Is energy market integration a green light for FDI?*

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Abstract

This paper contributes to a better understanding of the effects of the European single market strategy by studying the effect of energy market integration (EMI) on foreign direct investment (FDI). Enforcing an EMI diminishes energy uncertainty and price volatility and signals stronger and credible institutions. FDI may, as a result, increase both within and outside the EMI area through two channels: first, via energy price converge and, second, via price dispersion reduction. We develop a formal model to explain how these mechanisms affect the capital invested abroad by heterogeneous firms. The Iberian Electricity Market (MIBEL) integration of 2007 is used to quantify the effect of EMI on FDI empirically. Gravity estimates on a global dataset including bilateral FDI data show that the integration of Portugal and Spain's electricity market increased both the amount of FDI's participants and the number of foreign projects. In line with our theoretical expectations, our estimates show that the increase of FDI is mainly due to the reduction in price dispersion. However, the institutional credibility signal sent by MIBEL had a greater influence than expected by the actual price reduction. Furthermore, we also observe a positive increase in FDI from neighboring countries (in this instance, France), albeit lower in magnitude. **JEL Classification:** F20, F21, F23, Q40, Q43

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1 Introduction

On 28 October 2015, the European Commission presented a new Single Market Strategy aimed to reduce physical, legal and fiscal barriers between Member States in order to achieve the free movement of goods, services, capital and labour in the European Union (EU). Electricity, as a good, forms part of this free movement being promoted by the single market. The creation of an internal electricity market is expected to increase competition as a result of major interconnection capacity and hence a reduction of concentration at national and regional levels. Actors in an integrated energy market purchase electricity on an equal basis. The single energy market improves the security of supply. In an integrated market, efficiency is enhanced by greater interconnection, because the increase in resource availability reduces the need for spare capacity. The lower level of spare capacity for each country leads to less costly power plants and to the use of cheaper infra-marginal power plants available at times of peak demand.

The harmonisation of energy prices and a higher quality of service are some of the expected outcomes of a single energy market (Correlje and Van der Linde, 2006; Glachant, 2009). Additionally, a fully-integrated internal energy market, where providers freely compete and provide the best energy prices is expected to increase Europe's renewable energy potential (European Commission, 2015b). Energy Market Integration (EMI), as such, has a number of economic impacts (Mahlberg and Url, 2003); not least on foreign direct investment (FDI). This link between energy and FDI is well documented in the literature. Herrerias et al. (2013) show that energy intensity has an effect on FDI across the Chinese provinces. More recently, Herrerias et al. (2015) report that energy intensity impacts foreign innovation. The empirical results reported by Pao and Tsai (2011) suggest a causal link between energy consumption and FDI. Moreover, energy and FDI raises questions related to energy supply and geopolitics (Correlje and Van der Linde, 2006). Moreover, researchers link *green* FDI (i.e. the increase of cleaner and/or more energy efficient projects through foreign technologies) with sustainable development (Chakraborty and Mukherjee, 2013; Kardos, 2014; Golub et al., 2011). Yet, despite the interest in the relationship between energy and FDI, the literature on the subject is not very extensive. Indeed, this study is, to the best of our knowledge, the first to explain formally and report empirically the effect of EMI on FDI.

In recent years the main issues addressed by energy economics scholars examining the restructuring process of Europe's electricity markets have been prices convergence (Zachmann, 2008), prices dependence (Lindstrom and Regland, 2012), integration (Bunn and Gianfreda, 2010), cross-border integration (Balaguer, 2011), and renewable energy (Rubino, 2016). The law of one price (Fetter, 1924) has been used in most studies of electricity market integration as the theoretical foundation for determining whether two geographic regions comprise a single market. Robinson (2007) studied the prices in ten European countries (Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain and the UK), and concluded that electricity prices had converged. Similarly, Armstrong and Galli (2005) analysed the four wholesale electricity markets in the EU, which operate with similar pricing processes and share borders (France, Germany, The Netherlands and Spain), and found that the average price difference decreased in almost all pairs of markets. From this, they inferred that prices in the main continental European markets were converging.

The previous literature provides indications of price convergence and stability for groups of energy markets. The work of De Jonghe et al. (2008) examining the effect of market coupling on day-ahead prices in Belgium, France and The Netherlands, shows a marked fall in price differences after the coupling. Bosco et al. (2010) conclude that average prices in the German and French markets were integrated. Likewise, Huisman and Kilic (2013) observed a similarity in the parameter estimates of the Belgian, Dutch, French, German and Nordic prices modeling, and also noted a decrease in the impact of price spikes and volatility. In addition, Bunn and Gianfreda (2010), in an analysis of price levels and volatilities, find evidence of increasing market integration between Germany, France, Spain, the Netherlands and the UK.

To create the European Electricity Market, the European Commission (EC) proposed a bottom-up regional approach to integration: starting from regional integration between countries with similar features and moving on to the integrated electricity market as a solution to boost the integration. The Nordic and the Iberian integrated markets are the first inter-country markets with recognized success. The Iberian Electricity Market (MIBEL), fully launched in July 2007, was the result of cooperation between the Portuguese and Spanish Governments with the aim of promoting the integration of both countries' electrical systems. Indeed not only the has the MIBEL made a significant contribution towards establishing an electricity market at the Iberian level, it has also been an important step in establishing an Internal Energy Market at the European level.

Having the right infrastructure in place is a precondition for completing the energy market, integrating renewables and securing supply (European Commission, 2015a). In particular, an effective interconnection is one of the main conditions for achieving a fully integrated electricity market (Jacottet, 2012; Del Monte, 2013). However, when it comes to Europe's energy networks, Spain and Portugal might be considered energy islands due to their isolation. Furthermore, transmission activities are closely related to market design and regulation (Jamasb and Pollitt, 2005). The European Network of Transmission System Operators for Electricity (ENTSO, 2015) reports that the Iberian interconnection flows are higher within the MIBEL area than with its neighbour France. This stylized fact suggests likely spillovers of EMI in the path towards a single energy market.

In line with findings in the previous research, Figure 1 shows that the Spanish and Portuguese electricity prices have converged since the creation of the integrated market MIBEL. Moreover, the volatility of electricity prices has been reduced (as shown by the gray line). These stylized facts invite us to examine the relationship between EMI and FDI in greater depth.

[Figure 1 about here.]

EMI has several potential effects on the FDI of countries that have undergone integration. First, as a result of the greater electricity price stability attributable to integration, an increase in the attractiveness for FDI among the countries within the integrated electricity market (as well as from neighbouring countries) can be expected. This effect is augmented by the positive response of FDI to stronger and more credible institutions (Ali et al., 2010).

Second, given that electricity price harmonisation involves a readjustment of relative prices resulting in greater alignment, the flow of FDI between the two countries is expected to increase. Furthermore, the increase in FDI can be expected to be higher in the country with the initially higher electricity price (an input price decrease increases the attractiveness of the country for FDI). The aim of this paper is to explain and test these effects of EMI on the FDI of the integrated countries.

To study these effects, we develop a stylized theoretical model and undertake an empirical application on a global dataset including FDI data from 190 countries for the period 2003 to 2012. This paper is, to the best of our knowledge, novel in formally incorporating energy costs in the FDI gravity equation. In short, the model includes energy as a production input in a standard setup in international economics (Melitz, 2003). Heterogeneous firms afterwards gauge capital, labour and energy costs in their decision to invest abroad. The model derives a gravity equation which incorporates bilateral energy costs with two main predictions: First, that FDI's intensive and extensive margins increase with lower bilateral energy costs. Second, the model points out how two mechanisms (price stabilization and reduction) govern the effect on FDI after joining an EMI.

Gravity estimation results show that the electricity market integration between Portugal and Spain in 2007 increased FDI between them. Our results highlight the prevalence of price stabilization mechanisms over cost reduction. However, the institutional credibility effect of EMI outweighs the cost reduction effects. The results also show that the increase in FDI flow was greater from Spain to Portugal than vice versa. This appears to confirm that the country with an initially higher electricity price obtains greater gains from the integration in terms of greenfield foreign investments. These findings seem to suggest that, in addition to the effects of energy market integration traditionally identified by academics and policy makers, electricity market integration facilitates investment flows between the integrated countries. This is of particular relevance when most of the Member States within Europe's internal electricity market have recently started operating under a single price mechanism, as they move closer to achieving the targeted integration.

This article is organized as follows. Section 2 presents the theoretical model regarding the effect of electricity market integration on FDI. Section 3 describes the empirical methodology and the data used to estimate the impact of EMI on FDI. Section 4 presents the results and discussion from our analysis. Finally, section 5 presents the conclusions.

2 The model

2.1 Foreign production

The model follows closely standard trade and FDI setups like Melitz (2003) and Helpman et al. (2008). The basic setup is a world of J countries with the assumption of a Cobb-Douglas utility function $U_j = X_{Aj}^{\mu} X_{Bj}^{1-\mu}$, for a two sector economy with goods A (non traded) and B (traded). The aggregate consumption of a good in the traded sector is $X_j = \left[\int {x_{jz}}^{\iota} dz\right]^{1/\iota}$, where $\sigma \equiv (1-\iota)^{-1} > 1$ and z is a firm. The demand is $x_{jz} = \frac{p_{zj}^{-\sigma}(1-\mu)Y_j}{P_j^{1-\sigma}}$, where price index is a CES function $P_j = \left[\int_z {p_{ijz}}^{1-\sigma} dz\right]^{1/(1-\sigma)}$.

Let firm z from country i in the traded sector produce a variety of goods. The aggregate consumption in this sector is the sum of all goods produced by N_i active monopolistic firms. Firms may attack the market by producing at home and exporting or producing the goods in country j. The standard Nerlove's production function allows for complementarity between capital, energy and labour inputs. In particular, we use a nested CES production function allowing in a first level substitution between energy and capital, which are combined with labour to produce final goods. The intuition is that firms may invest in expensive energy efficient machinery and use less energy inputs or less efficient and less expensive capital inputs and use more energy inputs for production. The production of the goods x_{iz} is given by:

$$x_{iz} = \theta \left(\mu L^{\gamma} + (1-\mu) \left[(K)^{a} (E)^{b} \right]^{\gamma} \right)^{\frac{1}{\gamma}}, \tag{1}$$

where $\theta > 1$ is an exogenous technology parameter. L, K and E are the amount of labour, capital and energy units used for production. The parameters $\gamma < 1$ and $a + b = \eta < 1$ determine factor elasticity of substitution: η determines the elasticity of substitution between energy and capital; $1/(1-\gamma)$ is the elasticity of substitution between equipment (or energy) and labour. In this specification, μ governs the labour factor shares.

Since our main focus is to study capital investments, we can simplify the production function. Let us measure labour in units so that the total amount of labour is $\bar{L} = 1$ and let assume that that our firm operates in a sector with a relative low labour intensity ($\mu \approx 0$) and with a high labour elasticity of substitution ($\gamma \approx 1$). Without losing generality, this setup turns our analysis to standard CES Cobb-Douglas production with decreasing returns.

Upon entry, the firm discovers its productivity $1/\alpha$, where α is the number of input units per input bundle used by the firm to produce one unit of output. We follow the standard assumption that the distribution of α across firms is continuous Pareto c.d.f. $G(\alpha)$ with $[\alpha^{FDI}, \alpha^{Exp}]$, where $0 < \alpha^{FDI} < \alpha^{Exp}$. The density of $G(\alpha)$ is denoted by $g(\alpha)$ and the distribution is the same across countries.

To produce a good in destination j, an i-country firm incurs in a marginal cost of:

$$\omega_{ij}^{FDI}(\alpha) \equiv \tau_{ij}\alpha(r_{ij}K + e_{ij}E) \tag{2}$$

where transaction costs $\tau_{ij} > 1$ are proportional to the distance between the countries and $\tau_{ii} = 1$. Each unit of capital comes at a cost of r_{ij}, which reflects the capital and interest costs. Each energy unit has a cost for the firm of e_{ij}, which captures energy costs of a foreign firm. The firm has a fixed cost of production f (which includes fixed labour costs) and sells its product at prices p_j. Thus, the problem maximization of the firm is:

$$\max_{K,E,L} \pi_{iz}^{FDI} = \max\{p_j\theta\left[(K)^a(E)^b\right] - \omega_{ij}(\alpha) - f_j\}. \tag{3}$$

In equilibrium the market clears and the firms determines the optimal level of capital investment and energy consumption according to the first-order conditions:

$$p_j\theta a K^{a-1}E^b = \tau_{ij}\alpha r_{ij} \tag{4a}$$

$$p_j\theta b K^a E^{b-1} = \tau_{ij}\alpha e_{ij}. \tag{4b}$$

After the labour market clears, the optimal equilibrium for capital and energy yields,

$$K^*_{ijz} = \left(\frac{p_j \theta a \sigma^b}{\tau_{ij} \alpha \left(r_{ij}\right)^{1-b} \left(e_{ij}\right)^b} \right)^{\frac{1}{1-\eta}} \tag{5a}$$

$$E^*_{ijz} = \left(\frac{p_j \theta b \sigma^{-a}}{\tau_{ij} \alpha \left(r_{ij}\right)^{a} \left(e_{ij}\right)^{1-a}} \right)^{\frac{1}{1-\eta}}, \tag{5b}$$

where $\sigma = b/a$. This parameter controls the relative intensity of each input. Energy intensive firms ($\sigma > 1$) are relatively more constrained by energy costs than they are by capital costs. Equation (5a) is effectively a gravity equation for foreign capital and shows that foreign capital investment is governed both by capital and energy costs. Foreign investment decreases with transaction costs τ_{ij}, capital costs r_j, and energy costs e_j.

An energy market integration can be seen as the convergence of energy costs on both sides of the energy border. The energy prices on both sides of the border converge to a single energy price, which is equivalent to the energy costs of both countries. Due to economies of scale and efficiency in a larger energy market, the single energy price is expected to be lower in the long run for both countries after integration. In this setup, EMI has the following effect on the foreign capital invested:

Proposition. *An energy market integration affects bilateral investment flows between the country members. Foreign direct investment increases in countries which converge to a lower energy cost after the integration.*

Proof. Let EMI energy costs in country j be a strictly decreasing concave function of time e_{ijt}. After the integration, country j converges to a lower energy cost (e_{emi})

than that prevailing before the integration (e_{j0}), that is $\lim_{t\to\infty} e_{ijt} = e_{emi} < e_{j0}$. All other things considered, the change in foreign capital invested by our firm z during the convergence is:

$$\frac{\partial K^*_{ijz}}{\partial t} = \frac{-b}{1-\eta} e'_{ijt} \left(\frac{p_j \theta a \sigma^b}{\tau_{ij} \alpha \left(r_{ij}\right)^{1-b} \left(e_{ijt}\right)^{1-a}} \right)^{\frac{1}{1-\eta}}. \tag{6}$$

The variation in capital after the integration is a strictly increasing function, ${\partial K^*_{ijz}}/{\partial t} > 0$,since $e'_{ijt} < 0$ for a strictly decreasing concave function. □

Equation 6 reveals the mechanisms by which EMI affects FDI in the short run. The effect is governed by the magnitude of the price reduction, but also by the stability mechanism e'_{ijt}. During convergence in the short run, the price variation mechanism prevails over the price magnitude. In the long run, firms reassess their foreign investment options.

2.2 Extensive margin

The firm gauges production costs to determine the productivity level at which it enters the foreign market (Melitz, 2003). Exporting firms combine inputs at home and ship the products abroad. The firm faces the following problem:

$$\max_{K,E,L} \pi^{Exp}_{iz} = \max\{p_j \theta (K)^a (E)^b - \tau_{ij} \alpha (r_i K + e_i E) - f_i\}. \tag{7}$$

As in Helpman et al. (2004), the firm engages in foreign production if $\pi_{ijz}^{FDI} > \pi_{iz}^{Exp}$. Therefore, the cut-off productivity is:

$$\alpha^* = \frac{f_i - f_j}{\tau_{ij}((r_{ij} - r_i)K + (e_j - e_i)E)}.$$

Only a fraction of the active firms invest in country j, from the most productive firm with α_L to least productive with $\alpha^* > \alpha_L$. In the long run $e_j - e_i = 0$, EMI removes the energy border between the two countries:

$$\alpha^*_{EMI} = \frac{f_i - f_j}{\tau_{ij}((r_{ij} - r_i)K)}. \tag{8}$$

Firms no longer consider energy costs a constraint on their decision to invest (i.e., the extensive margin). For similar fixed costs, the capital threshold for investing abroad is governed by the differential wage to interest ratio in both countries. Additionally we expect a positive effect on the number of firms investing since EMI relaxes the investment threshold ($\alpha^*_{EMI} > \alpha^*$).

2.3 Multiple firms

Aggregating across firms, we obtain the aggregate capital investment:

$$\begin{aligned} F\tilde{D}I_{ij} = N_i \int_{\alpha_L}^{\alpha^*_{EMI}} K^*_{ijz} \frac{g(\alpha)}{G(\alpha^*_{EMI})} d\alpha = \\ = N_i \rho \left(\frac{p_j \theta a \sigma^b}{\tau_{ij} \left(r_j\right)^{1-b} \left(e_{j0}\right)^b} \right)^{\frac{1}{1-\mu}} \int_{\alpha_L}^{\alpha^*_{EMI}} \alpha^{\frac{1}{\mu-1}} \frac{g(\alpha)}{G(\alpha^*_{EMI})} d\alpha, \end{aligned} \tag{9}$$

where $\rho = (e_{j0}/e_{emi})^{\frac{b}{1-\mu}} > 1$ is the energy cost markdown after the integration.

We can re-write equation (9) as follows:

$$\tilde{FDI} = N_i K(\alpha_L) V_{ij}, \tag{10}$$

where

$$V_{ij} \equiv \int_{\alpha_L}^{\alpha^*_{EMI}} \left(\frac{\alpha}{\alpha_L}\right)^{\frac{1}{\mu-1}} \frac{g(\alpha)}{G(\alpha^*_{EMI})} d\alpha., \tag{11}$$

and

$$K(\alpha_L) = \rho \left(\frac{p_j \theta a \sigma^b}{\tau_{ij} \alpha_L (r_j)^{1-b} (e_{j0})^b}\right)^{\frac{1}{1-\mu}}, \tag{12}$$

captures the investment of the most productive firm.

Earlier we assumed that $1/a$ follows a Pareto distribution. We define $G(\alpha) = \frac{\alpha^\kappa - \alpha_L^\kappa}{\alpha^\kappa_{EMI} - \alpha_L^\kappa}$, with $\kappa > \frac{1}{1-\mu}$. Therefore, we can re-write V_{ij} in (11) as:

$$V_{ij} = \frac{\kappa}{\kappa - \frac{1}{1-\mu}} W_{ij}, \tag{13}$$

where$W_{ij} \equiv \max \left\{ \frac{\left(\frac{\alpha^*_{EMI}}{\alpha_L}\right)^{\kappa - \frac{1}{1-\mu}} - 1}{\left(\frac{\alpha^*_{EMI}}{\alpha_L}\right)^{\kappa} - 1}, 0 \right\}$ selects which firms engage in FDI. W_{ij}, is controlled by the cut-off variable α^*_{EMI} in (8). Using this expression, we can obtain a log-linear and estimable equation from (10):

$$fdi_{ij} = \theta_0 + n_i + \frac{1}{1-\mu} p_j - \frac{1-b}{1-\mu} r_{ij} - \frac{1}{1-\mu} \ln \tau_{ij} - \frac{b}{1-\mu} e_{ij} + w_{ij}, \tag{14}$$

where lowercase variables are the natural log of the uppercase. θ_0 is a constant that bundles the rest of parameters. Using a standard parametrization for the transfer cost:

$$\frac{1}{1-\mu}\ln\tau_{ij} = \zeta d_{ij} - u_{ij}, \tag{15}$$

where d_{ij} is the log of bilateral distance between countries, and $u_{ij} \sim N(0, \sigma_u^2)$ is an unobserved i.i.d investment friction. Recurring to standard notation we can obtain an empirical gravity-like equation:

$$fdi_{ij} = \theta_0 + n_i + s_j - \zeta d_{ij} - \zeta(1-b)r_{ij} - \zeta b e_{ij} + w_{ij} + u_{ij}, \tag{16}$$

where n_i and $s_j \equiv \frac{1}{1-\mu}p_j$ are the fixed country supply and demand masses.

In sum, we have derived a gravity equation for multiple heterogeneous which incorporates bilateral energy costs with the following predictions:

1. Reducing bilateral energy costs increases FDI in the intensive and extensive margins

2. Energy costs convergence of EMI increases FDI following two mechanisms:

    (a) Cost reduction via price difference converge and

    (b) Prize stabilization via variance reduction (which prevails in the short run).

In the next section we describe the estimation procedure to quantify these effects, which focuses on the estimation of ζb, which represents the bilateral energy costs.

3 Empirical methodology and data

The goal of this section is to describe the empirical methodology for estimating the impact of EMI on FDI. Our model presents a gravity-like equation for foreign capital investments. In equation (16), the capital invested by foreign firms (i.e., foreign direct investment or FDI) increases with demand (prices) and decreases with distance (transaction costs), financial costs (interest rates) and energy costs (energy prices). The most appropriate methodology for measuring the impact of EMI on FDI is, therefore, the gravity equation. Gravity for FDI is grounded in theory (Bergstrand and Egger, 2007; Portes and Rey, 2005; Kleinert and Toubal, 2010) and, consequently, provides an adequate empirical technique for estimating the effect of EMI unequivocally.

Our baseline specification is the following augmented gravity equation:

$$\begin{aligned} lnFDI_{ijt} = \beta_1 \ln(Y_{it} * Y_{jt}) + \beta_2 \ln(D_{ij}) + \beta_3 border_{ij} + \beta_4 colony_{ij} + \beta_5 lang_{ij} + \\ \beta_6 smctry_{ij} + \beta_7 rel_{ij} + \beta_8 locked_{ij} + \beta_{10} BIT_{ijt} + \beta_{11} FTA_{ijt} + \beta_{12} crisis_{ijt} + \\ \beta_{13} Pricediff_{ijt} + \rho_2 PriceSD_{ijt} + \lambda_t + \lambda_i + \lambda_j + u_{ijt}, \quad (17) \end{aligned}$$

where FDI_{ijt} is the aggregate investment, and total number of investments, between home country i and host j in year t. The equation measures market demand through a number of variables; Y denotes the domestic gross product (GDP); D is the distance in kilometers between countries; *border* takes a value of one when the countries share a common border and zero otherwise; *colony* is set at 1 if the two countries have ever had a colonial link; *lang* (Common language) takes a value of 1 if both countries share the same official language; *smctry* (Same country) is a dummy that indicates whether both countries where part of the same country in the past; *rel* (Religion) is a composite index which measures the religious affinity between country pairs with values ranging from zero to one; and *locked* is the number of landlocked countries (0,1 or 2). *BIT* (Bilateral Investment Treaty) is a dummy that takes a value of one if the country pair has a bilateral investment treaty in force; *FTA* (Free Trade Agreement) is a dummy that indicates whether both countries have a free trade agreement in force. The dummy variable *crisis* is the number of countries in the pair (0,1,2) with credit constraints during year t. This variable captures the impact of financial frictions. *Pricediff* is the difference in electricity prices between Portugal and Spain. This variable captures the effect of a reduction in the difference in prices. *PriceSD* is the standard deviation of the price difference and captures the price stability mechanisms proposed by the model. The baseline specification includes a full set of country and time fixed effects (λ). Lastly u_{ijt} represents a stochastic error term.

The baseline gravity equation (17) suffers from several biases. In the first instance, theoretical developments of the gravity equation show that the benchmark equation is mis-specified due to the omission of time-varying multilateral resistance terms. Secondly, the log version of the gravity equation has a self-selection bias, which stems from the omission of zeros. Thirdly, the estimation of FDI capital expenditure flows suffers a potential over-aggregation bias. To combat theses biases, we adopt different empirical strategies.

As in Helpman et al. (2008) (HMR), we define the first stage as a probit estimation:

$$\begin{aligned}\varrho_{ijt} &= Pr(T_{ijt} = 1|\text{Observed variables}) \\ &= \Phi(\lambda_i, \lambda_j, \lambda_t, Z_{ijt}, \eta_{ijt}) \end{aligned} \tag{18}$$

where T_{ijt} takes a value of 1 when country i invests in country j in year t and zero if the value is zero , $\Phi(.)$ is the cumulative normal standard distribution function, λ are the fixed effects for host and home countries and year and Z_{ijt} are the usual gravity variables. The error term, which is correlated with the error term of gravity equation is noted as η_{ijt}.

The second step runs a log-likelihood maximization estimation and includes variables control that for non-random firm selection (zeros) and firm heterogeneity[1]:

$$lnFDI_{ijt} = \beta Z_{ijt} + \lambda_i + \lambda_j + \lambda_t + \hat{\bar{w}}(\kappa) + \theta\hat{\bar{\eta}}_{ijt} + v_{ijt} \tag{19}$$

where $\hat{\bar{\eta}}^*_{ijt} = \phi(\hat{z}_{ijt})/\Phi(\hat{z}_{ijt})$ is the inverse Mills ratio and $\hat{z}^*_{ijt} = \Phi^{-1}(\hat{\varrho}_{ijt})$. The probabilities obtained in the first probit step of equation (18) are denoted $\hat{\varrho}_{ijt}$ and $\phi(.)$ is the standard normal density function[2]. The parameter which affects both firm selection and firm heterogeneity is defined as $w(\kappa) = \ln\left\{\exp\left[\kappa_1(\hat{z}^*_{ijt} + \hat{\bar{\rho}}^*_{ijt})\right] - 1\right\}$,where κ is the parameter obtained from W_{ij} in (13).

Additionally, Silva and Tenreyro (2015) show that HMR imposes too strict home-

[1]For identification, this step exclude variables which affect the probability of trade or FDI but not its volume. HMR proposes to drop religion.

[2]Following HMR, some dyads are such that their probability of investment indistinguishable from 1. The inverse Mills ratio would be undefined for predicted probabilities close to 1, therefore all probabilities >0.9999999 are converted to equal 0.9999999.

cedastic restrictions on the error term, which are hardly present in FDI or trade data. Alternatively, the authors show that the simpler PPML method yields similar results as the two-step procedure. To overcome this caveat, we use a non-linear variant of the gravity equation in line with that proposed by Silva and Tenreyro (2006), which does not require a log-linearization of the variables:

$$FDI_{ijt} = exp\left(Z_{ijt} + \beta_{13}Pricediff_{ijt} + \beta_{14}PriceSD_{ijt} + \lambda_t + \lambda_i + \lambda_j\right) + \varepsilon_{ijt} \quad (20)$$

We apply Pseudo-Poisson Maximum likelihood (PPML) to estimate (20). PPML offers additional advantages to the log-linear specification. First, it is robust to heteroskedascity in the error term (Silva and Tenreyro, 2010). Second, it ensures the convergence of the maximum likelihood estimation by prior inspection of the data (Silva and Tenreyro, 2011). Additionally, Baltagi et al. (2014) claim that the PPML estimator is appropriate for panel gravity data.

Since Anderson and Van Wincoop's (2003) seminal solution to McCallum's (1995) border puzzle, multilateral resistance has been standard in all gravity specifications, including gravity estimates of bilateral FDI (Anderson, 2011). Multilateral resistance is commonly interpreted as the home incidence of transaction costs from origin i and the host incidence from destination j. The home and host incidence measures are usefully explained as the incidence of Total Factor Productivity (TFP) frictions. Therefore, multilateral resistance varies substantially by country because of changing expenditure and supply shares (Anderson and Yotov, 2010). TFP may vary with time in each country, thus Baldwin and Taglioni (2006) note that country fixed effects (CFE) are more appropriate in cross-sectional data. To capture dynamic TFP, the gravity equation is accompanied with the interaction of time and CFE dummies (Baier and Bergstrand, 2009). The specialized literature refers to these estimates as country-year fixed effects (CYFE).

In our framework, the CYFE represents an additional gain. Independent variables which are time varying and fixed per country (i.e. GDPs, institutional quality indicators, population, market size) are perfectly controlled with CYFE. Hence, with CYFE we control unobservable country specific variables that might affect the aforementioned bilateral FDI.

Our empirical strategy would not be complete without the estimation of the extensive margin. We follow similar studies (Paniagua and Sapena, 2014; Gil-Pareja et al., 2013) and substitute the left-hand side variable of (20) for the number of foreign investments between country pairs. The estimation of the extensive margin reduces an over aggregation bias of capital flows in the estimation of the gravity equation Hillberry (2002). Additionally, the extensive margin reveals information about the creation of new partners (Felbermayr and Kohler, 2006).

The gravity framework is adequate to measure institutional and third-country effects. To do so, we use the standard approach that uses dummies to measure MIBEL's effect. In particular, we use *EMI* as dummy set at 1 for investments between the countries that signed an EMI (Spain and Portugal since 2007) and captures the effect within the *EMI*; *EMIROW* captures the effect of the FDI from the rest of the world within the EMI area with a dummy set at a value of 1 for all source countries that invested in the EMI area, excluding neighboring countries; *EMIFRA* specifically captures the effect of neighboring countries with a direct energy connection to the EMI area with a dummy set a at value of 1 if a neighboring country (France) invested in the EMI area.

3.1 Data

The data used in this study is standard in FDI gravity literature and similar to previous studies (see for instance Myburgh and Paniagua, 2016 or Cuadros et al., 2016). The Financial Times Ltd. cross-border investment monitor (FDIMarkets, 2013) is the source of the FDI dataset. The extensive margin is measured in firm-level projects counts, while the intensive margin is measured in capital flows in constant 2005 USD. The dataset covers bilateral firm-level greenfield investments from 2003 to 2012, aggregated between 190 countries. Greenfield projects initiate foreign production from scratch and are prone to have energy costs constraints. Consequently, greenfield investments are optimal for measuring the influence of EMI on FDI. Overall, the database is heavily unbalanced with 70% of zero observations, meaning that not all countries received investment in all years. We follow Paniagua's (2016) procedure to construct efficiently the datasatet reducing the self-selection bias.

Data on electricity prices is unique for this study and comes from the MIBEL market operator (OMIE) and the Portuguese energy regulatory authority (ERSE), for Spain and Portugal respectively. The prices are averaged yearly and are measured in euro/MWh. The evolution of the prices can be seen in figure 1.

As for the control variables, the World Bank (2013) is the source of GDP data, measured in constant 2005 US dollars. Distance, common language, colony and border come from the CEPII (2011) database and control for freight, information, cultural, historic and administrative transaction costs between country pairs. Religion is calculated with data from the CIA World Factbook (2011) according to the following formula for country each country pair: $\%Christian_i * \%Christian_j + \%Muslim_i * \%Muslim_j + \%Hindu_i * +\%Jewish_i * \%Jewish_j$. Institutional agreements such as Free Trade Agreements and Bilateral Investment Treaties reduce the foreign institutional uncertainty (Bergstrand and Egger, 2013). BITs are manually constructed with data from UNCTAD (2013). The source of FTA is Head et al. (2010) in conjunction with UNCTAD (2013). The source of banking crises is Laeven and Valencia (2013). We include this variable because the MIBEL integration period overlaps with that of the great recession period. Hence, to ensure that we are not capturing any spurious effects, we follow the procedure described in Gil-Pareja et al. (2013).

4 Results and discussion

To evaluate the effect of the creation of MIBEL on FDI we performed two sets of estimations of equations (17) and (20) for both the aggregate capital investment flows and the extensive margin. The results reported in Table 1 show that the gravity equation performs well when explaining bilateral FDI. The R^2 values are acceptable (nearly 80% for the extensive margin) and most of the variables of interest are significant and present the expected signs[3].

[Table 1 about here.]

[3]The variable religion was excluded in column two to ensure identification (HMR).

The estimates show the expected negative signs for the two control mechanisms predicted by the model (i.e., electrical price difference and its standard deviation). The effect is similar in both margins and quite robust to the choice of estimators and fixed effect combinations. The effect of price difference and variance is negative and significant in both margins. However, the results of column 1 suggests that these mechanisms do not affect the probability of FDI. Column 2 reports the estimates of the HMR method, which indicate that a reduction of one euro/MWh in difference increases the volume of FDI in approximately 0.14%. With this specification, which is subject to academic critique (Silva and Tenreyro, 2015)[4], price variance has no significant effect on FDI volumes.

Our preferred estimates, which use PPML and include time-varying country fixed effects, are reported in column 5 for the intensive margin and in column 8 for the extensive margin. These estimates indicate that reducing one euro/MWh in price difference increases 0.16% FDI flows and 0.14% foreign investment projects on average. Furthermore, reducing 1 standard deviation the price difference increases 1.6% FDI flows and 1.3% foreign investment projects on average. Our results suggest, as predicted by our model, that in the context of EMI the price stability mechanism has a greater effect on FDI than price converge. Intuitively, for FDI this means that foreign investors prime predictability over cost reduction.

[Table 2 about here.]

In the second set of estimations presented (see Table 2), we evaluate the overall institutional credibility effect of the creation of EMI on FDI. In line with our previous

[4]Additionally, HMR does not include country*year effects due to lack of convergence.

results, these estimates confirm that the creation of an integrated electricity market between Spain and Portugal exerted a significant and positive effect on the countries' FDI, for both capital invested and number of projects (see Table 2). The most conservative estimates indicate that EMI increased bilateral capital investment in Iberia by 64% on average[5]. Since the reduction in the variance of price difference was of 3 standard deviation (which would total an increase of 4.85), the results indicate that the institutional effect of the MIBEL is greater than the cost effect. The signal that Portugal and Spain sent to the foreign market had a positive effect that outweighed the pure cost analysis.

It should be stressed that the effect of EMI was similar for both margins. However, EMI had no effect on the probability of FDI, as indicated by the first step of HMR in column 1. If we look beyond the number of investment projects, the scale of these was significantly affected by the implementation of a common input market. Additionally, the results from the extensive margin regressions show that FDI from neighboring countries also increased after integration.

The positive effect of EMI is consistent and robust across the several specifications we tested. Furthermore, we manage to isolate the effect of EMI from those of the Great Recession. Several studies have shown that FDI has been affected by credit constraints following the 2007 crisis (Gil-Pareja et al., 2013; Paniagua and Sapena, 2015). The unfortunate coincidence in time of the two events is controlled by the negative coefficient of the crisis dummy in the regressions.

EMI does not, however, appear to have affected FDI from the rest of the world.

[5]Calculated by $(e^{0.495} - 1) * 100\%$

This seems to be capturing the fact that, relative to other EU markets, the falls in electricity prices within an EMI might not have been sufficient to attract any significant volume of this type of investments from the the rest of the world into the Iberian peninsula[6]. France, the neighboring country, is an exception in this regard, because since the creation of MIBEL French enterprises have increased their new projects by 148% on average. The volume invested by French firms remains unchanged.

In the third set of estimations (see Table 3) we decomposed the effect for the countries integrated so as to appreciate more fully the intensity of the effects on investment flows in two directions (i.e. from Spain to Portugal and from Portugal to Spain). Results from Table 3 show the direction of FDI flows. The theory underlying a gravity-like specification provides predictions on unidirectional bilateral trade rather than on two-way bilateral trade[7]. In this paper, we use unidirectional FDI data (i.e, $FDI_{ij} \neq FDI_{ji}$). Our specification is not only more closely grounded in theory; it allows us to inspect the direction effect attributable to the MIBEL.

[Table 3 about here.]

The estimated increase in FDI flows is stronger from Spain to Portugal than vice versa. These results seem to confirm that although both countries obtained benefits from the integration in terms of greenfield foreign investments, it is the country

[6]Although the MIBEL price has significantly decreased during the period cover in this study, around 28% until 2012, by that year while the Iberian price was 49 €/MWh on average, the price in other European regional markets was lower, for instance 45 €/MWh in PHELIX and 31 €/MWh in NordPool markets.

[7]Some authors treat the average of two-way bilateral trade as the dependent variable (e.g., Rose 2000). Baldwin and Taglioni (2006) referred to this procedure as the silver medal mistake.

with the initially higher electricity price that obtains the highest gains. As for the effects on FDI from the neighboring country, our results are in line with the previous estimations. Thus, EMI has a positive and significant impact on extensive margin FDI from France to both Spain and Portugal.

5 Conclusions

This paper is unique in incorporating energy considerations in a formal FDI setup and thus contributes to a better understanding of the relation between energy and international economics. Specifically, we have developed a model to explain the mechanisms by which EMI is related FDI. EMI signals institutional credibility and alleviates energy costs in a foreign market, thus encouraging FDI. We tested the model's predictions using the gravity equation and EMI created by Portugal and Spain in 2007. The estimates show that price stability mechanism has a greater effect than the cost reduction and converge on electricity prices. Moreover, the institutional credibility effects have a greater impact on foreign investment than cost analysis.

The paper's findings provide a number of insights into the economic implications of electricity markets integration. Specifically, the members of the integrated markets increase their bilateral investment. Moreover, EMI has a positive effect on the investments of neighboring countries. However, FDI from the rest of the world remains unchanged.

This paper suggests that energy market design and the way in which such markets operate have a direct effect on the cost-driven investment choices made by foreign firms, via energy prices. Thus, we identify additional policy implications that, in fact, extend beyond the energy sector and which have an effect on the whole of the economy. The expected effects of EMI require an effective energy market interconnection with sufficient cross-border energy interconnections. Our results point to the need to reformulate the methodology used in assessing cross-border priority energy investment plans so as to include the positive impact on FDI in the cost-benefits analysis.

Furthermore, major public investment plans in energy infrastructure (e.g., the current EU Commission's programme) are expected to have a greater impact on the Member States' economies than initially thought. Likewise, and from a broader perspective, the results from this paper suggest that the participation of supra-national financial institutions would be helpful in other contexts, such as the Mediterranean or Latin American countries, in providing soft loan and/or financial facilities for investment to accommodate the infrastructure required by EMI and its effects on FDI.

In short, the policy implications derived from this study stress the importance of considering the broader effects of energy market design. Moreover, future research of other single electricity markets and related features (i.e., domestic investment, environmental policies and sustainable development) is certainly encouraged. Policymakers pursue EMI as a policy to facilitate the development of renewable energy. Therefore, new research could explore the link between EMI and green FDI. Additionally, our theoretical setup allows to explore bilateral energy trade. Further research that explores the effect of energy integration dynamics on electrical trade is a promising avenue of future research.

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Table 1: Results

	T_{ijt}		FDI flows			Extensive Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\ln(Y_{it} \cdot Y_{jt})$	0.837***	1.281***	0.314***	-0.204	0.553***	0.267***	-0.351	0.658***
	(0.03)	(0.22)	(0.03)	(0.24)	(0.04)	(0.01)	(0.30)	(0.02)
$\ln(D_{ij})$	-0.326***	-0.980***	-0.401***	-0.333***	-0.321***	-0.175***	-0.367***	-0.254***
	(0.02)	(0.04)	(0.04)	(0.06)	(0.05)	(0.02)	(0.04)	(0.06)
$border_{ij}$	0.169***	0.215***	0.137	-0.012	0.059	0.183***	-0.152*	0.043
	(0.04)	(0.06)	(0.10)	(0.13)	(0.11)	(0.07)	(0.08)	(0.14)
$lang_{ij}$	0.274***	0.720***	0.256***	0.496***	0.543***	0.184***	0.514***	0.557***
	(0.03)	(0.05)	(0.08)	(0.11)	(0.10)	(0.05)	(0.06)	(0.14)
$colony_{ij}$	0.401***	1.267***	0.577***	0.527***	0.434***	0.368***	0.631***	0.315***
	(0.04)	(0.07)	(0.10)	(0.11)	(0.10)	(0.07)	(0.08)	(0.12)
$smctry_{ij}$	0.088	0.502***	0.201	0.418*	0.614*	0.136	0.584***	0.795***
	(0.07)	(0.12)	(0.19)	(0.24)	(0.32)	(0.12)	(0.14)	(0.26)
$religion_{ij}$	0.344***		0.284**	0.845***	0.266	-0.072	0.415***	-0.413*
	(0.04)		(0.12)	(0.23)	(0.20)	(0.06)	(0.13)	(0.21)
$locked_{ij}$	-0.022	-0.067	-0.030	-0.118	-0.171**	-0.057	-0.054	-0.193**
	(0.02)	(0.04)	(0.06)	(0.09)	(0.08)	(0.04)	(0.06)	(0.09)
BIT_{ijt}	0.006	-0.028	-0.175***	-0.096	-0.048	0.070**	-0.007	0.459***
	(0.02)	(0.04)	(0.05)	(0.07)	(0.07)	(0.03)	(0.04)	(0.09)
FTA_{ijt}	0.116***	0.280***	-0.086	0.245**	0.063	-0.114***	0.250***	-0.018
	(0.03)	(0.05)	(0.08)	(0.11)	(0.10)	(0.04)	(0.07)	(0.11)
$crisis_{ijt}$	-0.110***	-0.044	2.635	-0.014	0.592	-0.212***	-0.078***	-0.309***
	(0.03)	(0.05)	(2.48)	(0.06)	(0.64)	(0.04)	(0.03)	(0.06)
$Pricediff_{ijt}$	-0.108	-0.135***	-0.087**	-0.178***	-0.163***	-0.041*	-0.149***	-0.138***
	(0.10)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)	(0.02)
$PriceSD_{ijt}$	0.090	-0.675	-0.404	-1.361***	-1.586***	-0.248	-1.377***	-1.274***
	(0.22)	(0.58)	(0.32)	(0.33)	(0.47)	(0.19)	(0.42)	(0.28)
Inverse Mills ratio ($\hat{\bar{\vartheta}}^*_{ijt}$)		0.621**						
		(0.26)						
$\hat{\bar{w}}(\kappa)$		0.007***						
		(0.001)						
Observations	39157	14176	14330	39181	36796	14330	39181	38063
R^2	-	-	0.378	0.444	0.482	0.445	0.780	0.612
Method	Probit	HMR	OLS	PPML	PPML	OLS	PPML	PPML
Year FE	Yes	Yes		Yes			Yes	
Country FE	Yes	Yes		Yes			Yes	
*Country*Year FE*			Yes		Yes	Yes		Yes

Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Results

	T_{ijt}		FDI flows			Extensive Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\ln(Y_{it} \cdot Y_{jt})$	0.534***	1.567***	0.399***	-0.260	0.658***	0.232***	-0.372	0.658***
	(0.06)	(0.14)	(0.15)	(0.25)	(0.02)	(0.06)	(0.31)	(0.02)
$\ln(D_{ij})$	-0.329***	-0.980***	-0.423***	-0.340***	-0.257***	-0.251***	-0.368***	-0.304***
	(0.02)	(0.04)	(0.04)	(0.05)	(0.05)	(0.02)	(0.03)	(0.04)
$border_{ij}$	0.162***	0.215***	0.095	0.005	0.217*	0.056	-0.172**	0.022
	(0.04)	(0.06)	(0.09)	(0.132)	(0.12)	(0.052)	(0.07)	(0.07)
$lang_{ij}$	0.276***	0.720***	0.556***	0.521***	0.495***	0.423***	0.643***	0.623***
	(0.03)	(0.05)	(0.09)	(0.11)	(0.09)	(0.05)	(0.08)	(0.07)
$colony_{ij}$	0.408***	1.267***	0.171**	0.490***	0.423***	0.172***	0.509***	0.377***
	(0.04)	(0.07)	(0.08)	(0.11)	(0.08)	(0.05)	(0.06)	(0.06)
$smctry_{ij}$	0.090	0.502***	0.173	0.409*	0.177	0.155	0.595***	0.181
	(0.07)	(0.12)	(0.17)	(0.25)	(0.21)	(0.10)	(0.15)	(0.11)
$religion_{ij}$	0.344***	1.209***	0.500***	0.833***	0.122	0.227***	0.401***	-0.120
	(0.04)	(0.09)	(0.12)	(0.23)	(0.20)	(0.06)	(0.13)	(0.15)
$locked_{ij}$	-0.024	-0.067	-0.002	-0.119	-0.182**	0.008	-0.069	-0.108*
	(0.02)	(0.04)	(0.06)	(0.09)	(0.08)	(0.03)	(0.06)	(0.06)
BIT_{ijt}	0.004	-0.028	-0.165***	-0.103	-0.116	-0.103***	-0.009	-0.020
	(0.02)	(0.04)	(0.051)	(0.07)	(0.07)	(0.02)	(0.04)	(0.06)
FTA_{ijt}	0.110***	0.280***	-0.006	0.230**	0.162*	0.009	0.250***	0.239***
	(0.03)	(0.05)	(0.08)	(0.12)	(0.09)	(0.04)	(0.07)	(0.07)
$crisis_{ijt}$	0.003	-0.044	0.027	-0.021	-3.404***	0.019	-0.078***	-4.026***
	(0.03)	(0.05)	(0.05)	(0.06)	(0.88)	(0.019)	(0.03)	(0.47)
$EMIROW_{ijt}$	-0.108	-0.008	0.148	-0.287	-0.943	-0.014	-0.165	0.311
	(0.10)	(0.19)	(0.18)	(0.26)	(0.95)	(0.08)	(0.15)	(0.52)
$EMIFRA_{ijt}$	0.000	0.279	0.737	0.402	-0.241	0.598	0.908***	1.346**
	(0.10)	(0.39)	(0.58)	(0.31)	(0.94)	(0.50)	(0.19)	(0.53)
EMI_{ijt}	0.000	1.121***	0.495**	1.317***	1.318***	0.494*	1.431***	1.373***
	(0.11)	(0.44)	(0.25)	(0.31)	(0.30)	(0.26)	(0.31)	(0.38)
Inverse Mills ratio ($\hat{\bar{\vartheta}}^*_{ijt}$)		0.419***						
		(0.14)						
$\hat{\bar{w}}(\kappa)$		0.007***						
		(0.001)						
Observations	39157	14176	14176	38836	38253	14176	38836	38253
R^2	-	-	0.288	0.443	0.514	0.550	0.781	0.864
Method	Probit	HMR	OLS	PPML	PPML	OLS	PPML	PPML
Year FE	Yes	Yes		Yes			Yes	
Country FE	Yes	Yes		Yes			Yes	
*Country*Year FE*			Yes		Yes	Yes		Yes

Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Results within EMI

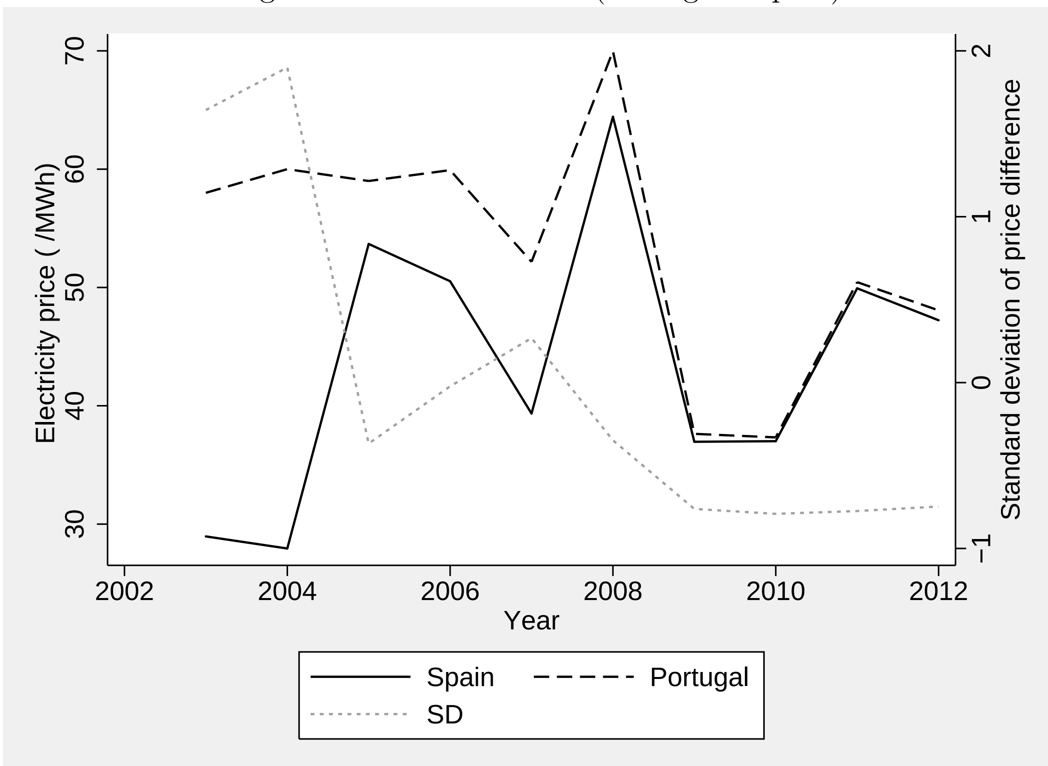
	FDI flows		Extensive Margin	
	(1)	(2)	(3)	(4)
$EMIROW_{ijt}$	-0.293	-0.223	-0.167	0.809
	(0.25)	(0.92)	(0.15)	(0.52)
$EMIFRA_{ijt}$	0.402	-1.000	0.905***	1.931***
	(0.30)	(0.91)	(0.18)	(0.53)
$POR \rightarrow ESP$	1.154***	0.908**	1.014**	0.861**
	(0.34)	(0.36)	(0.40)	(0.43)
$ESP \rightarrow POR$	1.358***	1.716***	1.722***	1.928***
	(0.47)	(0.28)	(0.23)	(0.20)
Observations	38253	36796	38253	36796
R^2	0.514	0.481	0.864	0.890
Year FE	Yes		Yes	
Country FE	Yes		Yes	
*Country*Year FE*		Yes		Yes

Robust standard errors in parentheses. PPML estimation.

Only variables of interest are reported (gravity control variables included)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Price Difference (Portugal - Spain)



Source: Based on data from the Iberian electricity market operator (OMIE)