Regulatory Authorities and Energy Market Liberalization

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Abstract This thesis analyzes the effect of regulatory activities on the degree of electricity and gas market liberalization. Empirical findings hint at a positive relationship between regulatory independence and reform efforts. Furthermore, a liberalization-enhancing effect of regulatory authorities pursuing their statutory objective to promote consumer interests is suggested by theoretical results. However, as soon as regulators rather focus on business-oriented (as, e.g., high profits) or government-oriented goals (as, e.g., high tax yields), regulatory interferences might hamper the process of reform to the detriment of consumers, as both empirical and theoretical findings indicate.

Keywords: Independent regulatory authorities, energy market liberalization, unbundling.

Kurzzusammenfassung Diese Dissertation untersucht den Einfluss von Regulierungsaktivitäten auf den Grad der Liberalisierung von Strom- und Gasmärkten. Empirische Ergebnisse deuten auf einen positiven Zusammenhang zwischen Unabhängigkeit der Regulierungsbehörde und Reformbemühungen hin. Zudem legen theoretische Resultate einen liberalisierungsfördernden Effekt von Regulierungsbehörden nahe, wenn diese ihr satzungsmäßiges Ziel verfolgen, die Konsumenteninteressen zu fördern. Sobald Regulierer ihr Augenmerk jedoch eher auf Ziele richten, die Unternehmen (wie z.B. hohe Gewinne) oder den Staat begünstigen (wie z.B. hohe Steuereinnahmen), könnten regulatorische Eingriffe den Reformprozess zum Nachteil der Konsumenten hemmen, wie empirische und theoretische Ergebnisse signalisieren.

Schlagwörter: Unabhängige Regulierungsbehören, Energiemarktliberalisierung, vertikale Entflechtung.

Contents

Chapter 1

Introduction

Since around 1990, electricity (OECD/IEA, 2005; Newbery, 2009) and gas markets (Conway and Nicoletti, 2006) in OECD countries have been liberalized. The key objective of these reforms has been the creation of competitive energy markets that ensure low electricity and gas prices to the benefit of consumers (OECD/IEA, 2005; European Commission, 2007a; Newbery, 2009).

The liberalization process has been accompanied by the establishment of independent regulatory authorities (Smith, 1997; OECD/IEA, 2001). One of the major tasks of these agencies is to foster reform by protecting end-users from the market power of the energy sector's natural monopolists (Kay and Vickers, 1990; Small, 1999; OECD/IEA, 2001) active in electricity and gas transmission and distribution as well as in gas storage. Equipped with often broad competencies (Johannsen et al., 2004) to realize this goal, autonomous regulatory agencies are rated as being a crucial factor for the success of energy market reform (OECD/IEA, 2001; European Commission, 2007a).

This thesis analyzes to what extent regulators have fulfilled their official mission to benefit consumers by promoting liberalization. Beyond that and even more important, it also discusses whether regulatory decision makers might have thwarted reform to achieve personal goals.

In particular, this thesis studies whether regulators pursuing self-serving objectives might have refrained from implementing reform measures that increase the level of vertical separation between the natural monopolies and the (potentially) competitive activities in the electricity and gas sector (i.e., generation/production, wholesale and

retail). Such regulatory interventions, referred to as *unbundling*, have been identified as being indispensable for achieving full competition in the energy industry (European Commission, 2001, 2004; OECD/IEA, 2005; Newbery, 2009): they (help to) eliminate anti-competitive behavior of monopolists integrated with non-network activities (as, e.g., cross-subsidies or a discriminatory grid access for rivals) that hampers both the development and the functioning of the market (European Commission, 2001, 2004). Various forms of unbundling (separation of accounts, of information, of staff, creation of separate entities) that differ in their intensity exist (OECD, 2001; European Commission, 2004); the only measure that is rated as being a truly effective remedy for the monopolists' incentives to impede competition, though, is unbundling by ownership (OECD, 2001; European Commission, 2007a).

Chapter 2 examines whether European electricity and gas market regulators have affected the level of vertical separation implemented in both sectors and, furthermore, the design of entry regulation and the market structure. More precisely, we estimate the effect of the authorities' formal (i.e., statutory) independence on these three indicators for the progress of reform. Authority autonomy is seen as a vital prerequisite for an effective regulation as it prevents undue interferences from both regulatees and politicians into the regulatory process (Smith, 1997; OECD/IEA, 2001). Our key finding of a positive relationship between formal independence and liberalization efforts suggested by instrumental variable estimations is hence in line with expectations and corroborates the picture of regulators being "advocates of consumers".

Chapters 3 and 4 then challenge this perception. They indicate that also ministry or authority employees in charge of regulation might hamper reform by taking decisions that, instead of promoting the interests of end-users, rather benefit the regulators themselves or market participants other than consumers. The model in Chapter 3 analyzes why despite the benefits Ownership Unbundling has for competition (OECD, 2001; Mulder and Shestalova, 2006; Buchan, 2007; European Commission, 2007a; Pollitt, 2008) several EU member states still unbundle their power transmission grids only legally, i.e., they require network and non-network activities to be separated into different entities, but not into entirely independent companies. Distinguishing between different objectives a regulator might pursue, we find that only agencies that act in the interest of consumers favor the implementation of Ownership Unbundling. Regulators

that strive for high industry profits since, e.g., they are captured (Stigler, 1971; Laffont and Tirole, 1991; Che, 1995; Agrell and Gautier, 2010, 2012a) or for high agency budgets to, e.g., satisfy personal needs (Niskanen, 1968, 1975; Noll, 1989; Train, 1991, ch. I.1), by contrast, are indifferent between separating the grid legally or by ownership. Possible drawbacks for the authority or the companies resulting from Ownership Unbundling that are, however, rated as minor compared to the benefits for consumers (Pollitt, 2008) might then induce regulators to mandate only legally separated networks, thus preventing a welfare-enhancing step of reform.

Chapter 4 takes up the notion that authority members focusing on high agency budgets instead of on consumer interests might refrain from implementing unbundling measures in the power sector. It empirically analyzes the effect of tax yields on the degree of vertical separation in OECD electricity markets. Tax revenues are proxied by the rates of the corporate income tax and the VAT on electricity and we argue as follows: regulatory decision makers striving for high appropriations for their institution favor high tax yields since higher tax revenues are associated with increases in the funding of ministries and agencies; consequently, these regulators refrain from implementing [foster] unbundling measures that reduce [raise] the base of a tax and therefore its revenues. Since the potential loss [increase] in tax yields is higher, the higher the tax rate, the regulatory actors' incentive to delay [promote] reform increases in the tax rate. Estimation results for the corporate income tax rate are in line with these considerations: with vertical separation reducing the base of the tax, a negative relationship between tax rate and unbundling intensity is suggested. For the VAT on electricity estimates hint at a liberalization-enhancing effect of high tax rates, further substantiating our reasoning in cases of high price elasticities of power demand. The theoretical results from Chapter 3 indicating that regulators pursuing objectives other than the promotion of consumer interests might hamper reform to the detriment of electricity end-users are hence further corroborated.

Chapter 2

Does Regulatory Independence Translate into a Higher Degree of Liberalization? - Evidence from EU Energy Regulators[1]

2.1 Introduction

The liberalization process initiated by the European Union in electricity and gas markets in the mid-1990s has aimed at achieving a single internal energy market (European Communities 1996, 1998). It was accompanied by the establishment of national independent regulatory authorities (IRAs) which foster reform by fulfilling three different tasks: first, they allow protection of investors from arbitrary government interferences with regulation that would otherwise occur due to short-term political pressures. Second, they monitor the natural monopolies that exist in both industries (i.e., transmission and distribution in both sectors as well as gas storage) to avoid competition-hampering impacts on the liberalized activities (i.e., generation/production, wholesale and retail); this prevents the monopolists from abusing their market power at the expense of consumers. Finally, IRAs are commissioned to enhance economic efficiency (Smith, 1997; OECD/IEA, 2001), which especially implies the enforcement of prices for monopoly services that eliminate excess profits, but still both ensure costs coverage and provide

[1]This chapter was presented at the 1st Annual Conference on the Regulation of Infrastructure Industries in Florence, the 35th IAEE International Conference in Perth (AUS), the 10th EEM International Conference in Stockholm, the 32nd USAEE/IAEE North American Conference in Anchorage, the 13th IAEE European Conference in Düsseldorf, the 2nd Lower Saxon Workshop in Applied Economics in Hannover and the Workshop on Public Economics in Kassel.

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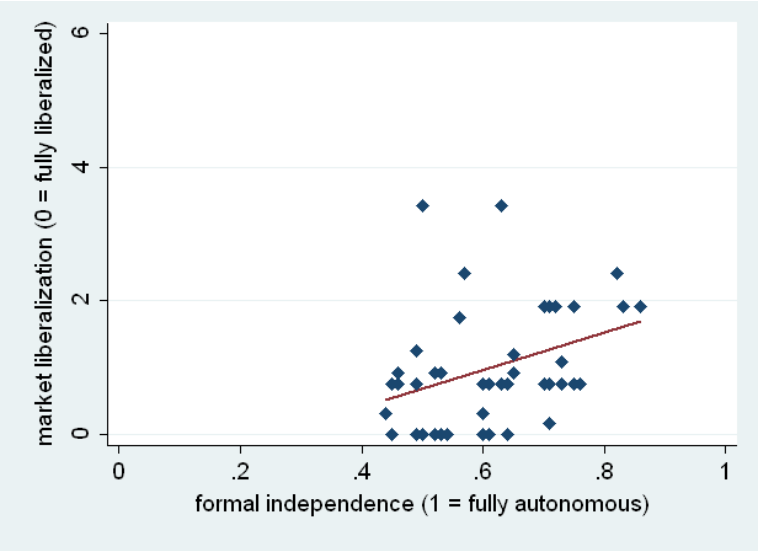

FIGURE 2.1: REGULATORY INDEPENDENCE AND ELECTRICITY MARKET LIBERALIZATION

incentives for cost reductions and adequate, timely investments (Small, 1999; Joskow, 2007).

A proper fulfillment of these tasks requires that neither politicians nor regulatees are able to affect agency decisions in any way. An authority's independence from both politics and stakeholders backed by an adequate endowment with financial and personnel resources is therefore rated as essential for an effective regulation (Smith, 1997; OECD/IEA, 2001). This notion, however, is challenged by the scatterplots shown in Figures 2.1 and 2.2: the diagrams contrast the degree of regulatory independence with the liberalization level realized in European energy markets; they include three (for electricity) and two (for gas) years, respectively, of the early 2000s as well as 16 countries

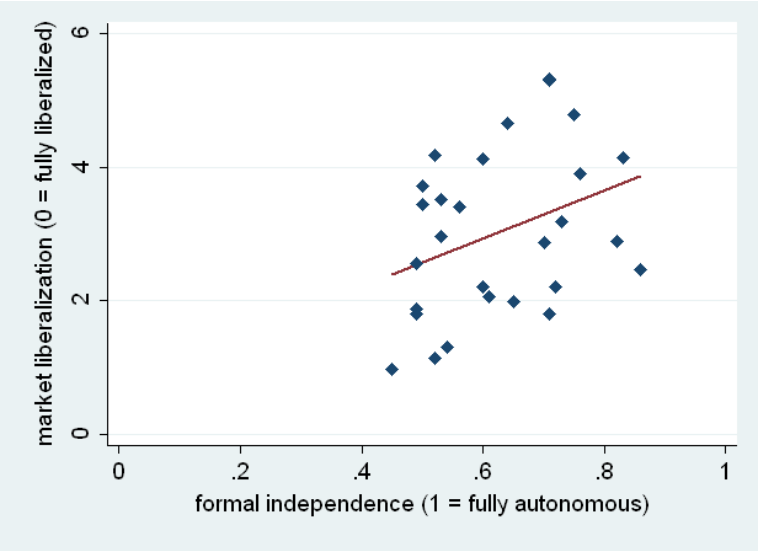

FIGURE 2.2: REGULATORY INDEPENDENCE AND GAS MARKET LIBERALIZATION

(EU-15 plus Norway). The regulators' autonomy is measured by an index developed by Gilardi (2002) that ranges from 0 to 1 and increases with higher degrees of formal (i.e., statutory) independence. Liberalization is operationalized by averaging OECD measures that evaluate market entry regulation, vertical separation provisions (in both sectors) and market structure (only in the gas sector) by assigning values between 6 (precluding competition) and 0 (fostering competition) (Conway and Nicoletti, 2006; OECD, 2011a)[2]. Contrary to what is expected, the fitted regression lines in the plots suggest lower reform efforts in energy markets supervised by more autonomous authorities; the higher slope in Figure 2.2 indicates that the negative relationship seems to be even more pronounced in the gas sector.

These observations are at odds with the conventional wisdom of competition-enhancing independent regulators. They rather emphasize the relevance of the warning to be found repeatedly in research on IRAs (Thatcher, 2002a; Maggetti, 2007; Gilardi and Maggetti, 2011): despite the substantial role that regulatory authorities (are supposed to) play during reform processes, a comprehensive analysis of their functioning and particularly their actual impact on liberalization is still missing.

Our paper now aims at narrowing this research gap: it empirically analyzes the effect of regulatory formal independence on the intensity of electricty and gas market reforms in Europe. At the same time, this study takes the first steps to overcome an issue identified as significantly impeding the empirical assessment of IRAs: the problem of lacking long-term data on the agencies' degree of statutory autonomy (Gilardi and Maggetti, 2011) is tackled by the construction of a small panel sample that captures the formal independence of the *same* European energy regulators in *different* years.

An agreed-upon measure of statutory agency autonomy does not exist in economics. Autonomy data for the first sample year are therefore borrowed from Gilardi's (2002) index of regulatory formal independence which was originally developed to verify two explanations for diverging degrees of agency autonomy prevailing in political science: the credibility and the uncertainty hypothesis.

The credibility hypothesis states that governments delegate decision-making powers in the area of market regulation to *agencies* detached from cabinets so as to be able to

[2]Methods and data sources used to construct both the independence and the liberalization index are described in detail in Section 2.2.1.

credibly display the ruling parties' commitment to regulatory provisions (Gatsios and Seabright, 1989). The giving up of power on the part of politicians is seen as necessary due to the governments' ongoing propensity to optimally adapt their policies to actual circumstances and their political discretion empowering them to do so (Kydland and Prescott, 1977): only an institutional arrangement eliminating decisional leeway allows cabinets to credibly rule out future changes in regulations (Shepsle, 1991). Agencies *fully independent* from government are expected to fulfill this requirement most effectively (Majone, 1997a, 1997b).

The uncertainty hypothesis claims that ruling politicians set up autonomous authorities to shield their political beliefs from opposing successors in case they lose majority: established with objectives that reflect the government's ends, their institutional structures durably resistant against any interference secure an adamant policy in the agencies' jurisdictions (Moe, 1989).

The employment of Gilardi's (2002) index requires a closer consideration of two of its properties, though. First and as mentioned above, the measure merely depicts "a snapshot of the formal independence of regulatory agencies" (Gilardi and Maggetti, 2011: 206): it covers only a single observation point in time, the first panel year. This makes the intended analysis of the long-term effects of agency autonomy on electricity and gas market liberalization impossible, so we extend the sample period: we use two surveys on European energy regulators (Johannsen et al., 2004; CEER, 2005) along with Gilardi's (2002) method of calculation to compute comparable values of the autonomy index for further years.

Second, Gilardi's (2002) measure only considers how "prescriptions, enshrined in the constitutions of agencies, [...] guarantee their independence from elected politicians" (Gilardi and Maggetti, 2011: 202); the results of *regulatory capture* theory are hence neglected. Based on Stigler's (1971) seminal paper claiming that politically influential industries are able to abuse state institutions to maximize the incumbents' profits, different strands of the *capture* approach solely blame the regulatees for welfare detrimental regulations: agency members are assumed to act in the interest of firms due to bribes (Laffont and Tirole, 1991), post-tenure job prospects in the industry (Che, 1995) or by intentionally applying biased information provided by the regulatees as a basis for regulatory decisions (Agrell and Gautier, 2010, 2012a, 2012b), while governments are

expected to strive for welfare maximization only. However, despite the definite source of adverse regulations suggested by *capture* theory, focusing on political instead of industry interference by applying Gilardi's (2002) index should provide reliable results: at variance with the theoretical predictions, Wilks and Bartle (2002) argue that especially the prevention of political influence is crucial for obtaining effective regulators; regulatees try to interfere with authorities mostly only indirectly via politicians who are prone to yield to political pressures and are therefore exploited by suppliers as well as industrial lobbyists.

We start our empirical analysis by running OLS regressions that control for several factors that might affect the degree of energy market liberalization besides regulatory formal independence (including those that have been identified to influence a country's reform efforts in previous studies). In these estimations, the sign of the coefficients on statutory agency autonomy turns out to be in line with the negative relationship between regulatory independence and liberalization suggested by the scatterplots, but the estimates cannot reach statistical significance.

However, the common notion that authority independence fosters liberalization might induce a government facing a poor reform progress in the energy sector to extend the responsible regulator's autonomy; in this case, our OLS estimates would be biased because of reverse causality. We cope with this problem by re-running our regressions, using 2SLS IV as the estimation method. To select the instrumental variables, we draw on the research on the determinants of formal regulatory independence: proxies for political uncertainty and for political credibility are employed. The instruments should accordingly be correlated with statutory agency autonomy and fulfill the first requirement to be valid. We furthermore argue that also the second condition for instrument validity, a lacking direct effect on liberalization, is met by the credibility and the uncertainty measure: in particular due to the high level of expertise needed for today's utility regulation, we expect that solely IRAs (are able to) determine the scope of energy market reforms. Their regulatory decisions, in turn, should be unaffected by both a feature of a country's polity (as a government's risk of losing office to a successor with a different ideology, captured by the uncertainty proxy) and the degree of an economy's globalization (applied as credibility proxy).

In line with the uncertainty hypothesis, first stage IV results reveal the formal reg-

ulatory independence to increase with a higher risk for governments to be replaced by warring politicians. Moreover, higher levels of statutory autonomy are suggested for less globalized economies. This contradicts expectations, though: an outstanding importance for cabinets to credibly commit to regulations is conjectured to exist especially in open countries where foreign investors have to be attracted and retained. We provide the following possible explanation for this inconsistent finding: evidence from EU member states indicates that, due the energy sector's importance for an economy, governments favor national energy suppliers to be controlled by domestic shareholders. The European Union, though, counteracts this tendency by all means to enforce the EC Treaty rules on the free movement of capital and the freedom of establishment. The only remaining possibility for politicians to influence the energy sector in their interest is therefore to interfere with the regulator; higher foreign investments should then induce governments to keep a foot in the authority's door, reflected by a limitation of formal regulatory independence. In the second stage of the IV regression, a considerable liberalization-enhancing effect of an authority's formal independence is suggested by the respective estimate. Supporting conventional wisdom in contrast to its OLS counterpart, it indicates that an interaction between the scope of reform and the statutory level of regulatory autonomy (and hence an endogeneity problem) indeed exists.

The remainder of the chapter is organized as follows: The next section illustrates the data used to test the hypothesis of a liberalization-enhancing effect of IRAs empirically and elaborates on our controls. Section 2.3 reports and discusses OLS regression results. Section 2.4 takes account of potential reverse causality problems. It introduces appropriate instruments for regulatory independence and substantiates their selection; then, the section presents and discusses IV regression results. Section 2.5 concludes.

2.2 Data and Variables

2.2.1 Liberalization and Regulatory Independence

To capture the degree of liberalization in national electricity and gas markets, we draw on the OECD's ETCR (*E*nergy, *T*ransport and *C*ommunications *R*egulation) index (OECD, 2011a). It provides a comparative measure for the overall liberalization

level in seven non-manufacturing sectors (electricity, gas, airlines, railways, road transport, post, telecommunications) by assessing how regulatory provisions impede competition in the (potentially) competitive stages of the industries' value chains. The comprehensive measure is composed of (equally weighted) sector indicator values. These, in turn, are the averaged scores of two to four sub-indicators, capturing the regulatory design in areas that are crucial for realizing a competitive market in the industry considered. They are chosen from the following: barriers to entry, public ownership, market structure, vertical integration, and price controls. Two or three main aspects of the structural arrangements in each selected field are then evaluated on the basis of data included in OECD and other institutions' official publications as well as on information on policy settings and regulatory rules gathered from OECD member states by a questionnaire (Conway and Nicoletti, 2006).

Since we are interested in a possible relationship between regulatory independence and liberalization in the *energy* sector, we concentrate on the indicators for the electricity and the gas sector. The sub-indicators originally included are entry regulation, public ownership and vertical integration (both sectors) as well as the market structure (only for the gas sector) (Conway and Nicoletti, 2006). Due to concerns about reverse causality, however, we disregard the ownership situation: according to Majone (1996a), the market power of natural monopolies existing in European energy markets has been curbed for a long time by nationalization. The nationalization of natural monopolies aimed at ensuring an appropriate consideration of the public interest in the companies' production and pricing decisions, but was increasingly perceived as failing to meet this objective: apart from the insufficient supervision of the firms' leaders due to a lack of specialist knowledge and information on the side of politicians, both vague responsibilities and managerial objectives prevented clear-cut performance ratings and enabled executives either to excessively expand corporate activities or to preserve convenient conditions. In the recent past, independent authorities have therefore taken over the regulatory function from public ownership.

To measure the liberalization levels in gas and electricity markets, we calculate the respective mean of the sub-indicators for each sector. The following major aspects are evaluated: the electricity entry regulation sub-indicator captures the conditions of third party access, the existence of a wholesale market and restrictions in the consumers'

choice of supplier; the vertical integration sub-indicator considers the level of vertical separation between transmission and generation as well as the overall degree of vertical integration in the sector. The gas entry regulation sub-indicator analyzes the terms of third party access, the extent of consumer choice and provisions curtailing market entry in the production/import stage; the vertical integration sub-indicator assesses the degree of vertical seperation between production/import and all residual stages, between supply and all residual stages and separately between supply and distribution. The sub-indicator for the market structure in the gas sector additionally evaluates the largest companies' market shares in the production/import, in the transmission and in the supply stage. Evaluation scores assigned to each of these issues range from 0 to 6 and increase with the anticompetitiveness of regulatory provisions. A weighting scheme adding up to 100 percent is then applied to all scores belonging to one sub-indicator, yielding index values between 0 and 6 for both the latter (Conway and Nicoletti, 2006) and our liberalization measure.

To measure the autonomy of energy regulators, an index of formal independence developed by Gilardi (2002) is applied as a benchmark. An authority's *formal* independence determines the degree of autonomy conceded to an IRA by statutes and laws that prohibit political interventions (Gilardi, 2002). It has to be distinguished from an agency's *de facto* independence (Gilardi and Maggetti, 2011) which captures the non-interference in an authority's day-to-day operations and is conceptualized and operationalized in Maggetti (2007). Unlike the formal independence concept, the de facto approach considers autonomy from both politicians and regulatees. Gilardi's (2002) index comprises five dimensions determining a regulator's formal autonomy: the agency head's status, the management board members' status, the authority's relationship with government and parliament, the regulator's financial and organizational autonomy and the regulatory competencies. The degree of independence in these areas is assessed by a questionnaire answered by regulators (Gilardi, 2002, 2005a, 2008, ch. 8). It assigns values between 0 and 1 to predefined answering possibilities to questions that capture the statutory provisions governing the respective aspect surveyed. The values increase when political interference is impeded by the relevant laws. The dimension indices are the average values of all questions composing a dimension; the overall autonomy values used in our paper are calculated as the means of the dimensions. Figures for the total

formal independence of electricity regulators are reported in detail in Gilardi (2008, ch. 8) and reflect the situation in one year of the 2001-2003 period that differs for the agencies included in the sample.

Since we are particularly interested in possible effects of regulatory independence on liberalization over time, we draw on the surveys by Johannsen et al. (2004) and the Council of European Energy Regulators (CEER) (2005) to add observations from additional years. Both reports use similar questionnaires as Gilardi (2002) to picture the formal autonomy of IRAs, so that constructing a small sample that captures the formal independence of energy regulators in 16 European countries (EU-15 plus Norway) in the recent past becomes possible: all answers were coded according to Gilardi's (2002) scale, so as to generate a comparable measure for the independence dimensions and the overall IRA autonomy. Unlike Gilardi (2002, 2005a, 2008, ch. 8), who explicitly refers to *electricity* regulators, both Johannsen et al. (2004) and CEER (2005) sent their questions to the CEER member authorities responsible for *energy* regulation. For the periods covered by these two studies (Johannsen et al. (2004): 2003/2004 and CEER (2005): 2005) we therefore consider both the *electricity and* the *gas* sector. As the regulator in Norway is not responsible for governing the gas market (International Energy Regulation Network, 2012), only the Norwegian electricity sector is included in our analysis[3].

2.2.2 Control Variables

Next to the impact independent regulators are expected to have on energy market liberalization, several other explanations for diverging reform efforts exist. We outline the associated theoretical approaches as well as related empirical evidence in the following and add appropriate control variables to our estimations. Furthermore, this section introduces additional covariates we include in the regressions and briefly substantiates

[3]Lacking data on regulatory independence further reduce the number of observations: the survey by Johannsen et al. (2004) does not include information about the Belgian and the German electricity and gas regulators, while Gilardi (2008, ch. 8) does not provide an index value for the Luxembourgian electricity agency. In addition, Gilardi (2008, ch. 8) assigns an index value of 0 to the German electricity authority for our first year of observation: an energy sector regulator autonomous from the government had not yet existed there in 2002. Since we want to assess the relationship between the formal independence of IRAs and the scope of energy market reform, we exclude this observation from our sample.

their selection. Detailed descriptions of the controls as well as summary statistics for all variables can be found in Tables 2.4 and 2.5 in the Appendix, respectively.

First, we distinguish between regulatory activities in the electricity and the gas industry. Compared to electricity markets, reform efforts in the gas branch were smaller in the early years of liberalization (Conway and Nicoletti, 2006), so we take account of the distinct initial situations newly established regulators had to face in both these sectors when they started their work.

Furthermore, the duration of a regulator's activity most likely plays an important role for the fulfillment of its (economic) task to eliminate anti-competitive behavior: determination, implementation and enforcement of reform measures as well as potentially necessary adjustments to improve their efficiency require a long time period. Besides, authorities organized in networks (as, e.g., the Council of European Energy Regulators) might, over time, benefit from a transfer of knowledge and best practices between member agencies (Maggetti, 2007) that facilitates their mission. We therefore control for the number of years that have passed by since an authority has started its operation.

Moreover, the so-called "crisis hypothesis" asserts that a (severely) deteriorating economy is a prerequisite for reform: only the distress occurring in such a situation can induce politicians to implement necessary changes and, above all, enable them to force through these adjustments against the resistance of the losing group every reform inevitably creates (Drazen and Grilli, 1993; Krueger, 1993; Rodrik, 1996; Drazen and Easterly, 2001); at this point, the costs of the crisis unacceptably exceed the advantages of its few, albeit often well-organized, beneficiaries (who, beyond that, are expected to reduce opposition as they get negatively affected by the pervasive economic problems as well (Rodrik, 1996)). The hypothesis is substantiated with respect to high inflation by Drazen and Grilli (1993) theoretically as well as by Drazen and Easterly (2001) and Pitlik and Wirth (2003) empirically. With regard to growth crises, Pitlik (2008), examining the joint effect of a country's economic performance and its political regime type, provides empirical evidence for negative growth to foster reforms in democracies, but not in autocratic polities. Pitlik and Wirth (2003) find that - compared to a situation without a crisis - liberalization efforts are higher in countries suffering from a deep growth crisis, whereas a medium crisis delays steps of reform[4]. Drazen and

[4]Pitlik and Wirth (2003) define the two types of crisis as follows: They assign a value of 1 to every

Easterly's (2001) and Pitlik's (2007) results point in the direction of a growth crisis effect as well, but are (mostly) not statistically significant. To check for a possible relationship between the state of an economy and its degree of liberalization, we include a control for potential economic downturns in the previous year. Based on Pitlik and Wirth's (2003) findings, rather a reform-hampering effect of a crisis should show up, since in the period considered a deep recession did not emerge in European states. Pitlik's (2008) (and, within limits, also Drazen and Easterly's (2001) and Pitlik's (2007)) results, however, suggest exactly the opposite. We refrain from additionally controlling for currency devaluation, since the inflation rates identified as inducing reform are way beyond those observable in Europe during our sample period[5].

We also account for a country's energy efficiency in production. Since the desire for cheap energy is stronger in economies with energy-intense manufacturing processes, a high energy intensity probably fosters competitive market structures in the national electricity and gas industry. Far-reaching reforms should thus mainly take place in countries where the total amount of primary energy necessary to produce one thousand US$ of GDP - a common proxy for energy efficiency (OECD, 2010a) - was high in the preceding year.

The intensity of liberalization might likewise be affected by the government's ideology: typically, left-wing parties are expected to favor state interventions and, thus, rather comprehensive regulatory regimes, while right-wing policies are associated with an unobtrusive state, trusting the market and fostering deregulation (Benoit and Laver, 2006, ch. 6). The propensity to liberalize the energy sector should hence be lower in

year with a non-positive growth rate being higher than -1%; years with a rate equal to or smaller than -1% recieve a value of 2. Then, a five year period with a sum between 3 and 5 is classified as a medium growth crisis, a five year period with a total value greater than 5 constitutes a deep crisis. Their finding that at least medium crises hamper liberalization is in line with Bean's (1998) conjecture: contradicting the "crisis hypothesis", he argues that policy changes are more likely in times of growth, since a good economic performance allows to better alleviate the disadvantages of the losers of reform.

[5]As in the case of growth (compare footnote 4), Pitlik and Wirth (2003) differentiate between medium and deep crises also for inflation: a year with an inflation rate higher than or equal to 10% and smaller than 40% scores with a value of 1, a year with an inflation rate equal to 40% or smaller than 100% with a value of 2 and a year with an inflation rate exceeding 100% with a value of 3. Values are then added for five year periods. A period with an aggregated score between 2 and 10 is classified as a medium inflation crisis, while a period with a total value greater than 10 constitutes a deep crisis. Drazen and Easterly (2001), dividing their sample into percentiles subject to the inflation rate, find a positive effect on reform only for the groups with a median annual rate of 68% or more. When they use another classification method, even an annual inflation of at least 100% was necessary for countries to benefit.

countries governed by left-wing parties, which would also be in line with Pitlik's (2007) and Potrafke's (2010) empirical studies: both find general reform efforts to be higher in countries with right-wing governments. The revealed relationship, however, might not only be caused by direct governmental decisions and actions, as suggested by the plain theory; given the key role assigned to regulators in the liberalization process, it might also reflect the political orientation prevaling in authorities not (yet) fully politically independent: Gilardi (2005b) argues that "IRAs need not be ideologically neutral" (Gilardi, 2005b: 92), and his view is in line with Thatcher's (2002b) remarks on the establishment process of agencies, indicating the consideration of all influencial (political) interests during their creation. Finally - although with reference to general competition authorities - also a comment in Wilks and Bartle (2002) points into the same direction: such agencies are suggested to allow for the ruling politicians' views and objectives when taking decisions and to adjust to potential shifts therein. Descriptive statistics from Thatcher (2002a) substantiate the conjecture of ideological influences on regulatory decisions: for a sample of IRAs active in four EU countries and eight domains[6], the paper shows that 73 (ITA), 46 (FRA) and 36 (GER) percent of the authorities' senior members have been affiliated to a political party[7], and that 32 (ITA), 15 (GER), 9 (FRA) and 3 (UK) percent of them have even held or run for a political office at the local, national or European level before or after their agency job. The control for the ruling parties' orientation hence captures ideologically-tinged changes in the regulatory environment induced by either the government or politically sympathetic regulators.

Finally, we take account of the level of corruption prevailing in the sample countries. Venal public servants are expected to use the various actions at their disposal - as, e.g., the implementation of different regulatory measures - to their own benefit by affecting the bribers' ability and inclination to pay kickbacks (Tanzi, 1994; Ades and Di Tella, 1997a; Treisman, 2000): rents enjoyed by firms due to malfeasance enable officials to extract part of these illegitimate profits via bribes (Ades and Di Tella, 1997a, 1997b, 1999; Treisman, 2000). Since such rents emerge in particular in non-competitive environments (Mauro, 1996; Ades and Di Tella, 1997a, 1999), corruption is seen as a

[6]The domains are: general competition, telecommunications, energy, water, railways, postal services, media and stock exchange/shares; in some of the countries surveyed independent regulators did not exist in all of these areas. See Thatcher (2002a) for details.

[7]The corresponding percentage in the UK has been zero.

serious obstacle to the removal of market imperfections (Tanzi, 1994): civil servants aiming at high kickbacks are suspected to curb competition in their own interest (Ades and Di Tella, 1997a; Treisman, 2000). Consequently, we expect a negative relationship between the degree of liberalization and the perceived susceptibility to bribery of a country's public sector, captured by the last control we add. This would also be in line with previous theoretical and empirical findings: Emerson (2006), employing a Cournot model with a competitive fringe, shows that a low number of Cournot competitors corresponds to large kickbacks and is hence optimal from a venal official's point of view. Attached estimations furthermore reveal a strong negative effect of corruption on a country's overall level of competition. Van Koten and Ortmann's (2008) study shows that in the EU-15 the degree of vertical separation between electricity transmission and generation - an essential condition to realize fully liberalized markets (European Commission, 2007a) - is higher in less corrupt member states[8].

However, it might also be possible that the direction of effect runs exactly opposite and a low level of competition induced by only modest previous liberalization efforts increases corruption: the excessive rents firms generate in a strictly regulated, non-competitive market constitute a strong temptation for agency employees to demand bribes from the companies that are interested in maintaining their profitable situation (Mauro, 1996; Ades and Di Tella, 1999); a higher degree of state interference might therefore be associated with officials becoming more corrupt (Tanzi, 1994; Mauro, 1996; Treisman, 2000). A general negative effect of non-competitive rents on the officials' integrity is suggested both theoretically and empirically: Ades and Di Tella's (1997a) model shows that the proportion of corrupt bureaucrats increases in the profits of the regulated firms. And Ades and Di Tella's (1997a, 1997b, 1999) and Treisman's (2000) estimations reveal a higher susceptibility to bribery in countries where domestic companies enjoy higher rents due to the following reasons: a low trade openness (Ades and Di Tella, 1997a, 1997b, 1999; Treisman, 2000), a market dominance of few firms (Ades and Di Tella, 1999), regulatory interventions (Treisman, 2000), subsidies, fiscal discrimination or the exclusion of foreign firms from public procurement procedures

[8]Although not linked to bribery by the author, also Duso's (2002) results for the *mobile telecommunications sector* seem to further substantiate the above considerations: he finds that the higher the market share of the incumbent (and thus the rents it enjoys), the lower is the intensity of industry deregulation.

(Ades and Di Tella, 1997b); Ades and Di Tella's (1999) and Treisman's (2000) results, however, are not statistically significant throughout. In our case, it would probably be reasonable to argue that the non-competitive profits companies earn in the partially still regulated energy markets do not crucially affect the measure of overall perceived public sector corruption employed as a control; but to entirely rule out results biased by endogeneity, we re-estimate all regressions by lagging the corruption proxy by one year. We briefly address the outcomes of these robustness checks after the findings of our main estimations are discussed.

2.3 OLS Estimations

To test for the relationship between an IRA's formal autonomy and the degree of energy market liberalization, we start with estimating the equation

$$lib_{it} = \alpha + \beta \cdot formind_{it} + \boldsymbol{\gamma} \cdot \boldsymbol{X_{it}} + \epsilon_{it}.$$

The dependent variable lib_{it} denotes the liberalization level of electricity and gas markets. Our main explanatory variable is the regulator's formal independence $formind_{it}$. The vector $\boldsymbol{X_{it}}$ includes all factors that might also affect reform efforts, outlined in Section 2.2.2. Finally, ϵ_{it} describes the usual error term.

Table 2.1 reports the results from a fixed-effects OLS regression with robust standard errors being clustered at the country level. Basically, the estimation outcome suggests the relationship already revealed in Figures 2.1 and 2.2: the coefficient of the independence measure has a positive sign, indicating less competitive energy sectors in countries with thoroughly independent regulatory authorities; statistical significance, however, is lacking. The widespread notion of a liberalization-enhancing effect of autonomous regulators is hence further challenged at this point; findings are rather in line with the accusation that IRAs have not been able to overcome the often industry-friendly climate prevaling in regulation prior to their establishment (Thatcher, 2002a).

The statistically significant coefficients of the control variables reveal a slower liberalization pace in gas compared to electricity markets as well as a positive relationship between long-lasting IRA activities and the intensity of competition in energy sectors.

Table 2.1: Fixed-Effects OLS

dependent variable: lib	coef.	std.err.
formind	.2922	.8851
gas dum	2.1625***	.2935
IRA age	-.2458***	.0581
lag GDPcap crisis dum	.4492	.3360
lag ensupGDPunit	-.0145	.0115
ideopotr	.1478	.1650
corruption	-.0928	.4598
constant	4.4831	4.1180
N	72	
R^2 *within*	.7314	

Note: Table 2.1 shows estimation results of a fixed-effects OLS regression. Dependent variable is the mean of the electricity and gas sector sub-indicators, respectively, apart from public ownership, as described in Conway and Nicoletti (2006). Robust standard errors are clustered at the country level. *** denotes statistical significance at the 1% level.

According to their size, the modest reform efforts in the gas sector earlier in time entail a liberalization divergence which is equivalent to approximately two OECD index units. Furthermore, about every four years of regulatory surveillance reduce the liberalization measure by one unit.

The other controls show the expected signs as well. Our conjecture of a more competitive energy sector in case of an energy-intense economy seems to be reasonable, but the relationship is not statistically significant. Besides, the findings hint at more comprehensive reform processes in countries with a good economic performance, right-wing governments and a low corruption level. However, unlike in the studies explaining diverging reform efforts by these three aspects, their coefficients do not reach statistical significance in our estimations.

Lagging the corruption proxy by one period leaves the regression outcome almost unaffected (see Table 2.6 in the Appendix for detailed results): the estimate on regulatory formal independence takes a value of 0.2848 and remains statistically insignificant. The coefficients on the gas dummy and the regulator's age reach statistical significance at the 1% level again and change their size by less than 0.005 units compared to the estimates reported in Table 2.1. And the regression outcome still indicates a lacking effect of a country's energy intensity, the government's ideology and the level of perceived corruption (even if lagged by one year this time) on liberalization. The only

deviation in the findings worth mentioning is that the lagged crisis dummy reaches statistical significance at the 10% level and suggests reform efforts to be lower after an economic downturn: in case of a negative GDP per capita growth rate in the previous year, liberalization measures corresponding to an index reduction of about 0.5 units are postponed. Pitlik and Wirth's (2003) finding of the reform-hampering effect of medium growth crises might explain this result.

2.4 IV Estimations

2.4.1 The Endogeneity Problem

The estimations in the previous section are based on the assumption of an unambiguous direction of effect: the degree of formal independence (co-)determines the scope of energy market reforms in Europe. This requires that a regulatory institution's autonomy is specified before the authority takes up its work; an order that also Albon (2012) states when he describes what he calls the *regulatory supply chain*. According to this sequence, the definition of the regulator's independence level from regulatees and politicians stands at the beginning (together with setting the objectives), whereas regulatory activities are located at the end of the chain, only followed by potential appeals of the authority's decisions. The power autonomous agencies established in such an environment furthermore need to alter the sectoral structures according to their intentions obviously exists as well: they are identified as "powerful participants in policy making" (Thatcher and Stone Sweet, 2002: 15 et seq.) that "are proactive and involved in market design" (Levi-Faur, 2004: 9). Since, after all, the advancement of market-oriented reforms is one of the broad goals of independent regulators and the establishment of the latter is perceived to be vital for the development and preservation of competitive energy makets (OECD/IEA, 2001), assuming that liberalization efforts are influenced by the degree of institutional autonomy seems to be reasonable. This conjecture is substantiated by Thatcher and Stone Sweet, pointing out that "regulatory agencies have vigorously promoted liberalisation" (Thatcher and Stone Sweet, 2002: 17) in the recent past.

However, some statements in OECD/IEA (2001) also allow for a different conclusion, suggesting an opposite direction of effect: they postulate that institutions responsible

for market regulation are modified over time so as to enable them to meet the changing challenges that arise when liberalization measures continually alter the structure of the regulated industry. The establishment of independent regulatory bodies is accordingly seen as a necessity in the course of reform: due to the associated increase in competition, an impartial decision-maker not discriminating against any of the market players is considered to be essential for the functioning of the market. Thatcher (2002b) argues in quite the same direction: he rates autonomous utility regulators only as a concomitant feature of the sectors' liberalization process. Finally, one of the reasons adduced at the beginnings of the Third Electricity (European Union, 2009a) and the Third Gas Directive (European Union, 2009b) for repealing the preceding rulings creates the impression that insufficient progress of liberalization triggers increases in regulatory independence:

> "Directive 2003/54/EC [2003/55/EC] introduced a requirement for Member States to establish regulators with specific competences. However, experience shows that the effectiveness of regulation is frequently hampered through a lack of independence of regulators from government, and insufficient powers and discretion. For that reason, [...] the European Council invited the Commission to develop legislative proposals providing for further harmonisation of the powers and strengthening of the independence of national energy regulators. [...]" (European Union, 2009a: 58, No. 33, 2009b: 97, No. 29 (with reference to Directive 2003/55/EC))

According to this argument, the EU's main reason for demanding more autonomous energy regulators was their inefficient functioning, probably manifesting itself in only modest market reforms. One could thus also argue that growing liberalization efforts induce an increasing autonomy of energy regulators rather than vice versa.

Consequently, we cannot rule out that our OLS results suffer seriously from endogeneity caused by reverse causality. One can tackle this problem by applying an instrumental variable approach which, however, generates estimates being significantly less precise than their OLS counterparts; the conjecture of endogeneity should thus be verified (Cameron and Trivedi, 2005, chs. 4.9 and 8.4.3). To this end, we run a robustified Durbin-Wu-Hausman test (Durbin, 1954; Wu, 1974; Hausman, 1978) that analyzes whether the debatable explanatory variable is indeed endogenous, making the use of instrumental variables necessary. The null hypothesis is that our regressor of the regulators' formal independence is exogenous (Cameron and Trivedi, 2005, chs. 8.3.2

and 8.4.3). For our sample, it is rejected at the 1%-level (p = 0.0093), fully justifying an application of the IV approach at this point. Consequently, we estimate the following equations:

$$formind_{it} = \nu + \boldsymbol{\rho} \cdot \boldsymbol{Z_{it}} + \boldsymbol{\mu} \cdot \boldsymbol{X_{it}} + \eta_{it} \tag{2.1.1}$$

$$lib_{it} = \alpha + \beta \cdot formind_{it} + \boldsymbol{\gamma} \cdot \boldsymbol{X_{it}} + \epsilon_{it} \tag{2.1.2}$$

Equation (2.1.1) describes the first-stage estimation, where the formal independence of regulators is regressed on the instruments, $\boldsymbol{Z_{it}}$. Equation (2.1.2) captures the second stage, estimating the effect of formal independence on the degree of liberalization. The vector of covariates, $\boldsymbol{X_{it}}$, includes all controls already used in Section 2.3.

We will discuss the instrumental variables included in $\boldsymbol{Z_{it}}$ as well as to what extent they fulfill the standard statistical requirements for instrument validity in the following section. Section 2.4.3 then elaborates on two of the covariates (the agency's age and government ideology) that might, besides the instruments, have an effect on the regulator's formal independence in the first stage, before Section 2.4.4 reports and discusses the regression results.

2.4.2 Instrumental Variables

For instrumental variables to be valid, they have to fulfill two statistical requirements (Wooldridge, ch. 5.1.1): first, they need to be correlated with the endogenous regressor, i.e., the variables we choose as instruments have to have an effect on formal regulatory independence. Second, the only channel through which valid instruments are allowed to affect the (second-stage) dependent variable is their influence on the instrumented regressor; put simply, this means that our instrumental variables need to be uncorrelated with the degree of liberalization (and, precisely, that they have to be uncorrelated with the second-stage error term). The remainder of this section provides arguments substantiating that our instruments meet both these conditions; the discussions are preceded by a brief introduction of the respective instrumental variable and a description of the data that are taken over one-to-one as an instrument or employed to construct one, respectively.

2.4.2.1 Political Uncertainty

The first instrument we employ to tackle the endogeneity problem between formal regulatory independence and liberalization is a proxy measuring the degree of political uncertainty, *uncert*. It captures two aspects that basically determine whether a governing cabinet will be able to pursue its agenda in the same (or at least a similar) way also after the next election or whether different political ideas will then be dominant, instead: both a government's hazard of losing office and the ruling party's ideological deviation from its successor are considered by the measure.

To create the proxy, we draw on three variables (*gov_new*, *elec* and *gov_gap*) from the Comparative Political Data Set I from Armingeon et al. (2011, 2012); the calculation of annual values is carried out as follows: first, a cabinet's probability of having a successor with a different political agenda is computed. To this end, the number of ideology changes in government induced by variations in the parties holding office (*gov_new*) in the last 25 years (i.e., 24 years back) is divided by the total number of elections (addition of all entries for *elec*) in the same period of time. Ideology changes are identified on the basis of an index that assigns integral values according to the political orientation of governing parties: a value of 1 is assigned when only right-wing or centre politicians are in the government, a value of 2 when less than 33% of the cabinet members are from left-wing parties, and a value of 3 when the left-wing share further increases up to less than 66%; values of 4 and 5 describe the opposite to values of 2 and 1 with an analogous dominance of left-wing parties. Whenever the index value switches compared to the previous year, an ideology change has occured. The second step, then, captures the overall scope of the ruling governments' ideology changes in the last 25 years by summing up the absolute values of *gov_gap*; *gov_gap* draws on the outlined ideology index as well and calculates the governments' ideology difference by subtracting the pre- from the post-replacement index value. Eventually, the sum of the moduli is multiplied by the fraction generated in the first step to obtain our political uncertainty proxy. Since the values of both components of the *uncert* index increase with higher threats of an ideological turnaround, also the overall measure used as an instrument in the following does so.

The calculation of our *uncert* proxy basically resembles the method Gilardi (2005a)

applies to construct an indicator of political uncertainty: both a cabinet's replacement risk and the extent of post-election ideology shifts are combined also in his measure[9]. In line with the uncertainty hypothesis, different studies employing his indicator reveal a higher regulatory formal independence when the level of political uncertainty increases (Gilardi, 2005a; Hanretty and Koop, 2012) (and, moreover, a higher basic inclination of governments to install autonomous authorities at all (Gilardi, 2005b)). These results together with the similarities between Gilardi's (2005a) and our uncertainty measure should hence allow us to assume a correlation to exist also between *uncert* and the statutory independence of regulatory agencies; the first condition for valid instruments would then be fulfilled by our uncertainty proxy.

Based on the following reasoning, we furthermore expect our uncertainty measure to meet also the second requirement for valid instruments. The liberalization of energy markets has been characterized by a growing complexity of regulatory challenges: to solve arising issues, a profound technical and scientific knowledge has become increasingly essential (Thatcher, 2002b). As a consequence, (ignorant) political decision makers responsible for the legal implementation of intended steps of reform have drawn extensively on the regulators' expertise (Moe, 1989; Majone, 1999; Maggetti, 2009). The authorities' specific capabilities to level information asymmetries between legislator and industry and to employ the internal specialist knowledge to ensure the provision of an efficient regulation (Thatcher and Stone Sweet, 2002) have thus turned regulators into central actors in the regulatory environment (Maggetti, 2009).

This gain in importance has become increasingly apparent also in the political process: certainly favored by the additional powers assigned to regulators in the last few

[9]Drawing on a calculation method originally introduced by Franzese (2002, ch. 3.2.8), Gilardi (2005a) constructs his indicator as follows: a government's hazard of losing office is captured by the reciprocal of the number of years that passed between the respective cabinet's inauguration and the date it was voted out of office again. The changes in the ruling parties' political orientation are operationalized by the standard deviation of yearly values rating the overall ideology of both government and parliament. The annual values are scores assigned to each party represented in these two political institutions according to their political orientation (ranging from 1 for right-wingers to 5 for left-wingers) weighted by their share of total seats; the period to which the standard deviation relates ranges from five years before the year of observation to one year after. In the end, both values are multiplied (Gilardi, 2005a, 2005b; see Gilardi (2008, ch. 8) for further details).

Two major differences exist between Gilardi's (2005a) measure and the uncertainty proxy we construct for this paper: first, we refrain from including future years, since we query that governments really have perfect foresight; twelve month before voting, election results are often entirely ambiguous. Second, we use a rather lengthy observation period of 25 years. This is mainly due to our simpler measure of a government's replacement risk that requires a longer time span to reveal variations.

years (Thatcher and Stone Sweet, 2002), independent authorities have developed own targets and liberalization concepts increasingly affecting regulatory policies and reforms (Thatcher, 2002b). Thatcher and Stone Sweet (2002) even argue that European autonomous agencies have taken over the function of rule-making in the domain they regulate, declaring them to be a potential "fourth branch of government" (Thatcher and Stone Sweet, 2002: 16).

Consequently, we expect the degree of liberalization in electricity and gas markets to be determined by the regulators responsible for monitoring both these sectors. A facet of the polity like a government's risk of losing office to a successor adhering to a different ideology, on the contrary, should not have an effect on the intensity of reforms, which is why we conjecture our uncertainty proxy to fulfill also the second condition for valid instruments.

Our assumption is substantiated by Maggetti's (2009) empirical results on the influence of regulators during the legislative procedure of regulatory laws (briefly labeled as "centrality"), albeit his sample does not include any energy agencies: on the one hand, his results suggest that five out of six surveyed financial market and general competition authorities are either the only or one out of two central actor(s) during political decision-making; in particular, they are found to be important not just in the enforcement, surveillance and penalization phases (as inherent in their monitoring task), but also in the early stages of legislation, where they can be key players during agenda-setting, preparatory inquiries and even draft formulation. On the other hand, his survey reveals that a regulator's "centrality" increases with a lower level of "professionalization", specifying a legislator's proficiency and means to develop an expedient regulation; the high expertise vital to regulate the energy sector should then, as conjectured, result in an exceptional role of the responsible independent agencies in the liberalization process of electricity and gas markets.

2.4.2.2 Economic Flows from and to Foreign Countries

The second instrument we apply is a measure that captures the intensity of economic flows from and to foreign countries, $econflows$. It is a sub-index forming part of the 2012 version of the KOF (*Konjunkturforschungsstelle*) index of globalization (Kon-

junkturforschungsstelle, 2012a), which, in turn, is an update of the globalization proxy originally introduced in Dreher (2006) and further developed and discussed in Dreher et al. (2008). The *econflows* sub-indicator takes account of four main items that affect the level of a country's economic interdependencies with foreign states: the trade (i.e., exports and imports) of goods and services; the scope of inward and outward foreign direct investment (FDI) stocks; the amount of portfolio investment asset and liabilities stocks; and the income payments to foreign nationals, i.e., the remuneration of both workers and investors residing abroad. The sub-index can take values between 1 and 100, with increasing values indicating higher levels of economic globalization (see Konjunkturforschungsstelle (2012b, 2012c) for further details on both the data and the calculation method).

One can draw on the credibility hypothesis to substantiate this choice: Majone (1997a) argues that political credibility is of particular significance in open economies, since with many of the market-dominating actors being located outside the power holders' sphere of influence, it is impossible for them to reach objectives by simply using their authority; Gilardi (2002), trying to operationalize the hypothesis, refers to this reasoning and tests a measure quite similar to our instrument. Since empirical findings in general support the credibility hypothesis (Gilardi 2002, 2005a; Hanretty and Koop, 2012)[10], expecting that economic flows have an effect on regulatory formal independence seems reasonable; in this case, also *econflows* would meet the first requirement for valid instruments.

The reasoning for why we conjecture cross-border economic flows to fulfill also the

[10]The regressions substantiating the credibility hypothesis, though, do *not* operationalize it with a proxy that captures the scope of a country's economic relations with foreign economies. Spiller (1993) argues that employing independent regulators to signal a government's commitment credibly is especially important in industries where large investments in sector-specific assets and thus considerable sunk costs are indispensable for business activities. Consequently, dummy variables dividing the sample authorities into groups of economic and social (Gilardi, 2002) and of utility, competition/financial and social regulators (Gilardi, 2005a; Hanretty and Koop, 2012), respectively, are used to test the validity of the hypothesis in these estimations.

However, a major issue that would arise if we adopted this approach for our analysis make us draw on cross-border economic flows as an instrument, instead: the pooling criteria applied by Gilardi (2002, 2005a) and Hanretty and Koop (2012) would imply the authority monitoring the electricity sector and that regulating the gas market to be aggregated in the same category. But modifying the original, rather rough classification and using the gas market dummy as an instrument instead of as a covariate would neglect the conjectured lower liberalization pace in this industry (suggested by the OLS results in Section 2.3); the requirement for an instrument to have no direct effect on the second-stage dependent variable would thus probably be violated, resulting in the gas sector dummy to be invalid.

second condition for valid instruments is basically the same as in the case of political uncertainty: we expect the regulator to decide on the degree of liberalization fully autonomously and without being affected by outside influences - as, in this instance, a country's level of globalization - at all.

However, albeit this would imply that a state's economic relations with foreign countries do not have an effect on reform efforts, it does not mean that $econflows$ and lib are uncorrelated, as empirical surveys indicate: a case study on the effects of the UK electricity market reform on foreign investment (Energy Information Administration, 1997) reveals that within the course of liberalization both the takeovers of British electricity firms by external investors and the cross-border acquisitions by UK companies have increased considerably; reform measures are hence suggested to raise the number of takeovers by and of foreign firms in the power industry, which would affect the indicator of economic flows. Such transactions might furthermore go along with the secondment of, e.g., management personnel into the acquired firms, raising the value of the proxy's payment component when the executives from abroad are remunerated by the new affiliation.

Electricity market reforms that induce (more) acquisitions of power companies by firms from abroad will probably increase cross-border remunerations also for another reason: Alesina et al. (2005) find investments to be higher in more liberalized industries; returns from investments undertaken by companies with foreign owners would accordingly accrue to investors from abroad.

Finally, liberalization might affect the globalization proxy regardless of whether takeovers by and of foreign firms take place: the European Commission has identified insufficiently unbundled national incumbents to defer the construction of cross-border transmission infrastructure in their efforts to foreclose rival power and gas suppliers from abroad from domestic energy markets (European Commission, 2007a). As the reform process includes the implementation of (often increasingly stricter) rules on vertical separation (OECD, 2001; OECD/IEA, 2005; Newbery, 2009), liberalization alleviates or even entirely solves this issue; cross-border flows of electricity and gas should hence increase. This would, in turn, positively affect the transnational trade of goods and services.

The different economic flows included in the index might hence be affected by a

country's degree of liberalization in various ways; a correlation between our proxy for governmental credibility and reform efforts implying $econflows$ to be an invalid instrument thus cannot be ruled out. For this reason, we lag our instrument by one year: regulatory provisions adopted at some day in the future most probably do not affect today's foreign trade and investment and payments to external production factors. Rather, it is reasonable to expect a delayed effect, as the results of Alesina et al. (2005) suggest: regarding investments, they find that adjustments are primarily caused by regulations implemented two years earlier. Employing *lag econflows* in the IV regression should accordingly avoid potential correlation issues induced by an effect of liberalization measures on cross-border economic flows; since the regulator's decision-making power probably eliminates, as outlined, any reverse influences, we expect the lagged index to meet also the second requirement for valid instruments.

We finally want to supplement our considerations on the lacking correlation between our instruments and the degree of energy market liberalization by reporting the result of Hansen's (1982) J statistic chi-squared test. In case of an overidentified model (i.e., when the number of instrumental variables exceeds the number of endogenous regressors, as in our estimation), this tests allows to assess whether the second validity requirement is met by the instruments employed: its null hypothesis claims that all instrumental variables are uncorrelated with the residual (Cameron and Trivedi, 2005, ch. 8.4.4). Yielding a p-value of 0.1978, the test does not reject the null and suggests that neither political uncertainty nor a government's need to credibly commit affects reform efforts through channels other than its effect on regulatory formal independence.

2.4.3 Potential First-Stage Effects of Covariates

Before we describe the IV estimation results, we briefly want to discuss the covariates that might affect a regulator's statutory autonomy besides the features of a country's political process and its economy, respectively, we employ as instruments.

First, the literature on agency independence suggests the authority's age to have an influence on its autonomy: Bernstein's (1955) theory on the *life cycle of regulatory commissions* divides the regulator's duration in four phases (gestation, youth, maturity and old age) and describes the agency's decline from a publicly desired, ambitious

institution to a useless, self-perpetuating social burden just aiming at defending its status quo. The growing failure to fulfill its regulatory task associated with this development is assumed to entail an incremental evaporation of the political succor initially existing and, consequently, an increasing lack of both content-related leadership and financial support; interests and resources of the industry are expected to gradually fill the emerging gaps, instead. Martimort's (1999) theoretical analysis of the *life cycle* approach substantiates the unfavorable picture drawn of long-established regulatory agencies: he shows that a government's sole possibility to prevent collusion between the authority and a regulatee is the curtailment of the rents this malfeasance produces; an interventionist solution the regulator's principal is forced to adopt that implies the realization of suboptimal production levels. Furthermore, Maggetti's (2007) empirical results are at least partly in line with the theory (but are, in contrast to the analysis at hand, related to an agency's *de facto* independence): for his sample of banking, competition and telecommunications authorities, he finds a regulator's age to reduce political interferences in its day-to-day operations; other than predicted by the *life cycle* approach, however, his results also suggest that if the authority's duration of existence has an effect on the relation with regulatees at all, it leads to less industrial influence. This deviation from the original considerations notwithstanding, theory and empiricism coincide with respect to the regulator's increasing alienation from politics over time; it would therefore be reasonable to expect also the formal independence from politicians to be higher when agencies are long-established, implying a positive IRA age coefficient in our first stage estimation.

Second, also the ruling party's ideology might influence the energy authorities' statutory autonomy: expecting that compared to left-wing governments right-wing cabinets are more strongly inclined to install IRAs in the course of liberalization due to the close proximity between the conservatives' market orientation and the agencies' conventional mission, Gilardi (2005b) finds the exact opposite. The explanation for this surprising result draws on Laver and Shepsle (1990) and Shepsle (1991) who argue that a party professing to aim at a situation conflicting with its political preferences lacks credibility: since a left-wing government's will to liberalize might be challenged, it more urgently needs to establish an autonomous institution promoting reforms to signal serious intentions than a right-wing counterpart (Gilardi, 2008, ch. 6). Adapted to *existing*

Table 2.2: 2SLS, first-stage estimates of the degree of formal independence

dependent variable: formind		
	coef.	std.err.
uncert	.0142***	.0024
lag econflows	-.0304***	.0069
gas dum	.0148***	.0054
IRA age	-.0228***	.0053
lag GDPcap crisis dum	.1261***	.0382
lag ensupGDPunit	.0058***	.0020
ideopotr	-.0059	.0137
corruption	-.0183	.0570
constant	2.5300***	.7380
country dummies	yes	yes
N	72	
R^2	.8705	

Note: Table 2.2 shows first-stage estimation results from a 2SLS IV regression. Dependent variable is the autonomy level of electricity and gas regulators, respectively, as measured on the basis of Gilardi's (2002) formal independence index. Robust standard errors are clustered at the country level. *** denotes statistical significance at the 1% level.

authorities, in turn, this would imply that left-wing cabinets have to provide regulators with a higher level of formal independence to credibly commit; we therefore expect a positive sign on the ideology index coefficient in the first stage.

2.4.4 Estimation Results

2.4.4.1 First-Stage Results

Table 2.2 shows the first-stage results with robust standard errors being clustered at the country level. As most of the significant coefficients call for further discussion (in part because they suggest that the respective regressor affects formal independence opposite to what was expected), we will proceed as follows: first, we will briefly report the regression results. Afterwards, we will elaborate on our findings and provide possible explanations for the effects the first stage estimates suggest; the remarks on the impact of economic flows on regulatory autonomy are rather comprehensive and are therefore placed in a separate section.

As expected, estimation results hint at a greater formal regulatory independence from politics when the office holders' risk of being voted out of government is high. The size of this effect, though, seems rather minor: if we assume elections to take place

every four years (i.e., six polls are included in the measure, neglecting years immediately after votings in the following) as well as governments to change from left-wing to right-wing dominated cabinets and back after every second election, the independence value just increases by slightly more than 0.04. Contrary to the expectations, regression results furthermore reveal a negative relationship between the previous year's economic flows from and to foreign countries and a regulator's formal autonomy: the corresponding coefficient suggests a 0.3-unit decrease in the independence index in case of a ten-unit increase of our globalization proxy. Both estimates are statistically highly significant, suggesting that our instrumental variables meet the validity requirement of a high correlation with the endogenous regressor. The first stage F-value of the excluded instruments is equal to 35.26, likewise indicating that we do not have a weak instrument problem[11].

In additon, also some covariates reach statistical significance. The gas dummy is significant at the 1% level, but hints at an only small independence gap between electricity and gas regulators: according to the coefficient, the statutory autonomy of gas market authorities exceeds that of their electricity counterparts by less than 0.015 units of Gilardi's (2002) index. At variance with our considerations, the highly significant estimate on the regulator's age furthermore suggests an agency's independence to decrease throughout its life cycle; it indicates that a fully independent regulatory authority has forfeited all of its autonomy after not quite 44 years. The crisis dummy coefficient, also significant at the 1% level, suggests a regulator's independence to increase by slightly more than 0.1 index units after a year of negative GDP per capita growth. And finally, the estimate on our energy efficiency proxy hints at a considerable effect of energy-intensive production processes on an authority's statutory autonomy: it indicates that a regulator's independence value on Gilardi's (2002) scale rises by nearly 0.6 units if the total primary energy supply needed to generate 1000 US$ of GDP grows by 0.1 tonnes of oil equivalent. The controls on government ideology and corruption do not

[11]Staiger and Stock's (1997) rule of thumb demands an F-value of at least 10. Furthermore, for regressions with one endogenous regressor and two instrumental variables, Stock and Yogo (2005) report the critical value to be 19.93 when strong instruments are defined in a way that the size distortion of a nominal 5% Wald test of the hypothesis that the estimated and the actual coefficient of the endogenous regressor are identical is limited to 5 percentage points. However, since this threshold is calculated under the assumption of homoskedastic errors, a comparison with our F-value can only serve as an informal test.

reach statistical significance.

The first-stage results are robust to the use of the lagged corruption index (see Table 2.7 in the Appendix for detailed regression outcomes): the coefficients on our uncertainty proxy and the lagged globalization measure continue to be statistically highly significant and take values of 0.0154 and -0.0360, respectively, indicating effect sizes very similar to those suggested by the estimates in Table 2.2; the high significance of both estimates together with a first stage F-value of the excluded instruments equal to 25.78 furthermore again suggests that no weak instruments are applied. Except for the gas dummy that reaches only the 5% significance level when the corruption proxy is lagged, also all significant control variables from Table 2.2 remain significant at the 1% level. Moreover, the change in their size is rather negligible: while the estimate on the lagged crisis dummy is reduced by slightly more than 0.02 units compared to its counterpart reported in Table 2.2, the coefficients on the gas dummy, the agency's age and the energy efficiency indicator are altered by only 0.002 units or less. The estimates on ideology and (lagged) corruption do not reach statistical significance again.

Our findings might be explained as follows: the increase in regulatory formal independence suggested as a consequence of a higher threat of being replaced in government by warring parties reflects the essence of the uncertainty hypothesis; with this threat to be growing, ruling politicians are willing to grant more and more autonomy to the regulatory authority. The notion that independent regulators serve as bulwarks against policy turnarounds induced by opponent successors expressed in the hypothesis is thus further substantiated by our results (albeit the size of the effect seems, as discussed, rather small).

To provide a possible explanation for the difference in the statutory autonomy of electricity and gas market authorities, one might argue on the basis of Spiller's (1993) interpretation of the credibility hypothesis that postulates the existence of more independent regulators in industries that employ large amounts of sector-specific assets (see also footnote 10): compared to electricity investments, various gas infrastructure projects are considerably larger because of the huge distances between production and consumption sites; a particularly high demand for a secure rate of return and investment protection should hence prevail in this industry. This, in turn, could be met by the establishment of a more independent regulator. However, given the negligible size of

the gas dummy estimate, the divergence between the credibility requirements prevailing for investments in the electricity and in the gas market should not be expected to be overly high.

The surprisingly negative relationship between an agency's age and its formal independence suggested by the first stage outcome might result from the exceptional role the energy sector plays in industrialized countries: providing all production processes with electricity and gas, it is seen as a crucial factor for a nation's economic development (Schneider and Jäger, 2003; Domanico, 2007; Karan and Kazdağli, 2011). Since the economic situation, in turn, considerably affects a ruling party's reelection chances, one might expect a government to try to counteract the alienation between regulator and politics as well as the associated growing neglect of the assigned tasks by the authority described in the *life cycle* approach: by gradually broadening the cabinet's influence on the regulator again, ruling politicians should be better able to make also a long-established agency properly fulfill its mission, thus ensuring a continuous effective monitoring of electricity and gas markets; the resulting protection of competition in the energy sector then does not only benefit the economy, but indirectly also the government aiming for votes.

Our finding that formal independence is increased in the wake of an economic downturn is in line with the credibility hypothesis and Pitlik's (2008) (as well as Drazen and Easterly's (2001) and Pitlik's (2007) statistically significant) results substantiating it: granting a higher autonomy to the authority responsible for market supervision separates decisions on the implementation of a non-discriminatory and hence competition-enhancing regulation from the struggles in the political arena; steps of reform accelerating the liberalization process are therefore facilitated.

The positive relationship between energy intensity and statutory autonomy finally suggested by the estimation results is consistent with our expectation that a high energy use during production is associated with an interest in cheap electricity and gas supplies: highly independent regulators deemed to foster competition (and thus to reduce prices) are primarily established in economies that provide energy-intensive goods.

2.4.4.2 The Negative Effect of Cross-Border Economic Flows on Formal Independence

This section now completes the discussion of our first stage results by providing a possible explanation for the negative relationship between the scope of economic flows from and to foreign countries and the level of statutory autonomy that is, contrary to our expectations, suggested by the regression outcome.

The above-mentioned relevance of the energy sector for a country's economic development serves as a starting point for our considerations: due to its importance, politicians try to keep the sector under national control to the greatest possible extent (Domanico, 2007; Belkin, 2008); some EU member states' recent efforts to save domestic energy companies from foreign takeovers are significant examples for this eagerness to protect national interests (Ahearn, 2006; Barysch et al., 2007). In France, the government initiated a merger between *Suez*, a domestic electricity, gas and water company, and *Gaz de France (GDF)*, a national gas and power utility (European Commission, 2006a), to prevent a takeover of *Suez* by *Enel*, an Italian electricity supplier (Domanico, 2007; Barysch et al., 2007).

In Spain, the government fought tooth and nail against the aquisition of the electricity and gas supplier *Endesa* by the German energy company *e.on* (European Commission, 2006b, 2006c, 2006d), ignoring an existing Commission approval for this transaction (2006e). To hamper *e.on*'s takeover attempt, an urgent law was passed that was deemed to be in violation of the EU Treaty principles of free movement of capital and freedom of establishment (European Commission, 2006b) and (presumably as intended by the Spanish legislator) expected to scare off investors from other member states (European Commission, 2006f); the conditions imposed on *e.on* by the Spanish regulator on the basis of the law were furthermore judged as breaching EU merger regulation (European Commission, 2006c). Modified conditions stipulated by the competent Spanish minister in response to objections of the Commission were not only seen as obstacles to the free movement of capital and the freedom of establishment, but additionally as a violation of the principle of free movement of goods (European Commission, 2006d).

The interventions of both the French and the Spanish government triggered the suspicion that these nations place their own concerns over Community ends (Ahearn,

2006) and culminated in the accusation that they pursue an (informal) target deviating from those determined by the Union's energy policy[12]: the creation and maintenance of national champions in the European energy market (Domanico, 2007). The detailed reasons advanced for the pursuit of this aim range from politicians favoring lobbying groups (Domanico, 2007) via concerns about foreign shareholders spying for their home-countries (The Economist, 2006a) (probably getting even more solid with the expected increase in the number of Russian and Chinese takeover attempts (The Economist, 2006b)) to less awkward ones like the fear of layoffs (Ahearn, 2006) and assumed advantages in securing a country's energy supply (Barysch et al., 2007).

The Commission's reactions to the governments' interferences in the energy market, however, did not fail to appear: In the French case, it rated the merger as a severe obstacle to competition in the Belgian gas and electricity market as well as in the French gas and district heating market (European Commission, 2006a, 2006h, 2006i), making comprehensive remedies a condition for approval under merger regulation (European Commission, 2006h): the most important requirements were the divestiture of the French district heating operator, of the holdings in the Belgian gas incumbent and in the second biggest Belgian electricity and gas supplier as well as the ceding of control over the Belgian gas infrastructure operator and the obligation to invest in the gas infrastructure of Belgium and France (European Commission, 2006i, 2006j).

In the Spanish case, the Commission launched infringement proceedings over both the additional authorities the regulator was vested with during the attempt to prevent the takeover (European Commission, 2006b, 2006f) and over the original as well as the modified conditions imposed on *e.on* (European Commission, 2006c, 2006d, 2006k, 2007b, 2007c) due to the provisions' violation of the above-mentioned EU Treaty principles. In consequence of the nonabrogation of the unlawful conditions, Spain was even taken to the European Court of Justice (European Commission, 2007d) which found in favor of the Commission (European Commission, 2008).

The Commission's rigorous course of action (backed, when necessary, by the Court of Justice) in both cases underlines its unbending will to eliminate any anticompetitive behavior jeopardizing the functioning of the European energy market. With this stee-

[12]These objectives are sustainability, competitiveness and security of supply (European Commission, 2006g).

Table 2.3: 2SLS, second-stage estimates of the degree of liberalization

dependent variable: lib	coef.	std.err.
formind	-2.4901***	.9545
gas dum	2.2150***	.2754
IRA age	-.3030***	.0485
lag GDPcap crisis dum	.9411***	.3131
lag ensupGDPunit	-.0020	.0142
ideopotr	.1159	.1234
corruption	-.3421	.4864
constant	5.4667	4.5747
country dummies	yes	yes
N	72	
R^2	.7959	

Note: Table 2.3 shows second-stage estimation results from a 2SLS IV regression. Dependent variable is the mean of the electricity and gas sector sub-indicators, respectively, apart from public ownership, as described in Conway and Nicoletti (2006). Robust standard errors are clustered at the country level. *** denotes statistical significance at the 1% level.

liness, the Commission also deprives European politicians of the possibility to support the achievement of their national aims by shielding domestic energy companies from foreign influences. Assuming that governments were principally aware of the uncompromising attitude already in the early 2000s prior to the outlined events (and thus in the period of time covered by our sample), one might explain the lower level of regulatory autonomy in more globalized countries as follows: expecting considerable foreign investments wresting domestic energy companies from national control, ruling parties might have tried to retain a certain degree of influence on these firms by limiting the authority's independence from politicians, keeping up the possibility to interfere at least in parts with regulation.

2.4.4.3 Second-Stage Results

Second-stage results are reported in Table 2.3; standard errors are again robust and clustered at the country level. The coefficient of the instrumented formal independence of energy regulators is negative and statistically highly significant, suggesting a strong effect of a higher statutory autonomy from politicians on the degree of liberalization: the establishment of a fully autonomous authority reduces the liberalization measure by

about 2.5, i.e. by approximately 40 percent of its maximum value[13]. For existing regulators this means that if the aspects covered by one of the five independence dimensions (see Section 2.2.1) are still under complete control of the government, the ruling parties can initiate steps of reform efforts corresponding to half an index unit by granting total autonomy to the authority in this domain.

All three highly significant covariates show the expected sign: the gas dummy coefficient is positive and of about the same size as in the OLS regression; the reform gap in gas markets approximates two units of the liberalization measure. Moreover, the positive relationship between experienced regulators and the degree of competition suggested by the regression results in Table 2.1 persists. However, different from its OLS counterpart, the second-stage estimate adumbrates that only about three years and four months periods of regulatory monitoring are necessary to lower the liberalization index by one unit. The coefficient of the lagged crisis dummy finally suggests a limitation of reform efforts to be induced by negative GDP per capita growth rates in the previous year; compared to periods with a positive economic development, every year of downturn prevents the OECD index to be reduced by nearly one unit. The estimates on the lagged energy intensity proxy, the government's ideology and the corruption measure do not reach statistical significance.

Lagging the corruption measure has hardly any influence on the results (Table 2.9 in the Appendix provides detailed regressions outcomes): the second-stage estimate on formal independence takes a value of -2.4940 and is hence almost identical to its counterpart in Table 2.3, even though its statistical significance reaches only the 5% level[14]. The coefficients on the gas dummy, the agency's age and the crisis dummy remain statistically highly significant and hint at effect sizes basically equal to those in-

[13]As an additional test for the strength of the instrumental variables employed in an overidentified regression, Angrist and Pischke (2009, ch. 4.6.4) advise to compare the second-stage 2SLS estimates with their LIML counterparts: large deviations hint at the presence of weak instruments. The LIML coefficient of the instrumented formal independence is statistically highly significant and takes a value of -2.6066, revealing only a minor difference from the 2SLS estimate; considering our instruments to be strong is thus further substantiated. Second-stage LIML results are reported in detail in Table 2.8 in the Appendix.

[14]As in the original regression with the corruption index not being lagged, second-stage 2SLS and LIML coefficients on the instrumented formal independence do not differ much when the corruption measure is included with a lag of one period: the LIML coefficient takes a value of -2.5833 and is statistically significant at the 5% level, again suggesting our instruments not to be weak. Detailed second-stage LIML results for this estimation are reported in Table 2.10 in the Appendix.

dicated by the estimates obtained with a non-lagged corruption proxy (changes amount to marginally more than 0.005 units at the maximum). The energy efficiency of production processes in the previous year, the ruling parties' political orientation and the previous year's perceived corruption are again suggested not to affect an authority's statutory independence.

2.5 Conclusion

Contradicting the first impression created by the scatterplots and OLS regressions neglecting the reverse causality problem, the IV estimation corroborates the conventional wisdom on the effect of regulatory independence: for our sample of EU energy regulators, a higher statutory autonomy from politics entails a higher liberalization level of electricity and gas markets. The European legislator's demand for an enhanced protection of regulatory authorities from government interferences is thus both justified and reasonable.

However, although our study can be seen as a helpful contribution to the understanding of long-term effects of independent regulatory authorities on energy market liberalization, it is obviously just a first step: in particular, a more comprehensive data set comprising information on the agencies' formal autonomy in additional years would be desirable. Likewise, panel data on the authorities' level of *de facto* independence from both politicians and regulatees would be useful; only the inclusion of these two dimensions of autonomy would allow for a complete and profound analysis of the impact of IRAs on the intensity of reform.

2.6 Appendix

Table 2.4: Control Variable Description

Variable	Description	Source
gas sector dum	Indicator variable, takes a value of 1 if the regulatory authority monitors the national gas market.	International Energy Regulation Network (2012)
IRA age	Number of years past since the national energy regulator has been introduced. Own calculations based on data on legal establishment dates.	International Energy Regulation Network (2012) (Establishment dates*.)
lag GDPcap crisis dum	Indicator variable, takes a value of 1 if the GDP per capita growth rate in the previous year was negative. Growth rates are calculated on the basis of GDP per capita values (constant 2000 US$).	World Bank (2011) (GDP per capita data.)
lag ensupGDPunit	Total primary energy supply (measured in tonnes of oil equivalent) per million US$ of GDP (constant 2000 PPP US$), included with a lag of one year. Original ratios (total primary energy supply per thousand US$ of GDP) were rescaled by multiplying by 1000.	OECD (2010a)
ideopotr	Ideology index capturing the political orientation of governments in office. It takes integral values between 1 and 5 and is reduced with the share of cabinet and parliament seats right-wing parties hold: a value of 1 is assigned if more than 2/3 of all positions are staffed by right-wing partisans, a value of 2 if this share lies between 1/3 and 2/3. The measure takes a value of 3 when centre party members fill half of the positions or a balanced coalition of right- and left-wing parties governs. Values of 4 and 5 correspond to the situations described for 2 and 1 with left-wing parties holding the respective shares.	Potrafke (2009)
corruption	Perceived susceptibility to bribery of a country's public sector as measured by Transpacency International's Corruption Perception Index (CPI). The indicator is based on answers to polls conducted by various proficient institutions and captures opinions about briberies, irregularities in public procurement, misappropriation of public funds as well as anti-corruption measures. The questions relate to public officials, civil servants and politicians. CPI values range from 0 (highly corrupt) to 10 (very clean).	Transparency International (2012)

**For Sweden the IERN homepage quotes the year of establishment of the Energy Market Inspectorate (EI), 2008, which is later than the execution of all three surveys analyzing the regulator's formal independence. We thus deviate from the source in this case and use the year in which the Swedish Energy Agency (STEM) was founded, 1998. The latter is stated in Gilardi (2002) and the CEER (2005) as being the regulator under assessment.*

Table 2.5: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Main Variables					
lib	72	1.797	1.426	0	5.333
formind	72	.6210	.1154	.4400	.8600
Instruments					
lag econflows	72	77.45	14.04	52.47	99.44
uncert	72	11.28	12.26	1.333	47.67
Controls					
gas sector dum	72	.3889	.4909	0	1
IRA age	72	4.889	2.614	1	14
lag GDPcap crisis dum	72	.0556	.2307	0	1
lag ensupGDPunit	72	153.5	35.55	110	250
ideopotr	72	2.792	.9132	2	4
corruption	72	7.707	1.563	4.200	9.767
lag corruption	72	7.672	1.609	4.200	9.867

Table 2.6: Fixed-Effects OLS

dependent variable: lib		
	coef.	std.err.
formind	.2848	.7602
gas dum	2.1667***	.2924
IRA age	-.2415***	.0600
lag GDPcap crisis dum	.4798*	.2648
lag ensupGDPunit	-.0145	.0120
ideopotr	.1604	.1812
lag corruption	-.2628	.2161
constant	5.7290	1.8442
N	72	
R^2 *within*	.7335	

Note: Table 2.6 shows estimation results of a fixed-effects OLS regression. Dependent variable is the mean of the electricity and gas sector sub-indicators, respectively, apart from public ownership, as described in Conway and Nicoletti (2006). Robust standard errors are clustered at the country level. ***/* denotes statistical significance at the 1%/10% level.

Table 2.7: 2SLS, first-stage estimates of the degree of formal independence

dependent variable: formind		
	coef.	std.err.
uncert	.0154***	.0027
lag econflows	-.0360***	.0075
gas dum	.0133**	.0053
IRA age	-.0248***	.0057
lag GDPcap crisis dum	.1046***	.0316
lag ensupGDPunit	.0062***	.0019
ideopotr	-.0078	.0142
lag corruption	.0490	.0409
constant	2.3998***	.7306
country dummies	yes	yes
N	72	
R^2	.8769	

Note: Table 2.7 shows first-stage estimation results from a 2SLS IV regression. Dependent variable is the autonomy level of electricity and gas regulators, respectively, as measured on the basis of Gilardi's (2002) formal independence index. Robust standard errors are clustered at the country level. ***/** denotes statistical significance at the 1%/5% level.

Table 2.8: LIML, second-stage estimates of the degree of liberalization

dependent variable: lib		
	coef.	std.err.
formind	-2.6066***	.9539
gas dum	2.2172***	.2758
IRA age	-.3053***	.0483
lag GDPcap crisis dum	.9617***	.3139
lag ensupGDPunit	-.0015	.0144
ideopotr	.1146	.1230
corruption	-.3525	.4893
constant	5.5618	4.6138
country dummies	yes	yes
N	72	
R^2	.7949	

Note: Table 2.8 shows second-stage estimation results from a LIML IV regression. Dependent variable is the mean of the electricity and gas sector sub-indicators, respectively, apart from public ownership, as described in Conway and Nicoletti (2006). Robust standard errors are clustered at the country level. *** denotes statistical significance at the 1% level.

Table 2.9: 2SLS, second-stage estimates of the degree of liberalization

dependent variable: lib		
	coef.	std.err.
formind	-2.4940**	.9968
gas dum	2.2201***	.2756
IRA age	-.3066***	.0484
lag GDPcap crisis dum	.9406***	.2854
lag ensupGDPunit	-.0005	.0150
ideopotr	.1416	.1342
lag corruption	-.3318	.3405
constant	5.0936*	2.9067
country dummies	yes	yes
N	72	
R^2	.7964	

Note: Table 2.9 shows second-stage estimation results from a 2SLS IV regression. Dependent variable is the mean of the electricity and gas sector sub-indicators, respectively, apart from public ownership, as described in Conway and Nicoletti (2006). Robust standard errors are clustered at the country level. ***/**/* denotes statistical significance at the 1%/5%/10% level.

Table 2.10: LIML, second-stage estimates of the degree of liberalization

dependent variable: lib		
	coef.	std.err.
formind	-2.5833**	1.0013
gas dum	2.2219***	.2760
IRA age	-.3087***	.0481
lag GDPcap crisis dum	.9555***	.2865
lag ensupGDPunit	-.0001	.0152
ideopotr	.1410	.1337
lag corruption	-.3340	.3456
constant	5.1122*	2.9625
country dummies	yes	yes
N	72	
R^2	.7956	

Note: Table 2.10 shows second-stage estimation results from a LIML IV regression. Dependent variable is the mean of the electricity and gas sector sub-indicators, respectively, apart from public ownership, as described in Conway and Nicoletti (2006). Robust standard errors are clustered at the country level. ***/**/* denotes statistical significance at the 1%/5%/10% level.

Chapter 3

Regulatory Objectives and the Intensity of Unbundling in Electricity Markets[1]

3.1 Introduction

In its endeavor to create a single internal energy market, the European Union has gradually increased the degree of unbundling vertically integrated electricity utilities within member states had to realize over the years. The growing separation of monopolistic transmission and distribution grids from (potentially) competitive generation, wholesale and retail operations was intended to eliminate anti-competitive practices integrated companies were suspected to use to undermine the development and the functioning of the market: discriminations in the network access or cross-subsidies, for example, hamper the utility's competitors in power production and supply and might even completely deter them from providing their services; if, on the contrary, the network activities' interests in generation and retail profits are removed due to unbundling, competition can thrive and benefit consumers (European Commission, 2001, 2004; European Union, 2003).

The positive welfare effects associated with *fully* competitive markets should hence induce governments or authorities in charge of regulation to seek the *complete* elimi-

[1]This chapter was presented at the 8th EEM International Conference in Zagreb, the 34th IAEE International Conference in Stockholm and Workshops on Public Economics in Paderborn and Dortmund.

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Unbundling Regime	**Countries**[2]
Ownership Unbundling	BEL, CZE, DNK, EST, ESP, FIN, GBR***, ITA, LTU, NLD, POL*, PRT*, SVK, SVN*, SWE
both	AUT, DEU
Legal Unbundling/ITO	BGR*, CYP**, FRA, GRC, HUN, LUX**

Notes: Data stem from the Commission's information on its certification of European TSOs (European Commission, 2014a) that is required by the Third Electricity Directive (European Union, 2009a); they reflect the state of facts as of February 2014. * In these countries, the certification process is still pending; data are obtained from European Commission (2014c) (BGR), URE (2013) (POL), ERSE (2013) (POR) and JARSE (2013) (SVN). ** Both the Cypriot and the Luxembourgian TSO are exempted from the new, stricter rules on unbundling (European Union, 2009a; de Hauteclocque and Ahner, 2012), but are obliged to be separated legally (European Commission, 2014d, 2014e). *** In the UK, Ownership Unbundling is only implemented in England and Wales. The TSOs in Scotland and Northern Ireland are certified under a vertical structure deviating from the three unbundling models provided for in the Third Directive; see footnote 2 for further details.

Table 3.1: Legal and Ownership Unbundling in EU member states

nation of discrimination incentives potentially persisting when utilities are not entirely unbundled: a thorough separation of the monopolistic and continuously regulated grid activities from generation and supply by means of a mandatory divestiture of all network assets - generally referred to as Ownership Unbundling - would be the logical (since most effective) consequence (OECD, 2001; Mulder and Shestalova, 2006; Buchan, 2007; European Commission, 2007a, 2007e, 2007f, 2007g; Pollitt, 2008). But when the Third Electricity Directive[3] (European Union, 2009a) required member states to implement one of three possible models further tightening the previous unbundling rules for transmission lines, several countries surprisingly refrained from choosing Ownership Unbundling, although it was one of the legal alternatives. Instead, these states mainly opted for the Independent Transmission Operator (ITO) model (see Table 3.1), which basically just amounts to a stricter enforcement of the Legal Unbundling provisions al-

[2]Apart from the countries listed, Latvia and Romania opted for the third model provided for by the Third Electricity Directive, the Independent System Operator (ISO) (European Commission, 2014a): under this regulatory regime, the ownership of the transmission system remains with the integrated utility, but an organization fully detached from the (legally separated) affiliated group is responsible for the system's operation, maintainance and development (European Union, 2009a). Due to its minor relevance in Europe, the ISO is neglected in the following. On Malta no transmission grid exists (European Commission, 2014b). Moreover, derogations from the unbundling provisions were granted to the Irish (European Commission, 2013a), the Northern Irish (European Commission, 2013b) and the Scottish (European Commission, 2012) transmission system operators (TSOs), since the Commission rated the models implemented in these countries as guaranteeing a higher degree of TSO independence than the least strict regime provided for by the Third Electricity Directive, the ITO: in each case, transmission system operation is shared between a legally unbundled entity owning the grid and another, entirely separated company.

[3]This is the commonly used shortening of the directive's official name, "Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC".

ready mandatory before[4]; Legal Unbundling requires vertically integrated companies to spin off their grid monopolies into separate entities (European Union, 2003; European Commission, 2004).

Our paper provides a possible explanation for the rather puzzling choice of some member states to keep their power utilities integrated to the highest degree that European legislation permits: based on a theoretical analysis, we argue that the decision to either implement Ownership Unbundling or adhere to Legal Unbundling depends on the objective the authority determining the level of vertical separation pursues.

By considering the relationship between regulatory goals and the type of unbundling this paper aims at contributing to the discussion about one of the recent core topics in the area of EU energy regulation. Especially after the results of an Energy Sector Inquiry (European Commission, 2007a) had been published in 2007, the European Commission vigorously called for transmission lines unexceptionally separated by ownership; the Inquiry, launched in 2005 to monitor the efficacy of regulations already implemented by this time (European Commission, 2005), revealed significant deficiencies in the functioning of national electricity markets and serious delays in the realization of the intended single European market. Consequently, the Commission made clear that it rated the then-valid combination of Accounting, Functional and Legal Unbundling[5] as insufficient, judging Ownership Unbundling as the only way to once and for all terminate any undue preference of associated non-network activities by transmission monopolies (European Commission, 2007a, 2007e, 2007f, 2007g). Research on unbundling supported the Commission's view and identified even further substantial advantages of entirely separated networks: a facilitation of regulation and privatization as well as a stronger focus of the different activities on their own business that, inter alia, enhances the security of supply. Potential disadvantages such as a possible increases

[4]Authors classifying the ITO model just as a (strict) form of Legal Unbundling are, e.g., Geldhof and Vandendriessche (2008), Höffler and Kranz (2011a), Meyer (2012) and Brunekreeft et al. (2014).

[5]In addition to Legal Unbundling, the immediate predecessor of the Third Electricity Directive demanded separate accounts for transmission and distribution activities (a measure denoted as "Accounting Unbundling") as well as the realization of several provisions subsumed under the term "Functional Unbundling": the preservation of a strict confidentiality with respect to comercially sensitive information gathered in the line businesses; the absence of any interference from the associated generation, wholesale or retail activities in decisions regarding the networks (like construction or maintenance); the endowment of distribution and transmission businesses with separate and sufficient funding and personnel; and decision-makers in the grid activities not affected by potential financial or occupational interests in any non-network business (European Union, 2003; European Commission, 2004).

in capital cost for separated firms, a facilitation of foreign takeovers and transaction costs due to contract renegotiations and necessary in-house reorganizations were seen as rather less serious ones (Pollitt, 2008; see also Mulder and Shestalova (2006) for most of the pros and cons mentioned). However, in general, solely the market participants benefiting from persisting linkages between network and non-network activities were blamed for delays in the realization of Ownership Unbundling: the just legally separated incumbents (European Commission, 2007a). Other actors that might potentially be interested in hampering liberalization as well, on the contrary, were rather ignored: for example, captured regulators acting in the interest of integrated companies due to bribes (Laffont and Tirole, 1991), posttenure job prospects in the industry (Che, 1995) or by intentionally applying biased information provided by the regulatees as a basis for regulatory decisions (Agrell and Gautier, 2010, 2012a, 2012b). By shedding light on the role agencies play in the process of network separation, this paper might hence add an important aspect to the discussion that has been neglected up to now.

By explicitly analyzing the decisions of the regulatory authority, the paper furthermore aims at contributing to the existing theoretical literature on Legal and Ownership Unbundling. In a nutshell, model results up to now are, rather surprisingly, far from being supportive of the consumer-benefiting effect ascribed to a full separation of monopolistic from (potentially) competitive stages of the value chain. But what is at least as surprising is that in all theoretical analyses questioning the benefits of Ownership Unbundling both the regulators and their rulings play, at best, a minor role.

The paper of Cremer and De Donder (2013) is a typical example of both these unexpected features of current research: their findings suggest that both the network capacity and the output of the final good are lower and the price of the end-product is higher when an upstream monopolist providing the network as an essential input for downstream suppliers is separated by ownership instead of just legally. However, at the same time, an authority does not really come into the picture at all: the network access fee is not determined by a regulator, but by the monopolistic grid firm itself.

That an abandonment of Ownership Unbundling can be beneficial for electricity consumers is also Bolle and Breitmoser's (2006) conclusion when they draw on figures from the EU power sector to interpret their model results. Their general findings inter alia show that Legal Unbundling is the suboptimal type of separation (i.e., leads to

lower quantities and higher prices of the final product) when the regulatory inefficiency supposed to be associated with an only legally separated utility is high; the assumption that regulatory surveillance under Legal, but not under Ownership Unbundling is poor and entails a network usage charge always exceeding the upstream firm's costs of provision is a key feature of the theoretical framework. That is, the model does not allow for the licensing of the optimal usage charge by the authority under one of the two regimes of interest; this, in turn, prevents a proper comparison of both types of vertical separation.

Also Höffler and Kranz (2011a) assume a deficient regulation to prevail: independent of the regime, the monopolist in their model is able to subtly sabotage its downstream demanders to increase their costs. Operationalizing Legal Unbundling as a parent company that maximizes joint profits of both its own and the separated division's activity while the legally unbundled affiliate solely considers its own profits (as first introduced by Sibley and Weisman (1989)), their main finding then reveals that it matters whether the upstream or the downstream activity of a formerly integrated utility is separated: while a legally unbundled downstream firm together with a monopolistic parent company results in a (weakly) lower final good output than that obtained under Ownership Unbundling, a downstream parent company with a legally separated affiliate active in the industry's monopoly area results in a (weakly) higher one. Throughout the analysis, identical usage charges for Legal and Ownership Unbundling are assumed, although it is at least briefly shown in the end that the outlined result also holds when the respective optimal fee is set under both regulatory regimes. The identification and the comparison of these optimal choices, though, is lacking in the paper as well.

Finally, Höffler and Kranz (2011b) study what they call "imperfect" Legal Unbundling for the scenario where the downstream supplier is the parent of a separated upstream monopolist which is again able to subtly sabotage; however, unlike as in Höffler and Kranz (2011a), the downstream firm no longer has to be the single shareholder. What makes the regulatory measure "imperfect" is that not only the parent company takes account of the unbundled division's profits in its decision-making, but that this also happens the other way round (in a different extent, depending on the level of "imperfection"). Differentiating between a situation where the downstream firm's share affects the upstream monopolist's objective to allow for its parent's profits and another

one where this is not the case, the following insights are of interest: without any influence of the share, the output of the final good weakly increases with a higher share as long as the upstream firm's weight on downstream income is not overly high; this contradicts a full ownership separation at least for (mid and) low levels of "imperfection". When, on the contrary, an influence exists, maximum production is not realized with a stand-alone monopolist when generic cases are considered; requiring full Ownership Unbundling would hence be suboptimal, again. Once more, however, all results are obtained without attaching great importance to authority decisions: a determination of optimal grid charges for different share sizes and "imperfection" levels does not take place at all; instead, the charge is assumed not to vary.

Besides the disregard of regulatory decisions on optimal access fees the narrow choice of the criteria the two unbundling regimes are evaluated against in the four mentioned papers stands out. Without exception, the assessment is solely carried out on the basis of classical textbook objectives of consumer-friendly authorities: a large network capacity as well as both a high output and a low price of the consumption good. That is, regulations possibly implemented by authorities acting in their own interest or to the benefit of market participants other than consumers are entirely neglected.

This paper extends the two-stage models common in theoretical analyses on Legal and Ownership Unbundling to figure out how empowering the regulatory agency to set the grid charge and the goal the agency aims for affect the optimal choice on the type of vertical separation. Before the upstream monopolist decides on the grid capacity and the generators, requiring the network to dispatch electricity and modelled as a Cournot duopoly, subsequently realize their production, the regulator included in our theoretical framework implements its rulings: it demands the monopolistic network to be separated either legally (what makes the grid firm become the parent company, taking account of the affiliate's profits) or by ownership and licenses the access fee optimal under the respective type of unbundling chosen before. In particular, all decisions the agency takes in the stages added in our model depend on the objective the authority pursues: we differentiate between "traditional" consumer-oriented goals (a high output, a low price or a high consumer surplus) and targets benefiting the government (high tax yields) or the industry (high company profits); we argue that especially the advantages associated with a departure from "traditional" objectives such as potential increases in

state appropriations in the course of growing public revenues or bribes and posttenure job prospects for captured regulators issuing producer-friendly provisions might induce the authority to ignore its official mission of end-user protection.

The results reveal that, regardless of the regulator's goal, the optimality of one or the other type of vertical separation depends on the level of the network charge if this is set identically under both regulatory regimes. When, according to the agency objective, the optimal access fee is licensed for both degrees of separation, the model shows that a grid unbundled by ownership is unambiguously superior to a legally separated one solely when the authority strictly acts in the interests of consumers (i.e., pursues the "traditional" aims of regulation); if, on the contrary, only the benefits of the industry or the government (and hence indirectly its own interests) are relevant for the regulator, Legal and Ownership Unbundling are equivalent in virtually all cases. Minor disadvantages and costs associated with a change in the ownership structure of just legally unbundled utilities could then result in the status quo to be preferable to full vertical separation, letting authorities focusing on business-oriented or government-oriented goals be a possible explanation for the adherence of several European countries to Legal Unbundling.

The remainder of the chapter is organized as follows: the next section justifies the choice of the different objectives attributed to the authority and discusses the regulatory goals in more detail. Section 3.3 sets outs our four-stage model and analyzes the optimal decisions of the downstream duopoly and the monopolistic upstream network; this allows us to derive the market outcome for every possible access fee. Based on these results, Section 3.4 then studies the agency's optimal choices of the grid charge and the unbundling regime for each of the objectives the regulator might pursue; possible explanations for the differences in the degree of vertical separation across EU member states as well as potential measures enhancing the focus of agencies on consumer-oriented goals are subsequently provided. Section 3.5 concludes. Proofs can be found in the Appendix.

3.2 Regulatory Objectives

3.2.1 Consumer-Oriented Objectives

We start our account of potential regulatory objectives with an illustration of the goals that are in line with the essential function typically assigned to regulators: the representation and promotion of consumer interests (Newbery, 1999, ch. 4.1; Small, 1999; Decker, 2010; Albon, 2012). The related literature and the mission descriptions of energy regulators active in EU member states indicate that three such targets can be discerned:

Maximizing the electricity dispatch: One of the basic objectives of regulatory interference is the prevention of anti-competitive behavior of dominant market players (as, e.g., incumbents) supplemented with a persistent promotion of competition in all those production stages where more than one firm can survive (Kay and Vickers, 1990; Small, 1999; Albon, 2012; see also the goals declared by the European Agency for the Cooperation of Energy Regulators (ACER, 2014), the Council of European Energy Regulators (CEER, 2014) and the German Bundesnetzagentur (BNetzA, 2014)). By this means, it shall (inter alia) be ensured that the consumers' demand for the product traded on the regulated market is fully satisfied (Newbery, 1999, ch. 4.1.1; Joskow, 2007; MIT, 2011, ch. 8.1). However, due to the power suppliers' need for grid capacity, realizing this aim in case of electricity implies that the authorities' interventions are not restricted to just monitoring both producers and sellers of the final good; instead, it additionally requires the surveillance of the monopolistic grid activities. Without regulation, network companies would restrain capacity to the profit-maximizing monopoly amount only (Demsetz, 1968; Kay and Vickers, 1990; Breyer, 1998; Ogus, 2004, ch. 3.2), which would of course lead to an undersupply of electricity as well.

Minimizing the power price: The outlined objective of maximizing output is closely related to another fundamental target of regulatory authorities: ensuring low commodity prices to protect consumers from excessive mark-ups otherwise claimed by firms with market power (Kay and Vickers, 1990; Small, 1999; Newbery, 1999, ch. 4.1.1). Related to electricity markets, the importance of this aim becomes obvious in the mission descriptions of European energy regulators: they, inter alia, require the authori-

ties to guarantee power prices that are "fair" (ACER, 2014; CER, 2014 (IRL); URSO, 2014 (SVK)), "cost-reflective" (ACER, 2014), "competitive" (Energiemyndigheten, 2014 (SWE)) and "on an affordable level" (MEKH, 2014 (HUN)), to ensure a "low-priced [...] supply of electricity" (BNetzA, 2014) or to "protect the interests of consumers [...] with respect to prices" (ERSE, 2014 (POR)). With the costs of network access being passed on to final customers by power suppliers, a core remit of electricity price regulation is the stringent control of the usage fee demanded by bottleneck owners: this is the only way to prevent that monopoly prices are claimed for granting capacity (Demsetz, 1968; Trebing, 1977; Kay and Vickers, 1990; Breyer, 1998; Newbery, 1999, ch. 4.1; Ogus, 2004, ch. 3.2; Joskow, 2007) while, at the same time, providing network companies with the financial means they need to construct and maintain all necessary assets (Breyer, 1998; Newbery, 1999, ch. 4.1; Small, 1999; Joskow, 2007; MIT, 2011, ch. 8.1).

Maximizing consumer surplus: The third possible goal finally combines the first two: the consumer surplus increases with higher amounts of output and lower end-user prices. Taking the surplus as the item to maximize in our theoretical anaysis allows for an appropriate operationalization of the above-mentioned target of promoting consumer interests prevalent in the literature as regulatory core objective (Newbery, 1999, ch. 4.1; Small, 1999; Decker, 2010; Albon, 2012). The exceptional significance this task actually has also in electricity market regulation is reflected in the frequency its fulfillment is named as a central aim of the European agencies' activities: numerous authorities emphasize their endeavors to protect, fortify and benefit end-users by their monitoring operations (ACER, 2014; AEEG, 2014 (ITA); BNetzA, 2014; CER, 2014; CNMC, 2014 (ESP); Energiemyndigheten, 2014; Energitilsynet, 2014 (DEN); ERSE, 2014; ERÚ, 2014 (CZE); JARSE, 2014 (SVN); MEKH, 2014; Ofgem, 2014 (GBR); RAE, 2014 (GRC); URSO, 2014).

3.2.2 Business-Oriented Objectives

Maximizing industry profits: Although responsible for serving the consumers in the first instance, regulatory authorities might take account of industry profits as well: in several cases, an agency's mission is expected to require welfare or total surplus maximization (Train, 1991, chs. I.1 and I.3; Small, 1999; Joskow, 2007) or - which

basically amounts to the same thing - the maximum possible reduction of dead-weight losses induced by market failures (Noll, 1989; Kay and Vickers, 1990); under both mandates, not only consumer surplus but also producer surplus is crucial. An authority will likewise consider company earnings in its decision when regulatory statutes demand to act in the "public interest" (Mitnick, 1980, chs. I.1.2 and V.1.0; Noll, 1989; Kay and Vickers, 1990): in general, scholars rate this provision as being an equivalent to welfare or total surplus maximization (Mitnick, 1980, ch. V.3.0; Noll, 1989; Train, 1991, ch. I.1; Newbery, 1999, ch. 4.1).

But not only the fulfillment of an official mission demanding welfare maximization might cause an authority to strive for high industry profits. Agency employees might also pursue own interests and objectives that are at odds with the statutory mandate of their employer (Noll, 1989; Kay and Vickers, 1990; Train, 1991, ch. I.1) and therefore focus on maximizing the power producers' and the network monopolist's profits. This might, for example, happen when the companies in the electricity sector succeed in using the authority for their own ends and induce the regulatory decision-makers to act and rule only in the firms' interests (Stigler (1971) was the first one addressing this potential abuse of regulation; see also Mitnick, 1980, chs. I.2.0, V.1.0 and V.2.0; Rourke, 1984, ch. 7; Kay and Vickers, 1990).

The reasons for such a *regulatory capture* can, as already indicated in the introduction, be rather diverse: in Laffont and Tirole (1991), the regulatee bribes the authority to achieve a more profitable regulation (Kay and Vickers (1990), maybe somewhat less precarious, just mention an employment of company resources by supervised firms to advantageously affect regulatory decisions). Che's (1995) model, including a "revolving door" (i.e. a regulator's posttenure opportunity to work in the sector under surveillance), suggests a less intense monitoring when the official's control efforts reduce the time and resources available to acquire skills valuable for the industry (and thereby the regulator's chance of getting hired); likewise, a laxer regulation occurs in case of an exogenous and unobservable posttenure competence as long as the negative relationship between the regulator's industry qualification and the intensity of supervision prevails[6]. (For a short non-theoretical discussion of the issues arising with a potential

[6]However, the existence of a revolving door can also lead to a stricter supervision: this is the case whenever posttenure competence also increases monitoring efficiency (independent of whether

industry employment of retired regulators see also Noll (1989).) And finally, Agrell and Gautier (2010, 2012a, 2012b) assume the authority to make use of biased information provided by the regulatee for free in order to save agency resources and working time, simultaneously accepting a suboptimal regulation derived from these noisy data.

However, unlike in the different strands of the *capture* literature, bribes, wage payments from postagency industry employment or (biased) information flows between regulated firms and regulator are not included in our model; instead, we simply operationalize *regulatory capture* by imputing an interest in high industry profits to the authority, implicitly assuming that the regulatees will benefit the regulator in return for decisions taken to favor the companies. For analytical convenience, upstream and downstream profits are discussed separately in the model section.

3.2.3 Government-Oriented Objectives

Maximizing revenues from electricity taxation: Finally, it might also be possible that the regulator focuses on the maximization of revenues generated from taxing electricity. The surveys of Johannsen et al. (2004), the CEER (2005) and Gilardi (2008, ch. 8) show that many European energy regulators are fully or at least partially funded by the government, and the OECD/IEA (2001) argues that the state's income from general taxation is an important source for this funding. As an increase in the national budget (which, in turn, is usually raised in times of high tax yields) is furthermore expected to be associated with an increase in agency budgets (or, at least, a lower probability that their requests for additional resources are denied) (Downs, 1967, ch. IX; Blais and Dion, 1990; Bowling et al., 2004; Wildavsky and Caiden, 2004, ch. 3), higher tax revenues might imply a better financial endowment of the regulatory authority, too.

The authority's intention behind its striving for higher means can be twofold: on the one hand, it might inherently be driven by the regulator's public mission. In this case, higher appropriations (are perceived as being necessary to) raise the agency's capability

industry knowledge has to be acquired or is given exogenously); and also in a setting without any postagency qualification where the door's porosity corresponds to the probability of a successful collusion between regulator and regulatee an entirely closed door is suboptimal as long as the government's financial means to correctly incentivize officals are limited (Che, 1995). In addition, also Salant's (1995) model assuming a company-funded consulting activity for retired regulators suggests a (weak) welfare-enhancing effect of revolving doors.

of competing with companies for specialists (Smith, 1997) indispensable in today's utility regulation due to the steadily increasing complexity of this task (Thatcher, 2002b) and of covering the substantial information costs that arise in this field (Agrell and Gautier, 2010). With adequate monetary and personnel resources being rated as vital for an agency to properly fulfill its function (Rourke, 1984, ch. 4; OECD/IEA, 2001; Thatcher and Stone Sweet, 2002), the regulator's behavior might then be explained by a pursuit of an equality of arms in the struggle against financially potent (Thatcher, 2002a) regulatees.

On the other hand, the regulator's wish for higher appropriations might - just as the potential interest in high industry profits - also be caused by purely self-serving motives: agency employees are, as Ogus (2004, ch. 4.4) points out, typically bureaucrats that, in turn, might act as suggested by Niskanen (1968, 1975) and aim at a maximized budget to finance, e.g., higher salaries or perquisites (see also Migué and Bélanger (1974), Rourke (1984, ch. 4) and Tullock et al. (2002, ch. 5) on that topic; Noll (1989) and Train (1991, ch. I.1) explicitly state the possibility of *regulators* behaving as officials à la Niskanen).

At least for bureaucrats in general, empirical evidence seems to support this conjecture in many cases: several papers reveal a striving for mostly considerable budget increases by various American agencies (Sharkansky, 1965, 1968; LeLoup and Moreland, 1978; Lauth, 1986; Thompson, 1987; Ryu et al., 2007; ASAP, 2008). Blais and Dion (1990) expect a bureaucratic self-interest to exist after (inter alia) reviewing the results of Krueger (1988), showing the number of applicants for U.S. federal jobs to increase when public compared to private wages increase, and Sigelman (1986), suggesting an eagerness for higher agency means to prevail among most American senior administrators. And finally, Bowling et al. (2004) and the American State Administrators Project's survey of 2008 (ASAP, 2008) do not only find a broad majority of U.S. agency heads favoring higher expenditures for their own authority (which, according to Ryu et al. (2007), strongly affects an office's request for a rising budget), but also that many of them likewise prefer a higher overall public spending. For Europe, Venetoklis and Kiander (2006) results suggest that Finnish higher-level officials especially advocate higher appropriations for tasks fulfilled by their agency, and also Bağdigen's (2003) interviews with Turkish local officials reveal a desire for budget expansions for

their own authorities. Jacobsen (2006) finds that Norwegian municipal bureaucrats favor increasing public expenditures in general and prefer these means to be allocated to their own remit as well as to internal administration (expected to be used to increase the bureaucracy's slack).

The problem of self-serving regulators might be even aggravated in the near future due to the growing number of highly skilled experts employed in utility authorities: such specialist are, according to Moe (1989), especially inclined to pursue personal objectives, confident that laymen outside their agency lack the knowledge to control them.

3.3 The Model

To provide a possible explanation for the variations in regulatory regimes across countries we analyze a multi-stage model that focuses on the differences between Legal and Ownership Unbundling from the perspective of the institution prescribing the intensity of vertical separation - the national regulatory authority. The structure of the model, which will be solved by backward induction in this and the next section, is illustrated in Figure 3.1 and can be described as follows: a regulator strives for the realization of one of the objectives elucidated in the previous section (a high electricity dispatch, a low power price, a high consumer surplus, high revenues from electricity taxation or high industry profits). The agency takes account of this goal when it determines whether Legal (LU) or Ownership Unbundling (OU) is implemented in the national electricity market in the first stage (which is discussed in Section 3.4.2). Subsequently, the authority sets the network access charge; as the type of unbundling, also the level of the fee is chosen so as to achieve the respective regulatory objective in the best possible way (Section 3.4.1). The licensing power assigned to the agency due to its market surveillance task allows for the enforcement of the charge that is optimal for the regulator. The grid company obligated to abide by the authority's decision hence

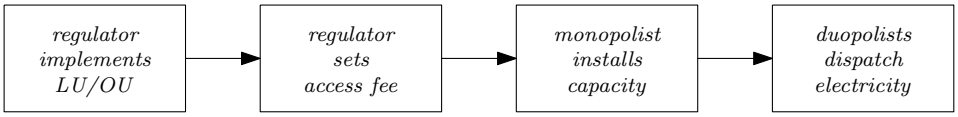

Figure 3.1: The stages of the game

faces an exogenously given fee as in Bolle and Breitmoser (2006) and Höffler and Kranz (2011a, 2011b); the full coverage of the construction costs via the usage charge assumed in these three papers independent of the network size, though, is no longer ensured due to the regulator's unconstrained second stage decision.

The third and the fourth stage, then, analyze the choices of the companies in the electricity industry. Since these stages are also considered in the papers on vertical separation that neglect the role of regulators, several of their assumptions and approaches of how to model different aspects of unbundling are adopted. As in Cremer and De Donder (2013), we assume the power sector to consist of one upstream monopolist that provides the grid and a downstream duopoly of identical generators that satisfies electricity demand and requires the network to dispatch power; with Legal Unbundling, one of the duopolists is an affiliate of the grid company, whereas in the case of Ownership Unbundling both generators are completely independent.

In the third stage, the upstream monopolist maximizes profits by deciding on the network capacity. A grid company that is just legally unbundled maximizes the overall profits of both the network and the affiliated generator (Section 3.3.2.1); a grid company separated by ownership, on the contrary, solely maximizes its own profits (Section 3.3.2.2). In the last stage, then, the network units are purchased by the downstream duopolists; each of them solely maximizes its own profits (Section 3.3.1), independently of which type of unbundling is implemented (Höffler and Kranz (2011a)[7]; Cremer and De Donder (2013); both papers borrow the modeling approach for Legal Unbundling originally introduced in Sibley and Weisman (1998)). When deciding on their power production, the generators consider that for every electricity unit they dispatch one unit of grid capacity is required. For each network unit, the duopolists have to pay the fixed per-unit fee (Bolle and Breitmoser, 2006; Cremer and De Donder, 2013; Höffler and Kranz, 2011a, 2011b) set by the regulator in the second stage; it is, as in reality (see, e.g. Sakhrani and Parsons (2010)[8]), assumed to be independent of the electricity price.

[7]To be precise, Höffler and Kranz (2011a) denote the setting equivalent to that analyzed in our paper (i.e., with an upstream monopolist maximizing total profits of the network and the legally separated downstream firm) as "reverse unbundling", while in their legal unbundling scenario the downstream producer maximizes joint profits.

[8]Sakhrani and Parsons (2010) analyze the network tariffs of four OECD countries in much detail; for both the EU member states included in their selection, Portugal and Spain, they find total access fees to be a mark-up on the power price paid by consumers that solely consist of price-independent capacity charges (€/kW/year, €/kW/month and €/kW/day), fixed charges (€/year, €/month and €/day) and

In cases where insufficient capacity constrains the power production, we finally suppose the two downstream generators to share the existing network units equally (Cremer and De Donder, 2013).

3.3.1 The Downstream Market

In the fourth stage, the two downstream generators, $i = 1, 2$, produce the electricity outputs q_i that add up to a total power supply of $q_1 + q_2 = Q$. When taking their production decisions, the duopolists face an inverse aggregate demand function $P(Q)$ that we assume to be decreasing and strictly convex (so that $P'(Q) < 0$ and $P''(Q) > 0$). This implies a reduction in electricity consumption after power price increases, as it is also suggested by recent empirical findings on the price elasticity of electricity demand for several EU member states (see below; we refer to long-run values since the decision on a potential change in the regulatory regime as well as its eventual implementation is a long-term process); the price elasticity, defined as

$$\epsilon = \frac{P}{Q(P)} \cdot \frac{\partial Q(P)}{\partial P} < 0 \tag{3.1}$$

(with $Q(P) = P^{-1}(P)$), describes the percentage change in electricity demand in response to a one percent increase in the power price (Varian, 2010, ch. 15.5).

For Austria, Denmark, Germany, Ireland, the Netherlands, Portugal (Madlener et al., 2011), Cyprus (Zachariadis and Pashourtidou, 2007), France, the UK (Narayan et al., 2007; Madlener et al., 2011), Greece (Hondroyiannis, 2004; Madlener et al., 2011), Spain (Madlener et al., 2011; Blázquez et al., 2012) and Italy (Narayan et al., 2007; Madlener et al., 2011; Dicembrino and Trovato, 2013), the long-run price elasticity of household electricity demand is found to be negative and inelastic; results indicate the same for the long-run price elasticity of industrial power demand in Greece (Christopoulos, 2000; Polemis, 2007), Italy (Dicembrino and Trovato, 2013), Cyprus (Zachariadis and Pashourtidou, 2007; restricted to the service sector) and Germany (Madlener et al., 2011; only for food and tobacco, chemicals, pulp and paper, non-metallic minerals and transport equipment as subsectors of manufacturing). A negative and elastic long-run

charges raised by consumption volume (€/kWh) (with their particular composition depending on both the country and the customer category).

price elasticity of residental electricity demand is furthermore suggested for Finland (Madlener et al., 2011) and Germany (Narayan et al., 2007).

In our model, the per-unit price $P(Q)$ paid by electricity consumers includes an ad-valorem tax with a tax rate t, so that the revenue a generator earns per power unit is equal to $(1-t)\cdot P(Q)$. Each duopolist incurs generating costs $C(q_i)$, with the cost function assumed to be strictly convex and increasing, $C'(q_i) > 0$, $C''(q_i) > 0 \; \forall \; q_i$; this reflects the *merit order* of generation, i.e. the disproportionately increasing marginal costs of the power plants gradually connected to the grid to satisfy an increasing demand (Sherman, 2008, ch. 18.1). Finally, for every network unit employed due to the required one-to-one relationship between supplied electricity and grid capacity, the generators have to pay the access charge a the upstream monopolist is entitled to raise to be able to construct and maintain the grid.

We assume the duopolists in the downstream market to compete in quantities. Since the generators take their decisions independently of the unbundling regime, fourth stage results hold for both types of vertical separation. Three different cases then have to be distinguished: in the first case, the network size exceeds the total amount of electricity the two generators dispatch; the grid capacity, denoted by X in the following, does not constrain power production. Consequently, the duopolists play a simple Cournot game and solve the maximization problem

$$\max_{q_i^*} \pi_i = \pi_i(q_1, q_2) = (1-t)\cdot P(Q)\cdot q_i - a\cdot q_i - C(q_i). \tag{3.2}$$

In equilibrium, the duopolists' generation levels $q_1^*(a)$ and $q_2^*(a)$, respectively, satisfy the first-order conditions

$$a + C'(q_i) = (1-t)\cdot[P(Q) + P'(Q)\cdot q_i] \;\; \wedge \;\; q_1 + q_2 = Q \qquad \text{for } i = 1, 2, \tag{3.3}$$

so that the generators' marginal costs equal their marginal revenues: the access charge and the production costs for the additional electricity unit add up to the former, whereas the latter includes the net price for the marginal power unit and the net price reduction for all inframarginal supplies resulting from the increase in generation. The duopolists' equilibrium power supplies sum up to the total electricity

amount in the unconstrained equilibrium, $Q^*(a)$; since a symmetric duopoly is assumed, $q_1^*(a) = q_2^*(a) = \frac{Q^*(a)}{2}$ holds.

In the second case, the network capacity exactly equals the overall power production of both duopolists in the Cournot equilibrium; this again allows the generators to dispatch $q_1^*(a) = q_2^*(a) = \frac{Q^*(a)}{2}$ units of electricity.

In the third case, the grid size finally undercuts $Q^*(a)$ and constrains the power production. As described above, we assume the duopolists to split the existing capacity equally in this situation, so that $\frac{X}{2}$ electricity units are supplied by each generator.

We can summarize the three cases as follows: let $Q(a, X)$ denote the *actual* amount of electricity dispatched; then,

$$Q(a,X) = \begin{cases} Q^*(a) & \text{if } Q^*(a) < X \quad \text{(i)} \\ Q^*(a) = X & \text{if } Q^*(a) = X \quad \text{(ii)} \\ X & \text{else} \quad \text{(iii)} \end{cases}$$

With a network size not constraining downstream generation in the first two cases, each duopolist is able to realize its profit-maximizing production level $q_i^*(a), i = 1, 2$; accordingly, $\frac{\partial \pi_i}{\partial q_i} = 0, i = 1, 2$ holds in (i) and (ii). In the third case, though, a capacity constraining the dispatch of power prevents the production of the profit-maximizing electricity amounts and the generators can only choose (identical) outputs smaller than $q_i^*(a), i = 1, 2$; hence, $\frac{\partial \pi_i}{\partial q_i} > 0, i = 1, 2$ follows in (iii).

The cases are illustrated in Figure 3.2: starting from the origin (and no network), an increase in the grid capacity enables the generators to raise their profits by expanding production to a level closer to the unconstrained Cournot equilibrium output; accordingly, all additional grid units are purchased by the power producers and the $Q(a_1, X)$-function has a slope of one in case (iii). When the function's kink, representing the second case, is then reached, the enlargement of generation is stopped: in this point, the network provided by the upstream monopolist is just equal to the aggregate downstream output that maximizes the duopolists' profits. Consequently, any further increases in X do not affect the production decision of the generators; they do not acquire more than $Q^*(a_1)$ grid units and with a non-binding capacity constraint (case (i)) the graph of the function becomes horizontal.

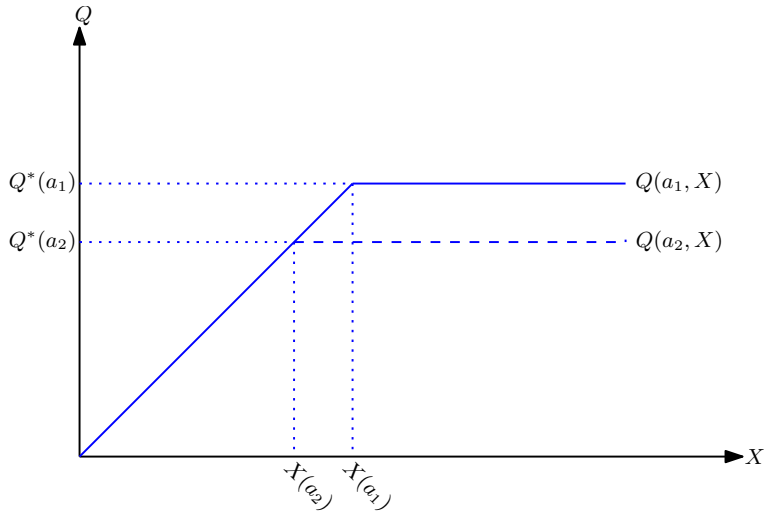

FIGURE 3.2: POWER DISPATCH AND GRID CAPACITY FOR $a_1 < a_2$

The above considerations finally allow us to derive how the actual total power supply $Q(a, X)$ reacts to a marginally higher network capacity X:

$$\frac{\partial Q}{\partial X} = \begin{cases} 0 & \text{in (i)} \\ 1 & \text{in (iii)} \end{cases} \tag{3.4}$$

The results for cases (i) and (iii) are straightforward. For case (ii), the derivative is not defined since $Q(a_1, X)$ is nondifferentiable at the kink point where $X = Q^*(a_1)$.

In addition, we can analyze the reaction of $Q(a, X)$ on marginal increases in a. We get

$$\frac{\partial Q}{\partial a} = \begin{cases} \frac{\partial Q^*(a)}{\partial a} < 0 & \text{in (i)} \\ 0 & \text{in (iii)} \end{cases} \tag{3.5}$$

In the first case, a higher usage fee reduces the total dispatch of electricity: the excess capacity allows the duopolists to realize their unconstrained Cournot equilibrium outputs. Since these decrease as soon as the generators face higher marginal costs, production in the unconstrained equilibrium and therefore also the actual total power supply is reduced whenever the access charge is increased (see Appendix A 3.1 for a derivation). Accordingly, a higher a leads to a parallel downward shift of the horizontal part of the $Q(a, X)$-function (as an example, see the dashed graph in Figure 3.2 that emerges after the fee is increased from a_1 to a_2). In case (ii), the reaction is again not

well-defined due to the the function's kink. In case (iii), finally, downstream output does not change. As in the first case, generation levels in the unconstrained Cournot equilibrium are reduced by an increase in the usage charge; but since $Q(a, X)$ is cut back below $Q^*(a_1)$ before due to the capacity constraint, the reductions in the unconstrained equilibrium outputs are not reflected in a lower network demand by the duopolists. Instead, the generators continue to exploit the existing grid completely.

3.3.2 The Upstream Monopolist

In the third stage, the upstream monopolist installs the capacity X that maximizes either total profits of the network and the affiliated generator (under Legal Unbundling) or network profits alone (under Ownership Unbundling). The monopolist generates revenues by selling capacity to the generators for the per unit price a; the costs to construct and maintain the grid are described by the cost function $G(X)$, which is assumed to be strictly convex and increasing, $G'(X) > 0$, $G''(X) > 0$. In the following, we use the subscripts L and O to distinguish network sizes and access fees under Legal and Ownership Unbundling, respectively.

3.3.2.1 Legal Unbundling

When statutory provisions require Legal Unbundling, the maximization of the aggregated upstream and downstream profits by the network company yields the optimization problem

$$\begin{aligned}\max_{X_L^*} \pi_v(X_L) = \; & a_L \cdot Q(a_L, X_L) - G(X_L) \\ & + (1-t) \cdot P(Q(a_L, X_L)) \cdot \frac{Q(a_L, X_L)}{2} \\ & - a_L \cdot \frac{Q(a_L, X_L)}{2} - C\left(\frac{Q(a_L, X_L)}{2}\right),\end{aligned} \tag{3.6}$$

with π_v denoting the total profits of the legally unbundled utility. The first line of (3.6) describes both revenues and costs of the grid company: for all electricity units the generators dispatch (adding up to either X_L if the network size constrains power production or $Q^*(a_L)$ if not), the monopolist earns the access fee a_L. Furthermore, the monopolist incurs the costs for providing X_L units of grid capacity, independent of

whether the whole or only a part of the network is eventually used by the downstream duopolists. The second and the third line of (3.6) then add both revenues and costs of the affiliated generator and include therefore all the components that are familiar from the duopolists' maximization problem (see (3.2)): the affiliate earns the net price for the electricity units it sells and has to bear both the access fees for all these units and the associated generation costs. Due to the duopolists' symmetry, always half of the actual total power production $Q(a_L, X_L)$ is supplied by the affiliated generator, regardless of whether generation is constrained by the network or not.

With the optimal grid capacity, X_L^*, marginal costs equal marginal revenues:

$$G'(X_L) + \frac{1}{2} \cdot \left[a_L + C' \left(\frac{Q(a_L, X_L)}{2} \right) \right] \cdot \frac{\partial Q}{\partial X_L} = a_L \cdot \frac{\partial Q}{\partial X_L} + \frac{1}{2} \cdot \left[(1-t) \cdot \left[P(Q(a_L, X_L)) + P'(Q(a_L, X_L)) \cdot Q(a_L, X_L) \right] \right] \cdot \frac{\partial Q}{\partial X_L} \tag{3.7}$$

Marginal costs comprise the monopolist's expenses for constructing and maintaining one more network unit and the costs the affiliated generator incurs for supplying half an additional electricity unit (consisting of both the generating costs and the aquisition expenditure for the grid capacity essential for dispatching). Marginal revenues include the access fee the downstream generators pay when they purchase the incremental network unit and the affiliate's earnings (i.e., the net market price) for half an additional electricity unit reduced by the net price decrease for its inframarginal power units. Except for the marginal construction costs that occur as soon as the incremental capacity is installed, all marginal costs and revenues arise only when the additional grid unit is employed by the downstream duopolists, i.e. when $\frac{\partial Q}{\partial X_L} = 1$. This is the case when the network size prevents the generators to produce their unconstrained Cournot equilibrium outputs, i.e. when $X_L < Q^*(a_L)$ (see (3.4)); by applying the left derivative of the $Q(a_L, X_L)$-function at its kink point here and in the following, we furthermore assume the duopolists to purchase the marginal capacity also when $X_L = Q^*(a_L)$.

We complete our discussion of (3.7) by shifting attention to the price reduction for the affiliate's inframarginal electricity units. The lowering of the power price is an aggregated effect that has two different origins: it results from the half-a-unit increases

in the electricity outputs of both the affiliated *and* the competing generator following the one-unit increase in the network capacity. This can be illustrated by rewriting the legally separated monopolist's first-order condition as[9]

$$\begin{aligned}\frac{\partial \pi_v}{\partial X_L} \;=\; & a_L \cdot \frac{\partial Q}{\partial X_L} - G'(X_L) \\ & + \underbrace{\frac{1}{2} \cdot \left[(1-t) \cdot \left[P(Q) + P'(Q) \cdot \frac{Q}{2}\right] - a_L - C'\left(\frac{Q}{2}\right)\right] \cdot \frac{\partial Q}{\partial X_L}}_{\frac{\partial \pi_1}{\partial q_1}} \\ & + \underbrace{\frac{1}{2} \cdot \left[(1-t) \cdot P'(Q) \cdot \frac{Q}{2}\right] \cdot \frac{\partial Q}{\partial X_L}}_{\frac{\partial \pi_1}{\partial q_2}} \stackrel{!}{=} 0\end{aligned} \tag{3.8}$$

(recall that $q_1(a_L) = q_2(a_L) = \frac{Q(a_L, X_L)}{2}$ due to the duopolists' identity). The second line of (3.8) describes the marginal effect the half-a-unit increase in the affiliate's power production has on its profits. But as an identically sized rise in the competitor's generation is induced by the capacity expansion, the monopolist also has to take account of the marginal effect the competing generator's production decision has on the affiliate's profits: it further lowers the price for inframarginal electricity units (see the third line of (3.8)). The incremental grid unit hence allows the affiliated generator to raise downstream profits by dispatching half an additional electricity unit, but at the same time it causes a *d*ouble *r*eduction *o*f *p*rices; henceforth, we will therefore refer to the competitor-induced power price decrease as the *drop*-effect of the network expansion.

We now draw on (3.8) to illustrate the effect of a one-unit increase in the grid size on the legally unbundled utility's total profits. Differentiating between the cases where the network size X_L is greater than, equal to and smaller than the total unconstrained Cournot output in the downstream market, $Q^*(a_L)$, we get

[9] Due to space restrictions, we refrain from mentioning the arguments of $Q(a_L, X_L)$ in (3.8).

$$\left.\frac{\partial \pi_v}{\partial X_L}\right|_{X_L > Q^*(a_O)} = \; - \; G'(X_L) < 0,$$

$$\left.\frac{\partial \pi_v}{\partial X_L}\right|_{X_L = Q^*(a_L)} = \; a_L - G'(Q^*(a_L)) + \frac{1}{2} \cdot P'(Q^*(a_L)) \cdot \frac{Q^*(a_L)}{2},$$

and

$$\left.\frac{\partial \pi_v}{\partial X_L}\right|_{X_L < Q^*(a_L)} = \; a_L - G'(X_L) + \frac{1}{2} \cdot \left[(1-t) \cdot \left[P(X_L) + P'(X_L) \cdot X_L\right] - a_L - C'\left(\frac{X_L}{2}\right)\right].$$

When the grid capacity exceeds the aggregate unconstrained power production, $X_L > Q^*(a_L)$, only the marginal upstream costs occur: neither generator dispatches more electricity than its Cournot amount, so that all additional network units which expand the grid beyond $Q^*(a_O)$ remain unused. Accordingly, the downstream affiliate does not incur any marginal costs, nor does it generate marginal revenues. The grid company, moreover, lacks purchasers for the overcapacity and hence gets no income via the usage charge for all excess units; instead, these parts of the network produce marginal losses, since the upstream monopolist is left with its marginal construction costs. Consequently, overcapacity is never installed by the grid company; it would unnecessarily reduce π_v that the legally unbundled monopolist strives to maximize.

If the network size coincides with $Q^*(a_L)$, the duopolists in the last stage choose their profit-maximizing production levels. The downstream marginal costs and marginal revenues the affiliate allows for when it takes its production decision then cancel out of the third stage first-order condition and the grid company has to compare its marginal revenues from the access fee with the remaining marginal costs: beyond the grid construction costs for the last unit, these also include the competitor-induced *drop*-effect.

When a low grid capacity finally prevents the generators from dispatching their unconstrained Cournot outputs, the marginal costs and revenues factored in by the affiliate differ from each other and become hence relevant for upstream decisions as

well. Compared to the situation where $X_L = Q^*(a_L)$ therefore both the marginal downstream costs beyond the *drop*-effect and all marginal downstream revenues enter the third stage optimization problem.

Whether it is optimal for the legally unbundled monopolist to choose the network size equal to or smaller than the sum of the generator's unconstrained Cournot outputs depends on the marginal effect the $Q^*(a_L)$-th unit has on overall profits:

Result 1: *Suppose that π_v is strictly concave in X_L and define $\Lambda(a_L) := a_L - G'(Q^*(a_L)) + \frac{1}{2} \cdot (1-t) \cdot P'(Q^*(a_L)) \cdot \frac{Q^*(a_L)}{2}$. Then,*

$$X_L^*(a_L) \begin{cases} = Q^*(a_L) & \text{if } \Lambda(a_L) \geq 0 \\ < Q^*(a_L) \text{ and } X_L^*(a_L) \text{ solves } \dfrac{\partial \pi_v}{\partial X_L} = 0 & \text{if } \Lambda(a_L) < 0. \end{cases}$$

Two different cases exist in which it is optimal for the upstream firm to provide a grid capacity equal to $Q^*(a_L)$: the first one occurs when the provision of the $Q^*(a_L)$-th unit has a positive marginal effect on aggregated upstream and downstream profits, i.e. when the access fee from selling one more network unit exceeds the sum of its construction costs and the *drop*-effect. In this case, the grid size undercuts the capacity that maximizes the overall profits, but the lacking downstream demand for still more capacity prevents the legally unbundled monopolist from further expanding the network. The second case arises when the marginal revenues and the marginal costs that remain to be considered by the grid company when the affilated generator produces its profit-maximizing output just cancel out. The number of grid units that lets the monopolist reach the maximum of π_v is then exactly twice as much as the amount of power the downstream affiliate dispatches to reach its own profit function's maximum and both the third and the fourth stage optimality condition are simultaneously fulfilled.

As soon as providing the $Q^*(a_L)$-th network unit affects aggregated profits negatively, the legally unbundled monopolist cuts back capacity below the total of the duopolists' unconstrained Cournot outputs: this happens when the usage charge does not cover both the marginal construction costs and the *drop*-effect. In this case, a capacity of $Q^*(a_L)$ would prevent the grid company from maximizing π_v since the optimal network size would be exceeded; to maximize aggregated profits, capacity is therfore curtailed by the monopolist until only $X_L^*(a_L)$ grid units are supplied.

As the regulator uses the access charge (together with the type of unbundling that is implemented) to optimally achieve its respective regulatory objective, we finally analyze the effect of a marginal increase in the network fee on the grid capacity. Depending on whether the network size constrains the dispatch of electricity or not, the capacity change resulting from a one-unit increase in the access fee differs:

$$\frac{\partial X_L}{\partial a_L} = \frac{\partial Q^*(a_L)}{\partial a_L} < 0$$

$$\text{for } \Lambda(a_L) > 0$$

$$\frac{\partial X_L}{\partial a_L} = -\frac{\frac{1}{2}}{-G''(X_L) + (1-t) \cdot \left[P'(X_L) + P''(X_L) \cdot \frac{X_L}{2}\right] - \frac{1}{4} \cdot C''\left(\frac{X_L}{2}\right)} > 0$$

$$\text{for } \Lambda(a_L) < 0. \tag{3.9}$$

As long as the grid size and the sum of the generators' unconstrained Cournot equilibrium outputs do not differ since the capacity demanded by the duopolists is smaller than the network size that maximizes the legally unbundled utility's total profits π_v, the reaction of the aggregated generation to small increases in a_L is decisive for the adjustment of the grid size: in this case, the monopolist's possibility to sell network units depends entirely on the generators' willingness to buy them. Since a higher access fee (and thus an increase in the marginal production costs) results in a reduction in the downstream demand for capacity (see (3.5) and Appendix A 3.1), the grid company will lower the network size to avoid the provision of redundant and hence loss-generating grid units.

When the duopolists' aggregated profit-maximizing electricity amounts and the network size maximizing the legally unbundled utility's profits coincide (i.e. for $\Lambda = 0$), the capacity change due to a marginal increase in the access fee cannot be determined; the derivative is not defined at the kink point of the $Q(a_L, X_L)$-function (see Section 3.3.1).

Whenever the generators would like to dispatch more electricity than the existing capacity allows, the monopolist will expand the grid when the usage fee is raised to take advantage of the downstream demand for additional network units: purchasing

them will allow the generators to produce electricity amounts closer to their profit-maximizing outputs (which will be slightly reduced by a small increase in a_L, but not in a way that the added capacity remains unused). Satisfying the additional downstream demand after a fee increase is the monopolist's optimal decision, as the application of the implicit function theorem to the legally unbundled utility's first-order condition shows: the denominator of the second fraction in (3.9) equals the second derivative of the legally unbundled utility's profit function with respect to the capacity at points where $X_L < Q^*(a_L)$; this has to be negative to let X_L^* denote a (local) maximum, so that the network is expanded whenever the grid size prevents the generators from dispatching their unconstrained Cournot outputs.

3.3.2.2 Ownership Unbundling

When Ownership instead of Legal Unbundling is implemented, the upstream monopolist does not have any incentive to influence competition in the downstream market since an affiliated generator which might benefit from a suboptimal grid expansion no longer exists. Accordingly, the grid company does not take account of any downstream marginal costs or revenues and solves the maximization problem

$$\max_{X_O^*} \pi_n(X_O) = a_O \cdot Q(a_O, X_O) - G(X_O),$$

where π_n denotes the entirely unbundled monopolist's profits and X_O the network capacity the grid company provides. As in 3.3.2.1, we draw on the monopolist's first-order condition,

$$\frac{\partial \pi_n}{\partial X_O} = a_O \cdot \frac{\partial Q}{\partial X_O} - G'(X_O) \stackrel{!}{=} 0, \tag{3.10}$$

at points where the network size is greater than, equal to and smaller than the sum of the generators' unconstrained Cournot outputs $Q^*(a_O)$ to analyze the effect of a marginal capacity increase on the grid company's profits. To substitute $\frac{\partial Q}{\partial X_O}$, we use (3.4) and apply the left derivative of the $Q(a_O, X_O)$-function at its kink. This gives

$$\left.\frac{\partial \pi_n}{\partial X_O}\right|_{X_O > Q^*(a_O)} = - G'(X_O) < 0,$$

$$\left.\frac{\partial \pi_n}{\partial X_O}\right|_{X_O = Q^*(a_O)} = a_O - G'(Q^*(a_O)),$$

and

$$\left.\frac{\partial \pi_n}{\partial X_O}\right|_{X_O < Q^*(a_O)} = a_O - G'(X_O).$$

As in the case of Legal Unbundling, grid units exceeding the duopolists' aggregated unconstrained Cournot output are not installed as they reduce upstream profits: they lead to marginal costs, but do no generate marginal revenues. When the network size coincides with $Q^*(a_O)$ or undercuts it, respectively, the grid company earns the access fee for supplying the marginal unit and incurs its marginal construction costs.

Whether it is optimal for the entirely separated, profit-maximizing monopolist to provide a capacity equal to or smaller than $Q^*(a_O)$ is described in

Result 2: *Define* $\Omega(a_O) := a_O - G'(Q^*(a_O))$. *Then,*

$$X_O^*(a_O) \begin{cases} = Q^*(a_O) & \text{if } \Omega(a_O) \geq 0 \\ < Q^*(a_O) \text{ and } X_O^*(a_O) \text{ solves } \dfrac{\partial \pi_n}{\partial X_O} = 0 & \text{if } \Omega(a_O) < 0. \end{cases}$$

Under Ownership Unbundling, it is hence optimal for the grid company to completely satisfy the downstream demand for capacity when the usage charge is higher than or equal to the marginal costs for providing the $Q^*(a_O)$-th network unit; in these cases, the grid size that maximizes π_n exceeds the aggregated power production that maximizes the sum of π_1 and π_2 or coincides with it, respectively. If, on the contrary, the $Q^*(a)$-th unit's marginal effect on upstream profits is negative, the monopolist reduces capacity below the total of the generators' unconstrained Cournot outputs and chooses a network size where the marginal unit's construction costs equal the access fee to realize maximum profits.

The linkage between total downstream capacity demand and optimal network size is also reflected in the capacity changes that are induced by small increases in the usage charge:

$$\begin{aligned} \frac{\partial X_O}{\partial a_O} &= \frac{\partial Q^*(a_O)}{\partial a_O} < 0 \quad \text{for } \Omega(a_O) > 0 \\ \frac{\partial X_O}{\partial a_O} &= \frac{1}{G''(X_O)} > 0 \quad \text{for } \Omega(a_O) < 0. \end{aligned} \tag{3.11}$$

Whenever the duopolists' demand for network units constrains the grid size, the reaction of the generators' aggregated unconstrained Cournot output determines the change in network size: since an increase in a_O leads to a lower $Q^*(a_O)$ (see (3.5) and Appendix A 3.1), the monopolist will downsize the grid. If, conversely, a network capacity undercutting $Q^*(a_O)$ constrains the dispatch of power, the demand for network units will exceed its supply also in case of a slightly higher usage charge. Applying the implicit function theorem to the grid company's first-order condition to identify the impact of a one-unit raise of a_O on the network size then reveals an increase in capacity to be optimal. For $X_O^*(a_O) = Q^*(a_O)$ (i.e for $\Omega = 0$) the optimal change in network size cannot be determined as the derivative is not defined at the kink of the $Q(a_O, X_O)$-function (see Section 3.3.1).

3.3.2.3 Comparisons

Based on the results from Sections 3.3.2.1 and 3.3.2.2 we now compare the two types of unbundling.

First, we draw on Results 1 and 2 which define the thresholds that determine when the optimal size of a legally or an entirely separated network, respectively, satisfies the duopolists' total capacity demand. Together, the Results allow us to identify when the optimal grid sizes under *both* regulatory regimes correspond to the generators' unconstrained aggregated Cournot outputs (and are therefore identical) when a uniform usage charge a is set under both types of unbundling:

(a) *Suppose* $\Lambda(a) \geq 0$*; then,* $\Omega(a) > 0$*. That is, whenever* $X_L^*(a) = Q^*(a)$*, then* $X_O^*(a) = Q^*(a)$*, too.*

Note that $\Lambda(a) = \Omega(a) + \frac{1}{2} \cdot (1-t) \cdot P'(Q^*(a)) \cdot \frac{Q^*(a)}{2} < \Omega(a)$ for every access fee: due

to the *drop*-effect a legally unbundled grid company takes into account in contrast to an entirely separated one, the marginal costs for providing the $Q^*(a)$-th network unit are always higher for an upstream monopolist under Legal Unbundling.

Accordingly, with identical grid charges under Legal and Ownership Unbundling, $a_L = a_O$, it is optimal for an entirely separated grid company to provide a capacity equal to the sum of the generators' unconstrained Cournot outputs whenever it is optimal to do so for a legally unbundled monopolist. $\Lambda(a) \geq 0$ implies that the legally unbundled grid company's marginal costs do not exceed its marginal revenues at $X_L = Q^*(a)$; then, the even lower marginal costs a grid company unbundled by ownership incurs if it provides $Q^*(a)$ will undercut the (identical) marginal revenues as well, and installing a network that accommodates the entire downstream capacity demand maximizes the entirely separated monopolist's profits.

Results 1 and 2 furthermore enable us to determine when the optimal capacities under *both* types of unbundling differ from the total amount of electricity the duopolists would like to dispatch when an identical access fee a is licensed under both regulatory regimes:

(b) *Suppose* $\Omega(a) \leq 0$*; then,* $\Lambda(a) < 0$*. That is, whenever* $X_O^*(a) < Q^*(a)$*, then* $X_L^*(a) < Q^*(a)$*, too.*

For a legally unbundled grid company it is hence optimal to constrain capacity below $Q^*(a)$ whenever the profit-maximizing network size of a monopolist separated by ownership is smaller than or equal to the generators' aggregated unconstrained Cournot outputs. In these cases, the marginal revenues the entirely separated grid company earns from providing the $Q^*(a)$-th network unit undercut or just cover, respectively, its marginal construction costs; and since in both cases the marginal costs a legally unbundled monopolist incurs are even higher due to the *drop*-effect it allows for, maximizing π_v implies a capacity lower than $Q^*(a)$.

Whenever a capacity $X_L = Q^*(a)$ is suboptimal for the legally unbundled grid company, $X_L^*(a)$ and $X_O^*(a)$ differ in all but one case when a uniform fee a is set because of the downstream marginal costs and revenues only the legally separated monopolist takes into account:

Result 3: *Define* $X_O^*(a)$ *as the solution to* $a - G'(X_O) = 0$ *and*

$$\begin{aligned}\Gamma(a) :&= \left.\frac{\partial \pi_v}{\partial X_L}\right|_{X_L = X_O^*(a)} \\ &= \frac{1}{2} \cdot \left[(1-t) \cdot \left[P(X_O^*(a)) + P'(X_O^*(a)) \cdot X_O^*(a)\right] - a - C'\left(\frac{X_O^*(a)}{2}\right)\right]\end{aligned} \tag{3.12}$$

Assume π_v *to be strictly concave in* X_L*. Then,*

$$X_L^*(a) \begin{cases} > X_O^*(a) & \text{if } \Gamma(a) > 0 \\ = X_O^*(a) & \text{if } \Gamma(a) = 0 \\ < X_O^*(a) & \text{if } \Gamma(a) < 0. \end{cases}$$

If the legally unbundled grid company installs a capacity equal to $X_O^*(a)$, the network's marginal revenues a and the marginal construction costs for providing the incremental grid unit cancel out in the optimization problem the legally separated monopolist has to solve whenever $X_L < Q^*(a)$. If the affiliate's marginal profits (including the *drop*-effect) associated with the installation of the $X_O^*(a)$-th grid unit (i.e. $\Gamma(a)$) are then positive, expanding the network is optimal for the legally unbundled grid company.

For such a situation to occur, the demand for electricity has to be price elastic[10]: if $\Gamma(a)$ defined in (3.12) is positive, then rearranging yields

$$\underbrace{1 - \left[\frac{a + C'\left(\frac{X_O^*(a)}{2}\right)}{(1-t) \cdot X_O^*(a)}\right] \cdot \frac{\partial X_O^*(a)}{\partial P(X_O^*(a))}}_{>\ 0} < -\frac{P(X_O^*(a))}{X_O^*(a)} \cdot \frac{\partial X_O^*(a)}{\partial P(X_O^*(a))}, \tag{3.13}$$

where the term on the right-hand side of (3.13) is the price elasticity of demand as defined in (3.1) at $X_O^*(a)$, multiplied by minus one. Consequently, to make inequality (3.13) hold, the elasticity has to be smaller than minus one.

From (3.13), a price elastic demand also prevails when $\Gamma(a) = 0$. In this case, the affiliate's marginal profits from selling half an additional electricity unit and the *drop*-effect add up to zero; the optimal capacity is then independent of the regulatory regime.

[10]See Section 3.3.1 for empirical examples of countries with an elastic long-run electricity demand. Examples for countries with an inelastic long-run demand - a situation discussed at the end of this section - can be found there as well.

Here, the network size is smaller than $Q^*(a)$: with $\Gamma(a) = 0$,

$$\left(\frac{\partial \pi_1}{\partial q_1} + \frac{\partial \pi_1}{\partial q_2}\right)\Bigg|_{q_1=q_2=\frac{X_O^*(a)}{2}} = 0;$$

and since the *drop*-effect affects the affiliated generator's profits negatively,

$$\frac{\partial \pi_1}{\partial q_2}\Bigg|_{q_1=q_2=\frac{X_O^*(a)}{2}} < 0, \tag{3.14}$$

the marginal profits generated by dispatching half another power unit have to be positive,

$$\frac{\partial \pi_1}{\partial q_1}\Bigg|_{q_1=q_2=\frac{X_O^*(a)}{2}} > 0. \tag{3.15}$$

Consequently, the affiliate and thus also its identical competitor would like to expand generation.

If installing a grid of size $X_O^*(a)$ finally has a negative overall effect on downstream (and hence also on the legally unbundled utility's total) profits, the legally separated monopolist cuts back the size of the network below the entirely separated monopolist's optimal capacity to maximize its profits. This can happen in case of a (less) elastic, a unit elastic or an inelastic electricity demand: consider (3.13) again; with an elasticity only slightly smaller than minus one, the left-hand side of the inequality might exceed its right-hand side. The inequality then no longer holds with a less-than, but a greater-than sign and $\Gamma(a)$ is negative. Correspondingly, the inequality sign turns with an elasticity equal to minus one or higher.

3.3.2.4 Upstream Capacities and Downstream Generation

We now outline the relationship between the generators' aggregated unconstrained Cournot outputs and optimal grid sizes under Legal and Ownership Unbundling (see Figure 3.3). The red curve depicts the downstream duopolists' total Cournot equilibrium production for different access fees, neglecting whether the capacity the generators need to dispatch their production is provided by the upstream monopolist or not. With $Q^*(a)$ being reduced by increasing grid charges (see (3.5) and Appendix A 3.1), the

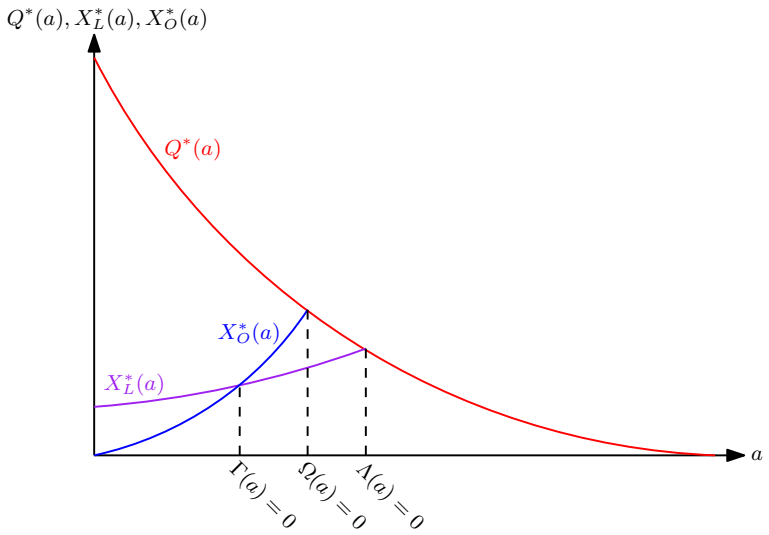

FIGURE 3.3: TOTAL DOWNSTREAM CAPACITY DEMAND AND OPTIMAL CAPACITIES UNDER LEGAL AND OWNERSHIP UNBUNDLING

graph is negatively sloped. The purple graph illustrates the profit-maximizing network size of a legally unbundled grid company when network capacity constrains downstream power production below $Q^*(a)$, and the blue curve describes an entirely separated monopolist's optimal grid size when generation is constrained. Both the purple and the blue graph are upward-sloping, since higher usage charges call for network expansions as long as the capacity is smaller than $Q^*(a)$, as (3.9) and (3.11), respectively, show.

We know from (3.14) and (3.15) that the capacity that is provided when $\Gamma(a) = 0$ is lower than the total electricity amount the generators would like to dispatch when the access fee that entails identical optimal grid sizes under both regulatory regimes is set; accordingly, the point of intersection of the $X_L^*(a)$- and the $X_O^*(a)$-curve lies below the graph for $Q^*(a)$. Calculating the derivative of $\Gamma(a)$ with respect to a yields

$$\frac{\partial \Gamma(a)}{\partial a} = \underbrace{-\frac{1}{2} + \left[\frac{\partial^2 \pi_v}{\partial X_L^2}\bigg|_{X_L = X_O^*(a)}\right]}_{<0} \cdot \underbrace{\frac{\partial X_O}{\partial a}}_{>0} < 0,$$

so that the optimal capacity under Legal Unbundling is higher than the optimal grid size under Ownership Unbundling in case of low access fees (i.e., left of the intersection), whereas it is just the other way round in case of high charges (i.e., right of the intersection). When purchasing network units is cheap, the legally unbundled utility provides a larger grid, since the affiliate's downstream profits (including the *drop*-effect) outweigh the profit setbacks or losses that arise in the upstream division when the network size

exceeds the capacity that maximizes an entirely separated monopolist's profits (i.e., $X_O^*(a)$). When the grid access gets more expensive, the legally unbundled monopolist refrains from installing a capacity equal to $X_O^*(a)$, since doing so would result in downstream profit reductions that could not be absorbed by the network's income increases; by providing $X_L^*(a)$, however, the network generates just enough excess profits to cover the affiliated generator's simultaneous losses. The dominating negative effect on the affiliate's profits that would occur *if* a capacity equal to $X_O^*(a)$ was provided originates solely from the *drop*-effect the legally unbundled monopolist takes into account: as long as $X_O^*(a) \leq Q^*(a)$,

$$\left.\frac{\partial \pi_1}{\partial q_1}\right|_{q_1=q_2=\frac{X_O^*(a)}{2}} \geq 0.$$

Differentiating $\Omega(a)$ gives

$$\frac{\partial \Omega(a)}{\partial a} = 1 \; - \; \underbrace{G''(Q^*(a))}_{>0} \cdot \underbrace{\frac{\partial Q}{\partial a}}_{<0} > 0,$$

suggesting unconstrained Cournot equilibrium outputs of the generators that, in total, exceed the optimal network size of an entirely separated grid when access fees are low. The small price for using the network does not allow for a cost-covering provision of the last $Q^*(a) - X_O^*(a)$ units and hence prevents the monopolist separated by ownership to satisfy the entire downstream demand. In case of higher charges (i.e., those that lead to $\Omega(a) > 0$), capacity is adapted to total generation (see Result 2).

Basically similar results can be observed for the relation between downstream capacity demand and the optimal grid size of a legally unbundled grid company. The first derivative of $\Lambda(a)$ with respect to a is

$$\frac{\partial \Lambda(a)}{\partial a} = 1 + \underbrace{\left[\left.\frac{\partial^2 \pi_v}{\partial X_L^2}\right|_{X_L=Q^*(a)}\right]}_{<0} \cdot \underbrace{\frac{\partial Q}{\partial a}}_{<0} > 0,$$

so that a cheap network access leads to a grid capacity smaller than the generators' aggregated unconstrained Cournot outputs also under Legal Unbundling: here, the *sum* of the fee and the affiliate's marginal profits (including the *drop*-effect) does not suffice

to cover the marginal construction costs for the last $Q^*(a) - X_L^*(a)$ units of the network and the electricity dispatch is limited to $X_L^*(a)$. For high usage charges (resulting in $\Lambda(a) > 0$), capacity is again determined by $Q^*(a)$ (see Result 1).

3.3.3 Interim Summary

We can briefly summarize the results from Section 3.3 as follows:

- In case of low access fees (i.e., those that lead to $\Lambda(a_L) < 0$ [$\Omega(a_O) < 0$]), downstream generation is constrained by the capacity the legally [entirely] separated grid company provides. When usage charges are high (implying $\Lambda(a_L) \geq 0$ [$\Omega(a_O) \geq 0$]), network construction is constrained by the low capacity demand of downstream generators (see Result 1 [Result 2]).

- When generation is constrained by the grid and access fees are slightly raised, capacity (and thus power production) is increased; when downstream capacity demand constrains network construction, a fee increase reduces power production (and thus the grid size) (see (3.9) [(3.11)]).

- With low [medium] access fees (i.e., those that result in $\Gamma(a) > 0$ [$\Gamma(a) < 0$]), the capacity under Legal Unbundling is higher [lower] than under Ownership Unbundling. There exists one usage charge that implies identical profit-maximizing capacities under both regulatory regimes (and $\Gamma(a) = 0$) when generation is constrained by the network size (see Result 3).

- The larger the network size (and the $\Gamma(a)$-value), the less price elastic is the electricity demand (see the analysis of Result 3).

3.4 The Regulatory Authority

3.4.1 The Regulator's Choice of the Access Charge

Being fully informed about the decisions the downstream generators and the (either legally or entirely separated) upstream monopolist take when a certain network charge is set, the authority licenses the access fee that ensures the achievement of the regulatory

objective in the best possible way in the second stage. This choice of the regulator is analyzed and compared for both types of unbundling and the different potential regulatory targets in the following; we draw on the order of objectives introduced in Section 3.2 during their elucidation to structure the analysis. In this section, a_L^{**} $[a_O^{**}]$ denotes the authority's optimal choice for the usage charge when Legal [Ownership] Unbundling is implemented; the capacity the legally [entirely] separated grid company installs when this charge is set is labeled with $X_L^{**}(a_L^{**})$ $[X_O^{**}(a_O^{**})]$.

3.4.1.1 Consumer-Oriented Objectives

Maximizing the electricity dispatch: We know from (3.9) and (3.11) that $\frac{\partial X_L}{\partial a_L}$ and $\frac{\partial X_O}{\partial a_O}$ are positive [negative] as long as $\Lambda(a_L)$ and $\Omega(a_O)$, respectively, are negative [positive]. For $\Lambda(a_L) = 0$ and $\Omega(a_O) = 0$ (i.e., at the kink points of the $Q(a, X)$-functions), we furthermore apply the right derviative here and in the following, assuming the demand for network units (and hence the capacity provided) to be reduced whenever the access fee is raised and $X_L^*(a_L)$ and $X_O^*(a_O)$, respectively, are equal to $Q^*(a_L)$ and $Q^*(a_O)$, respectively. To maximize the electricity dispatch for a given regulatory regime, the agency hence has to license the access fee that lets the generators' aggregated unconstrained Cournot outputs and the optimal capacity coincide: with $\Lambda(a_L) = 0$ and $\Omega(a_O) = 0$, every change in a_L and a_O, respectively, reduces the power supply below the maximum possible level. From our findings that $\Lambda(a) < 0$ whenever $\Omega(a) = 0$ (see Section 3.3.2.3) and that $\frac{\partial X_L}{\partial a_L} > 0$ if $\Lambda(a) < 0$ we can then derive $a_L^{**} > a_O^{**}$: an authority aiming at a maximum electricity dispatch licenses a higher grid charge when a legally unbundled rather than an entirely separated monopolist constructs the network. Since $\frac{\partial Q^*(a)}{\partial a} < 0$ (see (3.5) and Appendix A 3.1), this furthermore implies $X_L^{**}(a_L^{**}) < X_O^{**}(a_O^{**})$: with the optimal access fee being set in both regulatory environments, the capacity under Legal Unbundling is smaller than under Ownership Unbundling.

Minimizing the power price: Since $P'(X) < 0$, also this target requires the maximiziation of the electricity dispatch. Licensing the grid charges that lead to $\Lambda(a_L) = 0$ and $\Omega(a_O) = 0$, respectively, are hence again the optimal choices of the regulator. With both the fees that are set under Legal and Ownership Unbundling and the resulting

capacities being identical with those that are licensed and installed, respectively, when the agency's objective is a maximized power supply, $a_L^{**} > a_O^{**}$ and $X_L^{**}(a_L^{**}) < X_O^{**}(a_O^{**})$ also hold when the minimum price is sought.

Maximizing consumer surplus: The consumer surplus is defined as

$$CS(a) := \int_0^{X(a)} P(Q)dQ - P(X(a)) \cdot X(a),$$

i.e., as the sum of the consumers' willingness to pay for all electricity units supplied minus the total expenditures incurred to buy them. Then,

$$\frac{\partial CS(a)}{\partial a} = \underbrace{-P'(X(a)) \cdot X(a)}_{>0} \cdot \underbrace{\frac{\partial X}{\partial a}}_{\gtrless 0}.$$

Since, according to (3.9) and (3.11) (and due to the application of the right derivative for $\Lambda(a_L) = 0$ and $\Omega(a_O) = 0$), $\frac{\partial X_L}{\partial a_L}$ and $\frac{\partial X_O}{\partial a_O}$ are positive [negative] when $\Lambda(a_L)$ and $\Omega(a_O)$, respectively, take [non-]negative values, the derivative is only positive when $\Lambda(a_L) < 0$ and $\Omega(a_O) < 0$ hold. Increasing the access fee hence affects the consumer surplus positively as long as the additional network units the monopolist is willing to provide when the grid charge is raised are entirely purchased by the generators. Then, the electricity dispatch grows, the price drops and consumers are better off. If, however, the fee is raised further, so that the network size is constrained by the decreasing downstream demand, the power supply is reduced, the price increases and the consumer surplus falls. Maximizing consumer surplus thus again means maximizing electricity dispatch; the optimal usage charges for both types of unbundling and the ensuing capacities the monopolist installs are accordingly independent of which of the two objectives the regulator eventually pursues. Consequently, $a_L^{**} > a_O^{**}$ and $X_L^{**}(a_L^{**}) < X_O^{**}(a_O^{**})$ also result if the agency strives for the highest possible consumer surplus.

For a regulatory authority solely acting in the consumers' interest, we can hence summarize our findings in

Proposition 1: *The access charge set by a consumer-oriented regulator under Legal Unbundling will always exceed the fee licensed under Ownership Unbundling. An authority striving for a high power supply, a low electricity price or a high consumer surplus will always be better able to achieve its goal with an entirely separated monopolist.*

3.4.1.2 Business-Oriented Objectives

Maximizing upstream profits: Upstream profits under either regulatory regime (denoted by π_{up} in the following) are

$$\pi_{up}(a) = a \cdot X(a) - G(X(a)),$$

and vary with the access fee by

$$\frac{\partial \pi_{up}(a)}{\partial a} = \underbrace{X(a)}_{>0} + \underbrace{[a - G'(X(a))]}_{\geq 0} \cdot \underbrace{\frac{\partial X}{\partial a}}_{\gtrless 0}. \tag{3.16}$$

The additional income the monopolist earns due to the higher usage charge for inframarginal network units is reflected in $X(a)$, which is always positive. The effect the capacity change associated with a fee increase has on upstream profits, though, is ambiguous and depends on the sign of $\Omega(a)$: the difference between the access charge and the marginal construction costs (i.e., the term in square brackets) is either zero or positive (if the raise in the usage charge induces changes in the network size not only affecting the marginal grid unit). Accordingly, as long as a usage charge implies $\Omega(a) < 0$ (and thus $\frac{\partial X}{\partial a} > 0$, see (3.11)), a more expensive grid access always results in higher upstream profits: the additional gains generated by the inframarginal units are either not reduced (if the network is only expanded by a single unit, implying marginal construction costs that are just covered by the increased fee) or even further raised (if the incremental capacity is greater than one, therefore yielding positive marginal profits itself).

If, however, $\Omega(a) \geq 0$ (and thus $\frac{\partial X}{\partial a} < 0$), there is just one single case in which the capacity decrease induced by a higher fee does *not* diminish the additional income from the inframarginal units: it occurs when $\Omega(a) = 0$ and $\frac{\partial X}{\partial a} = -1$, i.e., when only the last grid unit generating zero marginal profits is no longer provided after an increase in a.

This exception aside, the smaller network always implies that previously profitable grid units can no longer be sold: with $\Omega(a) = 0$ and $\frac{\partial X}{\partial a} < -1$, the capacity reduction does not only involve the last unit whose sales revenues just cover its construction costs, but also (a) unit(s) that yield(s) positive marginal profits; with $\Omega(a) > 0$, marginal revenues exceed marginal costs for all units that are supplied prior to the fee raise.

While it is hence always optimal for a regulator striving for high upstream profits to further increase the usage charge when $\Omega(a) < 0$, it might be suboptimal to do so in case of non-negative Ω-values: whenever the marginal losses from downsizing the grid exceed the additional earnings generated by the inframarginal capacity, marking up the fee will reduce π_{up}. To determine the profit-maximizing charge we will therefore make use of the facts that both the fee is a cost component the generators cover by the power price and that its level is independent of this price (see Section 3.3), and then rearrange (3.16) so as to be able to base our considerations on our findings on the price elasticity of electricity demand (see Result 3 and its analysis).

First, let $P^-(X)$ denote the part of the gross market price for electricity $P(X)$ that is left when usage charge a is subtracted from $P(X)$. We can then rewrite $\frac{a}{X(a)} \cdot \frac{\partial X(a)}{\partial a}$ as

$$\frac{P(X) - P^-(X)}{X(P^-(X))} \cdot \frac{\partial X(P^-(X))}{\partial P^-(X)} = \frac{P(X)}{X(P^-(X))} \cdot \frac{\partial X(P^-(X))}{\partial P^-(X)} - \frac{P^-(X)}{X(P^-(X))} \cdot \frac{\partial X(P^-(X))}{\partial P^-(X)}. \tag{3.17}$$

Furthermore, suppose (3.16) to be greater than zero, implying the marginal effect of a fee increase to be positive. For $\Omega(a) \geq 0$, rearranging then yields

$$1 + \frac{a}{X(a)} \cdot \frac{\partial X(a)}{\partial a} > \underbrace{\frac{G'(X(a))}{X(a)}}_{>0} \cdot \underbrace{\frac{\partial X(a)}{\partial a}}_{<0}. \tag{3.18}$$

Finally substituting the right-hand side of (3.17) into (3.18) gives

$$1 + \frac{P(X)}{X(P^-(X))} \cdot \frac{\partial X(P^-(X))}{\partial P^-(X)} \underbrace{- \frac{P^-(X)}{X(P^-(X))} \cdot \frac{\partial X(P^-(X))}{\partial P^-(X)}}_{>\,0} > \underbrace{\frac{G'(X(a))}{X(a)}}_{>\,0} \cdot \underbrace{\frac{\partial X(a)}{\partial a}}_{<\,0}. \tag{3.19}$$

Inequality (3.19) holds as long as the electricity demand is inelastic or unit-elastic: in these cases, the left-hand side is positive. That is, for medium-high a-s (those not much higher than the fees yielding $\Omega(a) = 0$), a marginal increase in the access charge leads to higher upstream profits. The consumers' minor reaction to price increases in this area lets the additional income from inframarginal grid units outweigh the revenue losses induced by the decrease in power consumption. A further raise in the usage fee then leads to a further reduction in the network size, which, in turn, is associated with a more and more elastic demand. In the end, an authority aiming at maximized grid profits will choose the charge that entails an elasticity (smaller than minus one) exactly equating the left- and the right-hand side of (3.19), corresponding to an identity of marginal costs and marginal revenues of the fee increase. A precise identification of the usage charge to be chosen is hence not possible within the scope of our model; nevertheless, we can conclude that the optimal fees do not differ between the regulatory regimes, $a_L^{**} = a_O^{**}$, and that the resulting identical market equilibria ($X_L^{**}(a_L^{**}) = X_O^{**}(a_O^{**})$) lie on the downward-sloping part of the $Q(a, X)$-curves.

Maximizing downstream profits: The downstream generators' overall profits (labeled by π_{down} in the following) are

$$\pi_{down}(a) = (1-t) \cdot P(X(a)) \cdot X(a) - a \cdot X(a) - 2 \cdot C\left(\frac{X(a)}{2}\right),$$

and a higher usage charge alters them by

$$\frac{\partial \pi_{down}(a)}{\partial a} = \underbrace{-X(a)}_{<0} + \underbrace{\left[(1-t) \cdot \left[P(X(a)) + P'(X(a)) \cdot X(a)\right] - a - C'\left(\frac{X(a)}{2}\right)\right]}_{\gtrless 0} \cdot \underbrace{\frac{\partial X}{\partial a}}_{\gtrless 0}. \tag{3.20}$$

The higher costs for dispatching the inframarginal units always reduce the duopolists' income by $X(a)$. The effect of the marginal unit(s) on total downstream profits is positive [negative] whenever the sum of both marginal revenues and marginal costs that are relevant for the generators' production decision reduced by the *drop*-effect (i.e., the term in the outer square brackets in (3.20)) is positive [negative] and $\frac{\partial X}{\partial a} > 0$ (i.e., when

$\Lambda(a_L) < 0$ and $\Omega(a_O) < 0$, see (3.9) and (3.11), respectively); if $\frac{\partial X}{\partial a} < 0$ (and $\Lambda(a_L)$ and $\Omega(a_O)$ are non-negative), π_{down} is increased [decreased] when units generating marginal losses [profits] (implying a negative [positive] term in the outer square brackets in (3.20)) are no longer dispatched.

It is optimal for an authority aiming at the high overall downstream profits to choose the access fee that leads to $\Gamma(a) = 0$. This holds independent of the type of unbundling (see Appendix A 3.2 for a proof), so that $a_L^{**} = a_O^{**}$ and $X_L^{**}(a_L^{**}) = X_O^{**}(a_O^{**})$ when the regulator strictly acts in the interest of the generators.

For a regulator taking decisions only in the industry's interest, the results can be summarized in

Proposition 2: *The access charge set by a regulator pursuing business-oriented objectives is identical under Legal and Ownership Unbundling. An authority aiming at high upstream or downstream profits will always be able to reach its goal in the best possible way under both types of vertical separation.*

3.4.1.3 Government-Oriented Objectives

Maximizing revenues from electricity taxation: The overall tax yield is the product of the rate and the tax base, which is obtained by multiplying the gross price per power unit with the grid capacity:

$$TAX(a) = t \cdot P(X(a)) \cdot X(a)$$

With the tax rate $t > 0$ being determined exogenously, the regulator's only possiblity to affect the level of tax revenues is by influencing the network size via the access charge (which, of course, also alters the electicity price and hence the tax yield per unit). The change in the tax receipts resulting from a marginal increase in a is

$$\frac{\partial TAX(a)}{\partial a} = t \cdot \underbrace{[P(X(a)) + P'(X(a)) \cdot X(a)]}_{\gtrless 0} \cdot \underbrace{\frac{\partial X}{\partial a}}_{\lessgtr 0} \tag{3.21}$$

The network size increases whenever $\Lambda(a_L)$ and $\Omega(a_O)$, respectively, are smaller than zero (see (3.9) and (3.11), respectively). But since the downstream duopolists do not

take account of the overall price reduction additional grid capacity induces and consider only how their own increase in generation by half a unit affects the price, the *pre*-tax marginal revenues of the $X(a)$-th unit might also be zero or negative.

Result 3 and its analysis (especially the findings on a decreasing price elasticity of demand in case of an increasing capacity), though, allow us to draw some conclusions on the effects a raise in the access charge has on the income from electricity taxation: as long as the fee results in non-negative $\Gamma(a)$-values (see (3.12)), the *after*- and thus also the *pre*-tax revenues generated by additional network units have to be positive and the tax yields increase, too. When the price for the grid usage is then further raised, the (continuous) price elasticity of demand decreases more and more, until finally the fee is reached where the network size is associated with a unit-elastic electricity demand. At this point, the term in the square brackets in (3.21) becomes zero and the tax revenues no longer increase. With any further mark-up on the grid charge, demand becomes inelastic and income from taxation even drops again. To maximize revenues from electricity taxation, the regulator accordingly has to choose the fee that results in a capacity entailing an elasticity of exactly one. This is true independent of the regulatory regime, so that $X_L^{**}(a_L^{**}) = X_O^{**}(a_O^{**})$. However, the access charge necessary to induce such a network size under Ownership Unbundling implies a negative $\Gamma(a)$-value of $\frac{1}{2} \cdot \left[-a_O^{**} - C'\left(\frac{X_O^{**}(a_O^{**})}{2}\right)\right]$[11] and thus a lower capacity under Legal Unbundling; with a legally separated grid, the optimal fee hence has to be higher than with an entirely separated one, $a_L^{**} > a_O^{**}$.

These considerations hold as long as $\Lambda(a_L)$ (see Result 1) and $\Omega(a_O)$ (see Result 2), respectively, are negative. As soon as the maxima of the $Q(a, X)$-curves are reached and higher usage charges lead to a downsizing of the network under both types of unbundling (i.e., when $X_L^*(a_L)$ and $X_O^*(a_O)$, respectively, are determined by $Q^*(a)$; see Figure 3.3), tax yields initially grow again: the high capacities right of the maxima are, as mentioned above, associated with an inelastic demand and hence a negative value of the term in the square brackets in (3.21). Since $\frac{\partial X}{\partial a} < 0$ for high fees (see (3.9) and (3.11), respectively), the income from electricity taxation consequently rises at the beginning. However, with higher and higher usage charges, the grid size is more and more reduced;

[11] With a unit-elastic electricity demand $P(X_O^{**}(a_O^{**})) + P'(X_O^{**}(a_O^{**})) \cdot X_O^{**}(a_O^{**})$ disappears from the $\Gamma(a)$-term defined in (3.12) and the mentioned term remains.

this implies an increasing price elasticity until finally electricity demand is unit-elastic again and the marginal effect of a fee increase on tax revenues is zero. Raising the usage charge even further then would result in an elastic demand and hence decreasing tax yields (as the term in the square brackets in (3.21) turns positive). The maximum income from electricity taxation can accordingly also be realized with high access fees: the optimal capacities $X_L^{**}(a_L^{**}) = X_O^{**}(a_O^{**})$ do not differ from those identified above for negative values of $\Lambda(a_L)$ and $\Omega(a_O)$, but the usage charge/capacity-combinations that are realized now lie on the downward-sloping part of the $Q(a, X)$-curves; the fees under both regulatory regimes are identical in this case, $a_L^{**} = a_O^{**}$.

For an agency focusing on the achievement of its government-oriented goal, we can thus summarize our findings in

Proposition 3: *The access charge set by a regulator striving for high revenues from electricity taxation might be higher under Legal than under Ownership Unbundling; the grid capacity, though, is not affected by the level of the usage fee and, independent of the type of unbundling, always identical. An authority interested in high tax yields will thus always be able to reach its target in the best possible way under both regulatory regimes.*

3.4.2 The Optimal Regulatory Regime

Based on the results stated in Propositions 1 to 3 we can now derive the regulator's optimal first stage decision on the degree of vertical separation and formulate

Corollary 1: *A regulator striving for a high power supply, a low electricity price or a high consumer surplus will mandate Ownership Unbundling.*

A network separated by ownership together with the optimal usage charge for this regime, a_O^{**}, results in a grid capacity exceeding the highest possible one under Legal Unbundling, as has already been shown above. This allows authorities solely acting in the consumers' interest to better achieve its respective objective.

Furthermore, we get

Corollary 2: *A regulator aiming at high upstream or downstream profits or high revenues from electricity taxation is indifferent between Legal and Ownership Unbundling.*

That is, the degree of vertical separation becomes irrelevant for the authority as soon as it focuses on business-oriented or government-oriented objectives: when the optimal fees a_L^{**} and a_O^{**} are levied for the access to a legally and an entirely separated network, respectively, the grid capacities installed under both types of unbundling are, as analyzed above, identical. Consequently, also the agency's ability to reach its respective goal does not depend on the regulatory regime.

3.4.3 Interpretation of the Results and Policy Implications

It is this irrelevance of the unbundling regime in cases of authorities that strive for high industry profits or high electricity tax revenues that might also cause the adherence of several EU member states to Legal Unbundling: when solely the competition-enhancing effects of an entirely unbundled grid are important, the costs that arise from a change from Legal to Ownership Unbundling are considered rather negligible; but as achieving a business-oriented or government-oriented objective is equally possible for the agency without restructuring the electricity sector, these costs might tip the scales and prevent the realization of entirely separated grids.

With a regulator not focusing on consumer interests, different types of costs might induce the preservation of only legally unbundled electricity utilities: first, the implementation of Ownership Unbundling is expected to result in a facilitation of regulation (OECD, 2001; Mulder and Shestalova, 2006; European Commission, 2007a, 2007f, 2007g; Pollitt, 2008) due to the removal of the network's interest in generation and supply profits and the concomitant discriminatory actions (OECD, 2001; Mulder and Shestalova, 2006; European Commission, 2007a, 2007e, 2007f, 2007g). Actually an advantage, this might be rated negatively by an authority as soon as it is keen to preserve or even increase its importance (Ogus, 2004, ch. 4.4) - which is, according to the OECD/IEA (2001), virtually always the case (a behavior also in line with that expected from self-serving bureaucrats avid for power described by Downs (1967, ch. IX), Niskanen (1968), Peters (1978, ch. 7), Rourke (1984, ch. 4) and Tullock et al. (2002, ch. 5)). With a lower regulatory compexity probably being associated with a decline in the agency's influence as well as staff and resource reductions, it is reasonable to assume that the authority is interested in the ties between transmission and generation/supply

to persist.

Furthermore, transaction costs emerging in the course of a statutory split-off of the network division from an integrated utility because of, e.g., necessary contract renegotiations or in-house reorganizations (Mulder and Shestalova, 2006; Pollitt, 2008) might affect the choice on the type of unbundling as well: although most likely not outweighing the concurrent consumer benefits (Pollitt, 2008), they might induce an authority attaching importance only to industrial interests to avoid any structural changes.

Such a willingness to maintain the status quo of an industry-biased agency might also originate from the higher cost of capital expected as a possible consequence of Ownership Unbundling: either due to smaller firm sizes of the stand-alone divisions after full separation (Pollitt, 2008) or since, at least with respect to entirely unbundled generation and supply companies, high risks are no longer offset by a monopolist's low risk as in the case of vertical integration (Mulder and Shestalova, 2006). This would, again, undesirably reduce the unbundled companies' profits.

A regulator's reluctance to entirely separate an already legally unbundled firm might finally result from the higher risk of foreign takeovers a utility's split parts are probably exposed to (Pollitt, 2008). Most likely irrelevant to the authority, especially political pressure might play a decisive role at this point: due to the paramount importance the energy sector has for the production in industrialized countries (Schneider and Jäger, 2003; Domanico, 2007; Karan and Kazdağli, 2011) politicians are expected to clearly favor domestic ownership for national electricity (and gas) companies (Domanico, 2007; Belkin, 2008); to ensure the country's security of supply (Barysch et al., 2007), but also to curb the fear of layoffs (Ahearn, 2006) often linked to foreign takeovers and because of lobbying suspected to take place by incumbent owners[12] (Domanico, 2007).

The aspects regarding transaction costs, higher cost of capital and the desired prevention of foreign takeovers might gain even further relevance in the regulatory decision-making process when the legally separated electricity companies involved are state-owned. In these cases, politicians might perceive utilities primarily as sources of public revenue and might accordingly try to prevent regulations that reduce or even

[12]In line with this suspicion and our considerations, Wilks and Bartle (2002) argue that, instead of trying to influence authorities directly, regulatees rather try to interfere with regulations by inciting politicians to bias agency decisions in the affected companies' favor.

dry up this income flow in their own interest. That such political interferences might indeed affect agency decisions becomes obvious when the ownership structure of transmission firms in countries still adhering to Legal Unbundling is examined more closely: in Bulgaria, the high-tension grid is a 100% subsidiary of a fully state-owned holding company (European Commission, 2014c), and also in Hungary the network firm is controlled (European Commission, 2014f) by a public (MVM, 2014) parent company. In France, the government holds 84.49% of the group owning and operating the transmission lines (EDF, 2014), while the Greek state's share in the parent company fully owning (European Commission, 2014g) the country's high-tension network amounts to 51.12% (PPC, 2014). In Luxembourg, the state and the City of Luxembourg together with various Luxembourgian local governments hold 24.41% of the grid company in total, whereas 75.43% are owned by a holding (Creos, 2014); of this holding, in turn, 25.44% are owned by the state (being the largest shareholder), 10.01% by a public investment bank and 8.00% by the the City of Luxembourg (Enovos, 2014). The Cypriot transmission grid, finally, is owned by a so-called "semi-government company"; it is headed by an authority consisting of appointees of the national Council of Ministers and has to follow directives the government is allowed to issue when the general interest of Cyprus is affected (EAC, 2014). Still equipped with such a considerable influence on the electricity sector, politicians in these countries worrying about public revenue might hence have been prone to abuse their persistent powers to inhibit any structural changes that potentially threaten the treasury's income.

After discussing several possibilities for why a business-oriented or government-oriented agency might adhere to Legal Unbundling, we finally want to draw some inferences on potential modifications in the regulator-regulatee and the regulator-state relationship that might prompt such an agency to put its focus back on its genuine responsibility, the protection and promotion of consumer interests. Throughout the paper, we expect a regulatory authority neglecting this task to do so because of its interest in either financial and occupational amenities provided by the regulatees or additional, tax-funded appropriations. Successfully inducing a return of the regulator to consumer-oriented objectives hence implies that, on the one hand, the often still prevailing financial dependence of energy agencies on government funds has to be limited as far as possible: resources the authority receives should rather entirely stem from

regulated firms (as it is already the case in some, but by far not all EU member states; sometimes not even a partial contribution by the companies exists) and, if this cannot be guaranteed, government appropriations should at least not depend on the current budgetary position of the state; a fixed amount provided regularly over a long-time horizon together with the decoupling of the regulators' salaries from civil servant pay scales (that are normally affected by a country's economic situation as well) might be an appropriate solution. If, however, the financing of the authority by regulatees can be established, it is important to consider that industry payments should be as independent of the firms' profits as possible; otherwise, a similar misguided incentive could develop.

This eventually brings us to the necessary autonomy from regulated companies: to avoid that an authority accepts bribes or bases its decisions on freely provided, but biased information and acts in the interests of regulatees, the implementation of a collusion-proof incentive scheme is indispensable, as Laffont and Tirole's (1991) and Agrell and Gautier's (2010) findings suggest. Put another way, this means that a higher remuneration of regulators and a better resource endowment of agencies is recommended. Measures to reduce the porosity of the revolving door as, e.g., the often existing cooling-off periods previous to posttenure industry employments (Johannsen et al., 2004; CEER, 2005), on the contrary, should be applied rather carfully: as already mentioned, Salant (1995) and Che (1995) show that a more beneficial regulation might be implemented with an open door.

3.5 Conclusion

By analyzing a multi-stage model of electricity market regulation that focuses on agency decisions on network charges and the degree of vertical separation, our paper provides a possible explanation for the adherence of some EU member states to Legal Unbundling: with access fees set optimally under both Legal and Ownership Unbundling, electricity generation and consumer surplus are higher and power prices are lower when the network is separated by ownership; a regulator acting to the benefit of consumers will hence mandate Ownership Unbundling. As soon as an agency is in-

terested in high industry profits or high revenues from electricity taxation, however, neither type of unbundling allows for a better achievement of the regulatory objective; an adherence to Legal Unbundling might then be induced by the regulator's concern to lose importance, transaction costs or the fear of foreign takeovers or higher capital costs for the entirely separated activities.

These findings illustrate the importance of agency interests and incentives that cannot be reconciled with the regulator's formal mission. Although actually a well-known issue (addressed in particular in the *capture* literature), authorities potentially focusing on industry or government interests instead of on the benefits of end-users play virtually no role when, e.g., reasons for a delay or even a failure of (steps of) reform are discussed; in the political process, regulators are rather uniformly treated as reputable "advocates of consumers". By clarifying the impact an authority pursuing objectives deviating from its statutory task can have by means of an example from the area of electricity regulation, this paper might therefore raise the awareness for the relevance of properly designed agency incentives for the avoidance of unintended consequences of reform.

Including both the incentives that ensure the authority's focus on consumer well-being and those that cause the regulator to neglect its formal mission into the theoretical framework might also be an interesting possibility for future research. In this respect, the model at hand is parsimonious: it does not contain any remuneration for regulatory activities and also the assumed increase in government appropriations in the wake of higher tax yields is not implemented. Likewise, model elements familiar from the *capture* literature such as bribes or the regulator's chances for posttenure employment in the industry as well as the wages paid there are missing; we just suppose the agency to benefit from high upstream or downstream profits when it puts its focus on the business-oriented objectives.

Taking account of the different incomes the regulator earns depending on both the goal pursued and the resulting regulation might provide additional insights to better understand the reasons for the adherence of some EU member states to Legal Unbundling. Incorporating, e.g., the agency's budget cuts probably associated with Ownership Unbundling or potential payments regulatees make to the authority to prevent full separation into the model might allow for a possible explanation for why regulators

prefer legally unbundled grids within the theoretical framework: whenever agencies act in the interests of companies or the government and our results hint at their indifference between the two types of unbundling, the monetary (dis)incentives the suggested model extensions would capture might make Legal Unbundling become the authority's unique optimal choice.

3.6 Appendix

Appendix A 3.1:

If the downstream market is in equilibrium and the duopolists' production is not constrained by the network size, the set of the generators' first order conditions

$$\begin{aligned}\frac{\partial \pi_1}{\partial q_1} &= (1-t)\cdot[P(Q)+P'(Q)\cdot q_1]-a-C'(q_1)=0\\ \frac{\partial \pi_2}{\partial q_2} &= (1-t)\cdot[P(Q)+P'(Q)\cdot q_2]-a-C'(q_2)=0\end{aligned} \tag{3.22}$$

is fulfilled.

Linearization of (3.22) then yields

$$\begin{pmatrix}(1-t)\cdot[2\cdot P'(Q)+P''(Q)\cdot q_1]-C''(q_1) & (1-t)\cdot[P'(Q)+P''(Q)\cdot q_1]\\ (1-t)\cdot[P'(Q)+P''(Q)\cdot q_2] & (1-t)\cdot[2\cdot P'(Q)+P''(Q)\cdot q_2]-C''(q_2)\end{pmatrix} \cdot \begin{pmatrix}dq_1\\ dq_2\end{pmatrix} = \begin{pmatrix}1\\ 1\end{pmatrix}\cdot da \tag{3.23}$$

and Cramer's Rule can be applied to obtain the reactions of the power producers' outputs q_1 and q_2, respectively, on changes of the access fee a (Simon and Blume, 1994, ch. 15.3). Let $|J|$ denote the Jacobian determinant of (3.22). We get

$$\begin{aligned}\frac{dq_1}{da} &= \frac{1}{|J|}\cdot\Big[(1-t)\cdot[2\cdot P'(Q)+P''(Q)\cdot q_2]-C''(q_2)-(1-t)\cdot[P'(Q)+P''(Q)\cdot q_1]\Big]\\ \frac{dq_2}{da} &= \frac{1}{|J|}\cdot\Big[(1-t)\cdot[2\cdot P'(Q)+P''(Q)\cdot q_1]-C''(q_1)-(1-t)\cdot[P'(Q)+P''(Q)\cdot q_2]\Big]\end{aligned} \tag{3.24}$$

Now recognize that, first, $|J| = \frac{\partial^2\pi_1}{\partial q_1^2}\cdot\frac{\partial^2\pi_2}{\partial q_2^2} - \frac{\partial^2\pi_1}{\partial q_1\partial q_2}\cdot\frac{\partial^2\pi_2}{\partial q_1\partial q_2}$ which has to be positive for the Cournot-Nash equilibrium to be asymptotically stable (Fudenberg and Tirole, 1991, ch. 1.2.5), and, second, $q_1 = q_2 = q$ in this equilibrium. Equations (3.24) then

simplify to

$$\frac{dq}{da} = \underbrace{\frac{1}{|J|}}_{>0} \cdot \underbrace{\Big[(1-t)\cdot P'(Q) - C''(q)\Big]}_{<0} < 0. \tag{3.25}$$

Since $Q = 2 \cdot q$, $\frac{\partial Q^*(a)}{\partial a} < 0$ follows immediately from (3.25).

Appendix A 3.2:

First, note that the pagoda-shaped functions describing the actual total electricity generation under Legal and Ownership Unbundling (compare Figure 3.3) imply that, independent of the regulatory regime, every output level in the downstream market can be realized by two different usage charges. Choosing the higher fee to reach a given output then always means reducing the generators' overall profits: compared to the alternative with the cheaper grid access, the duopolists' total revenues and total generating cost are identical, while dispatching electricity becomes more expensive. A usage charge resulting in $\Lambda(a_L) \geq 0$ and $\Omega(a_O) \geq 0$, respectively, (inducing an equilibrium on the downward-sloping $Q^*(a)$-curve) can hence never be optimal for an authority striving for high total downstream profits.

Furthermore, recall from the analysis of Result 3 that, if $\Gamma(a) > 0$ [$\Gamma(a) < 0$], the profits of the legally unbundled monopolist's affiliate are raised when it increases [decreases] its power production - a finding that holds analogously for the identical, independent generator. Consequently, to maximize total downstream profits, the access fee implying that neither an expansion nor a reduction of the duopolists' outputs can positively affect their profits has to be implemented: this is the case when marginal revenues (including the *drop*-effect) equal marginal costs, or, put another way, when $\Gamma(a) = 0$. That is, with a regulator focusing on the maximization of π_{down}, $a_L^{**} = a_O^{**}$ and $X_L^{**}(a_L^{**}) = X_O^{**}(a_O^{**})$. ■

Chapter 4

Budgetary Interests and the Degree of Unbundling in Electricity Markets - An Empirical Analysis for OECD Countries[1]

4.1 Introduction

The degree of liberalization that has been realized in the electricity sector up to today varies considerably across countries (Conway and Nicoletti, 2006). Induced by an uneven pace of reform, empirical studies analyzing the reasons for policy changes offer several explanations for its divergence: economic performances (Drazen and Easterly, 2001; Pitlik and Wirth, 2003; Pitlik, 2008), the countries' levels of corruption (Emerson, 2006; van Koten and Ortman, 2008), or government ideologies (Pitlik, 2007; Potrafke, 2010).

We will elaborate on the related findings below, but advance another potential reason first: data suggest a relationship between taxation and electricity market reform. This is illustrated in Figures 4.1 and 4.2, respectively. To capture liberalization, we focus on the intensity of unbundling in the electricity sector, i.e. the degree of vertical separation between the industry's natural monopolies (transmission and distribution networks) and the potentially competitive stages of the value chain (generation, wholesale, and retail). Although somewhat restrictive, the particular importance of splitting these activities for a successful realization of fully competitive electricity markets (European Commission,

[1]This chapter was presented at the 9th EEM International Conference in Florence and the 31st USAEE/IAEE North American Conference in Austin.

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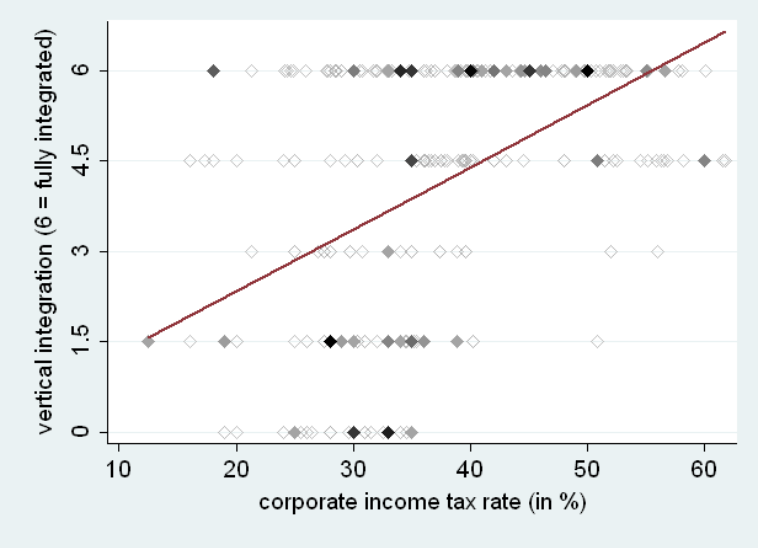

FIGURE 4.1: CORPORATE INCOME TAX AND VERTICAL INTEGRATION IN ELECTRICITY MARKETS

2007a; European Union, 2009a; Glachant and Léfêque, 2009) justifies this choice. In both scatterplots of Figures 4.1 and 4.2, the level of vertical separation is measured by an OECD indicator (OECD, 2011a). It ranges from 0 to 6 and decreases with stricter forms of unbundling[2]. The scope of taxation, in turn, is proxied by the rates of the corporate income tax rate (Figure 4.1) and the VAT rate on electricity (Figure 4.2); we thus cover two sources of public revenues that primarily affect one of the market sides each.

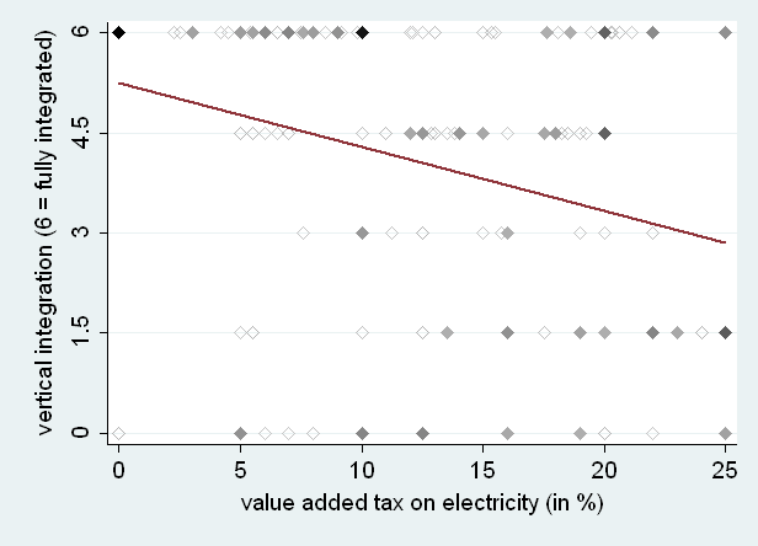

FIGURE 4.2: ELECTRICITY VAT AND VERTICAL INTEGRATION IN ELECTRICITY MARKETS

[2]See Subection 4.2.1 for a detailed description.

Data for 30 OECD countries[3] and a 27-year period (1981-2007) are used to construct the first scatterplot. The brighter an observation point in the diagrams, the fewer identical observations it stands for; in case of less than five observations, the point is aditionally depicted as hollow. The fitted regression line included in the first plot has a positive slope, suggesting the level of unbundling to be lower in countries with higher corporate income tax rates.

The second scatterplot that compares the electricity VAT rate with the degree of vertical separation indicates an opposite relationship: for a sample comprising 19 OECD countries[4] and the period from 1975 to 2007, the fitted regression line rather hints at a liberalization-enhancing effect of higher levels of taxation.

With a negative [positive] relationship between tax rate and vertical separation being indicated by the graphs, our paper aims at testing whether these findings can stand sound empirical examination: drawing on the data used to create the scatterplots, we estimate the effect of a heavier taxation of corporate income and power consumption, respectively, on the scope of a country's electricity market reform by OLS. The outcomes are in line with both Figures 4.1 and 4.2 and suggest that the differences in the tax rates that have existed among OECD countries over the years could have triggered notable deviations in their unbundling regimes. These inferences hold when various combinations of controls are included in the regression to allow for other factors that potentially affect liberalization; and also a change of the estimation model from OLS to ordered logit, justifiable with the method used to calculate the vertical separation index, does not challenge the relationship depicted in the scatterplots.

This paper provides a possible explanation for the yet latent but apparently robust effect taxation seems to have on the structure of the power industry. In a nutshell, we suggest ministry officials and authority members in charge of electricity regulation to strive for high government appropriations for their institutions and therefore to refrain from implementing [foster] unbundling measures that reduce [raise] the base of the corporate income tax and the electricity VAT, respectively; with a smaller [higher]

[3]The countries are AUS, AUT, BEL, CAN, CHE, CZE, DEU, DNK, ESP, FIN, FRA, GBR, GRC, HUN, ISL, IRL, ITA, JPN, KOR, LUX, MEX, NDL, NOR, NZL, POL, PRT, SVK, SWE, TUR and USA.

[4]The countries included are AUS, AUT, CAN, CHE, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, JPN, KOR, NDL, NOR, NZL, SVK and SWE. Compared to the sample used to construct the first scatterplot, the number of countries is reduced due to data restrictions.

tax base, tax yields are lower [higher], and thus also the funding for the ministry or regulatory agency is likely to decrease [increase]. As, for a given reduction [increase] in the tax base, the resulting decrease [increase] in tax revenues is higher, the higher the tax rate is, we expect a relationship to exist between how heavily corporate income and power consumption is taxed and the degree of vertical separation.

We discuss the different aspects of this potential explanation step by step. First, we illustrate why we assume regulatory actors to aim for high financial means for their institution. To this end, we split the period of electricity market regulation into two parts, differentiating between the early years where state ministries were responsible for industry oversight and the (ongoing) era of independent regulatory authorities. First concentrating on the early years of reform, we draw on the theory of bureaucracy (Niskanen, 1968, 1975; Migué and Bélanger, 1974; see also Downs, 1967, ch. IX; Rourke, 1984, ch. 4; Tullock et al., 2002, ch. 5) to substantiate our conjecture with respect to ministry employees: the theory claims that public officials strive to increase the power of the institution they work for and especially their remuneration to maximize their utility. To further corroborate our considerations, we present empirical studies indicating that an interest of bureaucrats in high funding for their offices or ministries might indeed exist.

Then, we provide two possible explanations for why we expect also members of regulatory authorities to aim for high government appropriations: on the one hand, it might be possible that regulators neglect their agency's official mission (Kay and Vickers, 1990) and pursue objectives similar to those ascribed to bureaucrats (Noll, 1989; Train, 1991, ch. I.1). On the other hand, the high financial resources authorities require to properly fulfill their mandate (OECD/IEA, 2001; Thatcher and Stone Sweet, 2002) might also induce regulators strictly focusing on their employers' official tasks to strive for budget increases. And as agencies are mainly publicly financed (OECD/IEA, 2001; CEER, 2005; Johannsen et al., 2005; Gilardi, 2008, ch. 8; Hanretty and Koop, 2009), any interest of a regulator in higher financial means induced by either of these motives basically amounts to being an interest in higher government appropriations.

Next, we briefly outline the literature that suggests that ministry and agency employees aiming for high institutional budgets also aim for high state budgets (Downs, 1967, ch. IX; Hood et al., 1984; Bowling et al., 2004) as the sizes of both budgets are interrelated (Blais and Dion, 1990; Wildavsky and Caiden, 2004, ch. 3) and discuss

empirical studies supporting this view. Since it is reasonable to assume that the state budget increases with increasing tax yields, this would likewise imply an interest of such regulatory actors in high tax yields.

Based on these considerations, we finally provide a potential explanation for the liberalization-hampering effect of high corporate income tax rates. With an increasing unbundling intensity, the level of competition in the electricity industry is raised. This, in turn, reduces the companies' (previously anticompetitive) profits and thus the base of the corporate income tax: the tax can basically be seen as a tax on capital costs (Myles, 1995, ch. 8.2.2) and the remuneration of (equity) capital is usually higher, the higher the profits are. The loss in tax revenues that results from the tax base reduction, in turn, increases with the tax rate, so that regulatory actors striving for high government appropriations should especially refrain from implementing unbundling measures when corporate income is heavily taxed; in this case, the negative relationship between tax rate and the degree of unbundling our estimation results indicate would emerge.

The liberalization-enhancing effect of high electricity VAT rates our empirical findings furthermore suggest would then imply the base of the VAT to increase with higher levels of vertical separation. It can be shown, though, that this is only true when power demand is price elastic, which is rarely the case in reality. However, with the erroneousness of our notion that regulatory actors aiming for high budgets affect vertical separation or reverse causality being possible explanations for this contradiction, an additional estimation hints at another potential reason: when the unbundling intensity is regressed on both tax rates, the coefficient on the VAT rate becomes negligibly small and loses statistical significance, suggesting both the estimates indicating a reform-fostering effect to suffer from an omitted variable bias and ministry officials and regulators to focus on corporate taxation when they take their decisions.

The remainder of the chapter is organized as follows: the next section describes the data and the estimation approach applied to empirically test the relationship between tax rates and unbundling level suggested by the scatterplots. Sections 4.3 and 4.4 report and discuss regression results and robustness checks. Section 4.5 then explains why we expect ministry officials and authority member responsible for regulation to be interested in high budgets for their institutions and and how this might induce an effect of tax rates on vertical separation. Section 4.6 concludes.

4.2 Data and Methods

4.2.1 Main Variables and Estimation Method

To capture the development of vertical separation in the electricity markets of different OECD countries, we draw on a sub-indicator of the ETCR (*E*nergy, *T*ransport and *C*ommunication *R*egulation) measure provided by the OECD (OECD, 2011a).

The ETCR indicator provides a summarizing index value for the overall effectiveness of regulation in seven non-manufacturing sectors by assessing their level of competition. It is obtained in several steps (Conway and Nicoletti, 2006): At first, two to four sub-indicators are calculated for the seven sectors (passenger air transport, telecom, electricity, gas, post, rail, and road freight). The number of sub-indicators differs depending on whether the issues covered by the five existing types (entry barriers, public ownership, vertical integration, market structure, and price controls) are relevant for the degree of competition in the respective sector or not. In case of an existing relevance, various questions that capture the situation prevailing in the respective sector with regard to the aspect the particular sub-indicator describes are answered on the basis of a wide range of data sources. Then, values between 0 and 6 are assigned to the answers, with higher values indicating less competitive environments. A weighted average of all answer values is calculated to obtain the sub-indicator. The values of the sub-indicators determined for a particular sector, in turn, are averaged in order to get the indicator for this industry. Finally, the simple average of all sector indicators yields the ETCR indicator which is available for 30 OECD countries and the period from 1975 to 2007.

Analyzing the relationship between taxation and the degree of separation in the electricity sector, we focus on the vertical integration sub-indicator for exactly this branch. Its value equals the average of the values assigned to the answers to the following two questions (answer values in parentheses) (Conway and Nicoletti, 2006):

1) What is the degree of vertical separation between the transmission and generation segments of the electricity industry?

- Separate companies. (0)
- Accounting separation. (3)
- Integrated. (6)

2) What is the overall degree of vertical integration in the electricity industry?

- Unbundled. (0)
- Mixed. (3)
- Integrated. (6)

Since the answer values are weighted equally, the sub-indicator increases in steps of 1.5 and can only take values 0, 1.5, 3, 4.5, and 6.

We apply the combined central and sub-central corporate income tax rate as well as the rate of the VAT on electricity as main explanatory variables. The data on the corporate income tax rate are taken from OECD (2011b) and cover, as already outlined in the introduction, 30 OECD countries and the years from 1981 to 2007. The data on the electricity VAT rate cover 19 OECD countries and the period from 1975 to 2007; values were obtained from national tax authorities. Summary statistics for both tax rates as well as for the vertical integration sub-indicator and all controls used in the regressions can be found in Table 4.6 in the Appendix.

To test the relationship between the degree of unbundling and the rates of the corporate income tax and the electricity VAT, respectively, we estimate the equation

$$vi_{it} = \alpha + \beta \cdot tax_{it} + \boldsymbol{\gamma} \cdot \boldsymbol{X_{it}} + \delta \cdot cdum_i + \theta \cdot ydum_t + \epsilon_{it}.$$

The dependent variable vi_{it} denotes the degree of vertical separation, measured by the vertical integration sub-indicator value outlined above. Our main explanatory variable is the tax rate tax_{it}. Since we are interested in the influence of the corporate income as well as the value added tax, we run different estimations and switch the tax type each time. The vector $\boldsymbol{X_{it}}$ contains further variables that might affect the intensity of unbundling; we describe these controls and substantiate their selection in the following section. The country and year dummies $cdum_i$ and $ydum_t$, respectively, enable us to control for differences in country characteristics as well as for possible shocks and trends over time. Finally, ϵ_{it} denotes the usual error term.

4.2.2 Control Variables

To allow for the effects factors other than the rates of the corporate income tax and the electricity VAT, respectively, might have on the level of vertical separation, we include the following control variables in our regressions:

- First, we add a country's total tax revenues as a control. As briefly outlined in the introduction, we suspect regulators to take account of what effect their decisions on the degree of unbundling have on tax yields, since they expect a shortfall in the receipts to be reflected in budget cuts for their agency. Such cuts, in turn, should carry rather little weight when high total tax revenues make high appropriations likely anyhow, and be painful for the authority when low tax yields already force the government to constrain the resources it allocates to public institutions. Regulatory measures that reduce tax receipts should accordingly be facilitated [hampered] by high [low] total tax revenues.

  As soon as a change in regulation increases tax receipts, on the contrary, we expect the relationship between tax yields and the implementation of new rules to be exactly opposite: with overall tax revenues being high, generating additional tax payments via regulatory provisions should not be so urgent; available funds already allow the state to allocate considerable resources to the agency. Low tax yields, by contrast, should promote the modification of the rules: the financial leeway gained through the new regulatory regime might induce the government to increase the appropriations for the authority.

  That is, we expect the coefficient on total tax revenues to be negative [positive] when unbundling measures lead to lower [higher] tax receipts. All these considerations make clear the influence of the type of unbundling on total tax revenues we assume to exist; to avoid the obvious endogeneity problem, we therefore include the control variable with a lag of one year (which reasonably implies that a state institution's funding depends on the country's financial situation in the previous period). Data are obtained from OECD (2010b).

- We furthermore control for a country's overall government debt (data are taken from OECD (2010b)). Since it is reasonable to assume that the funding for a regulatory institution increases with a decreasing national indebtedness, we expect

all conclusions drawn for the tax revenues to hold the other way round: regulatory measures that lead to higher tax yields are probably implemented when debts are high; the additional public revenues generated by the change in the rules should result in higher appropriations for the (underfunded) agency. With a low government debt, on the contrary, altering the regulatory framework to increase tax receipts and thus the authority's resources is most likely unnecessary; the financial means allocated to the agency can be expected to be already high.

When regulatory provisions reduce tax revenues, a high indebtedness probably prevents their implementation, as the already low funding of the authority would otherwise be further reduced; high government appropriations in times of low debt, by contrast, should facilitate such regulations.

Accordingly, we expect a negative [positive] estimate on total government debt when a higher degree of vertical separation increases [lowers] tax receipts. To avoid reverse causality issues, also this control is included in the regressions with a lag of one period.

- Next, we extend the estimation to allow for the economic performance of a country in the previous year. In general, each economic reform creates a group of gainers and a group of losers (Drazen and Grilli, 1993; Krueger, 1993; Rodrik, 1996; Bean, 1998), and while those gaining usually support the policy change, the market actors benefiting from the *pre*-reform situation are expected to often fiercely oppose it (Drazen and Grilli, 1993; Rodrik, 1996). The so-called "crisis hypothesis" therefore claims that a troubled economy is a prerequisite for reform: the associated detriments will force politicians to implement corrective measures, ensure the political support necessary for these changes (Drazen and Grilli, 1993; Krueger, 1993; Rodrik, 1996; Drazen and Easterly, 2001) and can - in case of a deep crisis which affects almost everybody - even reduce the resistance of beneficiaries of the old status quo (Rodrik, 1996).

  Theoretical (Drazen and Grilli, 1993) and empirical (Drazen and Easterly, 2001; Pitlik and Wirth, 2003) findings support the hypothesis with respect to inflation and identify considerable currency devaluations to be a trigger for reform. However, with respect to economic growth, empiricial results are less straightforward:

Pitlik and Wirth (2003) show that a country's liberalization efforts are only higher in the wake of a deep crisis; after a medium growth crisis, on the contrary, the willingness to reform is even weaker than in the aftermath of an upswing or a boom[5]. Pitlik's (2008) study reveals that the positive effect of an economic downturn on the scope of liberalization predicted by the hypothesis can only be observed in democracies or when a country's political system includes a high number of veto players; for autocratic regimes, his findings suggest reforms to be introduced only after periods of growth (with results holding independently of the severity of the crisis). And Drazen and Easterly's (2001) and Pitlik's (2007) results hint at a liberalization-enhancing effect of economic downturns, but they (often) do not reach statistical significance (particularly relevant in our case is that Pitlik (2007) cannot identify any statistically significant impact of growth crises on the design of regulatory regimes).

We decided to check for a possible effect of a country's economic problems on liberalization by including the growth rate of the real GDP (calculated on the basis of real GDP data obtained from the World Bank (2011)) lagged by one year as a control variable, thus neglecting the potentially existing relevance of the crisis's severity Pitlik and Wirth's (2003) findings suggest. Based on the outlined results (and since our OECD sample does not include any autocracies), we therefore expect the coefficients on the growth rate to be positive (albeit not necessarily statistically significant). With the inflation rates found to trigger reform being exceptionally high[6], we furthermore refrained from adding a control capturing

[5]Pitlik and Wirth (2003) define a medium and a deep growth crisis as follows: a value of 1 is assigned to each year with a non-positive growth rate being higher than -1%; years with a rate equal to or smaller than -1% recieve a value of 2. A five year period with a sum between 3 and 5 is then classified as a medium growth crisis, a five year period with an overall value greater than 5 constitutes a deep crisis. Pitlik and Wirth's (2003) result that medium growth crises lead to lower reform efforts than upswings and booms substantiates Bean's (1998) conjecture that, unlike as claimed by the "crisis hypothesis", changes are induced by good economic performances, as they facilitate the compensation of beneficiaries of the status quo opposing reform.

[6]As in the case of growth (see footnote 5), Pitlik and Wirth (2003) distinguish between a medium and a deep crisis also with respect to inflation, defining the two types as follows: a value of 1 is assigned to each year with an inflation rate being higher than or equal to 10% and smaller than 40%, years with an inflation rate equal to 40% or smaller than 100% receive a value of 2; finally, years in which the inflation rate exceeded 100% get a value of 3. Then, a five year period with a sum between 2 and 10 is classified as a medium inflation crisis, a five year period with a total value greater than 10 constitutes a deep crisis. Drazen and Easterly (2001), splitting their sample into groups according to the sample countries' inflation rate, find effects of currency devaluation on reform to exist only for the groups with a median annual inflation rate of 68% or of at least 100%, respectively (depending on whether they

currency devaluation.

- In addition, we control for the energy intensity in the sample countries by including the primary energy supply (measured in tonnes of oil equivalent) per GDP unit as a proxy (OECD, 2010a). Since high needs of primary energy caused by, e.g., extreme weather conditions or energy-intensive industries strengthen the desire for cheap electricity, we expect negative coefficients to occur.

- We also control for the level of corruption prevailing in the public sector. Venal bureaucrats in charge of regulation are expected to implement provisions or, conversely, to refrain from their implementation (Tanzi, 1994; Ades and Di Tella, 1997a) to ensure persistent high profits for the (usually few) firms active in the regulated industry. This malfeasance obviously reinforces existing market imperfections (Tanzi, 1994), since excessive earnings can only be generated in non-competitive environments, but, above all, it allows corrupt officials to demand high bribes for themselves (Tanzi, 1994; Ades and Di Tella, 1997a, 1997b, 1999): companies benefiting from the suppression of competition possess both the financial means and the willingness to pay large kickbacks in order to preserve their advantageous situation (Mauro, 1996; Ades and Di Tella, 1997a; Treisman, 2000). Bureaucrats aiming at a share in the incumbents' rents are therefore suspected of keeping them as high as possible by shielding oligopolistic markets from new entrants (Ades and Di Tella, 1997a; Treisman, 2000).
  Both theoretical and empirical research hints at the existence of such a malfeasant behavior by corrupt officials: Emerson's (2006) model shows that it is optimal for a venal civil servant regulating a market supplied by a Cournot oligopoly with a competitive fringe to constrain the number of Cournot competitors; this allows him to ask for higher bribes. Estimations included in the paper as well furthermore substantiate the conjectured competition-hampering effect of high levels of corruption. Van Koten and Ortman (2008), analyzing the relationship between corruption and the degree of transmission network unbundling in the electricity sectors of the EU-15 and ten further member states that acceded to the EU in 2004, find venal public officials and politicians to be associated with less stringent

apply an accurate or a rough classification).

separation levels in EU-15 states, but to higher ones in the ten accession states. However, the authors suspect the converse results for the new member states to be induced by fraudulent reports on their true unbundling situation especially in the years before 2004, because a failure in implementing the stipulated degree of separation would have jeopardized their accession to the EU. Since compared to restructuring the whole electricity sector to meet EU requirements misreporting was particularly easy to realize in very corrupt countries, it is conjectured that in fact the correlation between the degree of unbundling and the CPI was the same in EU-15 and accession states.

To allow for a potential effect of corruption on vertical separation, we include the Corruption Perceptions Index (CPI) compiled by Transparency International (2012; see Lambsdorff (2006) for details) as a control variable; it ranges from 0 to 10 and increases as the perceived susceptibility to bribery in a country's public sector decreases. Based on the literature suggesting that more corrupt countries tend to procrastinate on state interferences fostering competition, we therefore expect a negative coefficient to occur.

- Our next control variable captures the government's ideology. Right-wing politicians are usually seen as advocates of only minimal state interventions who promote deregulation whenever possible and prefer the free market to rule. Left-wing politicians, on the contrary, are expected to be rather interested in taming the market and therefore in comprehensive regulatory measures (Benoit and Laver, 2006, ch. 6). This notion is substantiated by Pitlik's (2007) and Potrafke's (2010) estimation results: both find the level of deregulation to be higher in countries where right-wing governments are in power.

  We check for the suggested liberalization-enhancing effect of right-wing cabinets by adding Potrafke's (2009) ideology index as a control. It takes values between 1 and 5 and increases as the share of seats left-wing parties hold in parliament and government grows; consequently, a positive coefficient on the ideology measure is likely to arise.

  Apart from being an indicator of government ideology, the index might also be seen as a proxy for the political orientation of those directly responsible for regu-

lation. On the one hand, it happens quite often that after a change of government leading positions in ministries are restaffed by civil servants that are close to cabinet members. In the period where electricity markets were regulated by ministry officials, a congruence of government ideology and the political orientation of senior civil servants hence most likely existed, implying the index to properly reflect the ideology of the officials supervising the sector as well. On the other hand, the workforce of today's regulatory authorities is usually formed by representatives of all relevant (political) parties (Thatcher, 2002b). If one now reasonably assumes that the number of representatives increases in the parties' strength, the political views prevailing among agency members should be appropriately captured by an ideology index that describes the distribution of seats in both government and parliament.

- Finally, we take account of a potential EU membership effect. The European Union has been very active and ambitious in the area of regulatory policy-making; as a consequence, the resulting legislation member states are obliged to implement frequently exceeds by far the exclusively national provisions both in terms of quantity and quality (Majone, 1996b). This is also true for energy policy, where the liberalization of European energy markets as well as the realization of a single EU market is the major objective of the Commission: three legislative packages for an internal EU gas and electricity market have therefore been adopted until today which include as many electricity directives (European Communities, 1996; European Union, 2003, 2009a). They require, inter alia, the implementation of increasingly stronger forms of unbundling in the member states, suggesting higher degrees of vertical seperation in EU compared to non-EU OECD countries surveyed in our sample. Beyond that, research emphasizes the pressure European institutions have put on member states in the recent past to prompt them to establish independent regulators and vest them with wide-ranging authorities (Döhler, 2002; see European Union, 2003, 2009a for the legal provisions). Given that such agencies are rated as a driving force for a profound liberalization process (OECD/IEA, 2001), this requirement should further reinforce the presumably

higher reform efforts in EU countries[7].

The conjectured relationship is anything but uncontroversial, though: a comparative study between the EU-15 except for Luxembourg and groups of 16 South American and eight developed democratic countries, respectively, concludes that in the electricity sector reliable evidence for a liberalization-enhancing effect of an EU membership is lacking (Levi-Faur, 2004). It shows that the steps of reform undertaken to promote competition in both wholesale and retail markets were more comprehensive in the European Union than in South America; but at the same time, it reveals that, compared to the economically more similar democratic countries, the liberalization efforts of EU member states were lower with respect to retail activities and only higher in wholesale markets.

To capture a potential effect of an EU membership in our regressions we add a dummy control variable that is constructed on the basis of EU accession dates (taken from European Union (2011)). Levi-Faur's (2004) findings challenging the liberalization-enhancing role of the EU notwithstanding and based on the non-empirical literature discussed above, we expect stricter forms of unbundling to be suggested by the estimation results for member states (i.e., a negative dummy coefficient); however, it appears questionable whether the estimate can reach statistical significance.

4.3 Estimation Results: Corporate Income Tax

4.3.1 Basic Results

We start with analyzing the relationship between the corporate income tax rate and vertical separation. Table 4.1 illustrates the regression results from OLS estimations. Independent of the model specification, the tax rate coefficient shows a positive and statistically highly significant sign; the conjecture of a liberalization-hampering effect of high tax rates suggested by Figure 4.1 is thus further substantiated. If the bivariate

[7]The cooperation between regulators initiated by the Commission (Thatcher, 2002b) might even amplify the conjectured effect: although his a sample of 16 European independent authorities does not include electricity regulators, it does not seem erroneous to assume that Maggetti's (2007) findings suggesting a reduction of the regulatees' competition-hampering interference in an agency's day-to-day operation when the authority is part of a network group also holds for energy markets.

Table 4.1: OLS Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CITrate	.1030***	.0546***	.0538***	.0592***	.0573***	.0351***	.0338***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)
totaltaxrev$_{t-1}$		-5.1e-09	-3.1e-09	-2.2e-09	-1.8e-09	1.3e-07	1.6e-07
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
totalgovdebt$_{t-1}$		4.3e-07***	4.2e-07***	4.1e-07***	4.0e-07***	3.8e-07***	3.5e-07***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDPgrowth$_{t-1}$			-.0304	-.0410*	-.0481*	-.0324	-.0217
			(0.024)	(0.024)	(0.026)	(0.028)	(0.029)
energysupGDP				-7.675***	-6.568**	-14.12***	-12.71***
				(2.776)	(3.172)	(3.900)	(3.969)
TIcor					-.0648	-.3052***	-.2873***
					(0.095)	(0.093)	(0.091)
ideopotr						.2145***	.2143***
						(0.061)	(0.061)
EUdum							-.3916
							(0.276)
constant	.2781	2.383***	2.526***	4.172***	4.464***	8.872***	8.303***
	(0.326)	(0.593)	(0.600)	(0.889)	(1.022)	(1.033)	(1.106)
country dummies	no	yes	yes	yes	yes	yes	yes
year dummies	no	yes	yes	yes	yes	yes	yes
R^2	.2102	.7877	.7883	.7912	.7906	.8265	.8275
N	682	588	588	588	557	470	470

Note: Columns (1)-(7) show estimation results of standard linear OLS estimations. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level.

model reported in the first column is neglected at this point, the coefficient size lies between 0.03 and 0.06; it reaches its minimum when all controls are included in the regression (and the associated data restrictions moreover notably reduce the number of observations). The most comprehensive estimation model thus suggests the vertical integration index to grow by about 0.35 units when the corporate income tax rate is increased by ten percentage points.

Apart from the tax rate also several control variables are statistically significant: first, all coefficients on the lagged government debt reach significance at the 1% level and hint at lower degrees of vertical separation in countries with high national deficits. Given that estimation results at the same time suggest only limited liberalization efforts in cases of higher corporate income tax rates, this is in line with our considerations briefly outlined in the introduction and Section 4.2.2, respectively: an increase in unbundling seems to reduce the tax base for and thus also the tax yields from corporate taxation; this results in a hesitant attitude towards separation measures especially when existing debts are already high. The size of the estimated effect, though, is virtually zero, indicating that decisions on the implementation of unbundling measures are basically taken independently of the level of indebtedness in the previous year.

The negative coefficient on the lagged GDP growth reaches statistical significance

only in columns (4) and (5) and there also just at the 10% level. The estimates in these cases rather challenge the "crisis hypothesis": they hint at stricter forms of unbundling after a high GDP growth in the previous year, which could only be reconciled with previous findings at least partially substantiating the hypothesis when the economic downturns covered by our sample would be classified as what Pitlik and Wirth (2003) call a "medium crisis"; the U-shaped relationship between growth and the scope of reform they identify suggests that liberalization efforts in the wake of such minor economic turbulences are lower than those following times without economic problems. However, given that the size of the significant coefficients is rather small (to reduce the vertical integration measure by half a unit, the growth rate has to increase by more than ten percentage points) and, above all, statistical significance is entirely lost when further controls are added in the last two columns, overall results seem to indicate that the unbundling level in our sample countries is not affected by their growth performance.

Energy-intensive production processes, on the contrary, are suggested to foster reform significantly: the respective coefficients are all negative and - except in column (5), where the estimate can only reach the 5% significance level - statistically highly significant. The size of the effect is furthermore suggested to be considerable: the coefficient provided by the most comprehensive regression model indicates that an increase in the amount of primary energy required to produce 1000 US$ of GDP by 0.1 tonnes of oil equivalent decreases the vertical integration measure by more than 1.25.

Estimation results likewise hint at higher degrees of unbundling in countries with officials less susceptible to bribery: the coefficients on the corruption index are negative and reach high statistical significance in columns (6) and (7). The significant estimates indicate an integration index reduction of approximately 0.3 for each one-unit increase in the CPI.

The conjectured relationship between government ideology and vertical separation is substantiated by the regression outcome as well: as expected, the highly significant control variables suggest lagging reforms in countries governed by left-wing parties. The size of the estimates imply that a change from a right-wing to a left-wing cabinet (leading to an ideology index increase from 1 to 5) ceteris paribus raises the unbundling measure by about 0.85.

Finally, the results suggest than the lagged tax revenue and a country's membership

in the EU do not have an effect on the degree of unbundling as the respective coefficients cannot reach statistical significance.

4.3.2 Robustness Checks

We check the robustness of our findings in four different ways: first, we change the estimation method and use ordered logit regression instead of OLS. Then, we substitute several control variables included in the basic estimation with alternative, but closely related measures and re-run the OLS regression. Afterwards, both modifications are combined and an ordered logit model with the new set of controls is estimated. Finally, we re-estimate the most comprehensive basic regression and all robustness checks with both the energy intensity proxy and the corruption index being lagged by one year to ensure that our results do not suffer from endogeneity problems these two controls might cause when they are not lagged.

4.3.2.1 Ordered Logit Regression

Calculated as the mean of the two answer values assigned according to the level of separation between generation and transmission and within the electricity sector, respectively, the vertical integration sub-indicator we employ as dependent variable requires the scales of the two questions it is composed of to be cardinal. It might be argued, though, that the assumption of cardinality inherent in the way the measure is constructed is at least problematic: according to the literature discussing the effects of unbundling (see, e.g., OECD, 2001; European Commission, 2007a; Pollitt, 2008), Ownership Unbundling, i.e. the *complete* separation of the monopolistic networks from electricity generation and retail, is essential to realize full competition in the non-network activities; only this strict form of unbundling ensures that incentives of network monopolists to discriminate against independent rivals of the affiliated generators and retailers are completely eliminated. That is, with reductions in the sub-indicator value supposed to reflect respective increases in the level of electricity sector competition, regulations requesting a separation of the grids by ownership should result in a considerably higher decrease of the integration measure than other, less drastic interferences. This, however, is not the case: sub-indicator values imply that, e.g., regulatory provisions for a

completely vertically integrated industry that demand accounting separation between generation and transmission and entail the coexistence of unbundled and integrated companies (leading to a sub-indicator decrease from 6 to 3) would have the same effect on competition as a subsequent reform step compelling ownership separation between natural monopolies and all other stages of the value chain throughout the sector (resulting in another 3-unit drop to 0). The calculation method of the sub-indicator assuming cardinality notwithstanding, we therefore suggest an alternative and simpler interpretation of changes in the integration measure value: they can be construed as solely reflecting the completion of a liberalization step. With each of them reducing the measure by 1.5, we get a simple ordinal scale, not rating the intensity of the different regulatory interventions.

This allows us to test the robustness of our OLS results by estimating the effect of higher tax rates on liberalization within the framework of an ordered logit model. The ordered logit model can be applied in case of discrete ordinal dependent variables that reflect a ranking of the possible outcomes, but do not allow for comparing the differences between response categories (Wooldridge, 2002, ch. 15.10.1). The basis of the approach is the latent regression

$$vi_{it}^{*} = \boldsymbol{\beta} \cdot \boldsymbol{Z_{it}} + \eta_{it},$$

where $\boldsymbol{Z_{it}}$ includes the tax rate tax_{it}, the controls composing $\boldsymbol{X_{it}}$ in the OLS regressions and country ($cdum_i$) and year dummies ($ydum_t$), but no constant; the error term η_{it} is logistically distributed with distribution function $\Lambda(\eta_{it}) = \frac{1}{1+e^{-\eta_{it}}}$. With a national electricity sector's actual level of unbundling at a certain year, vi_{it}^{*}, being a latent variable, we can draw on the sub-indicator values $vi_{it} \in \{0, 1.5, 3, 4.5, 6\}$ to approximate the degree of separation. There exist five unknown cut points κ_j with $j = 1, ..., 5$ and $-\infty = \kappa_0 < ... < \kappa_{j-1} < \kappa_j < ... < \kappa_5 = \infty$, so that

$$y_{it} = vi_{it} \quad \text{if} \quad \kappa_{j-1} < \ y_{it}^{*} \leq \kappa_j,$$

yielding response probabilities

$$Pr(y_{it} = vi_{it} | \boldsymbol{Z_{it}}) = Pr(\kappa_{j-1} < \ y_{it}^{*} \leq \kappa_j | \boldsymbol{Z_{it}}) = \Lambda(\kappa_j - \boldsymbol{\beta} \cdot \boldsymbol{Z_{it}}) - \Lambda(\kappa_{j-1} - \boldsymbol{\beta} \cdot \boldsymbol{Z_{it}}).$$

Table 4.2: Robustness Checks

	(1)	(2)	(3)
CITrate	.0580**	.0330***	.0596*
	(0.028)	(0.011)	(0.033)
totaltaxrev$_{t-1}$	4.6e-06***		
	(0.000)		
taxrevGDP$_{t-1}$		.0050	-.0481
		(0.033)	(0.086)
totalgovdebt$_{t-1}$	-2.0e-06**		
	(0.000)		
govdebtGDP$_{t-1}$		.0078*	-.0011
		(0.004)	(0.019)
GDPgrowth$_{t-1}$	-.0362		
	(0.090)		
GDPcapgrowth$_{t-1}$		-.0084	-.0098
		(0.029)	(0.074)
energysupGDP	-64.94***		
	(12.62)		
energysupcap		-.4328*	-.8313
		(0.239)	(0.789)
TIcor	-1.018***	-.1995**	-.4415*
	(0.288)	(0.088)	(0.238)
ideopotr	.6124***		
	(0.171)		
ideobjor		-.2662	-.2676
		(0.198)	(0.681)
EUdum	-1.902**	-1.004***	-1.877**
	(0.799)	(0.285)	(0.761)
constant		6.835***	
		(1.439)	
country dummies	yes	yes	yes
year dummies	yes	yes	yes
R^2		.7922	
$Pseudo - R^2$	.6456		.5850
N	470	438	438

Note: Columns (1) and (3) show estimation results of ordered logit regressions, column (2) those of a standard linear OLS estimation. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level.

These are then used to estimate both the coefficients $\boldsymbol{\beta}$ and the threshold values κ_j by the maximum likelihood method (Wooldridge, 2002, ch. 15.10.1; Cameron and Trivedi, 2005, ch. 15.9.1).

The estimates of the ordered logit regression are reported in the first column of Table 4.2. However, positive [negative] coefficients solely illustrate that the probability of the dependent variable to take on a value of 6 increases [decreases] and its likelihood to be 0 decreases [increases]; conclusions about the three intermediate scores or effect sizes, on the contrary, cannot be drawn (Wooldridge, 2002, ch. 15.10.1). We can thus only state

that the negative relationship between corporate income tax rate and unbundling level suggested earlier by the OLS results is further corroborated by the ordered logit findings for complete integration and full separation: the positive coefficient is statistically significant at the 5% level.

Likewise, also the liberalization-enhancing effects of energy-intensive production processes, low levels of corruption and right-wing governments suggested by the most comprehensive basic OLS regression (see column (7) of Table 4.1) are substantiated with respect to the lowest and the highest intensity of unbundling: the coefficients on both the energy intensity proxy and the corruption measure are negative, the estimate on the ideology index is positive, and all three coefficients are statistically highly significant.

Unlike the OLS estimation, the ordered logit regression furthermore indicates a higher [lower] probability for the electricity industry to be entirely unbundled [integrated] in EU member states: the coefficient on the EU dummy is negative and reaches statistical significance at the 5% level. Moreover, the ordered logit results suggest the power sector to be more often fully separated [integrated] when tax revenues are low [high] and government debt is high [low] (with the positive estimate on tax yields and the negative one on debt being significant at the 1% and the 5% level, respectively), which is at odds with our original considerations: as we assume the base of the corporate income tax to decrease with stricter forms of unbundling due to the positive tax rate coefficient, opposite signs of the estimates would have been in line with our expectations. A possible explanation might be as follows: regulatory decision makers focused on high tax yields might rather apply both total tax revenues and government debt as indicators of a country's economic performance than the GDP growth rate (which is why its coefficient is statistically insignificant); high tax yield would then indicate an upswing or a boom, while high government debt would hint at a downturn or a depression. With the energy sector rated as being essential for the economic development of a country (Schneider and Jäger, 2003; Domanico, 2007; Karan and Kazdağli, 2011), signs of an economic crisis (i.e., a high indebtedness) might then induce regulators to foster competition by unbundling to reduce power prices, while high tax revenues might prompt them to slow down reform.

To finally assess the *quantitative* relationship between corporate income tax rate and unbundling level within the framework of the ordered logit model, we follow the

Table 4.2A: Changes in Expected VI Subindicator Values

	corporate income tax rate base level ($\overline{CITrate}$)					
	10%	20%	30%	40%	50%	60%
$\Delta E(vi)$	.0171	.0169	.0165	.0158	.0150	.0140

Note: Table 4.2A reports changes in the conditional expected values of the vertical integration sub-indicator for the electricity sector induced by a one percentage point increase in the corporate income tax rate, starting from the respective base level $\overline{CITrate}$. Conditional expected values are calculated by means of the average predicted probabilities based on the ordered logit estimates reported in column (1) of Table 4.2.

procedure described in Wooldridge (2002, ch. 15.10.1): given a predefined tax rate $\overline{CITrate}$, we first estimate the average predicted probabilities for each value the vertical integration index can take. Based on these estimates, we then calculate the conditional expected value of the unbundling measure

$$E(vi|\overline{CITrate}, \boldsymbol{Z}^-) = \sum_s s \cdot P(vi = s|\overline{CITrate}, \boldsymbol{Z}^-),$$

with $\boldsymbol{Z}^-$ comprising all controls included in $\boldsymbol{Z}$ apart from the tax rate.

After the same is done for a tax rate exceeding $\overline{CITrate}$ by one percentage point, $\overline{CITrate^+}$, we compute the difference in the conditional expected values

$$\Delta E(vi) = E(vi|\overline{CITrate^+}, \boldsymbol{Z}^-) - E(vi|\overline{CITrate}, \boldsymbol{Z}^-).$$

$\Delta E(vi)$ is then comparable to the OLS coefficient on the corporate income tax rate reported in the last column of Table 4.1.

Table 4.2A reports the $\Delta E(vi)$-values for six different tax rate base levels that cover the range of rates observed in our sample (see Table 4.6). All of them confirm the liberalization-hampering effect of higher corporate income tax rates indicated by the positive ordered logit estimate, but at the same time they hint at a more modest impact than their OLS counterpart: decreasing with a higher $\overline{CITrate}$, the figures are about one half to three fifth lower than the OLS estimate, suggesting that a one percentage point increase in the tax rate raises the conditional expected value of the unbundling index by only 0.017 to 0.014 units.

4.3.2.2 Alternative Controls

The modified set of controls we employ to further check the robustness of our results is composed as follows: we replace the lagged total tax revenue as well as the lagged total government debt with the lagged tax revenue and the lagged government debt as percentages of GDP (data are obtained from OECD (2010b)). Furthermore, the lagged GDP per capita growth rate (calculated on the basis of GDP per capita data provided by World Bank (2011)) is used instead of the lagged GDP growth rate. The primary energy supply per capita, an alternative measure of energy intensity (OECD, 2010a), is substituted for the primary energy supply per GDP unit. Finally, we replace Potrafke's (2009) ideology index with Bjørnskov's (2008) measure which ranges from -1 to 1 and exhibits high values when right-wing parties dominate a parliament. It is obvious that except for the coefficient on the Bjørnskov's (2008) ideology index the expected signs of the new controls correspond to those of their predecessors. The coefficient sign of Bjørnskov's (2008) measure, on the contrary, is expected to be negative, since in comparison to Potrafke's (2009) measure the assignment of values to political orientations is carried out exactly the other way round. Transparency International's CPI as well as the EU dummy are incorporated unchanged in the estimations.

Column (2) of Table 4.2 reports the results from the OLS regression that includes all (modified) controls. Our main initial finding is again confirmed: as in Table 4.1, the coefficient of the corporate income tax rate is both positive and statistically highly significant and therefore indicative of a negative relationship between the level of corporate taxation and the degree of unbundling. Its size is furthermore almost identical to that of its counterpart in the most comprehensive basic regression (column (7) of Table 4.1).

The positive relationship between high government debt and low degrees of vertical separation already indicated by the basic results is also suggested when debt is measured as a proportion of the GDP. Contrary to its counterpart in the last column of Table 4.1, however, the robustness check coefficient reaches significance only at the 10% level. The size of the effect is rather minor, though: an increase in debts equal to ten percent of a country's GDP would raise the vertical integration index by less than 0.1. The coefficient on energy supply per capita is only significant at the 10% level as well. It

Table 4.2B: Changes in Expected VI Subindicator Values

	corporate income tax rate base level ($\overline{CITrate}$)					
	10%	20%	30%	40%	50%	60%
$\Delta E(vi)$	.0201	.0195	.0187	.0179	.0168	.0154

Note: Table 4.2B reports changes in the conditional expected values of the vertical integration sub-indicator for the electricity sector induced by a one percentage point increase in the corporate income tax rate, starting from the respective base level $\overline{CITrate}$. Conditional expected values are calculated by means of the average predicted probabilities based on the ordered logit estimates reported in column (3) of Table 4.2.

shows the expected negative sign and confirms the positive relationship between reform and a high energy intensity the comparable estimate in Table 4.1 already suggested. According to its size, each additional ton of oil equivalent supplied per person reduces the liberalization measure by approximately 0.4. The separation-enhancing effects of a low degree of corruption is estimated to be lower than indicated before: compared to the basic regression, the impact induced by a one-unit increase in the corruption index is lowered to about two thirds; at the same time, the significance level is reduced to 5%. Unlike the basic regression, the robustness check finally hints at higher levels of unbundling in EU member states. The coefficient of the EU dummy is statistically highly significant and suggests an EU membership to decrease the vertical integration index by one unit.

4.3.2.3 Ordered Logit Regression with Alternative Controls

The estimates of the ordered logit regression including the modified set of control variables are reported in the third column of Table 4.2. The results further substantiate the liberalization-hampering effect of heavily taxed corporate incomes, indicating the probability for full separation [integration] to decrease [increase] with higher corporate income tax rates: the coefficient on the tax rate is positive and reaches statistical significance at the 10% level. Moreover, the findings suggest a liberalization-enhancing effect of low levels of corruption and an EU membership with regard to the lowest and the highest degree of unbundling: the coefficients on both these controls are negative and statistically significant at the 10% and the 5% level, respectively.

Table 4.2B finally depicts the differences in conditional expected values calculated on the basis of the ordered logit model including the alternative controls. All $\Delta E(vi)$-values hint at lower levels of vertical separation in case of higher corporate income tax

rates. As those in Table 4.2A, also the conditional expected values reported in Table 4.2B suggest the effect of a higher tax rate on the unbundling intensity to be lower than their OLS counterpart in column (2) of Table 4.2: they range from about 0.02 to 0.015 and are hence one third to one half smaller than the OLS coefficient.

4.3.2.4 Lagged Controls

As a final robustness check, we re-estimate the regressions reported in the last column of Table 4.1 and all previous robustness checks with lagged proxies for energy intensity and corruption.

One might argue that the higher intensity of competition in electricity generation and supply that is expected to emerge in the course of increasing levels of unbundling affects the energy consumption of companies and households: because of the lower power prices prevailing in competitive markets, end-users might be less inclined to save energy. Since such a behavior would, in turn, raise the values of our energy intensity measures, an endogeneity problem would exist in all previous estimations. To ensure that we do not base our later considerations on the relationship between corporate income tax rates and vertical separation on biased results, we therefore lag the primary energy supply per GDP unit and per capita, respectively, by one period and check whether this will change the estimation results considerably.

We likewise lag the corruption index by one year to tackle another possible endogeneity problem: the public officials' susceptability to bribery might be higher, the higher the scope of regulatory interferences is (Tanzi, 1994; Mauro, 1996; Treisman, 2000). Due to the lack of competition usually prevailing in heavily regulated markets, the firms active in these markets enjoy considerable monopoly or oligopoly rents. This, in turn, might increase the bureaucrats' inclination to demand kickbacks, as they are aware of the regulated companies' willingness to pay them in order to shield their profitable environment against potential market entrants (Mauro, 1996; Ades and Di Tella, 1999).

Both theoretical and empirical findings provide some evidence for such a corruption-enhancing effect of excessive industry profits: in Ades and Di Tella's (1997a) model, the share of venal civil servants in the bureaucracy increases with increasing rents of the

bribing regulatees. And regressions reveal a higher susceptability to bribery in countries where non-competitive profits exist due to either a market dominance of few firms (Ades and Di Tella, 1999) or one of the following government interventions: a restriction of foreign competition in general (Ades and Di Tella, 1997a, 1997b, 1999; Treisman, 2000) or with respect to public procurement, a discriminatory taxation, subsidization (Ades and Di Tella, 1997b) or regulatory interferences (Treisman, 2000); Ades and Di Tella's (1999) and Treisman's (2000) findings, though, lack statistical significance in some cases.

Again, estimation results suggest a statistically significant liberalization-hampering effect of high corporate income tax rates (see Tables 4.7 and 4.7A, respectively, in the Appendix for detailed results). When the original [alternative] set of controls (with both the energy intensity and the corruption proxies lagged by one year, though) is used, the highly significant OLS coefficient on the tax rate takes a value of 0.0346 [0.0334] which is virtually identical to the comparable estimate in column (7) of Table 4.1 [column (2) of Table 4.2]. As its counterpart in column (1) [(3)] of Table 4.2, the positive ordered logit coefficient on the corporate income is significant at the 5% [10%] level; the changes in the conditional expected values of the vertical integration sub-indicator calculated on the basis of the ordered logit estimate range from 0.0166 to 0.0141 [from 0.0215 to 0.0163] (with values decreasing in the tax rate) and are hence effectively identical to the values reported in Table 4.2A [4.2B] as well.

4.4 Estimation Results: VAT on Electricity

4.4.1 Basic Results

We now examine whether the positive correlation between the taxation of power consumption and unbundling intensity indicated in Figure 4.2 can be corroborated by regression analysis. To identify the effect of electricity VAT rates on the level of vertical separation we start again with running linear OLS estimations with different combinations of control variables. We draw on all the controls already familiar from the regressions reported in Table 4.1.

Table 4.3 provides the estimation results. As with corporate income taxes, the regression output underpins the effect earlier implied by the scatterplot (Figure 4.2):

Table 4.3: OLS Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
elecVATrate	-.0962***	-.0653***	-.0632***	-.0713***	-.0639***	-.0466***	-.0439**
	(0.013)	(0.017)	(0.017)	(0.017)	(0.018)	(0.017)	(0.018)
totaltaxrev$_{t-1}$		1.8e-07	1.2e-07	-9.9e-08	3.5e-07	4.2e-07	4.4e-07
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
totalgovdebt$_{t-1}$		3.9e-07***	3.7e-07***	4.2e-07***	3.8e-07***	5.2e-07***	5.2e-07***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDPgrowth$_{t-1}$			-.0316	-.0596*	-.0356	-.0011	9.3e-04
			(0.029)	(0.031)	(0.031)	(0.037)	(0.037)
energysupGDP				-9.755***	-4.613	-15.98***	-15.68***
				(3.680)	(4.248)	(5.047)	(5.110)
TIcor					-.4614***	-.3674***	-.3624***
					(0.118)	(0.122)	(0.123)
ideopotr						.2851***	.2843***
						(0.079)	(0.079)
EUdum							-.1622
							(0.370)
constant	5.251***	4.197***	4.240***	6.677***	9.097***	10.72***	10.55***
	(0.184)	(0.284)	(0.300)	(1.045)	(1.099)	(1.369)	(1.437)
country dummies	no	yes	yes	yes	yes	yes	yes
year dummies	no	yes	yes	yes	yes	yes	yes
R^2	.0991	.8343	.8348	.8381	.8406	.8561	.8562
N	491	381	381	381	361	327	327

Note: Columns (1)-(7) show estimation results of standard linear OLS estimations. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level.

higher electricity VAT rates are suggested to induce higher degrees of vertical separation. All tax rate coefficients are negative and - with one exception in the last column where only the 5% significance level is reached - statistically highly significant. Their values range from about -0.04 to slightly below -0.07 when the bivariate model in the first column is again neglected at this point. According to the estimate provided by the most comprehensive model in column (7), a ten percentage point increase in the tax rate reduces the integration index value by around 0.45[8].

Signs and significance levels of the control variables largely correspond to those in Table 4.1: all coefficients on the lagged government debt are positive and statistically significant at the 1% level, again indicating a persistence of vertical integration especially in more highly indebted countries. However, although substantiating our findings from Section 4.3.1, the liberalization-hampering effect of budgetary deficits suggested by the results in Table 4.3 is rather surprising: based on the negative coefficient of the tax rate and the considerations outlined in the introduction and Section 4.2.2, we ex-

[8]The different effects the rates of the electricity VAT and the corporate income tax are suggested to have on liberalization do not result from the different samples that are used for the estimations. When the regressions depicted in the last column of Table 4.1 and Table 4.3, respectively, are re-run applying the largest possible identical sample, findings again hint at a negative relationship between corporate income tax rate and unbundling and a positive one between electricity VAT rate and vertical separation. See columns (1) and (2), respectively, of Table 4.8 in the Appendix for detailed regression results.

pect an increasing degree of vertical separation to enlarge the tax base of the electricity VAT. Regulators active in countries with high debts should hence promote unbundling measures to increase tax yields and thus (the chance for higher) government appropriations rather than defer them. Moreover, also our alternative explanation suggesting regulators to perceive a high government debt as an indicator of an economic downturn is at odds with the positive estimates on debt: as outlined in Section 4.3.2.1, we expect ministry and agency employees to promote competition by increasing the unbundling intensity when indebtedness is high, but again coefficients hint at the opposite. However, as in Table 4.1, the estimates suggest the size of the effect to be virtually zero, again indicating that by the amount of the national debt in the previous year does not affect the level of vertical separation in a notable way.

As in Table 4.1, the estimate on the lagged GDP growth rate reaches statistical significance (at the 10% level) only when some controls are not included in the regression yet. The only significant coefficient in column (4) again rather challenges the "crisis hypothesis" and indicates that an unusually high growth rate would be necessary to change the unbundling measure in a notable way: an increase in the growth rate by ten percentage points lowers the index value by about 0.6.

The coefficient of the lagged energy intensity is consistently negative and reaches significance at the 1% level in all but the fifth column (where it becomes statistically insignificant). The most comprehensive model specification hints at an impact of an economy's energy use that is even higher than that indicated in the last column of Table 4.1: an increase of 0.1 tonnes of oil equivalent in the amount of primary energy needed to produce 1000 dollars of GDP reduces the integration index in the following year by almost 1.6.

Unlike in Table 4.1, the corruption index is consistently statistically significant at the 1% level; the sizes of the coefficients, however, do not deviate substantially from the values their significant counterparts take in Section 4.3.1. According to the estimate in the last column of Table 4.3, a one-unit increase in the corruption index decreases the liberalization measure by slightly more than 0.35 units.

Compared to the results reported Section 4.3.1, the highly significant estimates of the ideology effect rise. They imply that a change from a right-wing to a left-wing government would lead to an integration index increase of above 1.1; this exceeds the

Table 4.4: Robustness Checks

	(1)	(2)	(3)
elecVATrate	-.1879***	-.0450**	-.1860***
	(0.057)	(0.018)	(0.063)
totaltaxrev$_{t-1}$	7.0e-06***		
	(0.000)		
taxrevGDP$_{t-1}$		.0549	.115
		(0.040)	(0.138)
totalgovdebt$_{t-1}$	-6.0e-07		
	(0.000)		
govdebtGDP$_{t-1}$		.0075	-.0188
		(0.005)	(0.023)
GDPgrowth$_{t-1}$	-.0755		
	(0.114)		
GDPcapgrowth$_{t-1}$		.0118	.0531
		(0.031)	(0.113)
energysupGDP	-72.83***		
	(16.64)		
energysupcap		.0961	-.3991
		(0.322)	(1.005)
TIcor	-1.216**	-.4995***	-1.641***
	(0.505)	(0.121)	(0.477)
ideopotr	.5997***		
	(0.226)		
ideobjor		-.7264***	-1.962**
		(0.251)	(0.939)
EUdum	-1.556	-.7836*	-1.041
	(1.272)	(0.405)	(1.077)
constant		6.019***	
		(1.935)	
country dummies	yes	yes	yes
year dummies	yes	yes	yes
R^2		.8481	
$Pseudo - R^2$	.6731		.6678
N	327	287	287

Note: Columns (1) and (3) show estimation results of ordered logit regressions, column (2) those of a standard linear OLS estimation. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level.

impact suggested by the estimation outcome depicted in Table 4.1 by more than 0.3.

Finally, the coefficients on the lagged tax revenue and EU membership are again statistically insignificant.

4.4.2 Robustness Checks

We check the robustness of the results by repeating the procedure from Section 4.3.2: First, we re-run the most comprehensive basic OLS regression using ordered logit

as estimation method. Then, we modify the controls for tax yields, debt, economic performance, energy intensity and government ideology and estimate an OLS model. Next, we run an ordered logit regression including the modified set of control variables. Finally, we re-estimate the basic OLS regression that comprises all controls as well as the three robustness checks described previously with the proxies for both energy intensity and corruption being lagged by one year.

Column (1) of Table 4.4 depicts the results of the ordered logit estimation containing the initial control variables. As in Table 4.3, a liberalization-enhancing effect of high electricity VAT rates is suggested: the coefficient on the tax rate is negative and statistically highly significant, indicating the likelihood for full unbundling [integration] to increase [decrease] with increasing tax rates. Substantiating the findings from the basic regression, the highly significant coefficients on the energy intensity proxy and the ideology index hint at higher reform efforts in countries with a high energy use and with right-wing governments. Likewise, also the estimate on the corruption measure (being significant at the 5% level) confirms the finding from Table 4.3 and indicates higher level of unbundling in less corrupt countries. Finally, the positive and statistically highly significant coefficient on tax yields suggests the probability for a fully integrated [separated] power sector to be lower in case of high public revenues, which is in line with our considerations: as the negative estimate on the tax rate makes us expect that unbundling increases the base of the electricity VAT, regulators striving for high appropriations should be prone to fully separate the networks; with tax yields being already high, we expect the incentive to do so to be lower.

Finally, we compute differences in conditional expected values as outlined in Section 4.3.2 to quantify the unbundling index reduction induced by a one percentage point increase in the VAT rate. Results for exemplary tax rate base levels relevant for our sample are depicted in Table 4.4A. They range from approximately -0.039 to -0.055 and confirm the positive relationship between the taxation of electricity consumption and vertical separation suggested by all previous findings. Besides, it becomes apparent that, unlike in the case of the corporate income tax rate, the marginal effects calculated on the basis of the ordered logit outcome partly undercut (for lower base levels) and partly exceed (for higher base levels) their OLS counterpart from the last column of Table 4.3. This also results in considerably lower deviations of reported $\Delta E(vi)$-values from the

Table 4.4A: Changes in Expected VI Subindicator Values

	electricity VAT rate base level ($\overline{elecVATrate}$)			
	5%	10%	15%	20%
$\Delta E(vi)$	-.0394	-.0442	-.0500	-.0551

Note: Table 4.4A reports changes in the conditional expected values of the vertical integration sub-indicator for the electricity sector induced by a one percentage point increase in the electricity VAT rate, starting from the respective base level $\overline{elecVATrate}$. Conditional expected values are calculated by means of the average predicted probabilities based on the ordered logit estimates reported in column (1) of Table 4.4.

OLS estimate: they reach only about 25 percent of the size of the OLS coefficient at the maximum.

The results of the OLS regression including the modified set of controls are reported in column (2) of Table 4.4 and substantiate the main finding of all previous estimations: again, the VAT rate coefficient implies a positive relationship between tax rate and degree of unbundling. Beyond that, the significance level, the sign and virtually also the size of the taxation estimate in column (1) and its counterpart in the most comprehensive regression model outlined in Table 4.3 (column (7)) coincide.

The negative and statistically highly significant corruption coefficient in column (2) corroborates the findings from the basic regression. Its size, however, implies a stronger separation-enhancing effect of low levels of bribery than the estimate in the last column of Table 4.3: a one-unit increase in Transparency International's (2012) measure is suggested to lower the vertical integration index by nearly 0.5. The impact of a government's ideology on the degree of liberalization might also be stronger than indicated by the basic OLS regression: being significant at the 1% level, the coefficient of the alternative ideology measure hints at a reduction of the integration index by nearly 1.5 whenever a left-wing government is replaced by a right-wing successor. Besides, column (2) reveals a separation-enhancing effect of an EU membership, which is not identified in Table 4.3. According to the estimate in Table 4.4 (which is, however, only significant at the 10% level), being a member states decreases the liberalization index value by more than 0.75.

The third column of Table 4.4 then shows the outcome of the ordered logit estimation containing the alternative controls. The negative and statistically highly significant tax rate coefficient corroborates the positive relationship between high electricity VAT rates and vertical separation indicated by the regression results in both Table 4.3 and columns

Table 4.4B: Changes in Expected VI Subindicator Values

	electricity VAT rate base level ($\overline{elecVATrate}$)			
	5%	10%	15%	20%
$\Delta E(vi)$	-.0378	-.0421	-.0475	-.0523

Note: Table 4.4B reports changes in the conditional expected values of the vertical integration sub-indicator for the electricity sector induced by a one percentage point increase in the electricity VAT rate, starting from the respective base level $\overline{elecVATrate}$. Conditional expected values are calculated by means of the average predicted probabilities based on the ordered logit estimates reported in column (3) of Table 4.4.

(1) and (2) of Table 4.4. Likewise, the liberalization-enhancing effect of low corruption levels and right-wing governments are further substantiated: the corresponding ordered logit estimates are negative and significant at the 1% and 5% level, respectively.

Differences in the conditional expected values of the vertical integration sub-indicator calculated on the basis of the ordered logit regression including the modified set of controls are reported in Table 4.4B. Further confirming all previous findings, the depicted $\Delta E(vi)$-values suggest the degree of unbundling to rise when the electricity VAT rate is increased by one percentage point; the effect is indicated to be higher, the higher the tax rate before the increase is. The values lie between about -0.038 and -0.05, hinting at a lower influence of taxation on vertical separation than their OLS counterpart when the VAT rate is low and a higher one when power consumption is rather heavily taxed (as it is also suggested by the results depicted in Table 4.4A); deviations from the OLS estimate reported in column (2) of Table 4.3 amount to not more than 20 percent of the OLS coefficient.

Finally, also the regressions including the lagged proxies for energy intensity and corruption suggest a liberalization-enhancing effect of high electricity VAT rates (see Tables 4.9 and 4.9A, respectively, in the Appendix for detailed results). The OLS estimation including the (otherwise) original [alternative] set of controls provides a coefficient on the tax rate of -0.0443 [-0.0480] that reaches statistical significance at the 5% level and is virtually identical to its counterpart in column (7) of Table 4.3 [column (2) of Table 4.4]. As the comparable estimate in column (1) [(3)] of Table 4.4, the ordered logit coefficient on the electricity VAT rate is negative and highly significant; the $\Delta E(vi)$-values of the vertical integration sub-indicator calculated on the basis of the ordered logit estimate range from -0.0403 to -0.0541 [from -0.0411 to -0.0566] (with values decreasing in the tax rate) and are thus almost identical to the values depicted in Table 4.4A [4.4B].

4.5 The Role of Regulators

In sum, our findings thus hint at a liberalization-enhancing effect of low corporate income tax rates and high VAT rates on electricity. As already outlined in the introduction, we conjecture that the decision-makers responsible for both organization and regulation of national electricity industries play an important role for these results. In the following, we will explain this notion step by step: initially, we will elaborate on why we assume those in charge of electricity market surveillance to strive for high state appropriations for the institution they work for; we will distinguish at this point between regulatory arrangements before (see Section 4.5.1) and after 1990 (Section 4.5.2), the year when the reform process in the power sector gathered momentum (Newbery, 2009). Subsequently, we will discuss why we furthermore expect an interest in high state budgets to exist among those responsible for regulation (Section 4.5.3). We will then draw on all these considerations to finally explain why we suspect that low corporate income tax rates (Section 4.5.4.1) and high electricity VAT rates (Section 4.5.4.2) induce both officials from ministries monitoring the electricity market and members of regulatory agencies to raise the level of unbundling.

4.5.1 The Pre-1990 Period: Regulation by Ministries

Before independent regulatory authorities were established in the course of energy sector liberalization and gradually fulfilled more and more tasks in the regulation of electricity markets, primarily ministries influenced all relevant decisions in the regulatory process (OECD/IEA, 2001). The monitoring of the power sector was hence conducted by ministry officials that most likely did not only pursue their formal objective, the supervision of the vertically integrated utilities active in all stages of the sector's value chain (generation, transmission, distribution and retail) at that time (Viscusi et al., 2005, ch. 12; Newbery, 2009). Instead, the theory of bureaucracy - originally going back to Niskanen (1968), revised by Migué and Bélanger (1974) and Niskanen (1975), and topic of various other publications (see, e.g., Downs, 1967, ch. IX; Rourke, 1984, ch. 4; Tullock et al., 2002, ch. 5) - suggests that they might likewise have aimed at maximizing their ministry's power and, above all, its budget. Theory explains the officials' interest in a high funding for their employer as follows (Niskanen, 1968, 1975;

Migué and Bélanger, 1974): with increasing financial means, a state institution gains power and reputation within the political process and its workforce gets higher salaries and additional perquisites; effects that, in turn, increase the civil servants' utility. The improvement in the officials' (non-)monetary remuneration is assumed to primarily result from an (illegitimate) siphoning off of resources that is possible for three reasons: the respective office is the only supplier of the output, i.e., the state does not have a (competing) alternative to satisfy its demand for the good or service the institution provides; the supply cannot be rewarded on a per unit basis, so that a fixed amount of funds has to be appropriated; and superordinated politicians lack the information essential to assess whether the requested funding is necessary to realize the output provided and therefore the possibility to prevent fraudulent use.

In power market regulation all these issues are prevalent: the industry is usually monitored by one single institution; surveillance activities are an intangible "output" (Dunleavy, 1985) the regulatory body's budget cannot be linked with; and specialist knowledge is inevitable to be able to meet the challenges of electricity regulation. It thus seem reasonable to assume that the regulatory actors before 1990 were, as suggested by the theory of bureaucracy, at least partly interested in high appropriations for their ministries.

This view is further supported by empirical research that provides some evidence for the interest of bureaucrats in high budget appropriations and the associated merits: various papers identify strong preferences for - often considerable - budget increases for the own institution to exist among heads of American state (Bowling et al. 2004; Ryu et al., 2007; ASAP, 2008) and Norwegian municipal (Jacobsen, 2006) agencies, higher-level officials in Finish ministries (Venetoklis and Kiander, 2006) and bureaucrats in Turkish local authorities (Bağdigen, 2003); the Norwegian senior bureaucrats were furthermore found to favor an allocation of ample funds to internal administration, which is interpreted as a potential expression of their striving for a high bureaucratic slack (Jacobsen, 2006). Studies surverying the actual budget requests of American agencies (which are, according to Ryu et al. (2007), significantly affected by the aforementioned preferences) draw a similar picture: they reveal the demands for financial means to substantially increase in most cases (Sharkansky, 1965, 1968; LeLoup and Moreland, 1978; Lauth, 1986; Thompson, 1987; Ryu et al., 2007; ASAP, 2008). And also Blais

and Dion (1990), discussing the results of several publications empirically analyzing the bureaucracy model, conclude that the reviewed findings support the theory. They base their view inter alia on Sigelman (1986), whose paper once more suggests preferences for high appropriations to prevail in governing bodies of U.S. agencies; on Krueger (1988) who finds the number of applicants for federal jobs to increase in America when the public-private sector wage ratio increases; and on Grandjean (1981), whose results (albeit not entirely without contradictions) hint at higher wages for full-time, white-collar officials in U.S. agencies with a steadily growing number of employees.

4.5.2 The After-1990 Period: Regulation by Independent Agencies

With the beginning of national reform processes in the electricity sector around 1990, (purportedly) independent regulatory authorities (IRAs) were established (Gilardi, 2008, ch. 6) to control the industry's natural monopolies persisting in transmission and distribution. Apart from their autonomy from regulatees, the authorities' independence from the state (including a *financial* autonomy) is rated as being essential for the IRAs' functioning: the distance from politics is supposed to prevent government interference in regulatory decisions (Smith, 1997). Nevertheless, we expect an interest in high government appropriations to exist also among regulators. We will substantiate this assumption by initially explaining why it is reasonable to assume that IRA members do not differ from ministry officials in their striving for high budgets for the institution they work for; then, we will discuss why this is equivalent to an interest in a high funding provided by the state.

Two possible explanation exist for why agency employees might aim for high financial resources for their employer. First, it might be possible that regulators pursue personal objectives that deviate from the authority's official task (Kay and Vickers, 1990) and are basically the same as the goals Niskanen (1968, 1975) ascribes to bureaucrats (Noll, 1989; Train, 1991, ch. I.1). The extreme complexity prevailing in regulatory environments after liberalization necessitates experts to be employed in authorities (Thatcher, 2002b). Such specialist working in state agencies, in turn, are expected to be eager for realizing (also) personal ends and to be willing to both neglect their official

mandate and to accept societal detriments just to promote their career or to benefit their institution. Their self-serving behavior is conjectured to remain undetected as neither politicians nor citizens possess the knowledge necessary to evaluate the experts' activities and since their output is furthermore often intangible (Moe, 1989); both the discretionary leeway and the (substantial) authority granted to the specialists in the course of their work are then assumed to enable them to enforce the decisions that serve their personal interests (Moe, 1990). Given this tarnished image of publicly employed experts, expecting also electricity market regulators to strive for high financial means for their agencies appears reasonable.

The second (and entirely different) possible reason for why a striving for high financial resources might exist within IRAs are agency members aiming for an effective regulation: on the one hand, the growing scientification of utility regulation requires both the aforementioned recruitement of profound expert knowledge (Thatcher, 2002b) and the incurrence of significant information costs (Agrell and Gautier, 2010) on the part of the agency; on the other hand, the companies which energy authorities have to supervise are equipped with considerable resources (Thatcher, 2002a) that can be abused to impede the regulators' work. To overcome all these problems and properly fulfil their tasks, IRAs thus need appropriate financial means (OECD/IEA, 2001; Thatcher and Stone Sweet, 2002); in particular, since the agencies' challenges to hire specialists and to counter the regulatees' financial superiority are obviously closely connected: with expertise being demanded not only by authorities but also by regulated firms (OECD/IEA, 2001), the possibility to pay higher salaries due to a higher budget increases the agencies' chances to get competent staff (Smith, 1997) by outdoing the industry. Consequently, we expect an interest in a good budgetary position of their authority also to exist among regulators when they exclusively pursue their public mission.

We finally want to explain why striving for high financial resources (and salaries) basically amounts to striving for high government appropriations for the agency. A first hint is given by OECD/IEA (2001), revealing that an important source of the budgets of independent authorities regulating OECD electricity markets is the public income from general taxation. Several studies analyzing the financial dependency of regulators from government provide further evidence.

Hanretty and Koop (2009) survey 175 regulators from 88 countries (including 31 energy regulators) and find that according to their statutes the funding of more than 60 percent of the authorities comes either fully or partially from government.

On a scale from 0 to 1 (where 1 stands for full statutory independence from government) 14 European electricity regulators reach an average financial and organisational independence of slightly more than 0.75 (Gilardi, 2008, ch. 8). This suggests that a certain budgetary dependence of the authorities on governments exists.

The survey results of Johannsen et al. (2005) are in line with these findings as well. The study shows that eight out of 15 energy regulators get all or parts of their funding from government. In addition, the government in four out of the 15 countries is in charge of the authorities' personnel policy and, inter alia, determines the level of salaries in the course of this function.

Finally, also the CEER (2005) confirms a limited financial independence of European energy IRAs: in eleven out of 27 countries surveyed the regulators are not financially autonomous since their budget forms part of the state budget. In eight of the countries the regulatees are not involved in the funding of the authority, implying that the state alone has to provide the financial means required to ensure the regulator's operations.

4.5.3 The Interest in a Large State Budget

We now explain why we expect officials employed in ministries and independent authorities responsible for electricity market regulation to be interested also in a high state budget when they favor high appropriations for their agency. The overall national budget is often described as a "pie" of which public agencies aim to get a slice as large as possible (Peters, 1978, ch. 7; Bowling et al., 2004). Since an increase in the size of the "pie" allows slices (i.e., the appropriations) for the single authorities to become larger as well (Blais and Dion, 1990; Wildavsky and Caiden, 2004, ch. 3), ministry members and regulators striving for additional resources for their institution should prefer a generous state budget, too (Downs, 1967, ch. IX; Hood et al., 1984; Bowling et al., 2004).

Empirical findings are in line with these considerations. First, results hint at a struggle for the "pie" to indeed exist between agencies: Jacobsen (2006) shows that the same authority heads that prefer additional means to be appropriated for their

own agency virtually always oppose budget increases (and, in few cases, even favor budget cuts) for Norwegian municipal agencies active in different remits. Venetoklis and Kiander (2006) reveal that the Finnish senior officials that generally strive for higher resources for departments and tasks attached to their ministry want the appropriations for other ministries to decrease in numerous cases. And the interviews conducted by Bağdigen (2003) convey the impression that Turkish bureaucrats try to outmaneuver their colleagues to secure additional funds for the local authority they are employed by.

Second, given the results of Hood et al. (1984), the assumption that public officials benefit from a larger overall "pie" seems plausible as well: their findings provide some evidence for payments and pay-related perks for officials in U.K. ministerial departments to increase on both the aggregate and the per-capita level in cases of expansions of the central government's budget.

And finally, also the expectation that public employees favoring high appropriations for their own institution want the state budget to be high, too, is supported by the data: a survey in the American State Administrators Project (ASAP, 2008) finds that almost three quarters of the officials included in the study endorse an increase in total state expenditures, while Bowling et al. (2004) show that, depending on the year of the period they analyze (1964-1998), about half to three quarters of the U.S. civil servants surveyed would prefer both their agency *and* the state budget to be higher.

4.5.4 The Effect of Tax Rates on Regulatory Decisions

4.5.4.1 Corporate Income Tax

We now illustrate why we expect ministry officials and regulators who are interested in both high government appropriations for their institutions and a high state budget to particularly foster unbundling when corporate income tax rates are low. The basic idea is as follows: the explanations in Section 4.5.3 suggest that the funding for the ministry or agency in charge of regulation is higher (or, at least, is expected to be so by the institution's employees), the larger the state budget is. Furthermore, it seems reasonable to assume that the state budget, in turn, is higher, the higher the tax yields are; with high public revenues, also state expenditures are probably higher. Regulators aiming for substantial financial means for the institution they work for should hence take their

decisions in a way that raises overall tax revenues or, if this is impossible, that reduces tax yields as little as possible. This most likely increases [prevents cuts in] the state budget, accordingly raising the probability that the ministry or the agency, respectively, receives higher [stable] government appropriations. As regulatory actors are unable to affect the tax rate, increasing [maintaining] tax revenues implies broadening [lowering] the tax base [as little as possible].

Let us compare the extreme cases of vertical connections in the electricity sector to discuss these considerations with respect to the corporate income tax rate: in case of full integration, the linkages between the natural monopoly (i.e., the grids) and generation, wholesale, and retail prevent any competition in the latter areas of the industry. This generates monopolistic market structures also in the potentially competitive stages of the value chain. With full separation, on the contrary, commercial interests of the natural monopoly in generation, wholesale and retail companies no longer exist. Hence, full competition arrives in this areas (OECD, 2001). Furthermore, microeconomic theory shows that, compared to a competitive market, industry profits are higher when demand is satisfied by a monopolist; the positive effect on profits that result from the higher price a monopolistic firm charges dominates the negative effect the associated output reduction entails (Katz and Rosen, 1998, ch. 13.2).

Fostering competition in generation, wholesale, and retail by implementing stricter forms of unbundling hence reduces the base of the corporate income tax: designed as a profit tax with payments to capital being treated as non-deductible expenses, the corporate income tax can be seen as a tax on capital costs (Myles, 1995, ch. 8.2.2). The remuneration of (equity) capital, in turn, is usually higher when profits are high, so that ministry officials or regulators requiring vertically integrated electricity utilities to separate their grids would eventually act against their own interests. Consequently, we expect an incentive to refrain from realizing unbundling measures to exist among regulatory actors and we furthermore expect it to be higher, the higher the corporate income tax rate is[9]: as soon as competition-enhancing steps of reform reduce the tax base by a certain amount, the loss in tax revenues and thus also the associated cuts in the ministry's or the authority's budget increase in the tax rate. Officials and regulators

[9]With the electricity industry being a very capital-intensive sector, we reasonably assume the corporate income tax not to distort factor input decisions and thus profit-maximizing outputs.

that are more reluctant to foster vertical separation the more they benefit from high payments to capital made in non-competitive environments might hence be a possible explanation for the negative relationship between corporate income tax rates and unbundling intensity suggested by the estimation results.

With this conceivable explanation for the regression outcome put forth, we now briefly want to discuss the problem of reverse causality. Since we apply OLS and ordered logit regressions to estimate the effect of tax rates on the degree of unbundling, we cannot rule out that our estimates are biased since the direction of effect runs opposite and taxation is affected by the level of vertical separation. However, existing literature discussing the determinants of the design of tax systems (see, e.g., Owens, 2006; James and Edwards, 2008; Brys et al., 2011; Bird and Wilkie, 2012) does not identify the regulations implemented in a country's electricity sector to be a relevant factor at all, so we expect endogeneity caused by reverse causality not to be an issue in our estimations.

4.5.4.2 VAT on Electricity

Given the previous considerations on the relationship between corporate income tax rate and the degree of vertical separation, the estimation results from Section 4.4 should finally make us expect a positive effect of higher unbundling levels on electricity VAT revenues: we assume regulators to refrain from implementing steps of reform when liberalization decreases the base of a tax and high tax rates imply that the loss in state revenue resulting from such a tax base reduction is considerable; if, conversely, high tax rates *foster* the implementation of reform measures (as the regression outcome suggests in the case of the electricity VAT), this should accordingly be induced by a raise in the tax base. In this case, the additional tax yields after reform would be higher, the higher the tax rate, and an authority interested in fiscal revenue would increasingly promote unbundling the more heavily electricity consumption is taxed.

Whether increasing the level of vertical separation indeed raises the base of the electricity VAT and thus the tax yields, though, is not clear: with a higher competition in the power market, (pre-tax) prices drop and the electricity amount the consumers purchase increases, so that the tax base is affected by two opposing effects (in addition,

also levying a VAT itself creates both price and quantity effects (Stiglitz, 2000, ch. 18)). In the following, we will therefore draw on empirical research on the price elasticity of electricity demand to analyze whether the positive relationship between VAT rates and unbundling suggested by our findings might, as conjectured, be induced by the regulators' higher incentives to benefit from a broad tax base that prevail when power consumption is taxed more heavily. Let $P(Q)$ denote the (decreasing) inverse aggregate after-tax demand for power and $t > 0$ the VAT rate, so that

$$VAT(Q) = t \cdot P(Q) \cdot Q$$

describes total electricity VAT revenues. To let an increase in the market equilibrium quantity together with the associated reduction in the equilibrium price (or, put differently, an introduction of more competition) be profitable from the regulator's point of view,

$$\frac{\partial VAT(Q)}{\partial Q} = t \cdot [P(Q) + P'(Q) \cdot Q] > 0 \tag{4.1}$$

has to hold; the additional tax receipts generated by the marginal power unit have to outweigh the loss in tax revenues that results from the price decrease for inframarginal units. Rearranging (4.1) yields

$$-\frac{P(Q)}{Q} \cdot \frac{1}{P'(Q)} > 1,$$

where the left-hand side is the price elasticity of electricity demand (Varian, 2010, ch. 15.5), multiplied by minus one. Fostering competition by implementing stricter rules on unbundling can hence only be optimal for a regulatory actor interested in high revenues from taxing power consumption when electricity demand is price elastic; in this case, the tax base increases when the equilibrium quantity is raised and also the conjectured incentive to promote reform more strongly when the tax rate is high might indeed exist.

Empirical findings suggest the power demand to be price elastic in some of the countries of our sample to estimate the effect of electricity VAT rates on unbundling (we discuss the results for long-run elasticities at this point, as reducing the degree of

vertical integration in the power sector is a lengthy process): elasticity values smaller than minus one are estimated for the Finnish (Madlener et al., 2011), the German (Narayan et al., 2007) and the Japanense (Narayan et al., 2007; Madlener et al., 2011) residental electricity demand. For several sample countries, though, empirical results indicate the exact opposite: for Austria, Denmark, Germany, Ireland, the Netherlands, Norway, South Korea (Madlener et al., 2011), Canada (Narayan et al., 2007), France, the UK (Narayan et al., 2007; Madlener, 2011), Spain (Madlener et al., 2011; Blázquez et al., 2012) and Italy (Narayan et al., 2007; Madlener et al., 2011; Dicembrino and Trovato, 2013) household electricity demand is estimated to be inelastic; furthermore, results suggest a price inelastic industrial power demand to exist in Italy (Dicembrino and Trovato, 2013) and Germany (Madlener et al., 2011; in the food and tobacco, the chemicals, the pulp and paper, the non-metallic minerals and the transport equipment subsectors of manufacturing).

The possible explanation for the positive relationship between electricity VAT rates and unbundling intensity we provide is hence at odds with most of the empirical findings on the long-run price elasticity of power demand: with an inelastic demand, the lower price power producers can charge in more competitive markets has a stronger effect on the tax base than the associated increase in electricity demand, so that, overall, the base of the electricity VAT decreases with stricter forms of unbundling. Tax revenue reductions are then higher, the higher the tax rate is, so that, following our original notion, higher VAT rates should increase the incentive for regulatory actors interested in high appropriations for their institution to *refrain from implementing* (further) steps of reform (just as in the case of the corporate income tax).

One might argue that the discrepancy between our regression results and our assumption that avaricious officials and regulators determine the liberalization speed results from inconsistent estimates. The degree of unbundling might affect the rate of the electricity VAT, implying that the coefficient on the VAT rate would be biased due to reverse causality. As already outlined in the previous section, however, a country's regulatory regime in the power sector is not found to be a factor having an influence on the design of the tax system by the relevant literature (see, e.g., Owens, 2006; James and Edwards, 2008; Brys et al., 2011; Bird and Wilkie, 2012); we therefore expect the estimates challenging our assumption not to be induced by reverse causality.

Table 4.5: OLS Regression Results

	(1)
CITrate	.0520***
	(0.011)
elecVATrate	-.0076
	(0.018)
all controls	yes
country dummies	yes
year dummies	yes
R^2	.8658
N	326

Note: Estimation results of standard linear OLS estimation; full estimation results can be found in column (3) of Table 4.8 in the Appendix. Robust standard errors in parentheses. *** denotes statistical significance at the 1% level.

Another possible explanation for the unexpected positive relationship between electricity VAT rates and unbundling intensity might be that the estimates on the VAT rate are inconsistent as they suffer from an omitted variable bias (Wooldridge, 2002, chs. 4.1 and 4.3.1). The estimation results reported in Table 4.5 might indeed create this impression (see column (3) in Table 4.8 in the Appendix for full results): while an estimation based on the same sample and with the same controls, but not including the corporate income tax rate as additional regressor provides a VAT rate estimate of -0.0437 significant at the 5% level (see column (2) of Table 4.8), the findings in Table 4.5 raise doubts whether an effect of the electricity VAT rate on vertical separation exists at all; the coefficient on the VAT rate is statistically insignificant and of negligible size (-0.0076) when the rates of both the VAT *and* the corporate income tax are included in the regression. The estimate on the corporate income tax rate, on the contrary, remains virtually unaffected by an inclusion of the electricity VAT rate as additonal regressor and drops only slightly from 0.0539 (see column (1) in Table 4.8) to 0.0520, with both estimates being statistically highly significant.

The results from the regression comprising both tax rates as explanatory variables hence indicate that officials and regulators striving for high ministry and agency budgets, respectively, might base their regulatory decisions only on how further unbundling measures affect the base of the corporate income tax; changes in the base of the electricity VAT, by contrast, are suggested not to have any influence.

4.6 Conclusion

Our paper provides a possible reason for diverging degrees of electricity market liberalization that goes beyond the scope of common explanations: based on the (substantiated) assumption of regulatory decision makers striving for the highest possible appropriations, we show that the linkage between the public budget and the regulator's funding existing in both past and present might influence a country's reform efforts in the power industry. Estimation results suggest that higher corporate income tax rates are significantly related to lower levels of vertical separation implemented in the sector. Since the increase in competition associated with higher unbundling intensities reduces the base of the corporate income tax, the loss in tax revenues is higher, the higher the tax rate is. Lower tax yields, in turn, lead to lower funding of ministries and regulatory authorities, so we conjecture ministry officials and regulators to refrain from implementing steps of reform especially when corporate income is heavily taxed: the size of the budget cut that is to be expected increases in the tax rate.

This means that, in electricity markets, a clear delineation of the regulator's budgetary or financial interests from its regulatory goals is vital to ensure the achievement of these aims. As long as the authority's budget and/or the salaries paid to its employees are indirectly affected by the sectoral tax payments that, in turn, depend on the prevailing market structure, competition-hampering regulations such as an insufficient degree of unbundling cannot be ruled out.

Empirical findings furthermore hint at a liberalization-enhancing effect of high electricity VAT rates. However, this result would only be in line with our notion that ministry officials and regulators eager for high budgets affect vertical separation when power demand is price elastic, which is a rather rare case in reality. Whether this outcome fundamentally challenges our explanation for the relationship between taxation and unbundling, or results from either reverse causality issues (which the literature on the design of tax systems indicates not to exist) or omitted variable problems (which an additional estimation indicates to exist) cannot be ascertained, though.

The partially contradictory findings rather reveal that this paper can only be seen as a first step in the analysis of how the interest of regulators in high institutional budgets might hamper or foster liberalization. Examining the potential effect of further taxes,

broadening the sample (especially the smaller one we used in the VAT rate regressions due to data restrictions) or identifying and applying appropriate instruments for the tax rates to fully exclude possible endogeneity problems could be meaningful extensions that have to be left for future research.

4.7 Appendix

Table 4.6: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Main Variables					
vi	682	4.137	2.214	0.00	6.00
CITrate	682	37.47	9.856	12.50	61.80
elecVATrate	491	12.82	7.384	0.00	25.00
Controls (Basic Regressions)					
totaltaxrev$_{t-1}$	588	1749723	1330000	771	186000000
totalgovdebt$_{t-1}$	588	434829	984176	293.3	7284065
GDPgrowth$_{t-1}$	588	2.818	2.367	-11.89	11.46
energysupGDP	588	.1890	.0623	.0900	.4500
TIcor	557	7.174	1.985	1.870	10.00
ideopotr	470	2.911	.8885	1	4
EUdum	470	.5830	.4936	0	1
Controls (Robustness Checks)					
taxrevGDP$_{t-1}$	588	35.52	8.203	14.35	52.23
govdebtGDP$_{t-1}$	588	48.38	28.66	.8210	164.3
GDPcapgrowth$_{t-1}$	588	2.200	2.340	-11.89	10.35
energysupcap	588	4.268	2.013	1.000	15.74
ideobjor	438	.2697	.3388	-.5167	1.000
energysupGDP$_{t-1}$	469	.1860	.0623	.1000	.4000
TIcor$_{t-1}$	469	7.762	1.484	2.990	10.00
energysupcap$_{t-1}$	437	4.333	1.824	1.000	11.40

Table 4.7: Robustness Checks

	(1)	(2)	(3)	(4)
CITrate	.0346***	.0571**	.0334***	.0634*
	(0.009)	(0.028)	(0.011)	(0.034)
totaltaxrev$_{t-1}$	-1.3e-08	4.4e-06***		
	(0.000)	(0.000)		
taxrevGDP$_{t-1}$			-.0037	-.0499
			(0.033)	(0.092)
totalgovdebt$_{t-1}$	3.9e-07***	-2.1e-06***		
	(0.000)	(0.000)		
govdebtGDP$_{t-1}$			.0075*	-.0071
			(0.005)	(0.019)
GDPgrowth$_{t-1}$	-.0348	-.0182		
	(0.027)	(0.087)		
GDPcapgrowth$_{t-1}$			-.0172	-.0183
			(0.028)	(0.075)
energysupGDP$_{t-1}$	-18.68***	-73.79***		
	(3.564)	(12.684)		
energysupcap$_{t-1}$			-.4398*	-1.148
			(0.250)	(0.901)
TIcor$_{t-1}$	-.1470	-.7079**	-.0933	-.0818
	(0.095)	(0.287)	(0.094)	(0.239)
ideopotr	.2425***	.6788***		
	(0.060)	(0.169)		
ideobjor			-.2876	-.3132
			(0.202)	(0.692)
EUdum	-.2405	-1.284*	-.9833***	-1.521**
	(0.271)	(0.766)	(0.280)	(0.723)
constant	8.674***		6.233***	
	(1.092)		(1.489)	
country dummies	yes	yes	yes	yes
year dummies	yes	yes	yes	yes
R^2	.8304		.7899	
$Pseudo - R^2$		.6463		.5825
N	469	469	437	437

Note: Columns (1) and (3) show estimation results of standard linear OLS estimations, columns (2) and (4) those of ordered logit regressions. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level.

Table 4.7A: Changes in Expected VI Subindicator Values

	corporate income tax rate base level ($\overline{CITrate}$)					
	10%	20%	30%	40%	50%	60%
$\Delta E(vi)$ (based on col. (2) of Tab. 8)	.0166	.0165	.0162	.0157	.0150	.0141
$\Delta E(vi)$ (based on col. (4) of Tab. 8)	.0215	.0209	.0202	.0192	.0179	.0163

Note: Table 4.7A reports changes in the conditional expected values of the vertical integration sub-indicator for the electricity sector induced by a one percentage point increase in the corporate income tax rate, starting from the respective base level $\overline{CITrate}$. Conditional expected values are calculated by means of the average predicted probabilities based on the ordered logit estimates reported in column (2) and column (4), respectively, of Table 4.7.

Table 4.8: Robustness Checks

	(1)	(2)	(3)
CITrate	.0539***		.0520***
	(0.011)		(0.011)
elecVATrate		-.0437**	-.0076
		(0.018)	(0.018)
totaltaxrev$_{t-1}$	7.7e-08	4.7e-07	1.4e-07
	(0.000)	(0.000)	(0.000)
totalgovdebt$_{t-1}$	4.8e-07***	4.9e-07***	4.8e-07***
	(0.000)	(0.000)	(0.000)
GDPgrowth$_{t-1}$	.0337	.0074	.0322
	(0.035)	(0.037)	(0.035)
energysupGDP	-16.33***	-15.71***	-16.57***
	(4.920)	(5.091)	(4.960)
TIcor	-.4342***	-.3580***	-.4280***
	(0.117)	(0.123)	(0.117)
ideopotr	.2724***	.2830***	.2711***
	(0.075)	(0.079)	(0.075)
EUdum	-.1609	-.1679	-.1316
	(0.371)	(0.370)	(0,385)
constant	8.469***	10.50***	8.617***
	(1.267)	(1.432)	(1.327)
country dummies	yes	yes	yes
year dummies	yes	yes	yes
R^2	.8658	.8563	.8658
N	326	326	326

Note: Columns (1) to (3) show estimation results of standard linear OLS estimations. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/** denotes statistical significance at the 1%/5% level.

Table 4.9: Robustness Checks

	(1)	(2)	(3)	(4)
elecVATrate	-.0443**	-.1855***	-.0480**	-.1951***
	(0.018)	(0.055)	(0.019)	(0.062)
totaltaxrev_{t-1}	4.1e-07	7.1e-06***		
	(0.000)	(0.000)		
taxrevGDP_{t-1}			.0318	.0714
			(0.042)	(0.136)
$\text{totalgovdebt}_{t-1}$	5.5e-07***	-1.1e-06		
	(0.000)	(0.000)		
govdebtGDP_{t-1}			.0062	-.0304
			(0.006)	(0.023)
GDPgrowth_{t-1}	.0065	-.0096		
	(0.036)	(0.109)		
$\text{GDPcapgrowth}_{t-1}$			.0056	.0252
			(0.032)	(0.120)
$\text{energysupGDP}_{t-1}$	-19.42***	-78.06***		
	(4.495)	(15.83)		
$\text{energysupcap}_{t-1}$			-.0293	-.9266
			(0.336)	(1.194)
TIcor_{t-1}	-.2472*	-.9343**	-.3245**	-.9940*
	(0.127)	(0.440)	(0.137)	(0.519)
ideopotr	.3134***	.6941***		
	(0.079)	(0.216)		
ideobjor			-.7372***	-2.048**
			(0.255)	(0.830)
EUdum	-.0729	-1.245	-.7433*	-.8345
	(0.371)	(1.211)	(0.419)	(1.050)
constant	10.69***		5.902***	
	(1.467)		(2.054)	
country dummies	yes	yes	yes	yes
year dummies	yes	yes	yes	yes
R^2	.8558		.8411	
$Pseudo - R^2$		.6713		.6561
N	327	327	288	288

Note: Columns (1) and (3) show estimation results of standard linear OLS estimations, columns (2) and (4) those of ordered logit regressions. Dependent variable is the vertical integration sub-indicator for the electricity sector as described in Conway and Nicoletti (2006). Robust standard errors in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level.

Table 4.9A: Changes in Expected VI Subindicator Values

	electricity VAT rate base level ($\overline{elecVATrate}$)			
	5%	10%	15%	20%
$\Delta E(vi)$ (based on col. (2) of Tab. 9)	-.0403	-.0450	-.0501	-.0541
$\Delta E(vi)$ (based on col. (4) of Tab. 9)	-.0411	-.0467	-.0522	-.0566

Note: Table 4.9A reports changes in the conditional expected values of the vertical integration sub-indicator for the electricity sector induced by a one percentage point increase in the electricity VAT rate, starting from the respective base level $\overline{elecVATrate}$. Conditional expected values are calculated by means of the average predicted probabilities based on the ordered logit estimates reported in column (2) and column (4), respectively, of Table 4.9.

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