Does market liberalization lead to lower household electricity rates? An empirical analysis of the European Union member-states.

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Abstract

Liberalization of electricity markets has become a dominant energy sector reform for most of the European Union (EU) countries since 1990s. Despite initial expectations that liberalization will reduce electricity prices and strengthen overall energy security, outcomes of the deregulation reforms proved to be unclear and even contradictory. This study seeks to examine the impact of electricity market liberalization on household electricity prices for EU-27 member-states (Croatia excluded) over a time period of 2000 – 2014. The paper adopts neoliberal classical framework based on assumptions that liberalization introduces competition into previously monopolized electricity markets, which leads to more efficient market outcomes including lower household electricity rates. The results were obtained by conducting panel data analysis where the main dependent variable was "household electricity rates excluding taxes" and the main independent variables were indexes that measure an extent of liberalization. The key results suggest that liberalization does not have a statistically significant impact on household electricity rates for the EU-15 states. However, liberalization proved to have an impact on electricity prices for New Member States (NMS) of the EU. This impact is asymmetric and depends on a specific liberalization sub-component. When "softening entry regulations" tends to result in more expensive electricity, "vertical disintegration of generation, transmission, and distribution" is likely to decrease household electricity rates. Overall competition seems to have limited effect on electricity prices, especially for the EU-15.

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1) INTRODUCTION

In December 2013, a BBC article by Richard Anderson raised an important and politically sensitive issue. Referring to the European Union (EU) official figures, the article stated that 47% of the Bulgarian population said they cannot afford to adequately heat their houses. Other countries, in particular Lithuania (34%), Cyprus (31%), Portugal (27%), and Greece (26%) also showed similar results (Anderson 2013).

Despite a relatively high level of economic development in the EU, residents of almost all its member-states experience difficulties in covering energy expenses. In 2013, the average household electricity price (US cents per kw/h) in Germany was 38 cents, Denmark – 39.42 cents, Bulgaria – 11.99 cents. In fact, Bulgarian rate was the lowest amongst the EU countries. For comparison, the USA population enjoyed a relatively low average household electricity price at 12 cents per kw/h. In 2013, the average EU-28 rate was more than two times higher - 26.57 US cents. The difference in electricity prices between the EU and the USA becomes evident and especially striking when comparing the GDP per capita based on purchasing power. In 2013, the GDP per capita of the United States was more than seven times that of Bulgaria ($53,042 compared to $7,498) and about the same as Germany ($46,268) and Denmark (59,831) (The World Bank 2014). At the same time, residential electricity rates in Bulgaria were the same, and in Germany and Denmark - more than three times higher than those in the United States.

This situation has become especially troublesome during the past decade. In between 2006 and 2013, residential electricity prices in the EU increased by about 45% while U.S. prices increased by only 16% (EIA 2014). The burden of expensive energy has led to increased energy poverty, a problem that is especially widespread in many Eastern and Southern European states.

Low-income groups, people already suffering from income poverty, tend to be the most affected by the phenomenon of energy poverty (Bouzarovski 2014).

A number of factors can be blamed for such a sharp increase in electricity prices. Some of these factors are quite obvious. Renewable energy development, growing fossil fuel prices, and complication of the electricity market infrastructure are likely to have a clear and predictable impact on electricity rates. For instance, if natural gas or coal prices go up, it is almost certain that the final electricity price will increase as well. However, there are factors whose impact is not that certain. Liberalization of the electricity market is one of them.

The process of electricity market liberalization in the EU started in the 1990s in the United Kingdom. One of its ultimate goals was to increase competition and, consequently, efficiency of energy market outcomes. Following the UK, liberalization started in other EU countries such as Germany and France. Even more states joined in the 2000s (Bacchiocchi et al. 2015). As a result, following two EU Directives (1996 and 2003), the European Union electricity markets were proclaimed fully liberalized in 2007 (Moreno et al. 2011).

Despite expectations that liberalization would decrease household electricity rates due to enhanced competition, the results of these reforms have proved to be unclear and even contradictory. As Emanuele Bacchiocchi et al. (2015) state, electricity prices in the UK before the reforms were well below the EU-15[1] average at 8 Euro cents per kw/h. However, by 2011, the prices increased by 14 Euro cents per kw/h exceeding the EU average. Understanding the impact liberalization has had on final household electricity rates became an important research agenda energy area researchers and policy specialists.

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[1]EU-15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

A large body of literature has been devoted to investigate the impact of regulatory reforms on household electricity prices. While some studies suggest that liberalization leads to higher electricity rates (Fiorio et al. 2007; Nagayama 2009), others find that electricity market reforms can result in lower prices (Moreno et al, 2011) or have asymmetric affects for different groups of countries (Bacchiocchi et al. 2015). In this study, we seek (by focusing on the EU electricity market) to learn more about the extent to which energy market liberalization influences energy affordability for final household consumers.

This research contributes to the ongoing scientific discussion by enlarging the samples used in previous studies (adding 2013-2014 years) and refining existing econometric models by simultaneously incorporating liberalization indices and industry competition proxies. Moreover, we incorporate a political index as a control variable, which has commonly been ignored. By doing so, we combine different studies thereby strengthening the statistical significance of our empirical model.

Finally, as Bacchiocchi et al. (2015) noted, liberalization may have different impacts on different groups of countries. Over two last decades, since the early 1990s, an average increase in nominal electricity prices in the EU-15 was around 30%. Over the same time period, an increase for the New Member States (NMS)[2] was around 100%. Based on this evidence, Bacchiocchi et al. (2015) conducted an empirical analysis and found that household electricity rates in EU-15 countries and NMS react asymmetrically to market liberalization. In this paper, we also test these results by refining their statistical methods (by incorporating an interaction term between the liberalization and regional dummy variables).

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[2]*NMS - NMS: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia (OECD, 2016). *Croatia excluded since joined only in 2013.*

Moreover, we update their time period and incorporate a more vigorous standard errors structure to examine whether the results hold under various conditions. The ultimate goal is to understand if electricity market liberalization is an efficient tool for dealing with energy poverty based on a sample of the European Union member-states.

This research is structured in the following way: first, the paper touches on the theory of liberalization and its potential theoretical outcomes for the EU electricity market; second, we provide a review of the existing literature on market liberalization and its impact on final household electricity rates; third, the empirical model, methods and data utilized in this research are introduced and described; finally, we analyze the model's results, discuss potential policy implications, and address some of the limitations of our study.

2) BACKGROUND AND THEORETICAL FRAMEWORK

Liberalism and its application to electricity markets.

Liberalism as an ideology in the economic realm emerged in the 18th century. Its foundations were laid by one of the most influential political economists and philosophers, the so-called "father of the modern economics" – Adam Smith (Schumpeter 1994). The theory of market liberalization is based on the principles of free market, private ownership and minimal interference of government. Therefore, liberalization is frequently identified with deregulation and both terms are used as interchangeable synonyms. Liberalism supports competition and opposes government restrictions on free market practices. According to advocates of economic liberalism, strong competition and privately owned market assets lead to more efficient market outcomes such as lower market prices and higher quantities produced (Xu and Uddin 2007).

Indeed, enhancing competition and supporting private ownership are essential features of liberalization. Although components of liberalization may differ, in most of the cases they include the following elements: privatization of public assets, softening institutional entry barriers, and preventing market monopolization. In general, market liberalization aims to minimize governmental influence on the market. Only some government regulations are considered to be acceptable; such as ones intended to strengthen competition and help avoiding monopolistic market structures. In the 20th century, economic liberalism evolved into so called “neoliberalism”, an economic doctrine closely associated with economic policies exercised by Margaret Thatcher in Great Britain and Ronald Reagan in the United States (Campbell 2005).

The liberalization approach was introduced into the electricity industry relatively late. The first electricity market reform for the European Union based on principles of liberalism took place in the 1990-s in Great Britain (so called “UK-type” electricity industry reform). Two major goals triggered the deregulation reform: to increase competition in the electricity industry and to enhance the security of energy supply (Bacchiocchi et al. 2015). The reform focused on three essential elements: privatization of publicly owned assets, lifting entry barriers (in other words – softening entry regulations), and disintegration of electricity transmission from generation, and distribution (Fiorio and Fiorio 2013).

Historically, three relatively independent segments have formed the electricity industry has been formed by: generation (production of electricity); transmission (transportation of electricity); and distribution (delivery of electricity to final consumers). Before liberalization, these three components were integrated in the same market. However, technological developments allowed the separation of these three segments into three independent markets, two of which (generation and distribution) have become competitive. Only the transmission component has generally remained a natural monopoly due to the high sunk costs associated with transmission of electricity. Disintegration, or unbundling, of generation and distribution became a critical component of the reform. The UK-style electricity market reform was quickly followed by Norway and eventually, by many other EU member-states (Glachant and Ruester 2014).

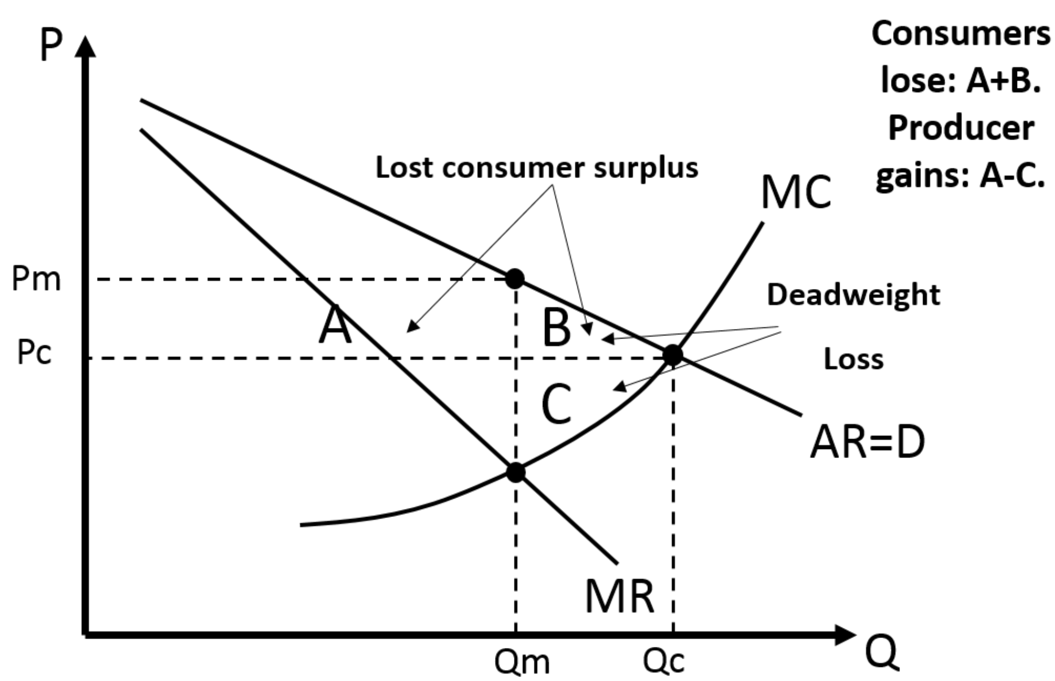
Electricity market liberalization reform has three main elements: privatization, disintegration (unbundling), and lifting entry barriers. These elements are designed to enhance competition and therefore result in more efficient market outcomes. The mechanisms are very simple. Lowering barriers to market entry allows more companies to join the market. Similarly, breaking up big vertically integrated firms prevents markets from monopolization thereby promoting increased competition. Moreover, unbundling divides the electricity market into three separated smaller markets (for generation, transmission, and distribution). This allows small and narrowly specialized companies to participate and survive competition. Consequently, the more firms enter the market, the stronger competition becomes.

Clearly, liberalization leads to increased competition via different means. And this has been the case for the EU electricity market over past two decades. But does competition result in more efficient market outcomes? How does competition impact price of goods and services? Does liberalization benefit regular household consumers? To answer these questions and thereby assess the efficiency of liberalized markets, scholars frequently compare competitive markets to monopolies. We also utilize this approach since the EU electricity market has been experiencing an evident transition from monopolistic/oligopolistic market structures to competition since 1990s. Hence, such a comparison will allow us to test the theoretical predictions based on real world evidence.

The economic theory of liberalization.

According to microeconomic theory, competitive industries are assumed to operate at a point where marginal cost equals price. Monopolized industries, on the other hand, tend to operate at a point where price is higher than marginal cost. This results in a lower output level. Therefore, consumers are usually worse off under a monopolized market structure compared to competitive markets (Varian 2010). The figure 2.1 shows a difference between price and quantity outcomes for monopolized and competitive markets (Varian 2010).

Figure 2.1. Deadweight loss of monopoly.



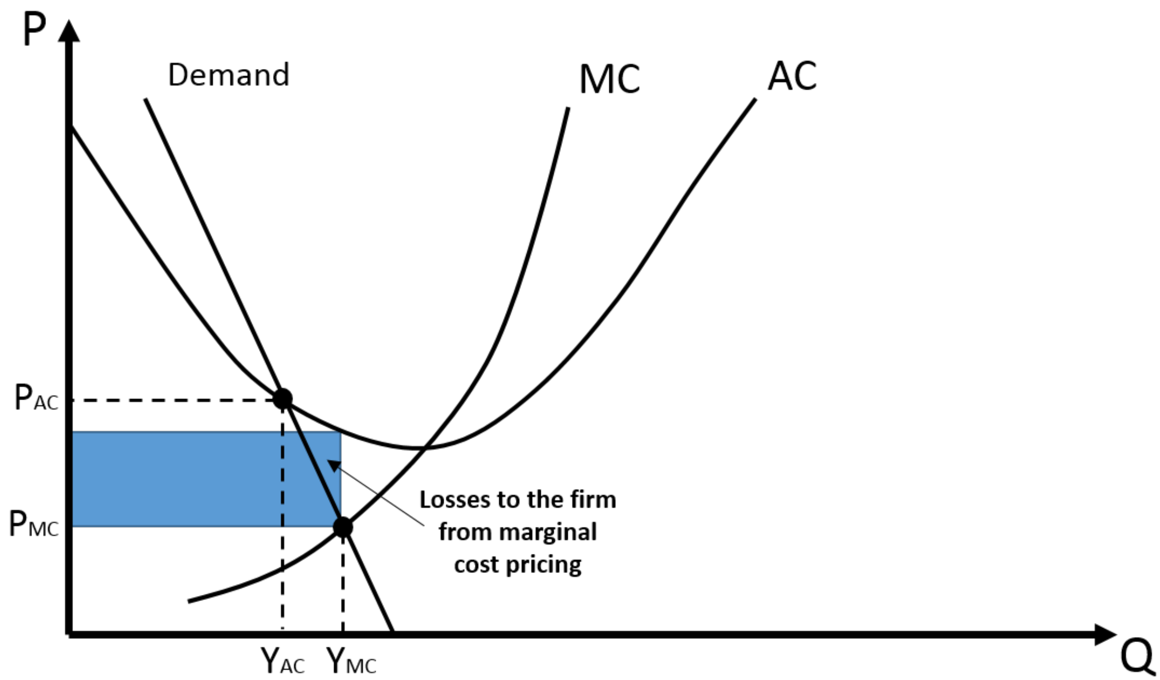
We can see from figure 2.1 that price under a monopoly (Pm) is higher than in a competitive market (Pc). This happens because competitive price is formed at a point where the marginal cost curve intersects the demand curve (Pc). Unlike the competitive market, price in a monopoly is formed at a point where the marginal cost curve crosses the marginal revenue curve (Pm). Due to the higher price, producers gain the area A but loose the area C due to lower demand for more expansive commodities. Consumers experience only losses equal to the areas of A and B due to the higher price and therefore lower purchasing ability. Such an outcome is Pareto inefficient meaning that society, overall suffers a deadweight loss equal to the areas B +C. Thus, according to the theory of competition, competitive market outcomes are more efficient.

At the first glance, it seems fairly easy to deal with the inefficiency of monopoly – a government regulator should set price equal to marginal cost thereby forcing market towards Pareto efficient outcomes. However, in some industries, such regulations might push firms out of business. This can happen if at the set price a monopolist receives negative profits (figure 2.2). In microeconomic theory, such industries are called “natural monopolies” and monopolistic structure for them is justified based on efficiency considerations (Varian 2010).

A natural monopoly occurs when a single firm can provide cheaper goods or services to a whole market than many firms. This typically happens due to high fixed costs. In the case of energy markets, large fixed costs often occur due to the cost of electricity transmission lines or large electricity generation plants. In such industries, existence of monopoly can be more beneficial for consumers. Usually, a government regulator sets a price that allows a natural monopoly to break even, a point where a firm can cover its average costs. Such industries require monopolistic organization along with governmental regulation to guarantee both efficient and fair outcomes (Varian 2010).

Figure 2.2 illustrates a natural monopoly case. Since the firm’s average cost (AC) is higher than the intersection of its marginal cost (MC) and demand curves, price setting at the marginal cost level will lead to losses (shaded area) and eventually result in companies leaving the market. Therefore, regulated price for natural monopolies is higher than their marginal cost. Ideally, regulated price should be equal to a firm’s average cost (Varian 2010).

Figure 2.2. Natural Monopoly (Varian, 2010).



A natural monopoly case is typical for public utilities. Since electricity is not a typical commodity, but basically a controlled flow of electrons inside of miles of metallic wires, for decades it has been viewed as a classic "natural monopoly" product (Glachant and Ruester 2014). That is why, there is no surprise that historically electricity markets have tended to be natural monopolies. However, in the EU the situation started changing in the 1990s. Developed electricity industries and improved technologies allowed first Great Britain and then other European countries to unbundle natural monopoly components of the electricity market from potentially competitive ones. In fact, it was an advance in information communications technology that allowed better control of electricity flow and enabled its trade (Glachant and Ruester 2014). Hence, generation and distribution segments of the electricity industry have become relatively competitive markets over last two decades.

Unlike lifting entry barriers and unbundling, the change from public to private ownership of industry assets does not have a direct impact on the extent of competition. However, ownership structures can still affect the efficiency of market outcomes. As a matter of fact, public ownership is frequently associated with lower productivity and efficiency loss. Advocates of privatization rely on neo-classical economic theories to suggest that better managerial control and a system of incentives result in lower production costs, and therefore, higher productivity for privately owned firms. They also claim that state-owned companies have a higher risk to be dependent on political agendas. Such dependency might potentially lead to politically motivated, biased or simply low paid managers and, as a result, low efficiency of their enterprises. Public companies can be used in "political games" and, therefore, operate to pursue some other goals, different from efficiency or productivity purposes (Hemming and Mansoor 1988). As an example, even if they suffer losses, publicly owned enterprises can be kept in business by government for many years to fulfill some strategically important purposes like providing employment or producing military equipment.

If political motivations are removed private companies can focus on their direct operation, provide better service for customers, concentrate on quality control within an organization, and pursue profit maximization goals. These behaviors should lead to gains in efficiency, productivity and ultimately better market performance (Martin and Parker 1997). More market-focused objectives allow private companies to enhance both the internal and the external (market) efficiencies of their operation (Uddin and Hopper 1999). This increased efficiency should, in turn, bring lower costs and reduce prices for goods and services supplied.

As we can see from the above comparison of competitive and monopolistic market structures, enhanced competition due to liberalization efforts is assumed to result into more efficient market outcomes including lower prices. Disintegration of generation, transmission, and distribution introduces competition into two previously monopolized elements of the electricity market. Lifting entry barriers provides an opportunity for more firms to join an industry that has been previously controlled by strict governmental regulations. Finally, private ownership is expected to lead to efficiency gains due to the elimination of external (such as political) pressures and allowing companies to focus on their direct operation. As a result, all the benefits of liberalization are transferred to consumers in the form of lower prices and higher quantities of goods and services supplied.

Electricity industry liberalization efforts in the EU.

In attempt to realize the benefits of liberalization, the EU started its electricity market reform in the 1990s. Two major goals were identified: to increase competition in the electricity industry and to enhance security of energy supply (Bacchiocchi et al. 2015). Moreover, liberalized electricity markets at a country level were presumed to allow a formation of the united pan-European electricity market, which means free and easy trade of electricity and therefore higher security and reliability of supply. With these considerations in mind, Great Britain became the EU pioneer in electricity liberalization in the early 1990s (Jamasb and Pollitt 2005; Bacchiocchi et al. 2015; Fiorio and Fiorio 2013).

Later, the European Union took leadership in promoting deregulation initiatives at the pan-EU, transnational level. In the beginning, only a requirement to take some early actions towards liberalization of electricity markets was put in place for the EU member-states. Despite the overall softness of the initial requirements, specific deadlines were already set to control the process. At the same time, the European Commission made preliminary efforts to develop and promote international electricity trade among EU members by improving existing rules and expanding cross-border transmission links. The ultimate purpose of these actions was to enhance competition and create a single EU energy market, thereby simultaneously improving the security of supply and reducing the cost of electricity (Jamasb and Pollitt 2005).

Following these early steps, the European Commission introduced two major EU directives focused on electricity market in 1996 and 2003. The first one, called "First Legislative Package", initiated the process of electricity market integration among separated national markets. It established basic rules for a smooth transition towards the united pan-EU generation, transmission, and distribution of electricity (Balaguer 2011). The second directive (aka the "Second Legislative Package") brought more clarity to the rules of the cross-border trade established in 1996. Furthermore, the 2003 Directive concentrated on promoting competition and called for independent energy regulators. Together, the directives aimed to:

- Unbundle transmission system operators (TSOs) and distribution system operators (DSOs) from the rest of the industry (i.e. from the generation);
- Provide regulation-free entry to electricity generation and enhance competition at all stages of the electricity market operation;
- Open national markets and push them towards the creation of a single European electricity market;
- Promote renewable energy sources (Jamasb and Pollitt 2005; Balaguer 2011).

Finally, the third and last Directive to date ("Third Legislative Package") was introduced in 2009. Its main aim was to continue promotion of efficient generation unbundling from the network and to support transparency of retail electricity markets (Glachant and Ruester 2014)

Although the European Commission proclaimed full liberalization of electricity markets within the EU in 2007 (Moreno et al. 2012), it was viewed skeptically by many observers

(Sioshansi 2008). Several major concerns about creating a pan-European electricity trade system were voiced at the time. First, it was noted that governments of EU member-states were inclined to intervene in the market operation in order to support the largest national energy companies, so called "energy champions". Second, there was concern expressed about a lack of interest by state governments to implement cross-border transmission rules and to build new electricity lines. Finally, at a country level, pan-EU institutions such as the European Commission were thought to have insufficient enforcement power. This led to a blockade of the process or, at least, to its deceleration (Sioshansi 2008).

Regardless all of the above concerns, the liberalization process has been started and, although slowly, changes have been introduced to many national electricity markets. Several local cross-country hubs/markets for electricity exchange have been created or supported. For example, Norway, Sweden, Finland, and Denmark have been already integrated into an energy exchange/trade organization called The Nord Pool for decades. The recent directives have only strengthened their cooperation (Balaguer 2011). Other countries have also made some integration efforts at the regional level. France, the Netherlands, and Belgium established the first continental cross-national electricity market in 2008. As of 2013, 13 countries were taking part in cross-border wholesale electricity exchange, including the UK market and the Nordic Pool (Statnett 2014).

Despite a number of obstacles and an overall slowness of the process, European electricity markets have become more open, competitive, and interconnected over last 25 years due to the introduction of deregulation reforms. Competition has been introduced to generation and distribution components of the electricity market. For example, a number of electricity retailers to final consumers in Hungary grew up from 12 in 2003 to 50 in 2014, and from 5 to 75 in Latvia during the same period. Similarly, the number of generating companies has increased thereby decreasing a market share of the largest generator in many countries. In Lithuania, for instance, the market share of the biggest electricity generator dropped from 72.8% in 2000 to 20.6% in 2014 while a number of generating companies representing at least 95% of the national net electricity generation raised by a factor of four, from 5 to 20 (Eurostat 2016).

Thus, liberalization has enhanced competition into previously monopolistic or oligopolistic electricity markets, however, it has not produced clear answers to whether competitive and privately owned electricity industry is more efficient. Nor did liberalization prove to be explicitly beneficial for final consumers as theory suggests. The questions still remain. What is the real impact of electricity market reforms on final household electricity price? Has competition indeed brought more affordable energy? Does liberalization help to overcome energy poverty, especially in poorer EU member-states? To address all these questions, a solid body of empirical research has been conducted over the past couple decades. In the following section, we provide an overview of the most prominent existing studies and introduce their findings.

3) LITERATURE REVIEW

As discussed in the previous section, theory suggests that liberalization should bring stronger competition and privately owned assets thereby resulting in more efficient market outcomes. Aiming for lower energy prices along with an aim to provide higher security of energy supply (Bacchiocchi et al. 2015), the UK started the process of the electricity market liberalization in the 1990s. Since then, the impact of deregulation on final household electricity prices has been actively investigated and discussed in different circles including business, public and academic societies. However, regardless of the massive body of literature, a consensus has not been reached and a variety of studies have produced mixed evidence concerning the actual effects of liberalization. Such uncertainty suggests the need for ongoing research, particularly research that takes advantage of the growing amount of data that allows more accurate and therefore reliable results to be obtained.

In order to understand the true impact of liberalization on electricity prices, it is essential to define what is understood by this general term - liberalization. Although there are different approaches on how to measure and estimate liberalization in the electricity market, most of the studies agree that a typical "UK-style" electricity industry reform incorporates three main dimensions (Bacchiocchi et al. 2015; Pollitt 2008): unbundling natural monopoly components from potentially competitive ones (e.g. electricity transmission from generation and distribution), privatization of electricity industry assets (reducing a share of public ownership), and lifting entry barriers. Some studies also mention a fourth component – transferring price regulation to an independent office (this element is frequently viewed as a temporary and transitory mechanism to ensure price adequacy before full liberalization is achieved) (Fiorio and Fiorio 2013). Eventually, the "UK-style" model was adopted not only by other European countries on their way to electricity industry deregulation, but also by such international organizations such as the European Commission and OECD. Ultimately, this approach has become dominant to assess an extent of electricity market liberalization (OECD: Indicators of Sector Regulation 2016).

Besides investigating the overall impact of liberalization on electricity prices, the above deregulation components should also be distinguished and evaluated separately. Their influence on price can vary significantly not only in terms of amplitude but also in terms of direction.

Moreover, liberalization sub-elements may have even an opposite effect compared to liberalization overall.

For example, the empirical study conducted on a dataset of EU-15 countries over a thirty-year time frame by C. Fiorio and M. Fiorio (2013) discovered that only change in ownership is associated with the dynamics of residential electricity prices. According to the study, other liberalization components (vertical integration of generation/transmission/distribution and softening entry regulations) have a weaker and a more uncertain association with electricity prices.

Similar findings were obtained in T. Hattori and M. Tsutsui (2004) which focused on another component of electricity market liberalization – the unbundling of generation, transmission, and distribution. Using a panel data for 19 OECD countries from 1987 to 1999, the study found that unbundling does not have a clear impact on final prices and, moreover, it is more likely to increase electricity price rather than decrease it.

Conversely, a study by E. Steiner (2000) suggested that all three components of liberalization have a significant impact on electricity market performance. According to study, unbundling tends to decrease both industry prices and the ratio between industry and residential prices, when privatization has an opposite effect.

The significance of unbundling was also highlighted in M. Pollitt (2008). The study included both empirical and case study analyses on the ownership unbundled transition models and compared them to classical integrated models. The study concluded that unbundling of transmission ownership is a key prerequisite of a successful energy market reform and it has a significant impact on the reform's outcomes.

An interesting and unusual approach was taken in H. Nagayama (2009), which investigated a reverse correlation between market liberalization and electricity prices. After testing a number of different model specifications, their findings suggest that liberalization by itself has a higher chance to be started if electricity prices increase. The author also concluded that deregulation is more likely to result in higher electricity prices rather than to decrease them. The results proved to be statistically significant for developed countries while the data for developing countries were not sufficient for any decisive conclusions.

The findings in the literature also suggest an existing difference in the liberalization influence on electricity price for different groups of countries. For instance, Bacchiocchi et al. (2015) conducted an empirical analysis on 27 European Union members (Croatia excluded). The study distinguished between the EU-15 group countries (mostly more developed, western members) and New Member States (less developed, Central, Eastern and Southern European members). The researchers found that electricity market liberalization reduces final household electricity price for the EU-15 group but increases it for the New Member States (NMS) group. The study also suggests that privatization matters only for the NMS and leads to higher price. Lifting entry barriers was found to increase electricity rate in the NMS and decreases for the EU-15 countries. Finally, unbundling did not seem to have any statistically significant impact on residential electricity prices in neither of the groups.

Similar conclusions were reached in N. Hrovatin et al. (2009) and M. Pollitt (2009), which analyzed the impact of liberalization on electricity markets in Central and South Eastern European countries. The findings show that although the liberalization processes have started only recently in the region, electricity price has already reacted by a prominent growth. Similar to Bacchiocchi et al. (2015), the authors emphasize existing dissimilarities among the European Union member-states.

Finally, some studies have gone even further questioning whether liberalization of the electricity market increases competitiveness at all. For instance, Baek et al. (2014) found that deregulation's effect on overall energy market competitiveness depends on the type of regulation and economic environment. In particular, lifting entry barriers and unbundling seem to enhance competitiveness in the countries with low levels of economic development and energy intensity while the effects of privatization are unclear. The issue of overall competitiveness constitutes an important prerequisite that is likely to be an important determinant of the final dynamic of residential electricity price.

Moreno et al. (2012) also took an indirect approach. Instead of looking at the commonly used liberalization indices, it concentrated on the correlation between a degree of electricity market competitiveness and household electricity prices. The researchers claimed that deregulation should lead to more competitive markets and, consequently, to lower electricity prices. They used a proxy for electricity market concentration/competitiveness - the market share of the largest generator in the electricity market. Their results do not support the hypothesis. A higher share of the largest generator in the market, according to their model specification, leads to lower electricity prices. In other words, this study found that monopolization is likely to result in more efficient outcomes (in the form of cheaper electricity) in the electricity market.

The following table represents the most important and relevant findings of the existing literature:

Table 3.1. Empirical literature review, main findings.

Authors	Sample/period	Main findings

Bacchiocchi et al., 2015	EU-27, 1990 – 2011	Liberalization reduces energy prices for the EU-15 countries but increases for the New Member States (NMS). Unbundling does not seem to have any statistically significant impact. Privatization matters only for the NMS and leads to higher prices. Lifting entry barriers increases prices in the NMS and decreases for the EU-15 countries.
C. Fiorio and M. Fiorio (2013)	EU15, 1978 – 2006.	Public ownership is associated with lower residential electricity prices. Vertical integration (unbundling) and lifting entry barriers have weak and more uncertain association with electricity prices.
T. Hattori and M. Tsutsui (2004)	19 OECD countries, 1987 - 1999	Unbundling does not have a clear impact on final prices. It is more likely to increase electricity prices rather than decrease them.
E. Steiner (2000)	19 OECD countries, 1986 - 1996	Unbundling tends to decrease both industry prices and the ratio between industry and residential prices. Privatization increases industry prices and the ratio between industry and residential prices.
H. Nagayama (2009)	78 countries in four regions (developed countries, Asian developing countries, the former Soviet Union and Eastern Europe, and Latin America), 1985 – 2003.	Liberalization is more likely to result in higher electricity prices rather than to decrease them. Liberalization by itself has higher chances to be started after electricity prices have increased.
N. Hrovatin et al. (2009); M. Pollitt (2009)	Central and South Eastern European countries.	Liberalization is associated with higher electricity prices although many other factors are involved.
M. Pollit (2008)	Review of a number of econometric studies.	Unbundling of transmission is a crucial element of a successful electricity market deregulation reform.
Baek et al.	28 OECD countries, 1980 – 2007.	Lifting entry barriers and unbundling seem to enhance competitiveness in the countries with low level of economic development and energy intensity.

(2014)		The effect of privatization is unclear.
Moreno et al. (2012)	EU-27, 1998 – 2009.	Electricity market concentration is associated with lower household prices. Renewable Energy Standards (RES-E) deployment leads to more expensive electricity for household consumers.

From the existing literature we can make a few conclusions. First, liberalization (aka deregulation) of the electricity market consists of three major components: privatization, unbundling, and lifting barriers to entry. Second, there is no consensus on how exactly these components influence household electricity prices. Their significance as well as the direction of their impact (positive vs negative) varies depending on the study. Third, liberalization can have different effects on different countries. The level of economic development is likely to be responsible for these differences. Finally, the possibility of a reverse causality exists (although this result was found in only one study).

Control variables.

Besides liberalization/deregulation indicators, the body of literature provides us with a comprehensive review of other factors that may have an impact on final household electricity prices. These factors should be also taken into account when developing a reliable empirical model as many economic, energy, and even political factors can play an essential role in determining the dynamics of electricity prices.

The most important economic indicator seems to be GDP per capita. Its inclusion aims to control for wealth differences among countries. Based on the reviewed literature, literally all of the empirical models incorporate this indicator in order to eliminate the impact of economic development from the impact of energy market reforms. In most cases, GDP per capita proves to be statistically significant and positively correlated with household electricity prices (Bacchiocchi et al. 2015; Fiorio and Fiorio 2013).

Besides economic variables, energy related factors can also have a significant influence on the electricity price dynamics. For instance, if fossil fuel prices grow, electricity generated from these fuels is likely to become more expensive. Therefore the final price of electricity can be significantly driven by cost of natural gas, crude oil, or coal. Although some studies include fuel price indicators to account for this issue (Bacchiocchi et al. 2015), others often fail to do so (Moreno et al. 2012; Hattori and Tsutsui 2004).

Development of renewable energy seems to play an important role for household electricity rates as well. According to Bacchiocchi et al., (2015), renewable energy share of total final electricity consumption can serve as a proxy to account for subsidies for renewables. States that subsidize renewable energy are frequently financed through electricity bills for final consumers. Moreover, a number of studies have proved the existence of a significant correlation between household electricity prices and a share of renewable energy in total electricity consumption. Renewable energy development tends to increase electricity prices (Moreno et al. 2012; Bacchiocchi et al. 2015).

Self-sufficiency of energy supply is likely to be another determinant of electricity affordability. Availability of sufficient energy sources within a country is often identified with the issue of energy security. Countries with self-sufficient energy supplies are less dependent on foreign resources which allows them to better handle global energy market shocks. According to Sovacool et al. (2011), energy availability and affordability are interrelated components of energy security. Thus, security of energy supply can have a crucial impact on energy prices including household electricity. Depending on the direction of the shock, the impact might be either positive or negative. This point is widely acknowledged by empirical research (Bacchiocchi et al. 2015; Fiorio and Fiorio 2013).

Some studies have also pointed to CO2 trading allowances as a factor of impact on energy generation cost and, as a result, energy price. Sijm et al. (2006) investigated a statistical correlation between CO2 and electricity prices for EU countries. They concluded that CO2 trading was at least partially responsible for a sharp increase in electricity prices in 2005 due to more expensive CO2 taxation schemes. Controlling for CO2 emissions is a common practice for empirical research focused on energy price dynamics.

Finally, even though most of empirical research ignores the importance of political factors for energy market outcomes, some studies do address this possibility. For example, Estache et al. (2009) examined how corruption can distort the results of energy regulatory reforms. The findings suggest that quality and affordability of energy may not be improved as expected if widespread corruption prevails, corruption may prevent deregulation from succeeding. Similar conclusions were drawn in Fredriksson et al. (2004), which found that the impact of corruption on energy market outcomes is mostly negative and that corruption tends to reduce energy policy stringency.

Overall, the above discussion of the existing literature emphasizes the need for additional research. Regardless of the number of existing studies, the relationship between liberalization and electricity market outcomes, in particular residential electricity prices, is still unclear. Remaining uncertainties include the impact of other factors that may potentially contribute to the dynamics of household electricity prices. Among these factors are the development of renewable energy, energy security, corruption level and others.

This paper seeks to shed some more light on these issues. It contributes to the ongoing discussion by expanding the dataset, incorporating new variables that help to estimate electricity market competitiveness, and controlling for such previously ignored factors as political/corruption indexes. Moreover, in this paper we apply a random effects model (unlike many previous studies) due to a low variability of our main variables of interest – liberalization indices. All these new specifications should allow us to add meaningfully to the existing scientific debate on the impact of liberalization on residential electricity prices in European Union member-states. The following sections describe our dataset and present the empirical model which is estimated to test whether electricity market deregulation is a suitable tool for fighting the problem of energy poverty around the globe in general, and in Europe in particular.

4) DATA AND METHODS

In order to examine the relationship between electricity market liberalization and household electricity prices we formulate and test the following hypotheses based on the theory of liberalization and the empirical literature.

Hypothesis 1. *Liberalization of the electricity market leads to lower final household electricity rates.*

In spite of the mixed evidence produced by previous research, the theory of market liberalization suggests that deregulation is assumed to bring stronger competition. In turn, enhanced competition should lead to lower (compare to monopoly) prices for goods and services. Therefore, our first hypothesis states that market liberalization, by means of boosted competition and private ownership, leads to more efficient market outcomes in the form of lower final household electricity prices.

Hypothesis 2a: *Privatization leads to lower final household electricity rates.*

Hypothesis 2b: *Unbundling (generation, transmission, and distribution) leads to lower final household electricity rates.*

Hypothesis 2c: *Lifting entry barriers leads to lower final household electricity rates.*

Similar to liberalization in general, the subcomponents of liberalization should lead to stronger competition and, consequently, lower electricity prices. Based on theoretical suggestions, we assume that each of these subcomponents has a significant correlation with the final market outcomes e.g. electricity prices.

Hypothesis 3a. *An increase in the market share of the largest generator in the electricity market leads to higher final household electricity rates.*

Hypothesis 3b. *An increase in the number of generating companies representing at least 95% of the national net electricity generation results in lower final household electricity rates.*

Hypothesis 3c. *An increase in the number of electricity retailers to final consumer results in lower final household electricity rates.*

In Moreno et al. (2012) the market share of the largest electricity generator was used to estimate the degree of competition in the market. We advance this approach a step further and also incorporate other industry competiveness proxies such as the number of generating companies representing at least 95% of the national net electricity generation and the number of electricity retailers to final consumers. All together, these estimators better reflect a degree of competition in the market.

Based on the theory, we expect that market liberalization enhances competition which, in turn, results in more efficient outcomes. In other words, more electricity retailers and generating companies in the market are assumed to decrease final household electricity prices. However, if the largest electricity generator increases its share, electricity prices are expected to grow due to a higher market monopolization extent.

Hypothesis 4: *The impact of deregulation is asymmetric for EU-15 countries and New Member States.*

Several studies have addressed an existing asymmetric effect of liberalization on different groups of countries. The most comprehensive analysis was performed by Bacchiocchi et al. (2015) who split a sample of EU-27 countries into two groups: EU-15 and New Member States (NMS). The researchers found that electricity market liberalization is likely to result in lower final household prices for more developed EU-15 countries and in higher prices for less developed NMS. These findings correspond with N. Hrovatin et al. (2009) and M. Pollitt (2009) who found that market deregulation leads to more expensive electricity in Eastern and Southern European countries. However, these results do not match with T. Hattori and M. Tsutsui (2004) who found that liberalization tends to increase final household prices for the EU-15 countries as well. Considering the existing uncertainty, we also test hypothesis 4 of whether liberalization has an asymmetric impact on the EU-15 and NMS countries.

To test the above hypotheses we develop and estimate the following model:

$$Eprice_{it} = \beta_0 + \beta_1' R_{it} + \beta_2' C_{it} + \beta_3' X_{it} + \alpha_t + \varepsilon_{it}; \qquad i = 1 \dots n, t = 1 \dots T$$

where i represents a given country and t indicates a given year. *Eprice* is our dependent variable: residential electricity prices for EU-27 members (see a more detailed description below). R

denotes a vector of liberalization indices incorporated to measure the extent of electricity market liberalization and to test hypotheses 1 and 2. The vector *C* characterizes three proxies for a degree of market competition and is used to test hypothesis 3. The *vector X* represents a set of control variables. The control variables are included to account for other factors that may impact the dynamic of residential electricity prices besides the variables of interest. Based on the existing literature, the following control variables are incorporated: the share of renewable energy in total final electricity consumption, an energy price index, GDP per capita, net energy imports, CO2 emissions per inhabitant, population, and a political index. Appendix A provides a detailed definition of all the variables and their sources.

Our dataset consists of 27 European Union countries (Croatia excluded since it joined the EU only in 2013) over the period of 2000 – 2014. Although the potential number of observations is 405, in most of the model estimations it is lower due to missing data. The most complete data run through 2004 – 2012. Our sample choice is driven by data availability and a desire to refine existing research by incorporation of the most recent data (after 2010) and previously ignored competition proxies. Descriptive summary statistics of the dataset are presented in Appendix B.

At this point, one more remark needs to be made: as was noted in the literature review, a possibility of reverse causality exists. Indeed, it is logical that if electricity prices grow, a government may decide to intervene and introduce stronger competition in order to provide more efficient market outcomes. Theoretically, such measures should make electricity more affordable. However, electricity affordability is not the only motive for market liberalization. Energy supply security and elimination of a corruption element are also important drivers for electricity market deregulation. Moreover, the body of literature suggests that prices are more likely to react to liberalization reforms, not vice versa. Among dozens of studies reviewed, only one article considered a possibility of reverse causality (Nagayama 2009). Thus, although we acknowledge that electricity prices may have some influence on a government's decision to launch deregulation reforms, this paper concentrates on an opposite effect.

Data and measurement: Household electricity rates (dependent variable).

Electricity rate (price) is one of the most powerful and distinct indicators of electricity market efficiency. It is closely related to final household consumers and has the most direct impact on an energy poverty condition. Therefore, investigating the influence of electricity market liberalization on regular household consumers, it is a common practice to look at the household electricity prices as at a good proxy of energy affordability. We also utilize this approach.

Average electricity prices for domestic (household) consumers are computed by Eurostat. Eurostat offers several variations of this indicator. The specification used in our model possesses the following features. First of all, the prices are assessed without taxes and levies. By excluding taxes, we eliminate a need to control for amendments in taxation rates. Secondly, the price is measured in Eurocents per Kilowatt/hour. Although the data are bi-annual, we consistently use the second half of a year price over all time periods and countries (in order to concentrate on the end-of-year values). Finally, Eurostat provides two datasets on household electricity prices (before and after 2007). The split occurred due to a change in the measurement methodology aimed to cope with newly emerging and more open liberalized electricity markets (Energy statistics, explanatory texts to metadata 2016). Regardless of the change, data are still comparable due to consistency of the approach over all EU countries.

Overall, a consensus exists that the dynamic of electricity prices is one of the most important outcomes of the electricity market. Considering its direct impact on energy affordability, many empirical studies have investigated the way market deregulation influences these dynamics. Choosing household electricity rates as the dependent variable, we are just simply following the way already paved by others who have attempted to explore the impact of liberalization on energy affordability.

Data and measurement: Liberalization indices and competition proxies.

While electricity price is a very good proxy to denote energy affordability, measuring the extent of market liberalization/deregulation is more complicated. As was mentioned in the previous section, a classical model of electricity market liberalization consists of three major components: vertical disintegration (unbundling), privatization, and lifting entry barriers. Luckily, the Organization of Economic Co-operation and Development (OECD) has created a set of indicators to estimate regulation in the energy, transport, and communication sectors (ETCR indicators). These indicators summarize regulatory patterns of the electricity industry for a number of countries (mostly OECD).

The indicators are presented in the form of indices that range from 0 to 6. The energy sector consists of two groups: electricity and natural gas indicators. In turn, the electricity market regulation structure embodies the following structural sub-indicators: entry barriers, public ownership, and vertical integration (refers to supply, transmission, and distribution fragments) (OECD 2016).

The indicator for entry-level regulation is measured on a scale from 0 to 6, where 0 means free entry and 6 denotes completely closed markets with the highest entry barriers. The public ownership index assigns the following values to the electricity market structure: 0 - private, 1.5 – mostly private, 3 – mixed, 4.5 – mostly public, 6 – public. The indicator for vertical integration denotes 0 as unbundled, 3 as mixed, and 6 as integrated markets. Besides these three indicators, the OECD dataset also provides an overall, summarized indicator of electricity market regulation. It ranges from 0 to 6, where 0 means fully liberalized (deregulated) electricity markets and 6 refers to fully controlled (monopolized) markets (OECD, Regulation in energy, transport and communications (ETCR) 2016).

For all indicators, the time series goes through 1975 – 2013, however not all of the EU countries are included in this dataset. SEU members such as Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Malta and Romania were added to the OECD dataset only in 2013 and therefore data for all previous years are missing. In order to fill in this gap, we use a dataset created by Bacchiocchi et al. (2015). Aiming to compare the effects of market liberalization on electricity prices between more developed EU-15 countries and less developed EU New Member States, the authors calculated missing ETCR indicators for all EU-27 countries. They precisely followed the methodology provided by OECD, which entitles us to employ their dataset with a high degree of statistical trustworthiness.

Different from most of the existing studies, we add three indicators of market competition in our model. Measuring competition helps us to indirectly estimate the extent of market liberalization. Moreno at all (2011) uses market share of the largest generator in the electricity market as a proxy of market competition. Besides market share of the largest generator in the electricity market, our model also includes two other proxies: number of generating companies representing at least 95% of the national net electricity generation and number of electricity retailers to final consumers. These data are provided by Eurostat (Eurostat, Electricity market indicators 2016). By using these indirect competition proxies, we improve the model and enable examination of separate aspects of such a complicated and multilateral process as liberalization.

<u>Data and measurement: control variables.</u>

A number of variables are utilized in our model to control for other factors that can potentially drive the dynamics of household electricity prices. These variables are derived from the existing literature. Most of our controls have been used frequently in other empirical studies and have frequently proved to be statistically significant. However, the corruption index variable is unique to our model. Although we have found evidence that a level of corruption may have a significant impact on electricity market outcomes including electricity prices (Estache et al. 2009; Fredriksson et al. 2004), empirical studies tend to ignore its importance. Our model refines this flaw by incorporating a control for corruption, an index calculated by the World Bank. Moreover, we go even further and test for other political indices such as the rule of law, regulatory quality, and government effectiveness. All these indexes range from -2.5 to +2.5, where higher values correspond to better outcomes (tougher control for corruption, higher regulatory quality, more efficient government, and higher dominance of the rule of law). Since all these indexes are highly correlated (see appendix C), we created a generalized "political index" by adding values of all indicators and dividing the sum by a number of indexes. In other words, we use a mean of four above-mentioned indexes and call it a "political index".

Among other variables that are included in the model because they might have an influence on household electricity prices are: GDP per capita (to account for a difference in wealth), energy price index (to control for changes in fuel prices), share of renewable energy in total electricity consumption (to control for change in technology and subsidies for renewables), net energy import measured as a percentage of total energy use (to account for energy security), CO2 emissions per inhabitant (to control for environmental impact on electricity industry), and population (to account for a possibility of economy of scale). Most existing studies incorporate these variables in different combinations in their econometric models.

Finally, we also aspire to test the conclusion by Bacchiocchi et al. (2015) which found that liberalization has an asymmetric impact on EU-15 countries and New Member States. For this purpose, our model also integrates a dummy variable that denotes a value of 1 to EU-15 countries and 0 to New Member States. This dummy is used only to test for hypothesis 4 and, therefore, is employed just in some of our model's specifications. Appendix provides accurate definitions of the variables and relevant data sources.

Table 4.1 summarizes all seven models that constitute a core of our research and test the hypotheses discussed above.

Table 4.1. Models summarized.

Model number	Hypothesis tested	Variables incorporated (DV – dependent variable, IV – independent variables)	Sample	Result
I	None	DV – average household electricity price (taxes excluded). IV – overall liberalization index.	EU-27	-
I'	None	DV – average household electricity price (taxes excluded). IV – ownership index, entry regulations index, disintegration index.	EU-27	-
II	1, 3a, 3b, 3c	DV – average household electricity price (taxes excluded). IV – overall liberalization index, three competition proxies, all control variables.	EU-27	Not confirmed
III	2a, 2b, 2c	DV – average household electricity price (taxes excluded). IV – ownership index, entry regulations index, disintegration index, three competition proxies, all control variables.	EU-27	Not confirmed
IV	4	DV – average household electricity price (taxes excluded). IV – overall liberalization index, three competition proxies, all control variables.	EU-15	Partially confirmed
V	4	DV – average household electricity price (taxes excluded).	EU-15	Partially confirmed

		IV – ownership index, entry regulations index, disintegration index, three competition proxies, all control variables.		
VI	4	DV – average household electricity price (taxes excluded). IV – overall liberalization index, three competition proxies, all control variables.	New Member States	Partially confirmed
VII	4	DV – average household electricity price (taxes excluded). IV – ownership index, entry regulations index, disintegration index, three competition proxies, all control variables.	New Member States	Partially confirmed

Model specification.

Appendix B provides basic descriptive statistics of our dataset. The dependent variable – electricity price - ranges from 4.8 to 24.14 Euro cents. The overall market deregulation index is in a range from 0.87 to 6, when all sub-components (entry barriers, ownership, vertical integrations) fluctuate from 0 to 6. As for the competition proxies, a market share of the largest generator varies from 15.3% to 100%, a number of companies representing 95% of the national generation and a number of retail distributors to final consumers change from 1 to 1600 and 1226 respectfully.

In order to account for the proxy variables related to competition, we have to check whether the correlation among them may exist. Highly correlated variables may result in the artificially low significance of the final results. As can be seen in Appendix C, all three competition variables are correlated, however, this correlation is weak enough to allow us incorporate all of them in the model simultaneously.

We also test for correlation among liberalization indices. The results suggest that the overall electricity market liberalization index is significantly and highly correlated with all three sub-indicators. At the same time, the correlation among sub-indicators is either weak (entry barriers with ownership and vertical integration) or even non-significant (ownership with vertical integration). Therefore, we develop two more specifications of the model. The first one tests only the overall liberalization index. The second specification incorporates three deregulation sub-indices and excludes the overall index in order to avoid a multicollinearity problem. This approach suites our goals very well since it provides an opportunity to address not only a general impact of market deregulation on electricity prices but also to distinguish its driving components.

Another important consideration regarding our model specification refers to a choice between fixed and random effects. Most of the existing studies give a preference to fixed effects (Bacchiocchi et al. 2015; Fiorio and Fiorio 2013; Moreno et al. 2012). We use a Hausman test to compare models with fixed and random effects. And, like much of the previous research, the test indicates that a fixed effects model is preferred. However, due to its nature, fixed effects specification is harmful to the significance of the results if the independent variables of main interest are time-invariant. Indices are especially vulnerable for fixed effects models. This is why, although the Hausman test for our data favors fixed effects, we proceed with a random effects model in order to prevent artificially deflated t-statistics (i.e. insignificant results). The justification for this decision can be derived from a time-invariant nature of the liberalization indices. As an example, an "entry barriers" index for Denmark takes a value of 0.33 from 2000-2001 and 0 from 2002-2013. For Estonia, an "ownership" index has a value of 6 over all time periods (2000-2013). Thus, fixed effects would result in artificially too low significance of such time-invariant variables as the ETCR indices. This is why all of our models are based on random effects.

In addition to a comparison of fixed and random effects models, we also checked our variables for time-stationarity. Most of the variables, including electricity prices, proved to be time non-stationary. To correct for this problem, we employ first differences for time non-stationary variables to deal with a potential autocorrelation problem (except variables that are indexes such as a political index and liberalization indicators). To control for time specific shocks, all model specifications incorporate time dummies.

Finally, to account for heteroscedasticity and assure robustness of the results, we employ unit-clustered standard errors. Such error structure prevents us from receiving artificially high t-statistics (i.e. artificially too significant variables). Although some of the variables may become less statistically significant, this measure is necessary to ensure that our results do not suffer from inflated and therefore too "forgiving" standard errors. Clustered standard errors also allow us to correct for contemporaneous (spatial) correlation.

5) EMPIRICAL RESULTS

The model described above entitles us to test the impact of electricity market liberalization on final household electricity prices with a high degree of statistical confidence. Besides our liberalization indices and competition proxies, inclusion of the control variables helps to control for many external drivers of electricity rates. However, due to missing information in the data, the more controls we incorporate, the less observations we are able to obtain. For a purpose of comparison, we start with simple models I and I' (table 5.1), both of which do not have any control variables. Model I includes only an overall liberalization index as an independent variable, when model I' incorporates only three liberalization subcomponents.

Table 5.1. The influence of liberalization on household electricity prices (no control variables)

	Dependent Variables: Domestic Electricity Price (taxes and levies excluded)	
	Overall Liberalization index)	**Liberalization sub-indicators**
	(I)	**(I')**
Overall Liberalization Index	-1.667045*** -5.80	
Entry regulation index		-.5267377*** -3.25
Ownership index		-.5470366*** -2.96
Vertical integration (unbundling) index		-.7831937* -1.79

*Note: b/t; * p < 0.10, ** p < 0.05, *** p < 0.01; N – 334*

All variables are statistically significant indicating that liberalization indeed has an impact on household electricity rates. However, the results are opposite to what theory suggests. According to the obtained results, liberalization seems to lead to higher electricity prices. Lower entry barriers, more private ownership and unbundling all lead to higher prices based on the above used specification. The problem with these results is quite obvious. Both models suffer heavily from an omitted variable bias and improper specification, which may distort both p-values and coefficient values.

This is why a well-specified model should incorporate control variables to account for other potential influences on electricity prices. Our models II – VII do so (tables 5.2 and 5.3). In model II, we test an overall impact of electricity market deregulation on household electricity prices (hypothesis 1). In model III, we break down the overall liberalization index into three electricity market reform sub-indicators: entry barriers, ownership, and vertical integration (unbundling) in order to test for hypothesis 2. Hypothesis 3 is tested in models II and III. Finally, models IV through VII test whether a difference between EU-15 and NMS exist. For this purpose, we split up the dataset into two parts and examine each group of countries separately (table 5.3). Thus, models IV and V are identical to II and III but based on a sample of EU-15 states only. Models VI and VII resemble models II and III as well but based on a NMS sample. This is done with an aim to test for hypothesis 4. The final results are presented in tables 5.2 and 5.3.

Unlike models I and I', credibility of models II-VII is much higher due to the elimination of the bias from omitted variable. As a result, the statistical significance and the coefficient estimates for our liberalization variables have changed. It should be noted that a number of observations have dropped due to missing data for some variables.

Table 5.2. The influence of liberalization on household electricity rates (controls variables included)

	Dependent Variables: Domestic Electricity Price (taxes and levies excluded)	
	Overall Liberalization index)	**Liberalization sub-indicators**
	(II)	**(III)**
Overall Liberalization Index	**-0.0079** **-0.8886**	
Entry regulation index		**-0.0241***** **-5.4139**
Ownership index		**0.0014** **0.2900**
Vertical integration (unbundling) index		**0.0069** **1.4141**
Differenced "Market share of the largest generator in the electricity market"	-0.0051 -0.0943	-0.0112 -0.2121
Differenced "Number of generating companies representing at least 95% of the national net electricity generation"	**0.0082**** **1.9624**	**0.0088**** **2.5612**
Differenced "Number of electricity retailers to final consumer"	0.0077 0.2501	0.0060 0.1867
Differenced energy price index	0.0129 0.1503	0.0203 0.2231

Differenced share of renewable energy in total electricity consumption	0.0606** 2.3236	0.0739*** 3.3964
Differenced GDP per capita	0.1489 1.2302	0.2009* 1.6794
Differenced Net Energy Import, % of energy use	0.0178* 1.8610	0.0188* 1.8481
Differenced CO2 emissions per inhabitant	0.1478 0.8345	0.1603 0.8677
Population	-0.0000 -0.7593	-0.0000 -0.9741
Political index	0.0077 0.4730	0.0028 0.1956

*Note: b/t, * p < 0.10, ** p < 0.05, *** p < 0.01; N – 152.*

Models II-III in table 5.2 represent the final results and address our hypotheses 1, 2, and 3. Model II addresses hypothesis 1, testing whether liberalization of the electricity market leads to lower final household electricity prices. The Overall Liberalization Index serves as a proxy for electricity market liberalization. According to the results, the correlation with household electricity price dynamics is not statistically significant even at the 90% confidence level (p-value = 0.3742). This suggests that, in general, deregulation, according to our model specification, has no impact on final household electricity rates.

Since the liberalization index is very general and vague, we also test three deregulation sub-indicators (entry regulations, ownership, and vertical integration) separately in hypothesis 2. Multidirectional effects of the sub-indicators can be a reason why an overall electricity market reform seems to have no influence on electricity prices. If one of liberalization's elements has a positive effect on prices and another has a negative effect, they can simply neutralize each other. Moreover, although some deregulation components might be significant, due to a small absolute affect others could offset them. With this in mind, we test the sub-elements of electricity market liberalization separately in hypothesis 2.

Out of three liberalization sub-indicators, only “entry” regulations variable is statistically significant (at the 99% confidence level). However, since the correlation is negative, lower index values (i.e. less regulations/easier entry) lead to higher electricity rates. This result does not meet our expectation on hypothesis 2c that lower entry barriers are likely to lead to reduce household electricity prices. At the same time, hypotheses 2a and 2b are not confirmed as well because a statistically significant correlation between the other two liberalization components and electricity prices has not been found.

Out of three liberalization sub-indicators, only the “entry” regulations variable is statistically significant (at the 99% confidence level). However, since the correlation is negative, lower index values (i.e. less regulations/easier entry) lead to higher electricity rates. This result does not meet our expectation on hypothesis 2c that lower entry barriers are likely to lead to reduce household electricity prices. At the same time, hypotheses 2a and 2b are not confirmed as well because a statistically significant correlation between the other two liberalization components and electricity prices has not been found.

Hypotheses 3a, 3b, and 3c were also tested using models II and III. In fact, both models demonstrate the same results. “Market share of the largest generator in the electricity market” proves to have no impact on household electricity rates. In both specifications it is insignificant even at the 90% confidence level. Therefore, the hypothesis 3a is not confirmed. Such results diverge from the findings of Moreno et al. (2012) who suggested that electricity market concentration is associated with lower household prices. According to our results, market concentration does not matter for household electricity prices.

Similarly, the “increase of a number of electricity retailers to final consumer” has also proved to be insignificant even at the 90% confidence level. This means that even if competition is enhanced at a distribution/retail stage, there is not influence at final household electricity rates. Hence, our hypothesis 3c is not confirmed.

However another energy market competition proxy is significant: “Number of generating companies representing at least 95% of the national net electricity generation” is statistically significant at the 95% confidence level in both specifications (table 5.2). The correlation is positive meaning that the more companies that represent at least 95% of the total generation – the higher electricity prices are. In other words, enhanced competition in generation does not lead to cheaper electricity. Moreover, the results suggest an opposite effect. Thus, although the variable is significant, hypothesis 3b does not find justification.

Only one out of three competition proxies proved to be statistically significant on a basis of our model specification. However, none of the hypotheses is confirmed. Competition at the electricity generation stage seems to result in higher electricity prices in spite of expectations to the contrary. Market share of the largest electricity generator and competition at the distribution phase have not shown any statistically significant association with final household electricity prices. These results imply that competition, in general, may have disproportionate or no effect on market outcomes. We discuss it in more details in the following section.

As for the control variables, based on the initial specification (model II), the only significant drivers of electricity prices (besides entry regulations and number of companies in generations) were the share of renewable energy in total electricity consumption and the share of energy import. GDP per capita, the energy price index, carbon emissions per inhabitant, and the political index are not statistically significant which suggests that these variables do not determine final household electricity rates according to the model II specification.

Noteworthy changes happen to our control variables when modifying the specification in model III. Unlike model II, in addition to the share of renewable energy and the share of energy imports, GDP per capita also became significant at the 90% confidence level (in addition to significant variables of interest described above). Evidently a separation of an overall liberalization index into sub-indicators helps to refine the model. Hence, the sub-indicators specification (model III) does a better job not only in determining the impact of specific liberalization components but also in identifying the drivers of the electricity price dynamics.

Finally, we also test hypothesis 4 on whether liberalization has different effects on the EU-15 and New Member States. For this purpose, we divide the sample into two separated ones: for EU-15 countries and NMS (12 countries). The specification for models IV - V (EU-15) and VI – VII (NMS) is identical to models II and III besides the fact that data samples are distinguished for two groups of countries. Such an approach enables us to examine whether the difference between wealthier and integrated early, and poorer and integrated later states within the EU exists in terms of the electricity market deregulation effects. The results of these models have also been confirmed by a different model specification (via incorporating dummy variables and interaction terms) in order to strengthen the model's credibility (appendix D). Both specifications provide qualitatively similar results.

Table 5.3. The influence of liberalization on household electricity prices for EU-15 and NMS

	Dependent Variables: Domestic Electricity Price (taxes and levies excluded)			
	EU15 for overall Liberalization index)	**NMS for overall Liberalization index)**	**EU15 for liberalization sub-indicators**	**NMS for liberalization sub-indicators**
	(IV)	**(VI)**	**(V)**	**(VII)**
Overall Liberalization Index	0.0116 0.5939	-0.0092 -0.6728		
Entry regulation index			-0.0296	**-0.0414*** **

			-1.2871	**-3.6544**
Ownership index			0.0013 0.1667	0.0159 1.3693
Vertical integration (unbundling) index			0.0055 0.1946	**0.0142**** **2.0232**
Differenced "Market share of the largest generator in the electricity market"	0.0362 0.5021	**-0.2276**** **-2.2492**	0.0087 0.1170	**-0.2798**** **-2.2406**
Differenced "Number of generating companies representing at least 95% of the national net electricity generation"	0.0028 0.7297	0.0107 0.4892	0.0034 1.0826	-0.0092 -0.5231
Differenced "Number of electricity retailers to final consumer"	0.0138 0.4190	-0.0218 -0.2089	0.0142 0.3623	0.0071 0.0741
Differenced energy price index	-0.1282 -1.3789	-0.0167 -0.1218	-0.0973 -1.0647	0.1405 0.7696
Differenced share of renewable energy in total electricity consumption	0.2219* 1.8728	0.0249 0.8180	0.2957* 1.8335	0.0348* 1.7265
Differenced GDP per capita	0.5334*** 3.0571	0.2669* 1.7532	0.5727*** 2.8016	0.2273** 2.3606
Differenced Net Energy Import, % of energy use	0.0077 1.4470	0.2466*** 3.6230	0.0103* 1.8050	0.2171*** 2.8094
Differenced CO2 emissions per inhabitant	0.5167* 1.7416	-0.4093* -1.6670	0.5830* 1.8436	-0.4165* -1.8941
Population	-0.0000 -0.8705	-0.0000 -0.4921	-0.0000 -0.8279	-0.0000 -0.5373
Political index	0.0583 1.1412	0.0939* 1.7577	0.0540 0.9375	0.0668 1.5509

*Note: b/t, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Bacchiocchi et al (2015) found that privatization and lifting entry barriers tends to increase electricity rates for NMS. At the same time, privatization is likely to decrease prices for EU-15 countries and unbundling does not matter for either of these two groups. Our findings only partially match these results. We compare models V and VII in order to understand whether an asymmetric impact of deregulation exists (table 5.3). As we can see, in the EU-15 sample, none of the liberalization indexes is significant. This suggests that liberalization does not have any statistically significant impact on household electricity rates for more developed EU-15 states. However, the results are very different in the NMS sample where two out of three liberalization sub-indicators are highly significant.

Thus, unlike the EU-15 member-states, deregulation does matter for later integrated and overall poorer New Member States. Correspondingly with the results of Bacchiocchi et al (2015), we found that lowering entry regulations in the electricity industry leads to higher household electricity rates. The results diverge from our initial expectations. Disintegrating of generation, transmission, and distribution proved to have a positive effect on prices. In accordance with theory, unbundling of the electricity industry seems to result in cheaper electricity for NMS. Again, no statistically significant impact has been found for the EU-15 group. Finally, privatization of assets in electricity industry seems to be irrelevant for both EU-15 and NMS groups. Consequently, hypothesis 4, that deregulation has asymmetric effects for EU-15 and NMS countries, is partially confirmed. Since the unbundling index has a negative coefficient and lowering entry regulations has a positive coefficient, we can argue that the insignificance of the Overall Liberalization Index may be due to the fact that there are opposing effects related to its subcomponents. We discuss this more in the next section.

To sum up, we have estimated several models in order to assess the real impact of electricity market deregulation on household electricity rates in the EU-27 counties sample. Hypothesis 1 was not confirmed. The overall electricity market liberalization index did not show any statistically significant correlation with household electricity rates. Out of three liberalization sub-indicators, only the softening entry regulations seems to have an influence on electricity prices. However, lower entry barriers lead to more expensive electricity, which does not confirm hypothesis 2c as we expected an opposite correlation. Neither privatization of assets nor vertical disintegration is associated with the electricity price dynamics based on the specification explained above.

Among competition related proxy variables, only competition at a generation level seems to have an impact on household electricity rates. And this impact is positive (more companies in generation – higher prices) which diverges from our theoretical assumptions. Furthermore, models VI and VII suggest that, unlike EU-15 countries, a market share of the largest generator matters for NMS. Once again, the result is unexpected since the bigger market's share is – the lower prices tend to be. In other words, enhanced competition is likely to result in more expensive electricity for final household consumers in New Member States. Hence, hypothesis 3 is not confirmed for the EU-27 sample.

Finally, we have identified differences in the effect of liberalization on wealthier EU-15 and poorer NMS groups. Although privatization is statistically insignificant for both groups, unbundling and softening entry regulations have impact only on the NMS countries. Therefore, our hypothesis 4 is partially confirmed.

Overall, most of our hypotheses have not been proven. The majority of the results diverge from theoretical expectations or existing research. In the following section we discuss our findings and attempt to explain unexpected discrepancies. Some limitations, possible policy implications, and potential venues for the future research are addressed at the end of this paper.

6) DISCUSSION

It is not a rare case that empirical research does not meet initial expectations and the results diverge from theoretical suggestions. Out of 4 hypotheses only 1 is (partially) confirmed. In this section, we shortly discuss each of them thereby trying to understand why our empirical findings correspond or do not correspond with the theory.

Entire EU-27 sample.

To begin with, we found that, in general, liberalization does not have a statistically significant impact on household electricity prices for EU-27 countries. A couple of possible explanations present themselves. First of all, as model III showed, out of three liberalization sub-indicators, only entry regulations matter. However, according to our results softening entry regulations tends to increase electricity rates. This said, since the Overall Liberalization Index (OLI) is basically an aggregation of its sub-elements, it is likely that insignificant disintegration and privatization are responsible for the overall insignificance of the OLI. A share of the entry regulations component, which is significant, seems to be proportionally small and therefore it does not have enough weight to deliver the overall OLI significance.

Besides the insignificance of the Overall Liberalization Index, two more questions stand. Why are other liberalization components, in particular, privatization and disintegration, insignificant? Why lower entry barriers result in higher prices? According to the theory of liberalization, such measures should have brought more competition and therefore decrease electricity rates. Does competition matter for household electricity prices in the EU electricity market? What is its real impact?

Answers can be found in the nature of the electricity industry, which is quite different from typical commodity markets. As Bacchiocchi et al. (2015) noticed, in many EU countries, especially ones with socially oriented governments (ones that practice high taxes and exercise redistribution mechanisms), electricity price is not cost reflective. In an effort to keep energy affordable, publicly owned utilities are subsidized and supported from the general budget. However, after liberalization begins, it is likely that public utilities can lose this support. Required to participate in market competition and without governmental assistance, utilities need to increase their prices in order to cover the cost. Furthermore, disintegration of generation, transmission, and distribution deprives some of the market players from economy of scale benefits. Additional expenses for marketing, R&D, and restructuring are required to survive newly introduced competition. Thus, although the operational efficiency of electricity market players is likely to increase, their total expenses may grow as well. These opposite effects can potentially cancel out each other and turn into statistically insignificant association of Overall Liberalization Index with household electricity prices.

This explanation can be clearly seen in model VII. After we tested the NMS sample, the results show that two liberalization subcomponents are significant. However, they have opposite effects. While reducing entry regulations results in higher prices, unbundling leads to lower electricity rates. Thus, having the privatization component statistically insignificant, two other elements just neutralize each other. Therefore, the OLI is insignificant in model VI. But why is the entry regulation index negative in all the model specifications presented above? Should not a facilitated process of entering the market lead to higher competition and, as a result, cheaper electricity?

Apparently, the real world situation seems to be more complicated than pure theory assumes. With a deregulated market, many more expenditures are likely to occur. And they might potentially be transferred on final household rates. First of all, losing government protection requires firms in electricity markets to deal with a lot of bureaucratic issues that have not been a problem before. Moreover, other competitors may potentially try to hinder its operation by creating obstacles in obtaining different types of legal restrictions. Therefore, firm in the electricity market might need to hire and maintain additional staff (lawyers, administrators and such) to survive a legal fight against its rivals which leads to additional expenses and, consequently, more costly electricity. Secondly, extra set of expenses as for marketing, R&D, public relations etc. can only aggravate the situation. In the end, lifted entry barriers may result in companies spending more money on hindering potential competitors from entering the market. Consequently, more expenses will inevitably increase final household electricity rates. This is why, an association between entry regulations index and electricity rates may be negative despite theoretical suggestions.

Besides our main variables of interest, it is worthwhile to briefly touch on control variables in order to get a more comprehensive understanding of the electricity price drivers. Based on model II, only two controls are consistently significant: share of renewable energy in total electricity consumption and net energy import. According to our results, the more renewable energy sources are incorporated in total electricity consumption, the cheaper electricity becomes (positive correlation). These results correspond with the results of Moreno et al. (2012) who found that deployment of Renewable Energy Standards (RES-E) leads to more expensive electricity for household consumers. Such an outcome seems to be plausible. Renewable energy, especially a decade ago, used to be much more expensive compare to traditional sources. Our study concentrates on the more current period of 2000 – 2014 and a rapid decrease in the cost of renewable energy occurred only closer to the end of this time period (Feldman et al. 2014). Hence, matching the results of other studies, our findings suggest that renewable energy development tends to increase electricity rates for household consumers, at least over the time period of 2000 – 2014.

Net energy import is also significant over most of examined models. Since the correlation is positive, it means that the larger percentage of total energy consumption is imported, the higher household electricity prices tend to be. In other words, countries that rely on domestic electricity production are likely to have lower rates. This finding corresponds to the existing research and proves, once again, that external energy security matters even for final household consumers.

When we test our liberalization sub-components model (model III), one more control variable becomes significant. It is GDP per capita which suggests that wealthier countries tend to have more expensive electricity. Significance of the GDP per capita variable is common for most of the existing studies. The reason why more developed countries tend to have more expensive electricity, is due to differences in relative wealth. Thus, in absolute terms prices might be higher in richer countries, but when comparing affordability of electricity (which is a function of both income and price), it is evident that in most cases, in fact, electricity is less affordable for residents of less developed states.

EU-15 vs NMS comparison.

Finally, hypothesis 4 stated that the impact of deregulation is asymmetric for EU-15 countries and New Member States. It was partially confirmed. Our models IV through VII compared these two groups of countries and found that liberalization does not have any statistically significant impact on electricity rates for EU-15 states. However, it does make a difference for New Member States of the European Union.

From model VI, the Overall Liberalization Index for NMS is insignificant which should imply that deregulation does not have any influence on household electricity rates. However, there is an explanation for this. Model VII shows that sub-components of OLI such as entry regulations and vertical integration have opposite effects on prices. Since the third component (ownership) is statistically insignificant, these two sub-indicators simply neutralize each other resulting in an overall insignificance of liberalization for OLI models (models II, IV, and VI). This is why it is very important to distinguish different elements of deregulation.

Furthermore, model VII demonstrates us that significance of the entry regulation index for the EU-27 (all 27 countries but Croatia) sample is driven by NMS. The EU-15 group just diminishes the overall statistical significance. Our results are quite clear in this respect and they partially match the findings of Bacchiocchi et al. (2015). However, unlike their results, we have not found asymmetrical effects between the EU-15 and NMS groups. Our findings suggest some asymmetry exits within the NMS group itself while for the EU-15 states liberalization does not seem to matter at all.

There may be several explanations of why liberalization has an impact for NMS and no effect on EU-15 countries based on the findings of the received literature (overall economic differences, more stable electricity market in the EU-15 states, better developed electricity trade etc.). However, one of the most probable explanations lies in our research design and, particular, in the selected dataset. The dataset spans from 2000 to 2014 and, therefore, covers the end of liberalization processes in some countries and their beginning in others. Liberalization in the UK, Scandinavian countries, Germany and some other EU-15 states started yet in 1990s when NMS began the reforms only in 2000s. In the initial stages, the deregulation effect might be much more prominent which has been captured by our analysis. If the impact indeed weakens with time, it is likely that due to the limited data frame, we could catch only the “tail” of the real liberalization impact for the EU-15. We will talk about this in the following section devoted to limitations of our research.

Lastly, we have already provided some thoughts on why lifting entry barriers may lead to more expensive electricity above. Why does disintegration of generation, transmission, and distribution decrease household electricity rates then? An explanation can be drawn from the theory of liberalization. Such an outcome (positive correlation between disintegration and prices), although based only on a sample of NMS, perfectly corresponds with our assumptions. Moreover, it satisfies hypothesis 2b. Indeed, if the previously monopolized single electricity market is divided into three separated ones, it becomes easier for smaller firms to enter. Small and narrowly focused companies (for instance, specialized in generation only) with less capital can join now and survive the pressure from rivals. Consequently, enhanced competition (according to liberalization theory) results in more efficient outcomes, in particular lower prices for final consumers.

We can summarize several conclusions from our results. First, liberalization has a statistically significant impact on household electricity prices only for New Member States of the European Union. Second, this impact is asymmetric and depends on liberalization's sub-elements. Vertical disintegration results in cheaper electricity due to enhanced competition in newly created independent markets of generation, transmission, and distribution. Softening entry regulations tends to increase prices (due to a loss of governmental support/economy of scale and newly occurred expenses to survive competition). Third, ownership of electricity market assets is not statistically associated with the dynamics of household electricity rates for EU-15 or for NMS groups. Finally, besides liberalization and competition, electricity prices are influenced by: development of renewable energy (more renewables – more expensive electricity), GDP per capita (wealthier countries tend to have higher prices in absolute terms), and energy security (states that import a lot of electricity from abroad are likely to have higher household electricity rates). CO2 emissions per inhabitant have asymmetric effect on electricity rates (positive for EU-15 and negative for NMS) (table 5.3), which is why, in the EU-27 sample, this control variables is insignificant since opposite effects just cancel each other. Overall, electricity market deregulation reforms have an impact on New Member States while there is no significant impact on the EU-15 states.

7) POLICY IMPLICATIONS AND LIMITATIONS

Policy recommendations/implications.

Having discussed and explained the results, we can proceed to policy implications of our research. What is the value of our results for the real world policy making process? Can the EU officials benefit from our findings? These were the most important questions and drivers of our study from the very first moment. Only a possibility of future use and practical application makes a research worthwhile. Therefore, in this concluding section we touch on policy implications and limitations of our findings thereby setting up an avenue for the future research.

As mentioned before, from the very beginning this study was driven by an aspiration to address problems of energy poverty in the EU member states, the problem which is especially prominent in Southern and Eastern EU members. Considering recent liberalization efforts by the EU countries, we decided to take a closer look on whether electricity market deregulation can actually result in more affordable electricity for regular household consumers. Now, when we can see that the impact of liberalization is not that clear and even contradictory, our findings allow us to make some recommendations for the future of electricity market liberalization process for the European Union. The following policy suggestions/implications conclude our research and aim to contribute to the overall effort of fighting energy poverty in the world:

- If continued, electricity market liberalization can benefit the EU-15 member-states. In general, deregulation has not shown any impact on final household electricity rates over past 15 years for this group of countries. However, the security of the energy supply and system reliability are likely to improve because of deregulation reforms.

- For New Member States of the European Union, further deregulation steps should be considered with caution. Liberalization in this group can potentially result in more expensive electricity for household consumes which, in turn, can lead to aggravating energy poverty. Since some countries within the NMS group are already experiencing serious problems with energy affordability, further liberalization may harm the most vulnerable categories of people. A tradeoff between market liberalization and energy prices should be taken into account when developing energy policy in the NMS countries.
- Vertical disintegration (unbundling) should be seen as a way to decrease household electricity price for the NMS group. If affordability of energy is chosen as a major goal of the liberalization effort, separation of electricity industry into three independent markets should be prioritized. Privatization is unlikely to cheapen electricity but can diversify the system and strengthen energy security. Softening entry regulation may lead to even more expensive electricity. Hence, considering an existing problem with energy affordability, the entry regulations component of electricity market reform should be thoroughly monitored and carefully implemented or even completely avoided.
- Competition within an electricity industry should be treated differently as well. Overall findings for EU-27 suggest that enhanced competition in generation should reduce household electricity rates. However, NMS might welcome a certain extent of monopolization (potentially in a form of natural monopoly or subsidization) during a transition period to fully liberalized market since the results suggest that high market concentration is associated with lower prices for this group.

- Indeed, certain differences exist among the EU members in terms of electricity market liberalization effects. Therefore, it is recommended for policy makers from NMS to be very cautious if adopting the experience from EU-15 states. Definitely, some implementation mechanisms can and should be considered as well as mistakes should be taken into account. However, it is possible that same patterns of electricity market reform can produce radically different results for different groups of states. Thus, a unique approach should be developed for every single country. This approach should account for all specific features of a state and resemble its way of economic development.
- Finally, the electricity market does not work in the same manner as regular commodity industries. This should be understood and taken into account when developing any kind of regulations and policies. Although the first steps have been already taken to transform the industry, we are many years away from achieving completely liberalized European electricity markets. During this transition period, both competition and natural monopoly paradigms should be considered as potential approaches for industry advances.

Limitations and avenues for further research.

No need to say that our findings, and consequently policy recommendations, are based on the chosen model design. If statistical methods or data are modified the results might differ. This seems to be the first limitation of our study. It is bounded by the variables we chose and statistical tools we applied. Moreover, as was mentioned earlier in this paper, the chosen time period (2000 – 2014) captures different stages of the deregulations reform for the EU-15 and NMS groups. For most of the EU-15 members, this process started in 1990s when the majority of the NMS countries began its liberalization efforts in early 2000s. Further can potentially refine our results by comparing the reforms at the same stages of implementation.

Also, our study does not touch on detailed mechanisms of how final electricity price is formed. We do not follow the entire cycle from the moment of electricity generation to the moment of its use by final consumers. Therefore, we are not able to identify exact components of electricity price formation responsible for a change. Although we can still distinguish the final effects of liberalization, at what stage of the electricity industry cycle the biggest change happens still seems to be unclear.

Moreover, this research mostly ignores the significance of wholesale electricity market in terms of its influence on final electricity rates. The majority of the reviewed studies state that liberalization has brought a considerable decrease to wholesale electricity prices. However, the final electricity price was not impacted or was impacted only slightly. The question remains: what stays in between the wholesale and retail electricity markets that prevents a transfer of the price decrease to final household consumers?

Altogether, the above-described issues provide an avenue for future research. Liberalization is a complicated process that can be comprehended only by approaching it from different perspectives. Therefore, future studies should not only try to replicate our results by modifying statistical methods and improving data but should also explore various new dimensions to address the issue of liberalization's impact on energy affordability. Engineering, economic, social and even cultural aspects should be considered. The best approaches will take a closer look at cost-price transfer mechanisms, wholesale-retail market links, and existing differences among the EU member states. Only a complex view of the electricity market can provide clear and consistent answers to the question of how liberalization affects electricity market outcomes. Future research should concentrate on pulling together many pieces of the same issue and test existing findings on a matter of their rigorousness and trustworthiness.

Indeed, there is still a lot of work to be done. But every single study makes us closer to achieving an ultimate goal: to understand the nature of the electricity market in order to ensure affordable energy and thereby overcome, or at least reduce, energy poverty around the globe. This research seeks to serve as another step towards the better, more prosperous future for generations to come.

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APPENDICES

APPENDIX A. Variables' Definitions and Sources.

Variable	Definition	Source
Residential electricity price	Average second half of the year electricity prices for households end-users. The prices include electricity/basic price, transmission, system services, meter rental, distribution and other services. The prices exclude taxes and levies. Unit of measurement - Eurocents / kWh.	Eurostat, the Statistical Office of the European Union http://ec.europa.eu/eurostat/web/energy/data/database
Overall Liberalization Index (OLI) Ownership index Vertical integration index Entry regulation index	These indicators measure regulation at the electricity sector level in 27 EU countries (Croatia excluded). They estimate the degree to which policies promote or inhibit competition in electricity market. All of them range from 0 to 6.	OECD countries: http://stats.oecd.org/Index.aspx?datasetcode=ETCR# Non-OECD countries: dataset by Bacchiocchi et al. – http://users.unimi.it/eusers/download/asymmetric-effects-of-electricity-regulatory-reforms-in-the-eu15-and-in-the-new-member-states-empirical-evidence-from-residential-prices-1990-2011/
Differenced "Market Share of the largest generator in the electricity market"	The indicator shows the market share of the largest electricity generator in each country. To calculate this indicator, the total net electricity production during each reference year is taken into account. It means that the electricity used by generators for their own consumption is not taken into account. Then, the net production of each generator during the same year is considered in order to calculate the corresponding market shares. Only the largest market share is reported under this indicator.	Eurostat Source: Eurostat (online data code: nrg_ind_331a) http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&pcode=ten00119&language=en
Differenced "Number of	Number of generating	Eurostat

generating companies representing at least 95% of the national net electricity generation”	companies representing at least 95% of the national net electricity generation	http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_market_indicators
Differenced “Number of electricity retailers to final consumer”	Number of electricity retailers to final consumer	Eurostat http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_market_indicators
Differenced share of renewable energy in total electricity consumption	A share of renewable energy in total electricity consumption is a ratio where: The numerator is the gross final consumption of electricity from renewable sources. The denominator is the gross final consumption of electricity. Unit of measurement – percentage (ranges from 0 to 100)	Eurostat http://ec.europa.eu/eurostat/web/energy/data/shares http://ec.europa.eu/eurostat/documents/38154/4956088/SHARES2014manual.pdf/1749ab76-3685-48bb-9c37-9dea3ca51244
Differenced energy price index	Index is an average of coal, gas, and oil price indexes. Crude oil, average price of Brent, Dubai and West Texas Intermediate, equally weighed. Natural Gas (Europe), average import border price with a component of spot price, including UK. Coal: equally weighed 3 indicators. Coal (Australia), thermal, f.o.b. piers, Newcastle/Port Kembla, 6,700 kcal/kg, 90 days forward delivery. Coal (Colombia), thermal, f.o.b. Bolivar, 6,450 kcal/kg, (11,200 btu/lb), less than .8% sulfur, 9% ash, 90 days forward delivery. Coal (South Africa), thermal, f.o.b. Richards Bay, 6,000 kcal/kg, 90 days forward delivery	World Bank World Bank Commodity Price Data (The Pink Sheet) http://databank.worldbank.org/data/reports.aspx?source=global-economic-monitor-(gem)-commodities&preview=on
Differenced GDP per capita	GDP per capita is gross domestic product divided by midyear population. GDP is the	World Bank http://databank.worldbank.org/data/reports.aspx?source=2&type

	sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.	=metadata&series=NY.GDP.PCAP.CD#
Differenced Net Energy Import, % of energy use	Net energy imports are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.	World Bank http://databank.worldbank.org/data/reports.aspx?source=2&type=metadata&series=NY.GDP.PCAP.CD#
Differenced CO2 emissions per inhabitant	The indicator provides the level of CO2 emissions per inhabitant in the EU in tones per inhabitant. This indicator is compiled using the data on CO2 emissions (excluding - land use change and forestry) provided in the official submission of the European Commission to the UNFCCC; and per capita emissions are calculated using Eurostat population statistics.	Eurostat http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdgp410
Population	Population on January 1 – total.	Eurostat: http://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-data/database
Political index	Index is an average of 4 indicators. **Control of Corruption** captures perceptions of the extent to which public power is	World Bank: Governance Indicators http://info.worldbank.org/governance/wgi/index.aspx#home

	exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. **Government Effectiveness** captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. **Regulatory Quality** captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. **Rule of Law** captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of a standard	

	normal distribution, i.e. ranging from approximately -2.5 to 2.5.	
EU15 dummy	A value of 1 denotes EU-15 member states, 0 – the rest, New Member States of the EU.	Created by author

APPENDIX B. Descriptive Summary Statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Electricity price (Eprice)	373	10.92971	3.291721	4.8	24.14
Overall electricity market regulation index (reg)	366	2.866885	1.366491	.87	6
Entry regulations (entry)	366	1.214891	1.869168	0	6
Ownership (owner)	366	3.825328	1.94448	0	6
Vertical disintegration (Vertinteg)	366	4.105246	1.522567	0	6
Market share of the largest generator in the electricity market (marketshare)	347	58.90432	27.41482	15.3	100
Number of generating companies representing at least 95% of the national net electricity generation (numcomp)	308	112.0812	264.5781	1	1600
Number of electricity retailers to final consumer (numret)	323	116.4025	208.1139	1	1226
Energy price index (energyindex)	405	87.28733	28.51844	45.09	125.56
Share of renewable energy in total electricity consumption (renshare)	301	19.31561	17.05902	0	70
GDP per capita (GDP)	404	28438.83	20171.15	1609.28	116664
Energy import, net, % of energy use (enimp)	372	53.24976	31.53729	-65.68	99.92

CO2 emissions per inhabitant in the EU (carbon)	351	8.760969	3.77717	2.9	26.3
Total population on January 1 (population)	405	1.82e+07	2.27e+07	380201	8.30e+07
Political index (polindex)	351	1.152191	.5933506	-.216477	2.20055

APPENDIX C. Pwcorr Test, Correlation among Independent Variables

- Liberalization indexes

```
. pwcorr reg entry owner vertinteg, sig

             |      reg    entry    owner vertin~g
-------------+------------------------------------
         reg |   1.0000
             |
             |
       entry |   0.8634   1.0000
             |   0.0000
             |
       owner |   0.6252   0.3607   1.0000
             |   0.0000   0.0000
             |
   vertinteg |   0.5102   0.4222  -0.0695   1.0000
             |   0.0000   0.0000   0.1845
```

b/p

- Competition proxies

```
. pwcorr marketshare numcomp numret, sig

             | market~e  numcomp   numret
-------------+---------------------------
 marketshare |   1.0000
             |
             |
     numcomp |  -0.2681   1.0000
             |   0.0000
             |
      numret |  -0.3394   0.2405   1.0000
             |   0.0000   0.0000
```

b/p

- Political indexes

```
. pwcorr corrup goveff regqual rulelaw, sig

             |   corrup   goveff  regqual  rulelaw
-------------+------------------------------------
      corrup |   1.0000
             |
             |
      goveff |   0.9419   1.0000
             |   0.0000
             |
     regqual |   0.8857   0.8847   1.0000
             |   0.0000   0.0000
             |
     rulelaw |   0.9444   0.9407   0.9000   1.0000
             |   0.0000   0.0000   0.0000
```

**b/p*

APPENDIX D. Interaction Term Model Specification (dependent variables: domestic household electricity price (taxes and levies excluded))

Independent variables	**b-coefficients, t-statistics**
Entry regulation index	-0.0384*** -4.26
Ownership index	0.0136 1.35
Vertical integration (unbundling) index	0.0113* 1.75
Differenced "Market share of the largest generator in the electricity market"	-0.0073 -0.13
Differenced "Number of generating companies representing at least 95% of the national net electricity generation"	0.0074** 2.52
Differenced "Number of electricity retailers to final consumer"	0.0193 0.54
Differenced energy price index	0.0493 0.51
Differenced share of renewable energy in total electricity consumption	0.0591*** 3.51
Differenced GDP per capita	0.1826

	1.56
Differenced Net Energy Import, % of energy use	0.0190** 2.02
Differenced CO2 emissions per inhabitant	0.1440 0.76
Population	-0.0000 -0.04
Political index	0.0151 0.55
EU-15	0.0947 1.15
Interaction term between Entry Regulation and EU-15	0.0365** 2.21
Interaction term between Ownership and EU-15	-0.0140 -1.21
Interaction term between Vertical Disintegration and EU-15	-0.0186 -1.21

*Note: * p < 0.10, ** p < 0.05, *** p < 0.01; N – 152*