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# Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models

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## HIGHLIGHTS

- We examine the energy–FDI–growth nexus for a global panel of 65 countries.
- Dynamic simultaneous-equation panel data models are used to address this issue.
- We also investigate this nexus for three sub-panels which are constructed based on the income level of countries.
- We show mixed results about the interrelationship between the three variables.

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## ABSTRACT

This paper examines the interrelationships between energy consumption, foreign direct investment and economic growth using dynamic panel data models in simultaneous-equations for a global panel consisting of 65 countries. The time component of our dataset is 1990–2011 inclusive. To make the panel data analysis more homogenous, we also investigate this interrelationship for a number of sub-panels which are constructed based on the income level of countries. In this way, we end up with three income panels; namely, high income, middle income, and low income panels. In the empirical part, we draw on the growth theory and augment the classical growth model, which consists of capital stock, labor force and inflation, with foreign direct investment and energy. Generally, we show mixed results about the interrelationship between energy consumption, FDI and economic growth.

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## 1. Introduction

The nexus between energy consumption, foreign direct investment and economic growth has newly started to be discussed in energy economics literature. This literature can be divided into three lines. The first line of research focuses on the nexus between energy consumption and economic growth. This nexus suggests that economic growth and energy consumption may be jointly determined, because higher economic growth requires more energy consumption. Similarly, more efficient energy use needs a higher level of economic growth. Therefore, the direction of causality may not be determined prior. Since the pioneer work of Kraft and Kraft (1978), the Granger causality test approach has become a popular tool for studying the relationship between

economic growth and energy consumption in different countries (see, *inter alia*, Stern, 1993; Belloumi, 2009; Pao, 2009; Ghosh, 2010; Ozturk and Acaravci, 2010) and this leads to four testable hypotheses; (1) a Granger causal relationship from energy to GDP, (2) a Granger causal relationship from GDP to energy, (3) a feedback relationship between energy and GDP, and (4) no Granger causal relationship between energy and GDP (neutrality). Ozturk and Acaravci (2010) have investigated the causal relationship between energy and economic growth and find a bi-directional Granger causality between energy variables and economic growth in Hungary. However, Belloumi (2009) has used a VECM Model and showed that, in Tunisia, there is a causal relationship between energy consumption and income over the period of 1971–2004.

The second line of researches has examined the relationship between foreign direct investment and economic growth. The role of foreign investment in economic growth has been considered one of the basic principles in economics. Many researchers conclude that the rate of capital formation determines the rate of economic growth (see, *inter alia*, Ekanayake et al., 2003; Tsang

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and Yip, 2007; Omri and Kahouli, 2013). For example, De Long et al. (1992) found a strong causal relationship between equipment investment and economic growth. Blomstrom et al. (1996) also reported that the growth rate is more closely related to the capital formation rates in succeeding periods than to the contemporary or preceding rates. Alfaro et al. (2010) have shown that FDI leads to higher additional growth in developed economies. Lee and Chang (2009) reported that FDI has a large direct effect on economic growth and extends the potential gains associated with FDI. Aitken et al. (1997) have shown evidence of beneficial spillovers from multinational enterprises to the host economy, whereas Hsiao and Shen (2003) reported that economic growth is one of the important factors in attracting FDI, in particular in developing countries. Some studies indicate that the direction of causality between economic growth and FDI is subject to country-specific factors (Zhang, 2001). Nguyen and Nguyen (2007) have identified the two-way linkage between FDI and economic growth in which FDI promotes economic growth, and in turn, economic growth is viewed as a tool to attract FDI. Moreover, Anwar and Nguyen (2010) study the two-way linkage between economic growth and FDI in 61 provinces of Vietnam over the period 1996–2005. They support the view that, in overall terms, reinforcing two-way linkage between FDI and economic growth exists in Vietnam and explored the link between FDI and economic growth across seven regions of Vietnam. The empirical analysis reveals that a two-way linkage between FDI and economic growth exists only in four regions.

The third line of researches has examined the relationship between foreign direct investment and energy consumption. In this issue, Tang (2009) opines that the influx of FDI is inducing energy consumption through the expansionary of industrialization, transportation and manufacturing sectors development while energy is required to support the manufacturing process. This area of research is relatively less researched and can be considered as nascent. Mielnik and Goldemberg (2000) found a positive relationship between FDI and energy intensity in a sample of 20 developing countries. Sadorsky (2010) also found a positive and statistically significant relationship between FDI and energy consumption in a sample of 22 developing economies. FDI allows businesses cheaper and/or easier access to financial capital, which can be used to expand their existing operations or construct new plants and factories, all of which increase the demand for energy. Consistent with this view that FDI leads to greater economic growth is the likelihood that energy demand should be positively affected by increases in FDI. Bekhet and Othman (2011) examine the causal relationship between electricity consumption and foreign direct investment in Malaysia, during a period of 1971–2009. The results were found to be cointegrated and indicated the existence of long run causal relationship among the variables. Bento (2011) showed a modest and negative effect of FDI on energy consumption in the context of Portugal, during the period of 1980–2007.

Finally, most previous studies have shown that higher economic growth requires more energy consumption. It has also been found that FDI is often a key determinant of economic growth. It is therefore worthwhile to investigate the nexus between energy consumption, FDI and economic growth by considering them simultaneously in a modeling framework.

The present study is different from the three lines of the literature identified above in the following ways. Compared to previous studies, this paper used dynamic simultaneous equations based on structural modeling to study the nexus between energy consumption, FDI inflows and economic growth for a global panel consisting of 65 countries. However, to the best of our knowledge, none of the empirical studies have focused on investigating the nexus between energy–FDI–growth via the

simultaneous equations model. The model allows to examine at the sometime the interrelationship between energy consumption, FDI and economic growth estimated by the Generalized Method of Moments (GMM). We investigate the three-way linkage between energy–FDI–growth for 65 countries by using the GMM-estimator. Specifically, this study utilizes three structural equations models that allow one to simultaneously examine the impact of (i) FDI and energy consumption on economic growth, (ii) economic growth and energy consumption on FDI, and (iii) FDI and economic growth on energy consumption. In addition, in this study we do not use panel unit root and panel cointegration approaches, as has been the case in this literature to date. Rather, we use a dynamic simultaneous-equation model with panel data, which follows the spirit of the conventional ‘growth model’ framework. This approach ensures that there is a strong theoretical foundation for the empirical analysis (Sharma, 2010). Our approach in this study is to estimate the short-run elasticities and not to estimate the long-run elasticity given our growth form modeling approach. There is a strong motivation for us to apply a growth form approach to analyzing the interrelationship between energy, FDI and economic growth. We were motivated by the fact that there are no studies that model this interaction using growth form models. Finally, we use a dynamic simultaneous-equation model with panel data of 65 countries, which allows us to derive short-run elasticities.

The paper is organized as follows: after introduction which is provided in Section 1 above, brief literature review is carried out in Section 2. The methodological framework is explained in Section 3. Data and results are discussed in Section 4. Final section concludes the study and gives some policy implications.

## 2. Overview of related literature

This section will be devoted to review the findings of all those studies on energy, FDI and economic growth nexus that have used panel data modeling techniques. Therefore, it should be noted that the modeling techniques with panel data are relatively recent compared with modeling techniques based on time series data. In this context, Payne (2010) shows that most of the previous studies are based on time-series model and very few are based on panel data models. We focus on reviewing studies on panel data models since they are closest to our study and hence provide some insights of the relationship between energy–FDI–growth at least.

Apergis and Payne (2009) examine the relationship between energy consumption and economic growth for a panel of 11 Commonwealth of Independent States using panel data for the period 1991–2005. By applying panel unit root, panel cointegration, and panel error correction models, their study shows the presence of unidirectional causality from energy consumption to economic growth in the short-run while bi-directional causality between energy consumption and economic growth in the long-run. Thus, the results lend support for the feedback hypothesis associated with the relationship between energy consumption and economic growth. In addition, Chen et al. (2007), using the Pedroni (1999, 2004) tests and panel data model for the time period 1971–2001, find evidence of bi-directional long-run causality between electricity and economic growth in 10 industrialized and developed Asian countries.

Lee (2013) examines the contributions of foreign direct investment (FDI) net inflows to energy use and economic growth using panel data of 19 nations of G20 countries from 1991 to 2009. The empirical results indicate that FDI has played an important role in economic growth for the G20 and no compelling evidence of FDI link with clean energy use is found. However, Mielnik and Goldemberg (2000) found a positive relationship between FDI

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