	0.25	0.33	0.57	0.26	0.28	0.54
	Chengdu	0.11	0.26	0.37	0.16	0.33	0.49	0.17	0.29	0.46
	Chongqing	0.23	0.32	0.55	0.18	0.39	0.57	0.25	0.36	0.61
	Guiyang	0.40	0.33	0.73	0.46	0.36	0.81	0.49	0.34	0.83
	Kunming	0.13	0.34	0.47	0.33	0.38	0.71	0.30	0.34	0.63
	Xi'an	0.18	0.31	0.49	0.29	0.34	0.63	0.35	0.28	0.63
	Lanzhou	0.19	0.34	0.54	0.26	0.40	0.66	0.29	0.36	0.66
	Xining	0.32	0.34	0.66	0.31	0.39	0.70	0.32	0.38	0.70
	Yinchuan	0.50	0.22	0.73	0.20	0.41	0.61	0.37	0.30	0.67
	Urumqi	0.12	0.38	0.50	0.11	0.40	0.52	0.16	0.39	0.55
	Average	0.23	0.32	0.55	0.23	0.37	0.60	0.28	0.33	0.61

Note: The value in the table is green growth inefficiency. The larger the value is, the lower the efficiency of green growth; the smaller the value is, the higher the efficiency of green growth.

4. An Empirical Analysis of FDI Impact on Green Growth Inefficiency

4.1. The Influence of FDI on the Green Growth Inefficiency

FDI not only has an impact on the economic benefits of urban growth, but also exerts environmental impacts on urban growth. FDI's positive (or negative) economic effect and environmental effect on cities' growth may induce higher (or lower) green growth efficiency. Therefore, green growth efficiency can be used as a comprehensive measure of FDI's performance. So we take Green Growth Inefficiency (GREENINEFF) as the dependent variable; Foreign Direct Investment (FDI) as the key independent variable; Environmental Regulation (ER), Per Capita Gross Domestic Product

(PCGDP), Industrial Structure (IS), Per Capita Scientific and Technology Investment (PCSTI) as the control variables, and established Equation (5):

$$\mathrm{GREENINEFF_t} = \mathrm{C_1} + \mathrm{a_1FDI_t} + \mathrm{a_2ER_t} + \mathrm{a_3PCGDP_t} + \mathrm{a_4IS_t} + \mathrm{a_5PCSTI_t} + \mu_{t1} \quad (5)$$

where subscripts *i* and *t* denote city and time period, respectively. The coefficient a_1 measures the magnitude of the comprehensive effects of FDI.

Among them, the selection of the variables and the data is as follows:

Dependent variable—Green Growth Inefficiency (GREENINEFF). The inefficiency of urban green growth is calculated as mentioned before. It should be noted that in the results of the regression model, the larger the dependent variable the lower the green growth efficiency.

Independent variable—Foreign Direct Investment (FDI). Foreign direct investment is an important form of foreign technology and knowledge inflow. It may bring technology spillover and knowledge expansion, which has a possible positive effect on the promotion of green efficiency. However, FDI can also bring resource-dependence and environmental damage and may play a negative role on the promotion of green efficiency.

In this section, FDI equals gross FDI inflows as a share of GDP (the FDI/GDP ratio) [3,10,32]. We also try to use different FDI indicators. We have looked at indicators for FDI such as the ratio of FDI in gross capital formation, the ratio of foreign firm employees in the total employees, the FDI inflows per capita, *etc.* However, the correlation coefficients of different FDI indicators are significantly higher, and none of the indicators are significantly different with the estimated results in Table 3.

Control variable—Environmental Regulation (ER). We use the sulfur dioxide (SO_2) removal rate to measure Environmental Regulation. Generally speaking, the higher the removal rate of SO_2, the stricter the city environmental regulation, and strict environmental regulations can guide enterprises to pay more attention to clean production technology, resulting in the reduction of environmental pollution, which promotes green growth efficiency.

Control variable—Per Capita GDP (PCGDP). The higher the GDP per capita, the better the city's economic development condition. The awareness of environmental protection of the local government and the public is relatively high in cities with high GDP per capita; meanwhile, these cities will also pay more attention to the protection of the environment, which can play a positive role in the green development efficiency.

Control variable—Industrial Structure (IS). We use the proportional measurement of value added as secondary to the GDP. The secondary industry is the main industry where FDI inflows, which is also the important source to promote the development of the urban economy, but also an important source of urban environment pollution.

Control variable—Per Capita Science and Technology Investment (PCSTI). Investment in science and technology is an important force of promoting the transformation of the green economy. Increasing investment in science and technology not only improves the production efficiency of economic activities, but also can increase the promotion and popularization of green technologies.

When examining the FDI's comprehensive effect on green growth, we recognize that there is a valid concern about possible reverse causality. The quality of green growth, whether it is low or high, may influence FDI flows. Therefore, we take on two methods to attenuate the problem of endogeneity. One is considering a model with one lag of all the explanatory variables, including FDI, for regression analysis. The other is a model where we use one lag of FDI as the Instrumental Variable (IV), and our justification for this strategy is that this measure is correlated with FDI flows and the quality of green growth is unlikely to have an effect on one-period lagged FDI flows. Table 3 columns (1), (2) and (3) report the OLS (Ordinary Least Squares), one lag of explanatory variables and IV results based on Equation (5) respectively. Column (1), column (2) and column (3) give consistent basic conclusions. The estimated results show that FDI has a negative effect on the dependent variable, which means the increase of FDI will cause a reduction in the dependent variable, which means that FDI is positive in improving the efficiency of green growth.

Table 3. The estimation results of the relation between FDI and green growth.

	Estimation Model (5)			Estimation Model (6)			Estimation Model (7)		
	GREEN	GREEN	GREEN	ECO	ECO	ECO	ENVIRON	ENVIRON	ENVIRON
	INEFF	INEFF	INEF	INEF	INEF	INEF	INEF	INEF	INEF
	column (1)	column (2)	column (3)	column (4)	column (5)	column (6)	column (7)	column (8)	column (9)
	OLS	One lag of explanatory variables	IV	OLS	One lag of explanatory variables	IV	OLS	One lag of explanatory variables	IV(TSLS)
FDI	−1.143 *** (0.1863)	−0.9240 *** (0.1794)	−1.206 *** (0.2497)	−0.4707 *** (0.1287)	−0.3388 *** (0.1301)	−0.4191 *** (0.1487)	−0.6725 *** (0.107)	−0.5852 *** (0.1043)	−0.7874 *** (0.1646)
ER	0.0885 *** (0.0217)	0.0546 *** (0.0205)	0.0108 (0.0233)	0.0305 ** (0.015)	0.0071 (0.0148)	−0.0158 (0.0189)	0.0580 *** (0.0124)	0.0476 *** (0.0119)	0.0266 ** (0.0123)
PGDP	−0.0321 *** (0.0029)	−0.0400 *** (0.003)	−0.0354 *** (0.0035)	−0.0176 *** (0.002)	−0.0214 *** (0.0022)	−0.0202 *** (0.0017)	−0.0146 *** (0.0017)	−0.0185 *** (0.0017)	−0.0152 *** (0.0026)
IS	0.0010 ** (0.0005)	0.0008 * (0.0004)	0.0006 (0.0004)	−0.0004 (0.0003)	−0.0006 * (0.0003)	−0.0007 ** (0.0003)	0.0015 *** (0.0003)	0.00145 *** (0.0003)	0..0013 *** (0.0003)
PCSTI	−0.4110 ** (0.213)	−0.3041 (0.2201)	−0.4370 * (0.2421)	0.119 (0.147)	0.157 (0.159)	0.117 (0.126)	−0.5301 *** (0.1221)	−0.4610 *** (0.128)	−0.5540 *** (0.154)
Constant	0.5435 *** (0.0248)	0.5942 *** (0.0237)	0.6356 *** (0.023)	0.2445 *** (0.0171)	0.2758 *** (0.0172)	0.2986 *** (0.0169)	0.2990 *** (0.0142)	0.3184 *** (0.0138)	0.3370 *** (0.0148)
R2	0.3103	0.39	0.43	0.1853	0.25	0.27	0.2975	0.35	0.4
Adjusted-R^2	0.3062	0.39		0.1804	0.24		0.2932	0.35	
F-statistic	74.34	94.12		37.58	46.88		69.96	79.31	
Prob	0	0		0	0		0	0	

Note: ***, **, * indicates significance at the 1% level, 5% level, 10% level, respectively; VIF (variance inflation factor) is smaller than two and the mean of VIF is 1.41 indicating the multi-collinearity is not serious; Columns (1), (4), (7) in Table 3 are pooled OLS because the LM test suggests OLS should be used for the 104 cities sample; Columns (2), (5), (8) in Table 3 take independent variables lagged one year instead of the original independent variables. Columns (3), (6) and (9) in Table 3 control for the endogeneity problem in FDI by instrumenting FDI with one-period lagged FDI.

As to the control variables, the environmental regulation (ER) has a positive effect on the dependent variable, which means that the enhancement of the environmental regulation is not effective in promoting the green growth efficiency. This result may be due to the administrative management's main role in the current environmental regulations in China, and therefore it may not have brought about the desired results. Per capita GDP (PCGDP) that passes the 1% significance test has a negative coefficient. This means that the economic development level has a positive effect on urban green growth efficiency. It seems that people's environmental awareness is stronger in cities with higher per capita GDP, and these cities' environmental protection is more general than that of other cities. Industrial structure (IS) that passes the 10% significance test has a positive coefficient. This means that the secondary industry has a negative effect on the urban green growth efficiency, and the main reason is that the secondary industry growth brings many energy consumption and pollutant emissions. Per capita scientific and technological investment (PCSTI) has a negative coefficient. This means that the growth of scientific and technological investment has a positive effect on the urban green growth efficiency.

4.2. The Impact of FDI on Urban Economic Growth

Since green growth efficiency is the comprehensive measurement of the economic and environmental benefits of FDI, we use the economic inefficiency (ECOINEF) as a dependent variable to discuss the impact of FDI on China's cities from the perspective of economic efficiency. We established the following regression in Equation (6):

$$\mathrm{ECOINEF_t} = \mathrm{C_1} + \mathrm{a_1FDI_t} + \mathrm{a_2ER_t} + \mathrm{a_3PCGDP_t} + \mathrm{a_4IS_t} + \mathrm{a_5PCSTI_t} + \mu_{t2} \quad (6)$$

When examining the FDI's economic effect on green growth, we also deal with the potential problem of the FDI increasing endogenously with higher economic efficiency. Therefore, we take on two methods to attenuate the problem of endogeneity. One is considering a model with one lag of all the explanatory variables, including FDI, for regression analysis. The other is that we use one lag of FDI as the instrumental variable (IV). Table 3 columns (4), (5) and (6) report the OLS, one lag of explanatory variables and IV results based on Equation (6), respectively. Column (4), column (5) and column (6) give consistent basic conclusions. The results show that FDI which passes the 1% significance test has a negative coefficient. This means that the introduction of FDI in China's economic growth has a positive effect.

4.3. The Impact of FDI on Urban Environmental Pollution

Since green growth efficiency is the comprehensive measurement of the economic effects and environmental effects of FDI, we use environmental inefficiency (ENVIRINEF) as a dependent variable to discuss the impact of FDI on China's cities from the perspective of environmental efficiency. We established the following regression in Equation (7)

$$\mathrm{ENVIRINEF_t} = \mathrm{C_1} + \mathrm{a_1FDI_t} + \mathrm{a_2ER_t} + \mathrm{a_3PCGDP_t} + \mathrm{a_4IS_t} + \mathrm{a_5PCSTI_t} + \mu_{t3} \quad (7)$$

Concerned that FDI may be an endogenous variable, we contrast the OLS, one lag of explanatory variables and IV results in columns 7–9 of Table 3. We see clear evidence that these estimates are mainly the same, negative and statistically significant. Using an OLS and IV strategy, we find that FDI is associated with high environmental efficiency, which means FDI does not appear to facilitate the growth of "pollution havens" in China. From the perspective of different sectors, FDI's promotion of environmental efficiency may be due to the FDI largely flowing into low-polluting sectors. The FDI's promotion of environmental efficiency can also be caused by clean technology transfer and environmental technology spillover to high-polluting sectors. We will present further study in Section 4.4.

In the controlled variable, ER has a positive effect on ECOINEF. ER is also a positive and significant factor for environment inefficiency mainly because most of the regulations are administrative regulations, not market-oriented regulations. The coefficient of IS to ECOINEF is negative and significant. The coefficient of IS to ENVIRINEF is positive and significant. It indicates that, though promoting the improvement of economic efficiency, the secondary industry is also the particular industry that causes China's environmental problems. The coefficients of PCGDP to ECOINEFF and ENVIRINEF are all significantly negative, meaning that per capita GDP contributes to the decrease of economic inefficiency and environmental inefficiency. Therefore, the increase of PCGDP is positive for China's economic green growth. The coefficient of PCSTI to ECOINEFF is positive but insignificant, and the coefficient of PCSTI to ENVIRINEF is significantly negative.

4.4. FDI's Effect on Different Industries

The above analysis viewed FDI as an integral index and analyzed the impact of FDI on green growth, economic growth and environmental protection, respectively. However, the effect of FDI may differ in different sectors. For instance, the effect of FDI on emission-intensive sectors may be different from that of non-emission-intensive sectors. We will analyze the comprehensive effect of FDI on the host country (China) from different sectors in the following.

We could not find official data about FDI in different sectors in most of the cities. We searched the statistical data for each of the 104 cities year by year, and only got qualified statistical data from seven cities (Shijiazhaung, Tangshan, Handan, Dalian, Changzhou, Nantong and Ningbo). The limitation of statistical data causes us to narrow down the samples. We analyzed the Manufacturing of Raw Chemical Materials and Chemical Products, Manufacturing of Communication Equipment and Computers of seven cities, respectively. The reasons for choosing these two sectors are as follows: Firstly, FDI in some industries among these seven cities is quite small, such as the Primary Industry. Very few of the cities reported the statistical data of FDI in some sectors such as the Manufacturing of Foods, Manufacturing of Textile, *etc.* The statistical data of these two sectors are relatively integral. Secondly, the Manufacturing of Raw Chemical Materials and Chemical Products, Manufacturing of Communication Equipment and Computers are the main sectors for FDI to flow into China. Taking the year of 2011 as an example, the FDI of the two sectors mentioned above is ranked third and first, respectively, among 36 industries. Thirdly, the Manufacturing of Raw Chemical Materials and Chemical Products is the typical emission-intensive sector, whereas the Manufacturing of Communication Equipment and Computers is the typical non-emission-intensive sector. Taking the year of 2011 as an example, the volume of sulphur dioxide emissions in the two sectors mentioned above is ranked third and 30th, respectively, among 36 industries.

In Section 3.1, this paper uses industrial coal consumption as the energy input and industrial sulfur dioxide emissions as the undesirable output. So we do not choose sectors such as software and real estate, because these sectors belong to the Tertiary Industry, whose coal consumption and sulfur dioxide emissions are quite low.

We replace the gross FDI with sectoral FDI which equals sectoral FDI inflows as a share of GDP, and estimate the regression in Equations (5), (6) and (7). Table 4 shows the analysis consequence of the seven cities. We can see that the effect of FDI in the Manufacturing of Raw Chemical Materials and Chemical Products (FDI1) on green efficiency, economic efficiency and environmental efficiency is quite different from that of FDI in the Manufacturing of Communication Equipment and Computers (FDI2). FDI1 promotes green efficiency mainly through the improvement of the economic efficiency. FDI1 does not significantly promote environmental efficiency. However, FDI2 promotes economic efficiency, environmental efficiency and green efficiency.

Table 4. The effect of FDI in different industries on cities' green growth.

	FDI in Manufacturing of Raw Chemical Materials and Chemical Products			FDI in Manufacturing of Communication Equipment and Computers		
	GREEN	ECO	ENVIR	GREEN	ECO	ENVIR
	INEFF	INEF	INEF	INEF	INEF	INEF
	Model (5)	Model (6)	Model(7)	Model (5)	Model (6)	Model (7)
FDI1	−0.1017 ** (0.0665)	−0.0340 ** (0.0160)	−0.0676 (0.0542)			
FDI2				−0.1189 *** (0.0429)	−0.0300 ** (0.0105)	−0.0889 ** (0.0351)
ER	0.1393 (0.1101)	0.0391 (0.0264)	0.1003 (0.0897)	0.0777 (0.1069)	0.0232 (0.0261)	0.0546 (0.0875)
PGDP	−0.0455 *** (0.0157)	−0.0081 ** (0.0038)	−0.0375 *** (0.0013)	−0.0362 ** (0.0154)	−0.0058 (0.0038)	−0.0304 ** (0.0126)
IS	0.00774 (0.0051)	−0.0013 (0.0012)	0.0071 * (0.0040)	0.0068 * (0.0038)	−0.0026 ** (0.0012)	0.0093 ** (0.0039)
PCSTI	1.7591 (2.0881)	0.4320 (0.5020)	1.3270 (1.7021)	1.8231 (1.9880)	0.4412 (0.4862)	1.3822 (1.6273)
Constant	0.6253 *** (0.2842)	0.1019 * (0.0683)	0.5232 ** (0.2317)	0.8689 *** (0.2675)	0.1720 ** (0.0654)	0.6968 *** (0.2189)
R^2	0.45	0.36	0.45	0.50	0.40	0.50
Adjusted-R^2	0.40	0.30	0.40	0.46	0.34	0.45

Note: ***, **, * indicates significance at the 1% level, 5% level, 10% level, respectively; VIF is smaller than 5.1 and the mean of VIF is 2.89, indicating the multi-collinearity is not serious; Table 4 is pooled OLS because the LM test suggests OLS should be used for the sample; FDI1 represents FDI in Manufacturing of Raw Chemical Materials and Chemical Products; FDI2 represents FDI in Manufacturing of Communication Equipment and Computers.

From the perspective of economic efficiency, FDI1 and FDI2 both promote economic efficiency, which is the same as the conclusion in Section 4.2. Concerning the environmental efficiency, the conclusion is that FDI promotes environmental efficiency inconsistently in different sectors. The Manufacturing of Communication Equipment and Computers is the biggest sector for FDI inflow and it is a typical low-emission industry. FDI in the Manufacturing of Communication Equipment and Computers largely accounts for the promotion of environmental efficiency in the above Section 4.3 when we lump FDI into one whole measure. However, FDI's promotion in environmental efficiency through clean technology transfer and environmental technology spillover may be not obvious, as can be seen from the fact that FDI in the Manufacturing of Raw Chemical Materials and Chemical Products did not promote the environmental efficiency significantly. As the research sample is limited, further study based on more cities needs to be carried out to support that point in the future.

5. Conclusions and Recommendations

Taking 104 cities in China as the research objectives, based on the SBMDDF model, this paper makes the green growth efficiency the comprehensive index of China's green growth. After dividing the green growth efficiency into economic efficiency and environmental efficiency, this paper discusses the effects of FDI on the green growth efficiency, economic efficiency and environmental efficiency of China's urban green growth, respectively. The main conclusions are as follows.

FDI has a positive correlation with the urban green growth efficiency. FDI is helpful for China's green economic growth, and plays an active role in China's green economic growth. When the green growth efficiency is broken into economic efficiency and environmental efficiency, we can see that FDI promotes China's green economic growth through the promotion of environmental effects and economic effects. The analysis of FDI in different sectors shows that FDI's promotion of environmental efficiency in China is largely due to FDI flowing into low-polluting and low-emission sectors. However, FDI's promotion of environmental efficiency by clean technology transfer and environmental technology spillover may be not obvious.

Finally, we give some suggestions for improving China's future green growth from the FDI impact perspective. When introducing foreign direct investment capital, the government should first consider the "quality" of FDI. It must not only be concerned about the "quality" of the economic effects, but must also pay attention to the "quality" of the environmental effects. In addition, the approval process for the resource pollution type of foreign projects should be more strictly regulated, and a higher quality FDI which is good for the economy and environmental benefits should be actively encouraged. All the above is to improve the quality of foreign investment and to promote China's green growth from the levels of economic efficiency and environmental efficiency.

This paper still has some limitations. With more available statistical data from other sectors, the effect of FDI on economic growth and environmental pollution can be considered more rigorously. The upstream and downstream effects of FDI can be estimated with the new city-level Input-Output Table released by the National Bureau of Statistics of China in the future.

Acknowledgments: This work is supported by the National Natural Science Foundation of China (71303042), National Social Science Foundation of China (12&ZD207), and the Key Project of Philosophy and Social Science Research in Colleges and Universities of Jiangsu Province (2015ZDIXM004).

Author Contributions: Shujing Yue and Yang Yang had the original idea for the study. Yaoyu Hu was responsible for data collecting. Shujing Yue and Yang Yang carried out the analyses.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Hu, A.; Jefferson, G. *FDI, Technological Innovation, and Spillover: Evidence from Large and Medium Size Chinese Enterprises*; Brandeis University: Waltham, MA, USA, 2001.
2. De Gregorio, J. The Role of Foreign Direct Investment and Natural Resources in Economic Development. In *Multinationals and Foreign Investment in Economic Development*; Palgrave Macmillan: London, UK, 2003.
3. Johnson, A. The Effects of FDI Inflows on Host Country Economic Growth. 2006. Available online: https://static.sys.kth.se/itm/wp/cesis/cesiswp58.pdf (accessed on 3 February 2016).
4. Cheung, K.Y.; Lin, P. Spillover effects of FDI on Innovation in China: Evidence from the Provincial data. *China Econ. Rev.* **2004**, *15*, 25–44. [CrossRef]
5. Yao, S. On economic growth, FDI and exports in China. *Appl. Econ.* **2006**, *38*, 339–351. [CrossRef]
6. Tang, S.; Selvanathan, E.A.; Selvanathan, S. Foreign direct investment, domestic investment and economic growth in China: A time series analysis. *World Econ.* **2008**, *31*, 1292–1309. [CrossRef]
7. Hong, L.M. Does and How does FDI Promote the Economic Growth? Evidence from Dynamic Panel Data of Prefecture City in China. *IERI Procedia* **2014**, *6*, 57–62. [CrossRef]
8. Aitken, B.; Harrison, A. Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *Am. Econ. Rev.* **1999**, *89*, 605–618. [CrossRef]
9. Lipsey, R.E. Home and Host Country Effects of FDI. 2002. Available online: http://www.nber.org/papers/w9293.pdf (accessed on 3 February 2016).
10. Carkovic, M.; Levine, R. Does Foreign Direct Investment Accelerate Economic Growth? 2002. Available online: http://dx.doi.org/10.2139/ssrn.314924 (accessed on 3 February 2016).
11. Herzer, D.; Klasen, S.; Nowak-Lehmann, F. In search of FDI-led growth in developing countries: The way forward. *Econ. Model.* **2008**, *25*, 793–810. [CrossRef]
12. Yalta, A.Y. Revisiting the FDI-led growth Hypothesis: The case of China. *Econ. Model.* **2013**, *31*, 335–343. [CrossRef]
13. Lian, L.; Ma, H.Y. FDI and Economic Growth in Western Region of China and Dynamic Mechanism: Based on Time-Series Data from 1986 to 2010. *Int. Bus. Res.* **2013**, *6*, 180–186. [CrossRef]
14. Copeland, B.R.; Taylor, M.S. Trade, growth, and the environment. *J. Econ. Liter.* **2004**, *42*, 7–71. [CrossRef]
15. Xing, Y.; Kolstad, C.D. Do lax environmental regulations attract foreign investment? *Environ. Resour. Econ.* **2002**, *21*, 1–22. [CrossRef]

16. He, J. Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO_2) in Chinese province. *Ecol. Econ.* **2006**, *60*, 228–245. [CrossRef]
17. Baek, J.; Koo, W.W. A dynamic approach to the FDI-environment nexus: The case of China and India. *J. Int. Econ. Stud.* **2009**, *13*, 87–108. [CrossRef]
18. Dasgupta, S.; Laplante, B.; Wang, H.; Wheeler, D. Confronting the environmental Kuznets curve. *J. Econ. Perspect.* **2002**, *16*, 147–168. [CrossRef]
19. Zarsky, L. Foreign Direct Investment and the Environment. 1999. Available online: http://www.oecd.org/investment/mne/2089912.pdf (accessed on 3 February 2016).
20. List, J.A.; Co, C.Y. The effect of environmental regulation on foreign direct investment. *J. Environ. Econ. Manag.* **2000**, *40*, 1–20. [CrossRef]
21. Tamazian, A.; Chousa, J.P.; Vadlamannati, C. Does higher economic and financial growth lead to environmental degradation: Evidence from the BRIC countries. *Energy Policy* **2009**, *37*, 246–253. [CrossRef]
22. Wang, H.; Yanhong, J. Industrial ownership and environmental performance: Evidence from China. *Environ. Resour. Econ.* **2007**, *36*, 255–273. [CrossRef]
23. Zheng, S.Q.; Matthew, E.K.; Liu, H.Y. Towards a system of open cities in China: Home prices, FDI flows and air quality in 35 major cities. *Reg. Sci. Urban Econ.* **2010**, *40*, 1–10. [CrossRef]
24. Natalia, Z.S. How does Foreign Direct Investment Affect Pollution? Toward a Better Understanding of the Direct and Conditional Effects. *Environ. Resour. Econ.* **2015**. [CrossRef]
25. Charnes, A.; Cooper, W.W.; Rhodes, E. Measuring the Efficiency of Decision Making Units. *Eur. J. Oper. Res.* **1978**, *2*, 429–444. [CrossRef]
26. Hailu, A.V.; Veeman, T.S. Non-parametric productivity analysis with undesirable outputs: An application to the Canadian pulp and paper industry. *Am. J. Agric. Econ.* **2001**, *83*, 605–616. [CrossRef]
27. Scheel, H. Undesirable outputs in efficiency evaluation. *Eur. J. Oper. Res.* **2001**, *132*, 400–410. [CrossRef]
28. Seiford, L.M.; Zhu, J. Modeling undesirable factors in efficiency evaluation. *Eur. J. Oper. Res.* **2002**, *142*, 16–20. [CrossRef]
29. Fare, R.; Grosskopf, S.; Lovell, C.A.K. Multilateral productivity comparisons when some outputs are undesirable: A nonparametric approach. *Rev. Econ. Stat.* **1989**, *71*, 90–98. [CrossRef]
30. Fukuyama, H.; Weber, W.L. A Directional Slacks-based Measure of Technical Inefficiency. *Socio-Econ. Plan. Sci.* **2009**, *4*, 274–287. [CrossRef]
31. Tone, K.R. Dealing with Undesirable Outputs in DEA: A Slacks-based Measure (SBM) Approach. *Oper. Res. Soc. Jpn.* **2003**, *5*, 44–45.
32. Zhang, Y.J. The impact of financial development on carbon emissions: An empirical analysis in China. *Energy Policy* **2011**, *39*, 2197–2203. [CrossRef]

© 2016 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons by Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/).