CERGE
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# The Road to Efficient Liberalization of EU Energy Markets: Obstacles and Consequences

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Dissertation

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# Introduction

The liberalization of the energy markets in the European Union has been underway for quite some time now. At the beginning of the 1990s the first countries started to open up their electricity and natural gas markets to competition. This process was formalized on the EU level with the first electricity and gas directives in 1998. As deficiencies and the need for further market liberalization were identified, new EU legislation was introduced, in particular a second set of directives in 2003 and a third in 2009. At the time of writing, the electricity and gas markets are officially open to competition for almost all customers and in almost all member states. Yet many countries are still characterized by high concentration, low entry rates and limited competition.

In this dissertation I study issues associated with the inadequate progress of the development of competition on these markets.[1] In particular, I first theoretically investigate the liberalization process in the gas sector in a country characterized by no domestic production and limited upstream[2] competition to find that an upstream monopoly may reap some of the fruits of the liberalization of the downstream market. Second, I extend this investigation by adding storage and discover that some storage structures may hinder competition and a simple separation of storage services from the incumbent cannot be welfare-enhancing. Third, I empirically examine the effects of the ownership unbundling of the electricity transmission system operator as this is one of the most debated measures of the latest European energy liberalization legislation.

The purpose of the liberalization of the monopolistic energy markets is to increase consumer welfare, eliminate (or at least reduce) the need for market regulation, provide equal opportunities for companies and enhance economic efficiency. The European energy markets liberalization process aims at achieving this objective by preserving regulation and monopoly of only those parts of the energy sector where it is absolutely necessary. This includes those parts that clearly exhibit the features of natural

[1] See for example European Commission reports CEC (2001), CEC (2004), CEC (2005a), CEC (2005b), CEC (2007), CEC (2008), CEC (2009), EC (2007e). These references are listed in the third chapter.

[2] In this dissertation the “upstream” market is understood as the market on the production level (gas producers) whereas the “downstream” market is the market of suppliers who buy the product (gas) from the upstream level and sell it to consumers.

monopoly such as the transmission grid, whereas other parts of the energy business should be open to competition. This strategy corresponds to the basic idea of liberalization that one can continue to capture the economies of scale arising from a single grid, but can do better overall by introducing competition into generation, production and supply. Ultimately, the entire liberalization process should lead to lower prices, higher security of supply, equal opportunities for companies and markets that are more driven by economic circumstances and rationale, thus requiring less regulation.

With these objectives in mind, the legislation of the European Union gradually introduced measures to be implemented by the individual member states. These measures include the introduction of the eligibility of customers to choose their suppliers, the establishment of national regulatory agencies and, importantly, the breakup of formerly vertically integrated utilities often controlling the entire supply chain from production/generation to transmission, storage and supply.

In the three chapters of my dissertation I therefore investigate various aspects of the energy market liberalization process, focusing on the identification of obstacles on the road to efficient liberalization and an examination of the effects of market opening measures, in particular ownership unbundling.

In the first chapter, which is motivated by the slow emergence of competition after the natural gas market in the Czech Republic was liberalized, I theoretically explore the impact of upstream competition on the downstream level. I extend standard Cournot models to understand current and likely future developments, paying particular attention to the impact of market liberalization on a country characterized by a lack of domestic production and limited foreign upstream competition. I show that the upstream producer might exercise his market power to capture some of the benefits of liberalization and increase the wholesale price, which hinders the desired decline of the end-user price in the long run. This pricing change in turn makes the entry of new downstream players, who thus do not have access to competitively priced gas, more difficult in the transition period. I find that this problem might be mitigated or even completely reversed if upstream competition develops simultaneously with downstream liberalization.

In the second chapter I extend the models elaborated in the first chapter by adding natural gas storage to explore the impact of the structure of natural gas storage on the development of competition and prices after market liberalization. I show that bundled, concentrated and unregulated control over storage does not promote competition. When ownership unbundling of storage is implemented simply by transferring the facilities to a separate company, lack of further mechanisms enables the storage operator to use its market power and set high prices for the storage service leading to a loss in consumer welfare in comparison with the pre-liberalization case. On the other hand, consumers might benefit from higher welfare if access to storage service is regulated.

The third chapter addresses one of the most debated issues of the third energy liberalization package adopted by the European Union in 2009: ownership unbundling of the transmission system operator. I empirically investigate the effects of market opening and especially full ownership unbundling of the transmission system operator from the supply and generation function in all EU member states on the prices of electricity for both industrial and household customers in those countries where it has been already implemented. I find that ownership unbundling plays a significant role in the development of prices. However, the effect is not exactly in line with the expectations and intentions of the legislative package and significantly differs depending on the level of corruption in the individual countries. In particular, in countries with good institutional quality, ownership unbundling is accompanied by price stagnation or an increase whereas a decline in electricity prices due to ownership unbundling can be expected only in countries with lower institutional quality.

In sum, I uncover some of the obstacles on the road to the efficient liberalization of the energy markets in the European Union that are not evident at first sight and that are relevant for some countries characterized by particular properties. Furthermore, I show that the effects of market opening and especially of ownership unbundling might differ across countries depending on the established institutional quality. The theoretical and empirical investigations consistently show that market opening should not be implemented uniformly across all countries of the European Union and that care has to be taken to follow the right selection procedure that would best benefit each particular country.

# Chapter 1

# Understanding the Lack of Competition in Natural Gas Markets: The Impact of Limited Upstream Competition


**Abstract**

Motivated by the slow emergence of competition after the natural gas market in the Czech Republic was liberalized, I explore the impact of upstream competition on the downstream level. I extend standard Cournot models to understand current and likely future developments, paying particular attention to the impact of market liberalization on a country characterized by a lack of domestic production and limited foreign upstream competition. I show that the upstream producer might exercise his market power to capture some of the benefits of liberalization and increase the wholesale price, which hinders the desired decline of the end-user price in the long run. This pricing change in turn makes the entry of new players in the transition period more difficult. This problem might be mitigated or even completely reversed if upstream competition develops simultaneously with downstream liberalization.

**Abstrakt**

S ohledem na pomalý rozvoj konkurence na českém trhu se zemním plynem po jeho liberalizaci zkoumám dopad omezené konkurence na trhu producentů na trh domácích obchodníků. Rozšiřuji standardní Cournotovy modely konkurence a snažím se pochopit současný a možný budoucí vývoj po liberalizaci trhu v zemi, která má jen minimální vlastní produkci. Docházím k závěru, že producent může využít svoji sílu na trhu, přivlastnit si část přínosu liberalizace a zvýšit velkoobchodní ceny, což vede k nižšímu poklesu koncových cen po liberalizaci. Navíc tento nárůst velkoobchodních cen znesnadňuje vstup nových obchodníků s plynem. Tento problém lze zmírnit či kompletně odstranit, pokud současně s liberalizací domácího trhu dojde i k zvýšení konkurence na úrovni producentů.



*Keywords:* natural gas, liberalization, deregulation, successive oligopoly, monopoly, Czech Republic

*JEL classification:* D42, D43, L11, L12, L13, L51

## 1.1 Introduction

The liberalization of monopolistic markets should increase consumer welfare, eliminate (or at least reduce) the need for market regulation, provide equal opportunities for companies and enhance economic efficiency. With exactly these objectives in mind, a liberalization process is underway in the European Union in the markets for electricity and natural gas, aiming ultimately at the creation of a single liberalized internal market. However, the interim results have not been exactly what was hoped for. In many EU member states, energy prices increased after deregulation and competition emerged only slowly.

In this chapter I focus on the situation on the natural gas market in the Czech Republic, which has experienced an increase in prices and no entry of additional suppliers after the first step towards market opening in 2005 and subsequently even saw the re-introduction of regulation in 2006. Currently, when the market is liberalized and all customers are allowed to choose their supplier, the market continues to be dominated by the incumbent, although recently some competition has emerged.

In light of these developments I analyze a factor that is likely to have contributed to the slow emergence of competition in the Czech Republic – and also other countries characterized by similar features – after market opening. I focus on the fact that the Czech Republic is almost completely dependent on foreign gas imports, which come from an upstream market with a very small number of producers. I extend standard Cournot models to understand this kind of configuration and further show how this problem could be mitigated.

My models demonstrate that import dependency and limited upstream competition impede efficient market liberalization in the long run due to a change in upstream pricing after end-user price regulation is revoked. This has implications for the transition period, i.e. the period before the contracts concluded (and thus also the prices set) before liberalization by the established players expire, in which it is difficult for new traders to buy gas at competitive wholesale prices. These results stem from comparisons of the pre-liberalization steady state with long-run steady states achieved under various scenarios of the liberalized setup after all players adjust to the structural changes of the market.

The remainder of this chapter is organized as follows: In section 1.2 I describe the stylized facts that motivate my inquiry. Section 1.3 reviews the existing literature and its deficiencies. Section 1.4 explains the key models. Section 1.5 provides a discussion of the results to be gleaned from these models. Section 1.6 concludes.

## 1.2 The Czech Natural Gas Market

Until recently the Czech natural gas industry was a state-owned and regulated monopoly. This was in line with the belief that this sector exhibits features of natural monopoly and that it would not be economically sensible to have parallel pipelines built and operated by different companies. In 2002, the whole sector was privatized and the majority (the bundled transmission system, the storage system operator and importer and six out of eight distribution companies) was sold to the German company RWE.[3] In line with EU Directive 2003/55/EC and the Czech Energy Act, the incumbent was forced to implement the legal unbundling of its activities, i.e. to separate physical transmission and import, physical distribution and sale,[4] and to provide network services (transmission and distribution) to other gas companies on a non-discriminatory basis. This strategy corresponds to the basic idea of liberalization that one can continue to capture the economies of scale arising from a single network, but can do better overall by introducing competition into trading, thus eliminating the need for regulation of some activities and reducing the final price for consumers through competition.

The opening of the Czech natural gas market was a stepwise process that started in January 2005 by letting the 35 largest consumers choose their supplier while other consumers continued to purchase gas from the incumbent for regulated prices. In

[3] In this paper I will use the term "incumbent" to refer to the companies of the RWE Group.
[4] The joint importer and transmission system operator was obliged to unbundle starting January 1, 2006. The distribution companies were obliged to unbundle into distribution system operators and traders-sellers starting January 1, 2007.

January 2006 all commercial customers became "eligible".[5] Full market liberalization[6] was achieved at the beginning of 2007.

Following the first step, natural gas prices for eligible customers increased, which prompted them to file complaints with the Energy Regulatory Office, which in turn responded by re-introducing the regulation of prices offered by the incumbent to eligible customers starting January 1, 2006 for the period of one year. Since disaggregated profit data are not publicly available, it is unclear whether natural gas prices increased due to the sharp parallel increase in oil prices, to which long-term natural gas contracts are indexed – the explanation advocated by the incumbent – or whether the incumbent tried to extract extra profits. While other explanations are possible, the response of the Czech regulator – who has access to the disaggregated data – can be read as an indication that the regulator believed that the liberalization process was not working the way it was supposed to work.

Indeed, had the liberalization plans worked as intended, new traders should have readily entered the market, a non-negligible number of consumers should have switched to new suppliers (or at least new consumers should purchase gas from new traders) and the end-user price should have declined. However, none of this happened. In 2007 the largest entrant (Vemex) claimed to have imported 100 million cubic meters of natural gas since October 2006, or approximately 1% of the annual consumption in the Czech Republic and less than 1.5% of the Czech winter consumption (Lidové noviny (2010)). Interestingly, this entrant is partially owned by the Russian upstream producer Gazprom, which naturally raises the question whether it was just this strategic alliance that enabled it to enter the market. The market share of the largest natural gas supplier in the Czech Republic, which was traditionally around 80%, declined to about 64% in mid-2009, whereas the share of the largest entrant affiliated with the Russian upstream producer increased to 8.5%. 2010 saw the development of further competition whereas the incumbent claimed that its share in the large industrial customers segment dropped to close to 40%, the market share borderline used by the European Commission to

[5] An "eligible customer" is a customer who is allowed to freely choose a gas supplier.
[6] Here, the term "full market liberalization" refers to the fact that all customers became eligible, not to be mistaken for a fully functioning and competitive market.

classify a company as a dominant player. On the other hand the incumbent's share in the household segment remained high, over 80 % (Lidové noviny (2010)).

In order to thoroughly understand the situation, another fact seems important. The Czech Republic is almost completely dependent on imports of natural gas,[7] with Russia being the dominant supplier providing about 75% of the domestic consumption and Norway providing 25%. The extent to which duopolistic competition takes place between these two producers is questionable, as the decision to buy gas from Norway was a politico-strategic decision made by the Czech government before privatization, notwithstanding the fact that buying gas from Russia would have been cheaper (at that point). Importantly, long-term take-or-pay contracts with these producers, which were written before liberalization, are in place; they are scheduled to expire in 2014 (Russia) and 2017 (Norway).

## 1.3 Existing Literature

My models below are based on the standard industrial organization models of Cournot and Stackelberg competition (e.g. Tirole (1988), Shy (1995)). A relevant variant of these models was formulated by Greenhut and Ohta (1979) who use market structure consisting of an upstream and downstream level – successive oligopoly – to investigate the effects of vertical integration.

The literature on energy markets, and in particular on natural gas markets, often uses a structure based on the two-level model of Greenhut and Ohta (1979). Various authors investigate this market either using numerical models to simulate a large and complex market or focusing on a smaller part of the market and finding closed-form solutions. The first and more numerous group of authors includes Golombek and Gjelsvik (1995), Golombek et al. (1998), Boots et al. (2004), Holz and Kalashnikov (2005) and Egging and Gabriel (2005), who calibrate and numerically solve simulation models of the market with natural gas. The most relevant paper with closed form solutions is Nese and Straume (2005) (and the work of Greenhut and Ohta (1979)

[7] The Czech Republic covers approximately 1 % of its consumption by domestic production.

which, however, is not formulated specifically for the natural gas market and therefore cannot be immediately applied.).

Golombek and Gjelsvik (1995) develop a numerical model for six Western European countries investigating the effects of radical liberalization. After calibrating the model (demand elasticities, costs, etc.), in which agents compete Cournot style, and numerically solving it, the authors conclude that the biggest winners of liberalization will be the end-users whose consumer surplus will increase significantly, while profits to producers, transporters and distributors will decline. However, the authors do not consider obstacles, such as upstream market power and storage structure, and their detrimental impact on post-liberalization development.

Golombek et al. (1998) use a numerical model with Cournot competition on the production (upstream) level and regulated returns on lower levels, investigating in particular the effect of liberalization on the upstream production. The authors claim that after market liberalization and the break up of former monopolies it will be optimal for gas-producing countries to break up their producing consortia. However, no formal proof or closed form solutions are specified.

Boots et al. (2004) (and their full report Boots et al. (2003)) formulate a model of the market for natural gas that has a structure of a successive oligopoly, i.e. they assume oligopolistic competition both on the side of traders as well as producers. Drawing on the notion of double marginalization (e.g. Tirole (1988), Spengler (1950)) they assume that producers anticipate the behavior of traders and maximize producer profits given the traders' actions. In addition to being able to distinguish between countries, producers are also able to distinguish between market segments. Their empirical model (called GASTALE) is very ambitious in the sense that the authors calibrate it to capture a market including several Western European countries and use numerical non-linear programming solvers to obtain the results. That means that there are no closed form expressions presented for prices, quantities, etc. Furthermore, no comparison is made with the situation when gas supply on the domestic market is regulated.

Holz and Kalashnikov (2005) have a similar approach to Boots et al. (2004), however, they consider iso-elastic demand functions. Using their own simulation model they analyze double marginalization and perfect competition scenarios.

Egging and Gabriel (2005) realize how market power could be detrimental to the consumers and set up a model in which foreign gas producers can adjust their production levels to alter the end-user price. However, instead of using a successive oligopoly approach with traders, producers directly consider the downstream demand. Storage is explicitly modeled, however, storage operators are considered perfectly competitive and have no market power.

Moving to literature with closed-form solutions, Nese and Straume (2005) use a successive oligopoly structure with two upstream producing countries, which they believe has the highest relevance in particular for the European natural gas market, to analyze the strategic behavior of policy makers in setting taxes. Their results are interesting in that they show how a decision on one level influences the other level and the wholesale and end-user price. However, their paper, which focuses primarily on strategic trade policy, does not consider gas storage, downstream costs other than the wholesale price and a tax, or market liberalization.

The presented natural gas market studies fail to provide a clear comparison of the regulated and liberalized situations using closed form solutions that would allow for the identification of the cause of the problems. My investigation addresses these issues using a full two-tier successive oligopoly structure and makes a direct comparison of the situation before and after liberalization, allowing me to identify and analyze problems associated with market opening.

## 1.4 The Models

I abstract from the more complex structure of the natural gas industry by classifying companies engaged in trading activities (import and sale to customers) as traders and the transmission and distribution system operators as a single entity providing the physical transportation of gas to the customers. This abstraction enables me to use models of successive oligopoly (e.g. Greenhut and Ohta (1979), Nese and Straume

(2005)) that involve two levels of competition only. Approximating the relevant scenario for the Czech Republic, I assume the upstream segment consists of a single producer while the configuration of the downstream segment depends on the discussed scenario.[8]

In the first part of this chapter I focus on the impact of limited upstream competition on market liberalization while in the second part I analyze possible configurations that could help mitigate the identified problems. I start with a benchmark model of the market before liberalization. I then compare the post-liberalization scenarios with the benchmark case. The post-liberalization scenario models are not necessarily intended to capture the current situation on the market; instead, they describe a situation after liberalization has been achieved, e.g. after new traders have entered the market. The comparisons of the scenarios before and after liberalization provide hints for why it might be difficult to achieve the outcomes that liberalization was supposed to bring about.

I use Cournot competition in quantities to model the behavior of $n$ players on the downstream market. This approach is in line with much of the literature on the economics of natural gas (see e.g. Nese and Straume (2005), Boots et al. (2004), Holz and Kalashnikov (2005), Golombek and Gjelsvik (1995)) and corresponds to the physical organization of the market and the way gas supply is secured. When purchasing gas, traders not only have to contractually arrange for the commodity, but they also have to book the corresponding transmission and storage capacities, which are often limited, in order to serve the customer. Therefore, Bertrand competition in prices would not be feasible since it assumes that a trader can readily sell as much quantity as the consumers demand at the price set by the trader. The introduction of capacity constraints into Bertrand competition does solve this issue, however, it leads to the problem of how to assign capacity limits to individual traders. Furthermore, Kreps and Scheinkman (1983) analyze two-stage duopolistic competition with quantity precommitment in the first stage followed by Bertrand competition in the second stage and show that under fairly weak assumptions, which are satisfied by the linear

[8] It can be shown that in the case of an upstream duopoly the effects are similar: identical in terms of direction, but smaller in magnitude. See Mravec (2006).

downward sloping demand function used in this research, Bertrand competition leads to Cournot outcomes; hence I might as well model Cournot competition directly.

Following a well-established practice in the existing literature (e.g. Nese and Straume (2005); Boots et al. (2004); Holz and Kalashnikov (2005)), I assume that the upstream producer establishes, in a Stackelberg-like manner, his pricing strategies contingent on the downstream structure. The solution strategy is thus as follows: downstream traders compete à la Cournot using the downstream market demand function and treating the wholesale price as fixed. The resulting quantity supplied to the market is expressed as a function of the wholesale price and defines the derived demand function for the upstream level. The upstream producer optimizes his profit using this derived demand function, which gives the wholesale price that can be used in downstream expressions to obtain the quantities and prices as a function of costs, number of firms, etc.

The basic building block of the modeling used in the majority of models is a Cournot market with *n* firms. Following much of the literature in this area (e.g., Golombek and Gjelsvik (1995); Golombek et al. (1998); Egging and Gabriel (2005); Gabriel and Smeers (2005); Nese and Straume (2005); Boots et al. (2004)), the market is characterized by a linear demand function

$$Q = a - bp \,, \qquad [1]$$

where Q is the quantity demanded, *p* is the price and *a* and *b* are parameters of the demand function. Each firm chooses a profit-maximizing quantity, treating the quantities supplied by other firms as given, i.e. firm *i* maximizes

$$\pi_i = q_i * \left(p - k_i\right) = q_i * \left(\frac{a - q_i - q_{-i}}{b} - k_i\right) \qquad [2]$$

with respect to $q_i$. In this expression $q_{-i}$ denotes the quantity supplied by all other traders except for trader *i* and $k_i$ denotes the unit cost (and also marginal cost) of firm *i*. Besides being computationally convenient, constant marginal costs can be justified empirically both on the downstream and the upstream level. On the upstream level, one can argue that even if the cost function were not linear, the overall quantity consumed on the downstream market in the Czech Republic is such a minor share of the overall production of the upstream producer that the producer acts as if it were linear. On the downstream level the costs consist of the commodity price charged by the upstream producer, who charges the same price for each unit consumed, the transmission and storage cost, which is also the same for all units consumed as a result of legislative requirements and regulation, and administrative (transaction) costs.[9]

Due to the concavity of the profit functions [2] the first order conditions yield the optimal solution

$$\frac{d\Pi_i}{dq_i} = \frac{a - q_i - q_{-i}}{b} - k_i - \frac{q_i}{b} = 0 \text{ for } i = 1..n. \qquad [3]$$

The solution of this system of linear equations yields the total quantity supplied as

$$Q = \frac{n}{n+1} a - \frac{b}{n+1} \sum_i k_i \ . \qquad [4]$$

Having specified the basic building block, I now proceed with the specific models. These are presented in section 1.4.1. where I study in particular the response of the upstream producer to a change on the downstream market after liberalization.

9 I do not explicitly consider the "portfolio effect", however, I touch on this issue in the discussion of the results.

*Summary Table: Structure of the Individual Models*

| Model | No. of downstream traders | Downstream market (liberalized / regulated) | Upstream market |
|---|---|---|---|
| **R-M** | 1 | regulated | Monopoly |
| **L-M** | *N* | liberalized | Monopoly |
| **L-D** | *N* | liberalized | Oligopoly |
| **L-F** | *N* | liberalized | Competitive fringe |

* Note on the numbering of models: The letter "R" stands for "regulated" and labels a regulated model before liberalization. The letter "L" stands for "liberalized" and labels a model after liberalization. The second letter in each model name denotes the upstream structure. M stands for monopoly, D stands for duopoly and F stands for competitive fringe.

### 1.4.1 Response of the Upstream to Downstream Liberalization

The basic idea of liberalization is that, rather than having a regulated monopoly, several firms (ideally a large number) serve the market and compete away the formerly regulated margin, rendering regulation moot. As more and more companies enter the market the margin shrinks and the end-user price declines to the (constant) unit cost. Therefore the end-user price after liberalization should equal the formerly regulated price minus the formerly regulated margin.

In this section I analyze what happens if there is an upstream monopoly and how this monopoly responds to the change in the market structure. In particular, I investigate whether the logic described in the previous paragraph still operates.

The first model (model R-M) is the benchmark case prior to the liberalization of the market. The second model (model L-M) captures downstream competition after deregulation.

#### 1.4.1.1 Model R-M

- **regulated downstream monopoly**
- **upstream monopoly**

The following setup corresponds to the situation on the Czech natural gas market prior to liberalization. The economy consists of consumers characterized by [1], a single downstream supplier with a regulated end-user price and a single upstream (monopolistic) producer with an unregulated wholesale price. The downstream monopolist purchases goods from the upstream producer for an unregulated wholesale price. The downstream monopolist then sells the goods to the end-users for a regulated price $p_e$ which is equal to

$$p_e = p_w + m + c, \qquad [5]$$

where

$p_w$ is the wholesale unit price

$c$ is the unit cost (marginal cost) of the downstream supplier and

$m$ is the margin allowed by the regulator.[10]

The downstream supplier simply supplies the quantity equal to the demand at the given end-user price $p_e$, therefore no optimization is involved on the downstream level.

On the other hand on the upstream level the upstream monopolistic producer is able to set the wholesale price to maximize its profit. Therefore the producer maximizes

[10] Alternatively, instead of a constant, the margin may be defined as a function of the wholesale price. According to Peltzman (1976) a change in the wholesale price changes the total wealth to be redistributed by the regulator and the redistribution itself. When the regulator defines *m* as an increasing function of the wholesale price, the results (i.e. the magnitude of the difference between the wholesale prices in the regulated and liberalized scenario) are more pronounced. On the other hand, when *m* is a decreasing function of the wholesale price, which is a more realistic case as regulators sometimes refuse to pass on cost increases to consumers (or spread the cost increase over a longer time period), the results are less pronounced. For steeply decreasing functions *m*, for which $m(p_w) > m'(p_w)[p_w - s]$, the result does not hold. However, when the regulated margin is a steeply decreasing function of the wholesale price, the regulator shifts profits from the domestic monopoly to the upstream monopolistic producer, who is motivated by the decreasing domestic margin to increase the wholesale price, which clearly should not be the objective of the domestic regulator.

$$\max_{p_w^r} \{Q(p_e)*(p_w - s)\}, \quad [6]$$

where

$Q$ is the domestic demand function and

$s$ is the producer's unit cost (marginal cost).

Therefore the maximization problem using the demand function specification [1] is

$$\max_{p_w} \{[a - b(p_w + c + m)]*(p_w - s)\}. \quad [7]$$

Since the objective function is concave, the optimal price and quantity can be computed from the first-order condition

$$\frac{d\Pi}{dp_w} = -b(p_w - s) + a - b(p_w + c + m) = 0. \quad [8]$$

The results are summarized in the following table:

*Model R-M Summary Table*

| Variable | Expression |
|---|---|
| Wholesale price $p_w^{R-M}$ | $p_w^{R-M} = \frac{1}{2}(\frac{a}{b} + s - c - m)$ |
| End-user price $p_e^{R-M}$ | $p_e^{R-M} = \frac{1}{2}(\frac{a}{b} + s + c + m)$ |
| Total quantity sold $Q^{R-M}$ | $Q^{R-M} = \frac{1}{2}(a - b(s + c + m))$ |

#### 1.4.1.2 Model L-M

- **liberalized downstream**
- **upstream monopoly**

Model L-M describes the natural gas industry after liberalization with a single upstream producer. Therefore the economy consists of a single upstream producer, *n* downstream suppliers and domestic end-users.

On the downstream level *n* downstream suppliers compete in quantities which leads to the total quantity supplied characterized by [4]. Similarly to model R-M, the upstream monopolist considers the downstream structure and optimizes its pricing strategy taking into account the quantity demanded by the downstream suppliers at different wholesale price levels. Therefore, using the outcome of Cournot competition [4] and the fact that the unit cost consists of the wholesale unit price $p_w$ plus the traders' other unit costs $c_i$ the upstream monopoly maximizes its profit

$$\max_{p_w}\left(\left(\frac{n}{n+1}a-\frac{n}{n+1}bp_w-\frac{b}{n+1}\sum_i c_i\right)*\left(p_w-s\right)\right). \qquad [9]$$

Since the objective (profit) function is concave, first order conditions may be used to obtain the optimal solution from the perspective of the upstream monopolist:

$$\frac{d\pi}{dp_w}=\frac{n}{n+1}a-\frac{n}{n+1}bp_w-\frac{b}{n+1}\sum_i c_i-\frac{n}{n+1}b\left(p_w-s\right)=0\ , \qquad [10]$$

which after simplification gives the expressions summarized in the following table.

*Model L-M Summary Table*

| Variable | Expression |
|---|---|
| Wholesale price $p_w^{L-M}$ | $p_w^{L-M} = \frac{1}{2}\left(\frac{a}{b} - \frac{\sum_i c_i}{n} + s\right)$ |
| End-user price $p_e^{L-M}$ | $p_e^{L-M} = \frac{1}{2}\left(\frac{a}{b} * \frac{n+2}{n+1} + \frac{sn}{n+1} + \frac{\sum_{i=1}^{n} c_i}{n+1}\right)$ |
| Total quantity sold $Q^{L-M}$ | $Q^{L-M} = \frac{n(a-bs)}{2(n+1)} - \frac{b\sum_{i=1}^{n} c_i}{2(n+1)}$ |
| Price differential $\Delta p_e^{R-M,L-M}$ | $\Delta p_e^{R-M,L-M} = \frac{1}{2}\left[\frac{a}{b(n+1)} - \frac{s}{n+1} + \frac{\sum_{i=1}^{n} c_i}{n+1} - c - m\right]$ |

It is now interesting to see how the endogeneity of the wholesale price impacts the market liberalization outcome. In particular, if all traders have the same unit cost ($c$), the wholesale price is

$$p_w^{L-M} = \frac{1}{2}\left(\frac{a}{b} - c + s\right), \qquad [11]$$

which is higher, by 0.5 $m$, than the original wholesale price before liberalization. Therefore, by optimizing over the downstream structure the upstream producer is capable of capturing one-half of the price benefit brought about by a liberalized downstream regardless of the number of downstream traders. Moreover, this expression does not depend on the number of traders $n$, which means that the change in the pricing of the upstream producer does not require fully functioning liberalization with many traders. Instead, the wholesale price changes as soon as regulation is revoked and the current contracts expire.

Nevertheless, even if the wholesale price increases, consumer may still benefit from deregulation. Perfect competition yields the end-user price

$$p_e^{L-M,comp} = \frac{1}{2}\left(\frac{a}{b} + s + c\right), \qquad [12]$$

which is 0.5 *m* lower than the price under regulation, i.e. the original margin is split equally between consumers and the upstream producer.

*Comparison of models R-M and L-M*

| Variable | Model R-M | Model L-M |
|---|---|---|
| Wholesale price $p_w$ | $p_w^{R-M} = \frac{1}{2}(\frac{a}{b} + s - c - m)$ | $p_w^{L-M} = \frac{1}{2}\left(\frac{a}{b} - \frac{\sum_i c_i}{n} + s\right)$ |
| End-user price $p_e$ | $p_e^{R-M} = \frac{1}{2}(\frac{a}{b} + s + c + m)$ | $p_e^{L-M} = \frac{1}{2}\left(\frac{a}{b} * \frac{n+2}{n+1} + \frac{sn}{n+1} + \frac{\sum_{i=1}^{n} c_i}{n+1}\right)$ |
| Total quantity sold $Q$ | $Q^{R-M} = \frac{1}{2}(a - b(s + c + m))$ | $Q^{L-M} = \frac{n}{2(n+1)}\left(a - bs - b\bar{c}\right)$ |
| End-user price $p_e^{comp}$ under perfect competition | | $p_e^{L-M,comp} = \frac{1}{2}\left(\frac{a}{b} + s + c\right)$ |

The fact that the upstream monopoly changes its pricing strategy and increases the wholesale price after the liberalization of the downstream market has two serious consequences that impact both the downstream traders and consumers. Firstly, it shows that as liberalization is introduced, some of the profits formerly captured by the downstream monopoly (and passed on to the domestic owners if the incumbent is owned by domestic entities or consumers) is transferred to the upstream monopoly which is most likely not owned by any of the domestic entities (this holds in particular in the case of the Russian gas producer that supplies gas to the Czech Republic). Secondly, this change in the pricing strategy makes the entry of new downstream players on the downstream market more difficult in the transition period before the old long-term contracts that the producer has concluded with the incumbent expire. The combination of these long-term contracts and the change in the pricing strategy might result in a situation where entrants are offered wholesale prices above the prices for which the incumbent purchases gas. This unavailability of competitively priced gas may thus in turn prohibit the entry of new players and the development of competition.

### 1.4.2 Introducing Upstream Competition

The preceding result is not very favorable to the development of competition on the downstream market. Some steps ought to be considered to eliminate or at last mitigate the problem. One step that could reverse the outcome outlined above is the development of upstream competition. Therefore, in this section I analyze what happens if competition, in particular duopoly, is introduced on the upstream level simultaneously with the liberalization of the downstream market.

Let's suppose that there are two upstream producers with marginal cost equal to the average cost (linear cost function) $s_1$ and $s_2$ and $n$ traders compete on the downstream market. Treating the wholesale price as given, the result of the downstream competition is

$$Q = \frac{n}{n+1}\left(a - bp_w - b\bar{c}\right). \qquad [13]$$

This is the demand function that the upstream producers face, which can be written as

$$Q = f - gp_w, \qquad [14]$$

where

$$f = \frac{n}{n+1}\left(a - b\bar{c}\right) \text{ and } g = \frac{n}{n+1}b\,. \qquad [15]$$

The profit of each producer, who competes in quantities a la Cournot, is defined as

$$\Pi_i = Q_i * \left(p_w - s_i\right) = Q_i * \left(\frac{f - Q_i - Q_{-i}}{g} - s_i\right) \qquad i = 1{,}2\ , \qquad [16]$$

which is concave with respect to *Qi*. The first order conditions are

$$\frac{d\Pi_i}{dQ_i} = \frac{f - Q_i - Q_{-i}}{g} - s_i - \frac{Q_i}{g} = 0 \qquad i = 1,\ 2 \qquad [17]$$

This system of linear equations can be solved similarly to the downstream market giving the following results.

*Model L-D Summary and Comparison with L-M and R-M Models*

| Variable | Model L-D | Model R-M | Model L-M |
|---|---|---|---|
| Wholesale price $p_w$ | $p_w^{L-D} = \frac{1}{3}\frac{a}{b} - \frac{1}{3}\bar{c} + \frac{2}{3}\bar{s}$ | $p_w^{R-M} = \frac{1}{2}(\frac{a}{b} + s - c - m)$ | $p_w^{L-M} = \frac{1}{2}\left(\frac{a}{b} - \frac{\sum_i c_i}{n} + s\right)$ |
| End-user price $p_e$ | $p_e^{L-D} = \frac{1}{3}\frac{a}{b}\frac{n+3}{n+1} + \frac{2}{3}\frac{n}{n+1}\left(\bar{c} + \bar{s}\right)$ | $p_e^{R-M} = \frac{1}{2}(\frac{a}{b} + s + c + m)$ | $p_e^{L-M} = \frac{1}{2}\left(\frac{a}{b} * \frac{n+2}{n+1} + \frac{sn}{n+1} + \frac{\sum_{i=1}^{n} c_i}{n+1}\right)$ |
| Total quantity sold $Q$ | $Q^{L-D} = \frac{2}{3}\frac{n}{n+1}\left(a - b\bar{c} - b\bar{s}\right)$ | $Q^{R-M} = \frac{1}{2}(a - b(s + c + m))$ | $Q^{L-M} = \frac{n}{2(n+1)}\left(a - bs - b\bar{c}\right)$ |

The results of the comparison with the L-M model are not surprising. The difference in the wholesale price in the model with the upstream duopoly and the model with upstream monopoly without regulation is

$$p_w^{L-M} - p_w^{L-D} = \frac{1}{6}\left(\frac{a}{b} - \bar{c} + s_1\right) - \frac{1}{3}s_2 \,. \qquad [18]$$

It can be shown that in order for the second upstream producer to supply (i.e., to have a positive profit) this expression must be positive. Therefore, the wholesale price in the model with upstream monopoly declines in comparison with the liberalized model with upstream monopoly. Comparing the wholesale price to the situation prior to liberalization, the difference in the wholesale price in the regulated model and in the liberalized model with upstream duopoly is

$$p_w^{R-M} - p_w^{L-D} = \frac{1}{6}\left(\frac{a}{b} - \bar{c} - s_1\right) + \frac{1}{3}(s_1 - s_2) - \frac{1}{2}m \,. \qquad [19]$$

Here, the first term is positive ($\frac{a}{b}$ is the price at which the demand is zero, $\bar{c} + s_1$ is the sum of the unit cost of supply, which has to be lower than the price in order for suppliers to supply), whereas the second (difference in the unit costs of upstream producers) might be positive or negative depending on the properties of the upstream producers and the third term is negative. Thus if the following condition is satisfied

$$\frac{1}{6}\left(\frac{a}{b} - \bar{c} - s_1\right) > \frac{1}{2}m - \frac{1}{3}(s_1 - s_2), \qquad [20]$$

the wholesale price in the model with upstream duopoly L-D is lower than the wholesale price in the regulated model R-M.

Therefore, the model shows that if a second producer enters the market on the upstream level the problem with the change in the pricing strategy identified in the first pair of models is mitigated and if certain conditions ([20]) are satisfied, the wholesale price after liberalization declines.

Furthermore, assuming that the costs of both upstream suppliers are the same, [20] turns into

$$\frac{1}{3}\left(\frac{a}{b}-\bar{c}-s_1\right)>m\,, \qquad [21]$$

where $\frac{a}{b}$ is the price of gas at which the consumer with the highest valuation starts to purchase gas and $\bar{c}+s_1$ is the unit cost of supply. Thus, if this difference between the highest valuation and the unit cost is high enough relative to the price margin set by the regulator, the wholesale price should decline. It is quite likely that this condition would be satisfied should a second upstream supplier enter, since the margin is usually set by the regulator to a few percent,[11] whereas the highest valuation (e.g., of a consumer who cannot use any substitutes or who uses only a negligible quantity of gas) is surely several times higher. Moreover, defining the margin as a share of the wholesale price

$$m = t * p_w^{R-M} = t * \frac{1}{2}\left(\frac{a}{b}+s-c-m\right) \qquad [22]$$

and assuming that the costs of all traders are equal and the costs of all suppliers are equal, condition [21] may be rewritten as

$$\frac{1}{3}\left(\frac{a}{b}-\bar{c}-s_1\right)>\frac{t}{(2+t)}\left(\frac{a}{b}+s-c\right)\quad , \qquad [23]$$

where $t$ is the share of the wholesale price that makes up the margin. Condition [23] does not hold for large t (e.g., for t=1) whereas it holds for $t$ close to zero. Thus the benefits of a second upstream producer are the most pronounced in the case when the regulated margin has previously been set low.

[11] As a rough estimate, since separate accounting was not kept and published during the regulated period, I calculated the profit margin from the sale of natural gas for one of the distribution companies, SČP, a.s. See SČP (2004) for the years 2002 to 2004 (when the market was still regulated), where the profit margin ranged from 6.5% to 7.5%.

### 1.4.3 Introducing Upstream Competitive Fringe

Oligopoly (duopoly) is not the only way to introduce competition into the upstream market segment. There are several smaller Asian gas producers interested in supplying gas to Europe. However, the transmission lines to the western markets are controlled by the Russian gas company Gazprom. Consequently, these producers have only indirect access to European markets by the means of sale of gas to the Russian monopoly that then markets it in European countries. Hoping that increased upstream competition would reduce the downstream price, recent initiatives of the European Union strive to ensure direct access of these Asian producers to the European market.

In this model I attempt to capture exactly such a development, i.e. an upstream segment characterized by a dominant producer and a competitive fringe. I base the modeling on some commonly used assumptions, however, I also introduce some elements which are characteristic for the given situation. In particular, in line with Carlton and Perloff (2000) I assume that the dominant firms sets the price knowing the response of the competitive fringe and that competitive fringe companies act as price-takers. However, due to transmission capacity constraints I assume that the size of the competitive fringe is fixed (corresponds to the dominant firm granting a certain transmission capacity to each firm). Consequently, instead of equating the marginal costs to the market price, as the competitive fringe firms would do in an unconstrained world, they supply a fixed amount of gas at the market price chosen by the dominant firm. For this to be true I also have to assume that the price is set within a "reasonable range", i.e., high enough so that the competitive fringe firms would be willing to supply, an assumption that is very realistic.

Similar to the previous model, the upstream faces demand [13]. Therefore the profit function of the dominant firm is

$$\Pi = (Q - K)(p_w - s) = \left(\frac{n}{n+1}[a - b(p_w \mp c)] - K\right)(p_w - s), \qquad [24]$$

where K is the capacity allocated to the competitive fringe. Due to the concavity of the profit function the first order condition yields the profit maximizing wholesale price:

$$\frac{d\Pi}{dp_w} = \left( \frac{n}{n+1} \left[ a - b\left(2p_w - s + \bar{c}\right)\right] - K \right) = 0 \qquad [25]$$

or

$$p_w^{L-F} = \frac{1}{2}\left( \frac{a}{b} - \bar{c} + s - \frac{n+1}{nb} K \right). \qquad [26]$$

The results for this model are summarized in the following table.

*Model L-F Summary and comparison with L-M and R-M Models*

| Variable | Model L-F | Model R-M | Model L-M |
|---|---|---|---|
| Wholesale price $p_w$ | $p_w^{L-F} = \frac{1}{2}\left( \frac{a}{b} - \bar{c} + s - \frac{n+1}{nb} K \right)$ | $p_w^{R-M} = \frac{1}{2}(\frac{a}{b} + s - c - m)$ | $p_w^{L-M} = \frac{1}{2}\left( \frac{a}{b} - \frac{\sum_i c_i}{n} + s \right)$ |
| End-user price $p_e$ | $p_e^{L-F} = \frac{1}{2}\left( \frac{a}{b} \frac{n+2}{n+1} + \left(s + c\right) \frac{n}{n+1} - \frac{K}{b} \right)$ | $p_e^{R-M} = \frac{1}{2}(\frac{a}{b} + s + c + m)$ | $p_e^{L-M} = \frac{1}{2}\left( \frac{a}{b} * \frac{n+2}{n+1} + \frac{sn}{n+1} + \frac{\sum_{i=1}^{n} c_i}{n+1} \right)$ |
| Total quantity sold $Q$ | $Q^{L-F} = \frac{1}{2}\left[ \frac{n}{n+1}\left(a - b\bar{c} - bs\right) + K \right]$ | $Q^{R-M} = \frac{1}{2}(a - b(s + c + m))$ | $Q^{L-M} = \frac{n}{2(n+1)}\left(a - bs - b\bar{c}\right)$ |

The comparison of these results with the liberalized model with upstream monopoly is quite straightforward. The wholesale price in the competitive fringe model is lower by

$$p_w^{L-M} - p_w^{L-F} = K\frac{n+1}{2nb}, \qquad [27]$$

The term that multiplies the competitive fringe quantity K is positive, which means that the wholesale price is decreasing as the amount of gas supplied by the competitive fringe increases, which is in line with the expected results (wholesale price decreases). Furthermore, the effect of competitive fringe on the wholesale price is more pronounced when the downstream market is served by just a few traders (since n+1/n is decreasing in *n*).

Comparing the wholesale price in the competitive fringe model with the price in the regulated model, the difference in the prices is

$$p_w^{R-M} - p_w^{L-F} = \frac{1}{2}(K\frac{n+1}{nb} - m), \qquad [28]$$

which means that the price in the liberalized model is lower than in the regulated model if

$$K\frac{n+1}{nb} > m. \qquad [29]$$

This condition is more likely to hold if the quantity supplied by the competitive fringe is large and the quantity of traders on the downstream market is small.

Similar to the liberalized model with upstream duopoly the problem with increasing wholesale price after market liberalization is mitigated or under the condition [29] even completely eliminated.

## 1.5 Discussion of the Results

The models above point out a major problem associated with the liberalization of the Czech natural gas market. In particular, models R-M and L-M outline that in an environment with a single upstream supplier the wholesale price is not invariant to the changes in the downstream market structure. Considering the organization of the downstream market, in particular the withdrawal of end-user price regulation, the upstream monopoly is capable of capturing one-half of the originally regulated margin, i.e., the upstream monopoly increases the wholesale price offered to downstream traders (for further implications of this result see below). Interestingly, the upstream producer does so regardless of the number of downstream traders, provided that the average unit cost does not change with the number of traders. Therefore, the upstream producer adjusts the pricing strategy immediately after both regulation is withdrawn and contracts that were concluded before liberalization expire even if the downstream market is served only by the incumbent. In such a case the magnitude of the wholesale price increase is one-half of the previously regulated end-user price margin. Despite the increasing wholesale price, a sufficient number of traders is capable of pushing the price below the formerly regulated price level, thus increasing consumer surplus.[12]

Therefore, looking at the first pair of models analyzed in this paper, two main results can be drawn:

1) liberalization can achieve lower end-user prices if the number of traders is sufficiently high and

2) the upstream captures some of the benefits of liberalization by changing its pricing strategy and increasing the wholesale price.

Considering the first result, it might be very difficult to achieve a sufficiently high number of competitors even when all traders have the same conditions. One reason is the fact that larger gas traders benefit from the portfolio effect, i.e. the fact that the aggregated demand of many customers is smoother and more stable than the demand of a single customer, and coping with demand fluctuations is costly. The significance of this reason even increases in light of the second result: in comparison with the standard liberalization setup, when changes in the wholesale price are not considered (i.e. the whole formerly regulated margin is competed away by entrants), the minimum efficient

[12] The theoretical calculations in this paper do not provide a concrete indication of what a "sufficient number" is. However, due to the change in the pricing of the upstream producer this number is higher than the number of traders required in the case of an exogenous price (e.g. in the case of perfect competition on the upstream level).

number of traders is higher[13] when the upstream producer responds to the market change.

As for the second main result, it hints at why it might be difficult to reach the liberalized competitive state. It shows that the slow emergence of new traders might be partly caused by the fact that upstream producers, expecting a competitive liberalized outcome, adapt their pricing strategies to the new conditions, and thus charge a higher wholesale price to new traders. In turn the entrants cannot compete with the incumbent to whom the upstream producer(s) supply gas for a price that has been set some time before liberalization and that cannot change until the long-term supply contracts between the incumbent and the producers expire.

As a response to the increasing wholesale price after market liberalization I analyze two models that could help mitigate or even completely eliminate the problem. Both of these models, upstream duopoly and competitive fringe, eliminate the upstream monopoly and show that if these kinds of structures are established together with market opening, the increase in the wholesale price is less pronounced or under some conditions even non-existent. Naturally, it might be very difficult to change the upstream structure and schedule such change simultaneously with the downstream market liberalization. However, in fact it is not necessary to actually change the upstream structure; instead, it is sufficient to change the behavior of the upstream monopoly by making it believe that the settings have changed. In particular, if the upstream monopoly is not able to distinguish the individual downstream markets and instead of optimizing over a single market it optimizes over several markets, some of which are served also by other upstream producers, the dominant upstream producer acts as if competition were introduced on the upstream level. Furthermore, if this merging of the downstream markets is implemented at the same time as market liberalization, the problem with the increasing wholesale price might be mitigated or even completely eliminated. Therefore, as a policy recommendation, multinational

[13] It can be shown that the minimum efficient number of traders, defined as the minimum number of traders required to push the end-user price below the end-user price in the regulated pre-liberalization scenario, is in case of an endogenous wholesale price higher than in case of an exogenous wholesale price by $\Delta n = \frac{m_w^0}{m}$, where m is the formerly regulated margin of the incumbent and $m_w^0$ is the profit margin of the upstream producer before market liberalization.

companies should be encouraged to operate on several similar markets[14] that are served by different upstream producers to make their upstream producers behave in a more competitive manner.

## 1.6 Conclusion

I use successive oligopoly models to analyze the Czech natural gas market with a special focus on the impact of the response of the upstream producer to market liberalization and on the organization of storage. The comparison of the benchmark pre-liberalization model with a liberalized scenario uncovers obstacles on the path to efficient liberalization. The main result of the investigation is that, although a sufficiently high number of competitors might ultimately drive the price down below the pre-liberalization level sometime in the future, the outcome is hindered by the fact that upstream producers are capable of capturing a significant share of the formerly regulated price margin. This change in the price, coupled with the existence of long-term supply contracts concluded by the established players under the old pricing strategy, prevents new traders from reaching a competitive gas supply and thus entering the market.

However, the problem with the increasing wholesale price after market liberalization might be mitigated or even reversed if more competition is introduced to the upstream level simultaneously with market liberalization. This development of upstream competition does not necessarily have to be implemented by bringing in new upstream producers; instead, if multinational companies operate on several similar markets with various upstream suppliers the upstream producers cannot distinguish the individual markets and face a more competitive environment.

[14] The recommendation that the countries should be similar is quite important here. If two different markets with two completely different demand functions and thus also price levels merge, the resulting price will be somewhere in between the two original prices, which clearly does not benefit the country with the lower price. On the other hand, if the demand functions of two countries are identical or if the ratio of the intercept and the slope of the demand functions are the same, the optimization over the merged demand function yields the same results as the optimization over only one of the demand functions and no country is hurt by the merging of the market.

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# Chapter 2

# What Role Does Storage Play in the Liberalization of the Natural Gas Market?


**Abstract**

Focusing on the liberalization of the natural gas market in the Czech Republic, in this paper I explore the impact of the structure of natural gas storage on the development of competition and prices after market liberalization. I extend standard Cournot models to understand current and likely future developments, paying particular attention to the impact of market liberalization on a country characterized by a lack of domestic production, limited foreign upstream competition, and highly concentrated (and bundled) control over an essential input in the production of the final product: gas storage. I show that bundled and unregulated control over storage does not promote competition. When ownership unbundling of storage is implemented simply by transferring the facilities to a separate company, lack of further mechanisms enables the storage operator to use its market power and set high prices for the storage service, leading to a loss in consumer welfare in comparison with the pre-liberalization case. On the other hand, consumers might benefit from higher welfare if access to storage service is regulated.

**Abstrakt**

S důrazem na liberalizaci českého trhu se zemním plynem zkoumám, jak struktura skladování plynu může ovlivnit vývoj konkurence a ceny po liberalizaci trhu. Rozšiřuji standardní Cournotovy modely konkurence a snažím se analyzovat současný a možný budoucí vývoj po liberalizaci trhu v zemi, která má jen minimální vlastní produkci a vykazuje vysokou koncentraci v oblasti uskladňovacích služeb – klíčového vstupu při tvorbě finálního produktu. Ukazuji, že vertikálně integrované uskladňovací služby bez regulace nepřispívají k rozvoji konkurence. Jednoduchým vyčleněním uskladňovacích služeb bez zavedení dalších mechanizmů se situace nezlepší, ba naopak, může se i z pohledu spotřebitele zhoršit. Na druhé straně regulace uskladňovacích služeb může přinést kýžené snížení koncových cen po liberalizaci.



*Keywords:* natural gas, liberalization, deregulation, successive oligopoly, monopoly, Czech Republic, gas storage

*JEL classification:* D42, D43, L11, L12, L13, L51

## 2.1 Introduction

The liberalization of natural gas markets, which has been underway in the European Union for over a decade now, influences all parts of the natural gas supply chain. Natural gas storage, which is a crucial part of the natural gas supply chain, is also affected by the changes in the structure and rules of the market. In turn, the changes implemented for natural gas storage and its structure have a great influence on the functioning of the natural gas market. In this paper I analyze the impacts of various natural gas storage structures on the natural gas market, placing it into a setting with very limited upstream competition, e.g., the Czech Republic. I investigate several natural gas storage scenarios to determine the response of market players and examine which scenario is likely to benefit consumers the most. I use and further develop successive oligopoly models from the preceding chapter to find that the storage structure is crucial for the development of competition on the market and improper structure might prevent entry. Storage is thus one of the factors that contribute to the slow emergence of competition on the Czech natural gas market after its liberalization. In particular, I show that efficient market liberalization is inhibited by the concentrated ownership of the gas storage structure and a simple unbundling of ownership cannot overcome these impediments. These results stem from comparisons of the pre-liberalization steady state with long-run steady states achieved under various scenarios of the liberalized setup after all players adjust to the structural changes of the market.

## 2.2 The Czech Natural Gas Market

Until recently the Czech natural gas industry was a state-owned and regulated monopoly. In 2002, the whole sector was privatized and the majority (the bundled transmission system, storage system operator and importer and six out of eight distribution companies) was sold to the German company RWE.[15] In line with EU Directive 2003/55/EC and the Czech Energy Act, the incumbent was forced to implement the legal unbundling of its activities, i.e., to separate physical transmission

[15] In this paper I will use the term incumbent to refer to the companies of the RWE Group.

and import, physical distribution and sale,[16] and to provide network services (transmission and distribution) to other gas companies on a non-discriminatory basis. It has also implemented legal unbundling of natural gas storage, which is an essential input for the production of the final product, used to cover seasonal and day-to-day fluctuations in gas consumption. The incumbent now owns six storage facilities (out of eight in the Czech Republic) and had long-term lease contracts for much of the remaining storage used for the Czech Republic immediately after market opening. Although there are some tools that the Czech authorities could have used and might use to control the storage price and access to storage, such as penalties in case the incumbent abuses its dominant position, there is no direct regulation mechanism established. Due to this the storage structure was, especially in the years immediately following the market opening, something between regulated access and the incumbent's monopoly.

Despite the legal separation of storage and other measures to promote liberalization, which started in 2005, the emergence of new players on the market has been slow. In 2009 the incumbent lost only about 10% of its market share and even claims that some customers, who previously switched to a new supplier, are coming back to the incumbent (Hospodářské noviny 2009). 2010 saw the development of further competition. The incumbent claimed that its share in the large industrial customers segment is dropping to close to 40%; on the other hand the incumbent's share in the household segment remains high, over 80% (Lidové noviny 2010).

## 2.3 Existing Literature

Much of the literature used in this paper is identical to the literature described in the preceding chapter (the influence of the upstream monopoly). The models below are based on standard industrial organization models of Cournot and Stackelberg competition (e.g., Tirole (1988), Shy (1995)). A relevant variant of these models was formulated by Greenhut and Ohta (1979), who use a market structure consisting of an

[16] The joint importer and transmission system operator was obliged to unbundle starting January 1, 2006. The distribution companies were obliged to unbundle into distribution system operators and trader-sellers starting January 1, 2007.

upstream and downstream level – successive oligopoly – to investigate the effects of vertical integration. For a full review of the literature that is based on these models and that is relevant for the natural gas sector, please refer to the previous chapter of the dissertation.

Perhaps the most relevant model is Nese and Straume (2005), who use a successive oligopoly structure with two upstream producing countries, which they believe has the highest relevance in particular for the European natural gas market, to analyze the strategic behavior of policy makers in setting taxes. Their results are interesting in that they show how a decision on one level influences the other level and the wholesale and end-user price. However, their paper, which focuses primarily on strategic trade policy, does not consider gas storage, downstream costs other than the wholesale price and a tax or market liberalization.

Most of the existing literature does not capture the real existing situation in the storage sector (in particular in the Czech Republic) or completely misses the crucial component of natural gas supply, for which an empirically observed as well as realistically contemplated structure should be considered. Egging and Gabriel (2005) consider perfectly competitive and capacity-constrained storage. Golombek and Gjelsvik (1995) and Golombek et al. (1998) use fixed storage prices derived from the standard rate of return, which is common in the natural gas sector. Boots et al. (2004) use a similar approach. Holz and Kalashnikov (2005) and Nese and Straume (2005) do not consider storage at all. My investigation addresses the issue using a full two-tier successive oligopoly structure augmented with storage and makes a direct comparison of the situation before and after liberalization, allowing me to identify and analyze problems associated with market opening and the structure of storage.

## 2.4 The Models

The models used in this paper are based on the same building blocks as in the preceding chapter. I again use Cournot competition and successive oligopoly models to capture the natural gas market. Again, I assume the upstream segment to consist of a single producer while the configuration of the downstream segment depends on the discussed scenario.

However, I extend these models by introducing natural gas storage. The possibility to store natural gas (usually in underground storage facilities) is a very important aspect of the natural gas sector, which distinguishes it, e.g., from the electricity industry. Due to this feature it is possible to uniformly use the full capacity of transit pipelines all year round regardless of the seasonal fluctuations in the downstream demand for gas (provided that storage is close to the place of consumption).[17]

In the following section I incorporate storage into the model of the natural gas market described in the preceding chapter. For the sake of calculation, I simplify the structure as follows: Instead of considering a (possibly different) demand schedule[18] for each firm, I split the gas year into high season (winter) and low season (summer) and consider a fixed ratio of consumption in high and low seasons, denoted by $\gamma$. This abstraction is in fact not that far from reality. Although the consumption curve of each firm is necessary for correctly supplying the right amount of gas each day (and in fact each hour), from the perspective of working gas storage capacity and the determination of prices of storage capacity, all that is necessary is the amount of gas that will be injected into the storage facility in the low season and consequently extracted from the storage facility in the high season, i.e., the capacity needed to accommodate the consumer. Moreover, the assumption that the seasonal consumption ratio $\gamma$ is the same throughout the economy does not necessarily mean that all firms have the same consumption profile but rather that all traders have the same mix of customers. Using equations to capture these features, a trader supplying quantity $q_i$ to the market will deliver $q_{Hi} = \gamma q_i$ in the high season and $q_{Li} = (1-\gamma)q_i$ in the low season where $\gamma \geq 0.5$. Therefore, if the supply of gas from producers to traders is uniform over the

[17] In fact foreign gas supply through long-distance transit pipelines is usually not absolutely uniform throughout the year as producers usually offer contracts with a certain band for fluctuations (e.g., +/- 20%). However, this bandwidth is far from sufficient to cover the difference between winter and summer consumption. In the analysis below I abstract from this option since the only difference for my investigation would be lower demand for storage capacity, i.e., a lower parameter $\gamma$, which is, in the case of closed form solutions without numerical results, irrelevant.

[18] Instead of a simple demand curve $D: p \to q$, consumers are best characterized by a demand function that transforms the price of natural gas $p$ into a function that captures the demanded consumption for each day of the year.

seasons and equal to $\frac{q_i}{2}$, in the low season it is necessary to accumulate a volume of gas equal to the difference between the volume actually delivered through gas pipelines from the producer and the volume demanded in the high season, i.e.,

$$q_{Si} = \gamma q_i - \frac{q_i}{2} = q_i\left(\gamma - \frac{1}{2}\right), \qquad [1]$$

which is also the required storage capacity for the given year. Having specified the basic principles of natural gas storage and seasonal consumption, it is now possible to elaborate models of the whole economy taking into account the market structure. In all models below I use the approach reflected in the preceding chapter (i.e., endogenous wholesale price), where upstream traders react to the change in the downstream structure, which is exactly what every profit-driven firm should do.

I start with benchmark model 1 prior to liberalization and then I look at three possible market development scenarios: In model 2ab, storage is unregulated and controlled by the incumbent; in model 3as, storage is owned by a separate entity and unregulated; in model 4ar, storage is controlled by the incumbent, however, the storage price is regulated.

### 2.4.1 Model 1

- **regulated downstream monopoly also owns all storage facilities**
- **upstream monopoly**

Model 1 captures the situation on the Czech natural gas market prior to liberalization. The downstream segment consists of a single regulated monopolist who also owns all storage facilities. Denoting the unit cost (constant marginal cost) of storage capacity as $c_s$, the end-user price is

$$p_e = p_w + m + c + s_s\left(\gamma - \frac{1}{2}\right). \qquad [2]$$

Using $c+s_s\left(\gamma-\frac{1}{2}\right)$ instead of $c$ in all results of model 1 gives the results summarized in the following table.

*Model 1 Summary Table*

| Variable | Expression |
|---|---|
| Wholesale price $p_w^1$ | $p_w^1=\frac{1}{2}(\frac{a}{b}+s-c-s_s\left(\gamma-\frac{1}{2}\right)-m)$ |
| End-user price $p_e^1$ | $p_e^1=\frac{1}{2}(\frac{a}{b}+s+c+s_s\left(\gamma-\frac{1}{2}\right)+m)$ |
| Total quantity sold $Q^1$ | $Q^1=\frac{1}{2}(a-b(s+c+s_s\left(\gamma-\frac{1}{2}\right)+m))$ |

### 2.4.2 Model 2ab

- **liberalized downstream**
- **storage controlled by incumbent**
- **upstream monopoly**

In this model I assume that one of the downstream traders, the incumbent, controls the storage capacity. This model is an extreme interpretation of the situation on the Czech natural gas market, where the former regulated monopoly has controlled all of the domestic storage capacity and still controls most of it.[19] In reality, the regulatory authorities do have some tools to control storage; nevertheless, it is interesting to see what happens if storage is left unregulated.

[19] In the Czech Republic there are eight underground gas storage facilities of which six are owned by RWE Transgas, one is leased to RWE Transgas and one is used solely for the needs of the Slovak gas system.

Intuitively, such a setup enables the incumbent to keep other traders from entering the market. The following section analyzes this problem.

The profit of the incumbent (trader/storage operator denoted no. 1) is

$$\pi_1 = q_1\left(\frac{a - q_1 - q_{-1}}{b} - p_w - c\right) - q_1 s_s\left(\gamma - \frac{1}{2}\right) + q_{-1}\left(\gamma - \frac{1}{2}\right)(p_s - s_s), \qquad [3]$$

which is highest when the quantity supplied by the other traders is zero. In order to achieve this, the trader/storage operator sets the storage prices to a sufficiently high level to drive away all competing traders and behaves as a monopoly on the whole market, i.e., the operator sets the storage price so that the unit cost of each trader (which includes the artificially exaggerated storage price) is higher than the monopoly end-user price.[20]

The profit-maximizing quantity of a downstream monopolist is

$$q_1 = \frac{1}{2}\left(a - bp_w - bc - b\left(\gamma - \frac{1}{2}\right)s_s\right) = Q. \qquad [4]$$

This result can be used for the analysis of the behavior of the upstream producer. Since both the downstream trader/storage operator and the upstream producer are monopolists on their segments, the overall economy has a structure of a successive monopoly. This structure was investigated by Spengler [1950] and further developed by e.g., Tirole (1988, pp. 169–198) and is now known as double marginalization. Under this structure both monopolists successively exercise their monopolistic powers, which results in a situation that is worse for the consumers (higher prices and lower quantity supplied) than in the case of a vertically integrated monopolist.

The upstream producer optimizes his profit

[20] The condition is $\left(\gamma - \frac{1}{2}\right)p_s + p_w + c > p_e$ .

$$\Pi = Q*(p_w - s) = \frac{1}{2}\left(a - bp_w - bc - b\left(\gamma - \frac{1}{2}\right)s_s\right)*(p_w - s), \qquad [5]$$

which gives the results summarized in the following table.

*Model 2ab Summary Table*

| Variable | Expression |
|---|---|
| Wholesale price $p_w^{2ab}$ | $p_w^{2ab} = \frac{1}{2}\left(\frac{a}{b} - c - \left(\gamma - \frac{1}{2}\right)s_s + s\right)$ |
| End-user price $p_e^{2ab}$ | $p_e^{2ab} = \frac{1}{4}\left(\frac{3a}{b} + s + c + \left(\gamma - \frac{1}{2}\right)s_s\right)$ |
| Total quantity sold $Q^{2ab}$ | $Q^{2ab} = \frac{1}{4}\left(a - bs - bc - b\left(\gamma - \frac{1}{2}\right)s_s\right)$ |

The results of this model are not surprising: by controlling the storage facilities, an essential input in the supply of gas to end-users, the bundled trader and storage operator is capable of using its monopolistic power on the downstream segment to exploit the market. However, the extent to which this model currently applies to Czech natural gas is questionable – see the discussion of the results.

### 2.4.3 Model 3as

- **liberalized downstream**
- **storage owned by separate monopoly**
- **upstream monopoly**

In this model the downstream segment consists of traders who purchase natural gas from the upstream monopolistic producer and storage services (storage capacity) from a separate monopolistic storage operator. This setup does not reflect the actual situation on the Czech market since Czech storage facilities are currently controlled by the incumbent. However, it is one of the possible scenarios of further development. In fact, it is a very relevant scenario as ownership unbundling is advocated by the EU as a liberalization-promoting measure.

Since the unit storage cost (in the sense of the cost of storage per unit of gas supplied, not the cost per unit of gas stored) for downstream traders is

$$c_s = \left(\gamma - \frac{1}{2}\right) * p_s, \qquad [6]$$

where $p_s$ is the storage price charged by the storage operator, and the profit of downstream trader $i$ is

$$\pi_i = q_i \left( \frac{a - q_i - q_{-i}}{b} - p_w - c - \left(\gamma - \frac{1}{2}\right) p_s \right). \qquad [7]$$

Due to the concavity of the profit with respect to the quantity supplied, the optimal solution and the total quantity supplied can again be computed from the first-order conditions:

$$Q = \frac{n}{n+1} a - \frac{n}{n+1} b p_w - \frac{b}{n+1} \sum_i c_i - \frac{n}{n+1} b \left(\gamma - \frac{1}{2}\right) p_s. \qquad [8]$$

Thus the total storage capacity used is

$$Q_s = \left(\gamma - \frac{1}{2}\right) Q = \left(\gamma - \frac{1}{2}\right) * \left[ \frac{n}{n+1} a - \frac{n}{n+1} b p_w - \frac{b}{n+1} \sum_i c_i - \frac{n}{n+1} b \left(\gamma - \frac{1}{2}\right) p_s \right]. \qquad [9]$$

This can now be used to define the storage operator's problem as a simple profit maximization exercise where the objective profit function is

$$\pi_s = Q_s (p_s - s_s) = \left(\gamma - \frac{1}{2}\right) * \left[ \frac{n}{n+1} a - \frac{n}{n+1} b p_w - \frac{b}{n+1} \sum_i c_i - \frac{n}{n+1} b \left(\gamma - \frac{1}{2}\right) p_s \right] * (p_s - s_s),$$

[10]

where $s_s$ is the unit storage cost of the storage system operator. Due to the concavity of the objective function with respect to the storage price, first order conditions give the optimal solution:

$$\frac{d\pi_s}{dp_s} = \left(\gamma - \frac{1}{2}\right) * \left[\frac{n}{n+1}a - \frac{n}{n+1}bp_w - \frac{b}{n+1}\sum_i c_i - \frac{n}{n+1}b\left(\gamma - \frac{1}{2}\right)p_s\right] - \frac{n}{n+1}b\left(\gamma - \frac{1}{2}\right)^2 * (p_s - s_s) = 0 \cdot$$

[11]

Solving for $p_s$ gives

$$p_s = \frac{a - bp_w - \frac{b}{n}\sum_i c_i + b\left(\gamma - \frac{1}{2}\right) * s_s}{2b\left(\gamma - \frac{1}{2}\right)} \cdot \qquad [12]$$

Now let's investigate the optimal behavior of the upstream producer given the downstream structure. The upstream monopolistic producer maximizes his profit, which is defined as

$$\Pi = Q(p_w) * (p_w - s), \qquad [13]$$

which after substituting for the various components of $Q$ gives

$$\Pi = \left[\frac{n}{2(n+1)}a - \frac{n}{2(n+1)}bp_w - \frac{b}{2(n+1)}\sum_i c_i - \frac{nb}{2(n+1)}\left(\gamma - \frac{1}{2}\right) * s_s\right] * (p_w - s). \qquad [14]$$

This function is again concave so FOC can be used to obtain the results.

*Model 3as Summary Table*

| Variable | Expression |
|---|---|
| Wholesale price $p_w^{3as}$ | $p_w^{3as} = \frac{1}{2}\left(\frac{a}{b} - \bar{c} - \left(\gamma - \frac{1}{2}\right)s_s + s\right)$ |
| End-user price $p_e^{3as}$ | $p_e^{3as} = \frac{1}{4}\frac{n}{n+1}\left(\frac{3n+4}{n}\frac{a}{b} + \bar{c} + \left(\gamma - \frac{1}{2}\right)s_s + s\right)$ |
| Total quantity sold $Q^{3as}$ | $Q^{3as} = \frac{1}{4}\frac{n}{n+1}\left(a - b\bar{c} - b\left(\gamma - \frac{1}{2}\right)s_s - bs\right)$ |

It is worth noting that the storage monopoly does not influence the wholesale price. The wholesale price of model 3as is similar to the wholesale price of model L-M in the preceding chapter, now only the storage cost is added to the trader's unit cost. Consequently, it is possible to observe the same development of the wholesale price after market liberalization as in the models in the preceding chapter, i.e., half of the original margin of the regulated monopoly is captured in an unregulated environment by the upstream producer due to which the wholesale price increases.

Where the monopolist structure of the storage matters is the downstream market. Let us therefore take a look at what happens as *n* gets large (the number of downstream traders increases). The end-user price in this case converges to the perfect competition outcome (perfect competition in trading, not perfect competition in storage services):

$$p_e^{3as,comp} = \frac{1}{4}\left(3\frac{a}{b} + \bar{c} + \left(\gamma - \frac{1}{2}\right)s_s + s\right). \qquad [15]$$

In comparison with model L-M in the preceding chapter, the end-user price is now driven more by the demand function than the actual costs.[21]

[21] In model L-M, the perfect competition price is $p_e^{L-M,comp} = \frac{1}{2}\frac{a}{b} + \frac{1}{2}(\text{unit cost})$, whereas in model 3as, the perfect competition price is $p_e^{3as,comp} = \frac{3}{4}\frac{a}{b} + \frac{1}{4}(\text{unit cost})$. The first term of each equation $\frac{a}{b}$ is the limit price, i.e., the price for which the quantity demanded is zero.

Moving to a comparison with model 2ab, notice that the results of model 2ab are identical to the results of model 3as under perfect competition and are better from the perspective of the consumers than in model 3as when perfect competition is not achieved (i.e., the end-user price is smaller). This might seem surprising at first glance; however, there is a straightforward explanation. While in model 2ab there is double marginalization, i.e., two monopolies successively charge a markup on the costs, in model 3as the markup is added on three levels. By splitting the bundled trader and storage operator, another level is created. Even though the lowest trading level is not monopolistic (there are *n* traders), unless there is perfect competition these traders charge prices above the unit costs which results in "triple marginalization." Similar to vertical integration being preferred by end users over two successive monopolies (as shown, e.g., by Tirole (1988)), two successive monopolies are preferred over a configuration with three levels, of which two are monopolistic and the lowest one is oligopolistic. In other words, although not optimal, double marginalization is preferred over triple marginalization.

### 2.4.4 Model 4ar

- **liberalized downstream**
- **storage owned by the incumbent**
- **upstream monopoly**
- **regulator sets the storage price**

In this model I introduce a regulator (an analogue of the Czech Energy Regulatory Office) who has the power to set the price of storage services. This is the polar opposite of model 2ab (unregulated storage controlled by the incumbent). It reflects the fact that, although storage prices are currently not directly regulated, the Czech Energy Regulatory Office can regulate (and in fact until the beginning of 2007 did regulate) end-user prices and both the ERO and the Czech anti-monopoly office have the power to impose fines on the incumbent in cases when they discover that the incumbent has abused its dominant position.[22] Moreover, the EU directive 2003/55/EC concerning common rules for the internal market in natural gas requires negotiated or regulated access to storage, therefore storage regulation should be considered as one of the two feasible approaches.[23]

This model consists of an upstream monopoly and downstream (Cournot) competition with trader 1 being also the monopolistic storage operator with regulated prices of storage services. To solve the model I will follow the usual procedure starting with the profit optimization of downstream traders. The profit of trader 1 is

$$\pi_1 = q_1\left(\frac{a-q_1-q_{-1}}{b} - p_w - c\right) - q_1 s_s\left(\gamma - \frac{1}{2}\right) + q_{-1}\left(\gamma - \frac{1}{2}\right)(p_s - s_s), \qquad [16]$$

which is concave in the quantity supplied $q_1$. The profit of other traders is

$$\pi_i = q_i\left(\frac{a-q_i-q_{-i}}{b} - p_w - c - \left(\gamma - \frac{1}{2}\right)p_s\right) \text{ for } i = 2,..,n, \qquad [17]$$

which is also concave with respect to $q_i$. The maximum values of the profit are thus derived from the first order conditions with respect to the quantities. These form a system of $n$ linear equations that can be solved to obtain the quantities and prices. The resulting quantity supplied by trader 1 is

$$q_1 = \frac{a-bp_w}{n+1} + b\left(\gamma - \frac{1}{2}\right)\frac{(n-1)p_s}{n+1} - b\left(\gamma - \frac{1}{2}\right)\frac{ns_s}{n+1} + \frac{b}{n+1}\sum_{i\neq 1} c_i - \frac{bc_1 n}{n+1}, \qquad [18]$$

while other traders supply

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[22] On 26 May 2006, the ERO imposed a fine of CZK 14.7 million on four gas companies from the RWE group for breaching the Act on Prices (ERO press release from May 2006). The proceedings were initiated after complaints of newly eligible customers concerning increasing gas prices in 2005. The Czech Office for the Protection of Competition (OPC, often referred to as the anti-monopoly office) imposed a fine of CZK 370 million on RWE Transgas on 11 August 2006 for abusing its dominant position (although this fine was later reduced, revoked by a court ruling and later reconfirmed by another court ruling). One of the mentioned reasons for the penalty was that the price of storage services for eligible customers was too high (OPC press release August 2006).

[23] Regulated access to storage is used, e.g., in Italy, Belgium and Spain.

$$q_i = \left(a - b\left(p_w + c_i + \left(\gamma - \frac{1}{2}\right)p_s\right)\right) * \frac{n}{n+1} - \frac{1}{n+1}\sum_{j \neq i,1}\left(a - b\left(p_w + c_j + \left(\gamma - \frac{1}{2}\right)p_s\right)\right) - \frac{1}{n+1}\left(a - b\left(p_w + c_1 + \left(\gamma - \frac{1}{2}\right)s_s\right)\right)$$
. [19]

Adding up the quantities supplied by individual traders, I obtain the total quantity supplied as

$$Q = \frac{1}{n+1}\left[a - b\left(p_w + c_1 + \left(\gamma - \frac{1}{2}\right)s_s\right)\right] + \frac{1}{n+1}\sum_{i \neq 1}\left[a - b\left(p_w + c_i + \left(\gamma - \frac{1}{2}\right)p_s\right)\right]. \ [20]$$

This quantity is now used by the upstream monopolist to maximize his profit. The profit function of the upstream monopoly is

$$\Pi = Q * (p_w - s) = \frac{1}{n+1}\left(na - nbp_w - bc_1 - b\left(\gamma - \frac{1}{2}\right)s_s - b\sum_{i \neq 1} c_i - (n-1)b\left(\gamma - \frac{1}{2}\right)p_s\right)(p_w - s).$$
[21]

This function is concave in the wholesale price so the first order condition gives the maximum profit and the results are summarized in the following table.

*Model 4ar Summary Table*

| Variable | Expression |
|---|---|
| Wholesale price $p_w^{4ar}$ | $p_w^{4ar} = \frac{1}{2}\left( \frac{a}{b} - \bar{c} + s - \frac{\left(\gamma - \frac{1}{2}\right)s_s + (n-1)\left(\gamma - \frac{1}{2}\right)p_s}{n} \right)$ |
| End-user price $p_e^{4ar}$ | $p_e^{4ar} = \frac{1}{2(n+1)}\left( (n+2)\frac{a}{b} + n\bar{c} + \left(\gamma - \frac{1}{2}\right)s_s + (n-1)\left(\gamma - \frac{1}{2}\right)p_s + ns \right)$ |
| Total quantity sold $Q^{4ar}$ | $Q^{4ar} = \frac{n}{2(n+1)}\left( a - b\bar{c} - b\frac{\left(\gamma - \frac{1}{2}\right)s_s + (n-1)\left(\gamma - \frac{1}{2}\right)p_s}{n} - bs \right)$ |
| Price differential $\Delta p_e^{1,4ar}$ | $\Delta p_e^{1,4ar} = \frac{1}{2b}\left[ \frac{1}{n+1}a - \frac{1}{n+1}s - \frac{n}{n+1}c_1 - \frac{n}{n+1}b\left(\gamma - \frac{1}{2}\right)s_s + \frac{1}{n+1}b\sum_{i \neq 1} c_i + \frac{n-1}{n+1}b\left(\gamma - \frac{1}{2}\right)p_s - bm \right]$ |
| End-user price under perfect competition $p_e^{4ar,comp}$ | $p_e^{4ar,comp} = \frac{1}{2}\left( \frac{a}{b} + \bar{c} + \left(\gamma - \frac{1}{2}\right)p_s + s \right)$ |

The expression for the wholesale price is very similar to previous models, in particular models 2ab and 3as. The main difference is that the average unit cost is not constant, i.e., it depends on the number of traders. Provided that the storage price is higher than the storage cost, the average unit cost is increasing in the number of traders *n* due to which the wholesale price is decreasing in *n*. As for the comparison with the regulated case of model 1, the results are not as straightforward as in the previous models. If the storage price margin is high, it might even happen that the wholesale price will decline after liberalization. On the other hand, a high storage price margin has a detrimental effect on the end-user price as it increases the average unit cost. Examining the effect of an extra downstream trader on the end-user price

$$p_e^n - p_e^{n+1} = \frac{1}{2(n+1)(n+2)}\left[ \left( \frac{a}{b} - \left( \bar{c} + s - \left(\gamma - \frac{1}{2}\right)p_s \right) \right) - \left(\gamma - \frac{1}{2}\right)(p_s - s_s) \right], \qquad [22]$$

it might even happen that increased competition in combination with high storage prices will lead to higher end-user prices, i.e., the increase in average unit cost prevails over the benefits brought by a higher number of traders. This can be seen from equation [22] where the first part is positive (the limit price minus the total unit cost of trader $i > 1$), whereas the second part, the negative value of the storage price margin, is negative. Nevertheless, if the storage price is set “reasonably”, liberalization leads to lower end-user prices and higher wholesale prices.

It is worth noting that these results are interior solution results; if the storage price margin is too high, it might turn out to be optimal for trader 1 to supply the whole market at a price below the cost price of the other traders (i.e., if the monopoly price is below the unit cost of other traders).

*Comparison of models 1, 2ab, 3as, 4ar*

| Variable | Model 1 | Model 2ab | Model 3as | Model 4ar |
|---|---|---|---|---|
| Wholesale price $p_w$ | $\frac{1}{2}(\frac{a}{b}+s-c-s_s\left(\gamma-\frac{1}{2}\right)-m)$ | $\frac{1}{2}\left(\frac{a}{b}-c-\left(\gamma-\frac{1}{2}\right)s_s+s\right)$ | $\frac{1}{2}\left(\frac{a}{b}-\bar{c}-\left(\gamma-\frac{1}{2}\right)s_s+s\right)$ | $\frac{1}{2}\left(\frac{a}{b}-\bar{c}-\frac{\left(\gamma-\frac{1}{2}\right)\left(s_s+(n-1)p_s\right)}{n}+s\right)$ |
| End-user price $p_e$ | $\frac{1}{2}(\frac{a}{b}+s+c+s_s\left(\gamma-\frac{1}{2}\right)+m)$ | $\frac{1}{4}\left(\frac{3a}{b}+s+c+\left(\gamma-\frac{1}{2}\right)s_s\right)$ | $\frac{1}{4}\frac{n}{n+1}\left(\frac{3n+4}{n}\frac{a}{b}+\bar{c}+\left(\gamma-\frac{1}{2}\right)s_s+s\right)$ | $\frac{n}{2(n+1)}\left(\frac{2n+1}{n}\frac{a}{b}+\bar{c}+\frac{\left(\gamma-\frac{1}{2}\right)\left(s_s+(n-1)p_s\right)}{n}+s\right)$ |
| Total quantity sold $Q$ | $\frac{1}{2}(a-b(s+c+s_s\left(\gamma-\frac{1}{2}\right)+m))$ | $\frac{1}{4}\left(a-bs-bc-b\left(\gamma-\frac{1}{2}\right)s_s\right)$ | $\frac{1}{4}\frac{n}{n+1}\left(a-b\bar{c}-b\left(\gamma-\frac{1}{2}\right)s_s-bs\right)$ | $\frac{n}{2(n+1)}\left(a-b\bar{c}-\frac{b\left(\gamma-\frac{1}{2}\right)\left(s_s+(n-1)p_s\right)}{n}-bs\right)$ |
| End-user price $p_e^{comp}$ under perfect competition | | | $\frac{1}{4}\left(3\frac{a}{b}+\bar{c}+\left(\gamma-\frac{1}{2}\right)s_s+s\right)$ | $\frac{1}{2}\left(\frac{a}{b}+\bar{c}+\left(\gamma-\frac{1}{2}\right)p_s+s\right)$ |

## 2.5 Discussion of the Results

The models above point out some problems associated with the liberalization of the Czech natural gas market and the selection of the storage structure. On top of the models described in the preceding chapter, in model 1 I introduce storage as a necessary input for the supply of gas to end-users. If I were to consider storage as an input supplied competitively at an exogenous price, the results from models R-M and L-M would not change. However, the difference rests in the scarcity of this input and the control of its production facilities. While in model 1 there is no explicit storage price charged as storage facilities are owned by the monopolistic trader, two different scenarios are presented in models 2ab and 3as: in model 2ab storage is controlled by the incumbent trader and in model 3as the storage operator is a separate storage monopoly.

Model 2ab, whose storage structure is one extreme interpretation of the reality, yields the results that were expected. The bundled trader and storage operator charges excessively high storage prices to prohibit other traders from entering the market. The response of the Energy Regulatory Office to the sharp increase in end-user prices after the first step of market liberalization and to the non-emergence of competition suggests that this model is (or at least was) not completely irrelevant for the Czech Republic as it provides a rationalization of the fines imposed on the incumbent for abusing his dominant position. However, no clear straightforward conclusion can be drawn on this topic, as there are potential confounds to this explanation. In its press releases, the incumbent naturally denied the accusations of charging excessively high prices, stating that prices had risen only because of rising prices of natural gas substitutes (oils) and the price formula in contracts with foreign gas producers includes a component reflecting the market price of oil.[24]

[24] The average monthly price of Brent oil increased from USD 44.23 per barrel in January to USD 64.12 per barrel in August, i.e., by almost 50% (Source: International Energy Agency).
There are two more reasons that support the opinion that the complaints are exaggerated and which might have contributed to the difference in the increase of prices for captive and eligible customers. One reason is that the price for captive customers was regulated and is adjusted on a quarterly basis as a result of which its development lags behind market price development. ERO was thus capable of buffering the effect of rising commodity prices by spreading the price increase into several periods. The second reason why the difference between the increase in prices for captive and eligible customers seems so high (17–19% vs. 30–40%) is the fact that the commodity component of the final price is greater for large-volume

One straightforward and at first glance viable solution to the problem of bundled storage control is the full ownership unbundling of the incumbent, which is captured in model 3as. In this model there is a separate storage owner. However, since this separate storage operator is a monopoly in storage services, the final outcome is even worse than in the bundled case of model 2ab. Instead of double marginalization presented in the bundled model, the unbundled model exhibits triple marginalization, i.e., markups are successively added by domestic traders, the separate storage monopoly and the upstream producer. Only if perfect downstream competition is achieved are the results identical with the results of the bundled model 2ab. This shows that in the case of storage monopoly the unbundling of storage services, even though it ensures equity among individual traders, is from the perspective of the end-user inferior to the regulated model 1 as well as the bundled model 2ab with a single domestic monopolistic trader. This result contradicts the results of Van Koten (2006), who, in a different setting in which a (partially) vertically integrated auctioneer and bidder participate in an electricity transmission capacity auction, concludes that vertical integration or incomplete unbundling is from the perspective of welfare inferior to complete ownership unbundling. This difference in conclusions is due to the differences in the structures of the analyzed problems, in particular due to the fact that my analysis treats the storage operator as a Stackelberg leader who is able to optimize over the downstream, whereas in Van Koten’s work, the seller markets the capacity using auctions and thus his powers are relatively weaker.

As one of the two options of the second EU gas directive (55/2006/EC), I introduce the regulation of access to storage to the analyzed models. This is done in model 4ar where the extending assumption is that storage price is set by the regulator. When examining this model it turns out that the wholesale price is no longer independent of the number of downstream traders. This is due to the asymmetricity in the storage costs: while trader 1 (bundled trader and storage operator) pays only the direct storage cost, other traders pay the regulated storage price. The wholesale price can be expressed as

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customers than for households. Therefore, the same increase in the commodity price will lead to a smaller overall percentage increase in prices for households.

$$p_w^{3ar} = \frac{1}{2}\left(\frac{a}{b} - \overline{c} + s - \left(\gamma - \frac{1}{2}\right)s_s\right) - \frac{1}{2}\frac{n-1}{n}\left(\gamma - \frac{1}{2}\right)m_s, \qquad [23]$$

where $m_s$ is the regulated storage price margin. In comparison to model L-M, the second component is new. A similar expression may be obtained for the end-user price:

$$p_e^{3ar} = \frac{1}{2(n+1)}\left((n+2)\frac{a}{b} + n\overline{c} + n\left(\gamma - \frac{1}{2}\right)s_s + (n-1)\left(\gamma - \frac{1}{2}\right)m_s + ns\right). \qquad [24]$$

Notice that the wholesale price is decreasing and the end-user price is increasing in the storage price margin. This has a serious impact for the economy. If the margin is set low or even negative so as to promote competition and favor new traders over the incumbent, the wholesale price charged by the upstream producer increases, and in the case of a negative storage price margin even exceeds the wholesale price of model 2ab. On the other hand, the high regulated storage margin increases the end-user price and favors the incumbent, which is clearly not the desired effect of market liberalization. Nevertheless, if the storage margin is not too high in comparison with the formerly regulated monopoly margin, i.e., if

$$\frac{n-1}{n}\left(\gamma - \frac{1}{2}\right)m_s < m, \qquad [25]$$

the wholesale price after liberalization increases similar to the results of the preceding chapter. The violation of this inequality would mean that the regulator allows the storage operator to earn such a high margin on storage that the end-user price under perfect competition is higher than the end-user price in the case of regulated model 1, i.e.,

$$\frac{1}{2}\left(\frac{a}{b} + \overline{c} + \left(\gamma - \frac{1}{2}\right)s_s + \left(\gamma - \frac{1}{2}\right)m_s + s\right) > \frac{1}{2}\left(\frac{a}{b} + \overline{c} + \left(\gamma - \frac{1}{2}\right)s_s + m + s\right). \qquad [26]$$

This is clearly not the desired outcome of liberalization and will not be supported in the long-term.

One more important observation drawn from this model concerns the timing of the change in the pricing strategy of the upstream producer. Similar to model L-M, the upstream producer does not wait to change the pricing strategy only after new traders enter the downstream market. The upstream producer adjusts the pricing strategy immediately after both regulation is withdrawn and contracts concluded before liberalization expire, even if the downstream market is served only by the incumbent. In such a case the magnitude of the wholesale price increase is, similar to models without storage, one-half of the previously regulated end-user price margin.

Similar to the comparison of the models R-M and L-M without storage structures from the preceding chapter, the pair of regulated/liberalized models 1 and 4ar shows two results. Firstly, liberalization can achieve lower end-user prices if the number of traders is sufficiently high; secondly, the upstream captures some of the benefits of liberalization by changing its pricing strategy and increasing the wholesale price. These two results and the feasibility of creating a competitive market are already discussed in the preceding chapter.

## 2.6 Conclusion

I have used successive oligopoly models to analyze the Czech natural gas market with a special focus on the impact of the organization of storage. The comparisons of the benchmark pre-liberalization models with the liberalized scenarios with storage yield results similar to the results derived from models without storage. Namely, although a sufficiently high number of competitors might ultimately drive the price down below the pre-liberalization level sometime in the future, the outcome is hindered by the fact that upstream producers are capable of capturing a significant share of the formerly regulated price margin.

As for the storage structure, from the perspective of the consumer, regulated storage outperforms both a bundled and even more significantly an unbundled storage monopoly. In light of these results, the ownership unbundling of storage to a single company, which is left unconstrained to set the quantity (or price) of storage services provided on the market, should definitely be rejected as the worst alternative from the perspective of consumer welfare. Although the ownership unbundling to a single separate company considered in this paper ensures non-discriminatory access for traders, if it is to yield higher welfare to consumers it has to be coupled with some kind of mechanism, perhaps auctions legislatively established by the regulator, that would prohibit the storage operator from exercising his power on the market.

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# Chapter 3

# Investigating the Effect of Ownership Unbundling on the European Electricity Market


**Abstract**

One of the most debated measures of the recently ratified third energy liberalization package is the ownership unbundling of the transmission system operator from the supply and generation function in all EU member states. In this paper I empirically investigate whether ownership unbundling has an effect on the prices of electricity for both industrial and household customers in those countries where it has been already implemented. I find that ownership unbundling does play a significant role in the development of prices. I also find that the effect of ownership unbundling differs across countries and in particular that it is related to the institutional quality of a country. In countries with good institutional quality, much of the benefit of market opening was realized without ownership unbundling and the more perfect separation of the transmission system operator is accompanied by price stagnation or increase. On the other hand a decline in electricity prices due to ownership unbundling may be expected especially in old member states with lower institutional quality.

**Abstrakt**

Jednou z nejkontroverznějších otázek nedávno přijatého třetího energetického legislativního balíčku je vlastnické oddělení provozovatele přepravní/přenosové soustavy od dodavatele a výrobce energie ve všech členských státech EU. Právě proto empiricky zkoumám, zda má vlastnické oddělení vliv na ceny elektřiny pro firemní zákazníky i domácnosti v těch zemích, ve kterých bylo zavedeno. Zjišťuji, že vliv vlastnického oddělení se v jednotlivých zemích liší v závislosti na institucionální kvalitě dané země. V zemích, které vykazují dobrou institucionální kvalitu, byly přínosy liberalizace realizovány i bez tohoto oddělení, jenž v tomto případě nevede ke snížení cen. Na druhé straně lze pokles cen při vlastnickém oddělení provozovatele soustavy očekávat zejména ve starých členských státech s nižší institucionální kvalitou.



*Keywords:* electricity, liberalization, deregulation, ownership unbundling, market opening, seemingly unrelated regressions, European Union

*JEL classification:* C33, L94

## 3.1 Introduction

In September 2007 the European Commission unveiled the third energy liberalization package, a set of legislative proposals aimed at further promoting competition on the European energy markets and progressing towards a single European internal energy market. Motivated by the malfunctioning of the European energy market as described in the European Commission sector inquiry EC (2007e), the third energy liberalization package advocated a set of more stringent measures and raised a debate concerning its true effects. One of the key issues revolved, and still revolves, around the need to more thoroughly separate energy production and supply from transmission networks, either in the form of ownership unbundling, the form of an independent system operator or an even weaker form of an independent transmission operator. In this paper I aim to shed more light on what the effect of ownership unbundling of electricity transmission system operators (TSO) is likely to be by empirically investigating the effects of such a structure in countries where this arrangement has been already implemented relative to countries where an imperfect separation of electricity transmission and electricity generation and supply persists. This investigation offers evidence based on data from all EU member states to which the legislation applies as to whether ownership unbundling in fact promotes competition or whether it is a redundant measure restricting the ownership rights of vertically integrated utilities and leads to unnecessary restructuring costs. Using a system of seemingly unrelated regressions to enhance the efficiency of the estimates, I jointly estimate price equations for industrial customers and households. I use the level of the institutional quality of a country to explain the differing effect of ownership unbundling and market opening identified across different countries or regions in previous studies.

## 3.2 The Sector Inquiry and the Third Energy Package

In 2005 the European Commission launched an investigation of the competition on energy markets in Europe in response to complaints from consumers and new entrants. The final report of this inquiry, published in January 2007, identified several key problems that prevented the emergence of new competitors, drove energy prices up and limited consumers in their choice of suppliers. Insufficient unbundling of vertically integrated utilities was one of the main reasons for the unsatisfactory market developments besides excessive concentration, lack of liquidity, little cross-border integration and lack of transparency, among others.

As a follow-up to the sector inquiry, the European Commission came up with a set of legislative proposals, called the third energy liberalization package, which amended the existing gas and electricity directives and regulations.[25] In order to ensure truly equal and non-discriminative access to networks and to foster investment into the construction of new transmission capacities where they are needed the most, the key measure of the new proposed legislation was the separation of production and supply from transmission applicable to both EU companies and non-EU entities wishing to engage in the energy business in the EU. According to the originally proposed legislative package this separation should have been implemented either in the form of ownership unbundling (strongly preferred) or in the form of legal unbundling coupled with the so-called Independent System Operator model, under which it is "possible for existing vertically integrated companies to retain network ownership, but provided that the assets are actually operated by a company or body completely independent from it" (ERPR (2007)).

The proposals triggered a heated debate not just between EU officials and representatives of the business community but also among individual member states. On the one hand, some organizations welcomed the efforts. On the other hand, concerns about the effectiveness of such measures were expressed for example by representatives from German vertically integrated companies E.ON and RWE (Euractiv (2007)).[26]

Finally, after a heated debate, all participants of the legislative process, i.e., the Council of the European Union, the European Parliament, the European Commission and the Czech presidency of the European Union, agreed to a compromise that allowed a third option, the so-called Independent Transmission Operator, which is a weaker

[25] For the original third energy package proposal see EC (2007a), EC (2007b), EC (2007c) and EC (2007d).

[26] E.ON's concern was that unbundling doesn't lead to lower prices while RWE's concern was that unbundling would discourage investment and competition.

form of the ISO model.[27] This compromise (EP&C (2009a), EP&C (2009b)) was finally ratified by the European Parliament on April 22, 2009, and officially approved by the Council on July 13, 2009. According to this new legislation the member states are obliged to implement provisions for the effective separation of transmission and generation by March 2012.

## 3.3 The Pros and Cons of Ownership Unbundling

Ownership unbundling is the most perfect form of the separation of companies. Article 8 of the proposed amendment of electricity directive 2003/54/EC (EC (2007b)) and similarly also Article 7 of the proposed amendment of the gas directive 2003/55/EC (EC (2007c)) defines the conditions that have to be satisfied in order for a structure to qualify as ownership unbundling. The basic idea is that under ownership unbundling the transmission system operator is the owner of the transmission assets and is completely separated in terms of control from other companies that operate as suppliers or producers. In particular, in the least perfect case, a company (e.g., an investment fund) could hold minority shares in both the transmission system operator and the supply or generation (production) companies. However, it is forbidden for a transmission system

[27] On June 6, 2008, the Council of the European Union, consisting of the ministers of EU member states responsible for energy or their deputies, met to further discuss this issue. Whereas all delegates supported the effective separation of supply and transmission activities, they could not reach a consensus concerning the actual form of this separation. Consequently, in addition to full ownership unbundling, the so-called "third option" (or independent transmission operator—ITO) supported by eight member states (Austria, Bulgaria, France, Germany, Greece, Luxembourg, Latvia and the Slovak Republic, see EP (2008)) was approved by the Council, which was a somewhat weaker version of the ISO model presented by the European Commission (see CEU (2008)).
The European Parliament responded to the Council's decision separately for the electricity and the gas sector. On June 18, 2008, the European Parliament took a vote on the electricity directive and chose "ownership unbundling as the only option for electricity companies" (EP (2008)). On the other hand, at their plenary session on July 9, 2008, the European Parliament permitted both ownership unbundling and ITO as the form of separation for the gas sector (EP (2008b)). These decisions of the European Parliament constituted the first reading of the co-decision procedure of the European Parliament and the Council of the European Union. However, the legislative process requires a full consensus of the European Parliament and the Council of the European Union in order for the laws to enter into force. In October 2008 the Council met again and slightly revised its position allowing three options for the separation of transmission for both the electricity and gas sector: ownership unbundling, ISO and ITO. In early 2009, representatives of the Czech presidency of the European Union, the European Parliament and the European Commission agreed to this compromise with the three options for the separation of the transmission system operator in both the electricity and gas sectors and this compromise was finally ratified by the European Parliament on April 22, 2009.

operator or its majority owner to hold any interest in a supply or generation company or for a supply or generation company or its majority holder to hold any interest in the transmission system operator. In cases when the transmission system operator is owned by the state and the state also owns generation or supply companies, the power to appoint company board members and to control the functioning of the companies should be clearly separated, e.g., by placing the companies under different ministries.

The rationale for the ownership unbundling of the transmission system operator is based on the belief that the less-perfect separation methods leave room for practices of vertically integrated utilities that inhibit competition. There are several ways how integrated or imperfectly separated companies may use their power to hinder competition.

- As evidenced by Lowe at al. (2007) on the case of an incumbent vertically integrated utility, integrated companies might try to inhibit non-discriminatory third party access.
- Van Koten (2006) and Van Koten (2007) show that imperfect unbundling (both full integration and legal unbundling) of the TSO distorts the incentives in auctions of transmission capacity where the auctioneer and one of the bidders are affiliated leading to higher transmission prices and lower welfare.
- Integrated companies might try to transfer some of the costs from the trading to the transmission division thus increasing the transmission price for all other traders. As Davies and Price (2007) note, in UK the regulator intervened in 1999 moving one-fifth of the costs of distribution companies from the distribution to the trading function.
- Transmission system operators that form a part of vertically integrated utilities might curtail investment that would otherwise be efficient if this benefits the supply or generation division of the undertaking (e.g., investment into cross border infrastructure that would otherwise bring in competition as evidenced by the case of the Italian company ENI described by Lowe at al. (2007)).

On the other hand, there are also reasons indicating that ownership unbundling may not be the ideal solution to the problems described above. Any restructuring, including the implementation of ownership unbundling, is costly and such costs could be passed on to the consumers, increasing the price of energy. Furthermore, the separation of transmission from other activities could lead to an efficiency loss due to higher transaction costs and the inability to freely share all information among the separated entities. Another aspect, rather political than economic, is whether investors could be forced to sell shares in a company. Ownership unbundling could also result in a decline in the value of the formerly integrated company and thus a loss to investors. For a more elaborate review of the benefits and drawbacks of the ownership unbundling of transmission systems see, e.g., Pollitt (2007).

## 3.4 Literature Review

The empirical literature that investigates the performance of the electricity (or energy) sector following market liberalization focuses on different aspects of the deregulation process. Some focus on a mixture of countries (Zhang et al. (2005), Steiner (2001), Hattori and Tsutsui (2005), Steiner (2004), Nagayama (2007)) , while others investigate a specific confined group such as the old EU member states (Nielsen et al (2005), Ernst and Young (2006) , Fiorio et al. (2007)) or a single country (Davies and Price (2007)).

Zhang et al. (2005) use a panel of 36 developing and transition countries in the period 1985—2003 to study the impact of competition, regulation and privatization on the performance of the electricity industry. Although they do not directly investigate the effect of ownership unbundling, they show that the key to achieving higher performance is higher competition whereas privatization and regulation play a smaller role. Thus, if ownership unbundling promotes competition, it should project into the performance of the electricity sector.

Steiner (2001) uses a panel of 19 OECD countries in the period 1986–1996 to investigate the impact of electricity market reforms on the performance of the electricity sector represented also by the price of electricity for industrial customers and the ratio of electricity prices for industrial customers and households. One of the investigated aspects is the separation of generation from transmission. In the regressions she distinguishes only two categories: the presence or absence of any kind of unbundling. In her paper even accounting unbundling qualifies as unbundling. The impact of unbundling on the price and the price ratio is consistently negative, however, it is not statistically significant.

Hattori and Tsutsui (2005) build on Steiner 2001, using a panel of the same 19 OECD countries but extending the time series to 1999. Similar to Steiner 2001, they estimate the impact of reforms on the price of electricity for industrial customers and the ratio of the prices for industrial customers and households. As one of the independent variables they include the unbundling of generation and transmission. However, they consider a company unbundled if there is at least legal unbundling. They found no statistically significant evidence of the benefits of unbundling.

Steiner (2004) further develops her model in order to account for the possible endogeneity of the regulatory reform variables. She simultaneously estimates both the electricity sector performance equation (i.e., how does energy sector performance respond to regulatory changes such as unbundling) and the regulatory reform selection equation (i.e., the equation capturing the choice of the regulatory reform) for 29 countries in the period 1986–1998. Similarly to her previous work she again defines unbundling as a separation of the activities at least on the accounting level. She shows that the impact of restructuring is overall good (price decrease) for industrial customers and bad (price increase) for households, however, it varies for various groups of countries from a decreasing effect on industrial and household customers in English-speaking and Scandinavian countries to an increasing effect on industrial customers in South American countries. However, this paper does not disentangle the effects of market opening and unbundling, so the presented results in fact capture the effect of the entire restructuring in countries that have implemented ownership unbundling. Furthermore, the differing effects across different country groups beg the question what is driving the differences between the groups of countries.

Nagayama (2007) uses a panel of 83 countries in the period 1985–2002 to investigate the effects of regulatory reforms in the electricity sector on prices for industrial customers and households. However, unbundling is not clearly defined as ownership unbundling (it seems to best correspond to legal unbundling). The paper claims that ownership unbundling on its own might lead to price increases and only when implemented along with other reforms can a price decline be expected.

Then there are also studies that focus more specifically on the European Union. Nielsen et al. (2005) investigate the effect of market opening in eight network industries, including the electricity and gas sector, in the EU-15 states in the period 1990–2003. They find that unbundling is crucial for proper market opening of the electricity sector leading to lower prices and higher productivity, however, unbundling is not rigorously defined in the paper. They present a general methodology for the selection of a model (a static or dynamic panel model), but they do not show the specific results and equations.

Another study, by Ernst and Young (2006) for the UK Department of Trade and Industry, again uses the EU-15 states, plus Norway, to investigate the development of electricity and gas prices upon reforms. However, the unbundling of the TSO (which is again not rigorously defined) is examined only for the gas sector in which case the authors claim that the presence of a TSO may lead to a 15% decline in gas prices.

Conversely, Fiorio et al. (2007) come to a different conclusion for the EU-15 states. In their investigation of the impact of the electricity market reform on electricity prices for households they find that countries with larger electricity sector disintegration (i.e., more perfect unbundling captured on a scale of 0 to 6) exhibit higher prices of electricity for households.

Besides panels of different countries, some studies focus on a particular country, empirically investigating issues associated with unbundling in the country. Similar to the country panel studies, the results are again mixed. Davies and Price (2007) investigate the impact of the ownership unbundling of electricity distribution companies in the United Kingdom on the development of the market share of the incumbent in each region. They distinguish vertically integrated and separated (i.e., ownership unbundling) retail and distribution functions and find that the market share of integrated companies declines less than the market share of those incumbents who divested their physical distribution business. Thus they provide evidence that ownership unbundling fosters competition on the distribution level under the conditions of the UK market. However, the question of what the effect of ownership unbundling would be on the transmission level across several countries remains unanswered.

The conclusions reached by Iimi (2003) for the Vietnamese electricity sector contradict the results of Davies and Price (2007). The author investigates whether vertical integration of generation and transmission is more efficient than the separation of these two activities. Based on the estimated degree of economies of scale the author concludes that due to double marginalization the two functions should be owned by a single entity.

Nillesen and Pollitt (2008) provide yet another country-specific paper, in this case focused on the ownership unbundling of electricity distribution in New Zealand. Some of their results seem to support the findings of Iimi (2003). In particular they claim that ownership unbundling in New Zealand did not lead to lower prices and brought about high one-off costs, network quality improvements, and a decline in operational costs, which however resulted in higher margins and not lower prices. Furthermore, the good effect of ownership unbundling was only temporary as the former vertically integrated supply/network companies were replaced by integrated generation/supply companies.

It is clear from the literature above that despite the existence of studies aiming to investigate the effect of unbundling on the performance of the electricity sector, the results are very mixed and do not provide a clear answer for what the expected effect of ownership unbundling is. There are no studies of the impacts of the ownership unbundling of the transmission system operator that would focus on all countries that are subject to the legislation of the European Union and that capture the differences in the impacts of the reforms on different customer groups. This gap begs for further investigation with the most recent data, with a focus on EU member states and rigorously using the definition of unbundling according to the provisions of the applicable ratified legislation. This is exactly why I focus in this paper on all EU countries to which the third energy liberalization package applies and apply the framework of the third energy liberalization legislative package. Furthermore, noticing that differences in the results for various countries or country groups have been identified in previous papers, I use the institutional quality of a country as a variable that might determine the success or failure of the implementation of ownership unbundling and help explain the differences across countries.

## 3.5 The Model

### 3.5.1 General Approach

The basic method used for the identification of the effect of ownership unbundling is to use panel data econometric methods to regress the electricity market performance variable (price of electricity for industrial customers or households) on regulatory reform variables R plus a set of control variables X, which is the approach taken by Steiner (2001), Hattori and Tsutsui (2005), Zhang et al. (2005), Davies and Price (2007), Nielsen et al. (2005), Nagayama (2007) and Fiorio et al. (2007):

$$I_{ti} = \beta_{0i} + \beta R_{ti} + \gamma X_{ti} + \varepsilon_{ti}, \qquad [1]$$

where $I_{ti}$ is either the price for industrial customers or the price for households,[28] $R_{ti}$ are regulatory reform variables and $X_{ti}$ are control variables. In line with most of the literature I treat the reforms as exogeneous unlike Steiner (2004), where the reforms are treated as endogeneous. I believe that this is a more proper approach given the set of countries that I am using and the investigated period. Whereas Steiner (2004) used a diverse set of countries from various parts of the world in the period 1986–1998, where the reform actions might be driven by various incentives and developments that are endogeneous in the particular country, I focus on EU member states throughout the period when market opening and ownership unbundling is requested by the EU legislation, and is thus exogeneous.

However, instead of running the regressions separately, I believe that it is more proper to treat the equations for the price for industrial customers and for the price of households as a system of seemingly unrelated regressions. Therefore, I use the methodology of Zellner (1962) and apply iterated feasible generalized least squares to estimate the pair of equations at the same time.[29] To account for the panel data

[28] To be consistent with Steiner (2001), Steiner (2004), Hattori and Tsutsui (2005) and Nagayama (2007), and to check the robustness of the results the sensitivity analysis section also includes estimates of equations where the ratio of the electricity prices for industrial customers and households is used as the dependent variable.

[29] This is the way I obtain maximum likelihood estimates; see Oberhofer and Kmenta (1974).

properties of the sample, I also use dummy variables to capture country-specific fixed effects (i.e., a least squares dummy variable estimation combined with SUR estimation).

I use the logarithmic form of the prices, i.e., the price equations are

$$\ln(p_{ti}^{I}) = \beta_{0i}^{I} + \beta^{I} R_{ti}^{I} + \gamma^{I} X_{ti} + \varepsilon_{ti}^{I} \qquad [2]$$

and

$$\ln(p_{ti}^{H}) = \beta_{0i}^{H} + \beta^{H} R_{ti}^{H} + \gamma^{H} X_{ti} + \varepsilon_{ti}^{H}, \qquad [3]$$

where the superscripts $I$ and $H$ denote industrial customers and households, respectively, and $\beta_{0i}^{I}$ and $\beta_{0i}^{H}$ are the country-specific fixed effects.

As an alternative method to check the results of the straightforward price regressions and to test for the significance of ownership unbundling, in the sensitivity analysis section 3.7.1 I investigate also the development of the ratio of the electricity price for industrial customers over the electricity price for households. By subtracting [3] from [2] I receive

$$\ln\left(\frac{p_{ti}^{I}}{p_{ti}^{H}}\right) = \left(\beta_{0i}^{I} - \beta_{0i}^{H}\right) + \beta^{H} R_{ti}^{H} - \beta^{I} R_{ti}^{I} + \left(\gamma^{I} - \gamma^{H}\right) X_{ti} + \left(\varepsilon_{ti}^{I} - \varepsilon_{ti}^{H}\right). \qquad [4]$$

Unfortunately, since equation [4] is a linear combination of equations [2] and [3], the covariance matrix in the SUR estimation of all three equations is singular and a system of the three equations cannot be estimated at the same time. Therefore, I estimate the equations in pairs. In particular, I use the pair of price equations [2] and [3] as the base model and estimate also the ratio equation [4] each time with either equation [2] or [3] to check the robustness of the results. Since in the estimation of the ratio equation [4] together with either of the price equations the regressors on the price equation form a subset of the regressors of the ratio equation, SUR does not yield any extra efficiency for the price equation compared to the standard standalone least squares estimation of the price equation. Therefore, when I estimate the system with the ratio equation I report only the estimates of the ratio equation and use them to check the consistency of the base model estimates.

### 3.5.2 Choice of Regulatory Reform Variables

The regulatory reform variables capture the development of the electricity market reform in each particular country. I focus in particular on two important components: market opening and ownership unbundling.

In terms of market opening, I use dummy variables for the opening of the market for each particular customer group. The approach somewhat differs from other studies. For example, Nielsen et al (2005) and Ernst & Young (2006) use a continuous variable for the percentage of the eligible market. Nagayama (2007) uses a dummy variable equal to unity if at least some of the customers are eligible to choose their power supplier. Steiner (2001) uses the eligibility threshold as an independent variable. Unlike these studies, I match each customer category in each country with the exact date when this particular customer group became eligible. I believe that this approach better captures the underlying process since the prices for a particular customer group should change the most when the market is liberalized for that particular customer group. Ideally, after the opening of the market the price of electricity for the liberalized customer group should decline, which should be exhibited in the estimated coefficients for the dummy variables.

To capture the impact of ownership unbundling, I use ownership unbundling dummies for those periods and countries when the TSO is separated in terms of the ownership from other electricity market activities. However, since ownership unbundling as such cannot achieve greater competition in markets that are not liberalized, I interact this dummy with the market opening for the particular investigated customer group. Therefore, I investigate the impact of ownership unbundling on the price of electricity for a particular customer group only after this customer group has become eligible to switch to a different supplier.

To see how the price develops in the individual years before and after the reform I use several year-ahead and year-after dummies for both market opening and ownership unbundling. This use of dummies for individual years of the reform is motivated for example by the development of prices in Sweden after market opening (where ownership unbundling was implemented) as described by the Sweden 2000 Report of the International Energy Agency: the prices rose immediately after market opening in 1996 and declined to the original level in 1999 (IEA (2000)). Such a development can be justified for example by the one-off restructuring costs required for the unbundling or by the time required for competition to develop.

To allow for a difference between new and old member states, I also include separate dummies for new member states.

Moreover, I interact the reform dummies with the corruption perceptions index provided by Transparency International. This is motivated for example by Van Koten and Ortmann (2008), who find that the level of corruption plays a role in the selection of the unbundling regime, and thus it may also affect the quality of the implementation of the reforms and the differences in the price data between the old and new member states identified in preliminary estimations. Furthermore, Nagayama (2007) hints that unbundling (although general unbundling is considered instead of ownership unbundling) implemented on its own may lead to price increases, whereas when coupled with other regulatory reforms a negative decline can be expected. The use of the institutional quality level may also help to explain the differences across different regions identified by Steiner (2004). In this spirit, the institutional quality could play an important role in the determination of the effect of ownership unbundling on prices. However, it is not clear beforehand what effect of the institutional quality should be expected. On the one hand, countries with low institutional quality could exhibit a high potential (high original price level) for a price decline due to reform. On the other hand, in countries with high corruption levels, the reforms might be imperfectly implemented as the various state institutions are likely to be more prone to the influence of the vertically integrated incumbent.

The details of the construction of the regulatory reform dummies are presented in Appendix No. 1.

### 3.5.3 Choice of Control Variables

Various control variables were selected to account for the development of the price independent of the regulatory reform. These include the costs for electricity generation (e.g., the price of natural gas for industrial customers) as well as indicators describing the general development of the economy, in particular the gross domestic product at market prices expressed using a Euro-based price index and a consumer price index without the impact of energy. The control variables used are in general similar to those used in previous studies. Following Hattori and Tsutsui (2005) and Steiner (2004) I include the share of electricity produced in hydroelectric power plants and nuclear power plants to account for the differences in the generation costs. Similar to Hattori and Tsutsui (2005), Steiner (2004) and Davies and Price (2007) I use a trend coefficient to account for a possible unexplained exponential trend in the price series. Instead of the input fuel index used in Steiner (2004), I use the price of gas and the price of oil. Since the sample of countries that I am investigating is much less heterogeneous and more affected by the common EU legislation than the samples used in other studies, I do not include some other controls, such as telecom privatization and neighbor restructuring as used, e.g., in Steiner (2004), to account for the differences in the legislative framework and the surrounding environment of a more diverse set of countries.

## 3.6 The Data

For the investigation I use data published by Eurostat (electricity prices, gas prices, GDP, CPI, share of nuclear and hydro power plants), the European Commission (unbundling and market opening), national energy regulators (unbundling and market opening), the Energy Information Administration (oil prices), the International Energy Agency (unbundling and market opening) and Transparency International (corruption perceptions index). The used data has a half-yearly frequency, spans from 1996 to 2007 and covers the 25 member states of the European Union: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. The remaining two states, Cyprus and Malta, are not included in the analysis due to the fact that they have a derogation from the energy market liberalization legislation since they are considered small isolated systems.

### 3.6.1 Ownership Unbundling Data

There is no single source of data that can be used to obtain precise information about the state of unbundling in individual member states. The general procedure that I used is as follows: I first consulted the benchmarking reports of the Directorate-General Transport and Energy of the European Commission on the progress in creating internal gas and electricity markets from 2000 to 2008 (CEC (2001), CEC (2003), CEC (2004), CEC (2005a), CEC (2005b), CEC (2007), CEC (2008), CEC (2009)) for a basic indication of the unbundling regime. Then I looked at the websites of the national regulators, transmission system operators and the International Energy Agency for the particular dates of the changes in the unbundling regime (i.e., the time when ownership unbundling was implemented in a particular country) and to verify the unbundling regime.

The criteria that I use to assess whether ownership unbundling is properly implemented in a particular country are based on the definition of ownership unbundling as specified in the proposal of the European Commission (EC 2007 a-d) and as described in section 3.3. However, I am not as strict in cases when a) the transmission system operator is owned by the state or b) when a power generator/supply company owns a relatively small share of the transmission system operator.

In the case of state ownership I do not rigorously require the transmission system operator and the generator/supply company to fall within the jurisdiction of different ministries. I believe that since ownership unbundling has yet not been required on the EU level, countries that opted for ownership unbundling, albeit state owned, really strive to make the market competitive and do not exercise joint control over the companies to inhibit competition.[30] Despite this more lenient definition of ownership unbundling I do not find any countries that would not have ownership unbundling according to the DGTREN benchmarking reports and would be classified as ownership unbundled according to this relaxed definition.

The case of minority shares in the transmission system operator held by a power company active in supply or generation applies only to the case of Spain, where such minority share was limited by law in 1997 to 10% and in 2005 to 3% (add reference to the laws). In line with the DGTREN benchmarking reports and Energy I classify the Spanish transmission operator as unbundled in terms of ownership.

Although, as I mention above, I have not changed the classification of any country from the DGTREN benchmarking reports that did not qualify for ownership unbundling, there were three countries for which I had to reject the reported ownership unbundling status. The first one of them is Finland where, however, according to the annual report of the Finnish transmission system operator Fingrid (Fingrid (2008)) there are two shareholders with over 25% of the shares each and over 33% of the voting rights each which are power generators/supply companies[31]. The second country which I believe that is incorrectly reported in DGTREN reports as unbundled in terms of ownership is Lithuania. Besides transmission services, the Lithuanian transmission system operator engages also in electricity trading, export and generation and thus cannot be assessed as a transmission system operator complying with ownership unbundling regulations[32]. The third country where I disagree with the DGTREN reports is Ireland, where the operator Eirgrid only leases the grid from the power company ESB that also owns generation assets and supplies electricity[33].

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[30] To be clear, I consider a state-owned transmission system operator unbundled in terms of ownership only when it is a separate company engaged only in transmission and not a subsidiary of any other power market participant.

[31] Fortum Power and Heat Oy and Pohjolan Voima Oy each have a share of 25.08 % and 33.44% of the votes.

[32] According to the 2007 annual report of the Lithuanian TSO Lietuvos Energija in 2007 the company generated 7 % of the total electricity generated in Lithuania and revenues from transmission services accounted only for 30% of the total revenues of the company whereas 50% of the revenues was generated by sale of electricity on the domestic wholesale market and a significant share came from exports.

[33] For more see the EirGrid and ESB websites www.eirgrid.ie and www.esb.ie.

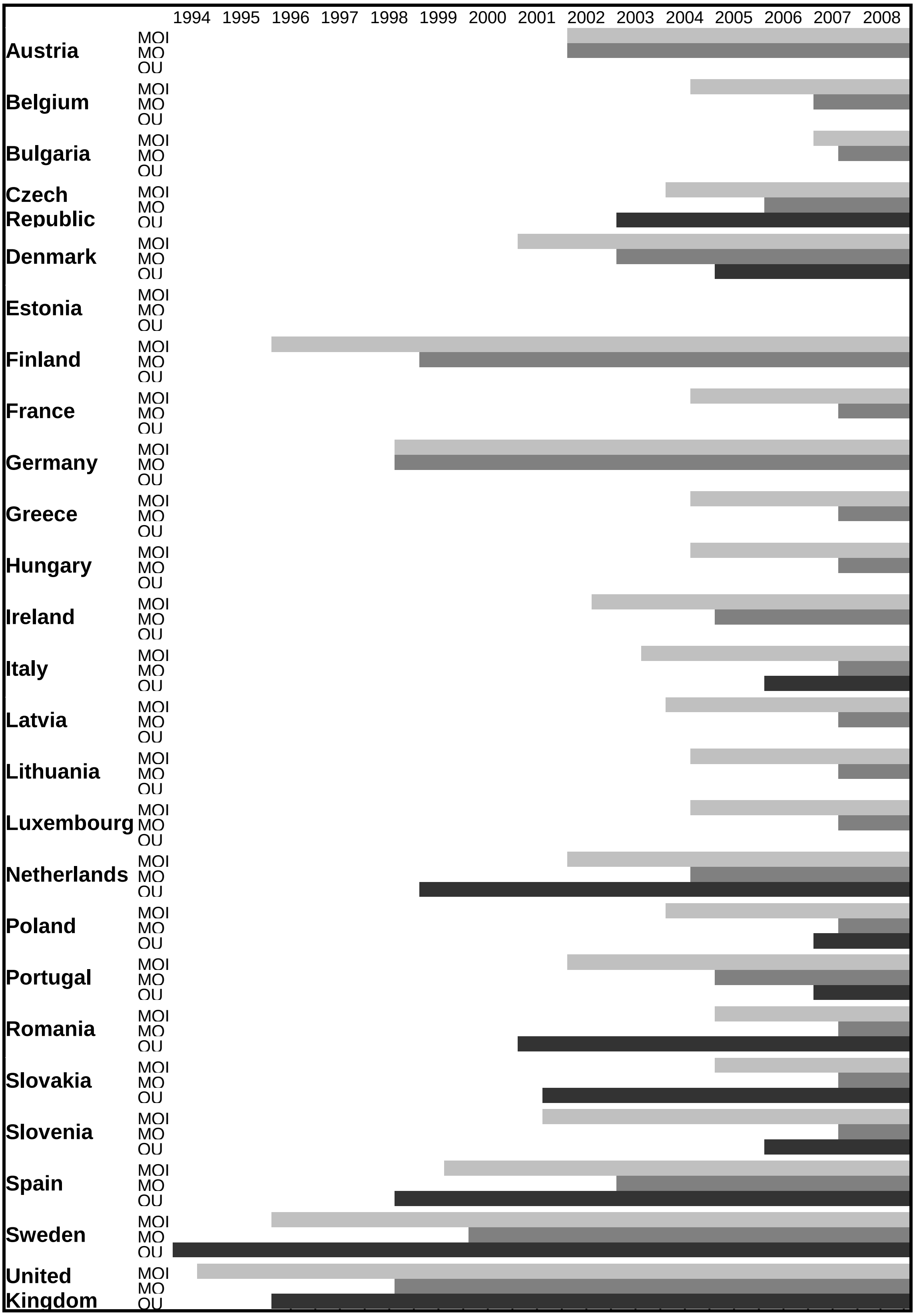
### 3.6.2 Market Opening Data

The procedure for the collection of market opening data is somewhat similar to the procedure used for ownership unbundling data. I started with national reports published by the Council of European Energy Regulators (CEER) and the European Regulator's Group for Electricity and Gas (ERGEG). These are reports that have been elaborated for the years 2005 to 2008 by national energy regulatory agencies and that are published on the joint CEER-ERGEG website.[34] In particular, the 2005 reports contain some basic data on market opening for each country. This data was further refined using sources such as the national regulatory agency websites, transmission system operator websites, national legislation and International Energy Agency reports. I focused on market opening data for two particular customer classes for which Eurostat provides the most data on prices: class Ie industrial customers,(industrial customers with annual consumption of 2000 MWh, maximum demand 500 kW and annual load 4000 hours) and households.

A detailed specification of the sources of both unbundling and market opening data for each country is provided in Appendix No. 2 – Data Sources. Figure 1 provides information on ownership unbundling and market opening in a graphical format.

Figure 1 (next page): Information about market opening and ownership unbundling. The figure illustrates the time of market opening for industrial customers (industrial customer with annual consumption of 2000 MWh, maximum demand 500 kW) depicted in light gray and marked MOI, the time of market opening for households depicted in darker gray and marked MOH and the time of ownership unbundling (if present) depicted in black and marked OU.

[34] http://www.energy-regulators.eu/


1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Austria
Belgium
Bulgaria
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Netherlands
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden
United Kingdom
MOI
MO
OU

### 3.6.3 Corruption Perceptions Index

The Corruption Perceptions Index data is provided by Transparency International with annual frequency. Therefore, for each observation I use the latest Corruption Perceptions Index that is valid in the current year. Moreover, before multiplying the regulatory reform dummies by the Corruption Perceptions Index to get the interaction terms I adjust it to simplify the interpretation of the coefficient as described in Appendix No. 1.

*Table 1: Summary statistics for the Transparency International Corruption Perceptions Index 1995 – 2007*

| Corruption Perceptions Index | | | |
|---|---|---|---|
| Country | Mean | Min | Max |
| Austria | 7.95 | 7.50 | 8.70 |
| Belgium | 6.62 | 5.25 | 7.60 |
| Bulgaria | 3.77 | 2.90 | 4.10 |
| Czech Republic | 4.52 | 3.70 | 5.37 |
| Denmark | 9.62 | 9.33 | 10.00 |
| Estonia | 5.94 | 5.50 | 6.70 |
| Finland | 9.63 | 9.05 | 10.00 |
| France | 6.90 | 6.30 | 7.50 |
| Germany | 7.88 | 7.30 | 8.27 |
| Greece | 4.61 | 4.20 | 5.35 |
| Hungary | 5.06 | 4.80 | 5.30 |
| Ireland | 7.63 | 6.90 | 8.45 |
| Italy | 4.85 | 3.42 | 5.50 |
| Latvia | 3.81 | 2.70 | 4.80 |
| Lithuania | 4.58 | 3.80 | 4.80 |
| Luxembourg | 8.64 | 8.40 | 9.00 |
| Netherlands | 8.86 | 8.60 | 9.03 |
| Poland | 4.17 | 3.40 | 5.57 |
| Portugal | 6.51 | 6.30 | 6.97 |
| Romania | 3.05 | 2.60 | 3.70 |
| Slovakia | 4.01 | 3.50 | 4.90 |
| Slovenia | 5.97 | 5.20 | 6.60 |
| Spain | 6.54 | 4.31 | 7.10 |
| Sweden | 9.27 | 9.00 | 9.50 |
| United Kingdom | 8.55 | 8.22 | 8.70 |

## 3.7 The Results

The main idea behind the investigation is quite simple. If ownership unbundling of transmission system operators really does matter, this should be captured in the existing data on the performance of the electricity sector, in particular the price of electricity for industrial customers and the price of electricity for households. The electricity performance patterns exhibited by countries where TSO is separated in terms of ownership from the supply and generation company should differ from countries where such ownership unbundling has not taken place.

Tables 2 and 3 show the results of the estimation of the equations which are estimated jointly as a system of seemingly unrelated regressions. Table 4 shows the tests of joint significance of the estimates belonging to the same variable group (e.g. dummies for market opening, dummies for ownership unbundling, dummies for the interaction of ownership unbundling and institutional quality, etc.). I particularly focus on the following questions: Does market opening in general play a role and what are the differences in individual countries due to the institutional quality? Does ownership unbundling of the TSO play a role and what are the differences across individual countries due to institutional quality? Naturally, these questions apply to both industrial and residential customers.[35]

The question of whether ownership unbundling plays any role at all can be formally captured in the form of a test of the null hypothesis that the ownership unbundling coefficient estimates are jointly equal to zero (ownership unbundling does not matter) against the alternative hypothesis that ownership unbundling does play a role (the ownership unbundling coefficient estimates are not jointly equal to zero). The second part of the question concerning the effect size, direction and differences across different customer categories, country groups and institutional quality levels can then be

[35] Even though I present the coefficient estimates and calculated percentage changes in the price of electricity, the values should be considered cautiously and should not be used to claim that the reforms have exactly these quantifiable effects. As described in the sensitivity analysis section and the discussion section, the values of the estimates might vary depending on the specification and the results shall be used only to uncover the general principles and directions in the development of the price after market opening and ownership unbundling and possibly the order of magnitude of these effects.

investigated less formally by looking at the values of the various parameters and interpreting the results.

Due to the structure of the reform variables the basic effect of the reform (market opening or ownership unbundling) captured in the particular estimated coefficient for the regulatory reform dummy variable applies to countries with perfect institutional quality (Corruption Perceptions Index = 10).[36] In addition to this effect, the reform dummies interacted with the adjusted corruption perceptions index capture a change relative to the base effect due to a lower corruption rating (lower Corruption Perceptions Index). Therefore, for each aspect of the reform I first report the effect for countries without corruption and then how the effect changes due to lower institutional quality.[37]

[36] There is no country with Corruption Perception Index equal to 10 throughout all years in the sample, therefore, the reform dummy interacted with the corruption perceptions is applicable to at least some extent to all countries. However, the best performing countries are very close to scoring straight tens (e.g., Denmark and Finland, see table 1).
[37] I use the methodology of Kennedy (1981) to calculate the percentage changes in the price due to the dummy variables.

**Table 2**: Estimation results for industrial customers from SUR estimation of the price equation for industrial customers and the price equation for households. The asterisk next to the coefficient estimate denotes the statistical significance of the estimate (*** means significant at 1%, ** means significant at 2%, * means significant at 10%).

| | | | | | | |
|---|---|---|---|---|---|---|
| System | SUR for industry and households (BASE) | | | | | |
| Equation | Industry | | | | | |
| Category | Industry | | | | | |
| R2 | 0.8355 | | | | | |
| Obs | 425 | | | | | |
| | Market opening | | Market opening x New member state | | Market opening x corruption perc. index | |
| Year | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| -6+ | 0.3597*** | (0.049) | | | | |
| -5 | 0.2925*** | (0.051) | | | 0.0231 | (0.111) |
| -4 | 0.2125*** | (0.048) | 0.0476 | (0.070) | 0.1942* | (0.101) |
| -3 | 0.1603*** | (0.047) | -0.0063 | (0.061) | 0.3323*** | (0.109) |
| -2 | 0.0858* | (0.048) | 0.0010 | (0.059) | 0.3988*** | (0.123) |
| -1 | 0.0190 | (0.049) | -0.0238 | (0.056) | 0.4942*** | (0.133) |
| 0 | | | | | 0.4750*** | (0.135) |
| 1 | -0.0329 | (0.044) | -0.0167 | (0.053) | 0.4311*** | (0.139) |
| 2 | -0.0074 | (0.047) | -0.0016 | (0.056) | 0.2919** | (0.145) |
| 3+ | -0.0906* | (0.047) | 0.0111 | (0.063) | 0.5225*** | (0.149) |
| | Ownership unbundling | | Ownership unbundling x new member state | | Ownership unbundling x Corruption Perc. Index | |
| | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| -6+ | -0.1866*** | (0.057) | 0.2930*** | (0.088) | | |
| -5 | -0.0926 | (0.060) | 0.1945** | (0.088) | | |
| -4 | -0.0466 | (0.057) | 0.1914** | (0.080) | | |
| -3 | -0.0109 | (0.065) | 0.1681** | (0.078) | -0.1017 | (0.142) |
| -2 | -0.0171 | (0.064) | 0.1266* | (0.073) | -0.0626 | (0.154) |
| -1 | 0.0295 | (0.061) | 0.0552 | (0.068) | -0.0113 | (0.165) |
| 0 | | | | | 0.1901 | (0.171) |
| 1 | 0.1389*** | (0.053) | 0.1937*** | (0.073) | -0.3262 | (0.207) |
| 2 | 0.0495 | (0.060) | 0.4184*** | (0.127) | -0.3312 | (0.309) |
| 3+ | 0.1465** | (0.060) | 0.6101*** | (0.126) | -0.6715** | (0.307) |
| | Coeff. | SE | | | | |
| log(gdp) | 0.4120*** | (0.135) | | | | |
| log(cpi) | 0.6179** | (0.240) | | | | |
| log(price of gas) | 0.1772*** | (0.038) | | | | |
| log(price of oil) | 0.0120 | (0.029) | | | | |
| hydro share | -0.0197 | (0.200) | | | | |
| nuclear share | 1.0271** | (0.398) | | | | |
| trend | 0.0014 | (0.003) | | | | |

**Table 3**: Estimation results for household customers from SUR estimation of the price equation for industrial customers and the price equation for households. The asterisk next to the coefficient estimate denotes the statistical significance of the estimate (*** means significant at 1%, ** means significant at 2%, * means significant at 10%).

| | | | | | | |
|---|---|---|---|---|---|---|
| System | SUR for industry and households (BASE) | | | | | |
| Equation | Households | | | | | |
| Category | Households | | | | | |
| R2 | 0.9337 | | | | | |
| Obs | 425 | | | | | |
| | Market opening | | Market opening x new member state | | Market opening x corruption perc. index | |
| Year | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| -6+ | 0.0585** | (0.023) | -0.1117** | (0.046) | | |
| -5 | -0.0249 | (0.034) | -0.0965 | (0.066) | 0.1168 | (0.102) |
| -4 | -0.0266 | (0.034) | -0.0877 | (0.065) | 0.0742 | (0.103) |
| -3 | -0.0079 | (0.037) | -0.0224 | (0.050) | 0.0342 | (0.116) |
| -2 | 0.0150 | (0.031) | 0.0421 | (0.048) | 0.0098 | (0.107) |
| -1 | -0.0017 | (0.033) | -0.0069 | (0.050) | -0.0547 | (0.119) |
| 0 | | | | | 0.0386 | (0.050) |
| 1 | 0.0117 | (0.036) | 0.4367*** | (0.119) | 0.0778 | (0.181) |
| 2 | 0.0595* | (0.033) | | | 0.0495 | (0.161) |
| 3+ | 0.0467 | (0.034) | | | 0.0609 | (0.173) |
| | Ownership unbundling | | Ownership unbundling x new member state | | Ownership unbundling x corruption perc. index | |
| | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| -6+ | -0.0219 | (0.026) | 0.0136 | (0.056) | | |
| -5 | 0.0244 | (0.047) | 0.0162 | (0.082) | -0.0965 | (0.138) |
| -4 | 0.0958** | (0.045) | 0.1390 | (0.086) | -0.2460* | (0.142) |
| -3 | 0.0784* | (0.046) | 0.1307* | (0.071) | -0.3105** | (0.153) |
| -2 | 0.0915** | (0.041) | 0.0290 | (0.066) | -0.2825** | (0.139) |
| -1 | 0.1102** | (0.044) | 0.0946 | (0.071) | -0.2908* | (0.158) |
| 0 | | | | | 0.0673 | (0.067) |
| 1 | 0.2227*** | (0.051) | | | -1.0800*** | (0.324) |
| 2 | 0.3589*** | (0.045) | | | -2.0720*** | (0.263) |
| 3+ | 0.2243*** | (0.046) | | | -1.3159*** | (0.251) |
| | Coeff. | SE | | | | |
| log(gdp) | 0.4486*** | (0.096) | | | | |
| log(cpi) | 0.2149 | (0.166) | | | | |
| log(price of gas) | 0.1027*** | (0.028) | | | | |
| log(price of oil) | -0.0295 | (0.021) | | | | |
| hydro share | -0.3766** | (0.148) | | | | |
| nuclear share | 0.5777** | (0.283) | | | | |
| trend | -0.0024 | (0.002) | | | | |

**Table 4:** F-tests for the joint significance of estimates of the same indicator group.

| F-tests for the joint significance of estimates | | | |
|---|---|---|---|
| **Industrial customers** | | **Households** | |
| **Market opening** | | **Market opening** | |
| F(9, 343) | 9.85 | F(9, 344) | 2.4 |
| p-value | 0.0000 | p-value | 0.0120 |
| **Market opening difference in NMS** | | **Market opening difference in NMS** | |
| F(7, 343) | 0.22 | F(7, 344) | 3.28 |
| p-value | 0.9816 | p-value | 0.0022 |
| **Market opening x CPI** | | **Market opening x CPI** | |
| F(7, 343) | 3.28 | F(9, 344) | 0.34 |
| p-value | 0.0008 | p-value | 0.9611 |
| **Ownership unbundling** | | **Ownership unbundling** | |
| F(9, 343) | 4.80 | F(9, 344) | 8.33 |
| p-value | 0.0000 | p-value | 0.0000 |
| **Ownership unbundling difference in NMS** | | **Ownership unbundling difference in NMS** | |
| F(9, 343) | 4.99 | F(6, 344) | 1.10 |
| p-value | 0.0000 | p-value | 0.3619 |
| **Ownership unbundling x CPI** | | **Ownership unbundling x CPI** | |
| F(7, 343) | 2.07 | F(9, 344) | 9.28 |
| p-value | 0.0462 | p-value | 0.0000 |

For industrial customers, market opening as such seems to lead to a significant decline in the prices of electricity for countries that perform the best in terms of corruption both in old and new member states. This effect is both immediate (in fact it starts already before the market opens) and persistent, and may be over 40% over the course of ten years.[38] The fact that the decline starts already several years before market opening might seem striking at first, however, there is a good explanation for such estimates. The dummies used in the estimation capture the time when the market was actually opened for the particular customer group. However, some market reforms and restructuring started taking place several years ahead in preparation of the opening and other larger customer groups became eligible to choose the supplier up to several years before this particular customer group. This gradual decline in the price of electricity several years ahead of the market opening for the particular customer groups shows that it is the overall reforms and restructuring of the electricity market rather than just the eligibility of the customers to choose their supplier that has a good effect on the price developments on the market.

This fairly large decline in prices applies only to countries with perfect institutional quality and is weaker or even non-existent in countries that are more corrupt.[39] Whereas the 95% confidence intervals of estimates six and more years before market opening and three or more years after market opening do not overlap for the mean corruption case in old member states, in the case of maximum corruption in the old member states the 95% confidence intervals of these estimates overlap. However, these estimates are still different at the significance level of $p = 0.012$. In new member states the situation is similar. However, this time the 95% confidence intervals of the first estimate and the last estimate[40] overlap regardless of the corruption level, but yet again, the difference between these estimates is statistically significant even in the worst case (maximum corruption) at $p=0.035$.

[38] This is the aggregate effect of market opening net of the development of inflation, GDP, etc., not to be mistaken for the actual development of the price on the market.

[39] Countries with perfect institutional quality (the "best" countries) are hypothetical countries scoring 10 on the corruption perception index in all years. The mean country is a hypothetical country with a corruption perceptions index equal to the mean of the corruption perceptions indexes across all countries at the time that corresponds to the particular year before, of or after reform. The worst country in terms of institutional quality is a hypothetical country with a corruption perceptions index equal to the lowest rating across all countries in the particular year before, of or after the reform. The best, mean and worst countries are only hypothetical: they do not refer to particular countries since the rating, and consequently the order, changes over time.

[40] I.e., the first is four years before market opening and the last is three or more years after market opening. Due to the lack of data for new member states the market opening dummies start 4 years before market opening whereas for old member states it is 6 years before market opening.

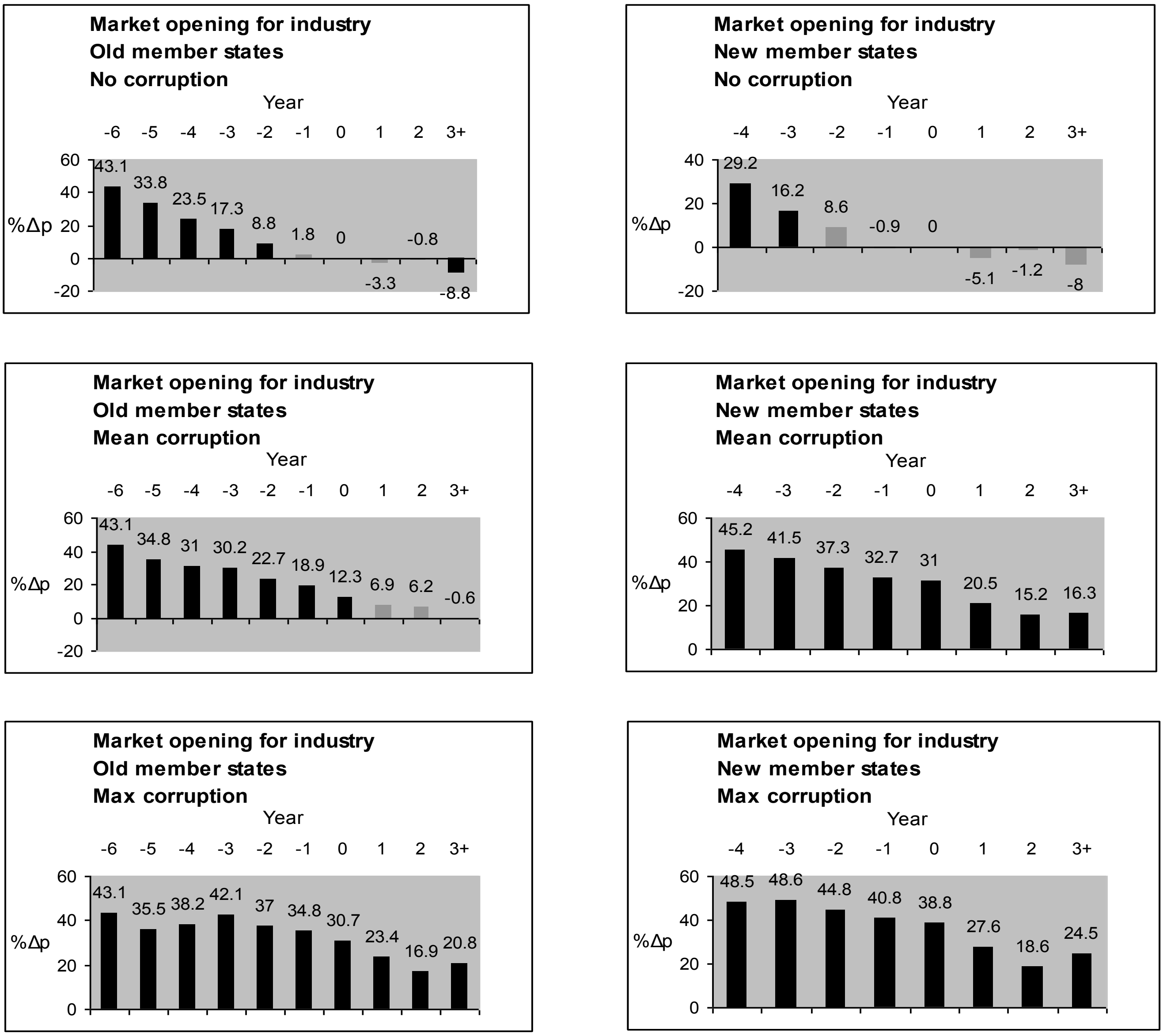



Figure 1: Development of prices for industrial customers due to market opening. The graphs show how the price of electricity develops with respect to market opening in both old and new member states depending on different levels of institutional quality (corruption). The horizontal axis shows the individual years before, of (0) and after market opening. The vertical axis shows the percentage change in the price. The benchmark year (level 0) is in each case the year of the reform (market opening) in the no-corruption case. The percentages are calculated by summing up the appropriate estimates from the estimated regressions, multiplying them by the corresponding corruption level, calculating the standard errors of these sums and products and then applying the methodology of Kennedy (1981) to calculate the percentages. Estimates that are statistically significant at least at the 10% level are shaded in black, changes that are not statistically significant with respect to the base level are shaded in gray. Clearly, inspecting the graphs from top to bottom, the decline in prices is less and less pronounced as more corruption is present.

Whereas for industrial customers the results showed a decline in prices in the years around market opening, the estimates for the electricity price for households are very different. They show no clear trend or change in the electricity prices with respect to market opening, which applies similarly both to old and new member states. Furthermore, the institutional quality of the individual countries does not seem to play a role in this case. There is no statistically significant difference in the prices six or more years before the market opening and two or more years after the market opening for the old member states. In the results for the new member states there is a large spike one year after the reform, which, however, can be attributed to a lack of data since market opening was implemented for households in new member states later than for other categories and many of the years and countries lie in this case out of the sample. Consequently, there are only two non-zero observations for the one-year-after-market-opening dummy for households and new member states in the sample based on which it is difficult to make any conclusions.

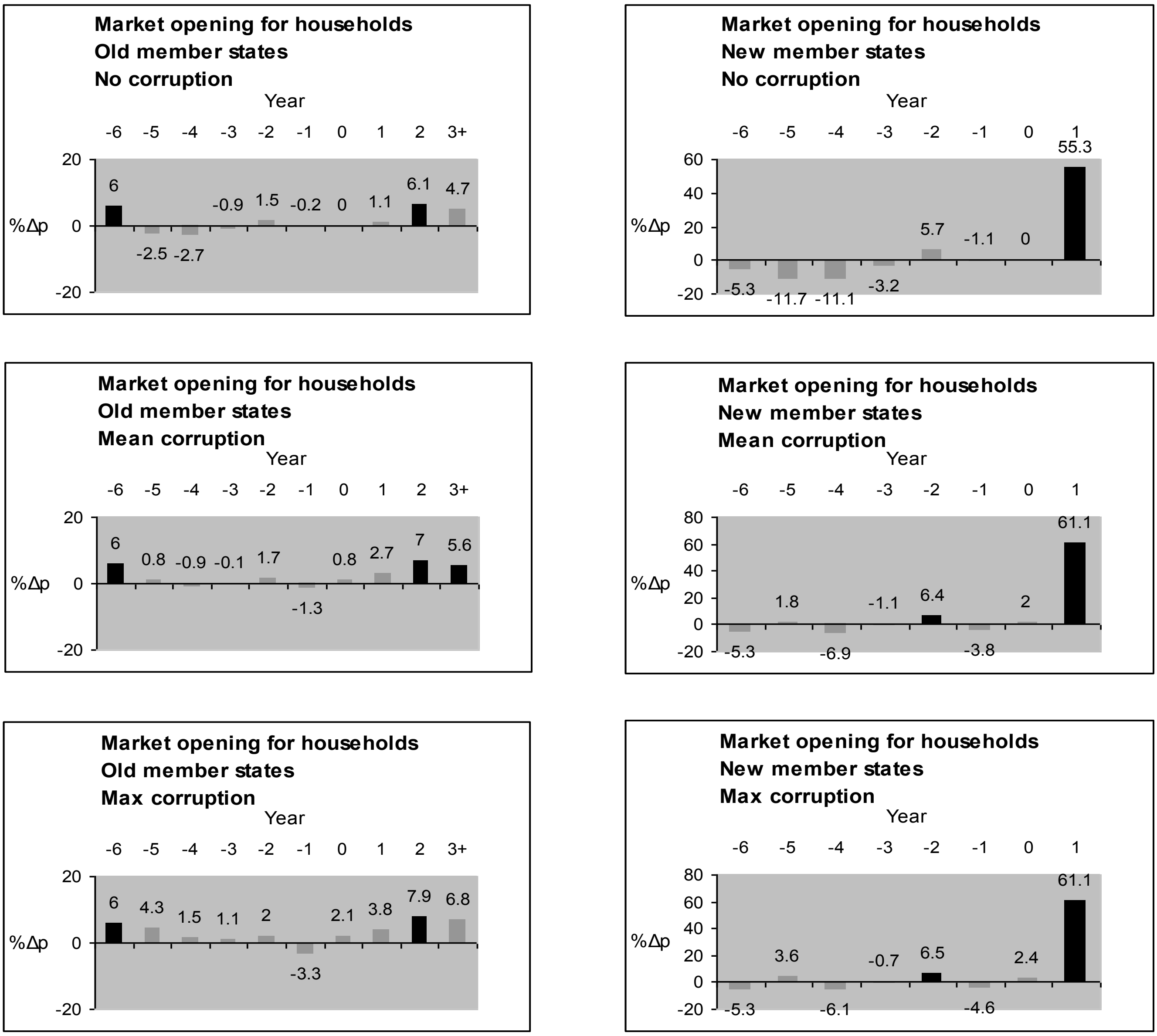



Figure 2: Development of prices for household customers due to market opening. The graphs show how the price of electricity develops with respect to market opening in both old and new member states depending on different levels of institutional quality (corruption). The horizontal axis shows the individual years before, of (0) and after market opening. The vertical axis shows the percentage change in the price. The benchmark year (level 0) is in each case the year of the reform (market opening) in the no-corruption case. The percentages are calculated by summing up the appropriate estimates from the estimated regressions, multiplying them by the corresponding corruption level, calculating the standard errors of these sums and products and then applying the methodology of Kennedy (1981) to calculate the percentages. Estimates that are statistically significant at least at the 10% level are shaded in black, changes that are not statistically significant with respect to the base level are shaded in gray. The graphs show no clear trend for the effect of corruption on the electricity price for households.

Now it is interesting to look at what happens to the price of electricity if ownership unbundling is implemented. First, the hypothesis that ownership unbundling has no effect on the electricity market, i.e., the ownership unbundling dummies are jointly statistically not significant, is rejected for both industrial and household customers (the p-value is in both cases 0.0000), as table 4 shows (line marked "ownership unbundling").

Looking first at the price for industrial customers, the price developments are portrayed on graphs on figure 3 again for old and new member states for the case with no corruption, mean corruption and maximum corruption. In old member states that exhibit no corruption, the price of electricity for industrial customers rises after ownership unbundling is implemented. The top-left graph on figure 3 shows that the price level stays about the same for about four years before ownership unbundling up to the year of ownership unbundling. Then one year after the implementation of ownership unbundling the price increases (positive and statistically significant price change in year 1) and this effect is permanent and equal to approximately 15% (positive and statistically significant price change in year 3+). The effect of corruption on this development of the price in old member states is shown on the middle-left and the bottom-left graphs of figure 3. These graphs show that in old member states with larger corruption there is no statistically significant increase in the prices of electricity for industrial customers. The bottom-left graph even suggests that ownership unbundling might be accompanied by a decrease in the prices of electricity for industrial customers in old member states with the weakest institutional quality. Although the 95% confidence intervals of the estimates for year 0 and years 3+ overlap, these estimates differ at the p=0.003 significance level.

The development of the price of electricity for industrial customers in the new member states follows a similar pattern. One year after the introduction of ownership unbundling the prices start to rise. This increase is the largest in countries without any corruption and persist also in countries with mean as well as maximum corruption. Nevertheless, even in new member states with the worst institutional quality the prices increase after the introduction of ownership unbundling. However, it is questionable how representative these results are, in particular as regards the unbelievably large magnitude of the estimates especially for the last two years, as similar to the results for market opening for households in new member states the number of positive observations is very small for these last years.

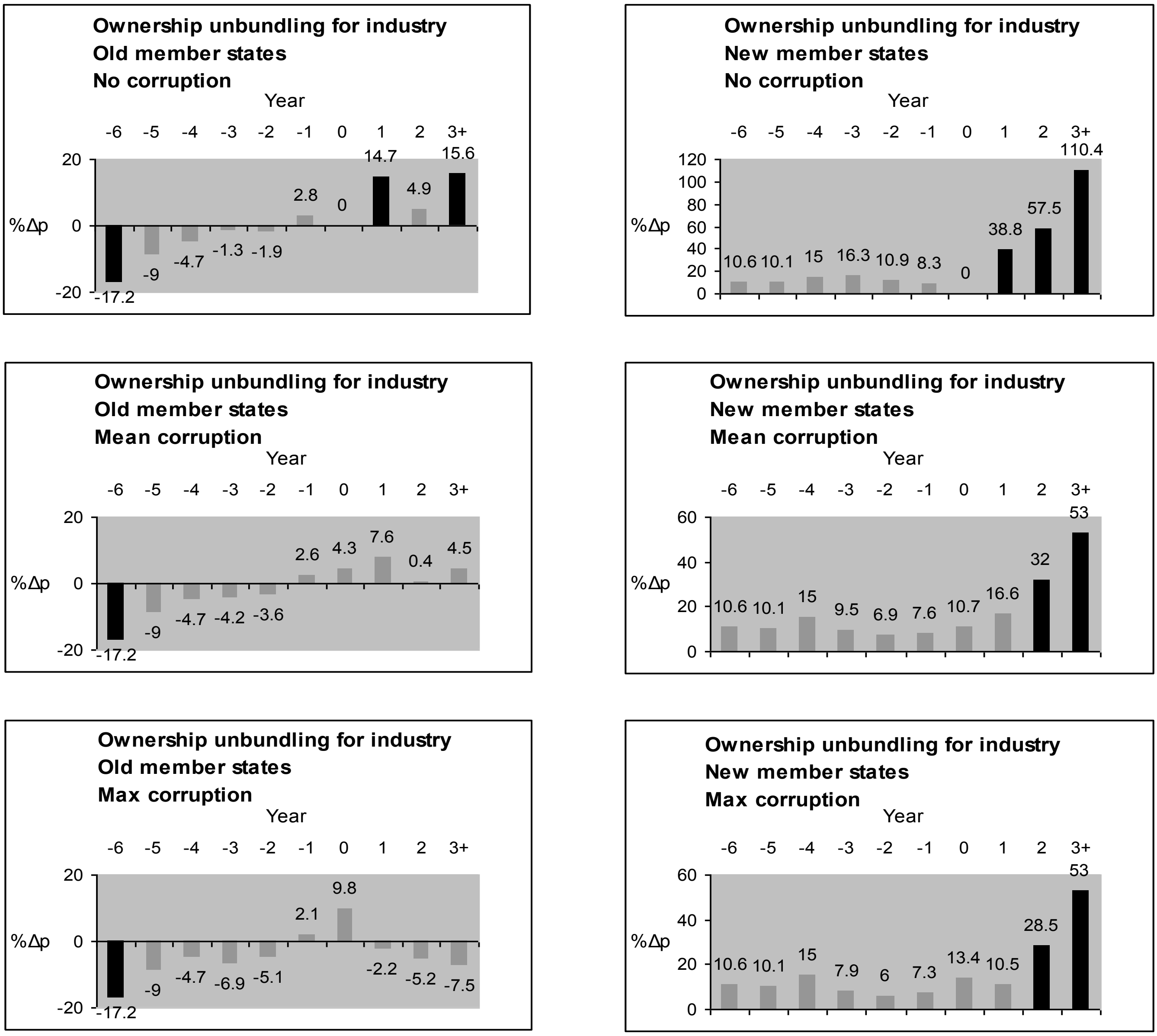



Figure 3: Development of prices for industrial customers due to ownership unbundling. The graphs show how the price of electricity develops with respect to ownership unbundling in both old and new member states depending on different levels of institutional quality (corruption). The horizontal axis shows the individual years before, of (0) and after ownership unbundling. The vertical axis shows the percentage change in the price. The benchmark year (level 0) is in each case the year of the reform (ownership unbundling) in the no-corruption case. The percentages are calculated by summing up the appropriate estimates from the estimated

regressions, multiplying them by the corresponding corruption level, calculating the standard errors of these sums and products and then applying the methodology of Kennedy (1981) to calculate the percentages. Estimates that are statistically significant at least at the 10% level are shaded in black, changes that are not statistically significant with respect to the base level are shaded in gray. The graphs show an increasing trend around ownership unbundling that is mitigated or even reversed in countries with lower institutional quality.

Moving to the development of prices of electricity for households in the years around the introduction of ownership unbundling, the results seem to be similar to industrial customers in particular in the old member states. In old member states with the best institutional quality, the prices increase starting one year after the introduction of ownership unbundling. It is interesting that the data in the top-left graph of figure 4 first shows a decline in the price in the year when ownership unbundling is implemented followed by an increase. Therefore, year –1 should be used to compare with the years after the reform. When such a comparison is made, it shows that the estimate for year –1 is different from the estimate for year 3+ at the p=0.024 significance level, which supports the hypothesis that there is an increase in the price of electricity for households in old member states with the best institutional quality. Again, as the institutional quality declines, this price development changes. While there is no clear price trend in countries with mean institutional quality, in countries with the worst institutional quality the prices of electricity for households decline after ownership unbundling. This decline is quite considerable as the difference between the price three years before ownership unbundling and three and more years after ownership unbundling is around 10%.

It is more difficult to assess the results of the estimation of the price of electricity for households in new member states due to lack of data. In particular, there are no positive observations that could be used to assess the price development one or more years after the introduction of ownership unbundling. Therefore, the issue of the household electricity price development in new member states after ownership unbundling remains open.

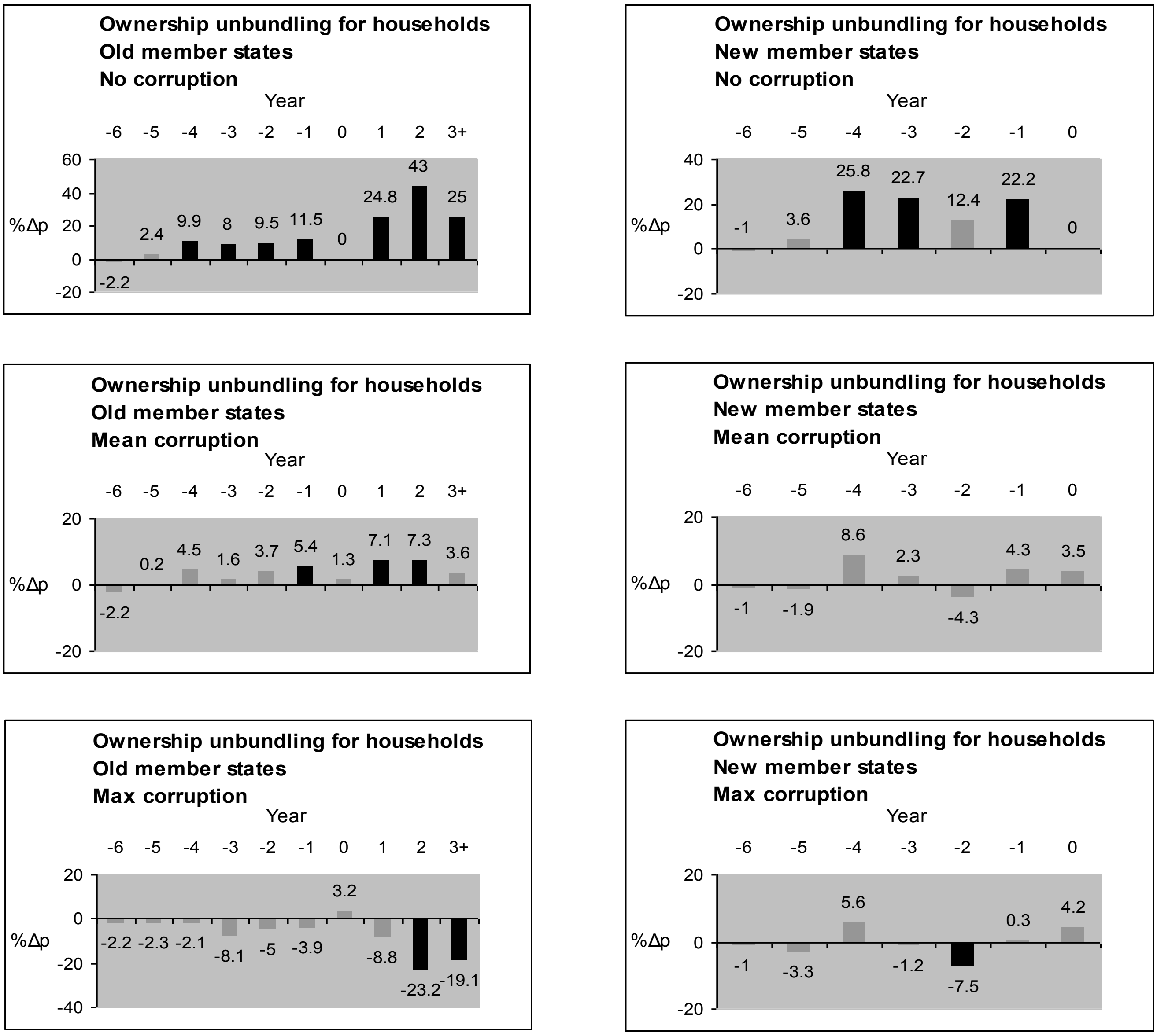



Figure 4: Development of prices for household customers due to ownership unbundling. The graphs show how the price of electricity develops with respect to ownership unbundling in both old and new member states depending on different levels of institutional quality (corruption). The horizontal axis shows the individual years before, of (0) and after ownership unbundling. The vertical axis shows the percentage change in the price. The benchmark year (level 0) is in each case the year of the reform (ownership unbundling) in the no-corruption case. The percentages are calculated by summing up the appropriate estimates from the estimated regressions, multiplying them by the corresponding corruption level, calculating the standard

errors of these sums and products and then applying the methodology of Kennedy (1981) to calculate the percentages. Estimates that are statistically significant at least at the 10% level are shaded in black, changes that are not statistically significant with respect to the base level are shaded in gray. The graphs show an increasing trend after ownership unbundling in old member states, which is mitigated or even reversed in countries with lower institutional quality. Lack of data prohibits any conclusions concerning new member states.

### 3.7.1 Sensitivity Analysis

I have used several other estimation alternatives to check the sensitivity and the robustness of the results of the base equation presented above. The results of these alternative estimations are presented below.

**Price Ratio Equations**

Besides the base estimation, whose results are presented in the previous section, the price ratio equation was also estimated within a SUR system with either the electricity price for industrial customers or households being the other efficiency-enhancing equation. In these two pairs of equations the regressors of the price equation (either the price for industrial customers or the price for households) form a subset of the regressors of the price ratio equation due to which there is no efficiency gain provided by SUR to the price equation. Moreover, the error term of the ratio equation is, according to the theoretical model, equal to the difference between the error term of the price equation for industry and the error term of the price equation for households due to which some information is also lost. Therefore, I use the results of the estimation of the price ratio equation, which has twice as many dummy variables as the base equation, only to check whether the results generally agree with the results of the base estimation. The full results of the estimation are presented in Appendix No. 3. They show that the estimation of the price ratio equation does not in either of the two cases contradict the results of the base estimation and they are in particular robust as regards the increase in the price for both industrial customers and households due to ownership unbundling and how this increase is mitigated or even offset in countries with lower institutional quality.

**Weighted Equations**

The weighting of observations is another matter that has to be considered within the analysis. The obvious question is whether small countries, e.g., Luxembourg, should be given the same weight as large countries, e.g., Germany, in the estimation. Perhaps from the perspective of the overall economic welfare of the European Union the contribution of each country to the European economy should be taken into account. Furthermore, perhaps some more information can be obtained from the regressions if countries in which the prices are more prone to international influence, i.e., very small countries, are given less weight in the regressions. Therefore, I have estimated the same regressions using the gross domestic product as the weight and the full results plus the graphs are presented in Appendix No. 4.

Let us now point out some of the differences between the results of the base estimation and the weighted estimation. The basic effect (with perfect institutional quality) and the effect of corruption differ somewhat in particular for ownership unbundling for industrial customers. Whereas the base regression shows an increase in the price of electricity for industrial customers in old member states after ownership unbundling (i.e., in countries with perfect institutional quality), and this increase is smaller, non-existent or even reversed in countries with lower institutional quality, the weighted regression identifies stagnation with respect to ownership unbundling and an unclear effect of the corruption level (it seems to be a rise followed by a decline in the price). In terms of the price of electricity for households, the base regression shows a stagnation after market opening whereas the weighted regression shows a small increase with a very small change due to institutional quality; the results for ownership unbundling for households from the weighted regression do not contradict the results from the base regression.

Nevertheless, one important observation is that in each investigated combination of countries and reforms (i.e., the total of eight investigated combinations characterized by the three binary variables: reform type [ownership unbundling or market opening], member state [old member state or new member state] and customer [industrial or household]) the effect of reforms tends to be for each of these combinations similar at least for one institutional quality level.

The results of the base estimation and the weighted estimation do not directly contradict each other, there is no estimate that would be positive and statistically significant in one estimation and statistically significant and negative in the other estimation, and a closer look at the weights and the underlying variables shows why there are such differences. It might well be that the weighted regression is unable to distinguish the effects of the institutional quality level due to the high regression weights (largest GDP) assigned to countries with institutional quality close to the mean institutional quality, and on the other hand very low weights assigned to countries that are at or close to the poles of the corruption perceptions index scale. This fact is illustrated in table A1 in Appendix no. 4, which shows that out of the five countries that are given the most weight in the regression summing up to over 70% of the total weight, the highest rank in terms of the distance from the mean corruption perceptions index is UK at rank 10 (1 denoting the most polar country with the largest distance from the overall mean corruption perceptions index and 25 denoting the country that is the closest to the overall mean corruption perceptions index). On the other hand, countries that are very close to the poles of the scale and thus are able to influence the institutional quality estimates the most are given much lower weights in the order of a magnitude of percentages or even below one percent, e.g., small countries with very bad institutional quality like Latvia, Bulgaria, Romania, Slovakia and small countries with very high institutional quality like Finland, Denmark or Sweden. Due to this reason I believe that in order to properly capture the effect of institutional quality it is more appropriate to use the unweighted regressions, which is also more representative of the spirit of the European Union.

**Additional Controls**

I also considered the use of additional control variables, in particular the share of the largest electricity generator, which could be statistically significant as suggested by the estimation of Van Koten and Ortmann (2008), albeit in a different setting. However, the problem with this variable is the availability of reliable data. The Eurostat dataset has many missing values, which substantially reduces the total number of usable observations (from 425 to 254). Moreover, the coefficient for the share of the largest generator is not statistically significant for both industrial customers or households.[41] There are no significant systematic differences between the estimated coefficients from the regression with the largest share included and excluded if the same observations (254) are used. Therefore, instead of sacrificing almost 200 valuable observations I decided not to include the share of the largest power generator as an explanatory variable. The results of the regressions with and without the largest share are presented in Appendix no. 5.

**Jack-knife**

Another method that I used to check the robustness of the results and identify influential countries is the jack-knife method, used to look at how the estimates change when one of the countries is excluded from the estimation. The full results are presented in Appendix No. 6 separately for industrial customers and households. These results are robust in particular for the industrial customers both in terms of the changes in the price with respect to market opening and ownership unbundling. In some cases, the omission of a country changes the statistical significance of the estimates, however, there is no country whose omission would drastically change the results, e.g., from a statistically significant positive estimate to a statistically significant negative estimate or vice versa.

As far as the price for households is concerned, the general effect of market opening is supported while in few cases the effect of the institutional quality changes. Whereas the base case has not identified any significant impact of the institutional quality on prices, when Denmark or Portugal is omitted market opening seems to lead to a slight price increase in countries with poor institutional quality. Conversely, when Finland or Germany are omitted, the effect of corruption is the opposite and in countries with worse institutional qualities the price decline is greater than in less corrupt countries. The results for ownership unbundling exhibit much smaller changes. Only the

[41] The p-value of the estimate of the coefficient for the share of the largest generator is 0.469 and 0.486 for industrial customers and households, respectively.

omission of Finland changes the general effect of ownership unbundling from increasing to stationary, nevertheless, the impact of institutional quality remains unchanged (i.e., ownership unbundling works better in countries with poor institutional quality). Therefore, this robustness check shows that in particular the results for ownership unbundling are very robust for both industrial customers and households.

**No Unbundling**

In order to address the concern whether the estimation is capable of separating the effects of market opening and ownership unbundling, since these two reforms often took place simultaneously or almost simultaneously, I ran the same regressions with only those countries that did not implement ownership unbundling. If the base estimation is successful in separating these two effects, the estimates from the regression with only those countries that did not implement ownership unbundling should not differ significantly from the base estimation. The full results are presented in Appendix No. 7 and indeed they show no systematic difference between the estimates especially for industrial customers. As far as households are concerned the reduced estimation shows a greater decreasing effect of the institutional quality, however, the basic stagnating trend around market opening for countries with high institutional quality is the same. This casts some doubt on the effect of corruption on the development of prices for households around ownership unbundling and suggests that this effect from the base equation (i.e., a mitigating or offsetting effect) might be smaller. Nevertheless, due to the differences in the size of the institutional quality effect in the base estimation for ownership unbundling and in the reduced estimation for market opening (coefficient estimates -1.08, -2.07 and -1.3 for years +1, +2 and +3 of the base equation versus 0.6, 0.78 and 0.67 for years +1, +2 and +3 of the reduced equation), it seems that the latter estimates are not strong enough to offset the estimates from the base equation.

### Estimation Using EC Classification

In my estimation I used regulatory reform data, which I have acquired from various sources (see Section 3.6 and Appendix No. 2 for the description) and which I believe are more accurate than the data presented in the benchmark reports of the European Commission. This concerns the question of whether Finland, Lithuania and Ireland conform to the definition of ownership unbundling claimed by the EC reports. Consequently, I estimated the same equations using the classification provided by the EC to see how the results might change. The results do not significantly change for the estimates for market opening for industrial customers and the change for households consists of a small increasing trend after market opening and a mitigating effect of the institutional quality. As expected, the impact of this classification on the ownership unbundling estimates are larger. The prices for industrial customers exhibit a smaller increase or even stagnation after ownership unbundling in old member states, the increase in new member states is also smaller and consequently the offsetting effect of the institutional quality is also smaller or even nonexistent. The price for households follows a stagnating trend with no long-term effect of the institutional quality. The full results are presented in a table in Appendix No. 8.

### 3.7.2 Discussion of the Results

The results of the estimation unveil some important relationships that drive the development of the prices of electricity for both industrial customers and households after market opening and ownership unbundling. Not only do they illustrate that prices change due to the opening of the market in electricity; they also show that ownership unbundling plays a significant role in this process. Moreover, the institutional quality of a particular country, as captured by the corruption perceptions index, helps explain the price developments when regulatory reforms are implemented.

Looking at the parameter estimates for the market opening variables for industrial customers, there is a clear relationship between the price change and the corruption perception index:

$$\Delta p^{MO} = a^{MO} + b^{MO} * TICPI ,$$

where $\Delta p^{MO}$ is the change in the price of electricity due solely to market opening, $a^{MO}$ is negative, $b^{MO}$ is positive and *TICPI* is the corruption perceptions index published by Transparency International adjusted using the transformation defined in Appendix No. 1 (i.e., higher *TICPI* means higher corruption). Even for countries with the highest corruption the price change is negative (i.e., price decrease). This relationship seems to hold for the price for industrial customers in both old and new member states, however, it is not valid for the price of households for which the estimation has identified no significant effect of market opening.

On the other hand, the effect of ownership unbundling seems to work in exactly the opposite direction relative to the corruption perceptions index for both industrial customers and households:

$$\Delta p^{OU} = a^{OU} + b^{OU} * TICPI ,$$

where $\Delta p^{OU}$ is the change in the price of electricity for industrial customers due to ownership unbundling, $a^{OU}$ is positive and $b^{OU}$ is negative. This relationship holds for both industrial customers and households in the old member states and the term capturing the lower institutional quality seems to be strong enough to offset the basic price increase due to ownership unbundling. In the new member states this relationship seems to hold only for industrial customers whereas the corruption term is not strong enough to offset the price increase due to ownership unbundling. Concerning the electricity prices for households in new member states it is difficult to make any conclusions due to lack of data.

The two relationships above imply that countries with good institutional quality, i.e., with a high corruption perceptions index, did a better job in the first place when they were implementing the market opening even without ownership unbundling. In particular, in these countries the benefits of market opening are realized for industrial customers already without ownership unbundling and ownership unbundling as such only leads to an increase in the price of electricity for both industrial customers and households. There are several possible explanations of such a price increase after ownership unbundling. Firstly, the separation of the transmission system operator from the generator/supplier requires some restructuring costs, which are projected into the price of electricity, despite the fact that this effect should be only temporary. Then there are also some long-term effects such as possibly lower efficiency resulting from more complicated information transfer between the generators/suppliers and the transmission system operator. Another possibility might be that despite the fact that ownership unbundling provides a fairer environment for competition, the number of players on the market might not be sufficient yet and it might take some more time for competition to develop, so this competition is not yet captured in the existing data.[42]

However, the situation differs for countries with poor institutional quality, where market opening without ownership unbundling leads to a smaller reduction in the price of electricity for industrial customers. In these countries with lower institutional quality the costs of ownership unbundling are offset by the benefits brought about most likely by a more competitive environment on the electricity market. This is in particular true in the old member states. Therefore, in countries with low institutional quality, ownership unbundling seems to be a competition-enhancing measure that eliminates the problems of the imperfect separation of the transmission system operator and electricity generators/suppliers.

## 3.8 Conclusion

In this chapter I studied the effect of electricity market liberalization—in particular the effect of market opening and the ownership unbundling of the transmission system operator—in the member states of the European Union on the prices of electricity for both industrial customers and households. This research was motivated by the recent

[42] The construction of a new power plant takes years or even decades in the case of a nuclear power plant from the first initiation to completion.

debate of the European Commission, European Parliament and the Council of the European Union resulting in the introduction of new energy legislation requiring a stricter form of the separation of transmission system operation from other activities, whereas ownership unbundling is the most stringent of the available options. In my estimation I find that ownership unbundling plays a role in the development of prices of electricity, however, this effect differs depending on the institutional quality of the individual countries. I find that countries that are the least corrupt do not benefit at all from ownership unbundling. On the contrary, in these countries ownership unbundling brings only extra costs, most likely since market opening was implemented well in the first place given the high institutional quality. On the other hand, the results of the estimation show that in countries with more corruption market opening still leaves some potential for a price decline and the ownership unbundling of the electricity transmission system operator might help to improve the situation.

Therefore, considering the above-mentioned results, which differ based on the institutional quality of various countries, the new package of energy liberalization legislation, which allows several options for a more perfect separation of the transmission system operator from the generator/supplier, is a good idea. It gives the countries with high institutional quality, where market opening as such seems to work best especially for industrial customers, the choice not to fully separate the transmission system operator since ownership unbundling would bring only extra costs. On the other hand, ownership unbundling is one of the options of the new legislation and it should be the preferred option especially for old member states with poor institutional quality. According to the results of the estimation, in these states ownership unbundling could considerably reduce the price of electricity especially for households by 10% or more.

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## Appendix 1 – Construction of Regulatory Reform Variables

For each of the two regulatory reform aspects, market opening and ownership unbundling, I define up to six dummies corresponding to the years before the reform and up to three dummies corresponding to the years after the reform. The first and the last dummies include also all the years before/after the period covered by the other dummies. The base group (no dummy) is the year of the reform. In some cases I do not include the whole range of dummies due to lack of data (e.g., for ownership unbundling for households in new member states). These dummies are also interacted with the new member state variable to account for possible differing effects in new and old member states.

Moreover, I interact these reform dummies with the corruption perceptions index provided by Transparency International. In this case I also include an interaction term for the year of the reform, to account for the effect of institutional quality in the year of the reform, and I omit the first dummy, i.e., six years and more ahead, which should not be statistically significant. Before multiplying the regulatory reform dummies by the corruption perceptions index to get the interaction terms I adjust it to simplify the interpretation of the coefficient:

$$TICPI_{new} = \frac{10 - TICPI_{reported}}{10} \ .$$

## Appendix 2 – Description of Data Sources

*Data on market opening and unbundling*

Data on market opening and ownership unbundling is unfortunately not available from a single source. Therefore, many different sources differing depending on the country concerned were used. In general, the basic information was obtained from Benchmarking Reports of the Commission of the European Communities on the progress in the development of internal energy markets (see the list below). However, the data was often incomplete (short time series) or imprecise. Another general source of information on market opening consisted of National Reports provided by the European Energy Regulators CEER & ERGEG at their website http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS, originally submitted by the member states to the European Commission. The data from these two general sources was then compared with information obtained from national regulators, energy companies, ministries, etc. Therefore, the data for individual countries comes from disparate sources that are listed for each country in the table below.

*Benchmarking Reports*

Commission of the European Communities: First Benchmarking Report on the Implementation of the Internal Electricity and Gas market, Brussels, December 3, 2001, http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/benchmarking_reports/2001_report_bencmarking.pdf

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Commission of the European Communities: Third Benchmarking Report on the Implementation of the Internal Electricity and Gas market, Brussels, December March 1, 2004, http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/benchmarking_reports/2003_report_bencmarking.pdf

Commission of the European Communities: Report from the Commission on the Implementation of the Gas and Electricity Internal Market, and its technical annex, Brussels, January 5, 2005, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52004DC0863:EN:NOT, http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/benchmarking_reports/2004_report_bencmarking_annex.pdf

Commission of the European Communities: Report on Progress in Creating the Internal Gas and Electricity Market, and its technical annex, Brussels, November 15, 2005, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52005DC0568:EN:NOT, http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/benchmarking_reports/2005_report_bencmarking.pdf

Commission of the European Communities: Prospects for the Internal Gas and Electricity Market, and its Implementation Report, Brussels, January 10, 2007, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0841:FIN:EN:PDF, http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/benchmarking_reports/2006_internal_market_country_reviews.pdf

Commission of the European Communities: Progress in Creating the Internal Gas and Electricity Market, and its Technical Annex, Brussels, April 15, 2008, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0192:FIN:EN:PDF, http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/benchmarking_reports/2007_report_bencmarking_annex.pdf

Commission of the European Communities: Report on Progress in Creating the Internal Gas and Electricity Market, and its Technical Annex, Brussels, March 11, 2009, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0115:FIN:EN:PDF, http://ec.europa.eu/energy/gas_electricity/doc/2008_52009dc0115_technical_annex.pdf

Table of Data Sources

The following table presents information about the sources of information on unbundling and market opening used in this chapter. Where applicable, the table also provides the web address and the date when the data was extracted from this address.

| Country | Source<br>Location<br>Date of extraction |
|---|---|
| Austria | The Austrian energy act EIWOG 1998, its amendment from 2000<br>www.e-control.at<br>November 18, 2008 |
| Belgium | Activity Report of the Belgian TSO Elia for 2001, Activity Report of the Belgian TSO Elia for 2007<br>http://www.elia.be/repository/pages/89a8087f9f8141268d3656cf1827474c.aspx#<br>January 23, 2009<br><br>Website of the power company Centrica<br>http://www.centrica.com/index.asp?pageid=39&newsid=67<br>January 23, 2009 |
| Bulgaria | Peter Ganev : Bulgarian Electricity Market Restructuring,<br>Institute for Market Economics, Bulgaria, CCP Working Paper 08-8<br>www.uea.ac.uk/polopoly_fs/1.104661!ccp08-8.pdf<br><br>Rules on the conditions and procedure for access to the transmission system and distribution networks<br>http://www.tso.bg/Uploads/File/eto/en/pdf/Rules_for_Access_to_the_Electricity_Grids.pdf<br>February 28, 2009 |
| Czech Republic | Annual Reports of the Czech TSO for 2001 and 2006,<br>http://www.ceps.cz/detail.asp?cepsmenu=1&IDP=62&PDM2=24&PDM3=0&PDM4=0<br>http://www.ceps.cz/detail.asp?cepsmenu=1&IDP=62&PDM2=24&PDM3=0&PDM4=0<br><br>Website of ČEZ<br>http://www.cez.cz/cs/o-spolecnosti/cez/struktura-akcionaru.html<br>November 7, 2008<br><br>Czech Energy Act,<br>http://www.eru.cz<br>November 7, 2009 |

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|---|---|
| Denmark | Act no. 1384 of December 20, 2004 – Act on Energinet Danmark<br>http://www.energinet.dk/NR/rdonlyres/276B7459-243C-4A83-BE5F-0FCFFC1BC0CF/0/Act_on_Energinetdk.pdf<br>January 23, 2009<br><br>Energy supply act 375 of june 2, 1999<br>http://www.juraportal.dk/links/010/010/040/020/?lang=en<br>January 23, 2009 |
| Estonia | Website of the Estonian TSO OÜ Põhivõrk<br>http://www.pohivork.ee/index.php?id=286&L=1<br>November 17, 2008 |
| Finland | Annual report of the Finish TSO Fingrid 2007<br>http://www.fingrid.fi/attachments/en/investors/reports/financial/fingrid_tp_07_en.pdf<br>January 29, 2009<br><br>Website of the Energy Market Authority<br>http://www.energiamarkkinavirasto.fi/data.asp?articleid=230&pgid=127<br>January 29, 2009<br><br>Eurostat: Customer switching and renegotiating in the electricity market in Finland, 2001, Contract number 200245501007<br>http://www.energia.fi/en/publications/customerswitchingandrenegotiating.pdf<br>January 29, 2009 |
| France | |
| Germany | German Energy Act Energiewirtschaftsgesetz (EnWG) 1998 and Energiewirtschaftsgesetz (EnWG) 2005<br>http://www.energieverbraucher.de/de/Allgemein/Service/Gesetze/site__452/<br>November 18, 2008 |
| Greece | Ekaterini Iliadou: Electricity Sector Reform in Greece, CCP Working Paper 08-9<br>http://www.uea.ac.uk/polopoly_fs/1.104662!ccp08-9.pdf<br>February 28, 2009 |
| Hungary | Annual report of the Hungarian TSO FGSZ for 2006,<br>http://www.fgsz.hu/en/documents/documents/annual-reports.html<br>February 28, 2009 |
| Ireland | Website of the power company Electicity Supply Board<br>http://esb.ie/main/home/index.jsp<br>November 20, 2008<br><br>Website of the Irish TSO EirGrid<br>http://www.eirgrid.com<br>November 20, 2008 |
| Italy | Annual report of the Italian TSO Terna for 2001,<br>http://www.terna.it/default/home_en/investor_relations_en/reports/reports_2001.aspx<br>February 28, 2009 |

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|---|---|
| Latvia | Annual report of the power company Latvenergo 2005<br>http://www.latvenergo.lv/portal/page?_pageid=80,304750&_dad=portal&_schema=PORTAL<br>November 18, 2008<br><br>Euroelectric-UCTE: 3rd systint report, 2006.<br>http://www.ucte.org/resources/publications/otherreports/<br>November 18, 2008 |
| Lithuania | 2007 annual report of Lietuvos Energia AB<br>http://www.lpc.lt/repository/ataskaitos/ANG_2007_ataskaita.pdf<br>November 18, 2008<br><br>Lithuanian Law on Electricity, 20 July, 2000, No. VIII –1881 as amended by 26 June, 2001, No. IX-408<br>http://www.regula.lt/index.php?750663183<br>November 18, 2008 |
| Luxembourg | International Energy Agency: Energy policies of IEA countries, Luxembourg review 2004<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1471<br>March 1, 2009 |
| Netherlands | Annual report of the Dutch TSO TenneT for 2001<br>http://www.tennet.org/english/tennet/publications/annual_report/annual_report_2001.aspx<br>March 1, 2009<br><br>Act of 2 July 1998 Providing Rules in Relation to the Production, Transmission and Supply of Electricity<br>http://www.nma-dte.nl/images/Electricity%20act%201998_tcm7-10720.pdf<br>March 1, 2009<br><br>Website of the Dutch Office of Energy Regulation Eneriekamer<br>http://www.energiekamer.nl<br>March 1, 2009 |
| Poland | Annual reports of the Polish TSO, PSE-Operator for 2004 and 2006<br>http://www.pse-operator.pl/index.php?modul=10&gid=116<br>November 17, 2008<br><br>Laurent Jouret: Electricity Market in Poland – Changes on the Horizon, ING Bank, April 2006,<br>http://www.ingbank.pl/_itemserver/wholesale/raporty/ING_Raport_Energetyczny_eng.pdf<br>November 17, 2008<br><br>Website of the energy market agency Agencja Rynku Energii S.A.<br>http://polishenergy.cire.pl/market.html<br>November 17, 2008 |

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|---|---|
| Portugal | Website of the Portugese TSO REN<br>http://www.ren.pt/vEN/RENGroup/ShareholderStructure/Pages/grupo-ren_shareholder-structure.aspx<br>March 1, 2009<br><br>International Energy Agency, Energy policies of IEA countries, Portugal 2000 review, Portugal 2004 review<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1148<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1470<br>March 1, 2009 |
| Romania | Annual report of the Romanian TSO Transelectrica for 2003<br>http://www.transelectrica.ro/en.php<br>February 28, 2009 |
| Slovakia | Website of the Slovak TSO SEPS<br>http://www.sepsas.sk/seps/<br>November 7, 2008<br><br>Public notice of the Ministry of Economy 562/2001<br>www.okonet.sk/Vseobecna%20legislativa/**562**-2001.pdf<br>November 7, 2008<br><br>Public notice of the Ministry of Economy 548/2002<br>www.okonet.sk/Vseobecna%20legislativa/**548**-2002.pdf<br>November 7, 2008<br><br>Act no. 656/2004<br>http://www.zse.sk/contents/documents/zakon_656_2004.pdf<br>November 7, 2008 |
| Slovenia | Website of the power company Gen Energija<br>http://www.gen-energija.si/strani.php?page_id=104<br>November 17, 2008 |
| Spain | Annual reports of the Spanish TSO REE for 1998, 2000<br>http://www.ree.es/ingles/accionistas/informe_anual_1998.asp<br>http://www.ree.es/ingles/accionistas/pdf/resultados_ree_0106_eng.pdf<br>March 1, 2009<br><br>International Energy Agency, Energy policies of IEA countries, Spain 2005 review, Spain 2001 review<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1570<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1123<br>March 1, 2009 |
| Sweden | International Energy Agency, Energy policies of IEA countries, Sweden 1994 review, Sweden 1996 review, Sweden 2000 review<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1331<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1379<br>http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1149<br>March 1, 2009 |

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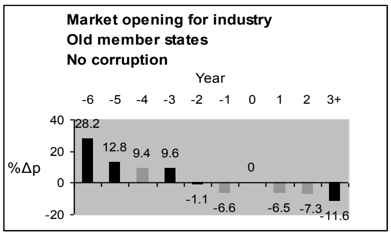
|---|---|
| United Kingdom | Website of the TSO National Grid<br>http://www.nationalgrid.com/uk/About/history/<br>December 15, 2008<br><br>Website of EnergyLinx, a price comparison company<br>http://www.energylinx.co.uk/uk_energy_industry.htm<br>December 15, 2008 |

# Appendix 3 – Estimation of the Price Ratio Equation

| System of equations | | SUR for industry and households (BASE) | | | | SUR for industry and price ratio | | | | SUR for households and price ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equation | | Industry | | Households | | Ratio | | | | Ratio | | | |
| Customer | | Industry | | Households | | Industry | | Households | | Industry | | Households | |
| R2 | | 0.8355 | | 0.9337 | | 0.8819 | | 0.8819 | | 0.8969 | | 0.8969 | |
| Obs | | 425 | | 425 | | 425 | | 425 | | 425 | | 425 | |
| | | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Market opening | -6+ | 0.3597*** | 0.049 | 0.0585** | 0.023 | 0.3288*** | 0.053 | -0.0251 | 0.027 | 0.3503*** | 0.059 | 0.0161 | 0.038 |
| | -5 | 0.2925*** | 0.051 | -0.0249 | 0.034 | 0.2761*** | 0.054 | -0.1056*** | 0.036 | 0.2688*** | 0.058 | -0.1249** | 0.051 |
| | -4 | 0.2125*** | 0.048 | -0.0266 | 0.034 | 0.1998*** | 0.051 | -0.0872** | 0.036 | 0.1874*** | 0.055 | -0.1299** | 0.051 |
| | -3 | 0.1603*** | 0.047 | -0.0079 | 0.037 | 0.1580*** | 0.048 | -0.0603 | 0.039 | 0.1179** | 0.050 | -0.1034* | 0.055 |
| | -2 | 0.0858* | 0.048 | 0.0150 | 0.031 | 0.0968** | 0.049 | -0.0014 | 0.034 | 0.0475 | 0.052 | -0.0081 | 0.047 |
| | -1 | 0.0190 | 0.049 | -0.0017 | 0.033 | 0.0167 | 0.050 | 0.0063 | 0.035 | -0.0290 | 0.053 | 0.0079 | 0.050 |
| | 1 | -0.0329 | 0.044 | 0.0117 | 0.036 | -0.0101 | 0.047 | 0.0552 | 0.034 | 0.0126 | 0.052 | 0.1208** | 0.048 |
| | 2 | -0.0074 | 0.047 | 0.0595* | 0.033 | 0.0257 | 0.049 | 0.0671** | 0.033 | 0.0875 | 0.055 | 0.1885*** | 0.046 |
| | 3+ | -0.0906* | 0.047 | 0.0467 | 0.034 | -0.0022 | 0.051 | 0.0633* | 0.034 | 0.0890 | 0.059 | 0.0785* | 0.047 |
| MO x new member state | -6+ | | | -0.1117** | 0.046 | | | 0.1809*** | 0.053 | | | 0.1031 | 0.074 |
| | -5 | | | -0.0965 | 0.066 | | | -0.0386 | 0.060 | | | -0.0284 | 0.085 |
| | -4 | 0.0476 | 0.070 | -0.0877 | 0.065 | 0.2935*** | 0.073 | -0.0750 | 0.059 | 0.1669** | 0.079 | -0.0717 | 0.084 |
| | -3 | -0.0063 | 0.061 | -0.0224 | 0.050 | 0.2000*** | 0.065 | 0.0118 | 0.046 | 0.1137 | 0.071 | 0.0622 | 0.066 |
| | -2 | 0.0010 | 0.059 | 0.0421 | 0.048 | 0.0336 | 0.060 | -0.0323 | 0.045 | -0.0074 | 0.063 | 0.0199 | 0.063 |
| | -1 | -0.0238 | 0.056 | -0.0069 | 0.050 | -0.0423 | 0.056 | -0.0457 | 0.047 | -0.0778 | 0.058 | 0.0425 | 0.067 |
| | 1 | -0.0167 | 0.053 | 0.4367*** | 0.119 | -0.0780 | 0.053 | | | -0.0792 | 0.056 | -0.1815 | 0.165 |
| | 2 | -0.0016 | 0.056 | | | -0.0355 | 0.056 | | | -0.0344 | 0.059 | | |
| | 3+ | 0.0111 | 0.063 | | | -0.0267 | 0.064 | | | -0.0755 | 0.065 | | |
| MO x corruption percept. index | -5 | 0.0231 | 0.111 | 0.1168 | 0.102 | 0.0112 | 0.110 | 0.2753*** | 0.098 | 0.0826 | 0.103 | 0.3426** | 0.139 |
| | -4 | 0.1942* | 0.101 | 0.0742 | 0.103 | 0.1955** | 0.100 | 0.2235** | 0.107 | 0.2585*** | 0.094 | 0.3063** | 0.151 |
| | -3 | 0.3323*** | 0.109 | 0.0342 | 0.116 | 0.3257*** | 0.109 | 0.1838 | 0.118 | 0.4245*** | 0.111 | 0.1813 | 0.167 |
| | -2 | 0.3988*** | 0.123 | 0.0098 | 0.107 | 0.4929*** | 0.126 | 0.0876 | 0.110 | 0.5666*** | 0.134 | 0.0063 | 0.155 |
| | -1 | 0.4942*** | 0.133 | -0.0547 | 0.119 | 0.6641*** | 0.140 | -0.0994 | 0.121 | 0.7276*** | 0.154 | -0.1746 | 0.170 |
| | 0 | 0.4750*** | 0.135 | 0.0386 | 0.050 | 0.6554*** | 0.138 | 0.0293 | 0.052 | 0.5836*** | 0.147 | 0.0294 | 0.073 |
| | 1 | 0.4311*** | 0.139 | 0.0778 | 0.181 | 0.5628*** | 0.143 | -0.1687 | 0.175 | 0.4620*** | 0.154 | -0.1426 | 0.247 |
| | 2 | 0.2919** | 0.145 | 0.0495 | 0.161 | 0.3593** | 0.150 | -0.0612 | 0.159 | 0.2207 | 0.162 | 0.0210 | 0.225 |
| | 3+ | 0.5225*** | 0.149 | 0.0609 | 0.173 | 0.5129*** | 0.153 | 0.1070 | 0.177 | 0.3996** | 0.162 | 0.7019*** | 0.250 |
| Ownership unbundling | -6+ | -0.1866*** | 0.057 | -0.0219 | 0.026 | -0.1142* | 0.066 | -0.0253 | 0.049 | -0.2515*** | 0.076 | -0.1282* | 0.070 |
| | -5 | -0.0926 | 0.060 | 0.0244 | 0.047 | -0.0452 | 0.064 | -0.0326 | 0.057 | -0.1543** | 0.070 | -0.0540 | 0.080 |
| | -4 | -0.0466 | 0.057 | 0.0958** | 0.045 | -0.0037 | 0.060 | -0.0046 | 0.051 | -0.0866 | 0.065 | 0.0165 | 0.073 |
| | -3 | -0.0109 | 0.065 | 0.0784* | 0.046 | 0.0101 | 0.067 | -0.0226 | 0.055 | -0.0502 | 0.073 | -0.0167 | 0.077 |
| | -2 | -0.0171 | 0.064 | 0.0915** | 0.041 | -0.0659 | 0.066 | -0.0559 | 0.051 | -0.1281* | 0.071 | -0.0474 | 0.072 |
| | -1 | 0.0295 | 0.061 | 0.1102** | 0.044 | 0.0194 | 0.063 | 0.0427 | 0.047 | -0.0357 | 0.069 | 0.0359 | 0.066 |
| | 1 | 0.1389*** | 0.053 | 0.2227*** | 0.051 | 0.1064** | 0.053 | 0.0936* | 0.049 | 0.0567 | 0.056 | 0.1350* | 0.070 |
| | 2 | 0.0495 | 0.060 | 0.3589*** | 0.045 | 0.0085 | 0.061 | 0.2207*** | 0.045 | -0.0503 | 0.064 | 0.3051*** | 0.063 |
| | 3+ | 0.1465** | 0.060 | 0.2243*** | 0.046 | 0.1247** | 0.063 | 0.1237*** | 0.044 | 0.0882 | 0.070 | 0.1204* | 0.063 |
| OU x new member state | -6+ | 0.2930*** | 0.088 | 0.0136 | 0.056 | 0.4288*** | 0.111 | 0.0312 | 0.081 | 0.6396*** | 0.135 | 0.2129* | 0.114 |
| | -5 | 0.1945** | 0.088 | 0.0162 | 0.082 | 0.3941*** | 0.108 | 0.1175 | 0.086 | 0.5645*** | 0.128 | 0.1965 | 0.122 |
| | -4 | 0.1914** | 0.080 | 0.1390 | 0.086 | 0.3279*** | 0.092 | 0.2074** | 0.085 | 0.4465*** | 0.105 | 0.2702** | 0.120 |
| | -3 | 0.1681** | 0.078 | 0.1307* | 0.071 | 0.2302*** | 0.080 | 0.1577** | 0.070 | 0.3014*** | 0.084 | 0.1531 | 0.098 |
| | -2 | 0.1266* | 0.073 | 0.0290 | 0.066 | 0.2067*** | 0.073 | 0.1131* | 0.064 | 0.2312*** | 0.076 | 0.0281 | 0.090 |
| | -1 | 0.0552 | 0.068 | 0.0946 | 0.071 | 0.0827 | 0.069 | 0.0610 | 0.069 | 0.0730 | 0.071 | -0.0225 | 0.098 |
| | 1 | 0.1937*** | 0.073 | | | 0.2226*** | 0.073 | | | 0.2290*** | 0.073 | | |
| | 2 | 0.4184*** | 0.127 | | | 0.3504*** | 0.128 | | | 0.2853** | 0.128 | | |
| | 3+ | 0.6101*** | 0.126 | | | 0.2466* | 0.141 | | | | | | |
| OU x corruption percept. index | -5 | | | -0.0965 | 0.138 | | | -0.0487 | 0.135 | | | -0.0966 | 0.191 |
| | -4 | | | -0.2460* | 0.142 | | | -0.1063 | 0.143 | | | -0.1946 | 0.202 |
| | -3 | -0.1017 | 0.142 | -0.3105** | 0.153 | -0.0301 | 0.144 | -0.2211 | 0.165 | -0.0078 | 0.151 | -0.1398 | 0.233 |
| | -2 | -0.0626 | 0.154 | -0.2825** | 0.139 | 0.1291 | 0.157 | -0.0575 | 0.154 | 0.2168 | 0.169 | 0.0874 | 0.217 |
| | -1 | -0.0113 | 0.165 | -0.2908* | 0.158 | 0.1525 | 0.168 | -0.0570 | 0.166 | 0.2721 | 0.177 | 0.0229 | 0.234 |
| | 0 | 0.1901 | 0.171 | 0.0673 | 0.067 | 0.3450** | 0.172 | 0.0459 | 0.068 | 0.3013* | 0.174 | -0.0344 | 0.096 |
| | 1 | -0.3262 | 0.207 | -1.0800*** | 0.324 | -0.1253 | 0.209 | -0.2903 | 0.307 | -0.0962 | 0.216 | -0.9389** | 0.434 |
| | 2 | -0.3312 | 0.309 | -2.0720*** | 0.263 | 0.0618 | 0.312 | -1.2205*** | 0.258 | 0.1582 | 0.319 | -2.5855*** | 0.365 |
| | 3+ | -0.6715** | 0.307 | -1.3159*** | 0.251 | -0.2004 | 0.319 | -0.8703*** | 0.251 | -0.4781 | 0.348 | -1.7325*** | 0.355 |
| log(gdp) | | 0.4120*** | (0.135 | 0.4486*** | (0.096 | | | 0.0996 | (0.105 | | | -0.0240 | (0.103 |
| log(cpi) | | 0.6179** | (0.240 | 0.2149 | (0.166 | | | 0.2289 | (0.195 | | | 0.2163 | (0.194 |
| log(price of gas) | | 0.1772*** | (0.038 | 0.1027*** | (0.028 | | | 0.0878*** | (0.029 | | | 0.1025*** | (0.028 |
| log(price of oil) | | 0.0120 | (0.029 | -0.0295 | (0.021 | | | 0.0318 | (0.022 | | | 0.0454** | (0.022 |
| hydro share | | -0.0197 | (0.200 | -0.3766** | (0.148 | | | 0.2857* | (0.149 | | | 0.2907** | (0.146 |
| nuclear share | | 1.0271** | (0.398 | 0.5777** | (0.283 | | | 0.4632 | (0.319 | | | 0.4348 | (0.318 |
| trend | | 0.0014 | (0.003 | -0.0024 | (0.002 | | | 0.0036 | (0.003 | | | 0.0026 | (0.003 |

## Appendix 4 – Weighted Estimation

| System of equations | | SUR for industry and households | | | | Weighted SUR for industry and households | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equation | | Industry | | Households | | Industry | | Households | |
| Customer group | | Industry | | Households | | Industry | | Households | |
| R2 | | 0.8355 | | 0.9337 | | 0.7793 | | 0.9113 | |
| Obs | | 425 | | 425 | | 425 | | 425 | |
| | | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Market opening | -6+ | 0.3597*** | 0.049 | 0.0585** | 0.023 | 0.2497*** | 0.053 | 0.0166 | 0.019 |
| | -5 | 0.2925*** | 0.051 | -0.0249 | 0.034 | 0.1225** | 0.060 | -0.0800* | 0.043 |
| | -4 | 0.2125*** | 0.048 | -0.0266 | 0.034 | 0.0916 | 0.056 | -0.0645 | 0.040 |
| | -3 | 0.1603*** | 0.047 | -0.0079 | 0.037 | 0.0927* | 0.051 | 0.0263 | 0.040 |
| | -2 | 0.0858* | 0.048 | 0.0150 | 0.031 | -0.0103 | 0.050 | 0.0102 | 0.035 |
| | -1 | 0.0190 | 0.049 | -0.0017 | 0.033 | -0.0674 | 0.049 | 0.0244 | 0.037 |
| | 1 | -0.0329 | 0.044 | 0.0117 | 0.036 | -0.0663 | 0.047 | 0.0846* | 0.043 |
| | 2 | -0.0074 | 0.047 | 0.0595* | 0.033 | -0.0742 | 0.053 | 0.1037*** | 0.040 |
| | 3+ | -0.0906* | 0.047 | 0.0467 | 0.034 | -0.1214** | 0.052 | 0.1517*** | 0.037 |
| MO x new member state | -6+ | | | -0.1117** | 0.046 | | | -0.1260 | 0.104 |
| | -5 | | | -0.0965 | 0.066 | | | -0.1223 | 0.131 |
| | -4 | 0.0476 | 0.070 | -0.0877 | 0.065 | -0.0556 | 0.134 | -0.0763 | 0.127 |
| | -3 | -0.0063 | 0.061 | -0.0224 | 0.050 | -0.0775 | 0.121 | -0.0066 | 0.101 |
| | -2 | 0.0010 | 0.059 | 0.0421 | 0.048 | -0.0929 | 0.114 | 0.0408 | 0.098 |
| | -1 | -0.0238 | 0.056 | -0.0069 | 0.050 | -0.0921 | 0.098 | 0.0543 | 0.098 |
| | 1 | -0.0167 | 0.053 | 0.4367*** | 0.119 | -0.0830 | 0.099 | 0.3082** | 0.153 |
| | 2 | -0.0016 | 0.056 | | | -0.0442 | 0.111 | | |
| | 3+ | 0.0111 | 0.063 | | | -0.1664 | 0.116 | | |
| MO x corruption perceptions index | -5 | 0.0231 | 0.111 | 0.1168 | 0.102 | 0.1628 | 0.118 | 0.2538** | 0.123 |
| | -4 | 0.1942* | 0.101 | 0.0742 | 0.103 | 0.1582 | 0.101 | 0.1274 | 0.130 |
| | -3 | 0.3323*** | 0.109 | 0.0342 | 0.116 | 0.1602 | 0.120 | -0.0784 | 0.142 |
| | -2 | 0.3988*** | 0.123 | 0.0098 | 0.107 | 0.3350** | 0.136 | -0.0545 | 0.133 |
| | -1 | 0.4942*** | 0.133 | -0.0547 | 0.119 | 0.3802** | 0.149 | -0.2519* | 0.142 |
| | 0 | 0.4750*** | 0.135 | 0.0386 | 0.050 | 0.0246 | 0.155 | -0.0358 | 0.062 |
| | 1 | 0.4311*** | 0.139 | 0.0778 | 0.181 | 0.0251 | 0.164 | -0.1700 | 0.192 |
| | 2 | 0.2919** | 0.145 | 0.0495 | 0.161 | -0.1648 | 0.180 | -0.1493 | 0.172 |
| | 3+ | 0.5225*** | 0.149 | 0.0609 | 0.173 | 0.0187 | 0.180 | -0.2006 | 0.151 |
| Ownership unbundling | -6+ | -0.1866*** | 0.057 | -0.0219 | 0.026 | -0.1145* | 0.064 | -0.0288 | 0.023 |
| | -5 | -0.0926 | 0.060 | 0.0244 | 0.047 | 0.0648 | 0.066 | 0.0122 | 0.052 |
| | -4 | -0.0466 | 0.057 | 0.0958** | 0.045 | 0.0809 | 0.063 | 0.1689*** | 0.050 |
| | -3 | -0.0109 | 0.065 | 0.0784* | 0.046 | -0.0261 | 0.076 | -0.0180 | 0.051 |
| | -2 | -0.0171 | 0.064 | 0.0915** | 0.041 | -0.0712 | 0.072 | 0.0188 | 0.047 |
| | -1 | 0.0295 | 0.061 | 0.1102** | 0.044 | 0.0405 | 0.069 | 0.0767* | 0.046 |
| | 1 | 0.1389*** | 0.053 | 0.2227*** | 0.051 | 0.0171 | 0.051 | 0.0944* | 0.052 |
| | 2 | 0.0495 | 0.060 | 0.3589*** | 0.045 | 0.0019 | 0.062 | 0.1996*** | 0.046 |
| | 3+ | 0.1465** | 0.060 | 0.2243*** | 0.046 | 0.0834 | 0.064 | 0.0582 | 0.045 |
| OU x new member state | -6+ | 0.2930*** | 0.088 | 0.0136 | 0.056 | 0.2872 | 0.187 | 0.0139 | 0.117 |
| | -5 | 0.1945** | 0.088 | 0.0162 | 0.082 | 0.1065 | 0.173 | 0.0266 | 0.150 |
| | -4 | 0.1914** | 0.080 | 0.1390 | 0.086 | 0.2316 | 0.145 | 0.2313 | 0.166 |
| | -3 | 0.1681** | 0.078 | 0.1307* | 0.071 | 0.1138 | 0.128 | 0.1196 | 0.121 |
| | -2 | 0.1266* | 0.073 | 0.0290 | 0.066 | 0.0577 | 0.125 | 0.0449 | 0.116 |
| | -1 | 0.0552 | 0.068 | 0.0946 | 0.071 | -0.0086 | 0.111 | 0.0369 | 0.114 |
| | 1 | 0.1937*** | 0.073 | | | 0.1943 | 0.122 | | |
| | 2 | 0.4184*** | 0.127 | | | 0.2666 | 0.168 | | |
| | 3+ | 0.6101*** | 0.126 | | | 0.7406*** | 0.228 | | |
| OU x corruption perceptions index | -5 | | | -0.0965 | 0.138 | | | -0.1863 | 0.147 |
| | -4 | | | -0.2460* | 0.142 | | | -0.5125*** | 0.155 |
| | -3 | -0.1017 | 0.142 | -0.3105** | 0.153 | 0.2935** | 0.149 | -0.1378 | 0.170 |
| | -2 | -0.0626 | 0.154 | -0.2825** | 0.139 | 0.4747*** | 0.162 | -0.1158 | 0.162 |
| | -1 | -0.0113 | 0.165 | -0.2908* | 0.158 | 0.4291** | 0.174 | -0.0403 | 0.169 |
| | 0 | 0.1901 | 0.171 | 0.0673 | 0.067 | 0.6516*** | 0.181 | 0.1887** | 0.089 |
| | 1 | -0.3262 | 0.207 | -1.0800*** | 0.324 | 0.4699** | 0.217 | -0.2946 | 0.275 |
| | 2 | -0.3312 | 0.309 | -2.0720*** | 0.263 | 0.6458** | 0.305 | -1.0328*** | 0.244 |
| | 3+ | -0.6715** | 0.307 | -1.3159*** | 0.251 | 0.2042 | 0.336 | -0.2920 | 0.226 |
| log(gdp) | | 0,4120*** | 0.135 | 0.4486*** | 0.096 | 0.0861 | 0.137 | -0.0434 | 0.093 |
| log(cpi) | | 0,6179** | 0.240 | 0.2149 | 0.166 | 1.8327*** | 0.386 | 0.8706*** | 0.267 |
| log(price of gas) | | 0,1772*** | 0.038 | 0.1027*** | 0.028 | 0.2687*** | 0.037 | 0.1693*** | 0.026 |
| log(price of oil) | | 0,0120 | 0.029 | -0.0295 | 0.021 | 0.0545* | 0.028 | -0.0416** | 0.020 |
| hydro share | | -0,0197 | 0.200 | -0.3766** | 0.148 | 0.3065 | 0.541 | 0.2685 | 0.363 |
| nuclear share | | 1,0271** | 0.398 | 0.5777** | 0.283 | 0.9909 | 0.820 | 1.3634*** | 0.512 |
| trend | | 0,0014 | 0.003 | -0.0024 | 0.002 | -0.0143*** | 0.004 | -0.0105*** | 0.003 |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No corruption
Year
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%Δp
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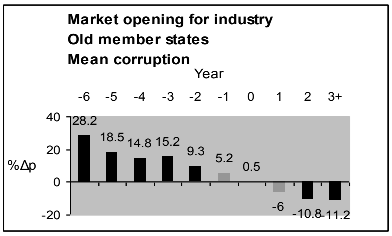
Market opening for industry
Old member states
Mean corruption
Year
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%Δp
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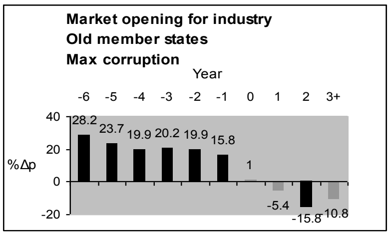
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Old member states
Max corruption
Year
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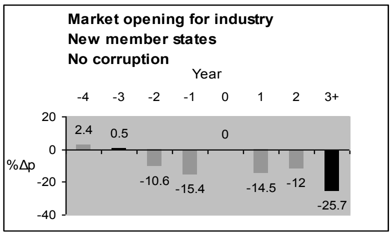
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New member states
No corruption
Year
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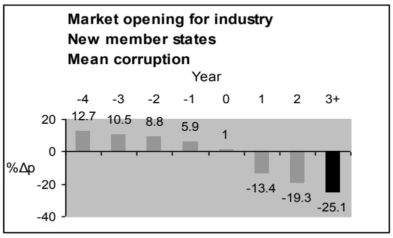
Market opening for industry
New member states
Mean corruption
Year
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%Δp
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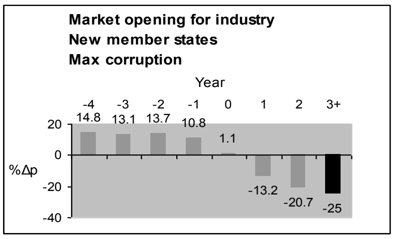
Market opening for industry
New member states
Max corruption
Year
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%Δp
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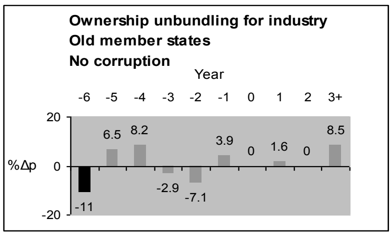
Ownership unbundling for industry
Old member states
No corruption
Year
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%Δp
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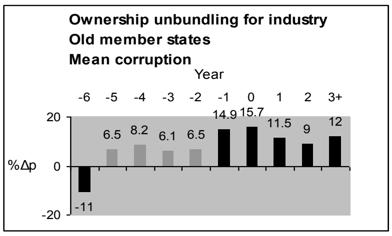
Ownership unbundling for industry
Old member states
Mean corruption
Year
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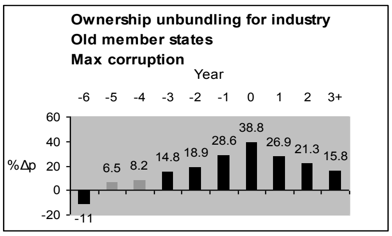
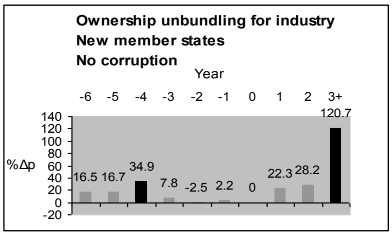
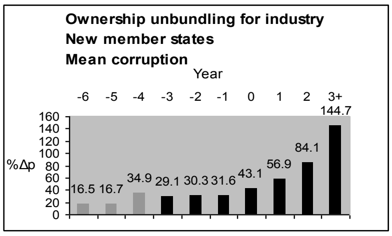
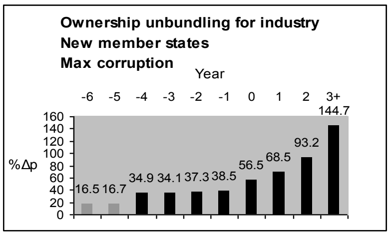
%Δp
-11 6.5 8.2 6.1 6.5 14.9 15.7 11.5 9 12


Ownership unbundling for industry
Old member states
Max corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
-11 6.5 8.2 14.8 18.9 28.6 38.8 26.9 21.3 15.8


Ownership unbundling for industry
New member states
No corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
16.5 16.7 34.9 7.8 -2.5 2.2 0 22.3 28.2 120.7


Ownership unbundling for industry
New member states
Mean corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
16.5 16.7 34.9 29.1 30.3 31.6 43.1 56.9 84.1 144.7


Ownership unbundling for industry
New member states
Max corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
16.5 16.7 34.9 34.1 37.3 38.5 56.5 68.5 93.2 144.7

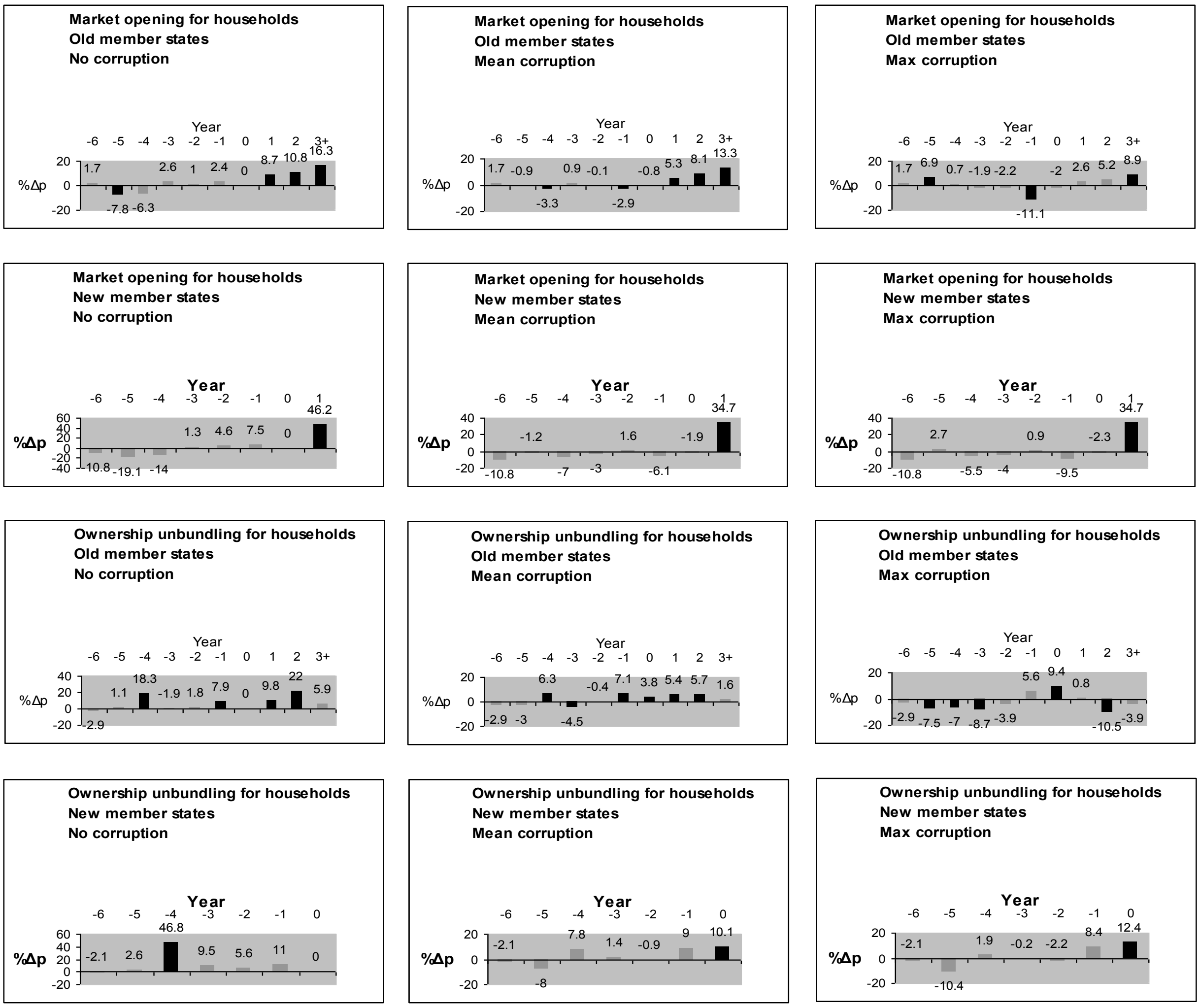

Market opening for households
Old member states
No corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
1.7 -7.8 -6.3 2.6 1 2.4 0 8.7 10.8 16.3
Market opening for households
Old member states
Mean corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
1.7 -0.9 -3.3 0.9 -0.1 -2.9 -0.8 5.3 8.1 13.3
Market opening for households
Old member states
Max corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
1.7 6.9 0.7 -1.9 -2.2 -11.1 -2 2.6 5.2 8.9
Market opening for households
New member states
No corruption
Year
-6 -5 -4 -3 -2 -1 0 1
%Δp
-10.8 -19.1 -14 1.3 4.6 7.5 0 46.2
Market opening for households
New member states
Mean corruption
Year
-6 -5 -4 -3 -2 -1 0 1
%Δp
-10.8 -1.2 -7 -3 1.6 -6.1 -1.9 34.7
Market opening for households
New member states
Max corruption
Year
-6 -5 -4 -3 -2 -1 0 1
%Δp
-10.8 2.7 -5.5 -4 0.9 -9.5 -2.3 34.7
Ownership unbundling for households
Old member states
No corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
-2.9 1.1 18.3 -1.9 1.8 7.9 0 9.8 22 5.9
Ownership unbundling for households
Old member states
Mean corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
-2.9 -3 6.3 -4.5 -0.4 7.1 3.8 5.4 5.7 1.6
Ownership unbundling for households
Old member states
Max corruption
Year
-6 -5 -4 -3 -2 -1 0 1 2 3+
%Δp
-2.9 -7.5 -7 -8.7 -3.9 5.6 9.4 0.8 -10.5 -3.9
Ownership unbundling for households
New member states
No corruption
Year
-6 -5 -4 -3 -2 -1 0
%Δp
-2.1 2.6 46.8 9.5 5.6 11 0
Ownership unbundling for households
New member states
Mean corruption
Year
-6 -5 -4 -3 -2 -1 0
%Δp
-2.1 -8 7.8 1.4 -0.9 9 10.1
Ownership unbundling for households
New member states
Max corruption
Year
-6 -5 -4 -3 -2 -1 0
%Δp
-2.1 -10.4 1.9 -0.2 -2.2 8.4 12.4

Table A1

| Country | GDP weight | Corruption perceptions index | Order according to the polarity of the mean CPI |
|---|---|---|---|
| Germany | 22.03% | 7.88 | 16 |
| United Kingdom | 17.65% | 8.55 | 10 |
| France | 15.58% | 6.9 | 20 |
| Italy | 12.76% | 4.85 | 17 |
| Spain | 7.04% | 6.54 | 24 |
| Netherlands | 4.47% | 8.86 | 7 |
| Sweden | 2.93% | 9.27 | 4 |
| Belgium | 2.73% | 6.62 | 23 |
| Austria | 2.25% | 7.95 | 15 |
| Poland | 2.08% | 4.17 | 11 |
| Denmark | 1.86% | 9.62 | 3 |
| Greece | 1.59% | 4.61 | 14 |
| Finland | 1.45% | 9.63 | 2 |
| Portugal | 1.29% | 6.51 | 25 |
| Ireland | 1.20% | 7.63 | 19 |
| Czech Republic | 0.72% | 4.52 | 12 |
| Hungary | 0.59% | 5.06 | 18 |
| Romania | 0.51% | 3.05 | 1 |
| Slovakia | 0.27% | 4.01 | 8 |
| Slovenia | 0.24% | 5.97 | 22 |
| Luxembourg | 0.24% | 8.64 | 9 |
| Bulgaria | 0.17% | 3.77 | 5 |
| Lithuania | 0.16% | 4.58 | 13 |
| Latvia | 0.11% | 3.81 | 6 |
| Estonia | 0.08% | 5.94 | 21 |

Table A1: GDP and Polarity of the Corruption Perceptions Index

This table shows the approximate weights assigned to individual countries (Mean GDP over the investigated period), the mean corruption perceptions index over the investigated period and the ranking of the country in terms of the polarity of the corruption perceptions index. Polarity is defined here as the distance of the index for a particular country from the mean index value across all the countries. The countries are sorted in descending order by weight.

## Appendix 5 – Estimation with and without the share of the largest generator

| System of equations | | SUR for industry and households | | | | SUR for industry and households with share of largest generator | | | | SUR for industry and households with the same 254 observations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equation | | Industry | | Households | | Industry | | Households | | Industry | | Households | |
| Customer | | Industry | | Households | | Industry | | Households | | Industry | | Households | |
| R2 | | 0.8355 | | 0.9337 | | 0.8549 | | 0.9616 | | 0.8539 | | 0.9617 | |
| Obs | | 425 | | 425 | | 254 | | 254 | | 254 | | 254 | |
| | | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Market opening | -6+ | 0.3597*** | 0.049 | 0.0585** | 0.023 | 0.3503*** | 0.098 | 0.0568** | 0.024 | 0.3417*** | 0.097 | 0.0564** | 0.024 |
| | -5 | 0.2925*** | 0.051 | -0.0249 | 0.034 | 0.4595*** | 0.161 | 0.0106 | 0.061 | 0.4852*** | 0.161 | 0.0146 | 0.061 |
| | -4 | 0.2125*** | 0.048 | -0.0266 | 0.034 | 0.2840*** | 0.103 | -0.1122*** | 0.034 | 0.2830*** | 0.103 | -0.1137*** | 0.034 |
| | -3 | 0.1603*** | 0.047 | -0.0079 | 0.037 | 0.2055** | 0.090 | -0.1038** | 0.051 | 0.1953** | 0.090 | -0.1112** | 0.051 |
| | -2 | 0.0858* | 0.048 | 0.0150 | 0.031 | 0.1628** | 0.067 | -0.0667 | 0.044 | 0.1656** | 0.067 | -0.0763* | 0.043 |
| | -1 | 0.0190 | 0.049 | -0.0017 | 0.033 | 0.0508 | 0.066 | -0.1050** | 0.045 | 0.0510 | 0.066 | -0.1102** | 0.045 |
| | 1 | -0.0329 | 0.044 | 0.0117 | 0.036 | 0.0078 | 0.068 | 0.0373 | 0.036 | 0.0135 | 0.068 | 0.0321 | 0.036 |
| | 2 | -0.0074 | 0.047 | 0.0595* | 0.033 | 0.0008 | 0.095 | 0.0697* | 0.037 | -0.0018 | 0.096 | 0.0684* | 0.037 |
| | 3+ | -0.0906* | 0.047 | 0.0467 | 0.034 | -0.3290*** | 0.116 | 0.0978** | 0.038 | -0.3367*** | 0.116 | 0.1016*** | 0.038 |
| MO x new member state | -6+ | | | -0.1117** | 0.046 | | | -0.0152 | 0.044 | | | -0.0148 | 0.044 |
| | -5 | | | -0.0965 | 0.066 | | | -0.0085 | 0.057 | | | -0.0049 | 0.057 |
| | -4 | 0.0476 | 0.070 | -0.0877 | 0.065 | -0.0664 | 0.090 | -0.0346 | 0.055 | -0.0553 | 0.090 | -0.0458 | 0.054 |
| | -3 | -0.0063 | 0.061 | -0.0224 | 0.050 | -0.0538 | 0.080 | -0.0250 | 0.045 | -0.0525 | 0.080 | -0.0281 | 0.045 |
| | -2 | 0.0010 | 0.059 | 0.0421 | 0.048 | -0.0447 | 0.076 | 0.0195 | 0.045 | -0.0293 | 0.076 | 0.0193 | 0.045 |
| | -1 | -0.0238 | 0.056 | -0.0069 | 0.050 | -0.0042 | 0.064 | -0.0326 | 0.050 | 0.0004 | 0.065 | -0.0276 | 0.050 |
| | 1 | -0.0167 | 0.053 | 0.4367*** | 0.119 | 0.0082 | 0.059 | | | 0.0048 | 0.060 | | |
| | 2 | -0.0016 | 0.056 | | | 0.0582 | 0.078 | | | 0.0479 | 0.078 | | |
| | 3+ | 0.0111 | 0.063 | | | 0.0596 | 0.123 | | | 0.0382 | 0.122 | | |
| MO x corruption percept. index | -5 | 0.0231 | 0.111 | 0.1168 | 0.102 | -0.3545 | 0.391 | -0.0498 | 0.153 | -0.4481 | 0.388 | -0.0568 | 0.153 |
| | -4 | 0.1942* | 0.101 | 0.0742 | 0.103 | -0.0257 | 0.272 | 0.2374** | 0.093 | -0.0553 | 0.272 | 0.2440*** | 0.093 |
| | -3 | 0.3323*** | 0.109 | 0.0342 | 0.116 | 0.1689 | 0.244 | 0.2047 | 0.132 | 0.1704 | 0.245 | 0.2202* | 0.132 |
| | -2 | 0.3988*** | 0.123 | 0.0098 | 0.107 | 0.1279 | 0.222 | 0.1937 | 0.126 | 0.0947 | 0.221 | 0.2118* | 0.125 |
| | -1 | 0.4942*** | 0.133 | -0.0547 | 0.119 | 0.3324 | 0.234 | 0.1447 | 0.134 | 0.3151 | 0.234 | 0.1502 | 0.134 |
| | 0 | 0.4750*** | 0.135 | 0.0386 | 0.050 | 0.3651 | 0.234 | 0.1122 | 0.157 | 0.3490 | 0.234 | 0.0957 | 0.156 |
| | 1 | 0.4311*** | 0.139 | 0.0778 | 0.181 | 0.2525 | 0.256 | 0.1616 | 0.290 | 0.2212 | 0.254 | 0.1899 | 0.290 |
| | 2 | 0.2919** | 0.145 | 0.0495 | 0.161 | 0.1676 | 0.322 | 0.2177 | 0.266 | 0.1585 | 0.323 | 0.2361 | 0.266 |
| | 3+ | 0.5225*** | 0.149 | 0.0609 | 0.173 | 0.9839** | 0.395 | -0.0130 | 0.261 | 0.9956** | 0.397 | -0.0244 | 0.260 |
| Ownership unbundling | -6+ | -0.1866*** | 0.057 | -0.0219 | 0.026 | -0.4346*** | 0.136 | 0.0426 | 0.032 | -0.4525*** | 0.135 | 0.0476 | 0.032 |
| | -5 | -0.0926 | 0.060 | 0.0244 | 0.047 | -0.3255** | 0.135 | 0.0900 | 0.068 | -0.3321** | 0.136 | 0.1006 | 0.068 |
| | -4 | -0.0466 | 0.057 | 0.0958** | 0.045 | -0.2743** | 0.129 | 0.1009* | 0.060 | -0.2791** | 0.130 | 0.1144* | 0.059 |
| | -3 | -0.0109 | 0.065 | 0.0784* | 0.046 | -0.1593 | 0.134 | 0.2110*** | 0.064 | -0.1619 | 0.135 | 0.2161*** | 0.064 |
| | -2 | -0.0171 | 0.064 | 0.0915** | 0.041 | -0.1131 | 0.127 | 0.0907* | 0.049 | -0.1229 | 0.127 | 0.1005** | 0.048 |
| | -1 | 0.0295 | 0.061 | 0.1102** | 0.044 | 0.0909 | 0.077 | 0.0742 | 0.047 | 0.0944 | 0.077 | 0.0831* | 0.047 |
| | 1 | 0.1389*** | 0.053 | 0.2227*** | 0.051 | 0.1921** | 0.087 | 0.0975* | 0.052 | 0.1615** | 0.081 | 0.1148** | 0.049 |
| | 2 | 0.0495 | 0.060 | 0.3589*** | 0.045 | -4.9302* | 2.982 | 0.1399** | 0.056 | -4.7502 | 2.995 | 0.1439** | 0.056 |
| | 3+ | 0.1465** | 0.060 | 0.2243*** | 0.046 | -0.1333 | 0.311 | 0.1426*** | 0.048 | -0.1249 | 0.312 | 0.1427*** | 0.048 |
| OU x new member state | -6+ | 0.2930*** | 0.088 | 0.0136 | 0.056 | 0.2041 | 0.142 | -0.1375** | 0.056 | 0.2153 | 0.142 | -0.1427** | 0.056 |
| | -5 | 0.1945** | 0.088 | 0.0162 | 0.082 | 0.1631 | 0.138 | -0.0258 | 0.078 | 0.1589 | 0.138 | -0.0327 | 0.078 |
| | -4 | 0.1914** | 0.080 | 0.1390 | 0.086 | 0.0054 | 0.117 | 0.0090 | 0.073 | 0.0081 | 0.118 | 0.0118 | 0.073 |
| | -3 | 0.1681** | 0.078 | 0.1307* | 0.071 | 0.0819 | 0.114 | 0.0793 | 0.063 | 0.0875 | 0.114 | 0.0819 | 0.063 |
| | -2 | 0.1266* | 0.073 | 0.0290 | 0.066 | 0.0828 | 0.095 | 0.0001 | 0.065 | 0.0867 | 0.095 | -0.0001 | 0.065 |
| | -1 | 0.0552 | 0.068 | 0.0946 | 0.071 | 0.0087 | 0.080 | 0.0494 | 0.069 | 0.0110 | 0.081 | 0.0446 | 0.069 |
| | 1 | 0.1937*** | 0.073 | | | 0.2242 | 0.153 | | | 0.2349 | 0.153 | | |
| | 2 | 0.4184*** | 0.127 | | | -3.3285 | 2.272 | | | -3.1802 | 2.281 | | |
| | 3+ | 0.6101*** | 0.126 | | | | | | | | | | |
| OU x corruption percept. index | -5 | | | -0.0965 | 0.138 | | | -0.1561 | 0.174 | | | -0.1697 | 0.173 |
| | -4 | | | -0.2460* | 0.142 | | | -0.1514 | 0.154 | | | -0.1665 | 0.153 |
| | -3 | -0.1017 | 0.142 | -0.3105** | 0.153 | -0.4757** | 0.231 | -0.4718*** | 0.166 | -0.4817** | 0.232 | -0.4829*** | 0.166 |
| | -2 | -0.0626 | 0.154 | -0.2825** | 0.139 | -0.5222** | 0.260 | -0.2321* | 0.141 | -0.5050* | 0.260 | -0.2505* | 0.140 |
| | -1 | -0.0113 | 0.165 | -0.2908* | 0.158 | -0.8987*** | 0.315 | -0.1192 | 0.157 | -0.8926*** | 0.316 | -0.1315 | 0.156 |
| | 0 | 0.1901 | 0.171 | 0.0673 | 0.067 | -0.6947** | 0.344 | 0.0714 | 0.175 | -0.6720* | 0.345 | 0.0932 | 0.173 |
| | 1 | -0.3262 | 0.207 | -1.0800*** | 0.324 | -1.4287*** | 0.454 | -0.5455 | 0.398 | -1.3350*** | 0.442 | -0.6395 | 0.391 |
| | 2 | -0.3312 | 0.309 | -2.0720*** | 0.263 | 15.5227 | 10.073 | -1.1129*** | 0.374 | 14.9391 | 10.117 | -1.1441*** | 0.373 |
| | 3+ | -0.6715** | 0.307 | -1.3159*** | 0.251 | -0.7335 | 1.055 | -0.8715** | 0.341 | -0.7213 | 1.059 | -0.8777** | 0.341 |
| log(gdp) | | 0.4120*** | 0.135 | 0.4486*** | 0.096 | 0.4827* | 0.246 | 0.7382*** | 0.115 | 0.4559* | 0.246 | 0.7367*** | 0.115 |
| log(cpi) | | 0.6179** | 0.240 | 0.2149 | 0.166 | -0.4144 | 0.536 | 0.5805** | 0.266 | -0.3557 | 0.536 | 0.5791** | 0.266 |
| log(price of gas) | | 0.1772*** | 0.038 | 0.1027*** | 0.028 | 0.0765 | 0.049 | 0.0034 | 0.030 | 0.0804* | 0.049 | -0.0002 | 0.029 |
| log(price of oil) | | 0.0120 | 0.029 | -0.0295 | 0.021 | -0.0139 | 0.043 | -0.0312 | 0.024 | -0.0083 | 0.043 | -0.0317 | 0.024 |
| hydro share | | -0.0197 | 0.200 | -0.3766** | 0.148 | -1.4302 | 0.943 | 0.8982* | 0.537 | -1.4320 | 0.937 | 0.9225* | 0.529 |
| nuclear share | | 1.0271** | 0.398 | 0.5777** | 0.283 | 0.4135 | 0.522 | 0.4389 | 0.282 | 0.2651 | 0.491 | 0.4797* | 0.270 |
| trend | | 0.0014 | 0.003 | -0.0024 | 0.002 | 0.0211*** | 0.005 | -0.0009 | 0.004 | 0.0203*** | 0.005 | -0.0009 | 0.004 |
| largest | | | | | | -0.1513 | 0.209 | 0.0834 | 0.120 | | | | |

## Appendix 6 – Jack-knife

| Country<br>Industry | | Base | Austria | Belgium | Bulgaria | Czech Republic | Denmark | Estonia | Finland | France | Germany |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R2 | | 0.8355 | 0.8425 | 0.8320 | 0.8290 | 0.8335 | 0.8421 | 0.8322 | 0.8268 | 0.8406 | 0.8380 |
| Obs | | 425 | 408 | 401 | 417 | 409 | 401 | 416 | 402 | 401 | 402 |
| | | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Market opening | -6+ | 0.3597*** | 0.3541*** | 0.3874*** | 0.3571*** | 0.3414*** | 0.4004*** | 0.3676*** | 0.3755*** | 0.3312*** | 0.3946*** |
| | -5 | 0.2925*** | 0.2771*** | 0.2992*** | 0.2901*** | 0.2768*** | 0.3218*** | 0.2975*** | 0.2973*** | 0.2791*** | 0.3093*** |
| | -4 | 0.2125*** | 0.1928*** | 0.2231*** | 0.2103*** | 0.1968*** | 0.2251*** | 0.2182*** | 0.2196*** | 0.1983*** | 0.2303*** |
| | -3 | 0.1603*** | 0.1392*** | 0.1719*** | 0.1592*** | 0.1454*** | 0.1320** | 0.1654*** | 0.1593*** | 0.1519*** | 0.1677*** |
| | -2 | 0.0858* | 0.0797* | 0.0863* | 0.0834* | 0.0731 | 0.0877 | 0.0896* | 0.0929* | 0.0858* | 0.0734 |
| | -1 | 0.0190 | 0.0155 | 0.0196 | 0.0160 | 0.0019 | 0.0256 | 0.0220 | 0.0154 | 0.0176 | 0.0052 |
| | 1 | -0.0329 | -0.0139 | -0.0442 | -0.0347 | -0.0383 | -0.0313 | -0.0315 | -0.0139 | -0.0373 | -0.0156 |
| | 2 | -0.0074 | 0.0269 | -0.0248 | -0.0085 | -0.0168 | -0.0625 | -0.0053 | 0.0262 | -0.0129 | 0.0249 |
| | 3+ | -0.0906* | -0.0981** | -0.1019** | -0.0924* | -0.0961** | -0.1188** | -0.0934** | -0.0889 | -0.1093** | -0.0712 |
| MO x new member state | -4 | 0.0476 | 0.0375 | 0.0393 | 0.0435 | -0.0084 | 0.0048 | 0.0536 | 0.0671 | 0.0481 | 0.0392 |
| | -3 | -0.0063 | -0.0105 | -0.0077 | -0.0153 | -0.0065 | -0.0724 | -0.0020 | 0.0118 | -0.0075 | -0.0092 |
| | -2 | 0.0010 | -0.0069 | 0.0088 | 0.0032 | -0.0066 | -0.0553 | 0.0016 | 0.0018 | -0.0014 | 0.0035 |
| | -1 | -0.0238 | -0.0296 | -0.0273 | -0.0185 | -0.0328 | -0.0511 | -0.0229 | -0.0226 | -0.0231 | -0.0309 |
| | 1 | -0.0167 | -0.0233 | -0.0021 | -0.0149 | -0.0570 | -0.0362 | -0.0174 | -0.0137 | -0.0164 | -0.0257 |
| | 2 | -0.0016 | -0.0020 | 0.0187 | -0.0013 | -0.0622 | -0.0382 | -0.0035 | 0.0093 | -0.0056 | -0.0224 |
| | 3+ | 0.0111 | 0.0093 | 0.0295 | 0.0134 | -0.0447 | -0.0109 | 0.0059 | 0.0149 | 0.0125 | -0.0259 |
| MO x corruption percept. index | -5 | 0.0231 | 0.0246 | 0.0755 | 0.0221 | 0.0193 | 0.0456 | 0.0185 | 0.0422 | 0.0081 | 0.0861 |
| | -4 | 0.1942* | 0.1953* | 0.2332** | 0.1923* | 0.1894** | 0.2497** | 0.1823* | 0.2039** | 0.1996* | 0.2494** |
| | -3 | 0.3323*** | 0.3337*** | 0.3527*** | 0.3271*** | 0.3239*** | 0.5060*** | 0.3173*** | 0.3650*** | 0.3313*** | 0.4156*** |
| | -2 | 0.3988*** | 0.3787*** | 0.4244*** | 0.3980*** | 0.3896*** | 0.4867*** | 0.3848*** | 0.4408*** | 0.3911*** | 0.5240*** |
| | -1 | 0.4942*** | 0.4652*** | 0.5231*** | 0.4974*** | 0.4914*** | 0.5620*** | 0.4779*** | 0.5634*** | 0.4816*** | 0.6456*** |
| | 0 | 0.4750*** | 0.4264*** | 0.4988*** | 0.4683*** | 0.4010*** | 0.5467*** | 0.4603*** | 0.5477*** | 0.4677*** | 0.6067*** |
| | 1 | 0.4311*** | 0.3567** | 0.4486*** | 0.4315*** | 0.3818*** | 0.5101*** | 0.4081*** | 0.4614*** | 0.4388*** | 0.5575*** |
| | 2 | 0.2919** | 0.1788 | 0.3012** | 0.2901** | 0.2674* | 0.5520*** | 0.2629* | 0.2848* | 0.3132** | 0.4262*** |
| | 3+ | 0.5225*** | 0.4990*** | 0.5220*** | 0.5265*** | 0.4892*** | 0.7159*** | 0.5004*** | 0.5859*** | 0.5675*** | 0.7424*** |
| Ownership unbundling | -6+ | -0.1866*** | -0.1641*** | -0.1930*** | -0.1865*** | -0.1952*** | -0.4263*** | -0.1820*** | -0.2330*** | -0.1836*** | -0.1942*** |
| | -5 | -0.0926 | -0.0708 | -0.0879 | -0.0921 | -0.1027* | -0.2939*** | -0.0877 | -0.1412** | -0.1020* | -0.0970 |
| | -4 | -0.0466 | -0.0286 | -0.0388 | -0.0467 | -0.0579 | -0.2595*** | -0.0415 | -0.0972 | -0.0572 | -0.0573 |
| | -3 | -0.0109 | -0.0078 | -0.0013 | -0.0115 | -0.0385 | -0.1501 | -0.0108 | -0.0372 | -0.0172 | -0.0052 |
| | -2 | -0.0171 | -0.0349 | -0.0059 | -0.0158 | -0.0521 | -0.2333** | -0.0188 | -0.0464 | -0.0253 | -0.0207 |
| | -1 | 0.0295 | 0.0252 | 0.0295 | 0.0307 | 0.0018 | -0.1172 | 0.0300 | 0.0317 | 0.0250 | 0.0267 |
| | 1 | 0.1389*** | 0.1378*** | 0.1500*** | 0.1408*** | 0.1286** | 0.0226 | 0.1369** | 0.1059** | 0.1388** | 0.1385*** |
| | 2 | 0.0495 | 0.0549 | 0.0706 | 0.0516 | 0.0170 | 0.0131 | 0.0480 | 0.0010 | 0.0488 | 0.0507 |
| | 3+ | 0.1465** | 0.1459** | 0.1783*** | 0.1492** | 0.1243** | 0.0100 | 0.1429** | 0.1230* | 0.1385** | 0.1510** |
| OU x new member state | -6+ | 0.2930*** | 0.3044*** | 0.3269*** | 0.2972*** | 0.3089*** | 0.2214** | 0.2896*** | 0.2486*** | 0.2769*** | 0.2539*** |
| | -5 | 0.1945** | 0.2083** | 0.2161** | 0.1922** | 0.1865** | 0.0870 | 0.1940** | 0.1541* | 0.1880** | 0.1397 |
| | -4 | 0.1914** | 0.1984** | 0.2091*** | 0.1900** | 0.1433* | 0.0992 | 0.1917** | 0.1644** | 0.1865** | 0.1434* |
| | -3 | 0.1681** | 0.1624** | 0.1794** | 0.1707** | 0.1681** | 0.1434* | 0.1692** | 0.1500* | 0.1664** | 0.1368* |
| | -2 | 0.1266* | 0.1196* | 0.1348* | 0.1251* | 0.1487** | 0.0779 | 0.1260* | 0.1149 | 0.1286* | 0.1044 |
| | -1 | 0.0552 | 0.0624 | 0.0581 | 0.0527 | 0.0672 | 0.0250 | 0.0558 | 0.0582 | 0.0569 | 0.0445 |
| | 1 | 0.1937*** | 0.1961*** | 0.1815** | 0.1940*** | 0.1784** | 0.1889** | 0.1898** | 0.1941*** | 0.1978*** | 0.2166*** |
| | 2 | 0.4184*** | 0.4391*** | 0.4037*** | 0.4213*** | 0.3417*** | 0.4813*** | 0.4178*** | 0.4004*** | 0.4278*** | 0.4438*** |
| | 3+ | 0.6101*** | 0.6009*** | 0.6184*** | 0.6102*** | (droppe | 0.5625*** | 0.6169*** | 0.5965*** | 0.5886*** | 0.6390*** |
| OU x corruption percept. index | -3 | -0.1017 | -0.0599 | -0.0949 | -0.0991 | -0.0547 | -0.3520* | -0.0890 | -0.1668 | -0.1159 | -0.1688 |
| | -2 | -0.0626 | 0.0208 | -0.0526 | -0.0653 | 0.0162 | -0.1469 | -0.0453 | -0.1300 | -0.0837 | -0.1255 |
| | -1 | -0.0113 | 0.0257 | 0.0393 | -0.0153 | 0.0538 | -0.3046 | 0.0012 | -0.1627 | -0.0451 | -0.1039 |
| | 0 | 0.1901 | 0.2180 | 0.2528 | 0.1884 | 0.1737 | -0.4730** | 0.2050 | 0.0334 | 0.1446 | 0.0576 |
| | 1 | -0.3262 | -0.2910 | -0.2657 | -0.3357 | -0.3462* | -0.7611*** | -0.3030 | -0.4162* | -0.3845* | -0.4916** |
| | 2 | -0.3312 | -0.3365 | -0.2594 | -0.3408 | -0.2445 | -1.1364*** | -0.3150 | -0.3734 | -0.4083 | -0.5097* |
| | 3+ | -0.6715** | -0.6323** | -0.6542** | -0.6864** | -0.6671** | -1.1048*** | -0.6560** | -0.7685** | -0.6914** | -0.8952*** |
| log(gdp) | | 0.4120*** | 0.3857*** | 0.3460** | 0.4054*** | 0.4070*** | 0.5147*** | 0.4368*** | 0.4279*** | 0.3731*** | 0.3401** |
| log(cpi) | | 0.6179** | 0.5635** | 0.7881*** | 0.6194** | 0.7878*** | 0.3180 | 0.6594*** | 0.5735** | 0.5234** | 0.4663* |
| log(price of | | 0.1772*** | 0.1545*** | 0.1862*** | 0.1776*** | 0.1812*** | 0.1842*** | 0.1766*** | 0.2058*** | 0.1978*** | 0.1959*** |
| log(price of oil) | | 0.0120 | 0.0217 | 0.0122 | 0.0119 | 0.0064 | 0.0191 | 0.0145 | 0.0133 | 0.0016 | 0.0114 |
| hydro share | | -0.0197 | 0.0384 | -0.1084 | -0.0243 | 0.0508 | -0.2294 | 0.0035 | -0.0843 | 0.0518 | -0.0974 |
| nuclear share | | 1.0271** | 1.0918*** | 1.1526*** | 1.0000** | 0.6071 | 1.0151** | 1.0664*** | 1.0180** | 1.0840*** | 0.9118** |
| trend | | 0.0014 | 0.0036 | 0.0002 | 0.0014 | 0.0001 | 0.0027 | 0.0014 | 0.0001 | 0.0035 | 0.0023 |

| Country<br>Industry<br>R2<br>Obs | | Base<br>0.8355<br>425<br>Coeff. | Greece<br>0.8351<br>401<br>Coeff. | Hungary<br>0.8341<br>411<br>Coeff. | Ireland<br>0.8355<br>409<br>Coeff. | Italy<br>0.8212<br>402<br>Coeff. | Latvia<br>0.8270<br>417<br>Coeff. | Lithuania<br>0.8339<br>417<br>Coeff. | Luxembo urg<br>0.8347<br>403<br>Coeff. | Netherlan ds<br>0.8422<br>408<br>Coeff. | Poland<br>0.8295<br>411<br>Coeff. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Market opening | -6+ | 0.3597*** | 0.4265*** | 0.3559*** | 0.3637*** | 0.3223*** | 0.3434*** | 0.3611*** | 0.3291*** | 0.3979*** | 0.3496*** |
| | -5 | 0.2925*** | 0.3538*** | 0.2865*** | 0.2783*** | 0.2732*** | 0.2837*** | 0.2922*** | 0.2761*** | 0.3698*** | 0.2713*** |
| | -4 | 0.2125*** | 0.2667*** | 0.2103*** | 0.1963*** | 0.1958*** | 0.2064*** | 0.2150*** | 0.2278*** | 0.2806*** | 0.1889*** |
| | -3 | 0.1603*** | 0.1863*** | 0.1598*** | 0.1604*** | 0.1344*** | 0.1563*** | 0.1615*** | 0.1848*** | 0.2131*** | 0.1514*** |
| | -2 | 0.0858* | 0.0948* | 0.0870* | 0.0843* | 0.0686 | 0.0762 | 0.0851* | 0.0946* | 0.1395*** | 0.0775 |
| | -1 | 0.0190 | 0.0232 | 0.0184 | 0.0194 | 0.0336 | 0.0112 | 0.0179 | 0.0158 | 0.0486 | 0.0158 |
| | 1 | -0.0329 | -0.0110 | -0.0306 | -0.0345 | -0.0459 | -0.0458 | -0.0316 | -0.0447 | -0.0173 | -0.0377 |
| | 2 | -0.0074 | 0.0341 | -0.0004 | -0.0062 | -0.0283 | -0.0122 | -0.0086 | -0.0299 | -0.0203 | -0.0188 |
| | 3+ | -0.0906* | -0.0544 | -0.0812* | -0.0906* | -0.1001** | -0.0897* | -0.0897* | -0.1079** | -0.0776 | -0.0993** |
| MO x new member state | -4 | 0.0476 | 0.1186 | 0.1428* | 0.0509 | -0.0085 | 0.0636 | 0.0166 | 0.0324 | 0.0373 | 0.1150 |
| | -3 | -0.0063 | 0.0245 | 0.0634 | -0.0072 | -0.0390 | 0.0118 | -0.0254 | -0.0127 | -0.0034 | -0.0267 |
| | -2 | 0.0010 | 0.0011 | 0.0437 | 0.0031 | 0.0062 | 0.0156 | -0.0128 | -0.0006 | 0.0199 | -0.0436 |
| | -1 | -0.0238 | -0.0265 | -0.0035 | -0.0218 | 0.0101 | -0.0043 | -0.0461 | -0.0265 | -0.0118 | -0.0370 |
| | 1 | -0.0167 | 0.0273 | -0.0503 | -0.0130 | -0.0294 | 0.0081 | -0.0224 | -0.0226 | -0.0123 | -0.0273 |
| | 2 | -0.0016 | 0.0863 | -0.0179 | 0.0000 | -0.0364 | 0.0268 | -0.0017 | -0.0057 | -0.0174 | -0.0083 |
| | 3+ | 0.0111 | 0.0886 | -0.0300 | 0.0027 | -0.0068 | 0.0119 | 0.0053 | -0.0067 | 0.0168 | 0.0183 |
| MO x corruption percept. index | -5 | 0.0231 | 0.0323 | 0.0315 | 0.0612 | -0.0043 | 0.0038 | 0.0339 | -0.0103 | -0.0766 | 0.0728 |
| | -4 | 0.1942* | 0.2384** | 0.1945* | 0.2243** | 0.1473 | 0.1670* | 0.2072** | 0.0924 | 0.1024 | 0.2593** |
| | -3 | 0.3323*** | 0.5046*** | 0.3321*** | 0.3374*** | 0.2806** | 0.2950*** | 0.3554*** | 0.1944 | 0.2672** | 0.3644*** |
| | -2 | 0.3988*** | 0.6464*** | 0.4091*** | 0.4015*** | 0.2758** | 0.3812*** | 0.4281*** | 0.2736** | 0.3090** | 0.4591*** |
| | -1 | 0.4942*** | 0.7397*** | 0.5181*** | 0.4885*** | 0.2676* | 0.4700*** | 0.5246*** | 0.3897*** | 0.4649*** | 0.5498*** |
| | 0 | 0.4750*** | 0.7208*** | 0.4965*** | 0.4656*** | 0.3341** | 0.4151*** | 0.4935*** | 0.3557** | 0.5160*** | 0.5308*** |
| | 1 | 0.4311*** | 0.5498*** | 0.4486*** | 0.4126*** | 0.3340** | 0.4225*** | 0.4419*** | 0.3317** | 0.4316*** | 0.5172*** |
| | 2 | 0.2919** | 0.2813 | 0.2916** | 0.2654* | 0.2313 | 0.2484* | 0.3078** | 0.1990 | 0.3738** | 0.4035*** |
| | 3+ | 0.5225*** | 0.5396** | 0.5063*** | 0.5051*** | 0.3977** | 0.4610*** | 0.5540*** | 0.4335*** | 0.5201*** | 0.6683*** |
| Ownership unbundling | -6+ | -0.1866*** | -0.1673*** | -0.1794*** | -0.1758*** | -0.1793*** | -0.1609*** | -0.1889*** | -0.1954*** | -0.1696*** | -0.1715*** |
| | -5 | -0.0926 | -0.0856 | -0.0854 | -0.0791 | -0.1890*** | -0.0647 | -0.0939 | -0.0958 | -0.0273 | -0.0816 |
| | -4 | -0.0466 | -0.0335 | -0.0389 | -0.0347 | -0.1171* | -0.0196 | -0.0462 | -0.0482 | -0.0097 | -0.0334 |
| | -3 | -0.0109 | 0.0097 | -0.0039 | -0.0032 | -0.0345 | 0.0000 | -0.0190 | -0.0235 | 0.0674 | -0.0237 |
| | -2 | -0.0171 | -0.0086 | -0.0178 | -0.0071 | -0.0327 | -0.0038 | -0.0347 | -0.0172 | 0.1091 | -0.0246 |
| | -1 | 0.0295 | 0.0313 | 0.0366 | 0.0336 | 0.0164 | 0.0505 | 0.0178 | 0.0356 | 0.1018 | 0.0300 |
| | 1 | 0.1389*** | 0.1344** | 0.1273** | 0.1380*** | 0.1431*** | 0.1561*** | 0.1354** | 0.1404*** | 0.1396*** | 0.1422*** |
| | 2 | 0.0495 | 0.0360 | 0.0452 | 0.0492 | 0.0505 | 0.0591 | 0.0401 | 0.0553 | 0.0491 | 0.0493 |
| | 3+ | 0.1465** | 0.1393** | 0.1376** | 0.1432** | 0.1584** | 0.1563*** | 0.1478** | 0.1395** | 0.0572 | 0.1497** |
| OU x new member state | -6+ | 0.2930*** | 0.3232*** | 0.1935* | 0.2924*** | 0.1958* | 0.2938*** | 0.3573*** | 0.3463*** | 0.2792*** | 0.2506** |
| | -5 | 0.1945** | 0.2340** | 0.1207 | 0.1917** | 0.2053* | 0.1984** | 0.2430*** | 0.2406*** | 0.1315 | 0.0935 |
| | -4 | 0.1914** | 0.2205** | 0.1393 | 0.1928** | 0.1630* | 0.1843** | 0.2158*** | 0.2311*** | 0.1582** | 0.1398 |
| | -3 | 0.1681** | 0.2058** | 0.1404* | 0.1701** | 0.2208** | 0.1529* | 0.1763** | 0.1823** | 0.1489* | 0.1831** |
| | -2 | 0.1266* | 0.1530** | 0.1140 | 0.1216* | 0.1522 | 0.1012 | 0.1268* | 0.1441* | 0.1406* | 0.1187 |
| | -1 | 0.0552 | 0.0612 | 0.0481 | 0.0547 | 0.0643 | 0.0419 | 0.0553 | 0.0626 | 0.0638 | 0.0327 |
| | 1 | 0.1937*** | 0.1831** | 0.2014*** | 0.1953*** | 0.2675*** | 0.1769** | 0.2087*** | 0.2030*** | 0.2002*** | 0.1664** |
| | 2 | 0.4184*** | 0.3751*** | 0.4311*** | 0.4187*** | 0.4551*** | 0.3739*** | 0.4136*** | 0.4122*** | 0.4368*** | 0.3286** |
| | 3+ | 0.6101*** | 0.6051*** | 0.6483*** | 0.6200*** | 0.6286*** | 0.6063*** | 0.5958*** | 0.5618*** | 0.5897*** | 0.5259*** |
| OU x corruption percept. index | -3 | -0.1017 | -0.1567 | -0.0999 | -0.0907 | -0.3337* | -0.0503 | -0.0818 | -0.0441 | -0.2257 | -0.0209 |
| | -2 | -0.0626 | -0.0705 | -0.0388 | -0.0421 | -0.2534 | -0.0216 | -0.0136 | -0.0305 | -0.3010* | -0.0062 |
| | -1 | -0.0113 | 0.0543 | -0.0035 | 0.0198 | -0.1877 | 0.0135 | 0.0385 | 0.0305 | -0.1639 | 0.0429 |
| | 0 | 0.1901 | 0.2759 | 0.2343 | 0.2342 | -0.0247 | 0.2747 | 0.2138 | 0.2568 | 0.1778 | 0.2356 |
| | 1 | -0.3262 | -0.1951 | -0.2262 | -0.2835 | -0.7121** | -0.2995 | -0.3031 | -0.2748 | -0.3428 | -0.2996 |
| | 2 | -0.3312 | -0.0851 | -0.2557 | -0.2780 | -0.6612* | -0.2309 | -0.2591 | -0.2405 | -0.3670 | -0.2100 |
| | 3+ | -0.6715** | -0.4940 | -0.5661* | -0.6125** | -1.0001*** | -0.5844* | -0.6344** | -0.4503 | -0.4654 | -0.5787* |
| log(gdp) | | 0.4120*** | 0.3663*** | 0.4834*** | 0.4056*** | 0.4151*** | 0.3849*** | 0.3130** | 0.3533** | 0.4403*** | 0.4282*** |
| log(cpi) | | 0.6179** | 0.8061*** | 0.3599 | 0.6618*** | 0.6796*** | 0.7477*** | 0.7243*** | 0.7890*** | 0.5311** | 0.3702 |
| log(price of | | 0.1772*** | 0.1643*** | 0.1576*** | 0.1744*** | 0.1709*** | 0.1779*** | 0.1825*** | 0.1610*** | 0.1601*** | 0.2016*** |
| log(price of oil) | | 0.0120 | 0.0159 | 0.0155 | 0.0224 | 0.0115 | 0.0137 | 0.0105 | 0.0248 | 0.0117 | 0.0036 |
| hydro share | | -0.0197 | -0.0344 | -0.0304 | 0.0071 | 0.0249 | 0.0343 | -0.0409 | 0.9431* | -0.1260 | -0.0665 |
| nuclear share | | 1.0271** | 1.0545** | 0.9056** | 1.0289** | 1.1421*** | 1.0732*** | 1.5304** | 1.1509*** | 0.8069** | 1.1152*** |
| trend | | 0.0014 | 0.0013 | 0.0028 | 0.0008 | 0.0017 | 0.0005 | 0.0013 | 0.0014 | 0.0034 | 0.0017 |

| Country Industry | | Base | Portugal | Romania | Slovakia | Slovenia | Spain | Sweden | United Kingdom |
|---|---|---|---|---|---|---|---|---|---|
| R2 | | 0.8355 | 0.8305 | 0.8339 | 0.8322 | 0.8331 | 0.8498 | 0.8490 | 0.8642 |
| Obs | | 425 | 412 | 419 | 417 | 409 | 402 | 403 | 402 |
| | | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Market opening | -6+ | 0.3597*** | 0.3625*** | 0.3488*** | 0.3616*** | 0.3506*** | 0.3340*** | 0.3191*** | 0.3878*** |
| | -5 | 0.2925*** | 0.2878*** | 0.2805*** | 0.2936*** | 0.2618*** | 0.2771*** | 0.2572*** | 0.3066*** |
| | -4 | 0.2125*** | 0.2127*** | 0.1995*** | 0.2146*** | 0.1898*** | 0.2002*** | 0.1832*** | 0.2196*** |
| | -3 | 0.1603*** | 0.1579*** | 0.1484*** | 0.1619*** | 0.1396*** | 0.1475*** | 0.1423*** | 0.1592*** |
| | -2 | 0.0858* | 0.0831* | 0.0747 | 0.0860* | 0.0668 | 0.0798 | 0.0860* | 0.0820* |
| | -1 | 0.0190 | 0.0148 | 0.0076 | 0.0205 | 0.0067 | 0.0165 | 0.0305 | 0.0133 |
| | 1 | -0.0329 | -0.0197 | -0.0496 | -0.0315 | -0.0442 | -0.0411 | -0.0222 | -0.0651 |
| | 2 | -0.0074 | 0.0077 | -0.0268 | -0.0105 | -0.0275 | -0.0215 | 0.0260 | -0.0445 |
| | 3+ | -0.0906* | -0.0834* | -0.1019** | -0.0880* | -0.0984** | -0.0910* | -0.0186 | -0.1401*** |
| MO x new member state | -4 | 0.0476 | 0.0658 | 0.0597 | 0.0460 | -0.1203 | 0.0318 | 0.0368 | -0.0006 |
| | -3 | -0.0063 | 0.0154 | -0.0100 | -0.0096 | -0.1006 | -0.0077 | -0.0003 | -0.0457 |
| | -2 | 0.0010 | 0.0072 | -0.0061 | -0.0052 | -0.1122* | 0.0202 | 0.0202 | -0.0224 |
| | -1 | -0.0238 | -0.0044 | -0.0273 | -0.0361 | -0.1073* | -0.0205 | -0.0083 | -0.0360 |
| | 1 | -0.0167 | -0.0144 | -0.0322 | -0.0170 | -0.0574 | -0.0163 | -0.0100 | -0.0078 |
| | 2 | -0.0016 | 0.0091 | -0.0175 | -0.0015 | -0.0577 | -0.0061 | -0.0028 | -0.0026 |
| | 3+ | 0.0111 | 0.0283 | 0.0045 | 0.0118 | -0.0183 | 0.0183 | 0.0022 | 0.0285 |
| MO x corruption percept. index | -5 | 0.0231 | 0.0447 | 0.0271 | 0.0241 | 0.1026 | -0.0040 | 0.0409 | 0.0315 |
| | -4 | 0.1942* | 0.2086** | 0.2053** | 0.1924* | 0.2591*** | 0.1502 | 0.2042** | 0.2124** |
| | -3 | 0.3323*** | 0.3469*** | 0.3373*** | 0.3325*** | 0.4106*** | 0.2913** | 0.3310*** | 0.3614*** |
| | -2 | 0.3988*** | 0.4339*** | 0.4010*** | 0.4042*** | 0.5049*** | 0.3288** | 0.3684*** | 0.4034*** |
| | -1 | 0.4942*** | 0.5075*** | 0.4931*** | 0.4964*** | 0.5928*** | 0.4441*** | 0.4602*** | 0.4816*** |
| | 0 | 0.4750*** | 0.5159*** | 0.4293*** | 0.4840*** | 0.5392*** | 0.4153*** | 0.4844*** | 0.4323*** |
| | 1 | 0.4311*** | 0.4442*** | 0.4510*** | 0.4360*** | 0.5459*** | 0.4003*** | 0.4347*** | 0.4491*** |
| | 2 | 0.2919** | 0.2911** | 0.3212** | 0.3118** | 0.4429*** | 0.2667* | 0.2674* | 0.3363** |
| | 3+ | 0.5225*** | 0.5274*** | 0.5302*** | 0.5231*** | 0.6483*** | 0.4428*** | 0.4304*** | 0.5437*** |
| Ownership unbundling | -6+ | -0.1866*** | -0.1746*** | -0.2196*** | -0.1863*** | -0.1534*** | -0.2121*** | -0.1433*** | -0.1871 |
| | -5 | -0.0926 | -0.0641 | -0.1251** | -0.0924 | -0.0635 | -0.1118* | -0.0489 | -0.0891 |
| | -4 | -0.0466 | -0.0301 | -0.0827 | -0.0459 | -0.0182 | -0.0725 | 0.0018 | -0.0503 |
| | -3 | -0.0109 | 0.0046 | -0.0481 | -0.0119 | -0.0130 | -0.0079 | 0.0551 | -0.0054 |
| | -2 | -0.0171 | -0.0066 | -0.0466 | -0.0146 | -0.0149 | 0.0023 | 0.0482 | -0.0010 |
| | -1 | 0.0295 | 0.0411 | -0.0034 | 0.0370 | 0.0389 | 0.0348 | 0.0721 | 0.0387 |
| | 1 | 0.1389*** | 0.1417*** | 0.0923* | 0.1375*** | 0.1480*** | 0.1619*** | 0.1472*** | 0.1900*** |
| | 2 | 0.0495 | 0.0566 | -0.0277 | 0.0454 | 0.0556 | 0.1044 | 0.0850 | 0.0574 |
| | 3+ | 0.1465** | 0.1565** | 0.0957 | 0.1436** | 0.1409** | 0.1582* | 0.2324*** | 0.1995*** |
| OU x new member state | -6+ | 0.2930*** | 0.2955*** | 0.2724*** | 0.2915*** | 0.4285*** | 0.3428*** | 0.2791*** | 0.2898 |
| | -5 | 0.1945** | 0.1836** | 0.1787** | 0.1934** | 0.3637*** | 0.2304** | 0.1759** | 0.1838** |
| | -4 | 0.1914** | 0.1941** | 0.1926** | 0.1889** | 0.4410*** | 0.2311*** | 0.1667** | 0.1783** |
| | -3 | 0.1681** | 0.1408* | 0.1774** | 0.1652** | 0.2429** | 0.1884** | 0.1483** | 0.1525** |
| | -2 | 0.1266* | 0.1345* | 0.1225* | 0.1240* | 0.2313** | 0.1405* | 0.1200* | 0.1114 |
| | -1 | 0.0552 | 0.0699 | 0.0486 | 0.0368 | 0.1161 | 0.0539 | 0.0575 | 0.0539 |
| | 1 | 0.1937*** | 0.1930** | 0.1837** | 0.1958** | 0.2361** | 0.1599* | 0.1926*** | 0.1425* |
| | 2 | 0.4184*** | 0.3996*** | 0.3573*** | 0.3903*** | 0.3995*** | 0.5742** | 0.4744*** | 0.4529*** |
| | 3+ | 0.6101*** | 0.5785*** | 0.5746*** | 0.5878*** | 0.5640*** | 0.6977** | 0.7103*** | 0.5742 |
| OU x corruption percept. index | -3 | -0.1017 | -0.0596 | -0.0892 | -0.0995 | -0.0186 | -0.1396 | -0.1589 | -0.1292 |
| | -2 | -0.0626 | -0.0656 | -0.0716 | -0.0704 | 0.0161 | -0.0977 | -0.1294 | -0.1179 |
| | -1 | -0.0113 | -0.0273 | -0.0181 | -0.0364 | 0.0619 | 0.0335 | -0.0262 | -0.0854 |
| | 0 | 0.1901 | 0.2192 | 0.0677 | 0.1910 | 0.2981* | 0.2581 | 0.2796* | 0.1231 |
| | 1 | -0.3262 | -0.2904 | -0.2687 | -0.3212 | -0.2529 | -0.2363 | -0.2492 | -0.4203** |
| | 2 | -0.3312 | -0.2646 | -0.0655 | -0.3020 | -0.1749 | -0.5776 | -0.3680 | -0.5189* |
| | 3+ | -0.6715** | -0.5861* | -0.6036** | -0.6426** | -0.4258 | -0.7539 | -0.9326*** | -0.9075*** |
| log(gdp) | | 0.4120*** | 0.4050*** | 0.4984*** | 0.4032*** | 0.4421*** | 0.3464** | 0.4474*** | 0.6971 |
| log(cpi) | | 0.6179** | 0.6044** | 0.5714** | 0.6048** | 0.3104 | 0.7425*** | 0.7621*** | 0.1642 |
| log(price of | | 0.1772*** | 0.1743*** | 0.1801*** | 0.1759*** | 0.1936*** | 0.1858*** | 0.1634*** | 0.1268 |
| log(price of oil) | | 0.0120 | 0.0096 | 0.0043 | 0.0125 | 0.0044 | 0.0022 | 0.0215 | -0.0009 |
| hydro share | | -0.0197 | -0.0122 | -0.0202 | -0.0434 | -0.0763 | -0.1378 | -0.0216 | -0.0387 |
| nuclear share | | 1.0271** | 1.0616*** | 1.1944*** | 1.1124*** | 1.1034** | 0.5294 | 0.8225** | 0.7511 |
| trend | | 0.0014 | 0.0015 | 0.0016 | 0.0015 | 0.0023 | 0.0006 | -0.0049 | 0.0086 |

| Country<br>Households | | BASE | Austria | Belgium | Bulgaria | Czech Republic | Denmark | Estonia | Finland | France | Germany |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R2 | | 0.9337 | 0.9357 | 0.9309 | 0.9292 | 0.9296 | 0.9427 | 0.9308 | 0.9378 | 0.9359 | 0.9289 |
| Obs | | 425 | 408 | 401 | 417 | 409 | 401 | 416 | 402 | 401 | 402 |
| | | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Market opening | -6+ | 0.0585** | 0.0449* | 0.0543** | 0.0577** | 0.0565** | 0.0556** | 0.0542** | 0.0338 | 0.0601** | 0.0531** |
| | -5 | -0.0249 | -0.0409 | -0.0200 | -0.0245 | -0.0288 | 0.0132 | -0.0279 | -0.0526 | -0.0178 | -0.0430 |
| | -4 | -0.0266 | -0.0315 | -0.0275 | -0.0270 | -0.0261 | -0.0295 | -0.0275 | -0.0443 | -0.0179 | -0.0515 |
| | -3 | -0.0079 | -0.0033 | 0.0060 | -0.0058 | 0.0019 | 0.0118 | -0.0089 | -0.0797* | 0.0012 | -0.0213 |
| | -2 | 0.0150 | 0.0292 | 0.0233 | 0.0150 | 0.0176 | 0.0275 | 0.0151 | -0.0316 | 0.0225 | 0.0175 |
| | -1 | -0.0017 | 0.0219 | 0.0142 | 0.0004 | 0.0022 | -0.0382 | -0.0016 | -0.0381 | 0.0005 | 0.0092 |
| | 1 | 0.0117 | 0.0255 | 0.0080 | 0.0130 | 0.0219 | -0.0507 | 0.0135 | 0.0793 | 0.0053 | 0.0180 |
| | 2 | 0.0595* | 0.0595* | 0.0506 | 0.0597* | 0.0793** | -0.0409 | 0.0609* | 0.1651*** | 0.0529 | 0.0612* |
| | 3+ | 0.0467 | 0.0691* | 0.0385 | 0.0481 | 0.0557* | -0.0115 | 0.0530 | 0.1344** | 0.0351 | 0.0815** |
| MO x new member state | -6+ | -0.1117** | -0.1016** | -0.1129** | -0.1193** | -0.1072** | -0.1077** | -0.1091** | -0.0828* | -0.1146** | -0.1091** |
| | -5 | -0.0965 | -0.0855 | -0.0999 | -0.0984 | -0.0810 | -0.0686 | -0.0962 | -0.0900 | -0.0955 | -0.0850 |
| | -4 | -0.0877 | -0.0746 | -0.0972 | -0.0880 | -0.0727 | -0.0542 | -0.0856 | -0.0717 | -0.0914 | -0.0808 |
| | -3 | -0.0224 | -0.0073 | -0.0205 | -0.0311 | 0.0029 | 0.0162 | -0.0222 | -0.0411 | -0.0229 | -0.0116 |
| | -2 | 0.0421 | 0.0498 | 0.0335 | 0.0420 | 0.0302 | 0.0722 | 0.0422 | 0.0330 | 0.0365 | 0.0436 |
| | -1 | -0.0069 | 0.0078 | -0.0392 | -0.0129 | -0.0133 | -0.0274 | -0.0076 | -0.0124 | -0.0106 | -0.0078 |
| | 1 | 0.4367*** | 0.4106*** | 0.4331*** | 0.4363*** | | 0.3235*** | 0.4359*** | 0.4499*** | 0.4303*** | 0.4375*** |
| MO x corruption perceptions index | -5 | 0.1168 | 0.1230 | 0.1108 | 0.1157 | 0.1306 | -0.0133 | 0.1199 | 0.1595 | 0.1020 | 0.1314 |
| | -4 | 0.0742 | 0.0613 | 0.0850 | 0.0772 | 0.0702 | 0.0349 | 0.0706 | 0.0824 | 0.0632 | 0.1101 |
| | -3 | 0.0342 | -0.0042 | 0.0140 | 0.0294 | -0.0083 | -0.0515 | 0.0355 | 0.2028 | 0.0169 | 0.0383 |
| | -2 | 0.0098 | -0.0300 | 0.0083 | 0.0153 | 0.0036 | -0.0629 | 0.0103 | 0.1168 | 0.0069 | 0.0040 |
| | -1 | -0.0547 | -0.1232 | -0.0207 | -0.0587 | -0.0696 | 0.0476 | -0.0531 | 0.0214 | -0.0522 | -0.0671 |
| | 0 | 0.0386 | 0.0438 | 0.0547 | 0.0520 | 0.0309 | 0.0396 | 0.0422 | 0.0190 | 0.0453 | 0.0623 |
| | 1 | 0.0778 | 0.0116 | 0.1319 | 0.0795 | 0.0458 | 0.3463* | 0.0821 | -0.1841 | 0.0989 | 0.0395 |
| | 2 | 0.0495 | 0.0440 | 0.0808 | 0.0605 | 0.0007 | 0.4457** | 0.0563 | -0.3421* | 0.0683 | 0.0251 |
| | 3+ | 0.0609 | 0.1509 | 0.0393 | 0.0672 | 0.0539 | 0.2805* | 0.0431 | -0.3524 | 0.0655 | -0.5380* |
| Ownership unbundling | -6+ | -0.0219 | -0.0121 | -0.0201 | -0.0229 | -0.0249 | 0.0527** | -0.0211 | 0.0013 | -0.0125 | -0.0127 |
| | -5 | 0.0244 | 0.0266 | 0.0145 | 0.0218 | 0.0144 | 0.0456 | 0.0258 | 0.0861* | 0.0250 | 0.0255 |
| | -4 | 0.0958** | 0.0884** | 0.0914** | 0.0956** | 0.1139** | 0.1709** | 0.0957** | 0.1380*** | 0.0979** | 0.0927** |
| | -3 | 0.0784* | 0.0710 | 0.0590 | 0.0756 | 0.0697 | 0.0546 | 0.0785* | 0.1562*** | 0.0822* | 0.0774 |
| | -2 | 0.0915** | 0.0968** | 0.0813* | 0.0915** | 0.0772* | 0.0687 | 0.0916** | 0.1451*** | 0.0944** | 0.0925** |
| | -1 | 0.1102** | 0.0884** | 0.0984** | 0.1086** | 0.0995** | 0.1200** | 0.1091** | 0.1329*** | 0.1094** | 0.0993** |
| | 1 | 0.2227*** | 0.1945*** | 0.2220*** | 0.2218*** | 0.2277*** | 0.2302*** | 0.2203*** | 0.1733*** | 0.2271*** | 0.2149*** |
| | 2 | 0.3589*** | 0.3482*** | 0.3634*** | 0.3586*** | 0.3535*** | 0.3912*** | 0.3585*** | 0.2884*** | 0.3592*** | 0.3562*** |
| | 3+ | 0.2243*** | 0.2045*** | 0.2124*** | 0.2235*** | 0.2202*** | 0.2512*** | 0.2219*** | 0.1627** | 0.2246*** | 0.1866*** |
| OU x new member state | -6+ | 0.0136 | 0.0070 | 0.0188 | 0.0207 | 0.0614 | -0.0690 | 0.0118 | -0.0285 | 0.0112 | 0.0063 |
| | -5 | 0.0162 | 0.0076 | 0.0271 | 0.0165 | -0.0086 | -0.0741 | 0.0178 | 0.0067 | 0.0130 | -0.0026 |
| | -4 | 0.1390 | 0.1274 | 0.1607* | 0.1408 | 0.0885 | 0.0681 | 0.1387 | 0.1208 | 0.1435 | 0.1328 |
| | -3 | 0.1307* | 0.1142 | 0.1505** | 0.1401* | 0.1158 | 0.0189 | 0.1308* | 0.1398** | 0.1297* | 0.1210* |
| | -2 | 0.0290 | 0.0303 | 0.0467 | 0.0292 | 0.0430 | -0.0512 | 0.0303 | 0.0404 | 0.0339 | 0.0253 |
| | -1 | 0.0946 | 0.0762 | 0.1236* | 0.1002 | 0.1027 | 0.0895 | 0.0955 | 0.0887 | 0.0976 | 0.0817 |
| OU x corruption perceptions index | -5 | -0.0965 | -0.0759 | -0.0876 | -0.0918 | -0.0815 | 0.0184 | -0.1016 | -0.2221 | -0.0824 | -0.0690 |
| | -4 | -0.2460* | -0.2074 | -0.2562* | -0.2497* | -0.3357** | -0.2730 | -0.2434* | -0.3115** | -0.2470* | -0.2276 |
| | -3 | -0.3105** | -0.2611* | -0.3057** | -0.3041** | -0.2929* | -0.0974 | -0.3098** | -0.4761*** | -0.3139** | -0.2916* |
| | -2 | -0.2825** | -0.2915** | -0.2887** | -0.2895** | -0.2458* | -0.1062 | -0.2831** | -0.4009*** | -0.2986** | -0.2817** |
| | -1 | -0.2908* | -0.2199 | -0.3282** | -0.2871* | -0.2586* | -0.2853 | -0.2888* | -0.3154* | -0.2965* | -0.2526 |
| | 0 | 0.0673 | 0.0673 | 0.0523 | 0.0568 | 0.0616 | 0.0747 | 0.0670 | 0.1011 | 0.0570 | 0.0533 |
| | 1 | -1.0800*** | -0.9268*** | -1.1144*** | -1.0790*** | -1.1195*** | -0.9882*** | -1.0735*** | -0.8654** | -1.0997*** | -1.0325*** |
| | 2 | -2.0720*** | -2.0066*** | -2.0972*** | -2.0755*** | -2.1040*** | -2.0753*** | -2.0646*** | -1.7822*** | -2.0747*** | -2.0524*** |
| | 3+ | -1.3159*** | -1.3890*** | -1.2168*** | -1.3166*** | -1.3173*** | -1.3994*** | -1.2898*** | -0.9783*** | -1.2973*** | -0.7001** |
| log(gdp) | | 0.4486*** | 0.4409*** | 0.4281*** | 0.4425*** | 0.3469*** | 0.4087*** | 0.4384*** | 0.4409*** | 0.4194*** | 0.4184*** |
| log(cpi) | | 0.2149 | 0.1919 | 0.1318 | 0.2084 | 0.3938** | 0.3049* | 0.2276 | 0.3356** | 0.1561 | 0.1876 |
| log(price of | | 0.1027*** | 0.0972*** | 0.1048*** | 0.1034*** | 0.0869*** | 0.1379*** | 0.1085*** | 0.1378*** | 0.1104*** | 0.1029*** |
| log(price of oil) | | -0.0295 | -0.0197 | -0.0291 | -0.0303 | -0.0288 | -0.0304 | -0.0325 | -0.0334 | -0.0325 | -0.0238 |
| hydro share | | -0.3766** | -0.3710** | -0.3347** | -0.3792** | -0.3461** | -0.4544*** | -0.3753** | -0.4217*** | -0.3454** | -0.3948*** |
| nuclear share | | 0.5777** | 0.6676** | 0.5547* | 0.5830** | 0.1766 | 0.4578* | 0.5797** | 0.4992* | 0.6239** | 0.6058** |
| trend | | -0.0024 | -0.0027 | -0.0011 | -0.0024 | -0.0031 | -0.0038 | -0.0027 | -0.0058** | -0.0004 | -0.0022 |

| Country<br>Households | | BASE | Greece | Hungary | Ireland | Italy | Latvia | Lithuania | Luxembourg | Netherlands | Poland |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $R^2$ | | 0.9337 | 0.9268 | 0.9349 | 0.9343 | 0.9222 | 0.9346 | 0.9347 | 0.9346 | 0.9356 | 0.9336 |
| Obs | | 425 | 401 | 411 | 409 | 402 | 417 | 417 | 403 | 408 | 411 |
| | | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Market opening | -6+ | 0.0585** | 0.0847*** | 0.0478** | 0.0675*** | 0.0787*** | 0.0542** | 0.0681*** | 0.0640** | 0.0666*** | 0.0532** |
| | -5 | -0.0249 | -0.0175 | -0.0345 | -0.0226 | 0.0041 | -0.0267 | -0.0179 | -0.0110 | -0.0222 | -0.0278 |
| | -4 | -0.0266 | -0.0191 | -0.0338 | -0.0257 | 0.0027 | -0.0296 | -0.0215 | -0.0169 | -0.0455 | -0.0260 |
| | -3 | -0.0079 | -0.0015 | -0.0125 | -0.0048 | 0.0037 | -0.0040 | 0.0068 | -0.0033 | -0.0192 | 0.0029 |
| | -2 | 0.0150 | 0.0151 | 0.0144 | 0.0071 | 0.0203 | 0.0162 | 0.0173 | 0.0092 | 0.0197 | 0.0178 |
| | -1 | -0.0017 | 0.0156 | -0.0030 | -0.0016 | -0.0009 | -0.0023 | -0.0002 | -0.0093 | -0.0249 | 0.0017 |
| | 1 | 0.0117 | 0.0199 | 0.0136 | 0.0123 | -0.0001 | 0.0162 | 0.0068 | 0.0089 | 0.0118 | 0.0122 |
| | 2 | 0.0595* | 0.0588* | 0.0613* | 0.0601* | 0.0398 | 0.0598* | 0.0504 | 0.0522 | 0.0537 | 0.0576* |
| | 3+ | 0.0467 | 0.0456 | 0.0487 | 0.0445 | 0.0266 | 0.0514 | 0.0298 | 0.0544 | 0.0456 | 0.0417 |
| MO x new member state | -6+ | -0.1117** | -0.1298*** | -0.0961*** | -0.1264*** | -0.1246*** | -0.1125** | -0.1285*** | -0.1138** | -0.1192*** | -0.0851* |
| | -5 | -0.0965 | -0.1388* | -0.0864 | -0.1010 | -0.0841 | -0.1008 | -0.0963 | -0.0941 | -0.0968 | -0.1036 |
| | -4 | -0.0877 | -0.1162 | 0.0546 | -0.0932 | -0.0904 | -0.0881 | -0.0870 | -0.0895 | -0.0883 | -0.0799 |
| | -3 | -0.0224 | -0.0442 | -0.0140 | -0.0335 | -0.0130 | -0.0436 | 0.0129 | -0.0243 | -0.0306 | -0.0073 |
| | -2 | 0.0421 | 0.0189 | 0.0604 | 0.0601 | 0.0477 | 0.0168 | 0.0548 | 0.0340 | 0.0450 | 0.0429 |
| | -1 | -0.0069 | 0.0167 | -0.0018 | -0.0056 | -0.0009 | 0.0208 | -0.0298 | -0.0165 | -0.0208 | -0.0077 |
| | 1 | 0.4367*** | 0.4389*** | 0.4245*** | 0.4349*** | 0.4060*** | 0.4290*** | 0.3607*** | 0.3446*** | 0.4231*** | 0.4503*** |
| MO x corruption perceptions index | -5 | 0.1168 | 0.1944 | 0.1263 | 0.1158 | 0.0548 | 0.1162 | 0.1177 | 0.0873 | 0.1182 | 0.1230 |
| | -4 | 0.0742 | 0.1195 | 0.0830 | 0.0748 | 0.0457 | 0.0729 | 0.0738 | 0.0554 | 0.1154 | 0.0696 |
| | -3 | 0.0342 | 0.0661 | 0.0384 | 0.0432 | 0.0000 | 0.0129 | -0.0049 | 0.0402 | 0.0680 | -0.0049 |
| | -2 | 0.0098 | 0.0533 | -0.0004 | -0.0130 | -0.0070 | 0.0034 | -0.0022 | 0.0412 | -0.0033 | -0.0021 |
| | -1 | -0.0547 | -0.1355 | -0.0608 | -0.0568 | -0.0806 | -0.0596 | -0.0640 | -0.0166 | 0.0126 | -0.0584 |
| | 0 | 0.0386 | 0.0388 | 0.0062 | 0.0353 | 0.0132 | 0.0336 | 0.0394 | 0.0408 | 0.0365 | 0.0526 |
| | 1 | 0.0778 | 0.0102 | 0.0512 | 0.0599 | 0.0731 | 0.0573 | 0.0597 | 0.1181 | 0.0657 | 0.1101 |
| | 2 | 0.0495 | 0.0207 | 0.0162 | 0.0344 | 0.0588 | 0.0523 | 0.0359 | 0.1087 | 0.0395 | 0.1059 |
| | 3+ | 0.0609 | 0.0170 | 0.0363 | 0.0450 | 0.0587 | 0.0465 | 0.1457 | 0.0958 | 0.0466 | 0.1728 |
| Ownership unbundling | -6+ | -0.0219 | -0.0370 | -0.0214 | -0.0277 | -0.0746** | -0.0201 | -0.0337 | -0.0600** | -0.0001 | -0.0296 |
| | -5 | 0.0244 | 0.0023 | 0.0207 | 0.0281 | -0.0566 | 0.0246 | -0.0022 | 0.0015 | 0.0725 | 0.0052 |
| | -4 | 0.0958** | 0.0779 | 0.0952** | 0.1071** | 0.0175 | 0.1000** | 0.0809* | 0.0795* | 0.0528 | 0.0938** |
| | -3 | 0.0784* | 0.0641 | 0.0769* | 0.0789* | 0.0227 | 0.0695 | 0.0586 | 0.0583 | 0.1343*** | 0.0572 |
| | -2 | 0.0915** | 0.0908** | 0.0903** | 0.0983** | 0.0432 | 0.0873** | 0.0625 | 0.0684 | 0.1125*** | 0.0717* |
| | -1 | 0.1102** | 0.0913* | 0.1096** | 0.1086** | 0.0780* | 0.1108*** | 0.0944** | 0.0964** | 0.1329*** | 0.1029** |
| | 1 | 0.2227*** | 0.2083*** | 0.2156*** | 0.2233*** | 0.1813*** | 0.2178*** | 0.2116*** | 0.1828*** | 0.2114*** | 0.2196*** |
| | 2 | 0.3589*** | 0.3467*** | 0.3517*** | 0.3570*** | 0.3264*** | 0.3565*** | 0.3337*** | 0.3131*** | 0.3493*** | 0.3573*** |
| | 3+ | 0.2243*** | 0.2103*** | 0.2192*** | 0.2206*** | 0.1974*** | 0.2170*** | 0.2236*** | 0.1812*** | 0.2146*** | 0.2310*** |
| OU x new member state | -6+ | 0.0136 | 0.0301 | | 0.0274 | 0.0714 | 0.0164 | 0.0722 | 0.0657 | -0.0100 | 0.0181 |
| | -5 | 0.0162 | 0.0359 | | 0.0279 | -0.0098 | 0.0306 | 0.0675 | 0.0742 | -0.0113 | 0.0553 |
| | -4 | 0.1390 | 0.1638* | | 0.1481* | 0.0871 | 0.1463* | 0.1649* | 0.1749** | 0.0916 | 0.1506* |
| | -3 | 0.1307* | 0.1564* | 0.1167 | 0.1427** | 0.0748 | 0.1449** | 0.0945 | 0.1526** | 0.1408** | 0.1351* |
| | -2 | 0.0290 | 0.0648 | 0.0054 | 0.0182 | 0.0037 | 0.0503 | 0.0126 | 0.0378 | 0.0182 | 0.0455 |
| | -1 | 0.0946 | 0.0773 | 0.0858 | 0.0895 | 0.0801 | 0.0658 | 0.1072 | 0.0829 | 0.0955 | 0.0968 |
| OU x corruption perceptions index | -5 | -0.0965 | -0.0911 | -0.0827 | -0.1124 | 0.1078 | -0.0994 | -0.0573 | -0.1429 | -0.1448 | -0.0619 |
| | -4 | -0.2460* | -0.2501 | -0.2424* | -0.2684* | -0.0166 | -0.2600* | -0.2358* | -0.2758* | -0.1011 | -0.2710* |
| | -3 | -0.3105** | -0.3275* | -0.3010** | -0.3269** | -0.1127 | -0.2741* | -0.2945** | -0.3208** | -0.4212*** | -0.2766* |
| | -2 | -0.2825** | -0.3466** | -0.2671* | -0.2709* | -0.1571 | -0.2648** | -0.2355* | -0.2595* | -0.2969** | -0.2448* |
| | -1 | -0.2908* | -0.2246 | -0.2784* | -0.2798* | -0.2141 | -0.2817* | -0.2460 | -0.2432 | -0.3340** | -0.2957* |
| | 0 | 0.0673 | 0.0578 | 0.1017 | 0.0722 | 0.0510 | 0.0657 | 0.0752 | 0.0943 | 0.0664 | 0.0174 |
| | 1 | -1.0800*** | -1.0091*** | -1.0215*** | -1.0627*** | -0.9357*** | -1.0511*** | -0.9158*** | -0.8107** | -1.0196*** | -1.1177*** |
| | 2 | -2.0720*** | -2.0158*** | -2.0059*** | -2.0487*** | -1.9701*** | -2.0572*** | -1.7899*** | -1.7240*** | -2.0006*** | -2.1441*** |
| | 3+ | -1.3159*** | -1.2350*** | -1.2561*** | -1.2657*** | -1.2645*** | -1.2828*** | -1.1683*** | -0.9654*** | -1.2561*** | -1.4488*** |
| log(gdp) | | 0.4486*** | 0.4248*** | 0.4839*** | 0.4438*** | 0.4682*** | 0.4723*** | 0.2673*** | 0.4092*** | 0.4780*** | 0.4526*** |
| log(cpi) | | 0.2149 | 0.2672 | 0.0263 | 0.1595 | 0.2479 | 0.2062 | 0.4192** | 0.3179* | 0.1721 | 0.2778 |
| log(price of | | 0.1027*** | 0.0961*** | 0.0845*** | 0.0927*** | 0.1045*** | 0.1080*** | 0.1077*** | 0.0841*** | 0.0937*** | 0.1100*** |
| log(price of oil) | | -0.0295 | -0.0243 | -0.0260 | -0.0276 | -0.0247 | -0.0368* | -0.0279 | -0.0272 | -0.0352 | -0.0313 |
| hydro share | | -0.3766** | -0.3734** | -0.3901*** | -0.3802** | -0.3509** | -0.3614** | -0.3621** | 0.8612** | -0.4527*** | -0.3711** |
| nuclear share | | 0.5777** | 0.6546** | 0.5117* | 0.5891** | 0.7189** | 0.6212** | 2.1097*** | 0.7725*** | 0.4766* | 0.6564** |
| trend | | -0.0024 | -0.0017 | -0.0012 | -0.0014 | -0.0014 | -0.0024 | -0.0016 | -0.0024 | -0.0015 | -0.0037 |

| Country<br>Households | | BASE | Portugal | Romania | Slovakia | Slovenia | Spain | Sweden | United Kingdom |
|---|---|---|---|---|---|---|---|---|---|
| R2 | | 0.9337 | 0.9287 | 0.9337 | 0.9328 | 0.9363 | 0.9477 | 0.9448 | 0.9489 |
| Obs | | 425 | 412 | 419 | 417 | 409 | 402 | 403 | 402 |
| | | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Market opening | -6+ | 0.0585** | 0.0592** | 0.0598*** | 0.0570** | 0.0568** | 0.0515** | 0.0460** | 0.0742*** |
| | -5 | -0.0249 | -0.0292 | -0.0219 | -0.0267 | -0.0278 | -0.0127 | -0.0296 | -0.0106 |
| | -4 | -0.0266 | -0.0291 | -0.0231 | -0.0277 | -0.0208 | -0.0104 | -0.0204 | -0.0180 |
| | -3 | -0.0079 | -0.0154 | -0.0010 | -0.0093 | 0.0107 | -0.0018 | -0.0110 | -0.0003 |
| | -2 | 0.0150 | 0.0151 | 0.0137 | 0.0137 | 0.0204 | 0.0158 | 0.0047 | 0.0044 |
| | -1 | -0.0017 | 0.0072 | -0.0007 | -0.0039 | 0.0089 | -0.0044 | -0.0032 | -0.0124 |
| | 1 | 0.0117 | -0.0093 | 0.0124 | 0.0131 | 0.0139 | 0.0130 | 0.0302 | -0.0034 |
| | 2 | 0.0595* | 0.0315 | 0.0727** | 0.0607* | 0.0627* | 0.0635** | 0.0766** | 0.0591* |
| | 3+ | 0.0467 | 0.0309 | 0.0471 | 0.0476 | 0.0463 | 0.0474 | 0.0571* | 0.0357 |
| MO x new member state | -6+ | -0.1117** | -0.1020** | -0.1107** | -0.1131** | -0.1165** | -0.1159*** | -0.1040** | -0.1377*** |
| | -5 | -0.0965 | -0.1053 | -0.0957 | -0.0982 | -0.0991 | -0.0869 | -0.0905 | -0.1217* |
| | -4 | -0.0877 | -0.0895 | -0.0851 | -0.0935 | -0.0784 | -0.0882 | -0.0773 | -0.1048* |
| | -3 | -0.0224 | -0.0437 | -0.0183 | -0.0226 | 0.0361 | -0.0228 | -0.0161 | -0.0140 |
| | -2 | 0.0421 | 0.0149 | 0.0341 | 0.0405 | 0.0537 | 0.0367 | 0.0490 | 0.0469 |
| | -1 | -0.0069 | 0.0315 | -0.0083 | -0.0091 | -0.0117 | -0.0150 | -0.0038 | -0.0026 |
| | 1 | 0.4367*** | 0.4359*** | 0.4222*** | 0.4431*** | 0.4696*** | 0.7667*** | 0.4351*** | 0.4227*** |
| MO x corruption perceptions index | -5 | 0.1168 | 0.1543 | 0.1120 | 0.1200 | 0.1270 | 0.0493 | 0.1071 | 0.0932 |
| | -4 | 0.0742 | 0.0926 | 0.0666 | 0.0760 | 0.0523 | 0.0290 | 0.0392 | 0.0591 |
| | -3 | 0.0342 | 0.0889 | 0.0118 | 0.0394 | -0.0402 | 0.0310 | 0.0245 | 0.0132 |
| | -2 | 0.0098 | 0.0565 | 0.0210 | 0.0156 | -0.0276 | 0.0308 | 0.0257 | 0.0240 |
| | -1 | -0.0547 | -0.1493 | -0.0544 | -0.0452 | -0.0917 | -0.0343 | -0.0485 | -0.0364 |
| | 0 | 0.0386 | 0.0140 | 0.0450 | 0.0427 | 0.0221 | 0.0270 | 0.0372 | 0.0193 |
| | 1 | 0.0778 | 0.4309* | 0.0812 | 0.0749 | 0.0976 | 0.0431 | 0.0198 | 0.1092 |
| | 2 | 0.0495 | 0.4001* | -0.0085 | 0.0437 | 0.0561 | -0.0151 | 0.0273 | 0.0067 |
| | 3+ | 0.0609 | 0.2194 | 0.0600 | 0.0604 | 0.1184 | 0.0140 | 0.1135 | -0.0043 |
| Ownership unbundling | -6+ | -0.0219 | -0.0267 | -0.0238 | -0.0225 | -0.0272 | -0.0574** | -0.0057 | -0.0042 |
| | -5 | 0.0244 | 0.0277 | 0.0210 | 0.0248 | 0.0009 | 0.0008 | 0.0521 | 0.0436 |
| | -4 | 0.0958** | 0.0839* | 0.1063** | 0.0962** | 0.1069** | 0.0803* | 0.1387*** | 0.1318*** |
| | -3 | 0.0784* | 0.0801* | 0.0737 | 0.0783* | 0.0513 | 0.0870** | 0.1235** | 0.1059** |
| | -2 | 0.0915** | 0.0918** | 0.0905** | 0.0878** | 0.0850** | 0.1152*** | 0.1388*** | 0.1077*** |
| | -1 | 0.1102** | 0.1009** | 0.1168*** | 0.1127** | 0.1169*** | 0.1245*** | 0.1445*** | 0.1252*** |
| | 1 | 0.2227*** | 0.2377*** | 0.2220*** | 0.2226*** | 0.2338*** | 0.2889*** | 0.2382*** | 0.2715*** |
| | 2 | 0.3589*** | 0.3841*** | 0.3447*** | 0.3581*** | 0.3687*** | 0.5177*** | 0.3816*** | 0.4075*** |
| | 3+ | 0.2243*** | 0.2349*** | 0.2231*** | 0.2242*** | 0.2444*** | 0.4445*** | 0.1265** | 0.3368*** |
| OU x new member state | -6+ | 0.0136 | 0.0119 | 0.0089 | 0.0206 | -0.0786 | 0.0405 | -0.0101 | -0.0008 |
| | -5 | 0.0162 | 0.0544 | 0.0149 | 0.0232 | -0.0951 | 0.0556 | -0.0026 | 0.0236 |
| | -4 | 0.1390 | 0.1356 | 0.1456* | 0.1498* | 0.1517 | 0.1726** | 0.1246 | 0.1540* |
| | -3 | 0.1307* | 0.1978** | 0.1240* | 0.1436** | 0.0675 | 0.1493** | 0.1309* | 0.1249* |
| | -2 | 0.0290 | 0.0876 | 0.0115 | 0.0320 | 0.0522 | 0.0197 | 0.0271 | 0.0417 |
| | -1 | 0.0946 | 0.0449 | 0.0971 | 0.1008 | 0.1572** | 0.0906 | 0.0874 | 0.1212* |
| OU x corruption perceptions index | -5 | -0.0965 | -0.1813 | -0.0985 | -0.0998 | -0.0365 | -0.1337 | -0.1221 | -0.1061 |
| | -4 | -0.2460* | -0.2282 | -0.2919** | -0.2467* | -0.3148** | -0.2892** | -0.3168** | -0.3191** |
| | -3 | -0.3105** | -0.4280** | -0.2995* | -0.3108** | -0.2477 | -0.3652** | -0.3944*** | -0.3544** |
| | -2 | -0.2825** | -0.3798** | -0.2883** | -0.2732* | -0.2926** | -0.3129** | -0.3736*** | -0.3390** |
| | -1 | -0.2908* | -0.1743 | -0.3255** | -0.2972* | -0.3607** | -0.3057** | -0.3561** | -0.3921** |
| | 0 | 0.0673 | 0.1029 | 0.0737 | 0.0750 | 0.0454 | 0.1073 | 0.0581 | 0.0325 |
| | 1 | -1.0800*** | -1.4122*** | -1.0741*** | -1.0688*** | -1.2029*** | -1.8821*** | -1.1245*** | -1.2857*** |
| | 2 | -2.0720*** | -2.4297*** | -2.0056*** | -2.0514*** | -2.2007*** | -3.8922*** | -2.2044*** | -2.1563*** |
| | 3+ | -1.3159*** | -1.4753*** | -1.2964*** | -1.3012*** | -1.5233*** | -3.5426*** | -1.0563*** | -1.5704*** |
| log(gdp) | | 0.4486*** | 0.4402*** | 0.4480*** | 0.4152*** | 0.3832*** | 0.5617*** | 0.6040*** | 0.8224*** |
| log(cpi) | | 0.2149 | 0.2586 | 0.2099 | 0.2366 | 0.5056*** | 0.0808 | 0.1742 | -0.2937* |
| log(price of | | 0.1027*** | 0.1101*** | 0.0994*** | 0.1032*** | 0.1053*** | 0.1203*** | 0.0903*** | 0.0645** |
| log(price of oil) | | -0.0295 | -0.0299 | -0.0297 | -0.0303 | -0.0273 | -0.0387* | -0.0274 | -0.0301 |
| hydro share | | -0.3766** | -0.3805** | -0.3731** | -0.3936*** | -0.3404** | -0.4749*** | -0.3767*** | -0.3669*** |
| nuclear share | | 0.5777** | 0.5872** | 0.6333** | 0.6013** | 0.1592 | 0.0570 | 0.5209** | 0.1899 |
| trend | | -0.0024 | -0.0029 | -0.0022 | -0.0024 | -0.0051** | -0.0028 | -0.0046** | 0.0015 |

## Appendix 7 – Estimation Using Only Countries without Unbundled TSO

| System of equations | | SUR for industry and households | | | | SUR for industry and households using only countries without unbundled TSO | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equation | | Industry | | Households | | Industry | | Households | |
| Customer group | | Industry | | Households | | Industry | | Households | |
| R2 | | 0.8355 | | 0.9337 | | 0.8913 | | 0.9644 | |
| Obs | | 425 | | 425 | | 220 | | 220 | |
| | | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Market opening | -6+ | 0.3597*** | 0.049 | 0.0585** | 0.023 | 0.3506*** | 0.052 | 0.0683*** | 0.020 |
| | -5 | 0.2925*** | 0.051 | -0.0249 | 0.034 | 0.2743*** | 0.057 | 0.0288 | 0.042 |
| | -4 | 0.2125*** | 0.048 | -0.0266 | 0.034 | 0.1578*** | 0.057 | -0.0131 | 0.042 |
| | -3 | 0.1603*** | 0.047 | -0.0079 | 0.037 | 0.1009** | 0.050 | 0.0181 | 0.036 |
| | -2 | 0.0858* | 0.048 | 0.0150 | 0.031 | 0.0918* | 0.053 | 0.0274 | 0.032 |
| | -1 | 0.0190 | 0.049 | -0.0017 | 0.033 | 0.0178 | 0.055 | -0.0461 | 0.032 |
| | 1 | -0.0329 | 0.044 | 0.0117 | 0.036 | -0.0401 | 0.048 | -0.0597* | 0.035 |
| | 2 | -0.0074 | 0.047 | 0.0595* | 0.033 | -0.1099** | 0.051 | -0.0504 | 0.037 |
| | 3+ | -0.0906* | 0.047 | 0.0467 | 0.034 | -0.0793 | 0.048 | -0.0119 | 0.030 |
| MO x new member state | -6+ | | | -0.1117** | 0.046 | | | -0.1158*** | 0.038 |
| | -5 | | | -0.0965 | 0.066 | | | -0.0633 | 0.056 |
| | -4 | 0.0476 | 0.070 | -0.0877 | 0.065 | -0.1082 | 0.082 | -0.0490 | 0.058 |
| | -3 | -0.0063 | 0.061 | -0.0224 | 0.050 | -0.1270** | 0.065 | 0.0464 | 0.046 |
| | -2 | 0.0010 | 0.059 | 0.0421 | 0.048 | -0.1008 | 0.067 | 0.0374 | 0.045 |
| | -1 | -0.0238 | 0.056 | -0.0069 | 0.050 | -0.0656 | 0.064 | -0.0255 | 0.043 |
| | 1 | -0.0167 | 0.053 | 0.4367*** | 0.119 | -0.0618 | 0.061 | | |
| | 2 | -0.0016 | 0.056 | | | -0.1065* | 0.062 | | |
| | 3+ | 0.0111 | 0.063 | | | -0.0111 | 0.068 | | |
| MO x corruption perceptions index | -5 | 0.0231 | 0.111 | 0.1168 | 0.102 | 0.1048 | 0.132 | -0.0473 | 0.126 |
| | -4 | 0.1942* | 0.101 | 0.0742 | 0.103 | 0.3954*** | 0.137 | 0.0106 | 0.135 |
| | -3 | 0.3323*** | 0.109 | 0.0342 | 0.116 | 0.5145*** | 0.125 | -0.0542 | 0.119 |
| | -2 | 0.3988*** | 0.123 | 0.0098 | 0.107 | 0.3948*** | 0.143 | -0.0121 | 0.111 |
| | -1 | 0.4942*** | 0.133 | -0.0547 | 0.119 | 0.5107*** | 0.156 | 0.0243 | 0.112 |
| | 0 | 0.4750*** | 0.135 | 0.0386 | 0.050 | 0.5465*** | 0.152 | -0.0056 | 0.042 |
| | 1 | 0.4311*** | 0.139 | 0.0778 | 0.181 | 0.5980*** | 0.154 | 0.5977*** | 0.201 |
| | 2 | 0.2919** | 0.145 | 0.0495 | 0.161 | 0.7767*** | 0.163 | 0.5998*** | 0.196 |
| | 3+ | 0.5225*** | 0.149 | 0.0609 | 0.173 | 0.6674*** | 0.150 | 0.3409** | 0.148 |
| Ownership unbundling | -6+ | -0.1866*** | 0.057 | -0.0219 | 0.026 | | | | |
| | -5 | -0.0926 | 0.060 | 0.0244 | 0.047 | | | | |
| | -4 | -0.0466 | 0.057 | 0.0958** | 0.045 | | | | |
| | -3 | -0.0109 | 0.065 | 0.0784* | 0.046 | | | | |
| | -2 | -0.0171 | 0.064 | 0.0915** | 0.041 | | | | |
| | -1 | 0.0295 | 0.061 | 0.1102** | 0.044 | | | | |
| | 1 | 0.1389*** | 0.053 | 0.2227*** | 0.051 | | | | |
| | 2 | 0.0495 | 0.060 | 0.3589*** | 0.045 | | | | |
| | 3+ | 0.1465** | 0.060 | 0.2243*** | 0.046 | | | | |
| OU x new member state | -6+ | 0.2930*** | 0.088 | 0.0136 | 0.056 | | | | |
| | -5 | 0.1945** | 0.088 | 0.0162 | 0.082 | | | | |
| | -4 | 0.1914** | 0.080 | 0.1390 | 0.086 | | | | |
| | -3 | 0.1681** | 0.078 | 0.1307* | 0.071 | | | | |
| | -2 | 0.1266* | 0.073 | 0.0290 | 0.066 | | | | |
| | -1 | 0.0552 | 0.068 | 0.0946 | 0.071 | | | | |
| | 1 | 0.1937*** | 0.073 | | | | | | |
| | 2 | 0.4184*** | 0.127 | | | | | | |
| | 3+ | 0.6101*** | 0.126 | | | | | | |
| OUx corruption perceptions index | -5 | | | -0.0965 | 0.138 | | | | |
| | -4 | | | -0.2460* | 0.142 | | | | |
| | -3 | -0.1017 | 0.142 | -0.3105** | 0.153 | | | | |
| | -2 | -0.0626 | 0.154 | -0.2825** | 0.139 | | | | |
| | -1 | -0.0113 | 0.165 | -0.2908* | 0.158 | | | | |
| | 0 | 0.1901 | 0.171 | 0.0673 | 0.067 | | | | |
| | 1 | -0.3262 | 0.207 | -1.0800*** | 0.324 | | | | |
| | 2 | -0.3312 | 0.309 | -2.0720*** | 0.263 | | | | |
| | 3+ | -0.6715** | 0.307 | -1.3159*** | 0.251 | | | | |
| log(gdp) | | 0.4120*** | 0.135 | 0.4486*** | 0.096 | 1.1770*** | 0.224 | 0.5706*** | 0.157 |
| log(cpi) | | 0.6179** | 0.240 | 0.2149 | 0.166 | -0.3053 | 0.352 | 0.5008** | 0.203 |
| log(price of gas) | | 0.1772*** | 0.038 | 0.1027*** | 0.028 | 0.1127*** | 0.042 | 0.0896*** | 0.030 |
| log(price of oil) | | 0.0120 | 0.029 | -0.0295 | 0.021 | -0.0381 | 0.031 | -0.0358* | 0.021 |
| hydro share | | -0.0197 | 0.200 | -0.3766** | 0.148 | -0.3914** | 0.174 | -0.6135*** | 0.121 |
| nuclear share | | 1.0271** | 0.398 | 0.5777** | 0.283 | 0.5122 | 0.413 | -0.6988** | 0.290 |
| trend | | 0.0014 | 0.003 | -0.0024 | 0.002 | 0.0039 | 0.004 | -0.0061** | 0.002 |

## Appendix 8 – Estimation with Ownership Unbundling Classification from European Commission Reports

| System of equations | | SUR for industry and households | | | | SUR for industry and households with EC classification | | | |
|---|---|---|---|---|---|---|---|---|---|
| Equation | | Industry | | Households | | Industry | | Households | |
| Customer group | | Industry | | Households | | Industry | | Households | |
| R2 | | 0.8355 | | 0.9337 | | 0.8283 | | 0.9300 | |
| Obs | | 425 | | 425 | | 425 | | 425 | |
| | | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Market opening | -6+ | 0.3597*** | 0.049 | 0.0585** | 0.023 | 0.3474*** | 0.051 | 0.0502** | 0.023 |
| | -5 | 0.2925*** | 0.051 | -0.0249 | 0.034 | 0.2801*** | 0.053 | -0.0419 | 0.036 |
| | -4 | 0.2125*** | 0.048 | -0.0266 | 0.034 | 0.2015*** | 0.050 | -0.0499 | 0.035 |
| | -3 | 0.1603*** | 0.047 | -0.0079 | 0.037 | 0.1431*** | 0.050 | -0.0572 | 0.043 |
| | -2 | 0.0858* | 0.048 | 0.0150 | 0.031 | 0.0684 | 0.051 | -0.0243 | 0.036 |
| | -1 | 0.0190 | 0.049 | -0.0017 | 0.033 | 0.0027 | 0.053 | -0.0447 | 0.041 |
| | 1 | -0.0329 | 0.044 | 0.0117 | 0.036 | -0.0379 | 0.049 | 0.0538 | 0.054 |
| | 2 | -0.0074 | 0.047 | 0.0595* | 0.033 | 0.0120 | 0.053 | 0.1058** | 0.044 |
| | 3+ | -0.0906* | 0.047 | 0.0467 | 0.034 | -0.0891 | 0.058 | 0.1675*** | 0.060 |
| MO x new member state | -6+ | | | -0.1117** | 0.046 | | | -0.1061** | 0.047 |
| | -5 | | | -0.0965 | 0.066 | | | -0.1078 | 0.067 |
| | -4 | 0.0476 | 0.070 | -0.0877 | 0.065 | 0.0606 | 0.073 | -0.0982 | 0.067 |
| | -3 | -0.0063 | 0.061 | -0.0224 | 0.050 | -0.0003 | 0.063 | 0.0028 | 0.055 |
| | -2 | 0.0010 | 0.059 | 0.0421 | 0.048 | -0.0046 | 0.061 | 0.0495 | 0.054 |
| | -1 | -0.0238 | 0.056 | -0.0069 | 0.050 | -0.0479 | 0.058 | -0.0172 | 0.056 |
| | 1 | -0.0167 | 0.053 | 0.4367*** | 0.119 | -0.0387 | 0.055 | 0.1737* | 0.103 |
| | 2 | -0.0016 | 0.056 | | | -0.0040 | 0.060 | | |
| | 3+ | 0.0111 | 0.063 | | | 0.0002 | 0.068 | | |
| MO x corruption perceptions index | -5 | 0.0231 | 0.111 | 0.1168 | 0.102 | 0.0205 | 0.114 | 0.1580 | 0.106 |
| | -4 | 0.1942* | 0.101 | 0.0742 | 0.103 | 0.1782* | 0.103 | 0.1126 | 0.107 |
| | -3 | 0.3323*** | 0.109 | 0.0342 | 0.116 | 0.3272*** | 0.112 | 0.1224 | 0.131 |
| | -2 | 0.3988*** | 0.123 | 0.0098 | 0.107 | 0.3944*** | 0.127 | 0.0805 | 0.120 |
| | -1 | 0.4942*** | 0.133 | -0.0547 | 0.119 | 0.5012*** | 0.138 | 0.0218 | 0.139 |
| | 0 | 0.4750*** | 0.135 | 0.0386 | 0.050 | 0.4383*** | 0.139 | 0.0079 | 0.055 |
| | 1 | 0.4311*** | 0.139 | 0.0778 | 0.181 | 0.4171*** | 0.143 | -0.1634 | 0.236 |
| | 2 | 0.2919** | 0.145 | 0.0495 | 0.161 | 0.2129 | 0.149 | -0.1767 | 0.196 |
| | 3+ | 0.5225*** | 0.149 | 0.0609 | 0.173 | 0.4772*** | 0.166 | -0.6095** | 0.277 |
| Ownership unbundling | -6+ | -0.1866*** | 0.057 | -0.0219 | 0.026 | -0.1643*** | 0.040 | -0.0027 | 0.024 |
| | -5 | -0.0926 | 0.060 | 0.0244 | 0.047 | -0.0692* | 0.041 | 0.0599 | 0.048 |
| | -4 | -0.0466 | 0.057 | 0.0958** | 0.045 | -0.0280 | 0.039 | 0.1428*** | 0.047 |
| | -3 | -0.0109 | 0.065 | 0.0784* | 0.046 | 0.0176 | 0.057 | 0.1502*** | 0.048 |
| | -2 | -0.0171 | 0.064 | 0.0915** | 0.041 | 0.0128 | 0.059 | 0.1497*** | 0.042 |
| | -1 | 0.0295 | 0.061 | 0.1102** | 0.044 | 0.0736 | 0.059 | 0.1307*** | 0.047 |
| | 1 | 0.1389*** | 0.053 | 0.2227*** | 0.051 | 0.0971* | 0.050 | 0.0660 | 0.058 |
| | 2 | 0.0495 | 0.060 | 0.3589*** | 0.045 | -0.0111 | 0.057 | 0.1455*** | 0.050 |
| | 3+ | 0.1465** | 0.060 | 0.2243*** | 0.046 | 0.0613 | 0.059 | 0.0235 | 0.066 |
| OU x new member state | -6+ | 0.2930*** | 0.088 | 0.0136 | 0.056 | 0.2652*** | 0.091 | -0.0039 | 0.056 |
| | -5 | 0.1945** | 0.088 | 0.0162 | 0.082 | 0.1729* | 0.090 | 0.0218 | 0.083 |
| | -4 | 0.1914** | 0.080 | 0.1390 | 0.086 | 0.1875** | 0.081 | 0.1560* | 0.086 |
| | -3 | 0.1681** | 0.078 | 0.1307* | 0.071 | 0.1835** | 0.080 | 0.0682 | 0.073 |
| | -2 | 0.1266* | 0.073 | 0.0290 | 0.066 | 0.1247* | 0.074 | 0.0354 | 0.068 |
| | -1 | 0.0552 | 0.068 | 0.0946 | 0.071 | 0.0883 | 0.069 | 0.0913 | 0.076 |
| | 1 | 0.1937*** | 0.073 | | | 0.2082*** | 0.074 | | |
| | 2 | 0.4184*** | 0.127 | | | 0.3543*** | 0.122 | | |
| | 3+ | 0.6101*** | 0.126 | | | 0.3800*** | | | |
| OU x corruption perceptions index | -5 | | | -0.0965 | 0.138 | | | -0.1650 | 0.145 |
| | -4 | | | -0.2460* | 0.142 | | | -0.3332** | 0.148 |
| | -3 | -0.1017 | 0.142 | -0.3105** | 0.153 | -0.1556 | 0.146 | -0.4023** | 0.162 |
| | -2 | -0.0626 | 0.154 | -0.2825** | 0.139 | -0.1026 | 0.157 | -0.4045*** | 0.143 |
| | -1 | -0.0113 | 0.165 | -0.2908* | 0.158 | -0.1292 | 0.167 | -0.2812 | 0.174 |
| | 0 | 0.1901 | 0.171 | 0.0673 | 0.067 | 0.1991 | 0.135 | 0.1019 | 0.069 |
| | 1 | -0.3262 | 0.207 | -1.0800*** | 0.324 | -0.2485 | 0.200 | -0.2269 | 0.316 |
| | 2 | -0.3312 | 0.309 | -2.0720*** | 0.263 | -0.1855 | 0.300 | -1.0335*** | 0.270 |
| | 3+ | -0.6715** | 0.307 | -1.3159*** | 0.251 | -0.3460 | 0.293 | -0.2625 | 0.329 |
| log(gdp) | | 0.4120*** | 0.135 | 0.4486*** | 0.096 | 0.5261*** | 0.138 | 0.5027*** | 0.099 |
| log(cpi) | | 0.6179** | 0.240 | 0.2149 | 0.166 | 0.4938** | 0.239 | 0.0748 | 0.172 |
| log(price of gas) | | 0.1772*** | 0.038 | 0.1027*** | 0.028 | 0.1757*** | 0.039 | 0.0891*** | 0.029 |
| log(price of oil) | | 0.0120 | 0.029 | -0.0295 | 0.021 | 0.0102 | 0.030 | -0.0286 | 0.022 |
| hydro share | | -0.0197 | 0.200 | -0.3766** | 0.148 | 0.0424 | 0.203 | -0.2746* | 0.152 |
| nuclear share | | 1.0271** | 0.398 | 0.5777** | 0.283 | 1.5661*** | 0.390 | 0.6544** | 0.290 |
| trend | | 0.0014 | 0.003 | -0.0024 | 0.002 | 0.0026 | 0.003 | -0.0008 | 0.003 |