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Electricity regulation and FDIs spillovers in the OECD: A panel data econometric approach

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ABSTRACT

The aim of this paper is to investigate the regulatory process in the electricity sector and determine the extent to which it has affected the level of Foreign Direct Investments (FDIs). For this purpose, we use an annual data set covering the period 1975–2010 and panel data econometric techniques. Our results suggest a feedback effect between electricity regulation and the attraction of FDIs in the OECD countries. This finding highlights the existence of a sound regulatory environment in the examined electricity sectors, implying that a liberalized and competitive electricity sector can be employed under specific settings by policy makers to attract FDIs. Further, we find a two-way Granger type causation between FDIs and effective regulation in the electricity sector, thus providing sufficient evidence that a proper regulatory environment is a prerequisite for increases in the level of FDIs.

1 Introduction

In the last few decades there is a wide spread movement to abolish electric monopolies and establish liberalized electricity markets with effective regulation (see for example Lesher & Miroudot, 2008; Sharma, 2005). Throughout the world, from the USA to China and from Australia to Mexico, there are strong initiatives to liberalize and properly regulate electricity markets in order inter alia to attract foreign direct investments (Borenstein & Bushnell, 2000; Zhang, 2012). A crucial role towards this change has played the expectations of various Governments that in this way they could enhance their electricity markets' performance through the attraction of FDIs in the field and the subsequent use of the FDIs' spillovers (Del Bo, 2013; Keller, 2004). However, despite expectations, there is no consensus that liberalized and regulated electricity markets can lead to increases in foreign direct investments' inflows and thus to more prosperous electricity markets regimes in the host countries (Lim, 2001; Moura & Forte, 2010; Shi & Kimura, 2010; Xuegong, Liyan, & Zheng, 2012).

Thus, despite the various empirical studies that have occasionally contributed in the topic through the use of various methods (see also Lim, 2001; Masayuki & Ivohasina, 2005; Moore, 1993; Singh & Kwang, 1995; Wafure & Nurudeen, 2010; Wheeler & Mody, 1992), it remains difficult to compare and determine results on the matter. In order to advance the field, this paper provides further insight about the potential links between effective regulation in the electricity sector and the level of FDIs.

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In order to address the problem and capture the complex phenomenon in the relationship between regulation in the electricity sector and the level of the FDIs, we empirically tested this relationship across 30 OECD countries for the period 1975–2010 by using panel data econometric techniques and cointegration analysis. To that end, we also use the regulatory reform index (RRI) for electricity sector provided by OECD as a proxy for the effectiveness of the regulatory environment. Further, unlike previous studies, we attempt to determine Granger type causation between the regulatory performance in the electricity sector and the investment activity.

The contribution of this paper is three-fold. First, it goes beyond the existing literature in that it uses cointegrated panel data analysis to assess the issue. Second, unlike previous studies, our analysis combines static and dynamic panel data econometric methodologies to test the robustness of our results. Third, but most important, the paper attempts to assess the relationship between the effective electricity regulation and the level of foreign direct investment activity in which rather scant attention has been paid in the past.

The rest of the paper is organized as follows. Section 2 reviews the empirical literature on the determinants of the FDIs' inflows. Section 3 describes the electricity regulatory framework in OECD countries. Section 4 presents the methodology used in our empirical analysis, while Section 5 reports the main empirical findings. Section 6 concludes the paper and provides some policy implications.

2 Review of the literature

During the last decades, various empirical studies suggested certain determinants of FDIs. These studies can be broadly classified into three categories regarding the following: (a) the type of data used (time series, cross-section, panel data), (b) the level of aggregation, and (c) the stage of transnational investment decision. The first category of those studies refers to the examination of the economic determinants of FDIs' inflows either at a micro or a macro-level with a special attention to the role of company taxation as one of the main determinants of the global FDIs flows (see for e.g. Bénassy-Quéré, Fontagné, & Lahrèche-Révil, 2005; Bénassy-Quéré, Gobalraja, & Trannoy, 2007; Devereux & Lockwood, 2006; Hajkova, Nicoletti, Vartia, & Yoo, 2006; Wolff, 2007).

As we noted above, part of the literature suggests that the taxation effect on FDIs is a rather controversial issue. An obvious hypothesis employed by such studies is that higher taxes discourage FDIs. However, some of the empirical studies highlighted that the last hypothesis may be also misleading (see for example Blonigen, Davies, Waddell, Glen, & Naughton, 2004; Bloningen, 2005; Desai, Foley, & Hines, 2004; Hallward-Dreimeier, 2003). As these studies indicate, the effects of taxes on FDIs can vary substantially by type of taxes, measurement of FDIs' activity, and tax treatment in the host and parent countries. For this reason, other empirical studies recently began to examine alternative related taxes beyond corporate income taxes. For example, Desai et al. (2004) find evidence that indirect business taxes have an effect on FDIs that is in the same range as corporate income taxes. Further, other scholars have recently examined the effect of bilateral international tax treaties on FDIs' activity, an issue which was also underexplored (Blonigen et al., 2004; Hallward-Dreimeier, 2003).

The second category of studies investigates the role of governance infrastructure of a host country as expressed by its political, institutional and legal environment (Altomonte, 2000; Bevan & Estrin, 2000; Globerman & Shapiro, 1999; Mody & Srinivasan, 1998; Morisset, 2000; Stevens, 2000; Tuman & Emmert, 1999). These studies utilize certain indicators to examine the effects of governance infrastructure on both FDIs' inflows and outflows for a broad sample of developed and developing countries. Along these lines it is suggested that governance infrastructure is an important determinant of both FDIs' inflows and outflows. Further, investments in governance infrastructure are considered not only able to attract capital, but also to create the conditions under which domestic multinational firms emerge and invest abroad. The majority of this category suggests that a country's economic performance over time is determined to a great extent by its political, institutional, and legal environment.

The last category of studies links the investment activity with the firm specific characteristics (i.e. R&D intensity, advertising intensity, managerial skills, etc.) that act as catalysts in attracting the FDIs' inflows (Blonigen, 1997; Dunning, 1993; Feenstra & Hanson, 2004; Kogut & Chang, 1991). This type of studies attempts to answer whether firm's characteristics, like certain technologies, managerial skills, and other intangible assets can be used as key drivers of the FDIs' activity.

Regarding the electricity sector there is limited research that examines the FDIs' effects. In particular, Jaraite and De Maria (2012) argue that FDIs' inflows of several EU countries are found to positively influence productivity in the electricity generation sector and enhance environmental efficiency. In another study, Lam and Shiu (2001) fail to find a significant effect of foreign presence on China's productivity in electricity generation. Lesher and Miroudot (2008) provide estimates of foreign spillovers and report the existence of positive vertical spillover effects in the aggregate sector of production and distribution of electricity, gas and steam, while also detecting negative and significant horizontal spillovers from foreign presence. In a recent study, Del Bo (2013) claims that regional FDIs' spillovers are different with respect to the analysis based on regional administrative boundaries. He suggests that spatial aggregation, along with industrial aggregation, is relevant in accounting for productivity spillover effects of foreign presence in the EU electricity sector.

To sum up, the literature on the determinants of FDIs is quite substantial, though arguably still in its infancy (Bloningen, 2005). A large body of literature examines how (exogenous) factors, such as taxes and exchange rates, affect the firm-level decisions to invest. A more recent body of literature attempts to frame such decisions in a general equilibrium framework

Table 1
Regulation of entry in the OECD countries (2007).
Source: OECD International Regulation Database.

Country	Third party access (TPA) to the electricity transmission grid	Wholesale pool	Ownership structure of the largest companies	Degree of vertical integration
Australia	Regulated TPA	Yes	Mostly public	Unbundled
Austria	Regulated TPA	Yes	Mostly public	Unbundled
Belgium	Regulated TPA	No	Mostly private	Unbundled
Canada	Regulated TPA	Yes	Mostly public	Unbundled
Czech Republic	Regulated TPA	Yes	Mostly public	Unbundled
Denmark	Regulated TPA	Yes	Mostly public	Unbundled
Finland	Regulated TPA	Yes	Mixed	Unbundled
France	Regulated TPA	Yes	Mostly public	Unbundled
Germany	Regulated TPA	Yes	Private	Unbundled
Greece	Regulated TPA	Yes	Mostly public	Unbundled
Hungary	Regulated TPA	Yes	Mixed	Unbundled
Iceland	Regulated TPA	No	Public	Unbundled
Ireland	Regulated TPA	Yes	Public	Unbundled
Italy	Regulated TPA	Yes	Mixed	Unbundled
Japan	Regulated TPA	Yes	Private	Unbundled
Korea	Regulated TPA	No	Mixed	Unbundled
Luxembourg	Regulated TPA	Yes	Mixed	Unbundled
Mexico	Regulated TPA	No	Public	Unbundled
Netherlands	Regulated TPA	Yes	Public	Unbundled
New Zealand	Regulated TPA	Yes	Mostly public	Unbundled
Norway	Regulated TPA	Yes	Mixed	Unbundled
Poland	Regulated TPA	No	Mostly public	Unbundled
Portugal	Regulated TPA	Yes	Mixed	Unbundled
Slovak Republic	Regulated TPA	No	Mostly public	Unbundled
Spain	Regulated TPA	Yes	Mostly private	Unbundled
Sweden	Regulated TPA	Yes	Public	Unbundled
Switzerland	Regulated TPA	No	Mostly public	Unbundled
Turkey	Regulated TPA	Yes	Public	Unbundled
United Kingdom	Regulated TPA	Yes	Private	Unbundled
United States	Regulated TPA	Yes	Private	Unbundled

and generates predictions of how fundamental country-level factors affect aggregate country-level FDIs' behavior (Del Bo, 2013). However, these studies fail to incorporate the role of regulatory environment in the foreign direct investment inflows. In particular, they ignore any possible effect of sectoral regulation on the level of FDIs. Our study attempts to advance our understanding in the field by exploring possible outcomes to the FDIs' inflows generated by the regulatory performance of a recently liberalized economic industry (i.e. electricity sector).

3 Regulatory framework and FDIs in the OECD countries

The OECD countries have implemented substantial regulatory and institutional reorganization of their energy sectors (electricity and natural gas). In particular, during the last thirty years we have witnessed significant efforts towards the deregulation of the electricity sector. This was done mainly through the introduction of wholesale electricity markets and the unbundling of the traditional vertically integrated monopolies. The pioneer in the electricity sector reform was Chile, commencing its efforts in 1987. Since then, many OECD countries (i.e. the USA, EU member-states, New Zealand, Canada, etc.) deregulated their electricity markets, following different paths. The differences in the pace and extent of market reforms are mainly related to the starting point of each reform and the problems associated with the internal environment of the market (Kalantzis & Sakellaris, 2012). This is more evident in the EU, where although a goal for a single market has been set back in 1996, different levels of unbundling and introduction of competition have been implemented across the member states.

As shown in Table 1, entry conditions in all of the three market segments of the electricity sector had been substantially relaxed by 2007. In particular, in all cases no country maintained a legal monopoly and only three countries had less than three competitors in the electricity sector (i.e. Canada, Greece and Mexico). However, the timing of entry liberalization was very different. In most continental European countries (Ireland, Italy, Spain, Portugal, Austria, Belgium, etc.), as well as in Korea and Mexico, full liberalization occurred during the mid-1990s, while in common-law countries, Japan and some Nordic countries, legal barriers to entry in the energy sector were removed earlier, as early as the beginning of the 1980s in the United States and the United Kingdom. Further, the liberalization of the electricity industry in most of the transitional economies (Czech Republic, Hungary) and Turkey occurred quite recently (Del Bo, 2013; Fafaliou & Polemis, 2010).

Of course, one can currently observe different unbundling regimes in the EU member states, but common to all EU countries is a gradual movement towards more advanced/stricter forms of unbundling of the transmission grid. In particular,

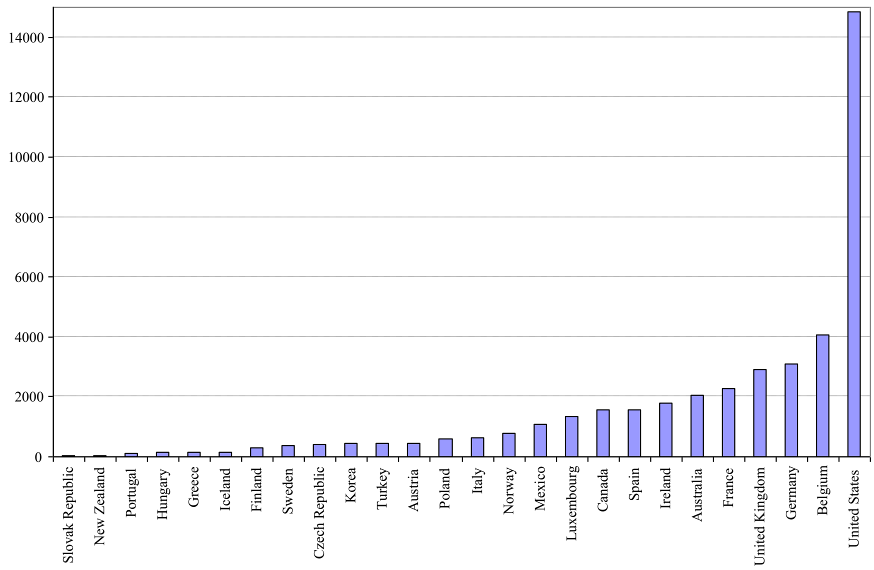

Fig. 1. Real Foreign Direct Investment per capita in OECD countries in 2010. *(USD dollars)* **Source:** UNCTAD statistical database.

initially accounting unbundling was mandatory according to the first electricity directive 96/92/EC, then there was the obligation to switch to legal unbundling according to the second directive and finally member states can only choose between three possibilities: full ownership unbundling, the Independent System Operator (ISO) option, or the Independent Transmission Operator (ITO) option according to the third directive. Table 1 also shows that while most countries adopted the European Commission's preferred approach of ownership unbundling of the transmission system operator (TSO), both Germany and France has not done so. Public ownership is very significant in transmission for many countries, indicating reluctance on the part of governments to relinquish control of this central part of their national electricity system (Pollitt, 2009).

Allowing for variations in population and economy size, FDIs' levels across the OECD countries vary considerably, as shown in Fig. 1. It is evident that United States, Belgium, Germany and France are among the first places in the world ranking, while Central Eastern European (Hungary, Slovak Republic and Czech Republic) and Mediterranean countries (i.e. Greece and Portugal) are still lacking behind.

4 Data and methodology

As noted earlier, in order to achieve the purpose of this paper we used an updated dataset of 30 OECD countries[1] covering the period 1975–2010. The starting date of our research is year 1975 because there were no available data before then. However, we must bear in mind that this could not raise any issue regarding the sample selection since little reform of the electricity sector occurred before that date. For the same reason we ended our research in the year 2010. The choice of the sample countries was based on access to data and especially information on the OECD electricity regulatory reform index and the level of FDIs. Due to absence of reliable quarterly or monthly data concerning our key variables, we focus solely on annual observations despite the fact that yearly datasets have many drawbacks (i.e. less information on the data generation process, lack of consistency and high volatility). All non-index variables and the long-term real interest rates are in their natural logarithms.

Two sets of control variables are employed to explain the behavior of the FDIs activity in the OECD. The first set of variables is based on the level of regulation, competition and privatization, as an effort to capture the impact of structural reforms. According to various studies, regulation plays a crucial role in terms of evaluating performance of the electricity industry by organizing the market and promoting competition in each segment (see for example, Zhang, Parker, & Kirkpatrick, 2008). Indeed, the primary purpose of a well-designed regulatory system is to protect consumers from concerted practices by the incumbent, while at the same time it creates an attractive environment fostering investment activities (Laffont & Tirole, 1993). However, as indicated by Averch and Johnson (1962), regulation that is too onerous can negatively affect firm's output decisions and depress productivity. Similarly, from a theoretical perspective, competition will induce reductions in retail prices and mark-up over costs leading to higher social welfare as well as to protect consumers from the

[1] The sample countries are the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States.

abuse of monopoly power by the incumbents. This in turn may trigger the level of FDIs activity and create a positive spillover effect (Zhang et al., 2008). Further, privatization can lead to an increase in productivity with higher utilization of the available capital stock (see for example Estache, Goicochea, & Manacorda, 2006; Gual & Thrillas, 2004; Wallsten, 2004) which in turn triggers the performance of the industry and subsequently the investment activity.

For assessing the first set of variables employed, we used the following proxies: (a) for regulation the Regulatory Reform Index (RRI), (b) for estimating competition two dummy variables (WHOL, TPA) accounting for the competitive conditions prevailing in the wholesale electricity market and the existence of a third party access, respectively, and (c) for privatization a dummy variable (PRIV) taking the value of one when the percentage of shares in the public power companies owned by the government is less than 50% and zero otherwise.[2] The data for all of the above variables is obtained directly from OECD regulation database for the years from 1975 to 2010.[3]

The second set of variables covers some macro and micro-economic indicators such as the GDP per capita, the level of population density, the real interest rate, the labor productivity per person employed, the unit labor cost index and, finally, the total number of patents. Data for the aforementioned variables is drawn from the World Bank Database. According to a part of the literature, an increase in GDP per capita can be expected to be associated with a higher demand for electricity, thus inducing higher investment by utilities (see for example Zhang et al., 2008). Similarly an increase in the population density will increase the level of investment and vice versa. On the contrary, an increase (decrease) of the interest rate, which is a proxy of the macro-economic conditions of a country will negatively (positively) affect the level of investment activity. Further, variations in the level of labor productivity of the industry and the unit labor cost will positively (negatively) correlate with the level of FDIs respectively. Finally, the number of patents in the electricity industry, which is a proxy of the level of R&D is expected to positively affect the level of investment activity. All data other than FDIs and GDP per capita are taken from the OECD statistical database[4]. The rest of the variables are drawn from the UNCTAD database.

Hence, the model to be estimated is given by the following reduced form equation:

$$FDI_{it} = a_0 + a_1\overset{+}{GDP}_{it} + a_2\overset{+}{POP}_{it} + a_3\overset{-}{IR}_{it} + a_4\overset{+/-}{RRI}_{it} + a_5\overset{+}{LAB}_{it} + a_6\overset{-}{UNIT}_{it} + a_7\overset{+}{PAT}_{it} + a_8\overset{+}{T}_{it} + a_9\sum_{i-1}^{n} DUM_i + \varepsilon_{it} \tag{1}$$

where FDIs are the real inward per capita foreign direct investment, GDP is the per capita gross domestic product in constant prices (base year 2005), POP is the population density measured as the ratio of population and country size (expressed in square kilometers), IR is the real long-term interest rate, RRI is the OECD electricity regulatory reform index, and LAB represents the labor productivity per person employed in constant prices. UNIT is the unit labor cost provided by the OECD (base year 2005), PAT is the total patents, T is a linear time trend denoting the technological effect and DUM denotes a vector of dummy variables controlling for privatization (PRIV) and competition effects respectively (WHOL, TPA). Finally, a_o is the constant term and ε_{it} is the disturbance term.

The RRI indicator takes the value from zero to six. A low score in the RRI is attributed to countries with the best regulatory environment. The RRI has been estimated at an annual frequency for the OECD countries, based on a number of published sources as well as on replies to the OECD Regulatory Indicators Questionnaire (Conway & Nicoletti, 2006). The indicator covers transmission, distribution and supply of electricity and includes the following low-level (sub) indicators: (a) barriers to entry, (b) public ownership, and (c) vertical integration.

The privatization dummy variable (PRIV) refers to the ownership structure of the largest companies in all of the market segments (i.e. generation, transmission, distribution, and supply) of the electricity industry. If the ownership structure is (mostly) public then the dummy variable takes the value of zero otherwise is set to one. Competition dummy variables (WHOL and TPA) capture the extent of competition in the electricity markets. Specifically, the existence of a liberalized wholesale market for electricity (wholesale pool) is measured by the WHOL dummy variable. This variable takes the value of one if a wholesale pool is existing, whilst is set to zero. Lastly, the other competition dummy variable (TPA) accounts for the third party access to the electricity transmission grid within the sample countries. It takes the value of zero if TPA is absent otherwise is set to one.

The relevant signs above the control variables show the expected impact (positive or negative) of each variable to the dependent variable. In other words, the direction of the causality between the variables (signs) and the magnitude of the relevant coefficients (elasticities) represent the main hypotheses to be tested. It is worth mentioning that the impact of the control variables related to the privatization and competition effects has not been previously tested by other empirical studies. The main reason for using the relevant variables in the empirical analysis is that we want to assess the effect of the industry structure and the level of the (intra-firm) competition in the electricity sector.

Despite the existing empirical literature on this issue (Del Bo, 2013; Jaraite and De Maria, 2012; Lesher & Miroudot, 2008) the econometric methodology adopted in this paper uses three different sets of estimators. Firstly, we apply the panel Ordinary Least Squares (OLS) methodology as a baseline. However, there might be a potential endogeneity issue regarding

[2] The competition dummy variables take the value of one if competition exists in each of the market segments and zero otherwise (monopoly or duopoly).

[3] From 2008 onwards the OECD does not provide data for the RRI on an annual basis. Therefore, for the period 2009–2010 the mean imputation method was used in order to fill the missing observations (Schenker and Taylor, 1996).

[4] The data can be downloaded by the following link: (http://stats.oecd.org).

the use of the control variables. Because of this, an OLS estimator would tend to underestimate the effect of these variables on the level of FDIs (coefficient biased towards zero). In order to overcome this problem, we include the GLS fixed effects estimator that allows among other things the unobserved country-specific factors to be filtered out.[5] Given the nature of the underlying model, we would expect a fixed effects model to be more appropriate than a random effects model. However, we tested this assumption using the Hausman test and the random effects model was consistently rejected in favor of a fixed effects model.[6] In addition, the fixed effects static model avoids the potential biases which could arise in the random effects model owing to correlation between the included exogenous variables and omitted country attributes (Cubbin & Stern, 2006).

It is worth mentioning that static models, which assume that all adjustment to disequilibrium occur within the period defined by observation frequency may be inappropriate (Cubbin & Stern, 2006). In particular, FDIs are not usually completed in a year so we would expect that scope for some adjustment process would need to be incorporated into our model. Such processes can be modeled generally by a combination of lags on the dependent variable (autoregressive) and on the explanatory variables (moving average). However, the presence of a lagged dependent variable in a fixed-effects model can result in biased estimates for the lagged dependent variable coefficient (Cubbin & Stern, 2006). The size of the bias will depend on the number of time series, N, the length of the time series, T, and the influence of other exogenous variables in the determination of the dependent variable (Hsiao, 1986).

In order to check for the robustness of our findings and allow for a dynamic element in the econometric model we employ dynamic panel data techniques. In particular, we estimate Eq. (1) with the use of the Generalized Method of Moments estimator (GMM) that controls for the endogeneity. The latter can be a problem because, if unobserved variables jointly affect both the dependent and control variables, then the coefficient estimates for the independent variables may be biased (Hausman & Ros, 2013). For this reason, we utilize a GMM estimator developed by Hansen (1982). This estimator takes into account the unobserved time-invariant bilateral specific effects, while it can deal with the potential endogeneity arising from the inclusion of several control variables (Cambini & Rondi, 2010; Polemis, 2015). Finally, we employ the difference Generalized Method of Moments (DIF-GMM) estimator (Arellano & Bond, 1991) for the coefficients in Eq. (1) where the lagged levels of the regressors are instruments for the equations in first differences.[7]

Having estimated the relevant elasticities for the OECD countries, we then use an Autoregressive Distributed Lag (ARDL) to assess the direction of causality between electricity regulation and FDIs. This method has been widely used in the empirical literature, while its main benefit is that it permits examining the intertemporal relationship between regulation and FDIs. In order to assess the magnitude and the direction of the Granger causality relationships between regulatory performance in the electricity sector and the level of FDIs we disentangle the following autoregressive equations:

$$FDI_{jt} = a_0 + a_1 FDI_{j,t-1} + a_2 FDI_{j,t-2} + \beta_1 RRI_{j,t-1} + \beta_2 RRI_{j,t-2} + \eta_{it} + \varepsilon_{it} \quad (2)$$

$$RRI_{ij} = a_0 + a_1 RRI_{j,t-1} + a_2 RRI_{j,t-2} + \beta_1 FDI_{j,t-1} + \beta_2 FDI_{j,t-2} + \eta_{it} + \varepsilon_{it} \quad (3)$$

where a_0 is the intercept, α_j and β_i are parameters to be estimated, η_{it} is an individual specific effect and ε_{it} is the disturbance term. In order to choose the appropriate number of lags in the above ARDL we followed a three step procedure. Firstly, we estimate the two equations in levels by allowing different lags. In the next step we compare our results choosing the lag length that minimizes the AIC and SIC criteria respectively. Finally, we confirm that for the lag length (AR=2) we chose in the second step, the residuals of the model are not correlated.

For this analysis, we employ an array of econometric techniques in order to infer about the robustness of our results. We first run pooled OLS and fixed effects regression (PGLS_FE). We then employ the GMM estimator and finally conclude with the difference GMM (DIF-GMM) estimator for the coefficients in Eq. (3) where the lagged levels of the regressors are instruments for the equations in first differences. In the model described in the above equations, the joint null $\beta_1 = \beta_2 = 0$ is interpreted as a panel data test for Granger causality. If the two annual lags are significant, we can predict that regulation causes FDIs, in the sense of changes in the regulatory performance of the electricity sector preceding changes in the level of FDIs. The sign of the causal relationship is determined by the sum of the jointly significant coefficients.

5 Results and discussion

In this section, we present our empirical findings from the estimation of the long-run (cointegrated) equation. The models were estimated incorporating corrections for autocorrelated errors within cross-sectional units. In order to handle for cross-section fixed effects we used differentiated data in the estimation procedure.

[5] All the specifications of the fixed effects specifications use White cross-section standard errors to permit for general contemporaneous correlation between the country residuals. The cross-sectional selection is adopted to show that covariances are allowed across cross-sectional units contemporaneously.

[6] Due to space limitations, the results are available upon request.

[7] However, the use of only internal variables as instruments may lead to biased estimations (Ai and Sappington, 2002). For this reason we use a vector of external instruments (i.e. stability, corruption, taxation, etc.) and the obtained results were in alignment with the ones reported in the paper. This means that the relevant estimations are robust under the use of certain internal and external instruments.

Table 2
Panel unit root test results.

Variable	Levin, Lin and Chu-t test	Breitung t-test	Im, Pesaran and Shin W-test	ADF–FisherChi-square	PP–FisherChi-square	Hadri z-statistic
Levels						
FDI	0.22	–	–	35.48	32.61	16.75*
GDP++	1.27	3.35	−0.05	64.36	24.68	11.47*
POP+	−0.67	−1.07	−3.12*	87.3**	62.6**	8.26*
IR++	−7.22*	−1.67**	−6.48*	174.51*	450.34*	6.84*
RRI++	8.82	7.17	6.96	67.80**	8.16	14.43*
LAB++	−7.79*	5.62	−3.03*	164.16*	166.28*	13.96*
PAT	6.48	–	–	3.65	3.76	19.78*
UNIT++	−5.38	4.44	−1.94	86.70*	143.52*	13.99*
First differences						
Δ(FDI)	−36.35*	–	–	1332.43*	1682.05*	0.47
Δ(GDP)++	−13.97*	−7.43*	−13.32*	278.66*	269.78*	3.28*
Δ(POP)+	−14.12*	−0.61	−18.12*	344.76*	959.43*	0.31
Δ(IR)++	–	–	–	–	–	–
Δ(RRI)++	−3.58*	3.34	−7.61*	262.41*	380.52*	8.22*
Δ(LAB)++	−10.80*	−7.95*	−15.61*	363.84*	570.69*	10.93*
Δ(PAT)	−40.01*	–	–	195.25*	201.26*	7.79*
Δ(UNIT)++	−18.89*	−10.70*	−19.98*	446.99*	109.59*	9.61*

Under the null hypothesis Hadri test assumes the absence of a unit root whereas the other unit root tests assume a unit root. The lag lengths were selected by using Schwarz criterion. + denotes the inclusion of an individual intercept as an exogenous regressor, ++ denotes the inclusion of an individual intercept and trend as exogenous regressors. Significant at
* 1%.
** 5%.

5.1 Panel unit root testing and cointegration

To avoid generating spurious results due to the presence of unit roots, all the variables of the model were first examined for stationarity and transformed by differencing if needed. To test for the existence of a unit root in a panel data setting, we have used various econometric tests (Im, Pesaran and Shin W-test, Fisher type tests, Levin, Lin and Chu-t test, and Hadri test). In all the above tests except for Handri test, the null hypothesis is that of a unit root. The ADF and PP tests are distributed as χ^2 with degrees of freedom twice the number of cross-section units (2 N), under the null hypothesis. Applying the relevant tests (Table 2), we observe that the null-hypothesis of a unit root cannot be rejected at 5% critical value for all of the relevant variables except for the real long-term interest rates (IR). In other words all the control variables but IR, which is stationary $I(0)$ and therefore must be excluded from the cointegration equation, are integrated of order one $I(1)$ including in some cases deterministic components (intercept or trend).

In the next stage, panel cointegration tests are used in order to draw sharper inferences since time spans of economic time series are typically short. The basic idea behind cointegration is that if in the long-run, two or more variables move

Table 3
Panel cointegration tests.

Series	*Fisher χ2 test*	*Kao test*	*Pedroni test*
FDI, GDP, POP, RRI, LAB, PAT	*Trace statistic* 115.14* [r=0] 17.23 [$r \geq 1$] *Maximum eigenvalues* 95.36 * [r=0] 6.45 [$r \geq 1$]	3.31*	−1.08* [Panel v-statistic] 3.77* [Panel rho – statistic] −7.92* [Panel PP-statistic] −8.44* [Panel ADF-statistic]
FDI, GDP, POP, RRI, UNIT, PAT	*Trace statistic* 75.12* [r=0] 25.10 [$r \geq 1$] *Maximum eigenvalues* 66.78* [r=0] 11.47 [$r \geq 1$]	3.32**	−6.64* [Panel v-statistic] 3.22* [Panel rho – statistic] −6.33* [Panel PP-statistic] −6.44* [Panel ADF-statistic]

Null hypothesis implies absence of cointegration, while r denotes the number of cointegrating equations with no deterministic trend. Significant at
* 1% level of significance.

closely together, the linear combination between them is stationary and hence we may consider those series as defining a long-run equilibrium relationship. For this reason, we apply panel cointegration tests (Johansen, 1988; Pedroni, 1999) on variables. However, when dealing with panel data the question of homogeneity arises. In order to investigate the existence of one or more cointegrated vectors we apply several tests. First, we use Pedroni's (1999) unit root panel version of the ADF statistic. Second, we use Kao test (Kao, 1999) based on Engle–Granger methodology and, finally, we apply a Johansen test in the context of panel unit roots, which we apply to estimated residuals from long run relations. This technique, which is based on the full system estimation can eliminate the simultaneous equation bias and raise efficiency by allowing the interaction in the determination of the relevant economic variables. There are two statistics from the Johansen test that determine the rank of the cointegration space. One is the value of the likelihood ratio (LR) test based on the maximum eigenvalue (λ_{max}) of the stochastic matrix. The other is the value of the LR test based on the trace of the stochastic matrix (λ_{trace}).

Table 3 presents the panel cointegration tests. It is clear that the null hypothesis of no cointegration is rejected at 1% level according to the employed cointegration tests. In particular, by employing the Fisher test, (Johansen, 1992; Maddala & Wu, 1999), it is evident that there is one cointegrating vector at the 1% level. In other words, the relevant test confirms the existence of a long-run relationship among the two separate groups of variables.

Table 4
Static estimations.

Control variables **Panel A – OLS**	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	0.76 (0.63)	0.57 (0.47)	13.97* (13.43)	13.60* (12.98)
GDP	−1.14* (−12.07)	−1.13* (−11.90)	−0.77* (−7.45)	−0.76* (−7.34)
RRI	−0.20** (−2.06)	−0.001 (−0.01)	−0.20** (−2.03)	0.02 (0.10)
PAT	0.49* (19.61)	0.47 (17.42)	0.53* (20.37)	0.50* (18.02)
POP	−0.10* (−2.95)	−0.11* (−3.14)	−0.11* (−3.20)	−0.12* (−3.46)
LAB	1.09* (26.48)	1.08* (25.87)	–	–
T	0.09* (14.73)	0.09* (12.41)	0.09* (13.90)	0.09* (11.73)
UNIT	–	–	−1.09* (−24.83)	−1.08* (−24.31)
PRIV	–	0.38* (2.45)	–	0.45* (2.82)
TPA	–	0.15 (0.86)	–	0.21 (1.20)
WHOL	–	0.06 (0.35)	–	0.02 (0.10)
Diagnostics/testing				
Observations	796	796	782	782
Adjusted R^2	0.61	0.61	0.58	0.59
S.E of regression	1.20	1.19	1.24	1.23
F-statistic	204.44* [0.00]	137.59* [0.00]	184.72* [0.00]	125.10* [0.00]
Durbin–Watson	0.43	0.43	0.41	0.42
Panel B – fixed effects				
Intercept	−47.70* (−13.51)	0.57 (0.45)	−38.61* (−10.96)	−16.47* (−4.80)
GDP	3.40* (8.77)	−1.13* (−11.51)	3.87* (10.50)	2.44* (7.44)
RRI	−0.26* (−2.92)	−0.002 (−0.01)	−0.24* (−2.67)	−0.34* (−3.34)
PAT	0.08 (1.14)	0.47* (18.69)	0.11*** (1.50)	−0.10*** (−1.73)
POP	2.17* (4.22)	−0.11* (−4.03)	2.25* (4.56)	0.06 (0.13)
LAB	0.90* (22.33)	1.08* (34.14)	–	–
T	–	0.09* (11.08)	–	0.10* (10.41)
UNIT	–	–	−0.96* (−22.40)	−1.00* (−27.00)
PRIV	–	0.38* (3.00)	–	0.27*** (1.60)
TPA	–	0.15 (0.94)	–	0.05 (0.45)
WHOL	–	0.06 (0.37)	–	0.08 (0.63)
Diagnostics/testing				
Observations	796	796	782	782
Adjusted R^2	0.79	0.61	0.80	0.88
S.E of regression	0.88	1.20	0.87	0.79
F-statistic	87.02* [0.00]	137.59 [0.00]	91.33* [0.00]	148.98* [0.00]
Durbin–Watson	0.79	0.43	0.83	0.97

Note: OLS = Ordinary Least Squares, PGLS_FE = Panel Generalized Least Squares with Fixed Effects. Figures in parentheses denote *t*-ratios, while figures in square brackets are the reported *p*-values. Significant at

* 1%.
** 5%.
*** 10%.

5.2 Static model results

Table 4 depicts the empirical results of the two static models (OLS and fixed effects model). It is evident that the fixed effects model (Panel B) clearly dominates the OLS model (Panel A) as shown from the reported standard errors of regression. Further, all the equations have very low Durbin–Watson statistics which suggest that *t*-values may be upward biased.

An increase in the level of economic growth (GDP/capita) leads to an increase in the per capita FDIs in nearly all of the specifications of the fixed effects model. The relevant magnitude ranges from 2.44 to 3.87. This outcome highlights the strong and statistically significant relationship between the level of economic growth and the investment activity (known as the "*accelerator effect*"). The positive relationship can be explained by the fact that as GDP per capita rises due to economic growth, company sales, cash flows, and profits rise too. Expectations of higher future profits and increased business confidence encourage companies to increase output and investment activity.

Regulation as measured by the OECD regulatory reform index (RRI) is found to be statistically significant in nearly all of the specifications (columns 1, 3 and 4). This result indicates that a better regulatory environment in the electricity sector is definitely associated with the increase of the FDIs. The sign of this variable is negative revealing that an increase in the relevant index, meaning that the regulatory environment in the OECD countries is getting worse, leads to a recession in the level of foreign investment activity. In other words, the existence of a more deregulated electricity market, in which case the value of RRI is small, reduces the barriers to entry (i.e. economies of scale, sunk cost, etc.) and therefore the level of foreign investment activity. Similarly, a decrease in the RRI, by implementing effective regulatory measures in the OECD countries, is related to an increase in the level of FDIs. This is explained by the fact that investors are usually looking for a stable environment where investments are insulated from arbitrary administrative action, sudden shifts in policy or market conditions. The relevant coefficient lies within the range of −0.24 to −0.34. This finding is not confirmed by other empirical studies. In particular, Cubbin and Stern (2006) explore the relationship between the private investment in electricity generation and the level of sector regulatory performance in nine Latin American countries. They find no significant positive effect of any of the regulatory governance measures on private electricity generation investment in the sample countries. This finding could be attributed to the different methodology applied in estimating the regulatory governance index.

It is worth mentioning that utilities such as electricity, water supply, telecommunications networks and certain modes of transport like rail all include natural monopoly characteristics arising from pervasive economies of scale and scope. These characteristics mean that competition is unlikely to develop, or if it develops it will be uneconomic because of the duplication of assets. In order to prevent this result, the standard approach of policy making from governments is to develop strong regulatory capabilities so that they can police the revenues and costs of production of the privatized utility firms and protect consumers from anticompetitive practices (Acemoglu & Robinson, 2013; Borenstein, 2002; Mulligan & Tsui, 2008). At the same time, there needs to be commitment on the part of government to the regulatory rules to establish credibility on the part of the investors that the regulatory rules will bring about the intended outcome. Where regulatory credibility is weak or absent, private investment decisions will be adversely affected. Hence, in network utilities where not only price but also quality matters, pure price regulation, in general, does not yield overall desirable outcomes (see for example Armstrong & Sappington, 2006; Bergantino, De Villemeur & Vinella, 2011·; Sappington, 2005). In these markets, where firms are usually subject to a price cap regulation[8], they are induced to cut costs, which may translate into lack of quality provision (Bergantino et al., 2011). Among the various quality aspects that might suffer from this type of regulation, most important seems to be service reliability in the form of reaction lags and supply interruptions (Crampes & Moreaux, 2001; Crew & Parker, 2006). Therefore, a crucial element in designing an effective regulatory scheme in the electricity market is related with the quality of regulation and the difficulties that are encountered in establishing a regulatory regime that is credible to private market actors, in particular to potential investors.

Further, the number of patents (PAT) has a positive and statistically significant relationship on the FDIs in nearly all of the specifications. The relevant elasticities range from 0.11 to 0.47 indicating that in the long-run, each unit increase in the number of patents increases per capita FDI by 11–47%. The population density (POP) has a positive and (highly) statistically significant effect in two specifications (columns 1 and 3). Similarly, labor productivity per person employed (LAB) is one of the key drivers that boost the level of FDIs in the OECD countries. The relevant elasticities range from 0.90 to 1.08 showing a small variation. The positive impact of the labor productivity on the FDIs could be attributed to the technology transfer and the spillovers since the increase in the labor productivity should occur, if the foreign companies have better productivity themselves and if they are able to transfer it to the local companies under the condition that local companies also have the ability to assimilate these spillovers. On the other hand, unit labor cost (UNIT) mitigates the increase in the foreign investment activity since the relevant elasticities are negative and statistically significant in all of the specifications (−0.96 and −1.00 respectively). This finding is confirmed by the empirical data showing that countries with increased unit labor cost such as Mexico and Hungary have low level of per capita FDI (see Fig. 1). Finally, the coefficient on the time trend is positive and statistically significant denoting that technological development boosts FDIs.

[8] Price cap and rate of return regulation are two major forms or regulation. Price cap regulation adjusts the operator's prices according to the retail price index (RPI) minus the expected efficiency savings (X), while in the rate of return regulation, the monopoly firms should be required to charge the price that would prevail in a competitive market, which is equal to efficient costs of production plus a market-determined rate of return on capital. Rate-of-return regulation was dominant in the USA for many years.

Privatization in the electricity sector is positively associated with investment activity since the relevant coefficients are positive and statistically significant. The sign of the estimated coefficients denotes that an increase in the Privatization policies (i.e. divestiture of state owned operators, selling of government minority shares in PTOs) will increase the per capita FDI. This means that the transfer of the ownership of the vertically integrated state-owned utilities into a more competitive and privatized schemes increases the investment activity of the stake holders, generating multiple effects in the economic growth of the host country. This finding is in alignment with similar studies (see for example Bergara, Henisz & Spiller, 1997), who argue that proper incentive regulation and competitive wholesale markets can help ensure that private sector investment does flow.

Competition in the electricity sector as expressed by its proxy dummy variable (WHOL) showing the presence of a liberalized wholesale market seems to leave unaffected the foreign direct investment activity since the relevant coefficients which come with a positive sign are not statistically significant. This finding could be attributed to the fact that price competition (‘a la Bertrand) is likely to reduce the returns on investment. Given the magnitude and the existence of sunk cost in the electricity sector, in tandem with the high risk investment power plants, diminished returns could greatly encourage the disinvestment. However, the final effect on FDIs depends on a number of market parameters such as the interaction between incumbents and entrants, the nature of pre-entry and post-entry regulation and the industry structure of the sector. Similarly, the dummy variable representing the terms and conditions of third party access to the electricity transmission grid (TPA) does not affect the level of per capita FDI since the relevant coefficients in all of the specifications are not statistically significant. These results are in alignment with the ones reported by Cubbin and Stern (2006) confirming the failure to find any statistically significant relationship between the competition proxy variables and the level of per capita electricity generation capacity.

Table 5
Dynamic estimations.

Control variables **Panel A – GMM**	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	0.59 (0.52)	0.23 (0.22)	4.01*** (1.89)	1.92 (1.28)
FDI(−1)	0.87* (19.05)	0.89* (10.27)	0.70* (5.07)	0.86* (10.34)
GDP	−0.14*** (−1.41)	−0.07 (−0.43)	−0.24*** (−1.55)	−0.07 (−0.53)
RRI	−0.003** (−1.94)	−0.38 (−1.46)	−0.02** (−2.05)	−0.33 (−1.28)
PAT	0.07** (2.14)	0.08 (1.31)	0.17** (2.02)	0.10** (1.77)
POP	−0.01 (−0.58)	−0.02 (−0.77)	−0.04 (−1.05)	−0.02 (−0.63)
LAB	0.09*** (1.42)	0.10 (0.96)	–	–
T	0.01*** (1.54)	0.02 (1.14)	0.03*** (1.44)	0.01 (0.79)
UNIT	–	–	−0.29*** (−1.76)	−0.12*** (−1.36)
PRIV	–	−0.27 (−0.81)	–	−0.37 (−1.23)
TPA	–	0.20 (0.48)	–	0.21 (0.52)
WHOL	–	−0.83 (−1.10)	–	−0.57 (−0.76)
Diagnostics/testing				
Observations	682	713	671	696
Adjusted R^2	0.83	0.82	0.83	0.82
S.E of regression	0.73	0.76	0.73	0.75
J-statistic	15.68 [0.21]	11.11 [0.49]	12.57 [0.83]	16.43 [0.58]
Panel B – DIF-GMM				
FDI(−1)	0.32* (15.99)	n/a	0.33* (15.16)	n/a
GDP	0.37 (0.30)	n/a	0.93 (1.02)	n/a
RRI	0.71 (1.05)	n/a	0.40 (0.59)	n/a
PAT	−0.13* (−2.48)	n/a	−0.12** (−2.34)	n/a
POP	1.70 (1.31)	n/a	1.38 (1.14)	n/a
LAB	0.79* (4.00)	n/a	–	n/a
T	0.10** (2.01)	n/a	0.08** (2.46)	n/a
UNIT	–	n/a	−0.77* (−4.51)	n/a
PRIV	–	n/a	–	n/a
TPA	–	n/a	–	n/a
WHOL	–	n/a	–	n/a
Diagnostics/testing				
Observations	736	n/a	726	n/a
S.E of regression	0.89	n/a	0.90	n/a
J-statistic	24.76 [0.36]	n/a	25.55 [0.32]	n/a

Note: GMM = Generalized Method of Moments, DIF-GMM = Difference GMM. Figures in parentheses denote *t*-ratios, while figures in square brackets are the reported *p*-values. Significant at

* 1%.

** 5%.

*** 10%.

The estimated equations appear to be well behaved to the diagnostic tests. The adjusted R-square exceeds in the most cases the value of 0.60 denoting that variation in the dependent variable is well captured by variations in the explanatory variables. The F-statistic of the joint significance of all the explanatory variables is rejected at 1% level of significance in all of the four models indicating that the control variables are valid.

5.3.2 Dynamic model results

In Table 5 below, we report our estimates of some relatively simple dynamic models. Panel A reposts the results of the model for per capita FDI, but adding a lagged dependent variable, which is estimated by applying the GMM, whereas Panel B presents our findings by applying the DIF-GMM. Comparing the two methodologies, it is evident that the (simple) GMM estimation (Panel A) is the most appropriate model since it has lower standard error of regression than the DIF-GMM in all of the specifications.

As it may be seen, the empirical evidence in favor of the electricity regulatory effect on the FDIs' activity does not change when employing GMM. This result shows that the liberalization of the electricity sector in the OECD countries is a significant prerequisite for the enhancement of the FDIs' activity. In particular, specifically, the estimated coefficients on the regulatory index are negative (−0.003 and −0.02 respectively) and statistically significant different from zero at the 5% level in two specifications (columns 1 and 3). This means that, in the long-run, each unit decrease in the regulatory governance index increases per capita FDIs so that a country with the worst regulatory governance practice and an index score of 6 could expect to have 1.8–12% lower per capita FDIs.

The number of patents (PAT) has a positive and statistically significant effect on the per capita FDI in nearly all of the specifications. The relevant elasticities range from 0.07 to 0.17. The population density (POP) has a negative and statistically insignificant effect in all of the specifications, while labor productivity per person employed (LAB) is confirmed as one of the key drivers boosting the level of FDIs. The relevant magnitude equals to 0.09, implying that a 100% increase in the labor productivity will lead to a 9% increase in the per capita FDI. On the contrary, unit labor cost (UNIT) mitigates the increase in

Table 6
Granger causality results.

Control variables	(1) OLS	(2) PGLS_FE	(3) GMM	(4) DIF-GMM
Panel A – Dependent variable FDI				
Intercept	0.76* (5.76)	1.19* (5.86)	3.84 (0.81)	–
FDI(−1)	0.63* (17.79)	0.61* (12.43)	2.15** (2.15)	0.49* (41.63)
FDI(−2)	0.28* (8.07)	0.24* (5.02)	−1.66 (−1.12)	0.17* (24.67)
RRI(−1)	−0.13 (−0.67)	−0.12 (−0.86)	−1.19 (−0.91)	−0.43 (−0.75)
RRI(−2)	0.04 (0.19)	−0.03 (−0.19)	0.57 (0.80)	0.38 (0.41)
$\sum(RRI)$	−0.09	−1.05	−0.63	−0.05
Diagnostics and testing				
Observations	771	771	654	741
S.E of regression	0.75	0.74	1.55	0.98
Adjusted R-squared	0.85	0.88	0.32	n/a
F-statistic	1066.78* [0.00]	176.04* [0.00]	n/a	n/a
Wald test $\{H_0\ \beta_1=\beta_2=0\}$	3.58 [0.17]	9.79* [0.00]	0.84 [0.65]	2.71 [0.26]
Wald test $\{H_0\ \beta_1+\beta_2=0\}$	2.59 [0.11]	8.53 [0.00]	0.60 [0.43]	0.02 [0.89]
J-statistic	n/a	n/a	1.51 [0.99]	27.77 [0.37]
Panel B – Dependent variable RRI				
Intercept	−0.08* (−2.98)	−0.04 (−1.13)	0.46 (0.85)	–
RRI(−1)	1.05* (28.23)	1.10* (16.61)	2.62** (1.87)	0.88* (505.54)
RRI(−2)	−0.002 (−0.04)	−0.07 (−0.99)	−1.84 (−1.13)	0.07* (59.57)
FDI(−1)	−0.01** (−1.97)	−0.01* (−3.79)	−0.04*** (−1.61)	−0.04* (−2.69)
FDI(−2)	0.01 (1.17)	0.003 (1.29)	0.02 (1.03)	−0.03* (−3.05)
$\sum(FDI)$	−0.01	−0.01	−0.02	−0.07
Diagnostics and testing				
Observations	769	769	667	739
S.E of regression	0.15	0.14	0.29	0.19
Adjusted R-squared	0.93	0.96	0.74	n/a
F-statistic	2702.76* [0.00]	581.23* [0.00]	n/a	n/a
Wald test $\{H_0\ \beta_1=\beta_2=0\}$	6.30** [0.04]	27.77* [0.00]	2.60 [0.27]	15.19* [0.00]
Wald test $\{H_0\ \beta_1+\beta_2=0\}$	4.04** [0.04]	21.92* [0.00]	0.72 [0.39]	8.14* [0.00]
J-statistic	n/a	n/a	0.15 [0.99]	34.77 [0.18]

Note: OLS=Ordinary Least Squares, PGLS_FE=Panel Generalized Least Squares with Fixed Effects, GMM=Generalized Method of Moments, DIF-GMM=Difference GMM. Figures in parentheses denote t-ratios. Figures in square brackets denote p-values. The use of the fixed effects specification is justified after a Hausman test for each model. J-statistic is a Sargan/Hansen test of the over-identifying restrictions for the GMM estimators. Significant at

* 1%.

** 5%.

*** 10%.

the foreign investment activity since the relevant elasticities are negative and statistically significant in all of the specifications (−0.12 and −0.29 respectively).

The coefficient on the time trend is positive and statistically significant in two specifications (columns 1 and 3) confirming the positive effect of technology on the level of FDIs. It is interesting to highlight that Privatization (PRIV) is negatively and statistically insignificant associated with the level of foreign investment activity. Similarly, with the static model results, and in alignment with other studies reported previously, we failed to find any statistically significant relationship between the competition level and the FDIs.

Finally, the *J*-test, known as the Sargan test of over-indentifying restrictions, is used to test the null of $E(\varepsilon_{it}/Z_{it})=0$. The *J*-test follows asymptotically the Chi-square distribution. The *p*-values of *J*-test statistics show that the null hypothesis is not rejected leading to the conclusion that the instrumental variables are exogenous, and thus, appropriately chosen in all of the specifications.

5.3.3 Causality testing

Table 6 reports the results of the Granger causality tests. In the first set of estimations (Panel A), the level of FDIs is estimated as a function of first and second order lagged FDIs and lagged electricity regulation as measured by the relevant index described above (RRI). Panel A shows that the first and second lags of FDIs are statistically significant different from zero, indicating that FDIs at time *t* are influenced by previous years' FDIs. In contrast, the coefficients of the electricity regulation variable at the first and second levels, respectively, are not statistically significant in all of the four specifications.

From the Wald test it is evident that the null hypothesis of no-causation is rejected in nearly all of the specifications (columns 1, 3 and 4). However, in the fixed effects model (column 2) the relevant hypothesis is rejected at 1% level of significance implying that effective regulation in the electricity sector does Granger cause the level of FDIs in the OECD countries. It is worth mentioning that the sign of the causal relationship is negative, denoting that a decrease (better regulatory environment) in the electricity regulatory index, Granger-causes an increase in the level of FDIs and vice versa. We must bear in mind that the fixed effects model is superior to other three model specifications as shown by the high adjusted *R*-squared and the small standard error of estimate for the regressions.

In Panel B the results for the causality running from FDIs to regulatory environment are reported. In particular, the significance of the coefficients for the first lag suggests that the dependent variable (RRI) is affected significantly by previous years' regulation. However, we cannot reach the same conclusion when testing the significance of the second lagged regulation levels since the relevant coefficients, albeit negative in most of the cases, are not statistically different from zero, implying that electricity regulation at time *t* is only influenced by previous year's level of regulatory performance. Further, the level of effective regulation at time *t* is influenced by the previous year's level of FDIs since the relevant coefficients are statistically significant in all of the four specifications.

From the Wald testing it is clear that the null hypothesis is rejected in nearly all of the specifications (columns 1, 2 and 4). The sign of the causal relationship is negative, denoting that an increase in the level of FDIs does Granger cause a decrease in the RRI implying a better regulatory environment. This means that increases in FDIs precedes decreases in the level of RRI resulting to a better regulation level. However, we shall bear in mind that Granger causality does not constitute causality in the economic sense (Greene, 2003).

To sum up, our results give further evidence that effective regulation in the electricity sector may have a positive effect on the attraction of FDIs in the OECD region. Indeed our results of the two way (negative) Granger type causation do provide support that there is a significant linkage between the regulatory performance of the electricity sector and the level of FDIs.

6. Conclusion

This is a first attempt to investigate the relationship between electricity regulation and FDIs within the OECD countries, by using panel data econometric techniques. For this purpose, we use a data set covering the period 1975–2010. Our analysis reveals that there is a significant linkage between effective electricity regulation and FDIs. Further, we find a two-way Granger type causation between FDIs and effective regulation in the electricity sector, providing sufficient evidence that a better regulatory environment is a prerequisite for increases in the level of FDIs. Our results seem to be quite robust when we apply dynamic panel data analysis. This finding highlights the existence of a sound regulatory environment in the electricity sector, implying that a liberalized and competitive electricity sector is one of the main elements in order to attract FDIs.

Given their strategic role in supporting growth as well as their technical characteristics, electricity and similar industries are among those most in need of strong and effective regulatory frameworks. The message for policy makers and government officials is that effective regulation by the national regulatory authorities to foster competition in the electricity sector helps to achieve one of the policy goals set out in the Electricity Community Directives that is the encouraging of the investment. This can be implemented by pursuing policies targeting at the removal of entry barriers in the electricity sector and lifting the restrictions that impede competition in all of its segments.

Despite great contribution, this research has a few limitations, which we acknowledge. To begin with, the sample is composed of OECD countries. An analysis using more disaggregated firm level data (i.e., cost of capital, mergers and acquisitions, company performance, etc.) may enrich our findings. Given the validity of the econometric results, the regulatory reform index may be improved with the addition of new parameters especially those regarding price formulation. Further, as more information and data become available, especially at the firm level, and more companies enter the electricity sector, more in-depth analysis can be constructed in order to examine aspects that are not covered by the OECD database, since the latter does not include information from all the new smaller entrants. Such a consideration will better capture the competitive dynamism of the electricity sector and can lead the research to further outcomes concerning consumer protection policies.

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