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Impact of Electricity Prices on Foreign Direct Investment: Evidence from the European Union*

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Abstract

In the course of recent years growing concerns over increasing energy prices have emerged in the context of maintaining Europe's international competitiveness. In particular, rising electricity price differentials adversely affect firms' total production costs and ultimately impact their investment decisions. Nonetheless, electricity prices as locational determinants of foreign direct investment (FDI) have received little attention in the literature so far. We address this gap by including electricity prices in the traditional framework of FDI analysis and examine the impact of price variation on net FDI inflows in countries of the European Union (EU). We use a panel of 27 countries for a period of 2003 - 2013 and system generalised method of moments (GMM) as method of estimation. The main findings of the paper confirm that besides tax rates, unit labour costs and competitive disadvantage in secondary education, also electricity prices contribute to eroding competitiveness of the countries. Yet, the effect of electricity prices does not seem to be uniform across the EU. In fact, south-western countries tend to be more adversely affected than north-eastern, both in the short and long run.

JEL classification: F21, O52, Q43
Keywords: foreign direct investment, electricity prices, European Union, generalised method of moments

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1 Introduction

In the course of recent years, regional energy price differentials sparked a debate on the role of energy costs in maintaining countries' international competitiveness. Electricity prices in particular, along with prices for gas, constitute a factor of great uncertainty. In the specific context of the European countries, the ratio of highest to lowest price has been estimated in the range of 4 - 2.5 to 1 for both electricity and gas for 2008 - 2012 (EC, 2014). To put this into perspective, the lowest price levels for medium size industrial consumers of electricity in the EU were comparable to those in New Zealand, India and Ukraine. On the other extreme, the highest price levels in the EU were well above the highest retail electricity prices charged globally.

Rising disparities in electricity prices, along with variation in other factor costs, impact total production costs and put producers in some of these countries to competitive disadvantage. This in turn adversely affects investment decisions by both domestic and international firms and might ultimately lead to altering the global pattern of investment, production and trade. In fact, the share of global FDI in the EU has been on decline during the past decade, dropping from half of the global inflows at the beginning of 2000s to below one fifth of total investment flows in 2012 and 2013 (Vetter, 2014). A large part of this decline is caused by a decrease in intra-EU flows attributed to slow recovery from economic crisis (EC, 2012). However, the uneven distribution of FDI inflows across the EU also points to the loss of international competitiveness by some of the countries.

Foreign direct investment has been acknowledged to induce growth and development through increasing capital stock, employment creation, and perhaps knowledge and technology spillovers. While classical factor cost determinants of FDI, such as labour, capital and natural resource costs, have been widely acknowledged in the literature, the potential impact of electricity prices has been neglected so far. We address this gap in the literature and investigate to what extent do electricity prices for industrial consumers lead to loss of international competitiveness within the EU. We do so by including electricity prices in the traditional framework of FDI analysis and examine the impact of price levels on net investment inflows for the sample of EU countries. Due to the short time series available on electricity prices we make use of GMM estimation method for a dynamic panel data model, which also allows us to address concerns on endogeneity and autocorrelation. We conclude that both short and long run effects of electricity prices on net FDI inflows are significant and negative. Furthermore, their magnitude varies across the EU, the adverse effect being stronger in the south-western sub-region.

The remainder of this paper is organised as follows: Section 2 discusses the theoretical framework for analysing FDI determinants. Section 3 identifies variable proxies and respective data sources. Section 4 presents the model and discusses the estimation method used. Results along with robustness checks are reported in section 5. Section 6 concludes.

2 Determinants of Foreign Direct Investment

The evolution of the literature on determinants of foreign direct investment is closely tied to the globalisation trend which arose during the past decades. The early theoretical models emerged from foundations of neoclassical trade theory and expanded further based on the theory of multinational enterprises (MNE). Yet, it was not until the late 1970s that a formal framework of FDI determinants was drawn up. In his eclectic paradigm of international production, Dunning (1988) brings together industrial organisation theory, theory of growth of firm, theory of property rights, economics of transaction costs and theories of location and trade, in order to explain international production: Ownership-specific advantages (O) such as technical knowledge, managerial experience, innovation capacity, economies of scope and specialisation are key to explaining the existence of MNEs. Location-specific advantages (L) explain how MNEs choose to locate the production in terms of access to new markets, input prices and trade barriers, as well as investment incentives and government policies. Finally, internalisation-incentive advantages (I) influence the mode of entry to foreign market based on search and negotiating costs, costs of enforcing property rights, buyer uncertainty, maintaining control over quality of products and avoiding or exploiting government interventions. These three potential sources of advantages for firms engaging in foreign direct investment form jointly the OLI framework.

An alternative framework for analysing FDI advanced from combining the OLI framework with industry and country characteristics. This industrial organisation approach to international trade, also labelled as new trade theory, was put forward by Helpman (1983, 1984, 1985), who within a general equilibrium model with horizontally and vertically integrated MNEs explains the simultaneous existence of inter-sectoral, intra-industry and intra-firm trade in finished goods and intermediate inputs. Together with the results by Ethier and Horn (1990), these models lay the basis for factor-proportions hypothesis for the location of vertically integrated MNEs. According to the latter, geographically fragmented production by stages across different countries increases with increasing differences in factor intensities and relative factor endowments of countries, as well as with low trade costs and interface effects. Contrary to this, proximity-concentration hypothesis explains the existence of horizontally integrated MNEs which produce same goods and services in multiple countries in order to exploit the proximity to customers. This model predicts that horizontal FDI occurs in countries with similar factor proportions, large markets and substantial firm specific and exports costs (Brainard, 1993; Horstmann and Markusen, 1987, 1992; Markusen, 1984).

The above hypotheses were later combined within the knowledge-capital model by Carr et al. (1998); Markusen et al. (1996); Markusen (1997). In this model, behaviour of horizontal and vertical MNEs can be explained simultaneously due to the existence of both different factor intensities and trade costs. According to their findings, outward investment from home to host country is increasing in similarity of their sizes, relative skilled-labour abundance of the home country, and the interaction between size and relative endowment differences. When countries are of similar size and trade costs are high, this increases production of horizontal MNEs in the host country. At the same time, production of vertical MNEs increases when the host country is small, trading costs are low and there is abundance of skilled labour.

Additionally, behaviour of diversified MNEs can be explained by the risk diversification hypothesis, which postulates that firms are risk averse and aim at decreasing the variance of their earnings by geographical diversification of their production (Rugman, 1975, 1976). Several empirical studies establish that macroeconomic shocks, changes in interest and exchange rates as well as in political risk, are the main risk factors which tend to alter FDI behaviour of firms (Aizenman, 1992, 1994; Goldberg and Kolstad, 1995; Spiegel, 1994). Yet, it was only later that literature started to distinguish the effect of uncertainty on different modes of FDI and on types of their financing (Aizenman and Marion, 2004; Russ, 2007; Sayek, 2009). These studies assert that MNEs are able to minimise negative effects of exchange and inflation rate increases by shifting the location of production between home and host countries. Yet, the extent of this investment smoothing strategy depends on the mode of FDI: being a horizontal integrated MNE allows for shifting production towards more efficient plants, while this is mostly not possible for vertically integrated MNEs. Indeed, the lower the degree of substitutability between factors of production, the higher the possibility that vertical FDI decreases in response to host country inflation.

Finally, an alternative view of foreign investment inflows is the interaction of MNEs and host country governments. Various econometric studies show how investment decisions are affected by government policies, such fiscal and financial incentives, as well as other incentives relating to building up infrastructure or subsidised services. An overview of early research on policy determinants of FDI can be retrieved from Faeth (2009).

To sum up, each of these theories proposes the use of a different set of FDI determinants. Faeth (2009) arguments that FDI should be investigated on by a combination of various theories since different models tend to complement each other by explaining different aspects of FDI. This approach has also been confirmed by Bolwijn et al. (2012) who calculate the annual FDI Attraction Index based on four key economic determinants of the attractiveness for FDI inflow into an economy: market attractiveness which captures market-seeking FDI, availability of low-cost labour and skills which captures efficiency-seeking FDI, presence of natural resources for resource-seeking FDI, and presence of FDI enabling infrastructure.

In terms of empirical studies on FDI determinants, these can be broken down into cross-section, time series and panel data, where unit of analysis are countries, regions or industries. Factor cost differentials as determinants of foreign direct investment were first formulated within the factor price theory of the Heckscher-Ohlin model (Ohlin, 1967), while energy costs in particular were first identified within the OLI framework (Dunning, 1988). However, to our knowledge, no empirical study has evaluated the effect of electricity prices as a locational determinant of FDI so far. In light of recent debates on energy prices undermining countries' international competitiveness (Bureau et al., 2013; Folkerts-Landau, 2013; Gawel et al., 2014; Heymann, 2014; Küchler et al., 2014), we address this gap in the literature by incorporating electricity prices in the traditional framework of FDI. We do so by examining a panel of EU countries for a period of 2003 - 2013. The choice of data and methodology are discussed in the subsequent sections.

3 Data

Our analysis is carried out on the sample of EU member states for the period 2003 - 2013. The dependent variable is proxied by net FDI inflow *(FDI)*. We construct this based on the Balance of payments - Financial account - Direct investment position reported within the *bop_fdi_main* dataset (Eurostat, 2014b), whereby we subtract outward investment flows by resident entities from inward flows by foreign enterprises, and scale this to GDP at market prices. We decided to make use of this dataset, which is consistent with BPM5 methodology by IMF Balance of Payments Manual, since the recently launched dataset based on the BPM6 methodology (ECB, 2014a; ECB, 2014b; Eurostat, 2014a) is currently still very limited in the coverage of these positions. Another advantage in using this dataset is that investments made or received by special purpose entities (SPE) are excluded for most of the countries. The latter are predominantly used by transnational corporations which channel investments indirectly through these countries, which however are not necessarily the ultimate beneficiaries (Zhan et al., 2014). Consequently, such investment flows are neither in line with the general of purpose of FDI (i.e. cross-border investment with the objective of establishing a lasting interest which is evidenced with an ownership of at least 10% of the voting power of the direct investment enterprise (OECD, 2009)), nor do they contribute to employment creation and local value added. Therefore, including such investments in FDI statistics leads not only to double counting but also to misinterpretation of the actual origin/destination of FDI flows. While Eurostat acknowledges that 85-90% of FDI in- and outflows for Luxembourg are due to the presence of SPEs, it does not provide for a time series which would be adjusted accordingly. Therefore we decided to exclude Luxembourg from our sample.

We also use the lagged level of the FDI *($FDI_{i,t-1}$)* as explanatory variable since we expect to find agglomeration or saturation effects. In line with this, a positive coefficient of the lagged dependent variable would reflect that investment in previous period attracts current investment inflows, while a negative coefficient would reflect negative externalities generated by saturation.

Bi-annual electricity price *(EP)* data is available from Eurostat, 2014b. However there is a break in the series in the second semester 2007 when reporting was changed. The industrial consumers are now characterised by annual consumption bands. Since we are interested in medium size industrial consumers, we use the consumption band IC after 2007 (annual consumption between 500 and 2000 MWh) and standard consumers IE until 2007 (annual consumption of 2 000 MWh). Also, according to the old methodology, prices valid on the first day of each semester were reported, while based on the new methodology average prices for each semester are reported. Accordingly, we use data as of 1st of January before 2007 and first semester averages after 2007, in Euro per kWh excluding VAT and other recoverable taxes and levies. The availability of data before 2003 is insufficient, especially for eastern European accession countries. By taking 2003 as the initial year for estimation, we minimize the number of missing data points for electricity prices. Furthermore, in order to reflect the heterogeneity of prices across countries, we split our sample into two sub-samples: north-east *(EP_NE)* and south-west *(EP_SW)*. We classify countries based on the variation of respective electricity prices overtime - see descriptive statistics in Table 1. Country classification is reported in Table 5. The variable used in our model is thus constructed by interacting the log of electricity prices with regional dummies. In line with the locational advantages as described within the OLI framework, we expect the sign of the coefficients for both regions to be negative.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
FDI	1.396	5.364	-22.71	28.75	293
GDP_G	1.838	3.973	-17.7	11	297
EP	0.09	0.030	0.041	0.224	289
EP_NE	0.083	0.030	0.041	0.224	160
EP_SW	0.099	0.029	0.049	0.186	129
ULC	0.599	0.079	0.38	0.86	296
EDU_SEC	47.765	13.529	13.4	72.2	296
GFCF	3.152	1.153	0.700	6.8	297
DEFL	2.545	4.143	-15.81	25.47	297
DEFL_LO	1.377	2.301	-11.41	8.23	121
DEFL_HI	3.348	4.880	-15.81	25.47	176
EATR	21.971	7.274	0	36.97	297
TRANSP	81.306	8.177	46.23	93.53	207
EU	0.906	0.293	0	1	297
PROP_R	30.606	19.83	5	70	297
CORR_F	38.212	19.302	1	74	297
LAB_F	38.486	14.094	0	69	243

We select the rest of determinants based on the theories of FDI reviewed in the previous section. Definitions of variables and sources are reported in Appendix - Table 4. From locational advantages we use real GDP growth *(GDP_G)* to proxy the growth of the market size and assume that this is to have a positive impact on investment inflow. Furthermore, we proxy countries' competitiveness by log of unit labour cost *(ULC)*, which we calculate as ratio of remuneration of employees to their labour productivity. We expect high unit labour costs to cause cost disadvantage to firms. Also, according to knowledge capital theory, differences in labour endowment are attractive for vertical FDI. Therefore, we use secondary education attainment *(EDU_SEC)* to proxy labour force skills. We expect these to affect FDI inflows with one period lag. A positive sign of the coefficient would mean that secondary education attracts investment which is intensive in this skill set, while a negative sign would point to the relative comparative disadvantage of the European labour force with secondary education.

In line with risk diversification literature, we consider a proxy of market risk. We do not include exchange rates since the fluctuation of currencies within the EU is rather small, due to the fact that most of the countries adopted the common currency. Instead, we include change in the index of GDP deflator *(DEFL)* in order to reflect the risk of inflation growth from the perspective of a producer. Again, there is a significant variation of inflation rates across countries and overtime. Since we foresee the impact of inflation in high and low inflation countries on FDI inflows to differ, we split the EU region into two sub-regions: countries with inflation growth rates of above 2% on average and over time are included in high inflation region *(DEFL_HI)*, while those below this threshold are in low inflation region *(DEFL_LO)*. Differences in standard deviations reported in Table 1 point to differences in inflation growth variation across the two sub-regions. The classification is reported in Table 5. Keeping inflation growth levels low, countries send signals of credibility to investors. Therefore, stable inflation rates are expected to have positive impact on investment decisions. Yet, as discussed in Sayek (2009), while the effects of inflation rate are straightforward in case of horizontal FDI, in case of vertical FDI these depend on degree of substitutability between factors of production.

Finally, in terms of policy variables, we use gross fixed capital formation by general government *(GFCF)* to proxy public investment in infrastructure and expect this to have a distributed effect over time. We assume a polynomial distributed lag of second order with lag length of four periods (*t-1* to *t-4*). We expect the investment inflow to be increasing in the level of government expenditure. Furthermore, according to previous empirical studies, fiscal incentives prove important determinants of investment inflows. Lacking a reliable and widely available proxy for corporate taxes, we decided to use effective average tax rate *(EATR)* as collected by DG TAXUD and Eurostat, 2014. We expect that increasing tax rates deteriorate the investment climate.

In an extended setting, we examine the influence of additional policy variables. The EU accession dummy *(EU)*, which we use as proxy for trade barriers, reflects the changing composition of the EU based on countries' year of accession. We also include transport costs *(TRANSP)* which we proxy with the trading across borders indicator as collected within the Doing Business project (World Bank, 2014). The latter measures time and cost associated with exporting and importing a 20-foot container filled with goods. We are aware that this indicator is not perfect, due to some of the assumptions based on which it is constructed. Also, data is only available from 2006 onwards. The sign of both trade cost coefficients will depend on whether FDI inflows are vertical or horizontal. According to the proximity-concentration and factor-proportions hypothesis, high trade costs increase market-seeking FDI across similar economies, while low trade costs across countries with substantial differences in factor endowments induce efficiency-seeking FDI. We also make use of property rights, freedom from corruption and labour freedom indicators as constructed by Index of Economic Freedom (Heritage Foundation, 2014). We assume that the degree to which countries' laws protect private property rights and to which their governments enforce those laws, along with corruption perception, and labour market flexibility, significantly influence FDI inflows. We expect all three of them to have a small yet positive impact on MNEs decision to enter the market.

4 Methods

We use the one-step system GMM method to estimate our model. This method is particularly useful to deal with endogeneity and autocorrelation and allows obtaining consistent parameter estimates even with short time series. We estimate the following linear-log model:

$$\begin{aligned} FDI_{i,t} &= \alpha + \beta_1 FDI_{i,t-1} + \beta_2 X_{i,t-j} + u_{i,t} \\ u_{i,t} &= \eta_i + \lambda_t + v_{i,t} \end{aligned} \tag{1}$$

where subscript i denotes ith country (i = 1, ..., N) and subscript t denotes tth year (t = 1, ..., T). $FDI_{i,t-1}$ is the dependent variable with one year lag and $X_{i,t-j}$ is the vector 1 x K of current and lagged values of additional explanatory variables. The error term $u_{i,t}$ is made up of three components: the unobserved country specific effect η_i, the year specific effect λ_t, and the disturbance term $v_{i,t}$ assumed independent across countries. β_1 and β_2 are the parameters of interest.

Static panel estimation methods such as ordinary least squares (OLS) and fixed effects (FELS) are in general not suitable for estimation of models like ours since they do not allow understanding the autoregressive dynamics of the model. In fact, presence of the lagged dependent variable $FDI_{i,t-1}$ among explanatory variables causes autocorrelation of this regressor with the error term $u_{i,t}$ due to the presence of individual effects. The estimator β_1 is thus inconsistent and biased upwards when estimated by OLS, which pools all cross-sections together. When fixed effects are introduced, the inconsistency is eliminated by the demeaning process. While individual heterogeneity is wiped out, the estimator remains biased downwards since the transformation causes correlation between transformed lagged dependent variable and transformed error term (Baltagi, 2013). Nickell (1981) shows that this bias is of order O(1/T) as N → ∞. Thus even with a small T of 11 periods, this bias represents roughly 9%. Additionally, if explanatory variables are correlated with lagged dependent variable, their coefficients tend to be biased as well.

A solution to this problem is to eliminate fixed effects by transformation. Anderson and Hsiao propose two stage least squares (2SLS), whereby they estimate the model by taking the first difference and then by instrumenting the dependent variable with two period lag (Bond, 2002). While this leads to consistent estimators for samples with large N and small T, the estimators remain inefficient. Arellano and Bond (1991) develop differenced GMM estimators *(GMMDIFF)* based on orthogonality conditions between lagged dependent variable and the error term, where fixed effects are eliminated by first-differencing. The use of all available moment conditions allows obtaining asymptotically efficient estimators for samples with small T. Yet, it has been argued that lagged levels are weak instruments for first differences, especially when series are highly persistent. In line with this, Arellano and Bover (1995) outline additional moment conditions on equations in levels and Blundell and Bond (1998) fully develop an augmented version of difference GMM by adding level equations to get the system GMM estimator *(GMM-SYS)*. They show that using lagged differences as instruments for level equations in addition to lagged levels for equations in differences, reduces the finite sample bias and substantially increases the efficiency of system GMM estimators.

For the estimation of our model we use the system GMM method. Also, we identified the one-step GMM procedure to be most suitable due to the small number of countries in our sample. In fact, N is somewhat small with 27 countries when compared to large cross-sections for which GMM method has originally been developed. Yet, in our model N is still larger than T and therefore GMM method is suitable to be applied. In his analyses of the validity of Blundell and Bond (1998) Monte Carlo simulation results with small number of cross-sections, Soto (2009) confirms that small N does not seem to have important effects on properties of the GMM estimator. He also compares the one- and two-step distributions and concludes that there is almost no gain in efficiency from using the two-step estimator. Additionally, he arguments that one-step system GMM is more reliable in terms of power and error type - I. In line with this, we use one-step GMM for estimating our model.

Furthermore, we find in our specification that the only endogenous variable is the lagged dependent $FDI_{i,t-1}$. We also find that the log of unit labour cost is correlated with earlier shocks but not with the current error $u_{i,t}$. Hence we treat this as a predetermined variable. In fact, labour costs tend to be influenced by past but not by current values of investment flows in a country. We investigate the endogeneity formally with Durbin and Wu-Hausman tests which confirm that none of the remaining variables is endogenous. These variables are thus treated as exogenous to net FDI inflows. Since they are uncorrelated with either past or present errors, they can enter the instrument matrix in the conventional instrumental variables fashion. The endogenous and predetermined variables instead are instrumented with their respective lagged levels and lagged differences: lags *t-2* and earlier are suitable instruments, provided that they are not correlated with the error term.

One of the main weaknesses of this estimation method is the instrument proliferation and the invalidity of instruments. The topic of instrument proliferation has been addressed by Roodman (2009b), who concludes that using too many instruments overfits endogenous variables and weakens the Hansen test of instruments' joint validity. He proposes two approaches to instrument containment: either using only certain lags instead of all available lags as a set of instruments, or collapsing instruments into smaller sets, what allows retaining more information since no lags are dropped. Also Okui (2009) is concerned about the number of valid moment conditions, which is of order T^2 and can become moderately large even with short T. He suggests using small number of moment conditions compared to the whole set available. This issue is even more pressing in case of small number of cross-sections, where number of moment conditions can easily exceed N (Soto, 2009). In line with these suggestions, we combine the two approaches proposed, using the *collapse* option as specified in Stata command *xtabond2* (Roodman, 2009a) with only the most relevant instruments. We limit the past realisation of the lagged dependent variable and only use *t-2* to *t-5* as instruments. Same for the predetermined unit labour cost where *t-1* to *t-7* are used as instruments. To check the robustness of the results we apply different lag lengths with and without collapse option and examine the behaviour of estimates, as well as Hansen and difference-in-Hansen test results for joint instrument validity.

The second line of qualifications is that of using weak instruments. This has been discussed in Bun and Windmeijer (2010) who point out that the Monte Carlo studies by Blundell and Bond (1998) were performed under the assumption that the variance of unobserved heterogeneity term is equal to the variance of idiosyncratic shocks. Yet it is often the case with country level panel data that series are persistent and variance of country effects is high relative to variance of transitory shocks. This may ultimately lead to weak instrument problem for system GMM estimator. In order to explore the strength of instruments in our model, we perform this diagnostic test in the next section along with the estimation results.

5 Results

We now present the results of estimation followed by robustness checks. Main estimation results are reported in Table 2. Extended results for additional policy variables are reported in Table 3. We estimate the model using the four standard estimation methods discussed above. Column (1) contains the estimation results from OLS where cross-sections are pooled together. In column (2) we use fixed effects to remove the individual heterogeneity. We then run Hausman specification test under the null hypothesis that there is no systematic difference in coefficients between fixed effects and random effects. We reject the null at 10% and conclude that fixed effects are present in our model. Subsequently, we eliminate these effects by difference and system GMM estimations, the results of which are reported in columns (3) and (4), respectively. Comparing the coefficients of lagged dependent variable across the four estimations, GMM coefficients fall inside the bounds of coefficients from OLS and FELS. The fact that the latter two are biased in opposite directions allows to conclude that GMM estimators are consistent. Furthermore, the system GMM estimator is more precise in estimating parameters than the difference GMM. Comparing standard errors across the two, we obtain a modest improvement in the precision of the parameter estimate by adding additional moment conditions for level equations.

The estimation results indicate that electricity prices have a negative effect on net FDI inflows as expected. While the immediate effect is relatively small, it is significant in both regions. Yet, it proves larger in the south-western region *(LOG_EP_SW)* than in the north-eastern region *(LOG_EP_NE)*, with a 10% increase in electricity prices leading to a decrease in net FDI inflows by 0.41% and 0.33% as share of GDP in the short run, respectively. In the long run, the overall response of FDI inflows to electricity prices increases to 0.60% for south-western and to 0.48% for north-eastern regions.

As expected, the effect of unit labour costs *(LOG_ULC)* is substantially more pronounced than that of electricity prices, a 1% increase in unit labour cost causing a 0.12% decrease in net FDI inflows in the short run. We also observe a negative impact of taxes *(EATR)*: one percentage point increase in effective average tax rate causes net investment inflow to decrease by 0.30%. Lagged FDI *(L1.FDI)* and GDP growth *(GDP_G)* have about the same effect but in the opposite direction. Both investment inflow from the previous period and market growth have a positive effect, with one percentage point of increase in each inducing 0.32% increase in investment inflow. This result confirms the presence of agglomeration effects and the importance of the growth of the market size. For what concerns government spending *(GFCF)*, coefficients reported within the Tables are those for polynomial distributed lags of second order. When recalculated, the real β coefficients indicate a negative effect of spending of -1.18% after one period lag, while FDI is increasing in the level of government spending after two, three and four period lags, with one percentage point increase in spending increasing FDI inflow by 0.93%, 1.02% and 0.09% respectively. This implies that after an initial negative impact of government spending, investment pays off in subsequent years, but its effect diminishes over time.

Table 2: Comparison of Estimates of FDI Determinants across Estimation Methods

	(1) OLS	(2) FELS	(3) GMMDIFF	(4) GMMSYS
L1.FDI	0.362***	0.187	0.234	0.320*
	(0.0881)	(0.143)	(0.178)	(0.184)
GDP_G	0.281***	0.263**	0.288*	0.322**
	(0.0907)	(0.115)	(0.158)	(0.119)
LOG_EP_SW	−2.910**	−0.264	−0.134	−4.045**
	(1.196)	(4.435)	(8.906)	(1.846)
LOG_EP_NE	−2.247*	−4.391*	−6.098	−3.294*
	(1.139)	(2.386)	(5.686)	(1.708)
DEFL_HI	0.153**	0.151*	0.147	0.196**
	(0.0710)	(0.0847)	(0.100)	(0.0748)
LOG_ULC	−5.101	−16.77*	−18.74	−11.49*
	(3.671)	(9.465)	(15.16)	(6.060)
L1.EDU_SEC	−0.0444**	−0.885*	−0.870**	−0.0532**
	(0.0176)	(0.449)	(0.385)	(0.0217)
EATR	−0.264***	−0.121	−0.384**	−0.296***
	(0.0479)	(0.145)	(0.187)	(0.0673)
PDL0_GFCF	−1.162*	−1.176	−1.110	−1.176**
	(0.602)	(0.760)	(0.874)	(0.551)
PDL1_GFCF	2.767**	2.523	2.434	3.112**
	(1.222)	(1.488)	(1.496)	(1.314)
PDL2_GFCF	−0.855**	−0.819	−0.802	−1.006**
	(0.384)	(0.507)	(0.526)	(0.449)
Observations	188	188	161	188
Instruments			27	30
R-sq	0.445	0.535		
AR(2)			0.581	0.352
Hansen Test			0.239	0.374
Difference-in-Hansen:				
GMM Instruments				0.476
Exogenous Variables				0.270

Notes: All estimators and standard errors are robust to heteroscedasticity and autocorrelation. We report one-step GMM estimators. $FDI_{i,t\text{-}1}$ is treated as endogenous and only its lags *t-2* to *t-5* are included in the instrument matrix. $ULC_{i,t}$ is predetermined and instrumented with lags *t-1* to *t-7*. Collapse option is used. Time dummies are included in all regressions. Standard errors in parenthesis. Significance of p-values is reported as follows: * $p < .1$, ** $p < .05$, *** $p < .01$.

Furthermore, the coefficient of secondary education *(L1.EDU_SEC)* is significant, yet very small and negative. This indicates a comparative disadvantage for the European labour force. Indeed, looking at the rates of secondary education attainment, these are very high relative to the rates of tertiary education attainment, especially for eastern European accession countries. This points to the fact that in order to attract more FDI, rather than high rates of low-skilled, high rates of highly skilled labour force might be required. This hypothesis is supported by the fact that during the past years inward and outward FDI was dominated by financial and insurance activities, which tend to be more high-skill intensive (Eurostat, 2014c). In line with this, we also tried using tertiary education attainment rate - its coefficient was again small, but positive and insignificant, while coefficients of the other variables remained unaffected.

Finally, we observe a positive and significant coefficient for GDP deflator in the high inflation level sub-region *(DEFL_HI)*. This is rather counterintuitive in terms of the risk diversification literature, since higher inflation rates erode purchasing power of earnings and create distortions in net returns of investment. We hypothesise that the positive coefficient for deflator growth could be a business cycle indicator. Indeed, examining the data closely, the deflator turns out pro-cyclical, as is FDI, increasing during expansion and decreasing during the period of financial crisis. The latter remains positive in the high inflation sub-region, while there is mostly negative net inflow within the low inflation sub-region. This in turn explains the negative, yet highly insignificant coefficient of GDP deflator in low inflation EU countries.

As part of robustness checks, we examine the variance inflation factors of coefficients in order to evaluate potential multicollinearity among variables. The inflation factor is much higher than the recommended value of 10 in case of interacted electricity price terms. This indicates that predictors are strongly correlated, what can also be seen in the correlation matrix in Appendix - Table 6. To correct for this, we tried using the overall log of electricity prices and one regional interacted term only, instead of both. Rerunning the regression and computing the inflation factors anew, these have decreased substantially. Also the standard error of the interacted term has improved. Yet, there were no changes in terms of significances and magnitudes of the other coefficients.

Some of the diagnostic test results are reported in the lower part of the Table. GMM estimator requires that there is first-order serial correlation but no second-order autocorrelation in errors terms (Arellano and Bond, 1991). Both difference and system GMM pass the test of first- and second-order serial correlation in disturbances. As the number of moment conditions increases, the Hansen test of joint validity of instruments is performed in order to test the overidentification restrictions. We cannot reject the null hypothesis of correct model specification and validity of instruments. Finally, we consider the test of validity for subsets of instruments. The p-values of difference-in-Hansen tests for both instrument subsets of GMM and IV instruments do not allow us to reject their validity. Therefore, we conclude that instruments satisfy the orthogonality condition and can be included in our model.

Last but not least, we verify the strength of instruments by computing the variance ratio as discussed in Bun and Windmeijer (2010). The authors warn against the weak instrument problem when the variance of the individual heterogeneity is larger than the variance of idiosyncratic shocks. In our case the variance ratio is very small at 0.15. While this is substantially below the Blundell and Bond (1998) assumption of 1, according to the Monte Carlo results by Bun and Windmeijer (2010) the absolute bias for a variance factor of this magnitude is relatively small, especially for highly persistent series. Considering this result, it is hard to see why our instruments should be weak.

Next, we extend our analysis by including policy variables. Due to multicollinearity issues we add them one by one. Results based on one-step system GMM are reported in Table 3. This exercise serves at the same time as sensitivity analysis. In fact, when introducing additional variables, main regression results from Table 2 remain unaltered. We find that coefficients for property rights *(PROP_R)* and freedom from corruption *(CORR_F)* are both significant. In fact, rule of law seems to affect investment inflows positively, a 10 units increase in the ability to accumulate private property increases net FDI inflow by 0.36% as share of GDP, while the impact of corruption perception index is somewhat stronger at 0.46% of FDI inflow as share of GDP. Contrary to this, the regulatory framework of a country's labour market *(LAB_F)* is insignificant with a p-value of 0.20, yet positive.

Last but not least, we add the EU accession dummy *(EU)* which is a proxy of barriers to trade. Its coefficient is negative but not significant with a p-value of 0.11. We interpret the negative sign of trade liberalisation as follows: prior to countries' accession to the EU, FDI was mainly market-seeking, whereby MNEs preferred to open plants in these countries to avoid trade costs. With the accession to the EU, trade barriers were removed and MNEs might have shut down the plants in these countries. We thus hypothesise that MNEs within the EU might now be more vertically integrated. Furthermore, the coefficient of transport costs is also negative and significant *(TRANSP)*, a 10 units increase in the indicator of transport costs decreases net FDI inflow as share of GDP by 1.20%. Unfortunately, the use of aggregate data does not allow us to conclude on the dominance of either vertical or horizontal FDI across the EU countries. Note also that adding transport costs in the model absorbs the distance and causes the the agglomeration effect to turn insignificant with a p-value of 0.24, while the coefficient of unit labour cost increases substantially and all other coefficients remain stable.

Here again, tests of first- and second-order serial correlation yield the expected diagnostics. Both Hansen and difference- in-Hansen tests do not reject the overidentification conditions and confirm the validity on instrument sets and subsets.

Table 3: Policy Variables as FDI Determinants

	(1)	(2)	(3)	(4)	(5)
L1.FDI	0.339*	0.336*	0.318*	0.316*	0.242
	(0.181)	(0.174)	(0.185)	(0.185)	(0.201)
GDP_G	0.319**	0.318**	0.331***	0.332**	0.324**
	(0.119)	(0.117)	(0.118)	(0.122)	(0.132)
LOG_EP_SW	−4.061**	−4.550**	−3.903**	−4.002**	−4.706**
	(1.692)	(1.812)	(1.857)	(1.845)	(2.116)
LOG_EP_NE	−3.366**	−3.990**	−3.139*	−3.212*	−3.945**
	(1.537)	(1.669)	(1.702)	(1.697)	(1.899)
DEFL_HI	0.183**	0.171**	0.195**	0.195**	0.191**
	(0.0708)	(0.0715)	(0.0739)	(0.0748)	(0.0773)
LOG_ULC	−11.24	−11.68*	−11.22*	−11.47*	−15.08*
	(6.847)	(6.781)	(5.974)	(6.084)	(8.274)
L1.EDU_SEC	−0.0646**	−0.0681**	−0.0530**	−0.0560**	−0.0830**
	(0.0282)	(0.0309)	(0.0228)	(0.0224)	(0.0350)
EATR	−0.273***	−0.256***	−0.315***	−0.299***	−0.349***
	(0.0712)	(0.0624)	(0.0685)	(0.0677)	(0.0962)
PDL0_GFCF	−1.267**	−1.270**	−1.217**	−1.132*	−0.944*
	(0.566)	(0.543)	(0.553)	(0.558)	(0.540)
PDL1_GFCF	3.161**	3.173**	3.183**	3.071**	2.624**
	(1.352)	(1.335)	(1.323)	(1.317)	(1.239)
PDL2_GFCF	−1.017**	−1.030**	−1.030**	−1.001**	−0.871**
	(0.461)	(0.459)	(0.452)	(0.450)	(0.413)
PROP_R	0.0361*				
	(0.0185)				
CORR_F		0.0460*			
		(0.0255)			
LAB_F			0.0214		
			(0.0164)		
EU				−1.419	
				(0.850)	
TRANSP					−0.120*
					(0.0608)
Observations	188	188	188	188	181
Instruments	31	31	31	31	31
AR(2)	0.305	0.318	0.356	0.355	0.946
Hansen Test	0.187	0.493	0.390	0.405	0.288
Difference-in-Hansen:					
GMM Instruments	0.142	0.246	0.544	0.424	0.179
Exogenous Variables	0.156	0.409	0.355	0.258	0.253

Notes: All estimators and standard errors are robust to heteroscedasticity and autocorrelation. We report one-step GMM estimators. $FDI_{i,t\text{-}1}$ is treated as endogenous and only its lags *t-2* to *t-5* are included in the instrument matrix. $ULC_{i,t}$ is predetermined and instrumented with lags *t-1* to *t-7*. Collapse option is used. Time dummies are included in all regressions. Standard errors in parenthesis. Significance of p-values is reported as follows: * $p < .1$, ** $p < .05$, *** $p < .01$.

6 Conclusion

In this paper we have examined the effect of electricity prices on net foreign direct investment inflows within a formal framework of FDI analysis. To our knowledge, no other study has attempted to quantify the effects of electricity prices as a locational determinant of FDI so far. Therefore, our main contribution is filling this gap in the literature. The main findings of the paper confirm that besides tax rates, unit labour costs and competitive disadvantage in secondary education, also electricity prices contribute to eroding competitiveness of the EU countries. Yet, the effect of electricity prices does not seem to be uniform. In fact, south-western countries tend to be more adversely affected than north-eastern, both in the short and long run. Higher electricity prices in the former seem to be driven mainly by increasing network costs and non-recoverable electricity tax rates (EC, 2012). This increase in non-market electricity price components reflects additional costs of primary fossil fuels due to emission trading schemes, as well as costs incurred by diversification of energy sources towards low carbon technologies. The fear of losing competitiveness due to charging higher consumer prices has already been addressed by national policies granting tax exemptions and reductions at industry levels. However, this burden is ultimately borne by households and policy makers should be cautious about overburdening these. Rather than shifting the price increase on end-consumers, policies should aim at fostering energy efficiency improvements on the one hand, and smoothing price differences on European level on the other, in order to mitigate the effect of electricity prices on locational choices for investment. Should electricity price differentials continue to persist, they might lead to alteration of the global pattern of investment, production and trade.

Limitations of this study stem from the limitations of the data used. Electricity prices are not comparable across countries due to various tax exemptions at country, industry and large industrial consumers levels which are not reflected in the data (EC, 2012; Eurostat, 2014b). Furthermore, this analysis considered prices for medium-size industrial users. The impact of electricity prices for large companies might be smaller in that these often source electricity directly from the wholesale market, are subject to long term contracts, and might be further exempted from certain network charges, taxes and levies. Consequently, the impact of electricity prices on FDI inflows by these are likely to be overestimated.

Further research might extend this analysis to individual economic activities. For example, it might be interesting to isolate the effect of prices on manufacturing as compared to services, where cost of electricity might be less important. This however also calls for better data coverage, especially for energy-intensive industries for which electricity price data is currently very limited.

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A Appendix

Table 4: Definition of Variables

Symbol	Description	Source
	Dependent Variable	
FDI	Net direct investment inflow	Net of FDI flows to EU from all countries of the world adjusted by GDP at market prices: own calculations based on dataset bop_fdi_main (Eurostat, 2014b)
	Independent Variables	
GDP_G	Real GDP growth rate	Percentage change on previous year in volumes (Eurostat, 2014b)
EP	Electricity prices	In EUR per kWh excluding VAT and other recoverable taxes and levies for medium sized enterprises - bands IE and IC (Eurostat, 2014b)
ULC	Unit labour cost	Own calculations based on compensation of employees, employees domestic concept, GDP at market prices in volumes, and total employment domestic concept (Eurostat, 2014b)
EDU_SEC	Upper secondary education attainment	Upper secondary and post-secondary non-tertiary education in % of total population between 15 to 64 years (Eurostat, 2014b)
GFCF	Gross fixed capital formation	For general government (Eurostat, 2014b)
DEFL	Deflator growth rate	Own calculations based on GDP at market prices in EUR, price index, 2005=100 (Eurostat, 2014b)
EATR	Effective average tax rates	In % for non-financial sector from DG TAXUD and Eurostat, 2014
TRANSP	Trading across borders	Measured as distance to frontier (World Bank, 2014) - values ranging from 0 to 100
EU	EU accession dummy	Dummy variable reflecting changing composition of the EU
PROP_R	Property rights	Index of Economics Freedom (Heritage Foundation, 2014) - values ranging from 0 to 100: Ability to accumulate private property
CORR_F	Freedom from corruption	Index of Economics Freedom (Heritage Foundation, 2014) - values ranging from 0 to 100: Corruption perception index
LAB_F	Labor freedom	Index of Economics Freedom (Heritage Foundation, 2014) - values ranging from 0 to 100: Legal framework of labour market
	Control Variables	
EP Dummies	South-west (SW) and north-east (NE)	Regional classification based on variation in EP
DEFL Dummies	High inflation (HI) and Low inflation (LO)	Regional classification based on variation in DEFL
Time Dummies	2003 - 2013	Year dummies

Table 5: Classification of Countries into Sub-regions

Region Country	North-East	South-West	Low Inflation	High Inflation
Austria		x	x	
Belgium		x		x
Bulgaria	x			x
Croatia	x			x
Cyprus	x			x
Czech Republic		x		x
Denmark	x			x
Estonia	x			x
Finland	x		x	
France		x	x	
Germany		x	x	
Greece		x	x	
Hungary	x			x
Ireland	x		x	
Italy		x	x	
Latvia	x			x
Lithuania	x			x
Malta		x		x
Netherlands		x	x	
Poland	x			x
Portugal		x	x	
Romania	x			x
Slovakia	x			x
Slovenia	x		x	
Spain		x		x
Sweden	x			x
United Kingdom		x	x	
Luxembourg	*excluded from sample*			

Table 6: Correlation Matrix

	FDI	GDP_G	LOG_EP	LOG_EP_NE	LOG_EP_SW	LOG_ULC	EDU_SEC	GFCF	DEFL	DEFL_LO	DEFL_HI	EATR	TRANSP	EU	PROP_R	CORR_F	LAB_F
FDI	1																
GDP_G	0.217*	1															
LOG_EP	-0.245*	-0.435*	1														
LOG_EP_NE	-0.225*	-0.242*	0.411*	1													
LOG_EP_SW	0.176*	0.141*	-0.169*	-0.968*	1												
LOG_ULC	-0.186*	-0.446*	0.357*	0.0920	-0.00105	1											
EDU_SEC	0.108	0.203*	-0.189*	-0.441*	0.424*	-0.0685	1										
GFCF	0.234*	0.157*	-0.330*	-0.409*	0.351*	0.0600	0.175*	1									
DEFL	0.237*	0.445*	-0.237*	-0.222*	0.175*	-0.00802	0.160*	0.232*	1								
DEFL_LO	-0.163*	0.0356	-0.00838	0.191*	-0.209*	0.0565	-0.105	-0.117*	0.223*	1							
DEFL_HI	0.303*	0.435*	-0.237*	-0.301*	0.260*	-0.0304	0.203*	0.281*	0.923*	-0.169*	1						
EATR	-0.292*	-0.121*	0.0650	0.703*	-0.742*	-0.0487	-0.488*	-0.426*	-0.201*	0.194*	-0.280*	1					
TRANSP	-0.358*	-0.0855	0.101	0.177*	-0.168*	-0.0254	-0.415*	-0.242*	-0.189*	0.0314	-0.207*	0.322*	1				
EU	-0.254*	-0.179*	0.289*	0.257*	-0.199*	0.291*	-0.184*	-0.112	-0.0706	0.0981	-0.110	0.216*	0.468*	1			
PROP_R	0.332*	0.149*	-0.191*	-0.316*	0.290*	-0.00334	0.381*	0.393*	0.267*	-0.0496	0.290*	-0.448*	-0.793*	-0.403*	1		
CORR_F	0.405*	0.168*	-0.0847	-0.176*	0.167*	-0.165*	0.341*	0.429*	0.251*	-0.106	0.295*	-0.433*	-0.732*	-0.368*	0.852*	1	
LAB_F	-0.0346	-0.0740	-0.0804	0.0916	-0.122	0.143*	-0.121	0.129*	-0.0151	0.182*	-0.0838	0.221*	-0.0989	-0.153*	0.162*	0.126*	1

* $p < .05$

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