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Set Me Free

Liberalization and Innovation in Electricity Production from Renewable Energies

Bachelor Thesis

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Abstract

This paper elaborates on the relationship between the institutional organization in terms of market and governance structures and the development of electricity produced from renewable energy sources. Building upon evolutionary theory in particular, it is assumed that a liberal market structure offers the best chance for the effective development of RES-E. It is further hypothesized, that governmental support is conditioning the effect of liberalization on the electricity production from renewable sources. Through governmental steering, the risk for investment is mitigated and renewable energy technologies are safeguarded from out-of-equilibrium dynamics, whose presence is an assumption at the heart of evolutionary theory. In order to test these assumption on the ideal economic organization of the electricity market, a quantitative, empirical approach, using a longitudinal research design, has been chosen. The data collected describes the institutional structures of all 28 Member states of the European Union. The objective of the study has been to compare those structures and identify the most valuable form of institutional organization for the electricity market, lastly under the somewhat normative presumption , that setting free the potential of electricity generation from renewable energy sources is indeed desirable. In the end, the hypotheses could not be confirmed. Still, the inquiry left valuable information about the challenges that research on economic organization and innovation is confronted with.

Abbreviations

EU	European Union
RE	Renewable Energies
RES	Renewable Energy Sources
RES-E	Electricity from Renewable Energy Sources
RET	Renewable Energy Technologies

Introduction

A step-wise liberalization process and lately the successful promotion of the renewable energy technologies throughout the past decades have caused a change of minds about the long-held belief that the electricity market is entirely monopolistic in nature and can only be managed in a hierarchical manner (Sioshansi, 2006). In fact, especially the unbundling of segments of the electricity market appeared to have paved the way for more liberalised structures. Still, we observe that regulatory measures such as feed-in tariffs and quotas are needed to ensure the competitiveness of renewable energy technologies. Apparently, the production and the supply of electricity have become more liberal, whereas transport and distribution are restrained by a natural monopoly and thus underlie increased regulation by governments (Künneke, 1999). More recent neo-classical economic theory suggest, that, in a fully free market economy, monopolies are the only economic agents in possession of the necessary capacities to fosters innovative activity despite of the inevitable imitation by the competition (Dosi, Freeman, Nelson, Silverberg, & Soete, 1988). So why would liberalization be desirable in the first place? In this paper I argue, that the behaviour of economic agents is considerably determined by the political sphere and that the energy market in particular has become much more complex in the light of environmental change. Under such complexity, institutions are needed as mediators of economic activity. North (1990) emphasizes the role of institutions in mediating the costs of production. The central question at stake is which set of institutions illustrates the best approach for the efficient expansion of RES-E. In order to clarify this question, this paper mainly builds upon evolutionary theory on innovation of Dosi et al. (1988). The evolutionary approach is concerned with describing the dynamics of economies in the light of technical change. It has been mainly influenced by Schumpeter's idea on economic theory and innovation. In contrast to neo-classical economics, evolutionary theory tries to explain and integrates heavy structural changes within an economy in the consequent theoretical assumptions. Building upon such theoretical framework I will inquire how markets and governance in various European countries are aligned in order to identify the most efficacious organizational form for the modern electricity market.

The social relevance of this objective is clearly not negligible. As a response to energy supply security issues, such as dependency on fossil fuels from Russia and the attainment of the goals set out in the European Renewable Energy Directive, the role of renewable energy technologies in the electricity market has become increasingly important. Both a 20 percent reduction of GHG emissions, as well as a 20 percent energy consumption from renewable energies are targeted by the EU's energy strategy 2020. RET contribute to the decarbonising of the energy sector, as they endorse carbon-free electricity generation. Moreover, they are expected to establish increased autarky in terms of energy production. Understanding how institutional organization shapes the economy of energy supply is key to the effective implementation of innovative electricity-generating technologies.

From a scientific perspective, this study seeks to develop a comprehensive model of institutional organization, that incorporates and depicts the alignment of market and governance structures.

Method

Research Question

The primary interest of this research is to clarify which market setting best drives the development of RES-E. Because of limits in time and resources this study will purely focus on the development of wind energy technologies. The objective of the research must be to capture the institutional structure, which comprises market structure and governmental influences, that is best suited for the expansion of electricity production from wind energy technologies. The main research question, that needs to be posed to achieve this objective, thus reads:

Does liberalization of electricity markets increase the share of renewable energy sources in electricity production and if so, what is the impact of policy support instruments?

Understanding the institutional organization of an electricity market means knowing how the national electricity markets in Europe are structured and to what extent governments do interfere in economic activity. Consequently the main question needs to be divided into two sub-questions. The information retrieved on national market settings and national support schemes allows to draw a clearer picture of the implications for the development of RES-E. The sub-questions and the objectives related to them are presented in Table 1.

Table 1

Sub-questions and objectives

To what extent do national market settings affect the electricity production from wind energy resources?	Understanding to which degree given market structures favour the expansion of electricity production from wind energy technologies.
What is the impact of public support instruments on the relationship between market setting and RES-E generation?	Understanding to which degree governmental policy interference channels economic organization to favour the expansion of electricity production from wind energy technologies.

Theory

In order to develop a sound model for understanding the institutional organization of national electricity markets within the EU, the meaning of concepts as institutions and institutional organization need to be clarified at first. Institutions are meant to provide structure and coordination to production by reducing the costliness of imperfect transactions (North, 1990). Under impersonal exchange, which is most common in developed economies, transformation costs are relatively low, whereas transaction costs are high and require mitigation by means of institutions (North, 1990). In the follow-up of this paper I will distinguish between institutional environment or framework and institutional structure or organization. This distinction is crucial to the understanding of this study. The term institutional environment or framework refers to formal rules and constrains that form the 'rules of the game'. Institutional structure or organization meanwhile describes the order in a given economy in terms of the interaction of economic structures and certain modes of governance.

To start with, I would like to focus on the role of economic organization within an institutional structure. Economic organization refers to a specific market setting, that can either be organized rather liberal, by relying on markets, or hierarchical, by relying on bureaucracies. Williamson (1998, p. 40) ties in with previous authors that the central problem of economic organization is adaption to changing environment. Sound organization is particularly challenged in the light of change. Hence, the rapid change that comes along with the pursued transition to RES, forces institutions of the electricity sector to adapt. Firms that operate within the energy market need to innovate or imitate in order to live up to the environmental aspirations of the political agenda of the 21st century. Revealing the origins for the need for innovation is highly important for the assumption we make about technological change. Assuming that the political agenda has induced technological change in the energy market means, that innovation is not endogenous, but exogenously introduced to economic organization. The innovation mechanism that is discussed here is much broader than specific innovations that emerge within the setting of an organization. In order to explain the diffusion of Renewable Energy Technologies, we need to understand the relationship between innovation and economic organization.

Neo-classical theory typically views technology as a public good and cannot explain why innovation would take place in a free market economy (Verspagen, 1992). The question, why firms should innovate if they can imitate instead, is left unanswered. In order to fully understand the implications of innovation on economic organization, two distinctive aspects of technology need to be discussed. Technology can either refer to generic knowledge, which inevitably becomes a public good sooner or later, or to technical artefacts, that are products or procedures, that can partly be safeguarded through property rights in order to create profits for the owner (Dosi et al., 1988). Apparently, technology can hold both, the properties of a public good as well as of a private good. I argue that these properties have different significance at various stages of the innovation chain.

Newer models standing in the neo-classical tradition, meaning that they incorporate the equilibrium notion and rational behaviour assumption, have tried to refine the theory, saying that monopoly power can incentivize the production of innovation, despite of inevitable spill-over to the competition (Verspagen, 1992). In their logic, the capacity of the monopolist to invest in innovation and the appropriability of artefact technology enables him to create profits from technological change. However, the neo-classical tradition regards innovation as a purely productivity-optimizing process and denies the implications created by the political agenda on environmental change. Gerald Silverberg (Dosi et al., 1988, p. 533) predicts that "a limitation of the(se neo-classical) large econometric models is their breakdown in the face of structural change, which they are not able to anticipate". Explaining innovation under the pull of environmental change requires to extend our theoretical framework beyond the realm of the neo-classical tradition. Building upon the important theoretical thoughts of Schumpeter, the evolutionary tradition has emerged explaining the economics of innovation from a more dynamic point of view. Dosi and Coricelli (1988, p. 141) describe the evolutionary or self-organization approach in explaining innovative environments as focusing on "behavioural diversity, out-of-equilibrium processes, various sorts of externalities, environmental selection and unintentional outcomes of decentralized decision-making processes". According to this view, information is limited and preferences are seldom computable. This very much questions rational behaviour of economic agents. Although agents are still believed to act strategically and goal-oriented, the approach acknowledges that agent's behaviour may differ even in a shared environment and identical information feed. In that sense, the evolutionary view rather complements neo-classical models for a behavioural order than completely abolishing their assumptions about strategic behaviour. But the actual added value of the evolutionary approach to my inquiry of the modern electricity market is the acknowledgment of the complexity of decision-making that affects economic organization. From a neo-classical point of view, the Renewable Energy Technologies have no standing in a free market economy, unless a monopolist would regard their deployment a profitable business. With the unchanging highly profitable conventional energy sources, this case is not to be expected. The evolutionary view though tries to account for externalities, such as the political agenda on environmental change. I assume, that the current environmental agenda pushes for the conversion of the properties of artefact innovative technologies into those of public goods. This ultimately affects the behaviour of economic agents, which is not necessarily rational, but goal-oriented, in such a way that they trust in potentially unprofitable technologies. This trust in innovation, abolishes the need for a monopolistic reformer and reactivates the importance of competitive market for the deployment of the given technology.

Traditionally, electricity markets had been organized in a hierarchical manner through extensive vertical integration (Finger, Groenwegen, & Kunneke, 2005, p. 14). That is, because economies of scope and scale were considered the most efficient organizations to deal with the monopolistic character of the electricity market. In the 1990s though, a paradigm shift caused the economic organization to change towards more liberalized structures (Sioshansi, 2006). A segmentation of the value chain resulted in a few sectors operating under increased competition. such as production, trade, metering and sales. Network-related sectors like transmission and distribution are considered natural monopolies and therefore remain under heavy governmental interference (Finger et al., 2005). Williamson (1998) argues that strongly bureaucratic forms of organizations are the least desirable in terms of economic organization. But as indicated by the evolutionary perspective on the dynamics of the economy, liberal structures alone cannot account for the proper implementation of RET into the electricity market. Hence, economic organization needs to be analysed in view of the prevailing political agenda. The complex composition of the political and economic sphere define the institutional structure of modern electricity markets.

As regards public policy support, various support schemes for renewable electricity generation can be found. Kitzing, Mitchell and Morthorst (2012) identify feed-in tariffs, feed-in premiums, tender schemes and quota obligations with tradable green certificates as the most common primary support schemes in Europe. Moreover, they list investment grants, fiscal measures and financing support as supplementary support schemes. From the perspective of institutional organization aiming at the promotion of renewable energy technologies, and taking up the previous dilemma in economic organization of the market setting, it is interesting to focus primarily on those policies, that effectively mitigate the risk exposure of investors to the price setting mechanism. For that reason, fiscal measures and financing support will be excluded from this study, since they are rather incentivizing investors liquidity in general, but are not directly linked to RET investment and serve to "internalise external costs" (Kitzing et al., 2012, p. 4). For the sake of theoretical argumentation, I will address feed-in tariffs and feed-in premiums under the same term FIT policies from now on. Although they differ on the extent to which risks are mitigated, they both are designed to regulate the price setting of electricity markets. Quota systems meanwhile aim at regulating the quantity of RES-E generated.

Mitchell, Bauknecht & Connor (2006) identify three components that make up the risk that is related to investment in RES-E generation, that is price risk, volume risk and balancing risk. Price risk is determined by the degree of price volatility in the market, volume risk by the degree to which produced volume can safely be sold into the value chain, and balancing risk by the degree to which load fluctuations are mitigated by producers. Mitchell et al. (2006) argue, that price risk reduction would become more valuable the more volatile the price for electricity. Furthermore they say, that obviously, price volatility would be higher in liberalised markets than in monopolistic markets. This ultimately means, that, in competitive markets, price risk reduction holds an increased value. In theory, as regards the price risk reduction profile of the existing policy measures, FIT policies have the advantage of allowing secure investment planning in the long-term, even for less mature and therefore riskier technologies (Polzin, Migendt, Täube, & von Flotow, 2015), because it is guaranteed, that the energy produced can be sold profitably. But, risk reduction shall not be confused with efficiency. FIT policies run the risk of increasing costs and set out little incentive for innovation, for the exact reason of long-term investment security is guaranteed. Quota systems in contrast like the Trade Green Certificate scheme represent the more market-based approach, where less regulative, governmental interference is in place. Generating companies are obliged to hold a certain amount of green certificates, which are traded among producers and suppliers under a free price mechanism. This would imply more volatile prices. In practice, there is mixed empirical prove for the advantage of FIT policies in reducing the price for investment in RES-E generation. Dong (2012) states that price-regulating policies have positively affected RES-E development, whereas quantity-regulating policies had a negative effect. Carley (2009) employs a more comprehensive state-level empirical study based on panel-data on the relationship between Renewable Portfolio Standards, that is a quota system, and RES-E generation attesting its correlation, but not its causality. Yin and Powers (2010) again find an actual effect of RPS on RES-E development by taking into account even fine differences in policy design. However, there appear to be very few more nuanced and complex studies concerned with empirically measuring the actual effectiveness of support policies, be it tariff or quota schemes (Jenner, Groba, & Indvik, 2013). Therefore, empirical data cannot irrefutably confirm the theoretical assumptions made about policy-specific characteristics. For the model of this study, it is taken for granted, that price-regulating policies are better capable of reducing investment risks, whereas quantity-regulating policies do less. This distinction however is yet too broad, since the majority of European countries applies price-regulating policies. We need to make a closer differentiation between fixed-price tariffs and premium tariffs. The main difference here is the extent to which the remuneration of electricity producers is dependent from the market price. By definition, fixed prices tariffs are market-independent, whereas premium tariffs are market-dependent, because a premium is added to the market electricity price. Couture and Gagnon (2010) argue that market-independent mechanisms create a higher investment security than market-dependent ones, again for the reason of a more effective risk reduction. This implies that fixed-price tariffs are the most effective support instrument in price risk reduction, followed by premium tariffs and quota obligation, as the instrument that offers the least investment security. The second argument of Mitchell et al. (2006) in favour of FIT policies regards volume risk. Within FIT support schemes, the risk of not selling the volume produced is excluded by law, because suppliers are obliged to buy in all the renewable capacities in the first place. Under a quota system, a minimum volume of supply is set, but as long as suppliers fulfil this volume, they can choose freely whose electricity to buy. Thus, there is a certain volume risk for individual RES-E producers. This makes any empirical proof for the advantage of FIT policies redundant, because any risk is excluded by definition. FIT policies again appear to be a more reliable option for the development of RES-E generation. The third component of investment risk is balancing risk. FIT policies guarantee the payment of a fixed price assigned to each technology and therefore producers do not need to balance load fluctuations at all. In a quota system, balancing risk is present due to competition, but fluctuation is penalised through the market mechanism. This creates an important incentive to reduce fluctuation (Mitchell et al., 2006). In both cases, a return on investment can be expected. Perhaps, as a consequence, differences in the structure of the power market would occur.

From the previous theoretical reflections, the following analytical framework can be constructed: The variable 'Liberalization of the market setting' has a positive effect on 'RES-E deployment, whereas the variable 'support instruments' exerts an interaction effect on the relationship between the other variables. This interaction model is illustrated in Figure 1. The hypothesis, that we derive from the assumed relationship, reads:

Liberalization of the electricity market fosters the development of RES-E generation, if cost-competitiveness of RET is guaranteed by support instruments of public policy.

Figure 1

model of the institutional organization of the electricity market

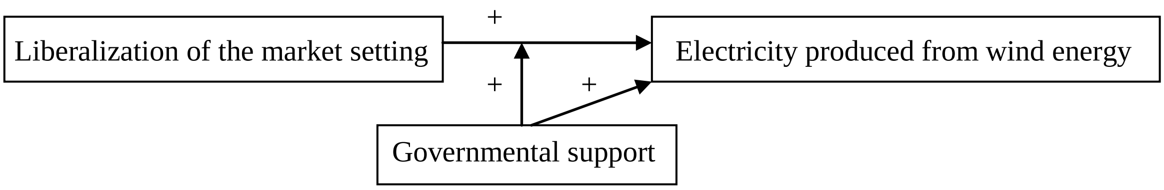
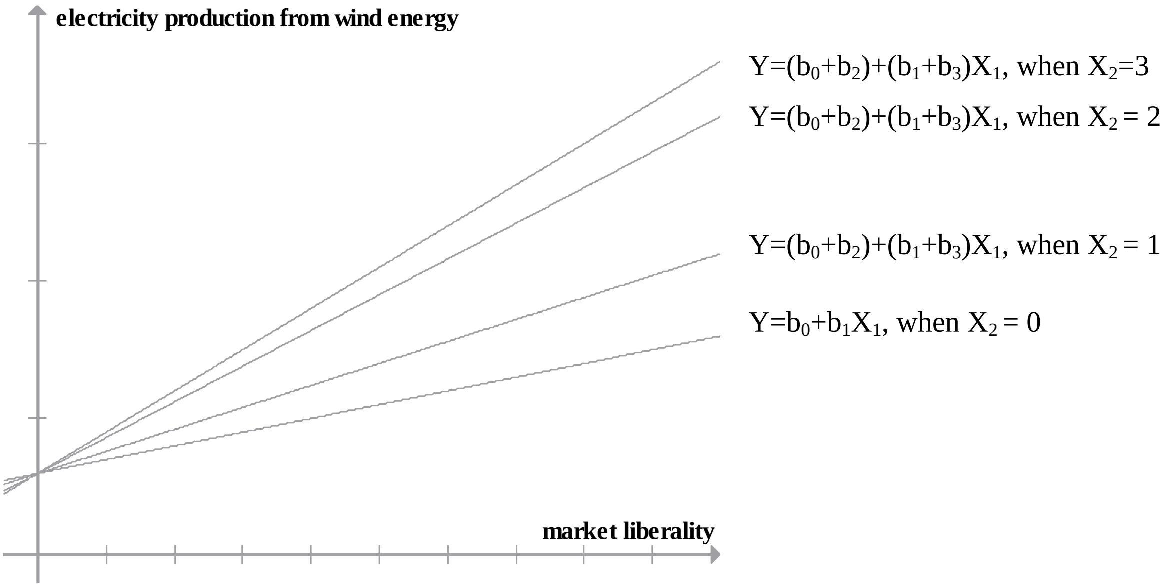


Figure 2 shows, the predicted relationship between electricity market liberalization and wind electricity production for different values of the interacting variable governmental support. It is assumed that even in very hierarchical market, with no governmental support at all, some electricity from wind energy is produced. With no support, the relationship is expected to follow a slowly increasing linear curve. The slope equals exactly the coefficient of X_1. But, the more stringent the support, as expressed as increase in X_2, the stronger the effect of liberal markets on the deployment of RES-E will be.

The theory has suggested, that different types of policies have proven to be more and less effective. Therefore, countries shall be grouped according to the type of policy they employ. Among all regulative measures, fixed-price feed-in tariffs are the most effective support instrument in mitigating the risks for investment in RES-E generation. Hence, this type of public support instrument is expected to have the strongest influence on the relationship between market setting and RES-E generation. Meanwhile, the interaction between market liberality and premium tariffs is expected to be less distinct. Still, being both price-regulating instruments, their influence is again expected to be considerably greater than under a quota obligation system.

Figure 2

Expected interaction effects for different public support instruments



Y = share of electricity generated from wind energy in gross total electricity consumption;

X_1 = degree of market liberality;

X_2 = stringency of policy support

Research design

In my analysis, I will employ a longitudinal study design measuring the degree of regulatory reform within the timeframe from 2004 to 2012. Hence, no manipulation by the researcher is taking place and data is collected at more than one point in time. However, in the statistical analysis the data that has been collected at multiple points in time for the respective variables, will be merged into one measure. Therewith the focus of the design is similar to a cross-sectional comparison of national electricity markets but trying to integrate a notion of developments over time when discussing the explanatory variables. With regard to this study design, the measurement must be carefully constructed. I will discuss the model specification in-depth in the results section.

Having collected data at differing points in time should rule out a threat of reverse causation. In any case, threats such as history or maturation can hardly be ruled out, but shall be discussed later.

As already indicated by the research question, the research is limited to electricity produced from wind energy. Any analytical outcome is therefore limited to wind technology and cannot be generalized to other sources of renewable energies without adjusted considerations.

Data and Operationalization

In order to confirm or reject the hypothesis, empirical data on the institutional structure of all 28 Member states of the European Union will be used. National electricity markets are thus the units of analysis within the setting of the European Union. They are very much suited, since to all of them apply - at least to a certain extent - the same 'rules of the game' as described by Williamson. In the course of continuous economic integration, these countries have incorporated the *acquis communitaire*, the shared body of law of the European Union. This shared feature makes them comparable in the first place. On August 28, 2009, the EU Directive 2009/72/EC, concerning common rules for the internal market in electricity, became effective as part of the third package on EU energy market legislation. It foresaw the further unbundling of the electricity sector until 2013.

The variable 'economic organization of the market setting' needs to be portrayed from two different perspectives, i.e. the *de jure* regulation of the market and the *de facto* organization of the market. For this reason, I will look at the legal framework within each national regulatory regime as well as the actual structure of given markets. The primary measure for economic organization will be the OECD's sectoral indicator of regulatory reform of the electricity sector. Foremost, this indicator entails a *de facto* perspective on the energy sector, describing the current state of organization as regards ownership structure, vertical integration and market concentration. However, it also incorporates a notion of the *de iure* regulatory framework by assessing the terms and conditions of entry regulation. Based upon these four topics i.e. *'entry regulation'*, *'public ownership'*, *'vertical integration'* and *'market structure'* (or: market concentration), the OECD issues an overall score to the state of regulatory reform of each OECD member state for the period from 2003 to 2013. According to the assigned score, which ranges from 0 to 6, economic organization of a country ranges from liberal (low score) to hierarchical (high score). For the countries Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta and Romania there is no data available.

The dependent variable, that is ‘wind electricity production' is operationalized as the electricity generation from wind energy divided by gross final consumption of energy. Capacity installed would have been preferable over electricity generated because it better reflects what could potentially be generated and if investment into a given technology has taken place. Generation purely measures the actual electricity production. Generation may fluctuate due to a temporary demand that may differ from season to season. Particularly in the case of wind technology, fluctuations are also dependent from annual weather conditions. However, in the case of capacity installed, no data for the full time span is available for the countries Greece, Cyprus, Malta, Poland and Slovakia. Very limited or limited data availability is the case for Slovenia and the United Kingdom. After all, generation provided data for a larger number of cases for the entire period from 2004 to 2014, than capacity installed did. Capacity installed might be a more constant measure, that better reflects the long-term planning dedicated to the deployment of wind technology, but the differences appear to be very small. I have chosen to use generation exceptionally for the descriptive analysis of wind electricity production. For the correlation analysis instead, I will use capacity installed in 2012, as it represents a more accurate measure for the state of wind technology at the given point in time. Generation though should be sufficient to analyze general trends over time. The data on wind electricity generation was retrieved from a data publication of the European commission. The so called 'SHARES tool' lists the annual electricity generation from wind energy in megawatt hours for each EU Member state. Consistent data was available from 2004 to 2014. Information from earlier years has not been added, because the analysis has already been constrained by data limitations on other variables. Consistent data for a sufficient number of cases for capacity installed could ultimately be retrieved from the webpage of the European Association for Wind Energy *WindEurope*.

In order to be comparable across countries, the data on electricity generated from wind energy and capacity installed of each country needed to be transformed into a variable that considers the overall energy consumption of each respective country. Therefore, generation, or capacity installed respectively, has been divided by consumption. Data on the gross final consumption of energy over the period from 2004 to 2014 has again been retrieved from the SHARES tool of the European Commission as well. It expresses the gross electricity production from all energy sources plus total imports of electricity minus total exports of electricity. The dependent variable of the regression model is expressed by the following equation:

$$wind\ electricity\ production\ = \frac{electricity\ generation\ from\ wind\ energy\ \text{or}\ capacity\ installed}{gross\ final\ consumption\ of\ energy}$$

The stringency of various support instruments, that is the intervening variable of the model, is captured by a sub-indicator of the Environmental Policy Stringency Index of the OECD. Although generally focusing on environmental policy, this index entails an assessment of the stringency of feed-in tariffs and Green Certificate Trading Schemes. In the first place, this approach discriminates between price-based and quantity-based instruments. Thus, it does not make an immediate distinction between fixed-price tariffs and premium tariffs. Instead, in case of premium tariffs, the premium is simply added to the average annual electricity price in order to make it comparable to an ordinary fixed-price feed-in tariff. This means, that premium tariffs are not entirely excluded from the analysis, but are merged with fixed-price tariffs to represent any price-based policy support. Data is available solely for the period from 2004 to 2012. There is no data available for the countries Estonia, Croatia, Cyprus, Latvia, Lithuania, Luxembourg, Malta and Romania.

Results

In the following, I will describe how the collected data has been constructed into a coherent model of analysis. Having the variables properly constructed, two analytical approaches are being used. At first, I will describe which trends and patterns can be observed on the single variables over the time period from 2004 to 2012. Afterwards I will present the results of a correlation analysis, and expose if and to what extent the variables are linked to each other.

Data construction

In preparation of the analysis of the relationship between economic organization and deployment of electricity production from wind energy, as well as the expected interaction of governmental support instruments, the data collected from the OECD and the European Commission have partly been constructed into appropriate measures for the respective model.

To begin with, I have reversed the scoring of the index which has been assigning low scores to liberal markets and high scores to hierarchical markets. Reversing the score shall avoid confusion when discussing the hypothesis. Afterwards, a high score indicates liberal market structures, whereas low scores are assigned to hierarchical market settings. In the next step, I have calculated the accumulated score on regulatory reform from 2004 to 2012. The accumulated score represents the degree to which liberal market structures have dominated the electricity sector in the given time period. Unfortunately, this measure does not indicate the extent to which a country has changed from one type of economic organization to another, that is form hierarchical to liberal or vice versa. Finally, the accumulated scores have been normalized allowing the even distribution of the values into four groups. Re-coding the variable into four groups from very little degree of market liberality over time to very high degree of market liberality reduces the variable level from scale level to ordinal variable level. Indeed, a model on ordinal variable level might facilitate the preliminary analysis of the data.

The variable 'governmental support', which is expected to interact with the first explanatory variable, has been constructed as the sum of the two indices measuring the effectiveness of Green Certificate Trading Schemes and Feed-in Tariffs. The annual scores have moreover been transformed into a single accumulated value that covers the time span from 2004 to 2012 and that expresses the strength of policy support over the entire period of time. Finally, this value has been normalized as well, again allowing the an even grouping and rescaling to ordinal variable level.

The dependent variable 'wind electricity production' has been grouped into a reduced data matrix according to a similar pattern, but the scoring has not been normalized. Instead the largest and the smallest wind electricity producer were taken as reference points for the recoding into groups. Therewith, the reduced codebook of the dependent variable does only express the relative differences across countries. Still, the reduced data matrix allows me to picture the assumed relationship in a more lucid manner and in case of the dependent variable, it is solely used for preliminary correlation analysis.

Descriptive Analysis

As Figures 3 to 5 show, national energy markets have continuously been liberalized over the period from 2004 to 2014. Periodic trends towards more hierarchical market settings are the exception but can be observed for France and the Czech Republic between 2004 and 2006 or for Greece after 2008. Notably, a number of countries did already have relatively liberal markets at the beginning of the measurement, such as Germany, the United Kingdom or Spain. Those countries have obviously demonstrated smaller efforts to further liberalize their electricity sector. The largest step in liberalizing their markets can be observed for Slovenia, Belgium, Ireland and Slovakia, whose score has increased by at least 1.5 points in the observed period.

Figure 3

Reversed OECD's electricity sector regulation index scores from 2004 to 2012for Spain, United Kingdom, Germany, Italy, Portugal, Hungary and Finland

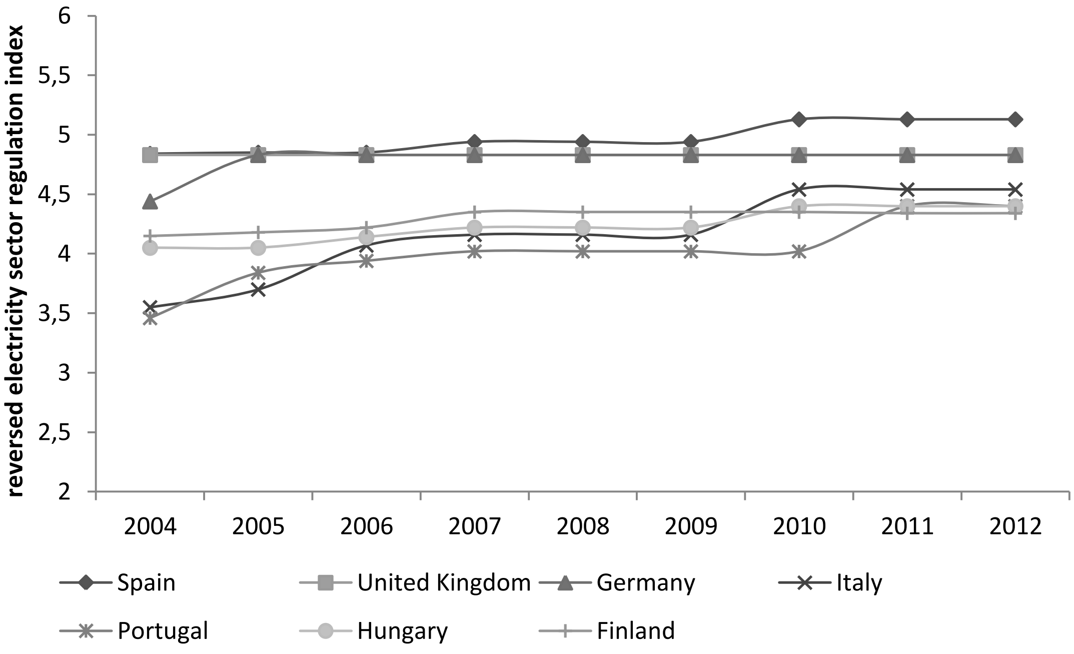


Figure 4

Reversed OECD's electricity sector regulation index scores from 2004 to 2012 for Austria, Belgium, the Netherlands, Poland, Slovakia, Ireland and Sweden

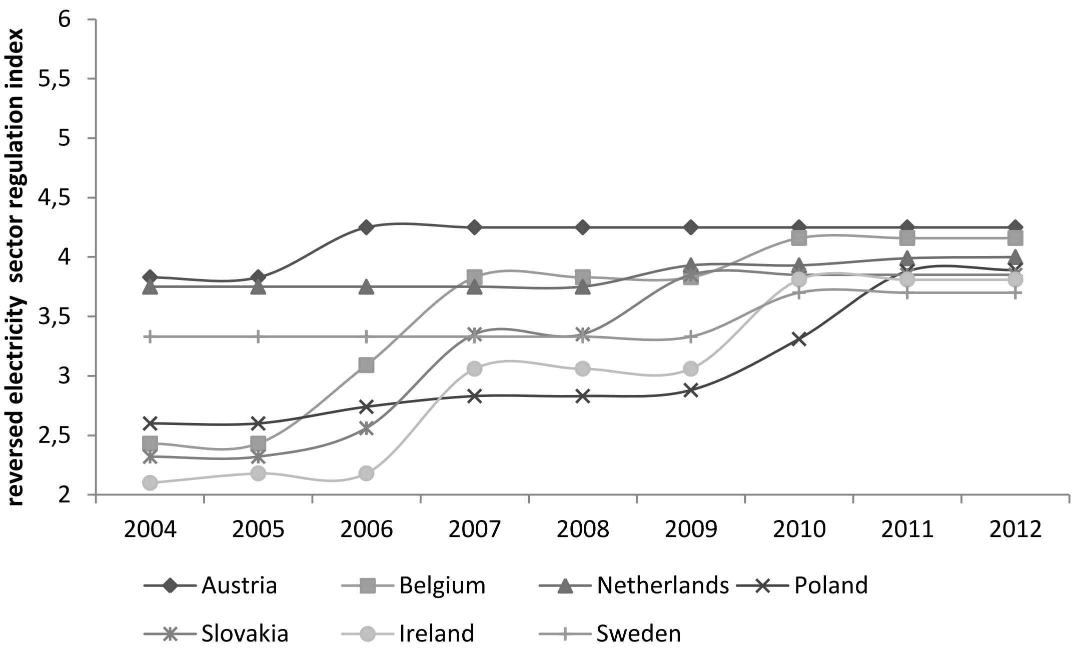
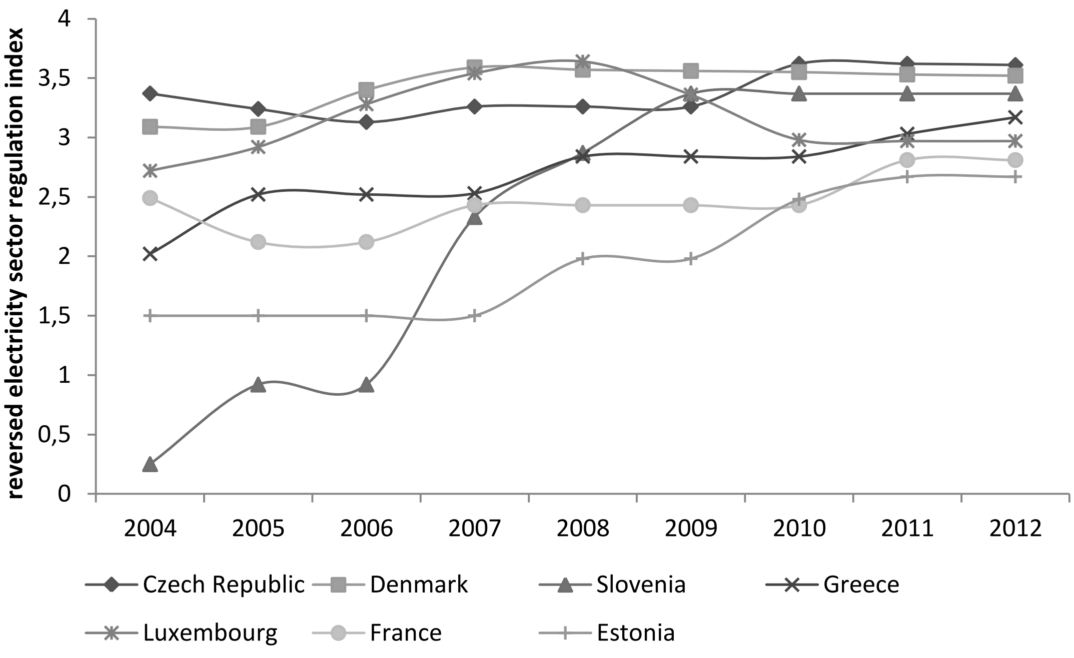


Figure 5

Reversed OECD's electricity sector regulation index scores from 2004 to 2012 for the Czech Republic, Denmark, Slovenia, Greece, Luxembourg, France and Estonia



Within the same timeframe, in all countries except for Malta the production of electricity from wind energy has increased, as it is depicted in Figures 6 to 8. The Figure presents the largest producers of wind electricity according to their absolute generation of electricity from wind energy divided by gross final consumption of energy. The different scale of each graph should be kept in mind when reading the graphs. Foremost, the huge differences in the development of wind electricity production become apparent although the score already accounts for the relative size of each country through its gross final consumption of energy. In absolute numbers, the largest expansion of wind electricity production has taken place in Portugal, Spain, Ireland, Denmark and Sweden. Their score has increase by at least .02 in the given period of time. Furthermore, it appears, that a number of countries have experienced an increase wind technology deployment from 2008 onwards, some also a bit later. This holds especially for those countries, that are not immediately associated with being the pioneers of RES-E generation, but rather following in their footsteps within the frame of the ambitious European targets for energy transition. They are typically located in the third graph of Figure 6 to 8. But not only for those countries, but generally, the increase in wind electricity production appears to be slightly steeper in the last five years of the period of observation.

Figure 6

Annual electricity production from wind energy from 2004 to 2014 for Denmark, Germany, Greece, Ireland, Portugal, Romania, Spain, Sweden United Kingdom and France

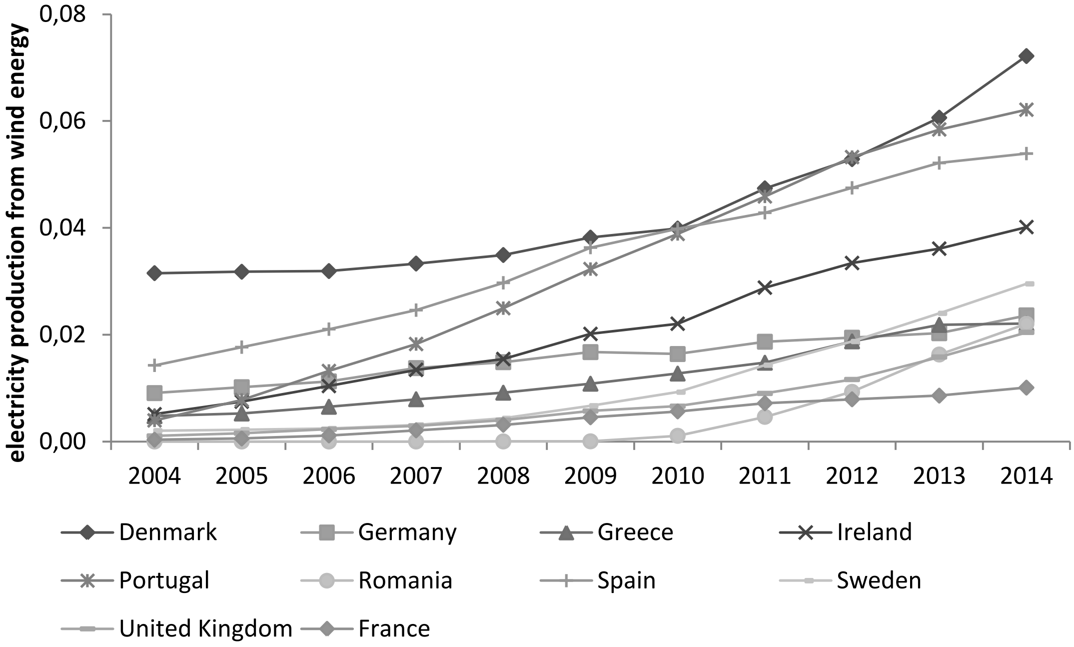


Figure 7

Annual electricity production from wind energy from 2004 to 2014 Austria, Belgium, Bulgaria, Estonia, Italy, Lithuania, the Netherlands and Poland

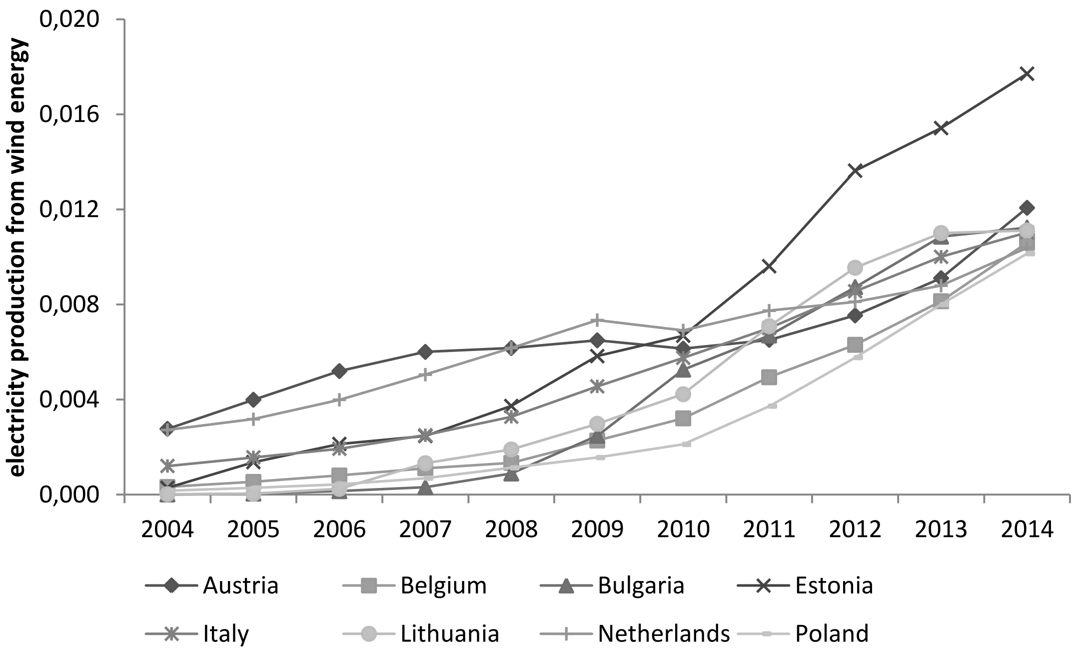
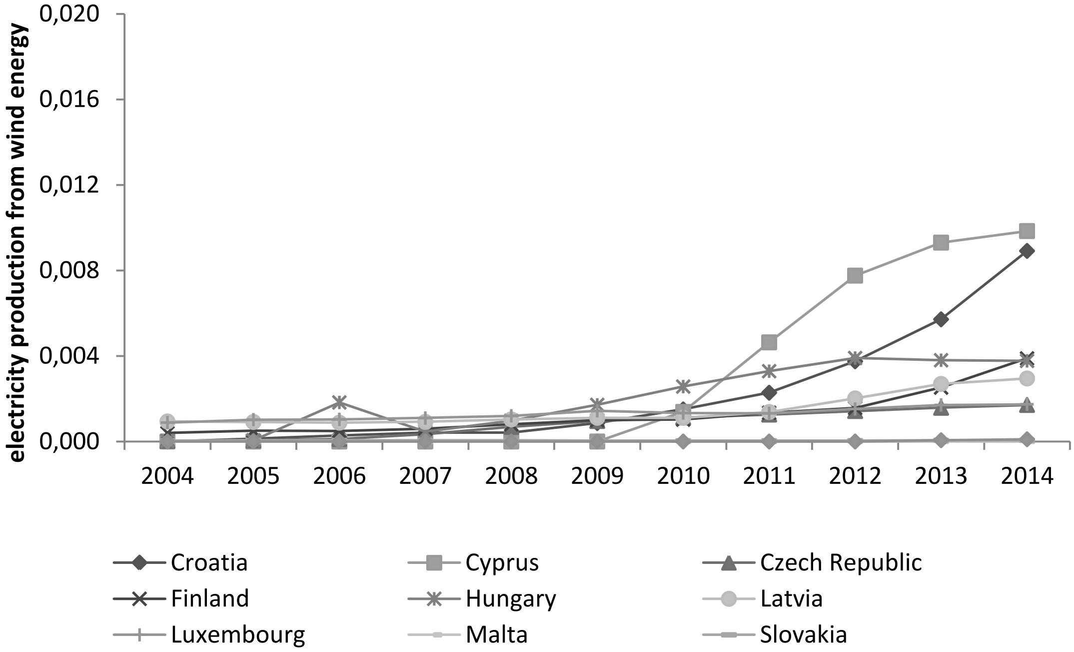


Figure 8

Annual electricity production from wind energy from 2004 to 2014 for Croatia, Cyprus, the Czech Republic, Finland, Hungary, Latvia, Luxembourg, Malta, Slovakia and Slovenia



Figures 9 and 10 show how support instruments' stringency has changed over the period from 2004 to 2012. Apparently, there is no clear trend for all countries towards increased policy stringency over the years. It is noteworthy, that a few radical policy improvements are followed by substantial deployment of wind electricity production. Denmark, for instance, has introduced a highly stringent policy in 2009. Wind electricity production in Denmark has gradually risen until 2009, but experiences a sharp upturn of production from there on. Similarly, Poland has continuously levelled up its support for wind electricity production until 2010. With little delay, the actual production of electricity from wind energy seems to follow that pattern and finally ends up in a steep slope after 2010.

Figure 9

Stringency of feed-in tariffs and premium tariffs from 2004 to 2012 for the United Kingdom, Poland, the Netherlands, Sweden, Denmark, Belgium, Finland, Italy and Austria

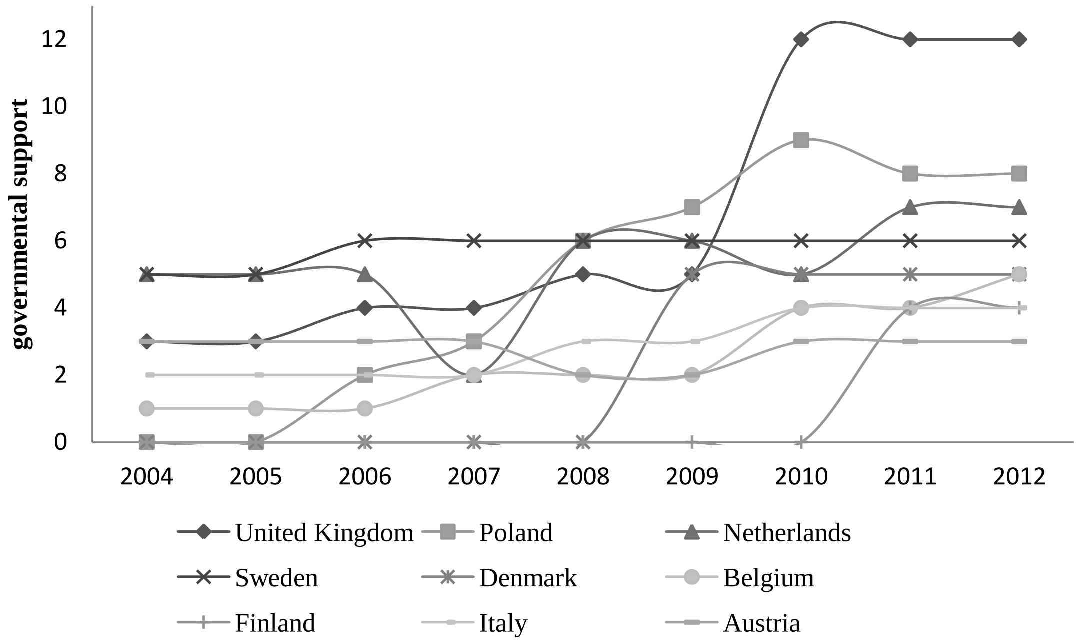


Figure 10

Stringency of feed-in tariffs and premium tariffs from 2004 to 2012 for Greece, France, Slovenia, Germany, Spain, Portugal, Ireland, Czech Republic, Hungary and Slovakia

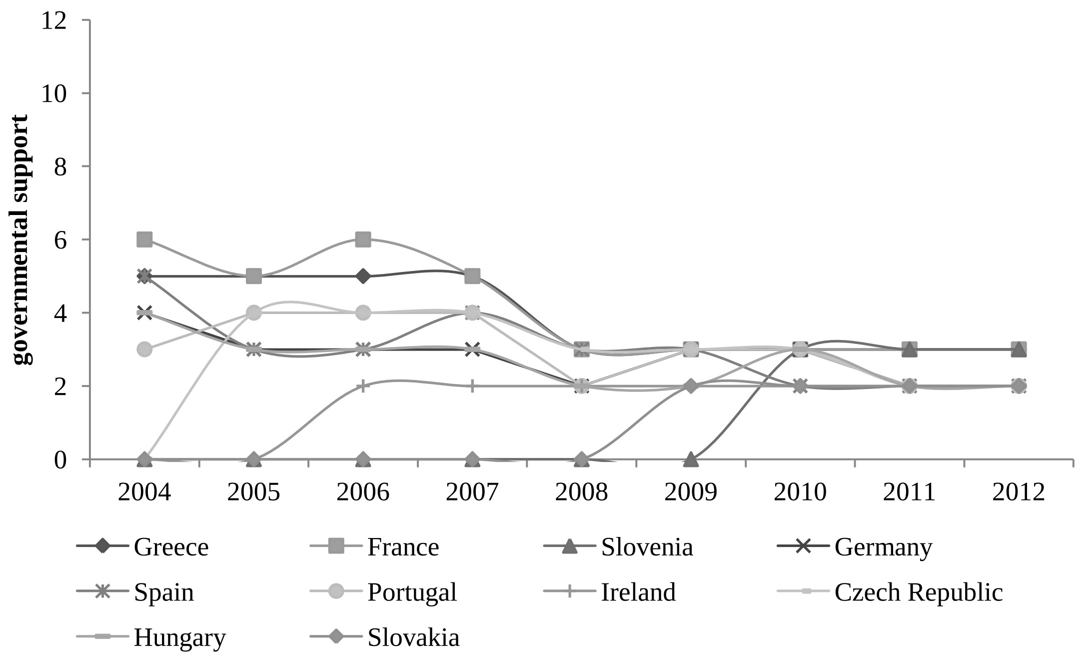


Figure 11 shows the installed capacity of wind energy in 2012. Capacity installed has been weighted by the gross consumption of each country. The countries with the largest capacities after putting into perspective their respective size, are Denmark (.2741), Portugal (.2704), and Spain (.2647), followed with some distance by Ireland (.1603) and Germany (.1434). The smallest production capacity is found in Slovakia (.00003), the Czech Republic (.0104), Luxembourg (.0107) and Finland (.0111). In Malta and Slovenia no electricity production capacities have been installed at all.

Figure 11

Capacity installed in 2012

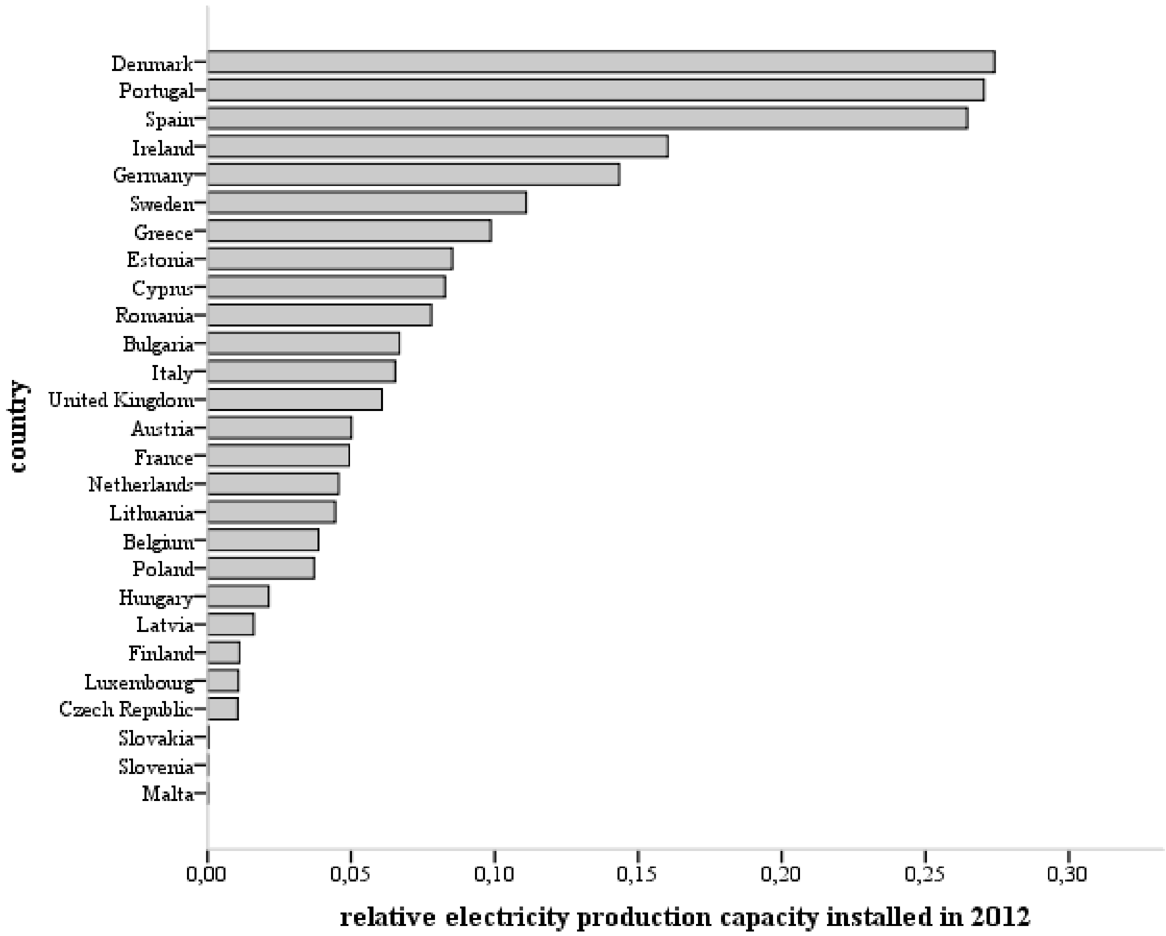


Figure 12 shows the reversed and normalized accumulated OECD's scores on electricity sector regulation per country. In 2012, Member states' electricity markets have been largely liberalized (*M* = .6, *SD* = .12). Having the accumulated score normalized, we can express the degree (in %) to which a country's electricity market has complied with the maximal liberalization criteria of the OECD's sector regulation index along the annual measurements. The leading countries with respect to market liberalization are Spain (.799), the United Kingdom (.776), Germany (.769) and Finland (.690). All those scored comparatively high on the OECD's sector regulation index from 2004 onwards. Ever since then, their markets have been largely liberal. In other words, they achieved more than 70 per cent of the ideal liberal market reform. In contrast to them, France (.394), Slovenia (.371) and Estonia (.318) have unfolded the least of their potential, that means less than 40 percent.

Figure 12

Electricity sector regulation over time per country

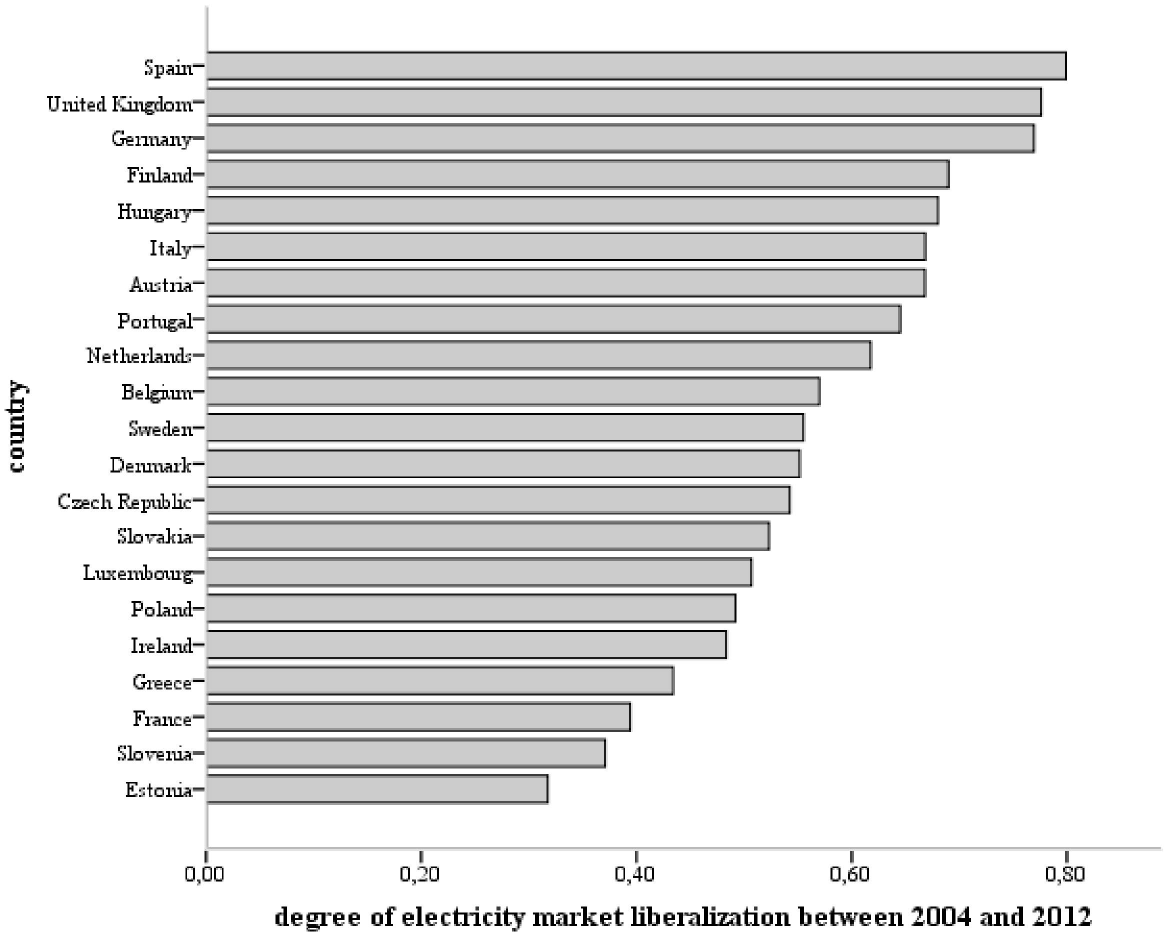
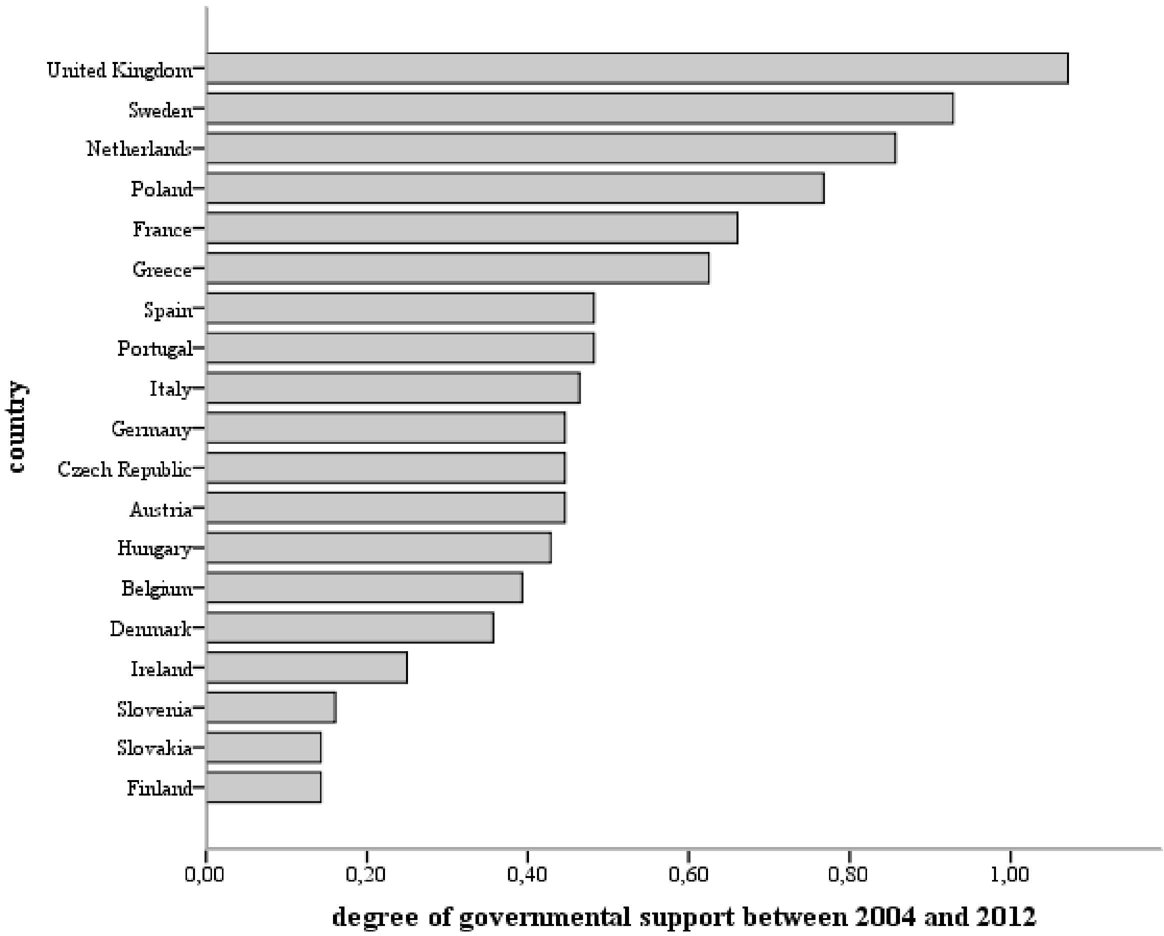


Figure 13 shows the accumulated and normalized degree of governmental support effectiveness exercised though either Green Certificates Trading schemes or feed-in tariffs. On average, the stringency of national policies was moderate (*M* = .5, *SD* = .23). The most stringent policies have been implemented by the governments of the United Kingdom, Sweden, the Netherlands, Spain, Poland and Greece. The least effective support was exerted by the governments of Slovakia, Slovenia, Ireland, Finland and Denmark.

Figure 13

Effectiveness of governmental support per country



Remarkably, Portugal (.645), Denmark (.552) and Ireland (.483), all of them among the leading producers of wind electricity, are ranked close to the median value for degree of market liberalization (*Mdn* = .555). Furthermore, Denmark is not found to exert very strong policy support within the period of observation, ranking just around the lower quartile of the support variable's range, which is located at .357. Portugal as well did not exercise strong policy support and is located just above the median value of .446. The strongest policy support in the given time period has been exercised by the British government. But despite of liberal market structure and extensive governmental support, the United Kingdom ranks just above the median case for wind electricity production.

In sum, out of those countries, who demonstrated high market liberality, only a few have actually achieved a high level of wind electricity production, namely Spain and Germany.. The fourth most liberalized market is located in Finland, which had the weakest policy support though. Despite its highly liberal market throughout the period of observation, Finland is among the smallest producers of wind electricity. Clearly, the descriptive analysis has revealed a few irregularities among the observed trends. Still, the overall trends of liberalization and increased production from wind energy comply with the theoretical expectations.

Explanatory Analysis

For both explanatory variables of the model, there are a few cases missing. When contrasting the variables against each other in a crosstabulation, we encounter a 32.1 percent loss of cases. This equals nine of twenty eight initial cases. Table 2 depicts the relationship between market liberalization and wind electricity production under varying degrees of governmental support. The genuine data has been reduced to ordinal variable level, in order to allow a preliminary visual inspection of the variable's relation to another. From the table first assumptions about the direction, association and significance of the relationship between market liberalization and electricity production from wind energy can be made. The reduced data matrix presents the respective variables after they have been recoded into groups. Note that Table 2 does not show the absolute production of electricity from wind energy, but allows a comparison of relative advances in electricity production across countries, having set the countries with the smallest and the largest deployment of wind electricity production, in terms of installed capacity, as reference points. In sum, recoding has eliminated the genuine codebook and established a new order ranking countries from very low to very high degree of market liberalization, from very low to very high level of support policy's stringency and from very small to very large relative electricity production capacity in wind energy.

Out of nineteen cases in the cross tabulation, 21.1 per cent (n = 4) have exercised policies with very low stringency, 47.4 percent (n = 9) policies with low stringency, 10.5 per cent (n =2) policies with high stringency and 21.1 per cent (n = 4) policies with very high stringency. None of the countries has been categorized as having a support policy with very low stringency. Across those countries with very low policy stringency, there were as many countries with a low degree of liberalization as they were with a high degree of liberalization. A majority (77.8 %, n = 7) of those countries with low policy stringency have had a highly liberal market in the observed timeframe. The other two have a very high degree of liberalization. From those countries with highly stringent policies, all countries possessed a low degree of market liberalization. Finally, those countries, that had employed policies with very high stringency, were highly (n = 2) or very highly (n = 1) liberalized between 2004 and 2012. One more country showed a low degree of liberalization.

In sum, little less than a quarter of all countries (26,3 %, n = 5) observed held a low degree of market liberalization over the given period. Three out of them, i.e. Slovenia, France, Poland, had very small relative electricity production capacities, another, Greece, had a small relative wind electricity production capacity and the last one, Ireland, had a large relative electricity production capacity. Slovenia and Ireland did employ very weak support policies, whereas France and Greece had stringent policies, Poland a very stringent policy.

The majority of countries (57.9 %, *n* = 11) possessed high market liberality throughout these nine years. Eight of them (Hungary, Czech Republic, Slovakia, Austria, Italy, Finland, Belgium, the Netherlands) have a very small relative electricity production capacity in 2012. One more, namely Sweden, has small relative wind electricity production capacity. And the remaining two, Portugal and Denmark, have very large relative wind electricity production capacities. Slovakia and Finland held very low governmental support, whereas Belgium, Denmark, Hungary, the Czech Republic, Austria, Italy and Portugal exerted low support. The Netherlands and Sweden in contrast had very stringent policies. Note, that neither of the most successful wind electricity producers, Denmark and Portugal, exerted strong governmental support via very stringent policies.

Only a small group of countries (15.8 %, *n* = 3) has been regarded to have possessed a very high degree of market liberality throughout the period from 2004 to 2012. Two of them, Germany and the United Kingdom, have had small relative wind electricity production capacities. Meanwhile, Spain has achieved very large relative electricity production capacity. Germany and Spain employed less stringent support policies, the United Kingdom a very stringent policy. However, the very high policy score by the UK is predominantly the source of two very powerful policies that have just been put into place in 2010.

At the bottom section of the table, the bivariate crosstabulation disregarding the influence of support policies is depicted. It illustrates, that a lion share of the countries has a relatively small or very small electricity production capacity (78.9 %, *n* = 15), although many of them have had high or very high liberal markets (57.9 %, *n* = 11). The remaining four countries (21.1 %) have either a large or very large wind electricity production capacity and are dispersed across various levels of market liberalization. Even though a slightly positive relationship between degree of market liberalization and electricity production capacity might be notable, there is a number of cases that contradict the expectations that are hypothesized, such as Ireland, which has a low market liberality score and very low degree of policy stringency, but has achieved a large relative level of wind electricity production capacity. Meanwhile, the United Kingdom possesses very high market liberality and even a very stringent support policy respectively, but very small relative wind electricity production capacity. Similarly, Sweden and the Netherlands have highly liberalized markets and very strong policies, but very small relative installed capacity.

Table 2

Relative capacity installed in 2012 by degree of liberalization between 2004 and 2012 by degree of public support policy stringency between 2004 and 2012

level of support policy's stringency between 2004 and 2012			degree of liberalization between 2004 and 2012			Total
			low	high	very high	
very low	relative capacity installed in 2012	very small	1	2	0	3
		small	0	0	0	0
		large	1	0	0	1
		very large	0	0	0	0
	Total		2	2	0	4
low	relative capacity installed in 2012	very small	0	5	0	5
		small	0	0	0	0
		large	0	0	1	1
		very large	0	2	1	3
	Total		0	7	2	9
high	relative capacity installed in 2012	very small	1	0	0	1
		small	1	0	0	1
		large	0	0	0	0
		very large	0	0	0	0
	Total		2	0	0	2
very high	relative capacity installed in 2012	very small	1	1	1	3
		small	0	1	0	1
		large	0	0	0	0
		very large	0	0	0	0
	Total		1	2	1	4
Total	relative capacity installed in 2012	very small	3	8	1	12
		small	1	1	0	2
		large	1	0	1	2
		very large	0	2	1	3
	Total		5	11	3	19

A visual inspection of the crosstabulation has approximately confirmed the direction of the assumed relationship, but a number of deviations gave rise to serious concern about the consistency of the association between the variables. A statistical test may clarify these concerns and either back up or contradict previous observations. To test the association between the given variables, a correlation coefficient can be calculated. Since the reduced data matrix presented in Table 3 is based on ordinal variable levels, Kendall's tau-β is the appropriate coefficient for the association analysis. The calculation of Kendall's tau-β is based upon the amount of concordant, disconcordant and tied pairs in the crosstabulation. Effectively, the variable's measurement has taken place in multiple points in time, and thus reverse causation is not plausible. For the statistical test two-sided relationships have been assumed and significance has been tested at α-level 0.05. For the relationship between liberalization and wind electricity production capacity, and not discriminating between varying levels of policy stringency, a non-significant effect was found (τ_b = .158, *p* = .458). The p-value of .458 suggests, that the null hypothesis cannot be rejected. Apparently, the association is far from being statistically significant. Notably, the tau-β value for the overall model indicates a positive relation between degree of market liberalization and wind electricity production capacity, though the effect is fairly weak. The tau-β values for each individual level of governmental support do not appear to follow a certain pattern. Most likely, the sample size for individual levels of governmental support is too small.

Table 3

Symmetric Measures

degree of public support policy stringency between 2004 and 2012 in groups			Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance
.00	Ordinal by Ordinal	Kendall's tau-b	-.577	.289	-1.414	.157
	N of Valid Cases		4			
1.00	Ordinal by Ordinal	Kendall's tau-b	.446	.251	1.524	.128
	N of Valid Cases		9			
2.00	Ordinal by Ordinal	Kendall's tau-b	.[c]			
	N of Valid Cases		2			
3.00	Ordinal by Ordinal	Kendall's tau-b	.000	.365	.000	1.000
	N of Valid Cases		4			
Total	Ordinal by Ordinal	Kendall's tau-b	.158	.207	.743	.458
	N of Valid Cases		19			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. No statistics are computed because degree of regulatory reform between 2004 and 2012 in groups is a constant.

Certainly, the validity of this model could still be increased by using the genuine, unreduced data for the independent and the dependent variables. The genuine variable data is measured on continuous variable level. Obviously, there are huge differences between the various countries. In the dataset, these differences are reflected in sometimes highly deviant cases. Hence, before using the genuine scale level data, any outliers, influential or noteworthy cases need to be identified and excluded. Note, that these extreme values are contextual, meaning that they do have a legitimate origin, but still must be taken out of the analysis for not distorting the statistical calculations. Contextuality of extreme values is why the analysis that has been conducted on ordinal variable level and its results should not be underestimated. In order to identify potential extreme values, the studentized residuals, centered leverage value and values for Cook's distance have been plotted against the dependent variable values (see Figure 16 to 18, Appendix A). Any cases that have a studentized residual larger than two (SRE > 2) are treated as outliers. In the present model, Denmark has slightly higher studentized residuals (SRE = 2,081). For the purpose of unbiased statistical calculation, they will be exempted from the study. For the centered leverage value, the critical value for a case to become influential has been calculated to be .3158. The critical value for a case to become noteworthy, as diagnosed by Cook's distance, is .25. Both thresholds are exceeded by the United Kingdom (COO = .654, LEV = .738) For both diagnostics, the distance to the critical value is distinct. Therefore, the United Kingdom is exempted from the analysis. In addition, the critical leverage value is exceeded by Slovenia (LEV = .498). Slovenia is exempted as well. Having cleared for extreme values, a correlation analysis with genuine scale level data can be conducted.

A visual inspection of the distribution of the continuous variables, has found that the data for each variable is approximately normally distributed, except for the dependent variable. The non-normal distribution of the latter has been partially corrected by calculating the squareroots of the dependent variable's values (see Figure 17 to 20, Appendix B). The scatterplot in Figure 14 shows that the relationship between market liberality and electricity production is far from being linear. The inclining trend across the values of the variables, that is the increase of the dependent variable values as independent variable values increase, suggests that the relationship could be at least monotonic. A monotonic trend, though it is less distinct, can also be observed in the scatterplot in Figure 15 between support policy's stringency and wind electricity production. Since linearity is not clearly given, but a monotonic trend has been presumed for both relationships after inspection of the crosstabulation in Table 2 as well as the scatterplots in Figure 14 and Figure 15, Spearman's rank-order correlation is believed to be the best option for a measuring strength and direction of the association between market liberality and electricity production, as well as policy stringency and electricity production. Besides allowing for the analysis of monotonic relationships, Spearman's correlation does not assume normal distribution of the data, so that the non-normal distribution of the dependent variable does not become problematic in this case. In fact, all necessary assumptions for Spearman correlation analysis to produce valid results, i.e. the correct variable level, paired observations and a monotonic relationship, are fulfilled.

Figure 14

Electricity production from wind energy by electricity market liberality

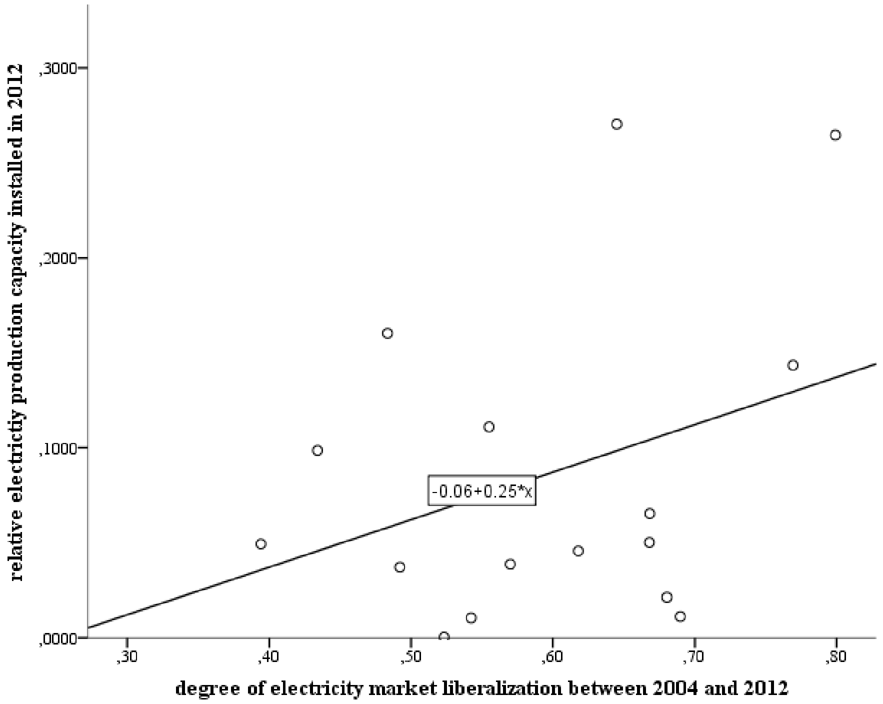
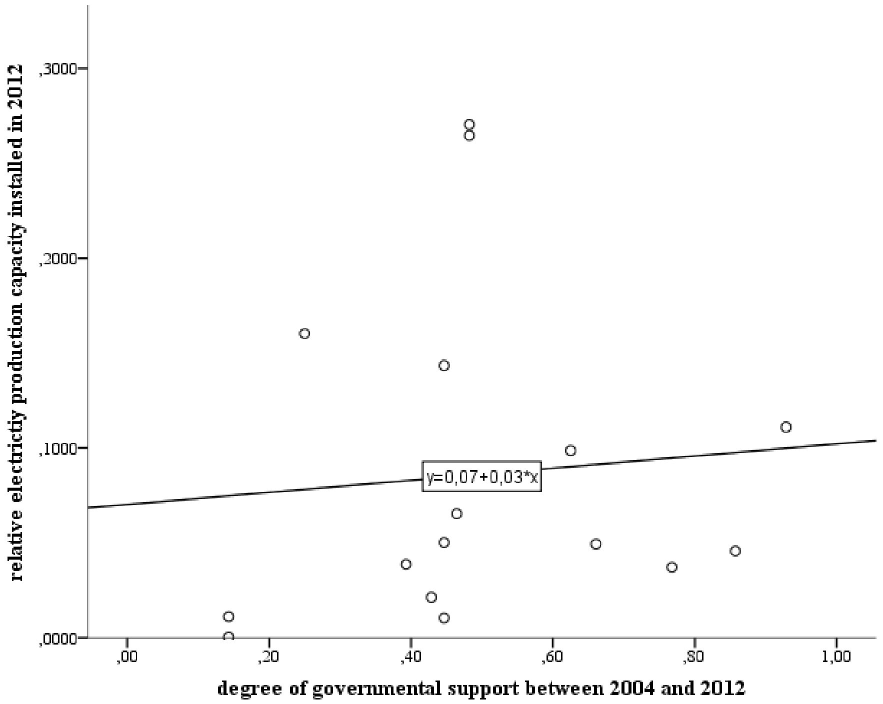


Figure 15

Electricity production from wind energy by support policy's stringency



The results of the pair-wise association analysis using Spearman's correlation are pictured in Table 4. Looking at the correlation coefficients, a weak positive correlation between market liberalization and capacity installed can be found (r_s (13) = .165, p = .542). The correlation is not significant at the 0.05 level. This is ultimately mirrored in dispersion of values in Figure 14. A stronger correlation is presumed between the two explanatory variables (r_s (13) = -.226, p = .400). The correlation is not significant at the 0.05 level. Note, that this relationship is negative according to Spearman's correlation. The strongest positive association though is found between stringency of support policies and electricity production (r_s (13) = .362, p = .168). The correlation is not significant at the 0.05 level.

Again, it can be well observed how a few cases stand out from the overall trends in the scatterplots, which might explain the weak correlations attested by Spearman's correlation. In Figure 15, those are Spain, Portugal and in particular Ireland, who have large installed capacities despite of low governmental support, and Poland and the Netherlands, who have very large support, but relatively small production capacities. It needs to be remarked, that the latter have not possessed very stringent policies over the entire time period, but have just build up a stringent support from 2005, and 2007 respectively, onwards.

Table 4

Correlations

			degree of electricity market liberality	degree of governmental support	standardized capacity installed in 2012
Spearman's rho (r_s)	degree of electricity market liberality	Correlation Coefficient	1.000	-.226	.165
		Sig. (2-tailed)		.400	.542
		N	16	16	16
	degree of governmental support	Correlation Coefficient	-.226	1.000	.362
		Sig. (2-tailed)	.400		,168
		N	16	16	16
	standardized capacity installed in 2012	Correlation Coefficient	.165	.362	1.000
		Sig. (2-tailed)	.542	.168	
		N	16	16	16

The preliminary correlation analysis has confirmed the urgency to improve the current model. In an attempt to concretize the model and to draw a more accurate picture of the interdependencies between the included variables, the conduction of a multiple regression analysis has been planned. But, as the correlation analysis has revealed, the present model and underlying data did not fulfil utmost important conditions of multiple regression analysis, first and foremost the condition of linearity. But besides nonlinearity, the data is not suffiently normally distributed and heteroscedastic. Hence, a meaningful regression analysis cannot be conducted.

Discussion

To begin with, it will be interpreted what the analysis has produced the value these findings add to the existing knowledge on innovation and technical change in electricity markets will be discussed. Subsequently, I will discuss some of the problems I have encountered during the analysis and make a few suggestions on how the model I have employed could be improved.

The inspection of the collected data has shown, that there is a clear trend towards ever liberal electricity markets. This is not at least the result of the neoliberal political agenda that has characterized the politics of the European Union and its Member states. In the past decades, the EU has pushed its Member states towards increased liberalization of their electricity markets through various Directives.

Certainly, these Directives are not adopted in each country to the same extent, as Directives by definition do not prescribe a uniform legislation. France, for instance, has maintained a relatively hierarchical market structure for the entire period of observation. But in general, be it from national ambition or supranational guidance, liberalization of electricity markets is taking place. External influence of the EU, for instance by means of the Third Energy Package, is partly mirrored in the data. Moreover, we can observe a strong trend towards increasing electricity production from wind energy, illustrating the success of innovative RETs. Again the implementation of the EU Directive 2009/72/EC could relate to a notable increase in wind electricity production in a few countries after 2009. This entire development actually matches with the expectations of evolutionary theory. Accordingly, economic agents are led not solely by rational behaviour, but are also following political or moral goals, like the creation of green electricity for instance. It is reasonable, that private investors have been sensitive to the political ambitions of putting another market reform package into place and thus have embraced wind and other renewable technologies despite a lower immediate return of investment. Despite the neoclassical assumption, that a monopolist is the only player with sufficient resources to foster innovation of a new technology, a few cases, such as Spain and Germany, have demonstrated relatively liberal markets and successfully pushed for increased capacity in electricity production from wind energy. The neoclassical approach proves to be to narrow-minded in practice. France, for instance, with hierarchical market setting and little governmental steering, does not show a lot of ambitions to innovate its energy supply. That does not necessarily prove the neo-classical argumentation wrong. The argument here is, that even in a hierarchical environment, innovation is driven by dynamics more complex than the presence or absence of a monopoly. It needs to be considered, that France is in strong favour of nuclear energy as the solution to climate change and decarbonisation strategy, which does not solely originate patterns of economic organization. A model that builds upon evolutionary theory and behaviour patterns has to acknowledge such individual treats and try to integrate them. In this study, besides economic organization, the role of governance of has been evaluated.

The analysis shows, that there have been cases, namely Ireland and Denmark, who have been highly successful in implementing wind electricity production and did not yield a very liberal economy or even supportive policies in the case of Ireland. I assume that their success is largely caused by factors different from economic organization in terms of liberalization. However, this study did not inquire these factors and this remains more an assumption than a proven argument. As proven by a generally weak association, the first part of the hypothesis, that presumed a relationship between economic organization and electricity production from wind energy has to be rejected. The statistical tests on those variables' association did not suggest a strong relationship, nor have they been statistically significant. The interaction effect, that was presumed to be exerted through governmental support for RETs could not be confirmed. Although the relationship between market liberalization and support policies' stringency was considerably strong and almost statistically significant, the construct validity of the governmental support policy needs to be discussed in the first place. Because only three countries - Belgium, Italy and Sweden - did make use of a quota system, and two more - the Netherlands and the United Kingdom - used a mix of quantity-based and price-based mechanisms, no sound distinction between the two mechanisms has rendered possible. In fact, quantifying the magnitude of governmental support, in particular standardizing the price level of the support, has been quite difficult. The legal conditions and rules that govern national policies differ starkly from one country to another. Too much to create a valid uniform measure for each respective support policy and the price level they govern. Ultimately, I have made use of the OECD's sector regulation index. This index is an appropriate measure for overall regulation, but has unavoidably due to data availability limited the analysis to nineteen cases. Furthermore, the low number of cases with quota system has forced me to merge the two types of support into one uniform measure for governmental support. Problems might have occurred when a country has employed two very successful policies, because in arithmetic terms this country was seen to be twice as effective as others. This has been the case for the United Kingdom. But I assume that the identification of outliers has effectively eliminated deviant cases in the end. In addition to that, Spearman's correlation is relatively robust against outliers. Therefore I argue, that validity of the variable 'governmental support' is still given.

Plotting the annual scores of the OECD's policy stringency indicator has demonstrated that for numerous cases the stringency of policies has decreased over time. This might be caused by the trade-off between investment risk reduction and increasing consumer prices, as suggested by previous literature on the effectiveness of price-based support instruments and quantity-based support instruments. Ever increasing electricity prices will probably incentivize governments to reduce the immediate market interference of rigid price regulation. The correlation coefficient Kendall's tau-β suggested that a higher level of policy support is accompanied by a stronger relationship between market liberalization and wind electricity production. Nevertheless, the null hypothesis cannot be rejected.

As mentioned before, Spearman's correlation is almost significant between the explanatory variables. Still, this weak hint cannot confidently be used as a proof for interaction between the two variables. Hence, the interaction hypothesis is rejected. As mentioned before, a more revealing regression model could not be employed. In the end, also the varying effect of price-based against quantity-based policies, as expected from my theoretical argumentation, could not be checked for. However, it was found that the overall support level's correlation to electricity production from wind energy is positive and even marginally significant, if a one-sided relationship is assumed. This is not very surprising, since that is the very purpose of those policies. From a theoretical perspective though, one has to question and reveal how those policies function, in other words which factors they stimulate, that ultimately lead to a increase in wind electricity production. Finally, all results presented here should be read carefully, due to the very low number of cases. At last, Spearman's correlation coefficient was also calculated for the relationship between the two explanatory variables. The weak correlation that was found does not support the assumption that an interaction effect is present between the two variables. Ultimately, testing conditionality would require a more elaborated regression model.

Clearly, the results have shown, that there is still much room for improvement with regards to the present model. To some extent, there were clear trends in line with the theory and previous findings. However a number of irregularities in combination with the low sample size, made a concise statistical analysis invalid. After all, the relationships between the two predictors and the dependent variable, have proven to be fairly weak, and it is necessary to analyze the shortcoming of the model.

Next, I would like to discuss a few of these cases and give some suggestions how the model that has been used in this analysis could be improved. The most irritating cases might be Ireland. Despite a hierarchical market setting and little governmental support, Ireland has managed to develop a relatively large wind electricity production capacity. The almost contrary pattern is the case for Hungary, the Czech Republic, Austria and Italy. In my opinion, a crucial factor should have been added to the analysis. This missing factor has most likely created an omitted variable bias. This factor is geography. It is reasonable, that a large share of the variation of wind electricity production is simply due to differences in the geophysical wind conditions, that vary on a regional basis and hold different domestic potentials. I imagine that Ireland, circumvented by Atlantic sea winds obviously has a geographic advantage compared to Austria that is largely located within the Alps. Geography may also explain why Ireland as well as Denmark do not need to employ very supportive policies in order to push the electricity production from wind energy. Unfortunately, I am not aware of a sound dataset for the precise wind conditions per country across Europe. Creating a good measure here might also be hardened by the linkage of wind resources to regions rather than entire countries, as well as differences on-shore and off-shore. In addition to the differences regarding the physical access to wind energy, the model could be improved by accounting for structural differences, mostly between Western and Eastern European countries. It is little surprising that among the less productive countries there are numerous countries from the former Soviet Union, e.g. Slovakia, Slovenia and the Czech Republic. These countries are still in a process of structurally catching up with the Western European states and cannot be expected to be forerunners of Renewable Technologies. The investment risk for economic agents is particularly high under these circumstances. The structural leeway of Slovenia and Slovakia is also reflected in the limited policy support that their governments are able to exert.

After all, the testing of the assumed relationship between the economic organization of electricity markets and the deployment of wind energy technology and the role of governmental support has rendered quite difficult, particularly in terms of proper measurement. The validity of the OECD's sector regulation index could be contested. An alternative approach would be the Herfindahl-Hirschman Index (HHI) as a measure of the degree of competition within the domestic electricity markets. Also the measurement of governmental support might require more fastidious discrimination between types of support and their functioning. The measurement of the dependent variable is not seen to be problematic, although the choice of the denominator, by which a standardization of the cases is pursued, could be discussed. One alternative could be the Gross Domestic Product, which could account for the strength of national economies and governments' means to push for innovation. Another, the population size.

As regards the underlying theory, there might have been some conclusions made. It has been presumed, that economic agents' trust in the EU's liberalization agenda and the supportiveness of national governments would create an atmosphere of confidence in innovation. But perhaps the contingency to innovate, i.e. a liberal environment is given, cannot be put equal to a necessity to innovate. The Netherlands for example may have willingly liberalized their electricity markets and also granted comprehensive support to Renewable Technologies. But the Netherland's traditional reliance on gas did not conflict with the political ambition of reducing Greenhouse emissions. That is also the case for France, whose electricity is unalteredly being produced from nuclear energy. In that sense, the necessity to innovate for those countries has been smaller, than in countries that needed to transform their energy economy to manage the decarbonisation process, that is being stipulated by the European agenda. After all, evolutionary theory already implies, that hardly any model can perfectly depict the real world dynamics.

Conclusion

The inquiry which lies at the bottom of this paper is concerned with the suitability of liberal and hierarchical modes of organization of the electricity market and the role of governments as mediators of market dynamics. The data that has been presented in this paper leaves no doubt that liberalization of domestic electricity markets is indeed taking place. Moreover, nearly every country within this observation has demonstrated an increased interest in the production of electricity from wind energy. Although there is no statistical proof that liberal market structures provide the most suited approach to pave the way for innovation, the results of this study suggest, that behavioural patterns and national interests play a crucial role in the organization of the electricity markets. The rational-choice assumption of neoclassical theory is not sufficient, to explain the dynamics that can be observed across domestic electricity markets. If rationality is equivalent to the choice of the most efficient and beneficial means of production and, even if it is bounded, it does not seem to fit to the ambitions of many economic agents to invest in the production of electricity from wind energy. Ultimately, this study demonstrates, that inquiry of dynamics of the electricity market should acknowledge the interdependencies between economic agents and institutions, such as national governments, the European Union, the agenda on climate change and the like. A thorough observation of individual cases has shown, that economic agents are sensitive to national and supranational political agendas and the interest of various stakeholders. Electricity markets in particular, are characterised by complexity and decentralism of stakeholders. I argue that this requires research and politics to have a very diversified perspective on how to deal with the organization of electricity markets. There is a reason to believe that evolutionary theory is closest to get a grasp of how dynamics of the electricity markets work, even if it does not clearly suggest the dominance of one type of economic organization over another in incentivizing innovation or the development of RES-E. The monotonic positive relationship that has been found between liberalization and wind electricity production capacity suggests, that liberalization can be fertile ground to alter the electricity production from wind energy, but that there must be a number of other factors shaping the dynamics of the different domestic electricity markets. After reflection of the difficulties accompanying the inquiry, it is suggested to future researchers to have a more meticulous look on individual cases in order to find out about the drivers of innovation and technical change in the light of liberalization.

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Appendix A

Figure 16:

Outliers determined by studentized residuals

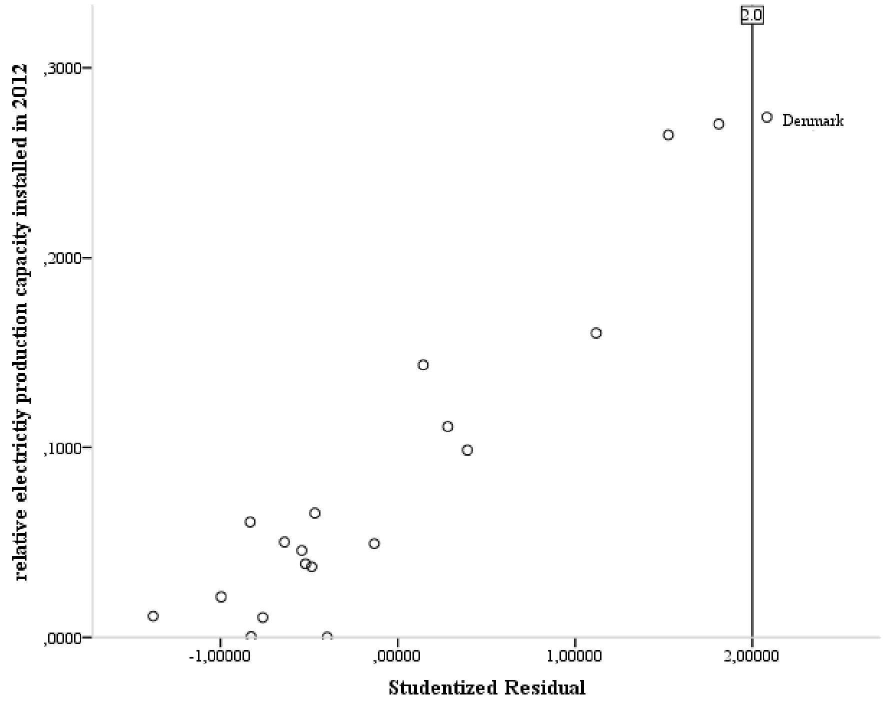


Figure 17:

Noteworthy cases as determined by centered leverage values

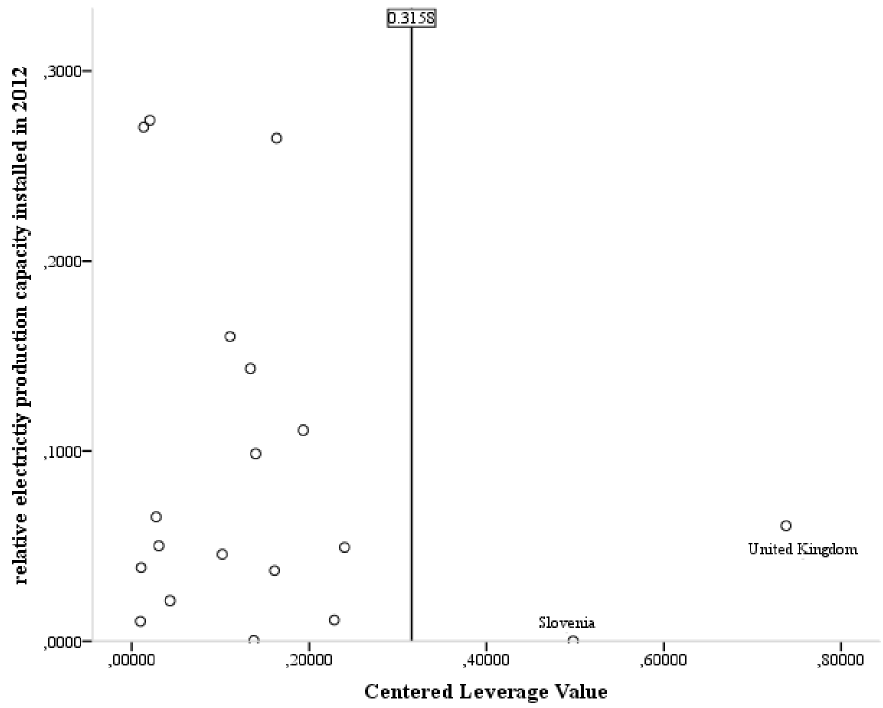
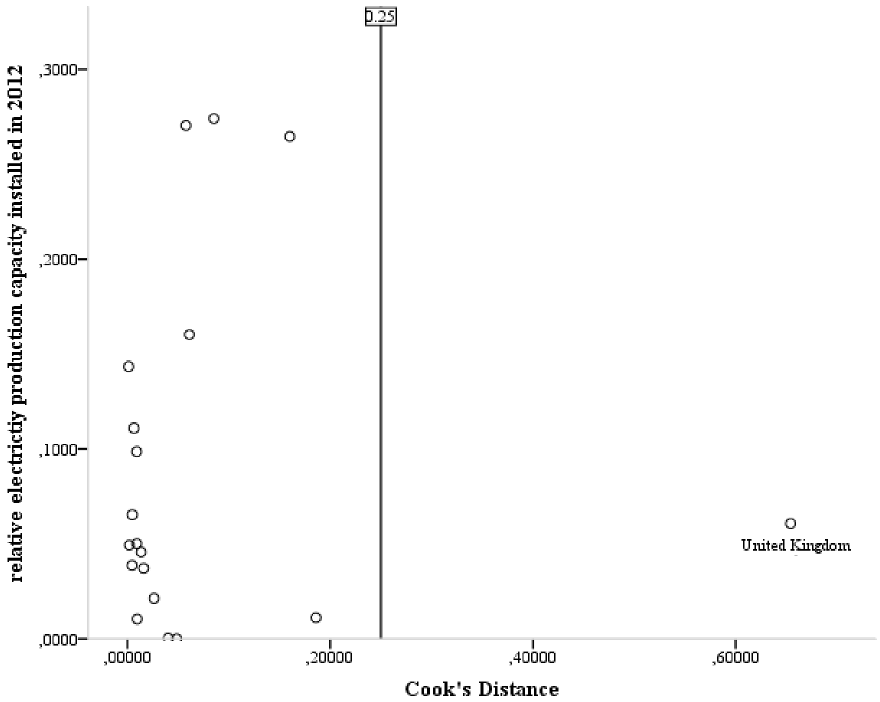


Figure 18

Influential cases determined by Cook's distance



Appendix B

Figure 17

Histograms showing frequency distribution for degree of electricity liberalization between 2004 and 2012

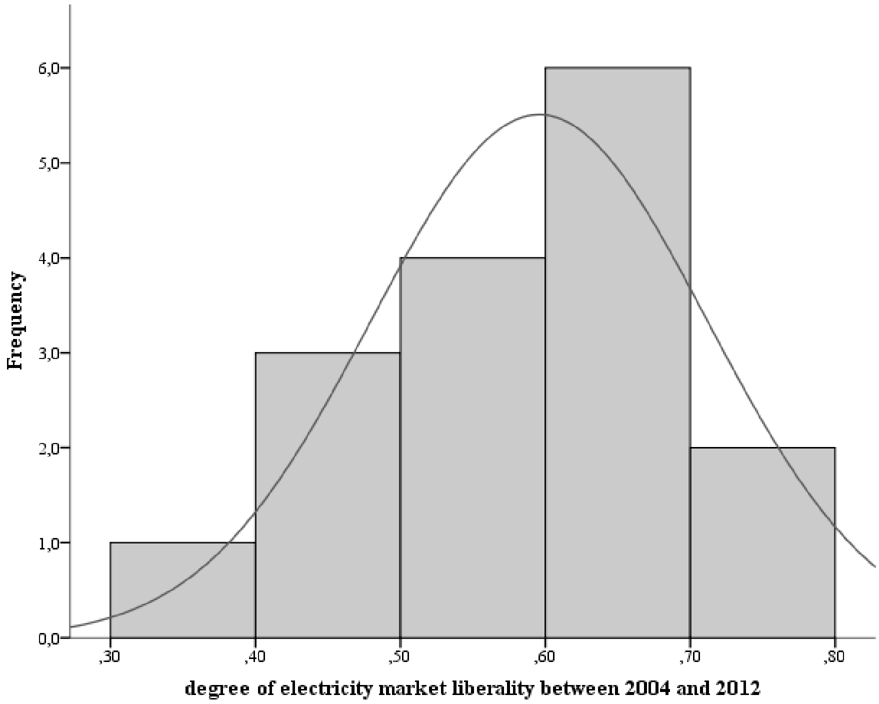


Figure 18

Histograms showing frequency distribution for governmental support

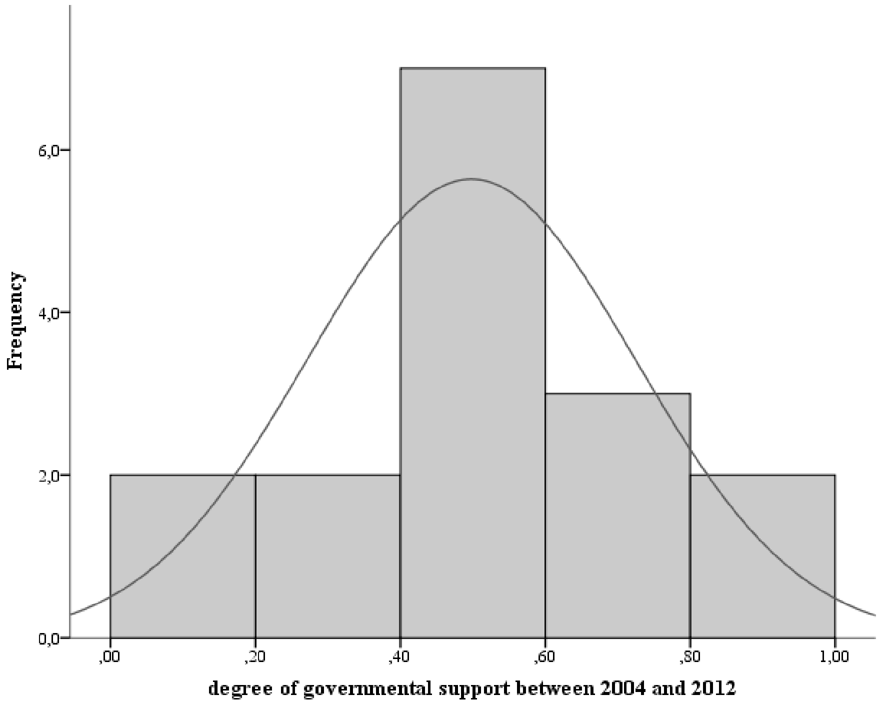


Figure 19

Histograms showing frequency distribution for installed capacity

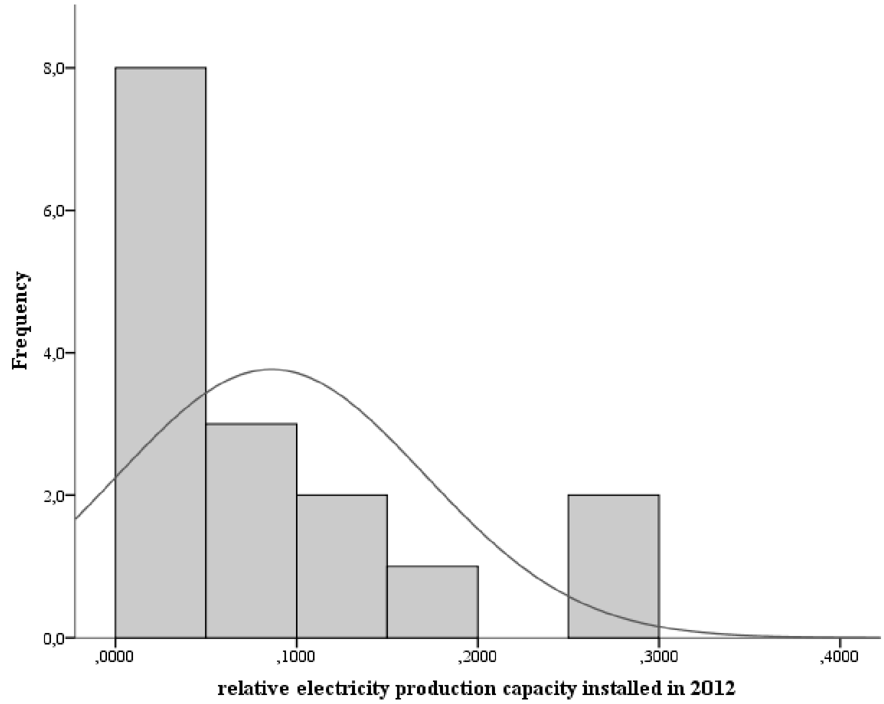


Figure 20

Histograms showing frequency distribution for square-rooted installed capacity