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On the Relationship between Foreign Direct Investment and Energy Consumption: The Mexican Case

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ABSTRACT

This paper is aimed at analyzing the interrelation between Foreign Direct Investment (FDI) and energy consumption (EC) in Mexico during the period 1970-2014. To do that, we carry out a cointegration test and a Granger causality analysis. The empirical results from the cointegration test show a stable link between the growth rates of FDI and EC in the long run. While the results from Granger's causality show that in the short run there is a unidirectional Granger causality from the growth rate of FDI toward the growth rate EC, while in the medium and long there is a bidirectional causality between the growth rates of FDI and EC in Mexico during the period under study.

Keywords: Foreign Direct Investment, Energy Consumption, Cointegration, Granger Causality
JEL Classifications: C32, F21, Q43

1. INTRODUCTION

Foreign direct investment (FDI) has been the subject of many theoretical and empirical studies that address its relevance from multiple perspectives in numerous investigations. For instance, its relationship with economic growth has been studied in Ozturk (2007), Vichy and Mansor (2009), Velásquez and Pichler (2010), and Aali-Bujari and Venegas-Martínez (2019). With respect to other perspectives and applications, we may mention, for instance: Chudnovsky and López (2007) studied the relationship of FDI with foreign trade; Chiatchoua et al. (2016) examined the relationship of FDI with employment; Asali and Campoamor (2011) analyzed the link of FDI with training of human capital; Leiva et al. (2014) highlighted the relationship of FDI with creating new entrepreneurs; and Sepulveda and Chumacero (1983) studied the nexus between FDI and trading of goods and services of transnational and multinational companies.

Energy consumption (EC) has also been a relevant issue related to different economic activities that have been widely studied. For instance: Tatom (1981) and Kuosmanen et al. (2013) highlight the importance of the energy sector in productivity and production; Aali-Bujari et al. (2017) relate EC to economic growth; Acaravci and Oztur (2010) examine the links among EC, economic growth and CO2 emissions in Europe; Aali-Bujari et al. (2018) examine the relation between energy to capital markets; Santillán-Salgado et al. (2019) examine the link between EC and financial variables; Sanchez-Loor and Zambrano-Monserrate (2015) highlight the relationship between EC and human development indexes; and, finally, Rutledge (2015) relates EC to capital flows, physical capital, human capital, trade and economic growth.

The link between the two important variables mentioned above, FDI and EC, has also extensively been studied. For instance, Elliott et al. (2013) study the relationship between energy intensity in Chinese cities and the location of foreign corporations in 206 larger cities in the period 2005-2008. The authors find evidence of a negative and significant relationship between FDI flows and the energy intensity just in one city; however, this effect varies according to the geographical location. On the other hand, Kivyiro and

Arminen (2014) examine the causal links between FDI, EC, CO2 emissions and economic growth in sub-Saharan Africa: Republic of the Congo, Democratic Republic of the Congo, Kenya, South Africa, Zambia and Zimbabwe. These authors find cointegration relationships among these variables in all countries. They also find empirical evidence that FDI increases CO_2 emissions in some countries, while in other countries they find the opposite impact. Finally, the authors find that FDI, gross domestic product (GDP), and EC Granger-cause CO_2 in all the countries under study. Leitão (2015) studies the relationship between FDI and EC in Portugal in the period 1990-2011. The author finds that globalization and per capita income have a positive impact on EC and that trade openness and the exchange rate have a positive impact on FDI. Paramati et al. (2016) analyze the impact of FDI inflows on the use of clean energy in 20 emerging economies in the period 1991-2012. The authors employ panel econometric techniques. Their results also show that FDI inflows have a positive and significant effect in clean EC. They use Granger causality tests and find short-term one-way causality that goes from FDI to clean EC. Moreover, Salahuddinm et al. (2018) assess the impact of EC, economic growth, financial development and FDI on CO_2 emissions in Kuwait. The authors use an autoregressive distributed lag (ARDL) bounds testing approach and found that cointegration exists among the series. Moreover, they find that economic growth, EC, and FDI stimulate CO_2 emissions in both the short and long run. Here, Granger's causality analysis shows that FDI, economic growth, and electricity consumption strongly Granger-cause CO_2 emissions. More recently, Olaoye et al. (2020) analyze the relationship between FDI and EC in Nigeria during the period 1990-2017. The authors use cointegration and Granger causality finding a negative and significant relationship between FDI and EC.

This research examines the interrelation of FDI and EC in Mexico during the period 1970-2014. To do this, a cointegration analysis and Granger causality tests are performed, with data from the World Bank, The distinctive characteristics of this investigation with regard to the current state of the subject are: (1) as far as the authors know this is the first research on the subject that focuses on Mexico, (2) there is a greater availability of data with respect to the past for the Mexican case, and (3) it provides several recommendations to promote the strengthening of the FDI-EC nexus. Finally, the hypothesis of this research is that there is a stable positive link between the growth rates of FDI and EC.

The rest of the paper is organized as follows: Section 2 deals with a short review of the literature on the interrelation of FDI with the energy sector; section 3 presents the descriptive statistics of the relevant variables; section 4 carries out a cointegration analysis and Granger causality tests between the variables under study, and provides an analysis and discussion of the main empirical findings for Mexico; finally, section 5 gives the conclusions and provides some policy recommendations derived from the obtained results.

2. FOREIGN DIRECT INVESTMENT AND ENERGY CONSUMPTION

The interrelationship between FDI and the energy sector has been a subject of much research and it has been examined from multiple perspectives. For instance, the relationship between FDI and energy has been analyzed by: Mielnik and Goldemberg (2002), Pao and Tsai (2011), Lee (2013), Chandran and Tang (2013), Sbia et al. (2014), Omri and Kahouli (2014), Tang and Tan (2014), Abidin et al. (2015), Yao et al. (2017), and Warsono et al. (2020), among others.

In the above sense, Mielnik and Goldemberg (2002) study a sample of 20 developing countries, and find that the largest inflow of FDI represents a decrease in energy intensity, explaining that it is probably linked to the use of modern technologies that arrived with FDI, which represents a leap from traditional technologies used in recipient countries.

Likewise, Pao and Tsai (2011) study the relationship between EC, FDI, carbon dioxide (CO_2) emissions, and gross domestic product (GDP) in Brazil, Russia, India and China, in the period 1980-2007. Their results suggest that FDI through technology transfer can use clean energy and avoid damage to the environment in developing countries in their study. Lee (2013) studies the contribution of FDI to the use of clean energy, CO_2 emissions and economic growth for a sample of 19 G20 countries, in the period 1971-2009. The author uses cointegration techniques to examine the long term behavior, finding that FDI has a positive impact on economic growth and limits emissions of CO_2, but the author does not find convincing evidence of the link between FDI with the use of clean energy.

On the other hand, Chandran and Tang (2013) study the impact of EC of the transport sector, FDI, and income on CO_2 emissions on the five ASEAN economies (Indonesia, Malaysia, the Philippines, Singapore and Thailand) by using cointegration and Granger causality. The authors find that FDI does not Granger cause CO_2 significantly. They find a two-way causality between EC in the transport sector with FDI in Thailand and Malaysia. Likewise, Sbia et al. (2014) examine the contribution of the FDI, clean energy, trade openness, CO_2 and economic growth in the energy demand in the United Arab Emirates, in the period 1975-2011. They use cointegration and Granger causality, and their results indicate that the FDI, trade openness and CO_2 emissions decrease energy demand, while economic growth and clean energy have a positive effect on EC.

In the same line of research, Omri and Kahouli (2014) examine the causal relationships among EC, FDI and economic growth by using simultaneous equation models for a global panel of 65 countries, in the period 1990-2011. The authors find mixed results on the interrelation between EC, FDI and economic growth. Moreover, Tang and Tan (2014) study the relationship among EC, economic growth, relative prices, FDI, and financial development in Malaysia, in the period 1972-2009, by using cointegration tests. They find that EC and economic growth cause each other in the short and long term, EC affects positively financial development and FDI.

Similarly, Abidin et al. (2015) examine the relationship among FDI, financial development, international trade and EC in some ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore and Thailand) by using stationarity and Granger causality tests finding significant long-term relationships between FDI flows, financial

Table 1: Descriptive statistics of the variables under study

Variable	Notation	Average	Deviation	Minimum	Maximum
Foreign direct investment	FDI	1.12e±10	1.20e±10	1.78e±08	4.72e±10
Energy consumption	EC	1368.677	549.1074	501.8794	2253.514

Source: Authors' own elaboration with data from World Bank

Table 2: Cointegration between FDI and EC

Null hypothesis	Series	Tau-statistics	Observation
No cointegration	LFDI LEC	−5.251063	H_0 is rejected

Source: Authors' own elaboration with data from World Bank

development, international trade and EC. Moreover, Granger's causality tests reveal short-term one-way causality ranging from FDI inflows toward EC, from EC toward financial development, and from EC toward international trade. Subsequently, Yao et al. (2017) study the short- and long-term dynamics between FDI and EC in China, with data from 1982 to 2012. They find that there is a stable link between FDI and energy, estimating that a 1% increase in FDI reduces EC by 0.21%; however, they indicate that there is a positive association in the short term between FDI and EC. More recently, Warsono et al. (2020) analyze the links among FDI, industrial growth, EC, and CO_2. Their results indicate that there is a direct effect of FDI on industrial growth, a direct effect of both FDI and industrial growth on EC, and a direct effect of industrial growth on energy use and on CO_2 emissions. In short, there is no consensus on the relationship between FDI and the energy sector.

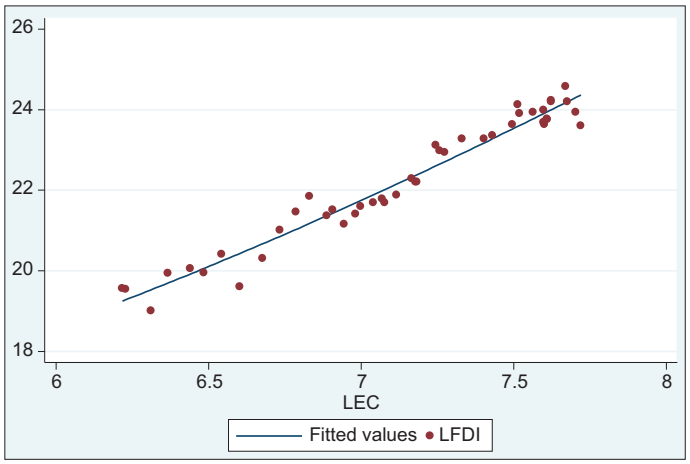
3. DATA AND DESCRIPTIVE STATISTICS

The statistical information used in this research was obtained from the World Bank (WB). FDI is the net inflow of capital is expressed in USD at current prices. While EC is the consumption of electrical energy measured by the production of power plants and cogeneration plants minus the losses that occur in transmission, distribution and transformation, and the own consumption of cogeneration plants. EC is expressed in kWh per capita. All variables correspond to the period 1970-2014. The period is restricted to data availability.

Table 1 shows the descriptive statistics of the variables used in this investigation, as well as their averages, standard deviations, minimum and maximum levels for Mexico in the period 1970-2014. Net FDI inflows in Mexico have an average of 1.12e ± 10 USD in the period 1970-2014, a standard deviation of 1.20e ± 10 USD, a minimum of 1.78e ± 08 USD that corresponds to the year 1972, and the maximum is 4.72e ± 10 USD that corresponds to the year 2013. The average EC in Mexico is 1368.677 kWh, the standard deviation is 549.1074 kWh in the period 1970-2014, the minimum of 501.8794 kWh that corresponds to 1970, while the maximum is 2253.514 kWh corresponds to 2012.

Next, we carry out a graphic analysis that relates FDI and EC for the Mexican economy. To do that, we present in Figure 1 the relationship between logarithm of FDI (LFDI) and the logarithm of EC (LEC) in Mexico, in the period 1970-2014. It can be observed a positive relationship between LFDI and LEC, which is an argument in favor of the hypothesis that FDI and EC are positively related.

Figure 1: Relationship between FDI and EC



Source: Authors' own elaboration with data from World Bank

4. ECONOMETRIC ANALYSIS AND DISCUSSION OF EMPIRICAL RESULTS

The objective of this section is to analyze the interrelation between LFDI and LEC. To do this, we perform cointegration and Granger causality tests. The period of study is 1970-2014 allowing 45 years. Estimates are obtained from *Stata* and *Eviews* statistical packages.

4.1. Cointegration Analysis

Cointegration means that although several series are not stationary at an individual level, a linear combination of two or more of them can be stationary (Wooldridge, 2013). If the series are cointegrated, then they move together in the long term, and the differences between them are stable (Gujarati and Porter, 2009). Likewise, the cointegration phenomenon is related to certain way of causality (Granger causality) between variables and is associated with predictions and forecasts. Likewise, if two series are cointegrated, at least one of them must cause the other (Granger, 1969). Cointegration from an economic perspective indicates that certain variables should not depart too much from others in the long term, such variables may depart in the short term, but there are market mechanisms and economic policies that tend to unite them over time. Regarding the contegration test for LFDI and LEC as shown in Table 2, the tau statistics, whose value is −5.251063, indicates that the null hypothesis of no cointegration is rejected and, therefore, the series are cointegrated.

In summary, the series LFDI and LEC are cointegrated. As we mention before, the cointegration evidence indicates the existence of causality between the variables object of this study. It also indicates the existence of long-term stable relationship between LFDI and LEC. Hence, there is empirical evidence of the existence of both long-term stable relationship and causality between LFDI and LEC, a fact that supports the hypothesis of this research.

Table 3: Granger causality between FDI and EC

Pairwise granger causality tests							
						Lag 1	Lag 2
Null Hypothesis				Obs.	F-Statistic	Prob.	Prob.
LFDI does not granger cause LEC				44	0.38586	0.5379	0.6718
LEC does not granger cause LFDI					22.0547	0.0005	0.0030
Lag 3	Lag 4	Lag 5	Lag 6	Lag 7	Lag 8	Lag 9	Lag 10
Prob.	Prob.	Prob.	Prob.	Prob.	Prob.	Prob.	Prob.
0.5015	0.4962	0.7029	0.7135	0.7753	0.6529	0.6237	0.6404
0.0645	0.0048	0.0715	0.1970	0.3364	0.3312	0.4647	0.2502
Lag 11	Lag 12	Lag 13	Lag 14	Lag 15			
Prob.	Prob.	Prob.	Prob.	Prob.			
0.6380	0.5321	0.6287	0.2057	NA			
0.4314	0.1606	0.2212	0.1103	NA			

Source: Authors' own elaboration with data from World Bank

4.2. Granger Causality Analysis

Granger causality is a technique used to analyze the correlation between current values of variables and its lagged values. The test consists of establishing the null hypothesis of non-existence of causality between two variables. The rejection criterion is based on detecting the value of the t statistic and the level of significance. The t statistics has associated levels of significance ≤0.05.

Table 3 shows the results from the causality tests among the variables with different lags. The null hypothesis that the first lag of LFDI does not granger cause LEC is rejected. This indicates that LFDI does granger cause LEC. Similarly, the first lag of LEC does not granger cause LFDI, and that the second lag of LFDI granger causes EC, while LEC does not granger cause LFDI. The third lag of the LFDI Granger causes LEC, and also the third lag of LEC granger causes LFDI. The fourth lag LFDI causes LEC while the fourth lag of LEC does not granger cause LFDI. Notice now that for the third lag and from the fifth to the fourteenth lags, it is found bidirectional Granger causality between LFDI and LEC.

In summary, there is a bidirectional granger causality between LFDI and LEC in 11 lags out of 14. On the other hand, for lags 1, 2 and 4, in the short term, LFDI granger causes LEC, while LEC does not granger cause LFDI for the same lags. Moreover, in the medium and long term there is a bidirectional causality between LFDI and LEC. Thus, from granger's tests, we can find that in the short term there is a unidirectional granger causality from LFDI toward LEC, while for the medium and long term there is a bidirectional causality between LFDI and LEC in Mexico in the period 1970-2014.

5. CONCLUSIONS

The empirical evidence presented in this research showed that there is a relevant positive link between the growth rates of FDI and EC in Mexico. The empirical results in the specialized literature reviewed in this investigation, by different authors, for different countries and regions around the world, highlight the FDI-EC nexus. Under this framework, we first illustrated through a graphic analysis that there is empirical evidence of a positive relationship between FDI and EC in Mexico in the period 1970-2014. Subsequently, the results of the cointegration analysis between the grow rates of FDI and EC showed a stable relationship in the long term. Likewise, the results from granger's causality showed that in the short term there is unidirectional Granger causality from the growth rate of FDI toward the growth rate of EC, while in the medium and long term there is bidirectional causality between the growth rates of FDI and EC for the Mexican economy.

Derived from this research, it is recommended that economic policy decision-makers should seek the appropriate instruments and incentives to promote the energy sector to increase cleaner energy sources that may attract FDI flows. FDI inflows will contribute to the development of the energy sector with more labor sources for the sector in favor of the development economic and the well-being of the population. It is also recommended that policy makers formulate appropriate and prudent policies to encourage the entry of FDI for improving the development of the financial sector, expanding the volume of exports, and guaranteeing energy supply to ensure sustainable growth in Mexico.

Decision makers are suggested to implement policies that favor the development of the energy sector to expand its infrastructure and installed capacity, and thus increase the supply of energy required by new FDI from abroad. Likewise, the development effort of the energy sector must be mainly local and complemented with the attraction of FDI from the global energy sector in order to stimulate and modernize the sector, as well as provide more efficient and cleaner energy sources for the Mexican economy, as a lever that contributes to attracting global FDI to enhance economic growth and development for the country.

Finally, quality is recommended in the country's energy policy, it is essential to open, in Mexico, the energy sector to transnational companies that can compete with local monopolies, pressuring them to be more efficient and competitive, as well as encouraging large government companies to be global organizations with presence abroad covering not only domestic demand, but also exporting energy demanded by commercial partners.

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