PESA Center for Political, Economic and Social Research PUBLICATIONS

INTERNATIONAL JOURNAL OF ECONOMIC STUDIES

ULUSLARARASI EKONOMİK ARAŞTIRMALAR DERGİSİ

March 2018, Vol:4, Issue:1 *Mart 2018, Cilt:4, Sayı:1*
e-ISSN: 2149-8377 p-ISSN: 2528-9942
journal homepage: www.ekonomikarastirmalar.org

The Impact of FDI on Renewable and Non-Renewable Energy Consumption: Does Sectoral Diversity Matter?

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ARTICLE INFO

Article History:
Received 4 December 2017
Received in revised form 12 February 2018
Accepted 16 February 2018

Keywords:
FDI, Energy Consumption, Renewable Energy, Nonrenewable Energy, Panel Data

ABSTRACT

The most of the previous studies investigating the impact of FDI on total energy consumption have failed to provide a concluding evidence in the literature. Thus, the main objective of this study is to measure the effect of sectoral FDI on renewable and non-renewable energy consumption for five OECD countries by employing panel data method for the period 1985-2012. The study has empirically proved that FDI promotes energy saving technologies in mining and quarrying sector. Yet, we could not find any effect of FDI on energy consumption in manufacturing and financial and intermediation sectors.

INTRODUCTION

Perception of Foreign Direct Investment (FDI) as an engine behind growth may be attributed to its spillover effect through the transfer of knowledge, technology and management practices from home to host country. FDI is known as main source of financing capitals to growth in the host market. At the same time, FDI may introduce new technology and know-how techniques in the foreign market and therefore may promote energy efficiency. In other words, while FDI may increase the energy consumption by increasing the number of businesses in the host market, it may also reduce energy consumption by introducing energy-saving technologies.

Furthermore, new trade theories suggest that domestic firms exposed to foreign competition are forced to use more efficient and productive methods to survive in the domestic market. Therefore, existing of foreign companies in the host market may put pressure on domestic firms to use energy-saving production techniques. Moreover, the multinational companies are likely to uphold to high environmental standards and thus may use clean energy from renewable energy. Thus, foreign companies may replicate energy-saving techniques that they have already used in the home country.

To date, there are a handful of studies that examine the linkage between FDI and energy consumption. Furthermore, these studies have offered a mixed findings based on total energy consumption. We hypothesize that the impact of FDI on energy consumption may change by type of energy. Meaning that, though the impact of FDI on energy consumption is still ambiguous, this impact may vary based on the type of energy usage. We also hypothesize that the impact of FDI on energy consumption depends on the type of industry. While the influence of FDI in manufacturing sector depends on the transfer of industrial technology and equipment, the influence of FDI in service sector on energy consumption depends on management, technical and marketing know-how, organizational skill and all knowledge in general. Therefore, we claim the impact of FDI on energy consumption depends on industry that is associated with energy-saving technologies (or renewable energy) or energy-exhaustive technologies (or nonrenewable energy). Service sector by its very nature is likely to depend on less energy consumption than manufacturing sector do. FDI toward manufacturing sector may induce additional FDI inflows toward service sector and thus may induce energy-saving technologies. Similarly, FDI toward service sector may influence new FDI inflows toward manufacturing sector and may lead energy-exhaustive technologies.

The main objective of this study is therefore to measure the effect of sectoral FDI on both renewable and nonrenewable energy consumption in five Organization for Economic Co-operation and Development (OECD) countries for the period 1985-2012. Due to the unavailability of data problems, we can only incorporate five OECD countries namely as Australia, Denmark, France, Italy and United States. We have employed Panel Corrected Standard Errors (PCSE) model for our long panel data set to find out the long-run relationship between sectoral FDI and decomposed energy consumption. The contribution of the study to the existing are three-fold: First, we focus on the impact of sectoral FDI on energy consumption rather than total FDI by allowing correlation among sectors. Second, we decompose energy into two categories as renewable and non-renewable energy consumption. Third, we are able to predict whether FDI into three sectors (mining and quarrying, manufacturing and financial intermediation) explains the consumption of renewable or non-renewable energy.

The rest of the paper is organized as follows: Second section overviews the previous studies dealing with the linkage between FDI and energy consumption. Following literature review, third section introduces data and methodology. Fourth section presents the empirical results and their interpretations. Last section concludes the study with important policy implications.

1. Literature Review

Analysis of the literature reveals that there is mixed evidence regarding the effects of FDI on energy consumption. Some of the studies claim that FDI brings energy saving technologies into the host country. For-example, the study of Mielnik and Goldemberg (2002) have found that FDI reduces energy consumption by introducing new technology into the developing countries. Furthermore, the study of Ting et al. (2011) have investigated the linkage between sectoral FDI

and energy consumption in the Jiangsu province of China for the period 1998-2003. For this period, the Jiangsu province is mostly concentrated with dirty industry. Yet, authors argue FDI toward this province has introduced energy saving technology and that thus lead a movement from dirty industry to the clean industry. A recent study by Jiang et al. (2014) have analyzed the effects of FDI into manufacturing sub-sectors. They concluded that FDI leads energy efficiency by introducing new technology. They have concluded that there is a positive relationship between energy consumption and energy consumption. Furthermore, Mert and Bölük (2016) have investigated the effects of FDI and renewable energy consumption on CO2 emission in 21 Kyoto countries. They have found out that FDI increase the renewable energy consumption thus brings clean technology and improves the environmental standards. Furthermore, the studies of Dube (2009), Foot Tang (2009), He at al. (2012), Sbia et al. (2014), Azam et al. (2015) have all investigated the impact of total FDI on energy consumption and all of them have supported that FDI reduce the demand for energy and may cause a clean energy consumption.

There are still some studies arguing that FDI is positively correlated with energy consumption. Lee (2013) has studied the contributions of FDI to the clean energy use, carbon emission and economic growth for 19 G20 countries for the period 1971-2009. He has found that while FDI leads economic growth, it also increases the energy use for G20 countries. He also confirmed that FDI is not related with clean energy thus does not affect the CO2 emissions in G20 countries. Leitão (2015) has investigated the relationship between FDI and energy consumption for the period 1990-2011 by employing panel data analysis. He found a similar result and argued that FDI is positively correlated with energy consumption.

Even though most of the literature support the idea that the FDI brings energy saving technology into the host country, there are still some studies that claim no relationships between FDI and energy consumption. Hübler and Keller (2010) have employed fixed panel data method but failed to find any effect of FDI on energy consumption. Another study that failed to find any effect between these two variables is done by Sadorsky (2010). He has measured the impact of the stock market developments and FDI on energy consumption for 22 emerging countries by employing Generalized Method of Moments (GMM) model. At the end of the study, he concluded that there is a positive linkage between stock market development and energy consumption but he has failed to find any effect of FDI on energy consumption. Chang (2015) has also failed to find any relation between FDI and energy consumption for 53 countries.

Previous studies have mostly analyzed the linkages between FDI and clean energy consumption, or linkages between FDI, financial developments and energy consumptions. Yet, many of these studies have failed to measure sectoral FDI on different types of energy consumptions. To receive a more precise results, we have investigated the effects of sectoral FDI on two types of energy (renewable and nonrenewable) consumptions to fill the gap in the literature.

2. Data and Methodology

2.1. Data

Renewable and non-renewable energy consumptions are determined as our dependent variables. We have used alternative and nuclear energy consumption % of total energy use to represent the renewable energy consumption. Alternative and nuclear energy is classified as clean energy by OECD and compromises hydropower and nuclear, geothermal, solar power and others that don't produce carbon dioxide. Furthermore, we have used fossil fuel energy consumption % of total energy consumption as indicator of non-renewable energy consumption. Fossil fuel energy consumption includes coal, petroleum, oil and natural gas products. We have determined followings as our explanatory variables: Net FDI inflows, Gross Domestic Product (GDP), Growth rate of GDP, Openness index, Inflation and lastly General Research and Development (R&D) expenditures % of GDP. All statistical data on dependent and independent variables are attained from World Bank Data retrieval too

(www.worldbank.org). Furthermore, all data is measured in USA Dollars. Expected sign of the coefficients are presented below:

Table 1: Data Descriptions and Expected Sign of Coefficients

Explanatory Variables	Expected Sign
Net FDI inflows	+/-
GDP	+/-
Growth	+/-
Openness	+/-
Inflation	+/-
GR&D Expenditures	+/-

Note: Expected sign of the coefficients are evaluated with respect to both renewable and non-renewable energy consumption.

2.2. Methodology

Panel data is an appropriate estimation model for repeated measurements at different points in time on the same individual unit such as firm, country or sector. Panel data method is complicated since standard error of data is needed to be adjusted in order not to be correlated with previous periods. Panel data models can be short panel data where there are few time periods (T) and many individuals or can be long panel data where there are many time periods and few individuals. In short panel data model, individual fixed effect may be correlated with explanatory variables thus estimators may be biased. To handle with possible correlation between individual fixed effect and explanatory variables, two well-known models (Fixed Effect or Random Effect) may be used. However, in case of long panel data models, individual fixed effect can be easily handled by including dummy variables for each individual as regressors. Yet, in long panel data models, as time (T) is more than individual units (N), one should control for time effect rather than individual fixed effects. In short panel data models, it is possible to obtain standard errors which is not correlated without stating a model for serial correlation. However, for long panel data models, it is necessary to specify a model for serial correlations in the error by relaxing the assumption that error $u_{i,t}$, is independent over i. Both pooled Ordinary Least Square (OLS) and Generalized Least Square (GLS) allow the error $u_{i,t}$ in the model to be correlated over i, allow the use of an AR (1) model for $u_{i,t}$ over t, and allow $u_{i,t}$ to be heteroskedastic. Specification a model for serial correlation in the error is known as Panel Corrected Standard Errors (PCSE) model for long-panel data sets.

PCSE model takes several steps:

General form of the long panel data regression can be written as;

$$y_{i,t} = \alpha_i + \gamma_t + X'_{i,t}\beta + \varepsilon_{i,t} \quad (1)$$

Where, α_i represents fixed individual effects and can be incorporated into the regression as dummy variable regressors.

Thus, pooled long panel data model can be written as;

$y_{i,t} = X'_{i,t}\beta + u_{i,t}$ where $i = 1, 2, \ldots\ldots N$ and $t = 1, 2, \ldots\ldots, T$ as (2)

As T is large relative to N, we should use AR (1) model to allow for $u_{i,t}$ over t. AR (1) model can be written as;

$$\boldsymbol{u_{i,t} = p_i u_{i,t-1} + \varepsilon_{it}} \quad (3)$$

where $\varepsilon_{i,t}$ is serially uncorrelated but correlated over i with $Cor(\varepsilon_{i,t}, \varepsilon_{i,s}) = \sigma_{ts}$.

With a balance long panel data, $y_{i,t} - \hat{p}y_{i,t-1}$ is regressed on $X^*_{i,t} = X_{it} - \hat{P}X_{i,t-1}$ for $t > 1$,

Then $\hat{P}$ is calculated as the average of the $\hat{p}_i$ used. We obtain Newey-West-type standard errors that allow autocorrelated errors of AR (1). At this point one may ask the reason of

restricting errors to be AR (1) rather than allowing autocorrelated errors of general form. As Beck and Katz (1995) proposed that when T is not much larger than N, there can be a finite-sample bias in the estimators and standard errors. Thus, we have used pooled OLS that assumes an AR (1) error and then gets standard errors (PCSE) that additionally permit correlation over sectors.

Our main can two PCSE regressions can be written for both renewable (RE) and nonrenewable (NRE) energy consumption as:

$RE_{i,t} = X'_{i,t}\beta + u_{i,t}$ and $NRE_{i,t} = Z'_{i,t}\delta + \varepsilon_{i,t}$ where $i = 1, 2, \dots \dots \dots N$ and $t = 1, 2, \dots \dots \dots, T$

While both RE and NRE represent dependent variable, $X'_{i,t}$ and $Z'_{i,t}$ represent explanatory variables including individual fixed effects as dummy variables in each time period. Furthermore, $u_{i,t}$ and $\varepsilon_{i,t}$ in each regression represent error terms respectively.

3. Empirical Results

We have specified two regressions for two dependent variables (renewable and nonrenewable energy consumption) for a pooled long panel data of three sectors (mining and quarrying, manufacturing and financial intermediation). Estimation results of PCSE for renewable and non-renewable energy consumptions are presented in Table 2 and Table 3 respectively. While first column of Table1 and 2 show the explanatory variables employed, second, third and fourth columns show estimation results for three sectors. Furthermore, to ensure the robustness of our estimates, we have provided post-estimation statistical results at the bottom of the both Tables.

Table 2: PCSE Estimation Results for Renewable Energy Consumption

Variables	Mining and Quarrying	Manufacturing	Financial Intermediation
Constant	102.1343 (0.000)**	101.4463 (0.000)**	101.3974 (0.000)**
Net FDI inflows	0.1476 (0.017)**	0.0069 (0.712)	0.0028 (0.866)
GDP	0.0057 (0.019)**	0.0052 (0.039)*	0.0054 (0.017)**
Growth	0.1245 (0.454)	0.1079 (0.493)	0.1143 (0.435)
Openness	-0.0371 (0.340)	-0.0568 (0.135)	-0.0578 (0.127)
Inflation	0.1735 (0.514)	0.2433 (0.293)	0.2360 (0.311)
GR&D expenditure	-10.1343 (0.000)**	-9.9333 (0.000)**	-9.8786 (0.000)**
Number of Observations	140	140	140
Number of Groups	5	5	5
Wald Ch^2 (6) Prob>Ch^2	73.36 (0.000)**	54.36 (0.000)**	52.70 (0.000)**
R-Squared	0.7215	0.7541	0.7586

Note: While ** represents % 1 significance level, * represents % 5 significance level. Furthermore, probability values of test statistics are given in parenthesis.

As seen from Table 2, renewable energy consumption is positively related with FDI inflows for the mining and quarrying sector but is not related with other sectors. Meaning that FDI

directed into the mining and quarrying sector brings new technology or know-how to enhance the consumption of renewable energy. Our intuition is that the size of foreign investments into the mining and quarrying sector are larger and more technology intensive investments compared to the FDI into manufacturing or financial intermediation sectors. Thus, foreign investments inflows into this sector, motivate both domestic and foreign investors to increase the usage of renewable energy. Furthermore, renewable energy consumption is positively correlated with GDP but negatively correlated with GR&D expenditures for all sectors. It is a mere fact that energy is a scarce resource in the world. Thus, as the market size (GDP) gets larger in these countries, investors are more likely to increase the consumption of renewable energy to meet higher demand with restricted energy source. Moreover, an increase in GR&D expenditures as % of GDP leads reduction in the consumption of renewable energy in all sectors. Meaning that, general R&D expenditures may produce more automated technologies, techniques or know-how that consume more non-renewable energy rather than renewable energy.

Table 3: PCSE Estimation Results for Non-Renewable Energy Consumption

Variables	Mining and Quarrying	Manufacturing	Financial Intermediation
Constant	1.0383 (0.735)	1.7316 (0.569)	1.8739 (0.536)
Net FDI inflows	-0.1218 (0.040)*	-0.0066 (0.715)	0.0028 (0.859)
GDP	-0.0051 (0.037)*	-0.0042 (0.086)	-0.0046 (0.042)*
Growth	0.0680 (0.627)	0.0724 (0.574)	0.0656 (0.578)
Openness	-0.0832 (0.010)**	-0.0606 (0.030)*	-0.0598 (0.029)*
Inflation	-0.1439 (0.569)	-0.1883 (0.375)	-0.1928 (0.369)
R&D expenditure	9.0299 (0.000)**	7.8736 (0.000)**	7.7957 (0.000)**
Number of Observations	140	140	140
Number of Groups	5	5	5
Wald Ch^2 (6) Prob>Ch^2	40.29 0.000**	31.86 0.000**	31.60 0.000**
R-Squared	0.1225	0.1028	0.1020

Note: While ** represents % 1 significance level, * represents % 5 significance level. Furthermore, probability values of test statistics are given in parenthesis.

Furthermore, it is clearly seen from Table 3 that FDI is negatively correlated with non-renewable energy consumption but is not related with other sectors. As noted before, as foreign investors direct their investments into the mining and quarrying sector, investors prefer to consume more renewable energy rather than non-renewable energy. The reason might be strongly tied to the size of investments in this sector and therefore to the ability of foreign investors to transfer energy saving technology from home to host country. Moreover, as expected, we have found that non-renewable energy consumption is negatively related with GDP (market size) for mining and quarrying sector and financial intermediation sector. Again, as we noted earlier, as the market size gets larger, investors prefer to move from nonrenewable energy consumption to renewable energy consumption to use scarce energy source more efficiently. Furthermore, non-renewable energy consumption is negatively related with

openness index but it is positively correlated with general R&D expenditure for all sectors. Meaning that, as the host country' involvement degree into the international trade increases, possibility of consuming non-renewable energy consumption reduces. This result can be attributed to the selection effects of international trade theory. With respect to the international trade theory, firms are more likely reallocate productive resources to efficient sectors to gain in international trade. Thus, as the multinational firms engage more in international trade, they are more likely to give up the consumption of non-renewable energy and move toward renewable energy consumption. This result does not come a surprise, not only energy is the most important input for all sectors but it is also most scarce and expensive input for production. Thus, multinational firms may move from non-renewable energy consumption toward new energy saving production techniques or methods to be more competitive in international markets. Finally, we have also proved that general R&D expenditures are positively correlated with non-renewable energy consumption. As we noted earlier, R&D expenditures may produce more automated technologies or energy exhaustive production techniques that facilitate the doing business but at the same time, increase the possibility of consuming non-renewable energy.

Concluding Remarks and Summary

Even though FDI is perceived as a vital source of the capital financing, its impact on energy consumption is still a controversial issue in the literature. So that, some of the researchers argue that FDI may transfer new energy saving technology or techniques that reduce energy consumption, yet still others claim that FDI may increase the volume of businesses and thus increase the need for energy.

Thus, the main objective of this paper is to investigate the influence of sectoral FDI on energy consumption for five OECD countries for the period 1985-2012. Novelty of the paper is three folds: First we have decomposed net FDI inflows into three different sectors as mining and quarrying, manufacturing and financial intermediation. Second, we have also decomposed energy consumption as renewable energy and non-renewable energy consumption. Third, we have employed PCSE panel data model to find out the long-run effect of sectoral FDI inflows on both renewable and non-renewable energy consumption.

Finally, we have proved that FDI promotes energy efficiency in the mining and quarrying sector but does not affect energy consumption in other two sectors (manufacturing and financial intermediation sectors). The reason may be that FDI directed into mining and quarrying sector is larger capital intensive investments compared to FDI into the other two sectors. Thus, foreign investors may introduce energy saving technologies or techniques or replicate the same technology they have used in the home country.

With respect to the control variables, we have confirmed that GDP (market size) is positively correlated with renewable energy consumption but negatively correlated with non-renewable energy consumption. Meaning that, as the market size gets larger, investors are more likely to use energy saving technologies to use energy efficiently. It is the mere fact that energy is the most important and scarce input for producing goods and services in all sectors. Thus, producers are likely to increase their production capacity by moving from non-renewable energy consumption to renewable energy consumption to avoid high input costs. Furthermore, general R&D expenditures are related negatively with renewable energy consumption but positively correlated with non-renewable energy consumption. Meaning that, R&D expenditures are likely to produce energy exhaustive techniques or technologies that increase the need for energy. Lastly, openness is negatively correlated with non-renewable energy consumption. As we noted before, international trade forces domestic firms to be more competitive to survive in international market. Thus, as the openness index increases, firms are more likely to reduce the consumption of non-renewable energy rather they are likely to move toward the energy-saving technologies.

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