FDI spillovers at different levels of industrial and spatial aggregation: evidence from the electricity sector

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Abstract: The European electricity sector has undergone significant reforms in recent years, in the direction of market opening, integration and privatization. National and regional markets are now characterized by the presence of domestic and foreign firms, both privately and publicly owned. Did foreign entry induce positive productivity spillovers to domestic firms in the electricity sector, both at the aggregate and disaggregated level, while also controlling for domestic firms' ownership? This paper examines this issue by focusing on regional foreign direct investment (FDI) spillovers in the aggregated electricity sector and in the disaggregated sub-sectors of generation and distribution. The results show the importance of industry aggregation in determining the existence and sign of regional FDI spillovers for domestic firms. FDI spillovers are then calculated based on a purely geographic scale, by considering the distance between each firm's city of location and firms in neighboring cities. The importance and sign of FDI spillovers is different with respect to the analysis based on regional administrative boundaries, suggesting that spatial aggregation, along with industrial aggregation, is relevant in accounting for productivity spillover effects of foreign presence in the EU electricity sector.
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1. Introduction

In recent years, the electricity sector in the European Union (EU) has undergone significant changes, mainly prompted by an array of EU-wide reforms aimed at creating a single, competitive and liberalized electricity market. Before the 1990s, the European electricity sector was characterized by vertical integration, no third party access to the transmission grid, the predominance of publicly owned (at the state or municipal level) enterprises and limited possibility for final users of switching providers, thus suggesting limited competition in the distribution and retail segments of the industry. Since the privatization and liberalization wave in the UK in the 1990s, however, a series of EU directives has given rise to a significant transformation of national electricity markets. The underlying policy goals are based on pro-competitive arguments that link privatizations and liberalizations to increases in economic efficiency. This has led to policy measures aimed at facilitating the creation and entry of private and foreign enterprises in markets previously characterized by widespread public ownership, and the creation of truly

competitive markets which should ultimately lead to both production efficiency and an increase in consumers' welfare (Jamasb and Pollitt, 2005; Florio, 2013). In detail, the first 1996 directive (Directive 96/92/EC) provided the foundations of a European internal market for electricity, but lacked concrete implementation provisions. To overcome this limitation, the 2003 directive (Directive 03/54/EC) set out the steps needed to achieve unbundling of transmission and distributions systems; establishes an independent national regulatory agency; and required free entry in the generation segment of the industry. The 2009 directive (Directive 09//EC) expands along these lines, requiring further advancement in terms of unbundling of transmission assets and the creation of transmission system operators within integrated groups.

Since each country, however, is at a different stage of the reception of EU directives and each national market has maintained certain idiosyncratic characteristics, the overall picture, especially in terms of ownership of active electricity firms, is quite varied. An interesting feature of the current situation is the coexistence of domestic, both publicly and privately owned, firms, following a wave of partial privatization of once mainly state-owned national firms, and a number of foreign firms that have expanded their activities outside national borders.

Following the debate in the international and regional economics literature, this paper thus exploits this feature and explores the possibility that foreign presence, considered as the share of cumulated foreign operating revenues in a given area over total revenues, may induce spillover effects on domestic firms' productivity, by first focusing on a regional dimension in the electricity sector and then considering different levels of industrial and spatial aggregation. Has the entry of foreign firms, accounted for at the regional level or simply by geographic distance, been associated with increases in domestic productivity levels? Are spillover effects, if present, visible at the aggregate electricity sector level, or is

further industrial disaggregation needed, thus distinguishing between electricity generation and distribution?

While there is a consistent literature exploring the existence, sign, and intensity of foreign spillovers for the manufacturing sector in general, no systematic study has explored this issue in the context of the European electricity sector. A further novelty of this study is related to the use of disaggregated industrial level data and the use of both administrative boundaries and physical distance to account for the importance of spatial aggregation. In what follows, the association between foreign presence and domestic productivity is accounted for by considering both intra-sectoral, or horizontal, spillovers, and inter-sectoral, or vertical spillovers, at the regional and disaggregated spatial level in the generation and distribution sub-sectors.[1] The analysis is complemented by the evaluation of foreign presence based on purely geographic distances, not limited by administrative regional boundaries, to examine the role of different definitions of spatial disaggregation on the existence and magnitude of foreign spillovers.

The results suggest that an unambiguous foreign spillover effect cannot be identified, as the sign and significance of the associated coefficient depend on the level of industrial and spatial aggregation. In terms of industrial disaggregation, sectors matter when evaluating foreign productivity spillovers since the results vary depending on the sub-sector or segment considered. In particular, while there is no evidence of horizontal spillovers in the aggregate sector and in the generation segment, the productivity of domestic firms in distribution is positively correlated to foreign presence. Regional vertical spillovers are significant for both the generation and distribution segments, but with opposite signs. A competition effect seems to dominate in generation, while a positive spillover is detected in distribution. The relative importance and sign of intra-sectoral, or horizontal spillovers, with respect to inter-sectoral, or vertical, spillovers, varies when considering the two

segments of the electricity industry. In fact, for firms in generation, regional horizontal spillovers are non-significant, while backward vertical spillovers (arising from the downstream distribution industry) are negative and significant at the regional level. In distribution, instead, horizontal spillovers are positive and significant as are vertical forward spillovers (arising from the upstream generation industry). To sum up, when considering regional boundaries, foreign presence in distribution entails a positive productivity effect on domestic firms, both from the distribution and generation segments. On the contrary, domestic firms in generation are negatively affected by foreign firms operating in distribution and unaffected by foreign firms within the sector. These findings are related to the local monopoly nature of the distribution segment and the more competitive environment in generation.

Focusing on spatial disaggregation, while in the aggregate electricity sector this issue does not seem to be particularly relevant, the situation is quite different in the two sub-sectors. In the generation segment of the industry, backward vertical spillovers seem to matter only at an administrative regional level when foreign presence is accounted for by the share of operating revenues. However, just considering physical distance, with three distinct cut-off levels, gives rise to significant negative horizontal spillover effects when foreign presence is accounted for by considering the absolute number of foreign firms. This result suggests that foreign firms exert a pure competition effect, based on geographic distance and this effect is not affected by administrative boundaries. On the contrary, for firms in distribution, the positive horizontal spillover effect is statistically significant when calculated on the basis of administrative regional boundaries and on different cut-offs based on geographic distance, suggesting that the sectoral effect prevails on the geographic effect in this segment of the electricity industry. Distance is however important, since spillovers estimated at the regional level may underestimate the impact of foreign

presence, the intensity of which increases when considering distance-weighted measures. Results on vertical forward spillovers are also supportive of the view on the predominance of a sector-specific effect at play, coupled once again with the importance of moving beyond administrative boundaries when analyzing potential foreign spillover effects.

Focusing on another dimension of the reform process, some considerations can be put forward regarding privatization and public ownership. In generation, where this process began earlier, ownership is not significantly affecting domestic firms' productivity, while in distribution, where privatization is more recent, public firms are, on average less productive. These results suggest that public ownership is not unambiguously associated with lower or higher productivity and also hint toward the fact that the reform process is removing some of the external barriers to efficiency and is making public or private ownership less relevant.

While the presence of significant spillover effects suggests a positive outcome of the reform process, the importance of both industrial and spatial disaggregation have relevant policy implications. Industrial and regional policies should take into account both the sector specific characteristics and the different spatial scale at which productivity spillovers arise to achieve the goal of increasing productivity in the EU electricity market.

The remainder of the paper is organized as follows. In the next section, a selection of the relevant literature on spillovers is presented, while section 3 describes the empirical strategy and the data. Discussion of results is given in sections 4 to 6, while concluding remarks and implications are presented in section 7. Additional descriptive statistics and empirical results are presented in the Appendix.

2. Related Literature

The possibility that domestic firms in host countries may benefit, in terms of innovation activity[2] and productivity, from foreign presence has been extensively explored in the literature. Foreign presence is usually accounted for as the share of foreign firms' in employment, sales or operating revenues in a given industry, country (or other spatial unit) and time.

Possible channels through which foreign presence in the host country may benefit domestic firms are mainly related to the possibility of knowledge and productivity spillovers. Blomström and Kokko, 1998, and Smeets, 2008 provide interesting overviews of these issues, highlighting the importance of the public nature of technology, which leads to the possibility of knowledge leakages and imitation; the role of supplier-buyer relations between foreign and domestic firms; and market access spillovers. Another possible channel through which foreign presence may impact on domestic productivity is related to workers' mobility (Teece, 1977): foreign knowledge may benefit domestic firms through mobility of the local workforce, which will first reap the benefits of foreign firms' higher wages and eventually transfer knowledge back to domestic firms by creation of a new firm (Gorg and Strobl, 2005) or by then transferring back to a local firm (Poole, forthcoming).

Aitken and Harrison, 1999, using plant-level information for a cross section of Venezuelan industrial firms, present two main results. First, by analyzing foreign presence at the firm level, an increase in foreign equity participation is positively related to increases in performance for small firms. Second, productivity in domestically owned plants decreases when foreign involvement in the sector increases. This result suggests the existence of a negative horizontal spillover effect, interpreted as a competition, market-stealing, effect.

Focusing further on horizontal spillovers, which account for the presence of foreign firms on domestic entities operating within the same sector and which have been the main object

of earlier studies, Gorg and Greenway, 2004 and Girma and Gorg, 2005 highlight the importance of the characteristics of domestic firms in explaining the existence and sign of spillovers. Specifically, Gorg and Greenway, 2004, suggest that the positive impact of foreign presence is related to locational characteristics of host countries, in particular to the degree of local absorptive capacity and the level of technological innovation. Girma and Gorg, 2005, examine this issue empirically using establishment data for the UK, with quantile regressions, and show that there is a U-shaped relationship between absorptive capacity and productivity spillovers from regional FDI. Results related to spillovers from foreign firms outside the region are the opposite, hinting towards the importance of the definition of the boundaries within which spillovers are accounted for.

Javorcik, 2004 moves beyond horizontal spillovers and examines the effect of foreign presence in down- or up-stream markets, thus focusing explicitly on vertical spillovers, which are currently considered more relevant than horizontal spillovers. In her analysis of Lithuanian firms, the author finds significant positive vertical spillover effects arising from backward linkages (from foreign buyers to local suppliers) between foreign and domestic firms. No significant effects are instead found when analyzing forward vertical linkages (from foreign supplies to local buyers) or within the same industry. A similar finding related to vertical backward spillovers is confirmed, for Mexican firms, by Jordaan, 2008, who further suggests that the motivation of the positive effect of foreign presence lies within the existence of large technological differences and geographic concentration of industries. Further, results suggest the importance of regional characteristics in determining the existence and sign of a vertical spillover effect, suggesting once again the importance of spatial factors. Barrios et al., 2011 point to a possibility of misspecification of previous studies which rely on a measure of spillovers that uses the share of foreign output in a given sector and the relation to other sectors is measured with input-output

tables of the host country. The authors suggest that sign and statistical significance of spillovers may be influenced by this definition, and propose the use of input-output tables of the home, and not host, country of the multinational. This new measure is tested with data from Irish firms and the main finding is that no spillover effects are found when using the standard measure, while positive and significant vertical spillovers from foreign presence arise when using the newly proposed measure. This finding suggest the importance of properly defining the links and nexuses between upstream and downstream sectors in evaluating vertical spillover effects.

For a recent overview of this burgeoning literature, see Havranek and Irsova, 2011, which in particular highlight, by means of meta-analysis and controlling for publication bias, the importance of positive and significant vertical backward spillovers, while spillover to buyers, albeit present, are smaller in magnitude.

The role of space and distance has also been considered in shaping the sign and magnitude of spillovers. Jensen, 2004 and Driffield, 2006 highlight the local dimension of spillovers for domestic firms in the Polish food industry and in manufacturing in the UK, respectively. Jensen, 2004 focuses on horizontal regional spillovers and highlights the predominance of a market-stealing effect, while Driffield, 2006 finds a combination of negative industry-level spillovers and positive regional spillovers. Crespo et al. 2009 broadly confirm these result for Portuguese firms, finding negative horizontal spillover effects and positive vertical spillover effects through backward linkages, when foreign presence is considered at the regional level. Girma and Wakelin, 2007 focus in particular on the regional dimension, finding significant horizontal and vertical spillovers for UK domestic firms in the electronics sector only if foreign firms are accounted for within regional boundaries. Halpern and Murakozy, 2007 examine instead the role of increased

distance between foreign and domestic firms in determining the strength of the spillover effect.

Focusing on the electricity sector, while FDI spillovers have not been analyzed explicitly in the literature, the generic role of foreign presence on different dimensions of the host country's economy has been considered. Jaraitė and De Maria, 2012, by using sector-specific aggregate data for several EU countries, examine the determinants of productivity in electricity generation. Among other independent variables, foreign presence through the share of FDI inflows is found to positively influence productivity and environmental efficiency. Blackman and Wu, 1997 analyze the impact of FDI on the economic efficiency of China's power sector. Their results suggest the existence of a positive effect, related to the more advanced generating technologies of foreign firms with respect to domestic firms. While the latter two results suggest the potential for positive spillover effects from foreign firms in the electricity sectors, Lam and Shiu, 2001, fail to find a significant effect of foreign presence on China's productivity in electricity generation. A more detailed analysis which may shed some light on these mixed findings is provided in Lesher and Miroudot, 2008. The authors provide estimates of foreign spillovers by performing sector-specific regressions on firm level data and report the existence of positive vertical (both through forward and backward linkages) spillover effects in the aggregate sector of production and distribution of electricity, gas and steam, while also detecting negative and significant horizontal spillovers from foreign presence.

As this brief overview has shown, while evidence, albeit mixed, on spillovers in manufacturing sectors is relatively abundant, an empirical investigation for the electricity sector, both at the aggregate and finer industrial disaggregated level, is missing and is the object of the present paper. A further contribution of the present paper is related to the explicit analysis of the role of spatial aggregation and distance issues, using both

administrative boundaries and physical distance, in a fairly homogenous sectoral setting, by using both aggregated and disaggregated sector data, but with wide cross-country variation. As a relevant portion of studies on foreign spillovers are based on single-country (or groups of rather similar countries) studies, mainly because of data availability, the EU-wide focus should allow a more precise evaluation of the existence, sign and magnitude of foreign spillovers in the electricity industry.

3. Empirical model and data

The empirical analysis is performed in two steps. In the first, a summary productivity measure is computed for each firm, by using the Levinsohn and Petrin methodology[3] for computing TFP as the residual of a firm-level production function (Levinsohn and Petrin, 2003) with data from 2002 to 2009. In the second step, productivity of domestic firms is regressed against FDI spillovers (main explanatory variable) and a set of firm-level determinants (control variables) for a cross-section of EU firms in 2009. Firm specific variables include a measure of firm size (total assets) and leverage, computed as the share of liabilities over total assets, to control for a firm's financial structure. Both variables are expected to be positively related to productivity as larger firms may take advantage of economies of scale and higher leverage may indicate a firm's openness to market investors and be related to higher productivity in a financial efficiency argument. A dummy variable which takes oin value one when the firm is publicly owned is also included. Estimation is carried out by OLS with standard errors clustered by country.[4]

With respect to the first step, TFP is estimated as the residual from a firm-level production function by means of the Levinsohn and Petrin estimation methodology to overcome issues of simultaneity of TFP levels (observable to the firm) and input level choices by using intermediate inputs as an instrumental variable. The production function to be estimated is the following:

(1) $y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + a_{it} + u_{it}$

where *y*, operating revenues, is the measure of output, *k* are tangible fixed assets, *l* employees and *m* material costs, a proxy for intermediate inputs used in the production process. The terms *u* represents the true, i.i.d. error term, while *a* represents unobserved productivity which can be expressed as a function of observable capital and intermediate inputs. The Levinsohn and Petrin methodology relies on semi-parametric techniques and uses firms' intermediate inputs as a proxy for unobserved (by the firm) productivity shocks. Lower-case letters in Equation 1 refer to natural logarithms, while subscript *i* refers to firms and *t* to time. Estimation is carried out for the 2002-2009 period for which firm-level balance sheet data is available, to fully exploit the panel dimension and better address the simultaneity issues, and separate regressions are performed in the NACE Rev. 2[5] 3-digit subsectors to account for sector-specific technological features.

In the second stage, the following specification for 2009 is considered:

(2) $TFP_i = \beta_0 + \beta_s Spill + \beta_{Xi} X_i + \beta_{Xc} X_c + u_{it}$

where *TFP* is firm-level productivity obtained in the first stage with the Levinsohn and Petrin methodology, *Spill* is a measure of foreign spillovers, as defined below in equations 3-5, X_i is a matrix of the previously described firm level controls which include total assets, public ownership and leverage, X_c is a matrix of country-level controls including consumer price levels and generation capacity of fossil fuels. Equation 2 is estimated in the aggregate and disaggregated segments[6] of the industry separately, and corresponding empirical results are presented in the following sections.

The firm-level data used in this analysis is taken from the Amadeus database (Bureau Van Dijk), which provides yearly balance-sheet data for European private and public firms, as reported to the national registers. The variables considered in the empirical analysis are operating revenues, the number of employees, total assets and tangible fixed assets,

material costs, and total liabilities (2002-2009). Ownership data (2009) allows the identification of the ultimate owner (defined as the independent shareholder of a firm with the highest direct percentage of ownership) for each firm, which is then classified, according to the country of origin, as foreign or domestic, and private or public, depending on the involvement of national or local governments. For each firm, the information on the city and region in which it operates is used to define the spatial dimension of FDI spillovers. Entries with obvious keypunch errors are corrected, while firms without ownership information are dropped from the sample. Country-specific price levels and generation capacity of combustible fuels are taken from Eurostat (2009). In detail, electricity prices are those paid by household consumers net of tax (in euro per kWh) [7] while generation capacity is measured as national electricity capacity of the main activity producers with respect to combustible fuels and is measured in Megawatts.

The dataset is comprised of 907 firms in 2009. The firms in the sample are operating in the electricity sector (351) according to the NACE Rev.2 classification. A further sectoral breakdown shows that 61% (n°=551) of firms declare, as primary activity, the generation of electricity (3511, NACE Rev. 2 classification), 7% (n°=68) declare transmission (3512) and 32% (n°=288) operate in the distribution sector (3513). There are 176 foreign firms, of which 79% (n°=139) are in the generation sector, 5% (n°=8) in transmission and 16% (n°=29) in distribution.

To quantify the impact of foreign presence on domestic firms' productivity, a measure of FDI spillovers is computed, first based on administrative boundaries, then on geographic distance. The presence of foreign firms is accounted for by considering the share of total foreign operating revenues over total operating revenues,[8] at the relevant spatial scale. When considering regional spillovers, foreign firms are considered within the administrative NUTS2[9] boundaries, while the distance-based spillover is computed by

considering, for each firm, foreign presence at a distance of 100, 250 and 500 kms and based on a distance decay matrix.

In detail, regional spillover effects are computed as the share of foreign operating revenues over total operating revenues in the same industry (horizontal spillovers) or in the upstream (vertical forward spillovers) or downstream (vertical backward spillovers) industry.

(3) $$\mathrm{HS}_{j,r} = \frac{\sum_i F_{i,j,r} OR_{i,j,r}}{\sum_i OR_{i,j,r}}$$

(4) $\text{Vertical Spillover}_{j,r} = \text{Horizontal Spillover}_{k \neq j,r}$

where F is a dummy variable taking on value one if the firm's ultimate owner is foreign, zero otherwise; OR are operating revenues and subscript r refers to the NUTS2 region, j to the sector considered (aggregate electricity, generation segment, distribution segment), i to individual firms.

When considering alternative spatial disaggregation, the spillover effect is computed by considering distance-based weight matrices. Distance is calculated between the cities[10] in which firms operate. The georeferentiation of the firm-level dataset allows to distinguish between 890 European cities. In the first alternative specification, the inverse of a distance matrix based on geographic distance, in km (D_{km}), between city pairs is considered. In the second specification, the inverse of a distance matrix, with a 100 km radius (D_{100}), is considered. In the Appendix, the 250 and 500 km radiuses are considered.

(5) $$\mathrm{HS}_{j,r} = \sum_k \frac{1}{D_{i,k}} \frac{F_{k,j,r} OK_{k,j,r}}{\sum_i OR_{i,j,r}}, \forall k \neq i;$$

where c refers to cities.

When foreign presence is accounted for by the number of foreign firms (Table A.3), spillovers are computed in the following way:

(6) $\text{HorizontalSpillover\_km\_n}_{c,r} = D_{km}^{-1} \sum_{i,\forall i \in j} nF_{ic}$; $\text{HorizontalSpillover\_100\_n}_{c,r} = D_{100}^{-1} \sum_{i,\forall i \in j} nF_{ic}$

where *nF* is the number of foreign firms in a given sector.

Table 1 shows some descriptive statistics highlighting the differences between domestic and foreign firms. Foreign firms are, on average more productive than their domestic counterparts in the disaggregated electricity sectors, and this difference is statistically significant at the 1% and 5% level in generation and distribution, respectively. Foreign firms are also characterized by significantly higher leverage,[11] both in the aggregate electricity sector and in the generation segment. On the contrary, foreign firms do not appear to significantly differ from domestic firms in terms of size, measured by total assets.

	Electricity		Generation		Distribution	
	Foreign	*Domestic*	*Foreign*	*Domestic*	*Foreign*	*Domestic*
TFP	6.098	5.951	5.779***	5.318	6.665**	6.283
Total Assets	715738	529238	832229	610167	311707	365191
Leverage	0.609**	0.563	0.635**	0.582	0.510	0.534

Table 1. Foreign vs. Domestic: descriptive statistics
Source: own elaboration on Amadeus data, 2009
*** Difference significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table 1 here]

4. Horizontal regional spillovers

Foreign presence is first considered within the sector (horizontal spillovers) and inside administrative regional boundaries. The choice of selecting administrative regional boundaries is suggested by the local dimension of electricity firms' service area, which in Europe is traditionally at the regional level (see for example Filippini and Wild, 2001 and Glachant and Finon, 2003).

The main results of this section can be summarized as follows:

- No significant horizontal regional FDI spillovers are found in the aggregate sector and in the generation segment;
- Positive and significant horizontal regional FDI spillovers are found instead in distribution.

Starting from the aggregate electricity sector (the 2-digit 351 sector, according to the NACE Rev.2 classification), Table 2 shows results of estimation of equation 2. Results highlight conclusions regarding the relationship between domestic firms' productivity, measured by the Levinsohn-Petrin TFP indicator described in the previous section, and the presence of foreign firms in the region where the firm is located. Here spillovers are computed as in equations 3 and 4, on the basis of administrative regional boundaries, using the NUTS2 classification. Additional independent variables, including firm- and country-level controls along with 3-digit NACE Rev.2 sector fixed effects, are added one at a time.

Electricity Dep. Var. TFP	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Horizontal spillover	-1.608	-1.296	-1.064	0.204	0.546	0.377	0.513
	0.110	*0.205*	*0.306*	*0.669*	*0.218*	*0.382*	*0.222*
Public Ownership		0.321*	0.328*	0.045	0.040	0.055	0.045
		0.074	*0.067*	*0.519*	*0.580*	*0.489*	*0.553*
Total assets (ln)	0.425***	0.409***	0.410***	0.416***	0.405***	0.408***	0.406***
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Leverage (ln)			0.125	0.132*	0.097	0.116	0.097
			0.103	*0.087*	*0.203*	*0.130*	*0.203*
Electricity Prices (ln)					0.739***		0.539
					0.001		*0.105*
Generation capacity (ln)						0.113***	0.049
						0.002	*0.291*
Sector fixed effects	*no*	*no*	*no*	*yes*[a]	*yes*[a]	*yes*[a]	*yes*[a]
Constant	1.437***	1.425***	1.495***	4.306***	6.072***	3.329***	5.155***
	0.002	*0.001*	*0.001*	*0.000*	*0.000*	*0.000*	*0.001*
Observations	731	731	726	726	706	726	706
F-test	98.352***	104.763***	81.145***	456.163***	854.050***	569.606***	1,058.946***
Adj. R^2	0.39	0.40	0.40	0.82	0.83	0.82	0.83

Table 2. Horizontal regional spillovers-Electricity

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level. [a] Jointly significant at the 1% level

[insert Table 2 here]

Coefficients for firm specific controls are remarkably stable across specifications, along with the coefficient associated to the dichotomous variable related to public ownership, which takes on value one if the firm's ultimate owner is public, zero if it is private. In detail, the estimated coefficients indicate that higher productivity levels are associated with larger firms, characterized by higher total assets, and those with higher levels of leverage,[12] although this latter effect is smaller in magnitude with respect to the former (average of significant coefficients across specifications of 0.13 against 0.41), and barely significant (significant at the 10% level only in columns 3 and 4 of Table 2). With respect to public ownership, public domestic firms are associated with higher productivity levels with respect to their private counterparts only in specifications in which only country- and sector-level controls are excluded (columns 2 and 3 of Table 2), with a relatively high coefficient of around 0.32. The estimated coefficient becomes however insignificant when sector specific fixed effects (columns 4-7 of Table 2) are added, suggesting that the productivity differences associated with domestic public ownership are sector-specific. This issue is further explored below, where a finer industrial disaggregation is used (sections 4.1 and 4.2). The inclusion of industry fixed effects from column 4, Table 2, onwards causes the adjusted R-squared to increase considerably, suggesting that the two sub-sectors present relevant idiosyncratic characteristics, and present evidence in favor of a further disaggregated sectoral breakdown (see following sections).

Considering instead the relationship between domestic productivity and foreign presence, regional spillovers in the aggregate electricity sector, at the 3-digit NACE Rev. 2 level, are not statistically significant. While foreign firms are on average more productive than domestic firms in the aggregate electricity sector (see Table 1), there does not seem to be a significant spillover effect in terms of productivity, when administrative regional boundaries are considered. This result appears in line with the recent findings surveyed in

section 2, which suggest that horizontal spillover effects, at this level of industrial aggregation, are not present.

In columns 5 to 7 of Table 2, additional country level variables, also related to the specific characteristics of the generation and distribution segments of the industry, are considered. In column 4, the log of national electricity prices for household consumers net of tax (in euro per kWh) is considered, to account for structural cross-country differences in prices of the final product. This variable should be particularly relevant in the distribution segment, and will be used in the analysis of this sub sector (see below). The estimated coefficient of 0.74 is positive and significant, suggesting that higher prices are associated, on average, with higher levels of productivity. The second country level variable considered is the log of national electricity capacity of the main activity producers with respect to combustible fuels. This variable, especially relevant for the generation segment, accounts for the size and partially for the composition of generation sources of countries in the sample.[13] The relationship with domestic firms' productivity is positive, with an estimated coefficient of 0.11, indicating both the importance of the size of the market and the fact that combustible fuels, while presenting environmental issues, are potentially less costly in purely monetary terms. Results are confirmed when both variables are included together, although the coefficient of capacity loses statistical significance.

4.1 Electricity generation

Zooming in on the electricity generation sub-sector, corresponding to the 3-digit NACE Rev.2 3511 sector (Table 3), results clearly indicate the absence of a correlation between foreign presence and domestic firms, when foreign spillovers are accounted for considering the regional administrative boundaries, both without and with additional firm- and country-level controls.

Generation Dep. Var. TFP	(1)	(2)	(3)	(4)
Horizontal spillover	-0.193	-0.176	-0.168	-0.114
	0.383	*0.439*	*0.461*	*0.505*
Public Ownership		0.078	0.083	0.087
		0.480	*0.442*	*0.461*
Total assets (ln)	0.369***	0.365***	0.366***	0.361***
	0.000	*0.000*	*0.000*	*0.000*
Leverage (ln)			0.051	0.036
			0.501	*0.634*
Generation capacity (ln)				0.092*
				0.072
Constant	1.401***	1.409***	1.429***	0.509
	0.000	*0.000*	*0.000*	*0.305*
Observations	412	412	409	409
F-test	260.439***	187.070***	148.934***	150.327***
Adj. R^2	0.62	0.62	0.62	0.63

Table 3. Horizontal regional spillovers: Generation

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table 3 here]

The coefficients of the other firm-level controls are in line with the general findings (Table 2), with larger firms, in terms of total assets, associated to higher productivity levels, on average, with an estimated coefficient of the order of 0.36. Leverage, on the contrary, does not appear as particularly relevant in this industrial context. Public or private ownership does not appear to be significantly correlated with TFP levels in this industry, as the coefficient associated to the ownership variable is never statistically significant (from columns 2 onwards in Table 3). Moving on to country-level variables, generation capacity of main producers with respect to combustible fuels is considered, since the mix of sources, at the national level, used in electricity generation activities, may be related to firm-level productivity. As before (Table 2, column 6), capacity is positively related to domestic productivity, with a coefficient of 0.10.[14]

4.2 Electricity distribution

Table 4 shows the results of estimation in the distribution sub-sector, corresponding to the 3-digit NACE Rev.2 3513 sector, which differ considerably from those for the generation sector (Table 3).

Distirbution Dep. Var. TFP	(1)	(2)	(3)	(4)
Horizontal spillover	0.397***	0.362**	0.367**	0.391**
	0.003	*0.013*	*0.041*	*0.025*
Public Ownership		-0.125**	-0.155**	-0.169***
		0.045	*0.029*	*0.006*
Total assets (ln)	0.489***	0.492***	0.487***	0.474***
	0.000	*0.000*	*0.000*	*0.000*
Leverage (ln)			0.243**	0.210*
			0.033	*0.053*
Prices (ln)				0.727***
				0.004
Constant	1.087***	1.141***	1.394***	3.061
	0.000	*0.000*	*0.000*	*0.595*
Observations	259	259	257	257
F-test	273.977***	227.055***	219.093***	273.482***
Adj. R^2	0.75	0.75	0.77	0.79

Table 4. Horizontal regional spillovers: Distribution
Notes: OLS estimation, p-values clustered by country in italics.
*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table 4 here]

Higher TFP of domestic firms is positively associated with foreign presence, as documented by the positive, and statistically significant, coefficient of regional horizontal spillovers in columns 1-4. This result is in line with the local monopoly nature of the distribution sector (Filippini, 1998; and Saplacan, 2008, for a critical perspective on the issue) which might have prevented, in the past, the achievement of high levels of efficiency and economic performance of domestic incumbents and success of productivity enhancing policies. The liberalization of the sector has exposed domestic actors to international management and innovation practices, potentially conducive to increases in the domestic productivity levels. The local monopoly hypothesis is also supportive of the

definition of the geographic scale of spillovers, here computed at the regional, NUTS2 administrative level. The magnitude of the coefficient, statistically significant across all specifications, is quite large, especially with respect to those associated to other relevant independent variables, ranging from 0.36 to 0.4.

Focusing on ownership, from column 2 onwards, domestic public ownership is negatively related to productivity, with an estimated coefficient between 0.13 and 0.17. Differently from the generation segment (Table 3), the ownership effect seems to dominate the purely sector-specific effect. A further reading of this result related to the local monopoly hypothesis suggests that, prior to the reform process in the EU, national firms, mainly publicly owned, were acting as monopolists at the regional level and were characterized by economic efficiency (as documented by the average high levels of productivity in public firms, compared to their private domestic counterparts, Table A.1). The liberalization of the market, allowing the entry of foreign competitors, may thus be negatively affecting domestic public firms, now forced to face efficient competitors.[15] The entry of more efficient foreign firms is however exerting, per se, a positive productivity spillover effect.

Considering firm-level characteristics, firms with higher levels of total assets and firms with higher leverage are significantly associated with higher productivity, in line with previous results, both in terms of sign and of relative magnitude of coefficients. The country-level information considered in the distribution segment of the industry is related to the prices to consumers firms are able to charge to consumers which are likely related to firm-level productivity. Estimation results suggest that higher consumer price levels are associated to higher productivity, as expected.

5. Vertical regional spillovers

Firms in the segments of the electricity industry considered are likely to be influenced by the presence of foreign firms not only in their specific sub-sector, as in section 4, but also

by those in up- or down-stream sub-sectors. Firms active in generation will thus be likely affected by those in the downstream distribution sector, as distribution firms will be by those in the upstream generation segment.

The main results of this section can be summarized as follows. Vertical regional FDI spillovers are:

- significant and negative in the generation segment
- significant and positive in distribution.

To examine this issue formally, vertical spillovers are added to the empirical model in the generation and distribution segments, in Table 5. Results related to horizontal spillovers are substantially unchanged with respect to section 4, while the results for inter-sector interrelations suggests interesting implications. Results related to firm- and country-level controls are comparable to those previously commented on in section 4, to which the interested reader is referred to.

Dep. Var. TFP	Generation (1)	Distribution (2)
Horizontal spillover	-0.088	0.354*
	0.593	*0.067*
Vertical spillover	-0.315**	0.149*
	0.031	*0.051*
Public Ownership	0.067	-0.169***
	0.538	*0.007*
Total assets (ln)	0.358***	0.476***
	0.000	*0.000*
Leverage (ln)	0.018	0.217*
	0.814	*0.052*
Generation capacity (ln)	0.098*	
	0.052	
Prices (ln)		0.770***
		0.003
Constant	0.498	3.095***
	0.310	*0.000*
Observations	409	257
F-test	145.239***	234.128***
Adj. R^2	0.63	0.79

Table 5. Vertical regional spillovers: Generation and Distribution

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table 5 here]

When considering firms in the electricity generation sector (Table 5, column 1), the vertical spillovers considered are those arising, through backward linkages, from the distribution segment of the electricity industry. As in the previous section, horizontal spillovers are not significant, while backward vertical spillovers are characterized by a negative and significant estimated coefficient of around -0.32. TFP levels of domestic firms in electricity generation are thus negatively related to foreign presence in the distribution sector. These results are not fully in line with previous literature where backward spillovers are mainly found to be positive (see, for example, Marcin, 2008; Kugler, 2006, Javorcik, 2004). A possible explanation of the results presented in this section can however be put forward: most of the cited studies on vertical spillovers have considered several manufacturing industries at the 2-digit level. This paper, instead, focuses on a specific 2-digit sector, electricity, and breaks it down in its 3 digit sub-sectors. The specific nature of the industry may thus be related to the findings in terms of the association between domestic firms' productivity and foreign presence between sub-sectors. Specifically, foreign firms in the distribution sector may have commercial agreements with other foreign generating firms, not necessarily located in the same regions, which might thus be direct competitors for domestic firms in generation.

Forward vertical spillovers are instead analyzed in column 2 of Table 5, where the relationship between foreign presence in the generation segment of the industry and domestic productivity in the distribution segment is considered, along with the usual set of controls, including horizontal spillovers. As in the previous section, results related to firm-level controls, public ownership and horizontal spillovers are unchanged with respect to those presented in Table 4.

Considering instead vertical forward spillovers, these might be relevant as the link between generation and distribution in the electricity sector is quite strong, and actual unbundling of the two activities is the result of the recent reform wave at the EU level which is still ongoing. Contrary to results for domestic firms in generation (column 1 of Table 5), however, vertical spillovers are positive and statistically significant in column 2 of Table 5. A potential explanation for this result may be related to the above-mentioned incomplete unbundling of generation and distribution activities. Foreign firms active in generation may, on the one hand, be active, within regional boundaries, at the same time in distribution, and the inter-sectoral spillover is equivalent to a horizontal spillover. Another explanation is related instead to the possibility that foreign firms in generation may establish commercial ties and contracts with domestic distributors, thus contributing to higher productivity levels. Both these explanations are difficult to verify empirically with the current dataset and are left for future research. The magnitude of the estimated coefficient of vertical spillovers (0.15), is however lower than the one related to horizontal spillovers, possibly suggesting a more relevant role for horizontal spillovers. While this result appears in contradiction with findings in the literature surveyed in section 2, a possible reading suggests the importance of industrial disaggregation, here at the NACE REV.2 3-digit level, while most of the surveyed studies were at most at the 2-digit level, in enhancing the possibility of detecting significant spillover effects from foreign presence.

6. Distance matters: spillovers at different geographic scales

In this section, potential productivity spillovers from foreign presence are accounted for by moving beyond administrative regional boundaries and by considering instead just physical distance by means of alternative spillover measures.

The main results of this section can be summarized as follows. When considering geographic based FDI spillovers:

- horizontal spillovers in the aggregate sector and in generation are mainly insignificant or, in few specifications, negative, and distance does not change these results. In distribution, instead, they are positive and decreasing with distance.
- vertical spillovers in generation are insignificant (or negative when based on the number of foreign firms) while they are positive and decreasing with distance in distribution.

The first spillover measure considered in this section is based on a distance weight matrix, where for each city in which firms operate, the presence of foreign firms is evaluated by considering the inverse of distance. This measure thus accounts for the potential foreign spillovers on domestic productivity in all locations in the sample, but their importance is inversely related to physical distance by city pairs. The second measure is based instead on the definition of a distance threshold above which the presence of foreign firms is ignored. In the tables presented in this section, the cut-off values is of 100 km, while in the Appendix (Table A.2) the cut-offs of 250 and 500 km, respectively, are considered.

The main goals of this analysis are, first, to verify whether the association between domestic firms' productivity and foreign presence in the European electricity sector is dominated by administrative regional boundaries, thus suggesting the predominance of a regional market and policy dimension and, second, if the role of distance, if any, varies across different segments of the industry. The results of this empirical exercise may help better understand the dynamics of the post-reform situation in this sector in the EU, and be of interest for the design of policies aimed at increasing overall domestic productivity, and for the selection of the appropriate spatial and administrative decision making level.

Since the different spatial disaggregation of spillovers does not alter significantly the estimated coefficients of other controls, a thorough comment is not provided here and the discussion of their magnitude and significance can be found in the previous sections.

Starting from the aggregate electricity sector (Table 6), and considering first the specification with the spillover measure and the firm-level size control, log of total assets, as in column 1 of Table 2, an interesting result emerges. While regional foreign spillovers, computed considering administrative boundaries (Table 2) were not statistically significant, considering a distance-weighted spillover measure yields significant results. In column 1 of Table 6, distance-weighted foreign presence is associated with negative productivity spillover effects, with a coefficient of around -0.61. This negative association between foreign firms and domestic productivity still holds when considering spillovers from firms located within a 100 km radius (column 3, Table 6), although the coefficient is relatively smaller.[16] However, when adding additional controls (columns 2 and 4, Table 6) no evidence of foreign spillovers is found, suggesting a greater role for firm, sector and country-specific variables in explaining domestic productivity levels. In particular, the insignificance of the regionally bounded spillover (Table 2) suggests that the appropriate economic dimension to be considered when analyzing the aggregate electricity sector, including generation, transmission and distribution, is not intrinsically at the NUTS2 level. The competition, or market-stealing effect related to foreign presence, based on purely geographic distance (columns 1 and 3, Table 6), may suggest that, on the one hand, the appropriate spatial scale at which competition effects of the liberalization process materialize is not intrinsically regional in nature. On the other, the negative sign seems to be signaling that domestic firms may be struggling in the competition with more productive foreign firms. This result is however not robust to the inclusion of additional controls and should thus be interpreted with caution.

	distance-weighted		100 km cut-off	
Electricity Dep. Var. TFP	(1)	(2)	(3)	(4)
Horizontal spillover	-0.606*	-0.032	-0.480**	-0.079
	0.072	*0.820*	*0.038*	*0.570*
Public Ownership		0.036		0.032
		0.627		*0.655*
Total assets (ln)	0.434***	0.403***	0.433***	0.403***
	0.000	*0.000*	*0.000*	*0.000*
Leverage (ln)		0.090		0.090
		0.259		*0.262*
Electricity Prices (ln)		0.504		0.498
		0.139		*0.144*
Generation capacity (ln)		0.052		0.053
		0.262		*0.262*
Sector fixed effects	*no*	*yes*[a]	*no*	*yes*[a]
Constant	1.437***	5.075***	1.355***	5.060***
	0.002	*0.001*	*0.002*	*0.001*
Observations	725	700	725	700
F-test	97.907***	915.635***	93.961***	913.216***
Adj. R^2	0.40	0.83	0.39	0.83

Table 6. Distance issues: Electricity

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level. [a] Jointly significant at the 1% level

[insert Table 6 here]

Moving on with sectoral disaggregation, interesting results emerge when analyzing domestic firms in generation (Table 7). Horizontal spillovers defined with the inverse distance matrix and based on the 100 km cut-off (as with the 250 and 500 km, see Appendix) are negative but insignificant, in line with regional spillovers (Table 3), both with and without additional controls.

Considering both horizontal and vertical spillovers at the same time, thus mirroring the specification in column 4 of Table 5, results related to horizontal spillovers are unchanged with respect to columns 1 and 2 of Table 7. Vertical spillovers from foreign firms in the distribution sector are not significant, albeit negative, when considering the distance decay

measure and the 100 km cut-off distance measure (column 3 and 4, Table 7), with similar results with the 250 and 500 km cut-offs (Table A.2). These findings seem to exclude the existence of foreign spillovers, both within and across sectors, for domestic firms in generation.

	distance-weighted		100 km cut-off	
Generation Dep. Var. TFP	(1)	(2)	(3)	(4)
Horizontal spillover	-0.135	-0.025	-0.180	-0.051
	0.531	*0.901*	*0.420*	*0.803*
Vertical spillover		-0.289		-0.294
		0.300		*0.301*
Public Ownership		0.079		0.074
		0.482		*0.495*
Total assets (ln)	0.373***	0.362***	0.372***	0.362***
	0.000	*0.000*	*0.000*	*0.000*
Leverage (ln)		0.023		0.023
		0.777		*0.772*
Generation capacity (ln)		0.094*		0.091*
		0.084		*0.087*
Constant	1.363***	0.481	1.362***	0.500
	0.000	*0.395*	*0.000*	*0.379*
Observations	407	404	407	404
F-test	192.083***	157.853***	199.536***	160.321***
Adj. R^2	0.62	0.62	0.62	0.62

Table 7: Distance issues: Generation

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table 7 here]

As a robustness check (Table A.3), an alternative definition of foreign presence is considered, based on the number of foreign firms. In this case, while the horizontal spillover measure based on the distance decay matrix is not significant, the spillover effect based the 100 km cut-off distance matrix (columns 3 and 4, Table A.3) is negative and highly significant. While this measure is less standard in the literature and does not account for the market share of foreign firms, the result lends itself to an interesting interpretation. The negative coefficient suggests the existence of a pure competition effect,

which may be linked to the competitive nature of the electricity generation sector, characterized by the first and most pervasive wave of reforms (see for example: Littlechild, 2002). In a competitive market, the presence of competitors, in this case foreign, is an indication of potential loss of market share and could also cause the disruption of market power, especially in a short/medium term horizon as in the case of the present analysis. An interesting conjecture is to examine whether this effect holds also in a longer term perspective and is left as an avenue for future research. With respect to vertical spillovers based on the number of foreign firms, only the coefficient associated with the distance decay matrix is significant and negative.

Horizontal spillovers, computed by considering once again the foreign share of operating revenues, for domestic firms in the distribution segment (columns 1 and 2, Table 8) are positive and significant with all distance-based spillover measures considered (Table A.2, for results related to the 250 and 500 km cut-off values). This finding is in line with results in Table 4, where the spillovers from foreign firms located within the regional boundaries were considered, suggesting that the sector effect dominates geographic distance issues in the distribution segment of the electricity industry. Domestic firms in this segment appear to potentially benefit, in terms of productivity, from foreign presence, and this result is independent of the level and type of spatial disaggregation adopted in the analysis.

With respect to vertical forward spillovers, evidence of a positive correlation between domestic productivity and foreign presence is confirmed when the distance decay measure is used (column 3, Table 8) and it remains positive and significant when the 100 km radius is considered, a result that is also confirmed with the 250 km and 500 km radius (Table A.2) suggesting that also vertical spillovers do not seem particularly affected by different spatial disaggregation. The sector effect, once again, seems to dominate the geographic effect in the distribution segment of the industry, although the magnitude of the coefficient

is slightly higher at the 100 km radius measure with respect to the distance decay spillover (and even more so when considering the 250 and 500 km radius, Table A.2), suggesting that distance does matter.

	distance-weighted		100 km cut-off	
Distribution Dep. Var. TFP	(1)	(2)	(3)	(4)
Horizontal spillover	1.109***	0.703***	1.048***	0.765***
	0.000	*0.004*	*0.000*	*0.005*
Vertical spillover		0.567*		0.565*
		0.048		*0.055*
Public Ownership		-0.136***		-0.139***
		0.001		*0.001*
Total assets (ln)	0.487***	0.467***	0.487***	0.468***
	0.000	*0.000*	*0.000*	*0.000*
Leverage (ln)		0.205*		0.199*
		0.066		*0.097*
Electricity Prices (ln)		0.683***		0.767***
		0.002		*0.001*
Constant	1.074***	2.903***	1.108***	3.155***
	0.000	*0.000*	*0.000*	*0.000*
Observations	258	256	258	256
F-test	319.692***	300.641***	311.149***	764.796***
Adj. R^2	0.75	0.80	0.75	0.80

Table 8: Distance issues: Distribution

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table 8 here]

To further explore this idea, in Figure 1 estimated spillover effects, all statistically significant, for the distribution segment of the electricity industry[17] are plotted according to the different levels of spatial disaggregation, with horizontal (vertical) spillovers represented by a dashed (continuous) line. A common feature of both types of spillover effects in the distribution segment is that focusing on administrative regional boundaries may lead to a possible underestimation of the positive correlation between foreign presence and domestic firms' productivity, with a higher misspecification in terms of magnitude for vertical spillovers. When focusing on spillovers computed with different distance weight matrices, distance issues are more relevant for horizontal spillovers, which

are maximized at the 100 km cut-off, suggesting that the positive effect of foreign presence may be highly localized and decreasing the farther away direct competitors are. The transmission channels at play in the electricity distribution industry may thus be those that are stronger at shorter distances, such as for example workers mobility or the role of supplier-buyer relations based on a small geographic market scale. Further exploration of this issue is left for further research. The irrelevance of this issue for vertical spillovers may hint towards the positive effect of the overall liberalization process at the EU level.

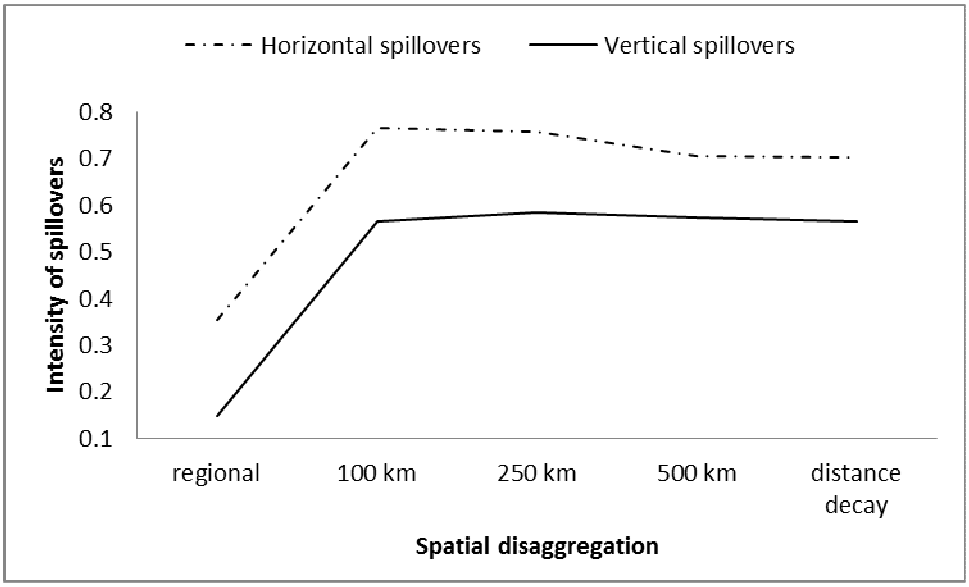

Figure 1. Distance matters in distribution

[insert Figure 1 here]

The general reading of the existence of positive horizontal and vertical spillover effects confirms the conjecture that the reform process aimed at opening and liberalizing a previously monopolistic and nation-specific sector might be related to increases in productivity for domestic firms.

7. Discussion and conclusions

Is increased foreign presence in the EU electricity sector, mainly due to the recent reform wave aimed at creating a single EU-wide electricity market, associated with higher productivity levels of domestic firms? Does space matter in shaping this relationship, if

any, in particular distinguishing between administrative regional boundaries and purely geographic distance? The analysis presented in this paper has shed light on these issues, also highlighting the role of industrial disaggregation. The first important conclusion of the empirical exercise is the following: the existence of significant spillover effects, at some of the considered industrial and spatial disaggregation, suggests that the recent EU-wide reform process of the electricity sector, aimed at creating a single market and at increasing efficiency and competition in a previously potentially distorted industry, is indeed correlated to variations in productivity of domestic firms. The entry of both private and foreign firms in national markets, previously dominated by public firms not exposed to competition, seems to have been potentially beneficial to the overall productivity of the market.

With respect to aggregation issues, two major results stand out: both industrial and spatial disaggregation matter. No unambiguous spillover effect is detected, unless the proper sector-specific and space related issues are taken into account. In the aggregate electricity sector, spillovers are relevant and negative only when firm-level and sector-specific controls are not added. This result is robust to different spatial scales, considering both regional boundaries and different distance-based weight matrices. While the negative spillover effect, present only when the single firm size control is added, may be an indication of a competition effect at play, the fact that it becomes insignificant with the addition of other relevant variables warrants caution in attributing particular relevance to this result.

A finer industrial disaggregation, at the 3-digit NACE Rev.2 level, however, gives rise to interesting and significant results. In the electricity generation sector, where the reform process started first and which is considered the most competitive segment of the industry, no evidence of horizontal foreign spillovers, based on the notion of foreign presence

computed as the share of foreign operating revenues over the total, can be found, irrespective of spatial disaggregation and distance measures. Considering instead the distance weighted number of foreign firms, a competition effect emerges, and this effect is significant when considering the presence of foreign firms within a specified radius (from 100 to 500 km). Spillovers from foreign presence for domestic firms in electricity generation could thus be related to a pure market competition effect and be directly influenced by the number of competitors. This result can be framed in a competition argument, suggesting that domestic firms in generation might suffer from the presence of foreign competitors and, at least in the short run, lose market shares and sales volumes, leading to lower productivity. Considering instead backward vertical spillovers, foreign firms in the downstream distribution sector seem to exert a negative effect only when their presence (both in terms of share of operating revenues and number of firms) is accounted for within administrative regional boundaries. This finding suggests that existing commercial agreements and the presence of foreign firms that are active in both sectors (i.e. generation and distribution) are mainly regional in nature and that just geographic distance is irrelevant. The fact that only the regional dimension appears to give rise to significant, negative, spillover effects from foreign distribution firms to domestic generation firms suggests that the ties between the two segments of the industry are relevantly regional in nature. The possibly incomplete process of unbundling still reflects the regional dimension of policies and the local monopoly nature of the distribution sub-sector. In the generation segment it can be thus concluded that spatial disaggregation matters (although for horizontal spillovers the effect is only significant when foreign presence is accounted for by the number of foreign firms), and that the relevant spatial scale for detecting the existence of vertical spillovers is at the regional, NUTS2, level.

In the electricity distribution sector, characterized by a local monopoly nature, results are quite different. Focusing on spillovers based on the foreign share of operating revenues, horizontal spillovers are always positive and statistically significant, both when considering the regional dimension and accounting for distance issues. The magnitude of the estimated coefficient is higher when considering distance weight matrices, suggesting that in this segment the positive foreign spillover on domestic firms' productivity is enhanced by physical vicinity, and is decreasing with distance. Foreign firms may be characterized by more efficient management and commercial plans, and contiguity and workers' mobility may enhance the possibility, for domestic firms, to benefit from this exposure. The local monopoly nature reinforces this line of reasoning, as liberalization and foreign entry may have paved the way for greater competition and efficiency in the sector. Vertical forward spillovers, from foreign firms in generation, are similarly positive and significant, highlighting once again the possibility of an incomplete process of unbundling. In the distribution segment, it appears that the sector effect is dominating the spatial effect, and foreign presence is positively related to domestic productivity.

Overall, empirical results suggest that both industrial and spatial disaggregation matter when evaluating the existence and sign of foreign firms for domestic firms in the electricity sector. While at the aggregate electricity sector level there is some evidence of a barely significant negative spillover effect, if any, sector specifities at a finer industrial disaggregation yield significant results. The spatial disaggregation appears particularly relevant in the generation sector, where negative vertical spillovers arise only within regional boundaries. In contrast, positive horizontal and vertical spillover effects in the distribution sector are distance-related, increasing in magnitude the closer the presence of foreign firms is. These findings may be read in terms of considering the relevant industrial aggregation level and appropriate spatial scale to evaluate the impact of liberalization and

foreign entry, on the one hand, and to specify relevant economic policies aimed at fostering firm level productivity, ultimately moving towards greater consumers' welfare levels.

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Appendix

A.1 The Levinsohn and Petrin estimator

Estimation of TFP from contemporaneous input and output levels may be biased due to simultaneity problems arising from the correlation between inputs and unobserved idiosyncratic productivity shocks. One solution put forward by Levinsohn and Petrin (2003) relies on the use of intermediate inputs as an instrument for the capital input. The method is performed in two steps. In the first, the firm's production function to be estimated is:

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_t t_t + \omega_t + \eta_t$$

where *l, k* and *t* are labor, capital and intermediate inputs. ω represents the transmitted component of productivity shocks, which impact on firms' decision processes and η, an i.i.d . productivity component.

The first step leads to consistent estimation of β_l.

In the second step, assuming that intermediate inputs are a function of capital and the transmitted productivity shocks () and that monotonicity holds, so that can be expressed as a function of intermediate inputs and capital, the production function to be estimated is:

$$y_t^* = \beta_0 + \beta_k k_t + \beta_t t_t + E[\omega_t \mid \omega_{t-1}] + + \eta_t^*$$

where $y_t^* = y_t - \beta_l l_t$, using results of the first stage, and $\eta_t^* = \xi_t - \eta_t$

Regressing y_t^* on the capital input and the expected value of ω conditional on its previous period value, produces a consistent estimate of the coefficient on capital, β_k.

In the actual implementation of the procedure, suitable proxies for intermediate inputs include material costs.

A.2 Additional Empirical Analysis and Tables

	Electricity		Generation		Distribution	
	Private Domestic	*Public Domestic*	*Private Domestic*	*Public Domestic*	*Private Domestic*	*Public Domestic*
TFP	5.537	6.283***	5.075	5.638***	6.172	6.321
Total Assets	519741	536840	644660	564822	252895	403592
Leverage	0.597***	0.536	0.619***	0.534	0.532	0.535

Table A.1:Private domestic vs. public domestic: descriptive statistics
Source: own elaboration on Amadeus data, 2009
*** Difference significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.

[insert Table A.1 here]

	Electricity		Generation		Distribution	
	250 km	500 km	250 km	500 km	250 km	500 km
Dep. Var. TFP	(1)	(2)	(3)	(4)	(5)	(6)
Horizontal spillover	-0.060	-0.053	-0.692	-0.042	0.759***	0.706***
	0.680	*0.718*	*0.049*	*0.839*	*0.005*	*0.004*
Vertical spillover			-0.298	-0.302	0.584**	0.573**
			0.297	*0.289*	*0.040*	*0.042*
Public Ownership	0.034	0.035	0.075	0.076	-0.135***	-0.134***
	0.644	*0.640*	*0.496*	*0.494*	*0.001*	*0.001*
Total assets (ln)	0.403***	0.403***	0.362***	0.362***	0.468***	0.468***
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Leverage (ln)	0.090	0.090	0.023	0.022	0.201*	0.205*
	0.261	*0.261*	*0.776*	*0.781*	*0.093*	*0.087*
Generation capacity (ln)	0.053	0.053	0.092*	0.093*		
	0.257	*0.252*	*0.082*	*0.082*		
Electricity Prices (ln)	0.500	0.501			0.723***	0.685***
	0.141	*0.139*			*0.001*	*0.002*
Sector fixed effects	*yes*[a]	*yes*[a]				
Constant	5.059***	5.058***	0.494	0.490	3.042	2.947
	0.001	*0.001*	*0.380*	*0.382*	*0.000*	*0.000*
Observations	700	700	404	404	256	256
F-test	919.897***	924.585***	159.094***	158.700***	401.440***	291.460***
Adj. R^2	0.83	0.83	0.62	0.62	0.80	0.80

Table A.2: Distance issues: Generation and Distribution

Notes: OLS estimation, p-values clustered by country in italics.

*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level. [a] Jointly significant at the 1% level

[insert Table A.2 here]

	distance-weighted		100 km cut-off	
Generation Dep. Var. TFP	(1)	(2)	(3)	(4)
Horizontal spillover	-0.018	0.014	-0.709***	-0.720**
	0.391	*0.193*	*0.013*	*0.014*
Vertical spillover		-0.248**		-0.589
		0.016		*0.777*
Public Ownership		0.083		0.076
		0.489		*0.466*
Total assets (ln)	0.373***	0.356***	0.374***	0.365***
	0.000	*0.000*	*0.000*	*0.000*
Leverage (ln)		0.038		0.044
		0.628		*0.582*
Generation capacity (ln)		0.080		0.099*
		0.127		*0.082*
Constant	1.340***	0.690	1.347***	0.425
	0.000	*0.209*	*0.000*	*0.474*
Observations	411	408	411	408
F-test	227.949***	183.840***	202.276***	146.981***
Adj. R^2	0.62	0.63	0.62	0.63

Table A.3: Distance issues: Spillovers based on number of foreign firms: Generation
Notes: OLS estimation, p-values clustered by country in italics.
*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.
[insert Table A.3 here]

[1] The transmission segment of the industry is considered only in the aggregate electricity sector analysis and not on its own because of the limited number of firms in each country, the monopoly nature of its operations, and the scarce foreign presence.

[2] Knowledge spillovers, or technological externalities, typically examined by means of a knowledge production function, stemming from foreign direct investment (FDI) have been the object of a lively literature, which is however outside the scope of this paper. For a review see Keller, 2004 and Audretsch and Feldman, 2003.

[3] See the Appendix for an overview of the methodology.

[4] The empirical analysis is based on a cross-section as ownership data is available only for 2009. While this issue clearly represents a limitation, several steps have been taken to minimize potential misspecification. In particular, TFP estimation is carried out by exploiting the full set of time-varying data and firm-level variables are included in the second step to account for firm heterogeneity. Country-level variables and sector specific controls, when appropriate, are also included to increase the reliability of estimation results.

[5] Nomenclature des Activités Économiques dans la Communauté Européenne http://ec.europa.eu/eurostat/ramon/nomenclatures/index

[6] With the exclusion of transmission as a stand-alone sub-sector, as explained in the previous note 1.

[7] Source: Eurostat. Definition: Average national price in Euro per kWh without taxes applicable for the first semester of each year for medium size household consumers (Consumption Band Dc with annual consumption between 2500 and 5000 kWh).

[8] In the Appendix, Table A3, foreign presence is accounted for by the number of foreign firms.

[9] Nomenclature of territorial units for statistics
http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

[10] In this dataset, cities refer to the municipality level (NUTS 4 or LAU 1 level,
http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/local_administrative_units).

[11] Defined as total liabilities over total assets.

[12] This control variable is significant and positive only in the distribution segment (see e.g. Table 4) suggesting that this sub-sector may be driving the result in the aggregate electricity sector.

[13] Adding a control for the share of renewables in the pool of sources to better account for the composition of sources yielded insignificant results. Using the percentage of capacity in combustible fuels yielded similarly insignificant results.

[14] Using the percentage of capacity in combustible fuels yielded insignificant results as in the previous footnote.

[15] To test this hypothesis an interaction term between public ownership and horizontal spillovers was added to the equation. The sign of the estimated coefficient of the interaction term turned out negative, with all other results stable, corroborating the view that domestic public firms might experience increased, with respect to domestic private firms, negative spillovers from foreign presence. The coefficient is however not statistically significant, not allowing a formal confirmation of this view.

[16] Similar results are obtained when considering the 250 and 500 km radiuses, details in the Appendix, Table A.2.

[17] From Tables 5, column 2, Table 9, column 4, Table A.2, columns 5 and 6, Table 9, columns 2, lines 1 and 2, respectively for horizontal and vertical spillovers.