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The impact of competition policy enforcement on the functioning of EU energy markets

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Abstract:

We investigate the impact of competition policy enforcement on the functioning of European energy markets, and how sectoral regulation influences these outcomes. For this purpose, we compile a new dataset on the European Commission's (EC) and EU member states' competition policy decisions, and combine it with firm- and sector-level data. We find that EC merger policy has a positive and robust impact on (i) the level of competition; (ii) investment; and (iii) productivity. This impact, however, only shows up in low-regulated sectors. Other competition policy decisions – EC state aid and anti-trust interventions; as well as all individual Member State policy variables – do not have a uniform effect on energy markets' functioning. Our findings are consistent with the idea that the EC's merger policy actions have been used to overcome significant obstacles to a well-functioning EU energy sector and may well have shaped the overall development of gas and electricity markets in Europe.

JEL codes: D24, L4, L98, Q4

Keywords: Ex-post evaluation, energy markets, competition policy

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1 Introduction

Competition policy enforcement in the EU energy sectors is very active. Since 2002, the Commission has increasingly exercised the full range of competition enforcement tools at its disposal, including merger control, antitrust legislation, and state aid control. Furthermore, until 2003, merger cases in gas and electricity markets were commonly handled via simplified procedures.¹ Since 2003, a significantly higher share of the merger cases in gas and electricity have received an in-depth investigation, thus indicating an increased level of merger scrutiny (ICF and DIW Berlin, 2015).

Given this high level of activity, EU competition policy decisions may well have shaped the overall development of the EU gas and electricity markets. Indeed, some commentators argue that the energy sector has been taken out of the domain of sector-specific regulation and put under the auspices of competition policy (Hellwig, 2008). These developments could then be interpreted as competition policy tools being used with the intent to overcome significant obstacles to a well-functioning energy sector (Eberlein, 2012).

To shed light on whether and how EU competition policy has influenced European gas and electricity markets, this study examines the its enforcement's impact on competition, investment, and productivity. Furthermore, given that regulation in energy markets has historically played an important role, we investigate if the degree of regulation influences this impact. Bergman et al. (1998), for example, argue that when an industry has reached a particular threshold of deregulation, competition should be introduced and safeguarded through competition policy. According to this logic, regulation and competition are substitutes. Thus, competition policy's role and impact should be higher in low-regulated industries. On the other hand, one might make the argument that the impact of competition policy interventions could be stronger in highly regulated markets. For example, in countries where companies are vertically integrated or monopolised, anti-trust interventions to avoid market foreclosure and abuse of dominance would have a larger effect. Therefore, one would observe complementarities between competition policy and regulation (Shelanski, 2011).

Our analysis identifies the broad impact of different policy instruments and looks at the interaction between competition policy enforcement and energy market regulation. Given their importance, both types of policies can be expected to influence market outcomes; yet little is

¹ If the merging firms are not operating in the same or related markets, or if they have market shares below a specified market share threshold, the merger will typically not generate significant competition problems: in these cases, the merger review follows a simplified procedure involving a routine check.

known about their interdependencies. Furthermore, we also briefly investigate whether the level of state aid that industries receive underlies the differential impact of competition policy instruments. Some commentators argued that – to stimulate renewables – countries’ spending in energy markets have created distortions in industries in terms of competition. This would, in turn, imply that competition policy is less relevant in industries where state aid is abundant (Gawel and Strunz, 2014).

The overall logic for our analysis is based on the following relationship between policy enforcement and market outcomes. First, competition policy enforcement – if well-functioning and far-reaching in its impact – directly impacts strategic interactions between firms in the involved markets, thus affecting competition (Aghion and Schankerman, 2004; Buccirossi et al., 2013).²

Second, there is another, more indirect, channel through which policy enforcement impacts competition. Each specific policy intervention not only affects the firms and markets directly involved in that specific case, but it also has indirect effects due to spill-overs across (vertical) markets, as well as deterrence effects (Seldeslachts et al. 2009; Clougherty and Seldeslachts, 2013; Clougherty et al., 2016).³ Similarly, the enforcement of antitrust rules sends signals about the strength of the competition authorities. Consequently, any given decision affects not only the firms involved in that case, but also other firms’ behaviour in same and other markets. These indirect effects are recognized to be important elements of competition policy enforcement (Duso et al., 2013; Joskow, 2002).

In response to policy interventions and changes in competitive pressure, firms optimally adapt their investment behaviour.⁴ Investment is particularly relevant as an outcome variable in energy markets. Indeed, it is widely accepted that more investment is needed in Europe’s energy sector in order to ensure the security of supply and to improve efficiency.⁵ Thus, measures of investments are pivotal variables to consider when investigating how competition and regulatory policies affect energy markets.

² For example, some of the merger remedies put in place in the GdF-Suez merger in 2006 may have effectively been used to promote market liberalisation in order to achieve effective unbundling of network and supply activities and, thus, to enhance competition (Argentesi et al., 2017).

³ For example, specific policy decisions affecting investment in electricity generation capacity also affect incentives and market outcomes in transmission and distribution.

⁴ In this vein, Holmes and Schmitz (2010) show that firms facing stronger competition make substantial investments to increase productivity in order to stay competitive.

⁵ To meet the EU’s ambitious climate and energy targets, and at the same time secure the provision of energy, companies are expected to increasingly invest in electricity generation capacity —particularly in renewable energies— as well as in national and cross-national infrastructure projects, such as interconnector transmission grids (Hirschhausen et al., 2014).

Changes in market competition and firms' investment behaviour might further impact outcomes, such as firms' productivity.⁶ There are several channels through which changes in competition (policy) could lead to changes in productivity (Backus, 2014). First, competition acts as a disciplining device, placing pressure on the managers of firms to become more efficient. This decreases 'X-inefficiency', the difference between the most efficient behaviour that the firm is capable of and its observed behaviour in practice. Furthermore, competition drives firms to innovate. Innovation increases firms' dynamic efficiency through technological improvements of production processes, as well as the creation of new products and services. Furthermore, competition increases productivity by reallocating resources from inefficient to efficient firms, and by forcing inefficient firms to exit. Thus, market forces may cause a reallocation in market shares from inefficient to efficient firms. Hence, productivity-based variables are appropriate measures of long-term competitive outcomes, as they not only capture the static effects of competition but they also measure the selection effects of competition as a process.

To assess these research questions, we create a dataset that merges several sources of information. First, we create a complete map of competition policy enforcement at both the EU and the Member State levels. We match these unique data with OECD data on regulation, firm level data from the Bureau van Dijk's Amadeus/Osiris database, as well as additional data from the World Bank, OECD, and the European Commission.

Our results suggest that EC merger policy has a positive and robust impact on the level of competition, investment, and productivity. This impact, however, only shows up in low-regulated countries and sectors. Other competition policy decisions, such as EC state aid and anti-trust interventions, as well as all individual Member State policy variables, do not have a consistent effect on the working of energy markets.

The remainder of the paper is as follows. Section 2 presents the data, Section 3 explains the model specifications and discusses the results, and Section 4 concludes.

2 Data and variables used for the econometric analysis

The analysis is based on data on competition policy enforcement (our main explanatory variables) and measures on regulation, state aid, competition, and market outcomes. To accomplish this, we merge information from various sources and at different levels of aggregation. In the next sections, we describe the data sources and the main variables used in the study.

⁶ Empirical evidence shows that more competition can drive greater productivity (e.g. Syverson, 2010, for an overview). Investment should also directly lead to changes in productivity (Lichtenberg and Siegel, 1991).

2.1 Policy enforcement data

2.1.1 EU competition policy enforcement data

A detailed dataset on EU-level competition policy enforcement in energy markets between 2005 and 2013 was created to quantify the Commission's activities. At the EU level, there are 200 key merger decisions, 17 antitrust decisions (16 abuses and 1 cartel), and 203 state aid decisions concerning energy markets during the relevant sample period.⁷ From the files documenting these decisions, we constructed indicators of competition policy enforcement at the EU level. This was then transformed to match the national level of analysis proposed in this study, i.e. the Member State/year unit of observation, as energy markets still – to a large extent – function at the national level.

In state aid cases and in most of the antitrust cases, only one country is involved. Therefore, these cases are supposed to only affect that specific geographic national market and it is 'allocated' to the particular Member State involved. Mergers, on the other hand, are often more complex. In most cases, the geographic market definition is not national. Therefore, we identified the geographic markets involved. If the market definition was broader than national, we allocated the case to all Member States involved in that decision. If the market definition was EU-wide, all EU countries in our sample are considered to be affected by the decision. If the market definition was left open, we allocated the case to the countries of origin of the merging firms.

Variables measuring the number of mergers and state aid cases affecting one country in a given year are used as control variables to capture the level of activity in the area of mergers and state aid that could have, *per se*, an impact on competitive outcomes (Clougherty and Seldeslachts, 2013). Figure 1a shows the evolution of the merger and state aid cases in box- and whisker plots; mergers are considerably more frequent than state aid cases.⁸

[Insert Figure 1 about here]

In the case of mergers and state aid, the measures of intensity of competition policy enforcement used in the regressions are defined as the ratio between the number of interventions and the number of (notified) cases (see Clougherty and Seldeslachts, 2013, for a detailed rationale). The construction of the enforcement variable is particularly delicate in merger cases. We define

⁷ The EC publishes all official decisions on its web site. We downloaded all cases with NACE code D35 (Electricity, gas, steam and air conditioning supply). We used the decision date as the criterion for the selection. We include all cases where the Commission's decision was made between January 1, 2005, and December 31, 2013.

⁸ These graphs represent the entire distribution of the depicted variables. Within the solid blocks, the first and third quartiles of the distribution are represented, the line in between representing the median. The lines extending vertically from the boxes (the so called 'whiskers') indicate the upper and lower adjacent values (the most extreme values within 1.5 inter quartile range of the nearer quartile). The dots represent outliers.

‘intervention’ as follows: remedies – during phase 1 or phase 2 – plus merger withdrawals during phase 2. While prohibitions should be considered the most extreme form of intervention, no merger was prohibited in the energy sector during the sample period.⁹ In the case of state aid, we define an intervention as the decision to initiate a formal investigation.¹⁰ For abuses and cartels, we simply use the number of cases as a measure of intervention.¹¹

Figure 1b illustrates that the Commission intervened in a sizeable fraction of energy mergers, but there appears to be a negative trend in later years.¹² State aid programs are not frequently investigated (see Figure 1c). Similarly, few cartel and abuse cases were opened during the sample period (see Figure 1d).

Table 1 defines all our variables, while Table 2 summarises the indicators of activity and EU competition policy enforcement. On average, there are more mergers notified and merger interventions than is the case for state aid (control) and antitrust activities.

[Insert Table 1 about here]

[Insert Table 2 about here]

2.1.2 National competition policy enforcement data

Constructing measures of national competition policy enforcement was a more significant challenge. Since no clear source of data is available, we created a questionnaire that was sent to all national competition authorities in the EU.¹³ Based on this information, we constructed measures of national competition policy enforcement in a similar fashion as for the EU, with the exception that there are no state aid cases at the national level. Table 3 shows the descriptive statistics for these variables.

[Insert Table 3 about here]

The dynamics of national competition cases and policy enforcement variables are also represented through box and whiskers plots (Figure 2). Although not visible on the figures, there

⁹ Three mergers that were eventually withdrawn by the firms during the in-depth investigation phase were coded as cases in which the Commission intervened. One case that was referred to a member state was dropped from the data.

¹⁰ EC officials agreed that this is the best (albeit imperfect) indicator of intervention in this area.

¹¹ We further collected additional data on fines imposed. However, these EU data are too sparse for econometric analysis and, thus, are omitted from our analysis.

¹² Note that this is not at odds with the increase in EU merger policy activity mentioned in the introduction. The number of mergers investigated by the Commission increased from an average of 11 in the period up to 2005 to an average of 22 in the period since. The decline observed here is (i) due to the choice of sample period; and (ii) due to the allocation mechanism of cases to member states.⁹

¹³ We gratefully acknowledge the support we had in this data collection exercise through DG Competition of the European Commission, the European Competition Network, and the National Competition Authorities. Without their help, it would not have been possible to create this dataset. Only Austria is missing from the sample because the national competition authority was unable to supply us with data on national competition policy enforcement.

is some variation in merger notifications at the country level. While some large Member States – particularly Germany and Italy – average more than 30 energy mergers per year, some smaller Member States have very little or no activity. This holds also true for cartels and dominance cases, where Germany and Poland show most activity.

[Insert Figure 2 about here]

In terms of interventions, although national competition policy enforcement is rather low on average (the Member State/year observations are zero up to the 75th percentile), there is some variation across countries and time (Figures 2b and 2c).

2.1.3 Regulation

Regulation is the additional policy dimension in our study. The OECD Indicators from the Product Market Regulation project, specifically the indicators of regulation in energy, transport, and communication (ETCR) are used as measures of intensity of regulation. This is the most comprehensive, accurate, and widely used database to measure the effect of regulation on market outcomes (e.g. Alesina et al., 2005; Duso and Seldeslachts, 2011; Bourles et al., 2013).

The OECD indicators of Product Market Regulation show the overall level of regulation in electricity and gas markets across Europe. The indicator is the average of four sub-indicators measuring the degree of public ownership, entry regulation, vertical integration, and market structure.¹⁴

The regulatory environment in electricity and gas markets varies across Europe. Electricity and gas markets are more liberalized in Germany, Spain and the UK than in Estonia, Greece and Poland, where they are highly regulated. Figure 3 illustrates the evolution of the regulation indicators in electricity and gas markets over the 2005-2012 period. On average, regulatory pressure has decreased over the years.

[Insert Figure 3 about here]

To simplify the interpretation of the results, we use the median intensity of regulation in national energy markets in our econometric analysis.¹⁵

¹⁴ Bulgaria, Croatia, Latvia, Lithuania and Romania were dropped because OECD product market regulation data is unavailable.

¹⁵ As a robustness check, we also estimated all our models with the separate indicators instead of the average regulation index. All main results on the effects of competition policy enforcement are not affected.

2.2 Outcome variables

We focus on three different outcome measures: intensity of competition, investment, and productivity growth. The choice of the specific outcome variables implicitly also defines the level of aggregation. Some variables, such as investment and productivity growth, can be defined at the most disaggregated *firm-country-year* level, while the degree of competition instead is naturally defined at the *sector-country-year* level. The database and exact indicators are described below.

2.2.1 Firm-level data

Firm-level data was obtained from the Amadeus/Osiris database. The database covers 1997-2014, but since data availability thins out considerably for the earliest and latest years, we focus only on the 2005-2012 period. We focus on firms active in energy markets as represented by the NACE group D35.¹⁶

We analyse those firms classified by Amadeus as ‘very large,’ to focus on the sizeable players in the market.¹⁷ Only these firms are expected to engage in significant investment activities and to (strongly) react to changes in the regulatory and competitive environment. The firms in our sample have a median of 117 employees and median fixed assets of around €130m.

For these firms, we collected information on variables such as total assets, fixed assets, revenue, cost of labour, and material expenditures, which are then used to build the main measures of interest as discussed below.¹⁸ Table 4 reports preliminary statistics including the yearly number of firms in the database and the yearly means of the selected variables (all values are in million Euros and are PPI-adjusted using a country-year specific producer price index collected from the OECD).

[Insert Table 4 about here]

¹⁶ The firms in the sample fall in the subgroups D35.1 (Electric power generation, transmission and distribution) and D35.2 (Manufacture of gas; distribution of gaseous fuels through mains). The few firms active in NACE D35.3 (Steam and air conditioning supply) were dropped from the sample.

¹⁷ Amadeus contains information on more than 80,000 European firms indicated to be active in the energy sector, most of which are very small. The 25th percentile/median/75th percentile of employees of firms are 1/2/6, with median total assets of just €600,000. Companies in Amadeus are considered to be very large when they have: operating revenue larger than €100m, or total assets larger than €200m, or more than 1,000 employees.

¹⁸ Total assets represent the sum of total current assets, long term receivables, investment in unconsolidated subsidiaries, other investments, net property plant and equipment and other assets. Fixed assets represent total assets excluding current assets, which represent cash and other assets that are reasonably expected to be realized in cash, sold or consumed within one year or one operating cycle. Operating revenues is turnover. Labour costs represent the cost of staff.

Over the entire sample period, we observe 1,438 different firms operating in 19 countries.¹⁹ Unfortunately, some of the variables are missing for some of the firms over time. In the various regressions we, therefore, have different numbers of observations depending on how demanding the data requirements are.²⁰

2.2.2 Outcomes

We discuss here the different outcome variables, their relevance to our analysis, and how they are measured via the Amadeus database.

Intensity of competition

Intensity of competition is naturally defined at the market-level. Well-defined product markets as used in competition cases would be desirable, but are not feasible for a study of this scope. The NACE codes discussed above represent the best alternative to define relevant sectors and are available for each firm in our sample.

We use the elasticity of relative profits with respect to relative costs, the ‘Boone indicator’ as measure of competition (Boone, 2008). This indicator is based on the idea that when a market is more competitive, then firms that have relatively lower costs can earn relatively higher profits in this industry. In particular, Boone (2008) shows that for three efficiency levels $n_1 > n_2 > n_3$ and a level of competition intensity θ , it is the case that

$$\frac{d\left(\frac{\pi(n_1, \theta) - \pi(n_3, \theta)}{\pi(n_2, \theta) - \pi(n_3, \theta)}\right)}{d\theta} > 0,$$

where $\pi(n_i, \theta)$ are a firm’s i variable profits. Thus, relative variable profit differences are increasing in the intensity of competition, θ .

This measure of competition is particularly useful in markets that are subject to intense reallocation dynamics, which entail significant changes in market shares, since it is monotonic with respect to the direction of the competition shock – i.e. it increases (decreases) with higher (lower) competition arising from lower entry barriers, as well as from reallocation of output to more efficient incumbent firms within the sector.²¹ One further key advantage of this measure is

¹⁹ Our final sample contains 19 member states: Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. The most prominent countries in the sample are Germany, Italy, and the UK with shares of 24%, 15% and 14% of total observations, respectively. Cyprus, Luxembourg and Malta are missing from the sample because there is no firm level data for energy companies in these countries. Other European countries are missing since regulation or competition policy variables are not at hand (see footnotes 13 and 14).

²⁰ Specifically, the labour cost and material expenditures are the variables most likely to be missing and, therefore, reduce the sample on which we can estimate productivity measures.

²¹ Mark-ups are often used as a measure of competition. However, mark-ups have problems to consistently pick up the following two ways in which competition can be intensified in a market: (i) having more firms in a market due to a fall in entry barriers; and (ii) a more aggressive conduct by incumbent firms. In the former case, more firms in the market reduce mark-ups in standard

that it holds for any subset of firms within one market. This makes it a very attractive for empirical purposes as firm level data are often only available for a sub-sample of the active firms in the market (Boone, 2008).

The degree of competitive pressure is empirically measured via the relation of the firms' profits (relative to other firms in the industry) to their (relative) cost, which we estimate based on Amadeus data. The relative profit difference (RPD) for firm i , in sector s , in country c , in time t is then defined as:

$$RPD_{isct} = \frac{\pi_{max,sct} - \pi_{min,sct}}{\pi_{isct} - \pi_{min,sct}}, \quad (1)$$

where $\pi_{max,sct}$ is defined as the profit rate (profits over revenue) of the most profitable firm in sector s of country c and year t , $\pi_{min,sct}$ is defined as the profits of the least profitable firm in the same sector, country, and year and π_{isct} is defined as the profits of the focal firm.²² In a similar fashion, the firms' relative cost efficiency (RCE) is calculated as

$$RCE_{isct} = \frac{c_{max,sct} - c_{min,sct}}{c_{isct} - c_{min,sct}}, \quad (2)$$

where c represents the cost rate (total costs over revenue) of the most profitable firm in sector s of country c and year t .

Since competition in most energy sectors mainly occurs at the national level, especially for the period of our sample, we estimate the relationship between relative profits and relative costs at this level of observation. We estimate the equation for three energy sectors, namely production, transmission and distribution and trade. Specifically, we run a pooled regression where we regress the log of RPD on the log of RCE and identify separate coefficients for each sector, country, and year:

$$\ln RPD_{isct} = \alpha + \beta_{sct} \ln RCE_{isct} + \varepsilon_{isct}. \quad (3)$$

The resulting coefficients (the betas) – which represent the elasticity of the relative profits with respect to the relative costs – are an indication of the intensity of competition in that particular country, year and sector. In particular, the more negative the beta, the more firms are being

models. In the latter case mark-ups can go up in response to an increase in competition intensity, incorrectly suggesting that competition went down (Amir, 2002; Bulow and Klemperer, 1999; Rosenthal, 1980; Stiglitz, 1989). Boone's measure does not suffer from these problems.

²² As a measure of profit we use the variable 'profit and loss,' while as a measure of revenue we use the variable 'operating revenues' from Amadeus. As a measure of cost we use the variable 'Cost of goods sold' from Amadeus (e.g. Altomonte et al., 2010).

‘punished’ for being inefficient. Thus, if a policy serves to increase competition, this would result in a lower beta. The resulting ‘Betas,’ averaged over all countries, are shown in Table 5.²³

[Insert Table 5 about here]

Investment

We follow Grajek and Röller (2005), who use monetary measures of investment defined as the change in fixed assets owned by the firms. This variable is not a perfect measure, but it is the best available indicator of investment for a study like ours. The main advantage of using a monetary measure of investment is that fixed assets are observable for all firms present in the different sectors of energy markets and can be easily compared. On the downside, we cannot precisely identify the type of investment carried out by the firms. Specifically, we calculate the investment (I) of firm i in year t as the yearly change in firm-specific fixed assets:

$$I_{it} = FA_{it} - FA_{it-1}. \quad (4)$$

Total Factor Productivity

At the firm level, we estimate the level of total factor productivity (TFP) as the residual from an industry-specific, firm-level translog production function, where output is related to inputs – specifically labour, capital and material.²⁴ More formally, we calculate total factor productivity of firm i in sector s in year t as the residual of a sector-specific (s), translog production function:

$$TFP_{ist} = \ln VA_{ist} - f_s(\ln K_{ist}, \ln L_{ist}, \ln M_{ist}), \quad (5)$$

where VA_{ist} is the value added of firm i in sector s , in year t ; K_{ist} , L_{ist} , and M_{ist} represent its capital (as measure by total assets), labour (as measured by staff costs), and material expenditures, respectively. We refer to Appendix 1 for exact estimation details.

The second and third columns of Table 5 present the yearly summary statistics and the time evolution, respectively, for investment and TFP. As illustrated, investment follows a cyclical pattern with negative average investment in two years (2008 and 2011). The TFP values are calculated from parameters estimated to minimise the squared prediction errors of the model; thus, their overall mean is (very close to) zero by construction. The yearly averages therefore

²³ Using estimates as a dependent variable in a second stage regression introduces an additional error to the model. Consider the equation of interest $y = \alpha + \beta X + \varepsilon$. Assume that we do not observe y but have to rely on estimates of y given by $\hat{y} = y + u$. Therefore, we are effectively estimating the model $\hat{y} = \alpha + \beta X + \varepsilon + u$, meaning that the variances of both ε and u enter the variance-covariance matrix (e.g., Hausman, 2001). Thus, a dependent variable obtained from prior estimations is equivalent to a dependent variable observed with measurement error, i.e. the uncertainty introduced by the first stage model makes the dependent variable noisy. However, under the assumption that this error is not correlated with regressors X in the model of interest, while this inflates the estimated standard errors it does not bias the resulting coefficients’ estimates.

²⁴ The production function is also estimated in sub-samples at the sector level for the production, transmission, and trade sectors.

indicate to which degree each firm over- or underperformed relative to the model predictions in that particular year.

2.2.3 Other control variables

We use several additional sources to construct possible control variables. To account for differing institutional qualities across EU member states, we use data sourced from the World Bank (GDP per capita, population growth, energy imports as a share of total energy consumption). Information on the energy mix (i.e. the share of different fuels in energy production) used in different countries are obtained from the Commission's energy's fact sheets.

3 Model specification

Our econometric framework builds on recent empirical literature analysing the link between policy enforcement and market outcomes; specifically, (i) on the impact of regulation on investment (e.g. Alesina et al., 2005; Lyon and Mayo, 2005; Grajek and Röller, 2005; Cambini and Rondi, 2010); and (ii) on the relationship between competition enhancing policies and productivity (e.g. Aghion et al., 2009; Buccirossi et al., 2013; Bourles et al., 2013). Given that we use different dependent variables – as well as levels of aggregation – the specific models differ slightly, as further explained below.

3.1 The framework

3.1.1 Sectoral competition outcomes

We postulate that there is a direct impact of policy enforcement on the level of competition. Since competition is naturally defined at the market-level, we conduct our first analysis at the country-sector-year level. Hence, the estimated coefficients measure the impact of policy enforcement on Boone's Beta, after controlling for other observable shifters. Specifically, we estimate the following specification:

$$Y_{sct} = \gamma EUEnf_{ct-1} + \delta NatEnf_{ct-1} + \beta Reg_{ct-1} + \rho Z_{ct-1} + \omega_c + \omega_s + \omega_t + \varepsilon_{sct}, \quad (6)$$

where Y_{sct} is the outcome in sector s , in country c , at time t (*Boone's Beta*). The vectors $EUEnf_{ct-1}$ and $NatEnf_{ct-1}$ are the lags of the above explained measures of competition policy enforcement at the EU and national levels, respectively, covering the different policy areas (mergers, abuse of dominance and cartel cases and, for the EU, state aid cases).²⁵ The variable

²⁵ As discussed in the data section, for each policy action taken by the EU, we allocated the enforcement to the country (countries) that was (were) affected by that particular decision so that EU policy enforcement asymmetrically affects member states. We chose to aggregate the policy variables at the country-level rather than at the sector-country level, as we believe that policy enforcement in a specific product market has important indirect effect that spill-over into other markets. This might be due to

Reg_{ct-1} denotes the intensity of regulation in a given national market c in year $t-1$, measured by using the means of the OECD regulation index for the energy sectors.

To identify the effect of enforcement, we need to control for the number of merger cases notified to the Commission as well as for the number of notified state aid cases, as they are, of course, important drivers of the level of competition. Specifically, the former measures the extent of country-specific merger waves, while the latter measures the potential country-specific distortions in competitive outcomes (e.g. Seldeslachts et al., 2009).

We also control for time-varying country-specific factors, such as GDP per capita and population growth, as well as the share of imports in total energy consumption (Z_{ct-1}). Additionally, the same vector includes controls for country-specific existing production capacities in combustible fuels, nuclear and renewable energy. The reason to include these variables is that (excess) capacities are important factors determining the level of competition in an industry. Finally, we control for unobserved time-invariant country-sector specific heterogeneity by means of country and sector fixed-effects (ω_c and ω_s), as well as unobserved firm-invariant time-specific aggregate heterogeneity by means of year fixed-effects (ω_t).²⁶ The error term ε_{sct} is assumed to be correlated among observations within the same country-sector. All explanatory variables are lagged by one period to reduce endogeneity issues due to reverse causality. The issue of identification is further discussed in the following subsection.

3.1.2 Firms-specific outcomes

The second level of analysis focuses on firm-level outcomes: investment and productivity. We suggested that policy enforcement affects firms' outcomes in a given market through their impact on competition. Following recent literature (Pavnick, 2003; Buccirosi et al., 2013; Bourles et al., 2013), we identify the effect of policy on outcomes by looking at the relationship between country-specific measures of enforcement and firm-specific outcomes. Our estimated model is represented by the following equation:

$$Y_{ict} = \gamma EUEnf_{ct-1} + \delta NatEnf_{ct-1} + \beta Reg_{ct-1} + \rho Z_{ct-1} + \omega_i + \omega_t + \varepsilon_{ict}. \quad (7)$$

Y_{ict} is now the firm-specific outcome to explain —investment or total factor productivity— of firm i in country c , at time t . The explanatory variables are the same as discussed above. The difference is that we now control for unobserved time-invariant *firm* rather than *country-sector*

deterrence effects or to the fact that different sectors in energy markets are interrelated through the vertical chain (Buccirosi et al., 2013).

²⁶ For example, in 2007 the EU conducted a sector inquiry in gas and electricity markets to assess the state of competition. The effect of this investigation on the sector should be captured by the year dummy for 2007.

specific heterogeneity by means of firm fixed-effects (ω_i). The error terms are clustered at the country level.

When we use productivity measures, we further augment the model to account for the distance to the technological frontier (Aghion et al., 2009). Therefore, we add the productivity of the leading firm(s) in the specific industry and year as an additional control variable to our basic regression. This leader productivity measure is defined as the 90th percentile of firm-level productivities in that particular sector and year.

3.1.3 Competition policy and regulation

We separately analyse the effect of competition policy in the sub-samples of high- vs. low-regulated countries/periods. These sub-samples are defined by using the median of all regulation indices for each Member State and year, as reported by the OECD. We then assign sectors and firms to the high-regulation sub-sample if the value of the regulation index in that country and year is higher than the median of the OECD regulation index over all countries and time periods in our sample. Conversely, a country is low-regulated if the index takes a value lower than the median. In this way, we use not only the cross-sectional but also the time variation in the measures of regulation, as countries can move from one to the other sub-sample over time by implementing regulatory reforms.

We choose to use sub-samples based on this dichotomous definition of high- vs. low-regulation rather than interactions between competition policy enforcement and the continuous regulatory indexes to better exploit the rather limited variation in the data. While the second option would allow a precise fine-tuning of the interaction effects, it might fail to deliver clear-cut results due to the too scarce time-series variation in both variables. We therefore consider our approach to deliver more robust and easily interpreted findings.

3.2 Identification

The identification of a causal nexus between competition policy enforcement and outcomes relies on being able to account for potential endogeneity of our key policy variables. The enforcement of competition policy in some specific cases might, in principle, be focused on solving problems of under-investment or to increase productivity, which in turn might lead to correlation between enforcement and the error term in the investment or productivity equations. However, we do not examine the effect of a specific decision on the behaviour of the firms involved in that specific case, but focus on how the general enforcement of competition policy tools in one particular geographical market (Member State) affected the behaviour of all players in that market.

Regardless, to reduce the potential bias resulting from two-way causality, we use lagged values of the policy variables. This is a standard approach that relies on the assumption that the lagged values of the policy are uncorrelated with the error terms of the estimated equation. Indeed, several other studies (Alesina et al., 2005; Buccirossi et al., 2013; Bourles, et al., 2013; Griffith et al., 2004) use this type of exclusion restrictions to identify the causal effect of deregulation, competition policy, and R&D on both investment and industry TFP growth.

Furthermore, the panel structure of our data-set allows us to control for time-invariant unobserved individual heterogeneity at the firm/industry/country level through fixed-effects, and for time fixed-effects. However, there could still be time-varying unobserved heterogeneity due to other policies correlated with competition policy enforcement affecting firms' behaviour. Therefore, following the existing literature (e.g. Alesina et al., 200; Grajek and Röller, 2011), we control for those factors that we believe are the most prominent policies affecting competition in energy markets, namely product market regulation, liberalisation, and privatisation.

Finally, we look at heterogeneous patterns in the sense that we distinguish between effects in sectors with high versus low regulation. If results differ across subsamples according to our expectation, this is an indication that our analysis does not suffer from endogeneity. Indeed, it is hard to come up with a story for why an omitted shock should yield different results for different subsamples.

4 Results

4.1 Intensity of competition

We begin with the analysis of the link between competition policy enforcement and the level of competition at the country-sector level. In this model, the outcome variable of interest is the country-sector Boone's Beta – i.e. the elasticity of relative profits with respect to relative costs. Remember that this measure of competition intensity reflects the negative relationship between profits and cost efficiency, faced by firms in a competitive environment. Thus; a decrease in this measure can be interpreted as an increase in competition. To facilitate the comparison of the coefficients' estimates of the various explanatory variables that are measured in different units, we report standardized beta coefficients. Therefore, the measured effects represent the change in standard deviations of the dependent variable due to one standard deviation change in the variable of interest.

We find a negative and significant impact of EU merger enforcement on elasticity of relative profits with respect to relative costs in low-regulated countries, as Table 7 shows. In particular, a standard deviation increase in EU merger enforcement relates to a decrease in the relative profit

elasticity by 0.487 standard deviations in the sub-sample of low-regulated countries – thus increasing competition. The effect is still negative but (much) smaller and non-significant in the full sample and in the sub-sample of high-regulated markets.

On the contrary, other measures of enforcement at EU or national level are mostly not significant. Only the number of national cartel and abuse investigations significantly reduces the beta in the sub-sample of high-regulated countries. State aid schemes, on the other hand, have a significant positive impact on the relative profit's elasticity and, thus, reduce competition: one standard deviation increase in the state aid schemes increases the beta by 0.198 standard deviations. This should perhaps not come as a surprise, since state aid may have a distortive effect on competition. For the sake of brevity, we do not discuss the impact of the control variables in these and the following estimations.

[Insert Table 7 about here]

4.2 Investment

Table 8 shows the estimation results for equation (7) to examine the impact of competition policy on investment. We estimate a significant positive relationship between the enforcement of EU merger control on firms' investment in the sub-sample of low-regulated countries. In particular, one standard deviation increase in the merger interventions increases firm-level investment by 0.226 standard deviations.

[Insert Table 8 about here]

Few of the other competition policy enforcement variables have a significant effect on investment. Only EU cartel and abuse cases significantly increase investment in high-regulated markets, while significantly decreasing it in low-regulated markets.

We further estimate a positive and significant coefficient for state aid notifications in low-regulated countries. This variable identifies the effect of the state aid programs themselves. These programs often aim to support companies in financial distress and might be expected to have been used to acquire additional assets, thus increasing investment.²⁷

²⁷ We also estimated a (non-reported) autoregressive model where we added the lagged dependent variable as an additional regressor. This augmented model potentially allows us to more precisely specify the investment process, as investment is often characterised by inertia. Results are comparable to those reported here. Moreover, the coefficient estimate for lagged investment is not significantly different from zero, casting doubts on the fact that the auto-regressive model would more appropriate in our context.

4.3 Total Factor Productivity (TFP)

Finally, we analyse the effect of competition policy enforcement on firm-level total factor productivity. The standardised beta coefficients are reported in Table 9. Consistent with our results on competition and investment, EU merger enforcement increases TFP in the sub-sample of low-regulated countries. In particular, a one standard deviation increase in the ratio of merger interventions and merger notifications increases TFP by 0.219 standard deviations. The effect is also positive, but significantly smaller, in the pooled and the high regulation sample. Most other policy enforcement variables, on the other hand, have little effect on TFP.

Among the control variables, we estimate a significant positive coefficient for the productivity level of technology leaders. This can be interpreted as the ‘catching-up’ effect to the productivity frontier. The magnitude is similar in the full sample as well as in the low-regulated markets, while it is much smaller and not significant in high-regulated markets: a standard deviation increase in the leader’s TFP increases firms’ TFP by 0.041 to 0.072 standard deviations. We also estimate a negative and significant effect of regulation in the high-regulation sub-sample.

[Insert Table 9 about here]

4.4 State aid subsamples

There has been a surge of state aid in energy markets to promote, among other things, renewable energy. Indeed, the average spending on state aid shows a steep upward slope over time, as depicted in Figure 3.²⁸ A potential negative side-effect of this additional public money spent in gas and electricity markets, however, may be the introduction of market distortions. The idea here is that the surge of state aid in EU energy markets may have resulted in competition issues and the impact of competition policy becomes of secondary importance. Indeed, if all firms – including inefficient ones – are flush with cash, then competition policy will have little impact on the functioning of markets, since most companies will not have to adapt their behaviour as markets do not become more competitive after policy interventions. This, in turn, would mean that investment and the resulting productivity are also not affected.

To address these questions in this section, we perform a similar exercise using state aid subsamples as we did for regulation subsamples. In the same fashion, we partition observations into two categories: those coming from high state aid markets and those coming from low state aid markets. We then investigate whether competition policy enforcement has a differential

²⁸ We gathered data on state aid levels from the EC’s State Aid Scoreboard. Data can be downloaded from http://ec.europa.eu/competition/state_aid/scoreboard/index_en.html (accessed 2.3.2017). We use the amount of state aid spent under the label “Environmental protection and energy saving”. While this is an imperfect proxy for state aid spent on energy projects and particularly on renewables, EC officials confirmed that this is the best available data on these issues.

impact along this dimension. To account for size effects, we normalize the country/year state aid levels by the number of firms active in a country's energy sector. This provides us with a measure of state aid intensity, which we use to define the subsamples of low and high state aid regimes.

Table 10 shows the results of the impact of competition enforcement on the different outcomes for low and high state aid industries. Columns one and two show that EU merger policy actions are significantly negatively related to Boone's Beta in low state aid industries, but they have no effect on high state aid industries. Further, columns three and four show that EU merger policy merger policy actions have no impact on investment in either subsample. Finally, columns five and six show that there is a significant positive relationship between EU merger enforcement on productivity growth in low state aid countries, but not in high state aid countries.

[Insert Table 10 about here]

These results are in line with our hypothesis that competition policy actions only have an influence on competition in sectors where state aid has been low. Indeed, in line with our previous results, EU merger policy enforcement has a negative impact on Boone's Beta and productivity and, hence, a positive impact on competition. However, the same EU merger policy actions have no impact on investment. All in all, this yields some support to the above-made reasoning that high state aid distorts the well-functioning of energy markets.

5 Conclusions

This paper focuses on identifying the broad effects of competition policy enforcement on the functioning of EU energy sectors as well as its interactions with regulation. The evidence we provide paints a comprehensive picture of the different channels through which competition policy affects market outcomes: the elasticity of relative profits with respect to relative costs (a measure of competition intensity), investment, and productivity.

Our analysis captures both direct and indirect effects of these policies because it examines broad national energy sectors, capturing both the impact of policy decisions on the firms involved in competition policy cases, and on other firms active in the same market(s), via spill-over and deterrence effects in (vertically) connected markets.

One overall picture emerges. EU merger policy enforcement is consistently and significantly related to better outcomes, particularly in low-regulated sectors. First, EU merger policy enforcement is associated with a lower Boone's indicator, showing that national energy sectors became more competitive after these interventions. A more active EU merger control is also

related to higher investment and higher total factor productivity. This is consistent with the reasoning that EU merger policy actions – through the channel of competition – encourage energy firms to invest more, ultimately improving productivity.

These results are strongest in low-regulated sectors. This finding is in line with previous studies showing that competition policy is most effective where the competitive process is not influenced by high regulation (e.g. Buccirossi et al., 2013). One potential mechanism may be that if firms are highly regulated, changing the way competition works through competition policy has little impact. For example, if investment is indirectly set by the regulator then a different market structure will most likely not change it. If it is not, a different market structure may induce different behaviour from market participants.

The fact that it is EU merger policy that especially has an impact in energy markets should perhaps not come as a surprise since the EC might have used the ‘windows of opportunities’ created through large European cross border merger proposals (Pakalkaite, 2014). Indeed, some of the remedies put in place, in principle only to mitigate the potential anti-competitive effects of mergers, may have effectively been used to promote market liberalisation in energy markets (Argentesi et al., 2017; Böckers et al., 2017). Thus, one question is whether the EC has overreached by using merger control to create competition that would not have arisen absent the merger. However, as the European Court of Justice pointed out in its 2010 judgment on the ENI/EDP/GDP merger, “there is no legal impediment to the Commission pursuing liberalisation of energy markets through its merger control policy, to the extent that both share the aim of increased competition” (Harrison and Mordaunt, 2012: 10/8). More detailed retrospective research in this specific area is needed to shed further light on these issues.

Finally, there are two caveats. First, other policy enforcement measures show a patchier impact, i.e. they show a more limited correlation pattern with market outcomes. But this does not conclusively prove lack of effectiveness. It is possible that their low frequency of occurrence prevents us from empirically identifying consistent relationships. Second, while we try to deal with issues such as reverse causality bias (by lagging the policy variables) and omitted variable bias (by using fixed effects and other controls and by finding heterogenous effects in low and highly regulated industries), our identification strategy is not based on a clear source of exogenous variation since it is virtually impossible to find such exogenous variation in a broad and heterogeneous framework as is ours.

Therefore, we cautiously interpret our results as illustrating strong correlations between EU merger policy enforcement and market outcomes rather than truly causal links. But the

conceptual framework behind our empirical analysis – policy enforcement affects competition, which then affects firms' investment behaviour; changes in the intensity of competition and firms' investment behaviour generate changes in productivity – suggests a plausible causal link between competition policy enforcement and productivity.

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Appendix - Estimation of total factor productivity (TFP)

We calculate total factor productivity of firm i in year t as the residual of a sector-specific (s), translog production function:

$$TFP_{it} = \ln VA_{it} - f_s(\ln K_{it}, \ln L_{it}, \ln M_{it}), \quad (A1)$$

where VA_{it} is the value added of firm i in year t , K_{it} , L_{it} , and M_{it} represent its capital (as measure by total assets), labour (as measured by staff costs) and material expenditures, respectively.²⁹ Note that as a proxy for value added we use the log of operating revenues (which are a measure of turnover).

The sector s specific production function $f_s(\cdot)$ is a second-order trans-log specification comprising all interactions of $\ln K^j$, $\ln L^j$, and $\ln M^j$ with $j \leq 2$ (for a total of 20 terms of up to degree 6) as well as year fixed effects and firm fixed effects. This functional form can be interpreted as a second-order Taylor approximation to a general, but unknown, production function. The sector-specific production function is estimated separately for firms in the production, transmission and trade sectors. The results of the estimation in the specific sub-samples are reported in Table A1

The models perform well as they are able to explain more than 90% of the variation in the log turnover. They also produce reasonable coefficient estimates for the marginal productivities. Specifically, we can calculate the average marginal productivity for each input at the mean value of the other inputs. We estimate an average marginal productivity of labour between 0.11 and 0.36, an average productivity of materials between 0.28 and 0.55 and an average marginal productivity for capital between 0.26 and 0.45.

[Insert Table A1 about here]

²⁹ For Denmark, Ireland and the UK no data on material expenditures are available; we proxy for these values by calculating the difference between total cost and staff expenditures.

Tables

Table 1 – Variable definitions

Outcomes	
Beta	Elasticity of relative profits with respect to relative costs per year, country and industry cluster
Investment	Yearly change in firm-level fixed assets, in million Euros
TFP	Total factor productivity, estimated from a translog production function, at the firm/year level (see Appendix)
Competition policy and regulation	
EU abuse & cartel enforcement	Number of abuse of dominance cases and cartels prosecuted by the EC, at the member state/year level
EU merger cases	Number of mergers investigated by EC, at the member state/year level
EU merger enforcement	Number of mergers cases with intervention by EC, at the member state/year level
EU state aid cases	Number of state aid cases notified by EC, at the member state/year level
EU state aid enforcement	Number of state aid cases investigated by EC, at the member state/year level
National cartel & abuse cases	Number of abuse of dominance cases and cartels prosecuted by NCAs, at the member state/year level
National cartel fines	Total amount of fines imposed by NCAs in cartel and antitrust cases, at the member state/year level
National merger enforcement	Number of mergers investigated by NCAs, at the member state/year level
National merger decisions	Number of mergers cases with intervention by NCAs, at the member state/year level
Regulation (OECD indicator)	Average regulatory intensity of energy markets, at the member state/year level
Control variables	
Electricity capacity (combustible)	Total energy production capacity, combustible fuels, at the member state/year level
Electricity Capacity (nuclear)	Total energy production capacity, nuclear, at the member state/year level
Electricity Capacity (renewable)	Total energy production capacity, renewables, at the member state/year level
Energy imports (% of tot. cons.)	Percentage of total energy consumption imported
GDP per capita	GDP per capita in thousand €, at the member state/year level
Population growth	Population growth in %, at the member state/year level
Leader Productivity	90 th percentile of TFP, by sector and year
Sector Inquiry	Dummy variable indicating the EC's 2007 sector inquiry into energy and gas markets

Table 2 - EU competition policy enforcement at the member state/year level: Descriptive statistics

Variable	Mean	St. Dev.
Mergers		
Cases	4.54	4.01
Interventions	0.45	0.73
State aid		
Cases	0.68	1.16
Interventions	0.06	0.23
Antitrust		
Abuse & cartel cases/interventions	0.14	0.47

**Table 3 - National competition policy enforcement at the member state/year level –
Descriptive statistics**

Variable	Mean	St. Dev.
Mergers		
Cases	4.38	9.49
Interventions	0.12	0.49
Antitrust		
Abuse and cartel cases/interventions	1.36	3.32
Fines (million Euro)	3.17	22.23

Table 4 - Mean values of Amadeus variables (PPI-adjusted million €)

Year	# Firms	Revenue (VA)	Total Assets (K)	Fixed Assets (FA)	Labour Cost (L)	Material Expend. (M)
2005	902	773.65	1,264.16	882.26	62.79	546.35
2006	1021	836.32	1,191.54	828.88	60.87	640.76
2007	1149	785.81	1,251.79	870.37	56.80	565.18
2008	1244	761.64	1,175.59	809.13	45.07	578.53
2009	1325	775.21	1,343.40	977.50	52.11	556.99
2010	1344	783.10	1,355.57	970.77	49.27	553.84
2011	1365	775.34	1,256.22	898.21	42.01	564.84
2012	1329	791.48	1,282.31	922.60	41.96	579.20

Table 5 - Outcome variables over time

Year	Beta		Investment		TFP	
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
2005	-0.53	1.10	30.98	323.91	0.00	0.20
2006	-0.34	1.33	19.56	325.17	0.02	0.18
2007	-0.11	0.35	20.96	306.25	-0.01	0.21
2008	-0.06	0.14	-12.66	310.65	-0.01	0.20
2009	-0.02	0.18	73.92	377.86	0.03	0.19
2010	-0.06	0.17	25.77	311.03	0.02	0.20
2011	-0.13	0.40	-19.49	328.99	-0.01	0.20
2012	-0.13	0.32	14.71	222.99	-0.02	0.22

Table 7 – The impact of competition policy variables on Boone’s Beta

	Full sample		Low Regulation		High Regulation	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
EU merger enforcement (lagged)	-0.274	(-1.59)	-0.484***	(-6.14)	-0.040	(-0.29)
EU State aid enforcement (lagged)	-0.018	(-0.38)	-0.018	(-0.36)	-0.012	(-0.15)
EU abuse & cartel enforcement (lagged)	0.056	(0.73)	-0.242	(-1.58)	0.049	(1.02)
National merger enforcement (lagged)	-0.021	(-0.56)	-0.021	(-0.99)	0.120	(1.62)
National cartel fines (lagged)	0.056*	(1.79)	0.094	(1.13)	0.018	(0.46)
National cartel & abuse cases (lagged)	-0.403	(-1.29)	0.245	(1.27)	-1.364**	(-3.02)
Sector inquiry	0.273	(1.47)	0.094	(0.74)	0.254*	(2.14)
Regulation (OECD index) (lagged)	-0.078	(-0.15)	-0.303	(-0.58)	-0.573	(-1.67)
EU merger cases (lagged)	-0.016	(-0.11)	-0.134	(-0.53)	-0.066	(-0.51)
State aid cases (lagged)	0.089	(1.03)	-0.341	(-1.61)	0.197**	(2.34)
National merger cases (lagged)	-0.379*	(-2.04)	0.016	(0.06)	-0.055	(-0.33)
GDP per capita	-0.934	(-0.77)	-2.628	(-1.08)	-1.966	(-0.59)
Population growth	0.111	(0.75)	0.104	(0.27)	0.262	(0.90)
Energy imports (% of tot. cons.)	1.288	(1.09)	1.556**	(2.47)	1.579**	(2.67)
Electricity capacity (combustible)	-1.544	(-0.99)	-3.063	(-1.14)	3.568*	(2.16)
Electricity capacity (nuclear)	15.310	(0.82)	10.327*	(2.00)	-14.539	(-1.11)
Electricity capacity (renewable)	0.811	(1.38)	0.621	(0.83)	-2.011**	(-2.67)
R-squared	0.20		0.60		0.36	
Observations	251		126		125	

Notes: The level of observation is country-sector-year. The dependent variable is the sector-country specific elasticity of relative profits with respect to relative costs, Boone’s beta. All policy variables are lagged one year. We report standardised coefficients. Standard errors are robust and clustered at the country level. The t-statistics are reported in parentheses. We control for country-sector fixed-effects as well as year dummies. The symbols ***, **, * represent 1%, 5%, and 10% significance level respectively.

Table 8 - The impact of competition policy variables on investment

	Full Sample		Low Regulation		High Regulation	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
EU merger enforcement (lagged)	-0.007	(-0.31)	0.226***	(2.90)	-0.006	(-0.20)
EU State aid enforcement (lagged)	-0.001	(-0.07)	-	-	-0.008	(-0.38)
EU abuse & cartel enforcement (lagged)	0.020	(0.51)	-0.265***	(-2.60)	0.059**	(2.29)
National merger enforcement (lagged)	0.008	(0.36)	0.002	(0.05)	0.005	(0.26)
National cartel fines (lagged)	-0.003	(-0.11)	-0.038	(-0.34)	-0.018	(-1.01)
Sector Inquiry	0.058	(1.07)	-0.059	(-0.65)	0.062	(1.23)
Regulation (OECD indicator) (lagged)	0.178	(1.67)	2.815***	(3.30)	0.153	(1.59)
EU merger cases (lagged)	-0.037	(-1.49)	-0.378***	(-2.87)	-0.060	(-1.10)
State aid cases (lagged)	0.029	(1.55)	0.195**	(2.37)	0.024	(0.91)
National merger cases (lagged)	0.015	(0.27)	-0.210	(-0.63)	0.010	(0.12)
National cartel & abuse cases (lagged)	0.020	(0.70)	0.008	(0.08)	0.065	(1.20)
Electricity capacity (combustible)	-0.627	(-1.52)	-0.486	(-0.72)	-0.604	(-1.44)
Electricity capacity (nuclear)	-0.448	(-1.00)	9.016***	(3.46)	4.234	(1.40)
Electricity capacity (renewable)	0.329**	(2.54)	0.909***	(2.66)	0.223*	(1.70)
GDP per capita	-0.676**	(-2.56)	-0.577	(-1.20)	-0.621	(-1.53)
Population growth	0.088*	(1.99)	0.654***	(5.29)	0.034	(0.83)
Energy imports (% of tot cons)	0.077	(0.62)	0.288	(0.86)	0.223	(1.14)
R-squared	0.17		0.18		0.21	
Observations	8,344		4,098		4,246	

Notes: The unit of observation is firm-country-year. The dependent variable is firm level investment. All policy variables are lagged one year. We report standardised beta coefficients. Standard errors are robust and clustered at the country level. The t-statistics are reported in parentheses. We control for firm fixed-effects as well as year dummies. The symbols ***, **, * represent 1%, 5%, and 10% significance level respectively.

Table 9 – The impact of competition policy variables on total factor productivity (TFP)

	Full Sample		Low Regulation		High Regulation	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.-stat
EU merger enforcement (lagged)	0.057*	(2.08)	0.219**	(1.99)	0.073**	(2.09)
EU State aid enforcement (lagged)	-0.028	(-1.41)			-0.001	(-0.02)
EU abuse & cartel enforcement (lagged)	0.012	(0.29)	-0.065	(-0.43)	-0.032	(-0.96)
National merger enforcement (lagged)	0.013*	(1.94)	0.035	(0.65)	0.019	(0.67)
National cartel fines (lagged)	0.015	(0.53)	0.129	(0.76)	0.011	(0.48)
Sector Inquiry	-0.021	(-0.40)	-0.043	(-0.32)	-0.032	(-0.52)
Regulation (OECD indicator) (lagged)	-0.099	(-0.53)	0.023	(0.02)	-0.167	(-1.54)
EU merger cases (lagged)	-0.036	(-1.07)	0.117	(0.58)	-0.133*	(-1.93)
State aid cases (lagged)	-0.033	(-0.88)	-0.005	(-0.04)	-0.028	(-0.78)
National merger cases (lagged)	0.077	(0.72)	-0.296	(-0.64)	-0.050	(-0.43)
National cartel & abuse cases (lagged)	0.029	(0.69)	0.095	(0.65)	0.010	(0.17)
Electricity capacity (combustible)	-0.775	(-1.30)	1.445	(1.35)	-0.636	(-1.19)
Electricity capacity (nuclear)	0.396	(0.97)	0.209	(0.05)	-7.786*	(-1.86)
Electricity capacity (renewable)	0.239	(0.90)	-0.378	(-0.77)	0.463***	(2.72)
Leader Productivity	0.070**	(2.61)	0.072**	(2.28)	0.041	(1.38)
GDP per capita	-0.446	(-0.91)	-0.403	(-0.57)	-0.086	(-0.16)
Population growth	-0.021	(-0.38)	0.129	(0.71)	0.033	(0.61)
Energy imports (% of tot cons)	-0.438	(-1.69)	-1.407***	(-2.98)	0.519*	(1.85)
Adjusted R-squared	0.26		0.23		0.34	
Observations	4,773		2,305		2,468	

Notes: The unit of observation is firm-country-year. The dependent variable is firm level total factor productivity. All policy variables are lagged one year to reduce endogeneity issues. We report standardised beta coefficients. Standard errors are robust and clustered at the country level. The t-statistics are reported in parentheses. We control for firm fixed-effects as well as year dummies. The symbols ***, **, * represent 1%, 5%, and 10% significance level respectively.

Table 10 –State aid subsamples

	Beta		Investment		Productivity (TFP)	
	Low aid	High aid	Low aid	High aid	Low aid	High aid
EU merger enforcement (lagged)	-0.395*	-0.009	0.003	0.240	0.081**	0.055
	(-2.02)	(-0.31)	(0.07)	(1.55)	(2.05)	(1.04)
EU State aid enforcement (lagged)	-0.021	-0.024	0.024	0.140	0.006	-0.014
	(-0.35)	(-1.07)	(1.03)	(1.75)	(0.21)	(-0.45)
EU abuse & cartel cases (lagged)	0.001	0.086***	-0.042	-0.186	-0.021	0.091
	(0.01)	(2.99)	(-0.67)	(-0.86)	(-0.54)	(1.08)
National merger enforcement (lagged)	0.056	-0.004	0.104***	-0.659*	-0.005	0.003
	(1.03)	(-0.20)	(4.37)	(-2.12)	(-0.17)	(0.11)
National cartel and abuse fines (lagged)	0.049	-0.019	0.109**	0.081	0.005	-0.060
	(0.99)	(-1.08)	(2.22)	(0.55)	(0.22)	(-0.84)
Sector Inquiry	0.250	0.091	0.014	-0.036	-0.122	0.058
	(1.03)	(1.16)	(0.21)	(-0.10)	(-1.15)	(0.73)
Regulation (OECD indicator) (lagged)	0.323	0.185	0.533*	-0.648	-0.052	0.215
	(0.95)	(1.27)	(1.75)	(-0.61)	(-0.31)	(0.49)
EU merger cases (lagged)	-0.288	0.025	-0.112**	0.331	-0.002	-0.176**
	(-1.62)	(0.41)	(-2.04)	(1.29)	(-0.02)	(-2.29)
EU State aid cases (lagged)	0.013	0.073**	0.030	0.153	0.020	-0.063
	(0.12)	(2.08)	(0.90)	(1.33)	(0.39)	(-1.35)
National merger cases (lagged)	-0.518	-0.055	0.012	0.284	-0.094	0.483*
	(-1.76)	(-0.66)	(0.07)	(0.56)	(-0.76)	(1.92)
National cartel and abuse cases (lagged)	-0.506*	0.048	0.076	0.177	-0.022	0.100
	(-1.91)	(0.90)	(1.32)	(0.65)	(-0.36)	(1.17)
Electricity capacity (combustible)	-1.958	-0.416	-1.731	0.665	-0.135	-7.538***
	(-1.06)	(-0.92)	(-1.51)	(0.18)	(-0.21)	(-3.81)
Electricity capacity (nuclear)	-6.668	6.512	-0.306	-0.380	-15.207***	0.848
	(-0.08)	(1.50)	(-0.66)	(-0.03)	(-2.60)	(1.17)
Electricity capacity (renewable)	1.191	0.213	0.379	-1.025	0.317*	1.686***
	(1.60)	(1.44)	(1.04)	(-0.95)	(1.66)	(2.73)
Leader Productivity	-	-	-	-	0.091***	0.056*
					(3.07)	(1.82)
GDP per capita	-3.981	-0.248	0.359	1.150	0.624	-0.194
	(-1.06)	(-0.60)	(1.44)	(0.75)	(0.99)	(-0.55)
Population growth	0.185	0.107**	0.069	0.879	-0.004	-0.042
	(0.67)	(2.15)	(0.48)	(1.43)	(-0.06)	(-0.20)
Energy imports (% of tot cons)	2.838**	-0.142	0.442***	0.588	-0.511*	0.062
	(3.02)	(-0.72)	(2.58)	(0.73)	(-1.80)	(0.27)
Observations	125	4169	4175	126	2428	2345
R-squared	0.303	0.276	0.185	0.480	0.322	0.267

Notes: The unit of observation is firm-country-year. The dependent variable is the sector-country specific elasticity of relative profits with respect to relative costs (Boone's beta), firm level investment, and firm level total factor productivity, respectively. All policy variables are lagged one year to reduce endogeneity issues. We report standardised beta coefficients. Standard errors are robust and clustered at the country level. The t-statistics are reported in parentheses. We control for firm fixed-effects as well as year dummies. The symbols ***, **, * represent 1%, 5%, and 10% significance level respectively.

Table A1 - Production function regressions for the different sectors

	Production		Transmission		Trade	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
ln(K)	-0.173*	(-1.78)	0.468***	(4.95)	0.799***	(7.95)
ln(L)	0.378***	(4.32)	0.381***	(4.47)	-0.209*	(-1.72)
ln(M)	0.409***	(7.33)	0.431***	(6.45)	0.751***	(19.22)
ln(K) ²	0.081***	(7.27)	-0.013	(-1.27)	0.017	(1.26)
ln(L) ²	0.059***	(5.73)	0.047***	(2.81)	-0.008	(-0.41)
ln(M) ²	-0.036***	(-4.14)	0.092***	(10.50)	0.113***	(16.51)
ln(L)*ln(K)	-0.067**	(-2.14)	-0.006	(-0.22)	0.213***	(4.61)
ln(L)*ln(M)	-0.046***	(-2.82)	-0.137***	(-6.68)	-0.058***	(-3.16)
ln(K)*ln(M)	0.030	(1.36)	-0.047*	(-1.69)	-0.256***	(-13.08)
ln(K)*ln(M)*ln(L)	0.005**	(1.98)	0.008**	(2.30)	0.001	(0.24)
ln(L) ² *ln(M)	-0.007***	(-6.08)	-0.009***	(-9.31)	0.006***	(3.02)
ln(L) ² *ln(K)	-0.002	(-0.94)	-0.006	(-1.04)	-0.010	(-1.60)
ln(K) ² *ln(L)	0.004	(1.26)	-0.001	(-0.39)	-0.025***	(-5.54)
ln(K) ² *ln(M)	-0.009***	(-4.10)	0.004	(1.20)	0.024***	(9.00)
ln(M) ² *ln(L)	0.005***	(6.61)	0.009***	(8.83)	0.008***	(5.50)
ln(M) ² *ln(K)	0.018***	(7.32)	-0.015***	(-5.34)	-0.013***	(-6.61)
ln(L) ² *ln(K) ²	-0.000	(-0.44)	0.001*	(1.90)	0.002***	(2.74)
ln(L) ² *ln(M) ²	-0.000	(-1.07)	0.000	(1.04)	-0.001***	(-4.04)
ln(M) ² *ln(K) ²	-0.001***	(-6.86)	0.001**	(2.31)	0.000	(0.30)
ln(K) ² *ln(L) ² *ln(M) ²	0.000***	(3.41)	-0.000	(-0.84)	0.000	(0.01)
Constant	1.516***	(6.34)	1.161***	(5.29)	-0.674***	(-3.23)
R-squared	0.953		0.975		0.952	
Observations	2,862		2,327		1,929	

Notes: The level of observation is country-firm-year. The dependent variable is the country-firm-year specific log of operating revenues. Standard errors in parentheses are robust and clustered at the country-sector level. The t-statistics are reported in parentheses. We control for firm fixed-effects as well as year dummies. The symbols ***, **, * represent 1%, 5%, and 10% significance level respectively

Figures

Figure 1 (a) – EU merger and state aid cases; (b) – EU merger interventions; (c) – EU state aid interventions; (d) EU abuse and cartel cases (=interventions)

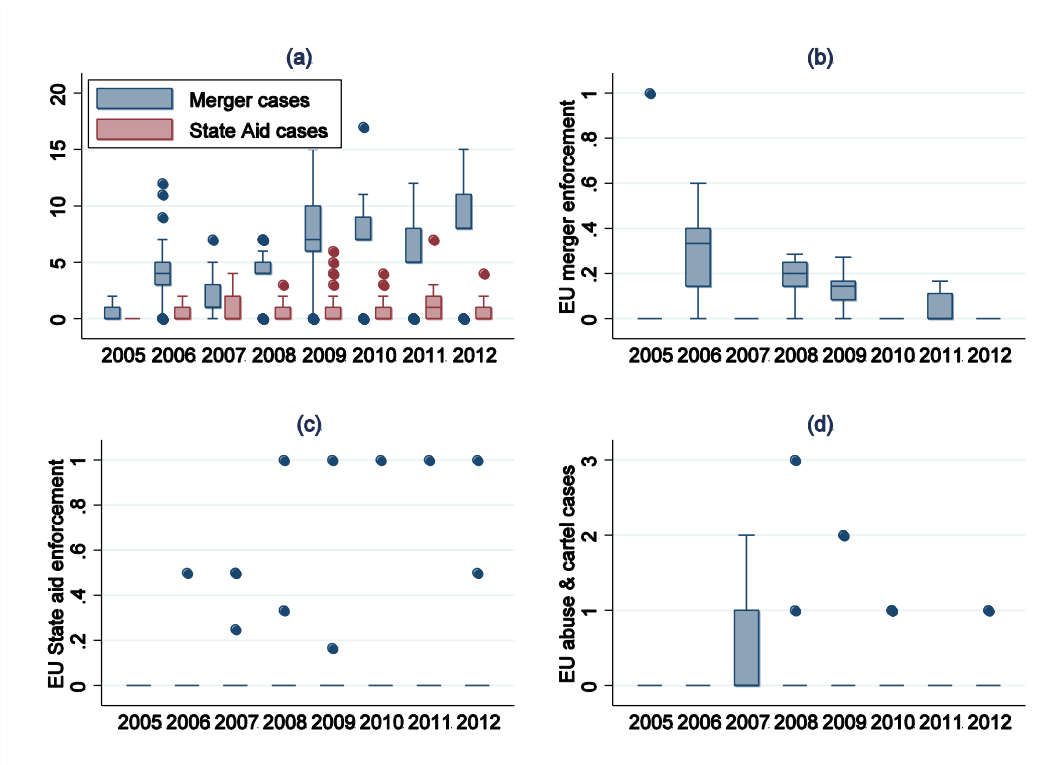


Figure 2 – (a) National merger cases; (b) National merger interventions; (c) National cartel and abuse cases (=interventions)

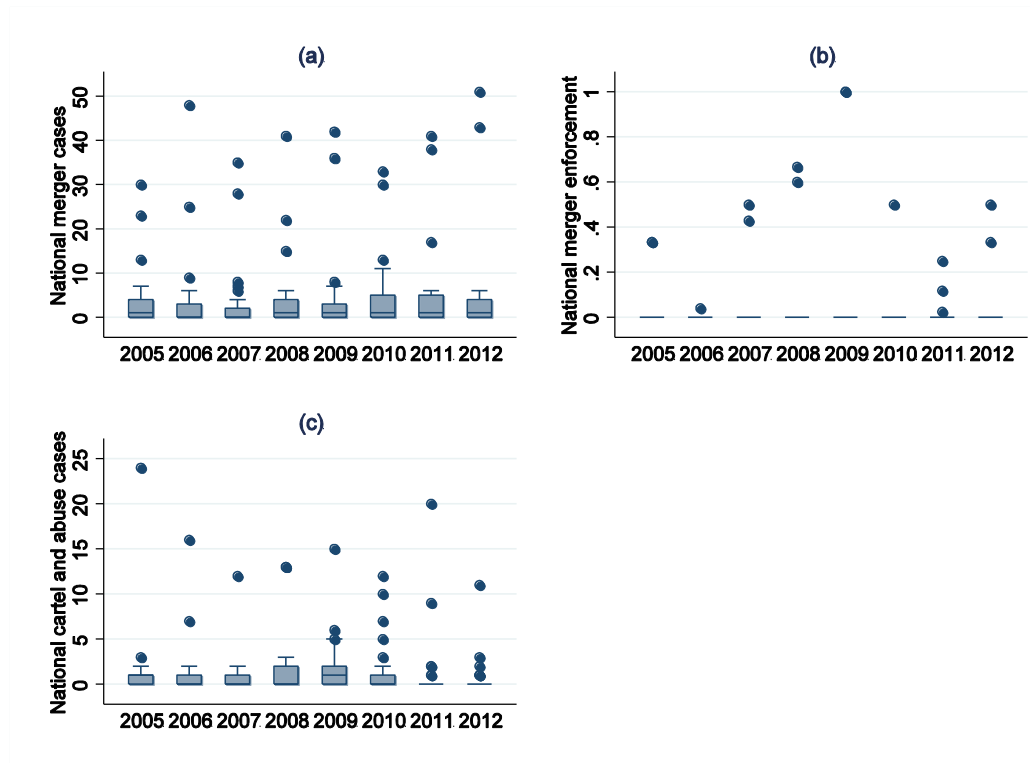


Figure 3 – Regulation and state aid in EU electricity and gas markets

