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Assessing the Influence of the Market Structure on the Capacity to produce electricity from Renewable Energy Sources in European Countries

David Y. Pohl

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Supervisors:

Dr. Maarten J. Arentsen

Dr. P.J. Klok

Change and Innovation in Energy Supply

Faculty of Behavioral, Management and Social Sciences

University of Twente

Postbus 217

7500 AE Enschede

Abstract

Following findings of previous research and the New Institutional Economics approach introduced by Oliver E. Williamson, it will be argued that the institutional structure of a market influences the degree to which the energy fed in into the grid is produced through renewable energy sources (RES). As the institutional structure is assumed to have insufficient leverage to solely account for the degree of production of RES-Energy, regulatory support schemes such as Feed-in tariffs, premiums and trading schemes are expected to alter the effect of the institutional structure on the degree of RES-energy produced. Based on data about the 28 member states of the EU provided by the OECD and the European Commission the study in the context of the present paper examines whether the structure of electricity markets (economic organization of the market setting) of the Member States of the European Union influences the capacity to produce electricity from renewable energy sources and further whether policy support instruments have a moderating effect on that relation. The presented results of performed correlation- and moderation analyses on the basis of the data available cannot unambiguously be interpreted but provide heuristic perspectives regarding approaches to further investigation.

Content

Abbreviations

CO_2: Carbon Dioxide

EU: European Union

FIT: Feed-In Tariff

FIP: Feed-In Premium

NMR: Non-Manufacturing Regulation

OECD: Organization for Economic Cooperation and Development

PV: Photovoltaic

RES: Renewable Energy Sources

RES-E: Electricity from Renewable Energy Technology

RET: Renewable Energy Technology

R&D: Research and Development

TFEU: Treaty on the Functioning of the European Union

TGC: Tradeable Green Certificate

Tables and Figures

1 Introduction

In 2016 Germany imported 69% of its electricity used from abroad. Unstable political situations in exporting or transit countries such as Ukraine and the Crimea-crisis has aggravated the importance of security in energy supply in today's political discussions. Germany's energy supply depends on delivery from United Kingdom, Norway, and Russia as it receives nearly all (97%) of its oil from these countries. The technology of Nuclear power plants, once seen as the possible future of electrical power supply, has been proven as unsustainable and unsafe in Chernobyl and Fukushima (Amelang, 2015). Today, 80% of domestically produced energy is generated through sustainable energy resources and lignite. Sustainable energy resources account for 21% of Germany's total power generation, which in absolute numerical values is more than lignite but only nearly a third of mineral oil. Examining recent data, the share of nuclear and coal-fired power plants in Germany experienced a decrease in consumption compared to 2015 whereas sustainable energy resources experienced an increase of 10%. This demonstrates that more weight is given to the German energy transition – "Energiewende" – which can be seen as an indicator of the change taking place in the German energy sector (Energiebilanzen, 2016). In terms of sustainability as well as the security of resources and thus the security of supply in populations and the economies of highly industrialized countries, renewable energy sources will play an important role that should not be underestimated. Security of supply is a concern politicians are confronted with when negotiating with states involved in for example the Crimea-crisis or debates regarding the shift from conventional energy resources to renewable energy technology. Even though conventional energy resources provide a higher degree of certainty and supply reliability than renewable energy sources (RES) to date, at least when stationed in the own country, the EU Directive of opening the energy markets (Art. 194 "TFEU,") not only aims at supply security but also at economic efficiency and protection of the environment (Bonneville & Rialhe, 2005). These additional goals are the starting point of renewable energy sources. Since even short blackouts have the potential of posing high political, economic and social costs, states cannot yet fully rely on renewable sources, but the amount of electricity produced through RES is steadily growing (Joskow, 2008). By promoting investments in an increase in capacity to produce electricity from renewable energy sources as well as research and development (R&D), RES appear to be the most promising technology to fulfill the goal of a more environmental-friendly production of electricity set by the European Commission. With an expansion of investments, the technology can grow, resulting in a country's stronger independence from conventional energy plants respectively other countries as well as the promotion of research and thereby constant enhancements in regards of energy-efficiency (Philibert, 2014). Furthermore, in times of global warming, the transition to RES itself is a constant matter of debate. It often is highlighted as the future of energy production and the only way to keep the earth hospitable. For that reason, the European Union, and various countries not belonging to the EU put an effort in promoting RES.

The research reported in the present paper is concerned with the factors that are thought to cause an increase in the capacity of producing electricity from renewable sources in particular Photovoltaic (PV), as solar photovoltaic technology entails plenty of advantages regarding independence from energy imports, security of supply and sustainability, which makes it a predestined object of analysis as the importance of RES most likely will only increase. By taking into account assumptions derived from Transaction cost theory and the consequent developed New Institutional Economics approach (North, 1993), Evolutionary Economics (Markard, Truffer, & Imboden, 2004) and previous studies (see ch. 2.1), a theoretical model is constructed for the study in the context of the present paper in order to test for whether a relationship between the organization of the electricity markets and the respective generation capacity of renewable energy can be confirmed (see ch. 2.2). Previous studies have covered the relationship between market structure and renewable energy capacity concerning innovation in the sustainable energy sector. Horner, Azevedo, and Hounshell (2013) studied the influence of government incentives on wind innovation in the United States and found a significant positive effect. Following Fritz-Morgenthal, Greenwood, Menzel, Mironjuk, and Sonntag-O'Brien (2009), support policies, when applied appropriately, should enable renewable energy technologies to compete with conventional/ fossil fuel based energy production. These and other studies, as will be presented in chapter 2.1, allow for the assumption that support policies have an influential effect on the capacity to produce electricity from renewable energy sources (RES-E).

The electricity sector used to be vertically integrated as the suppliers of electricity "provided essential services of national interest" (Newbery, 2002a) and it was argued that these services, more specifically energy security, could best be provided by regulated monopolies (Newbery, 2002b). The electricity sector is understood as activities concerning the production, transmission and distribution of electricity (Botta & Koźluk, 2014). In a vertically integrated market, a company is in control of all respectively certain essential steps of the chain of production or distribution (Investopedia, a). As opposed to this, horizontal integration refers to a company merging with other companies which are at the same point of the production or distribution chain (Investopedia, b). The increasing trend of globalization and the concomitant market liberalization led the European Commission to pass the Single Market Directive for Electricity in 1999 (Müller-Jentsch, 2001). This directive obliged the Member States of the EU to open their power markets to the competition from outside and gave rise to the process of unbundling in the electricity value chain. The energy transition initiated in 2000 ("Gesetz für den Ausbau erneuerbarer Energien," 2000) by the German government implied legal and financial support for the energy production through sustainable energy resources and aims at promoting and supporting private businesses to shift towards the production and the use of renewable energy (Müller-Jentsch, 2001).

The research in the paper at hand aims at revealing the relationship between the market setting, meaning whether the respective electricity market is liberalized or hierarchical, and the capacity of the European Member States to produce RES-E and asks: Is a more liberalized market offering better conditions for businesses to produce renewable energy and to what extent do supportive policies play a role in this relation? In the following chapter 2, the theoretical context and relevant models from previous studies are presented and discussed. Empirical findings and theoretical reasoning lead to the formulation of a research question (see ch. 2.2) and the deduction of empirically testable hypotheses (see ch. 2.3). Chapter 3 clarifies the methodological approach taken in the research of the paper at hand. In this context, the sample, the process of collecting data necessary for subsequent analysis, the conceptualization of the very as well as the research design are portrayed. Ensuing, the research question is answered through quantitative data analysis and the findings are presented and annotated (see ch. 4). In chapter 5 conclusions are drawn based on the previously calculated output, limitations for this research are presented together with recommendations for further research.

2 Theoretical Framework

With reference to the development of the electricity markets in regard to renewable energy (see ch. 1), the study reported in the present paper focuses on influential factors that have the ability to enhance the deployment of RES-E within these markets. In Chapter 2, empirical findings and theoretical concepts relevant to the study of the present paper are described and explained and the current state of research will be outlined (see ch. 2.1 up to ch. 2.1.4). Chapter 2.1.5 describes the variables observed within the framework of the study in the paper at hand and establishes their associations. Coming from this, the research question will be formulated and following statistically testable hypotheses will be deduced (see ch. 2.2).

2.1 Models and Constructs

The subsequent chapter elaborates on terms and constructs and the respective model concepts that were essential for the setup of the study reported in the present paper.

2.1.1 Institution and Institutional Organization. First of all, in the context of the study reported in the present paper, the two central concepts of *institution* and *institutional organization* require further explanation. Institutions "form the incentive structure of society, and the political and economic institutions, in consequence, are the underlying determinants of economic performance" (North, 1994, p. 359). Institutions are created in order to curtail uncertainty in the process of impersonal exchange, which is the prevailing form of exchange in an economy with large-scale production and distribution, being the predominant form of exchange in today's economies. The more an economy grows, the more complex the agreements made in it become (North, 1993). This complexity gives rise to uncertainties of the contractual partners, facilitating opportunistic behavior (see Williamson, 1993) and cheating. Thus, parties can only make decisions on the basis of imperfect information regarding the behavior of the counterpart (North, 1990). In order to prevent a situation in which each side is afraid of contracting it is called for Institutions, as will be further clarified in chapter 2.1.2 and 2.1.3. Williamson (1996) summarizes the principle of actors making decisions in complex transactions based on imperfect information with the term *bounded rationality* (see Simon, 1991). As a result of this bounded rationality, actors in an economy need to put extra expenses to gain information, negotiate and set up contracts to secure transactions and subsequently control their accurate implementation. These extra expenses are called transaction costs since they are an integral part of every transaction.

North (1990) distinguished between *institutional environment* also referred to as "the rules of the game" and *institutional structure / organization*. The former covers "normative and regulatory pressures exerted on organizations by the state or society and the professions. These pressures can be coercive and direct and enforced through mechanisms such as courts and regulations" (Wade & Swaminathan, 2015, p. 1). The latter refers to the way economic units such as electricity producing companies can compete and / or collaborate concerning the structure they are arranged in (Williamson, 1995). The institutional structure covers the distinction between a liberalized organization of a market, meaning to let the market organize itself, as for instance highlighted by Adam Smith's *Invisible Hand* (Smith, 1776), and a hierarchical organization, referring to a bureaucratic, centralized way of arranging the market (Williamson, 1995).

This differentiation offered by Williamson (1995) is guiding for the conception and realization of this study, as it provides the scientific foundation for the choice of the independent variables as presented in detail in chapter 2.2.The European Union, which is the international frame of countries the study in the context of the present paper refers to, provides a quite consistent *institutional environment* as all Member States agreed on the *acquis communautaire*, a term comprising rights and duties of the Member States. These rights and duties follow from legal acts, legislation as well as court decisions portraying the body of European Union law (Zandonella, 2007). Therefore, it can be assumed that all countries included in this study have similar legal prerequisites for the development of the electricity market. Within the *institutional structure* as defined by Williamson (1995) various modes of governance play a role. These can, generally speaking, be defined as "the role of the state in society" (Pierre, 2000), meaning activities regarding legislation, regulation and coordination. In this context, the term governance also depicts the structure of the market, meaning the distinction between the two ideal types of a liberal or a hierarchical structure. On a spectrum that is defined by these two contrarious types different modes of governance are situated (Treib, Bähr, & Falkner, 2005). This will be further clarified in chapter 2.1.4.

2.1.2 Economic Concepts. According to Hayek (1945), markets are under constant pressure of adapting to changes in the environment. Following the ideal liberal model of an economy, this adaption can best be managed autonomously by the market itself. The *Laissez-faire economics* model of an utterly liberalized market, where businesses, and thus the economy and the society as a whole, are thought to be best off with the least amount of government intervention, is rather outdated and has been criticized by various economists such as Adam Smith (Pack, 1991) and John Maynard Keynes (Dostaler, 2007) over the past centuries. In the given context it is used to display the characteristics of an ideal type that is used to classify the structure of the electricity market. Drawing the line to the topic of the paper at hand, the legislative-induced introduction, implementation and further development of renewable energy sources poses such an above-mentioned current source of change to the electricity markets of the European states. Following Hayek, the free market would be the best measure to adapt to the constant advancement, as the process of developing a centralized, bureaucratic answer to an abrupt change would take too much time, which with reference to the electricity market has the potential to cause immense political, economic and social problems. Yet Hayek highlights the problem of *bounded rationality* of those taking the decisions, a concept that has been readopted by Williamson (1995) in the construction of his theoretical models (see ch. 2.1.1).. Joskow (2008) argues that the state of change, uncertainty and instability in the market rules lead to a lack of willingness to carry in capital by potential investors, as they are too afraid of the contingent occurring *sunk costs*, a concept that will be explained in the following paragraph. However, these investments are needed due to the distinct *asset specificity* of RES, inasmuch as the purchase of a photovoltaic system, where the investment to set up a plant has to be made nearly entirely in advance, has a time-to-value of 15 years for private use ("Kosten Einer Photovoltaikanlage ", 2016).

The term asset specificity refers to the variety of functions a certain product, also called *asset*, offers. Photovoltaic-panels respectively solar cells have a high asset specificity as they can only be used for one purpose, that is converting sunlight into electrical energy. In theory, high asset specificity goes with a lower potential to use it for other than its intended purchasing reasons and therefore, the asset loses in value and will only be resalable below the purchasing value. Investments in highly specific goods, therefore, are called sunk investments, for the above-mentioned reasons (Investopedia, c). Groenewegen, Spithoven, and van den Berg (2010) link the level of transaction costs (see ch. 2.1.3.) directly to the asset specificity of an investment. They assume that a higher risk for investments requires precautionary administrative schemes which are nonexistent in a self-organizing market. Therefore, a different governance structure, one that is associated with a lower level of uncertainty is needed. With reference to chapter 2.1.1, uncertainties can be seen as a trigger for an arising chance of opportunistic behavior and through that to an increase in transaction cost as extra effort and expenses need to be put into gaining information, negotiating and the drawing up of contracts to secure transactions and ensure precise implementation of the very (Williamson, 1995).

2.1.3 A Closer Look at the Electricity Market. Next, this chapter will provide a closer look at the development of the electricity markets of the European Member States in order to facilitate a better understanding of the current state of scientific knowledge about the topic covered by the study in the context of the present paper in the context of the present paper, as will be presented in the subsequent paragraphs.

Caroll and Teece (1999) explain the development of the electricity markets from vertically integrated industrial hierarchies to increasingly unregulated / liberalized markets (see figure 2 in chapter 3.2.2). Horizontal levels, such as transmission and distribution, are natural monopolies and therefore under hierarchical control, as "for economical and environmental reasons, building parallel electrical networks makes no sense" (Bonneville & Rialhe, 2005, p. 8). The shift from hierarchical to liberalized markets leads to the question whether one organizational structure can undoubtedly be preferred over the other or if perhaps a compromise with certain features of both structures is more eligible. Following the evolutionary economics approach (Markard et al., 2004), changes in the structure, in this case, a move towards a more liberalized market, strongly influences the innovative behavior of Electricity distributors within the electricity market. Technological change generally affects transformation costs, which is the cost of producing a certain good, while, to alter transaction costs, institutional change is necessary (North, 1994).

Scientific publications present a rather discordant position based on empirical facts on the role of regulatory institutions for investments and more general the facilitation of economic development regarding RES-E. Rodrigo and Rimmer (2010) assert the importance of effective, respectively market-enhancing state policies on the economic development and present studies of the World Bank (Clarke et al., 2005), Olson, Sarna, and Swamy (2000) and Kauffman and Kraay (2002) to underline their argument. On the other side, Sioshansi (2006), also presenting his argument rather as a "general perception", negates the view that the regulatory interference is essential for the efficiency of economic activities. Both arguments find common ground in agreeing on the need for further research. Sioshansi (2006) does not rank one institutional organization over the other, as the influence of these on the economic activity has not been conceived in its entirety. Rodrigo and Rimmer (2010) agree with North, Acemoglu, Fukuyama, and Rodrik (2008) that, in first place, the general tone of scientific literature is that institutions play a strong role in the development of an economy, be it positive or negative. Moreover, they agree on the fact that the very research does not get into much detail in clarifying the exact specific regulatory mechanisms that exert an influence on the economic activities and its outcomes.

Caroll and Teece (1999) cite Pablo T. Spiller, who argues that with regard to a rather hierarchical structure, the threat of sunk investments (see chapter 2.1.2.) being expropriated through opportunistic behavior by the government must be approached. To foster investments in RES, investors need incentives that minimize the threat of illiquidity through the sunk investments as well as the eventual immediate expropriation in such a situation. In a market with constantly evolving regulatory rules, possible stakeholders are hesitant to invest without having assurances that the rules on which they base their investments might not be changed in near future and thereby impair the expected profit.

Taking into account the theoretical approaches presented in chapters 2.1.2 and 2.1.3. as well as the scientific literature introduced in the previous paragraphs, no clear preference of one institutional structure over the other can be given. In an ideal liberalized market, renewable energy technologies (RET) would get ruled out by opportunism as the market would become more and more complex and uncertain, whereas a hierarchical structure may create a regulated "bottleneck" of the natural monopolies in the transmission and distribution segments that is insuperable for RETs. The bottleneck can be illustrated as a situation for an electricity-generating company that needs to further merchandise its produced electricity. In order to do so, this company relies on companies from other sectors, in this case from the transmission and distribution sector as the producing company does not have an own electricity grid available. Transmission and distribution companies acting from a monopolistic position, now have the ability to exploit the dependence of the producer as well as of the consumer. This situation results in the necessity to develop reliable institutions, meaning regulatory governance and regulatory incentives as to prevent the abuse of market power by the natural monopolists and support investments in the generation of RES-E. Regulatory governance is a summarizing term for the drafting of new regulations and rules respectively amendments of already existing ones, the monitoring and safeguarding of compliance with the very and in cases of non-compliance their enforcement. Regulatory incentives, referring to rules and regulations "governing utility pricing, cross- or direct-subsidies, entry, interconnection, etc." (Rodrigo & Rimmer, 2010, p. 285) start playing a role when regulatory governance has proven itself as viable, meaning the minimization of uncertainties, so as to foster incipient investments, as will be explained further in the following chapter 2.1.4 (Rodrigo & Rimmer, 2010).

2.1.4 Regulatory Incentives as Modes of Governance. In the context of the European Union's approach to counteract climate change, various policies have been implemented that serve to directly diminish the amount of carbon dioxide (CO_2) produced in the process of generating electricity and / or provide incentives to invest in and switch to renewable generating sources. In most of the European Member States combinations of different policies were implemented varying in purpose and therefore in the objective they are aimed at (Bertoldi, Rezessy, Langniss, & Voogt, 2005). Feed-In tariffs (FITs) and Feed-In Premiums (FIPs) as well as Trading Schemes have so far been the most established policies. FITs and FIPs aim at stimulating deployment and thus target at an increase in capacity in RES-E whereas the term Trading Schemes comprises different manifestations of tradeable certificates, in particular, Brown, Green and White certificates as will be further explained in the third paragraph of this chapter (Philibert, 2014). In their research Kitzing, Mitchell, and Morthorst (2012) differentiate between *Major support* *instruments* involving Feed-in tariffs, Feed-in Premiums as well as Quota obligations with tradable green certificates (TGCs) and supplementary support instruments covering investment grants, financing support and fiscal measures. Even though most countries implement a combination of major and supplementary support instruments, for the study reported in this paper only the major instruments that serve to regulate the price setting of the electricity market will be taken into account as will be explained in the following paragraphs. Investment grants aim at supporting the construction of a certain project through direct monetary funding, rather than mitigating the risk of sunk investments (see ch. 2.1.2). Financial support refers to a range of support measures enabling investors to enter the energy market with renewable projects at appropriate terms as for example low interest rates on loans. Fiscal measures mainly refer to tax reliefs or reductions. (Kitzing et al., 2012)

FITs directly aim at alleviating the risk for investors by eliminating threats posed by the price-setting mechanism of the market. The idea of FITs is, that renewable energy sources are connected to the electricity grid and operators are required to feed in the electricity produced in these plants and remunerate the owner with a certain amount per kWh. Different manifestations of these tariffs have developed over time. Feed-in Tariffs exempt the producer of renewable energy from direct market participation and the concomitant problem of price volatility and oblige the distribution system operator to pay a fixed price per kWh to the producer. Feed-In Premiums just guarantee a premium on top of the market price of one kWh in order to obviate the threat of losses through a decline of the electricity price. The "Gesetz für den Ausbau erneuerbarer Energien" 2014 (EEG) in Germany for example ensures a Remuneration for 20 years, also if no electrical output is fed into the grid (Mitchell, Bauknecht, & Connor, 2006). The proposed increase in economic security for the producers does not necessarily go hand in hand with market efficiency. FITs may provide financial stability for the long-term, but yet be inefficient from an economic perspective (Lesser & Su, 2008). Nevertheless, Mitchell et al. (2006) suggest that risk reduction is a critical factor in making a support mechanism adequate for promoting RES. Couture and Gagnon (2010) consider Feed-in premiums to be a part of Feed-in Tariffs (FITs), which complies with the data used in the study of the paper at hand, as also the index used to display the support policies comprises these two (see chap. 3.3.).

Quotas of Tradeable Green Certificates are an instrument used in rather liberalized electricity markets such as Italy. It aims at increasing the share of renewable energy produced and fed into the grid by issuing certificates to producers for a certain, pre-defined unit of RES-E, measured in Megawatt. The number of certificates must reflect the legally required amount of RES-E produced. An operator of a conventional generation plant can now decide whether to produce renewable electricity on its own or to buy certificates from other producers, as falling short on the required volume of TGCs has financial penalization as a consequence. As regards *brown certificates*, the Emission Trading System (ETS) creates a financial incentive for emitters to reduce their production of greenhouse gasses. Since 2005, the ETS has set a cap on the absolute amount of for instance CO_2 that companies can emit each year and requires monitoring of these emissions. The fundamental idea is similar to green certificates, as each year, a fixed number of certificates or *allowances*, which are the currency of the carbon market, are issued. At the end of each year, companies are required to hold enough allowances to equal the amount of CO2 produced or otherwise face substantial fines. In case a company does not hold enough allowances equaling the expected amount of emission produced, this company is required to cut these emissions or otherwise buy extra allowances. These can be bought from another emitter that has successfully cut his emissions, so as to now be able to sell his surplus of allowances on the market that is set up just for the trading of these certificates. Over time, the cap is reduced and fewer allowances are issued, techniques to cut emissions are expected to be developed and thus total emissions drop as companies get a financial incentive to cut emissions or otherwise pay others to do so. This system covers nearly half of the EU's emission ("The EU Emissions Trading System," 2016; Meran & Wittmann, 2012). The idea behind the introduction of these certificates is to establish a second market parallel to the *commodity* electricity. In other words, the electricity itself is traded on the electricity market, unattached from whether it is produced from conventional, respectively fossil fuel based or renewable sources. Concurrently, certificates are traded on the market that was established just for this very purpose. It is considered "a cost effective way to meet […] renewable energy target[s]" (Schaeffer, Boots, Martens, & Voogt, 1999) as the prices of the certificates depend on the demand of the very, which in turn depends on the amount of greenhouse gasses produced respectively on the share of electricity that has been produced through renewable energy sources.

Polzin, Migendt, Täube, and von Flotow (2015) report their own research that emphasizes the "superiority of feed-in tariffs […] to spur deployment and technological diversity" (Polzin et al., 2015, p. 99) and thereby follow the same track as Lesser and Su (2008) and Abdmouleh, Alammari, and Gastli (2015) who back up their reasoning on previous research. As adduced in the previous paragraph, quotas also are said to have a positive influence on the deployment of renewable energy, but in accordance with findings of a majority of relevant studies to a lower degree than FITs (Butler & Neuhoff, 2008; De Jager et al., 2011; Mitchell et al., 2006). While FITs appear to be evidentially the more effective measure to promote development in less mature sources of renewable energy such as Photovoltaic, Tradeable Green and Brown Certificates, on the other hand, are thought to be more effective in supporting renewable energy technologies that are rather mature and have the capability of competing on prices with conventional electrical production sources. Once again, scientific papers do not show much unanimity on the distinctive virtues of the two major support instruments (Polzin et al., 2015).

For the study of the paper at hand both, Feed-In Tariffs and Trading Schemes will be examined together, as most of the countries in the European Union have adopted at least one of the policy measures and some even adopted a policy mix consisting of both, and more policies in order to counteract the frailties each of the policies might entail as depicted in this chapter. The study in the context of the present paper aims at bringing more light to the question of a favorable regulatory structure for electricity markets with regard to the amount of electricity the very is theoretically capable of producing.

2.1.5 Variables and Associations. This chapter serves to provide clarification regarding the construction of the research question and empirically testable hypotheses (see ch. 2.2) that are the result of the evaluation of previous scientific studies that were put into a theoretical framework. It is assumed that in order to obtain an increase in capacity to produce electricity from renewable energy sources, as in this case photovoltaic, investments are needed. These investments heavily rely on the willingness of possible investors to mobilize capital towards the construction of new plants. If the cash flow is held back due to uncertainties regarding the expectable returns on an investment, the increase of capacity is brought to a halt as photovoltaic plants need proportionally large a priori investments. With reference to the New Institutional Economics approach (see ch. 2.1.1), institutions are necessary in order to impair uncertainties by implementing rules and regulations and enforcing them on the actors within the market. Scientific evidence as presented in chapter 2.1.3 and further elaborated in the first paragraph of this chapter provides reason to assume that the structure of the electricity market is of importance regarding the influence on investments in capacity and a concomitant growth of the very. Nevertheless, the heterogeneity of the findings provides reason for further investigation on the conduciveness of regulation regarding an increase in capacity respectively the degree to which a market should be regulated in order to provide the strongest increment in capacity. Once a distinct market structure is established, investments need to be secured and further expanded in order to eventually reach a certain surplus in capacity so as to ensure security of supply. Environmental support policies are supposed to provide for this stimulus by alleviating uncertainties regarding the remuneration for investments. In Europe, Feed-In Tariffs and Trading Schemes were established and their subsidiary virtue is thought to be proven (see ch. 2.1.4). Bechberger and Reiche (2004)for instance recognize the fostering effect of support policies on solar PV technology in the scope of the German electricity market. Nevertheless, without the establishment of a structure removing fundamental uncertainties, supportive policies will fail.

As indicated in chapter 2.1.3, disagreement prevails regarding the preferability of either a more hierarchical respectively a more liberal structured electricity market. Vagliasindi and Besant-Jones (2013) scrutinize whether a liberalized wholesale market will provide sufficient investments in capacity in the long run by referring to the electricity crisis in California in the year 2000, where illicit shutdowns of pipelines and manipulated electricity prices caused a large blackout. *Kemppi and Perrels (2003)* investigated the Nordic countries Denmark, Finland, Sweden and Norway and found that the opening, or liberalization of the electricity markets led to a decrease in electricity prices, which was followed by a reduction in investments in capacity as the expected return subsequently was diminished. Pfaffenberger and Hille (2004) analyze the willingness to invest in the liberalized German electricity market and expect that the introduction of hierarchical measures, meaning regulations influencing the price volatility, would hinder investments in the generation sector. The opening of the electricity markets in Europe led to an overall decrease in capacity surplus, causing rising prices which are needed in order to enable new investments into capacity-building. Governmental interference in the price-setting mechanism, as for example with the implementation of a price ceiling, is assumed to reduce these investments. By referring only to RES, some governmental exertion of influence is assumed to be necessary as renewable sources are not yet as reliable and efficient as conventional production technologies and therefore, should be integrated actively into the grid. Ultimately, scientific evidence exposes a certain latitude regarding the necessity for regulatory interference in the market respectively the interplay between regulation and liberalization (Rodrigo & Rimmer, 2010).

Following the line of argumentation, regarding the study presented in the paper at hand, it is assumed that initially, a market structure needs to be established that is conducive to achieve an increase in capacity to produce electricity from renewable energy sources (see Hypothesis 1 in ch. 2.2.1). Once this structure is established and secured, additional (governmental) incentives can be offered and will have an impact (see Hypothesis 2 in ch. 2.2.1).

2.2 Research Question and Hypothesis

The following chapter depicts the formulation of a research question based on the theoretical and scientific assumptions as presented in chapter 2.1.5. Subsequently, empirically testable hypotheses are deduced (see ch. 2.2.1 and ch. 2.2.2).

2.2.1 Moderation Hypotheses. The discordance respectively lack of information in scientific literature concerning the influence of the structure of the electricity market on the capacity to produce RES-E (see ch. 1 and 2) leaves room for and stimulates further investigation. Emerging from the disagreement in the scientific literature as presented in chapter 2.1.5, in the context of the study presented in the paper at hand it will be further examined whether more regulated or more liberal structure of the electricity market is conducive for the development of renewable energy production capacity and consequentially, whether the introduced supportive policies (see ch. 2.1) for PV have an impact on the economic development of the market.

To answer the following research question consequently sets the objective for the study reported in the present paper: *Does the structure of electricity markets influence the share of renewables in electricity production and if yes, what is the impact of policy support instruments?*

This main question is segmented into two sub-questions to allow clearer predictions of the associations between the *structure of the electricity market* and the *capacity to produce RES-E* and he expected moderating effect of *supportive policies*:

1. Is energy produced by photovoltaic technologies being encouraged respectively discouraged by the structures of a certain market. Therefore, the first sub-question is:

   Does the national market setting affect the capacity of photovoltaic energy resources?

2. Do governmental policies such as Feed-In tariffs and Trading Schemes alter the influence of the institutional structure on the photovoltaic energy capacity. Therefore, the second sub-question is:

   Do national support schemes affect the electricity capacity from photovoltaic energy sources?

In order to answer the above-formulated questions, the following empirically testable hypotheses were formulated (see ch. 4.4 & 4.5).

Hypothesis 1: The *structure of the electricity market* exerts a positive effect on the *capacity to produce RES-E*.

Hypothesis 2: The relation between the *capacity to produce RES-E* and the *structure of the electricity market* is moderated by the manifestation of *environmental support policies*.

Following the formulation of the hypotheses, two explanatory variables can be derived: "structure of the electricity market" (predictor) and "support instruments" (moderator), where *support instruments* moderate the influence the predictor *structure of the electricity market* has on the criterion variable *capacity to produce RES-E from Photovoltaic* (see Figure 1). As described in chapter 2.1.2, the largest impediment to investments in new capacity for RES-E is the uncertainty about the expectable returns. In order to get this uncertainty out of the way, the organization of the market has to provide and ensure a certain stability so as to enable advance planning and guaranteed enforcement of property rights. Once a definite structure is established and the actors in the electricity market were able to adapt, it is vital to encourage further investments and / or attract new entrants to the market since in a competitive liberal market as well as in a centralized hierarchical market, barriers still exist that might cause restrained behavior (see ch. 2.1.5). These restraints are supposed to be impaired by introducing financial incentives such as *environmental support policies*. Following the argument of Fritz-Morgenthal et al. (2009) and other studies as presented in chapter 2.1.5 regarding the relevance of appropriate supportive policies on increasing the *capacity to produce electricity from renewable energy* sources, it is assumed that including support policies into the analysis, the very will account for a certain amount of inconsistency in the findings of previous studies regarding the association between the *structure of the electricity market* and the *capacity to produce RES-E*. The hypothesized relationships between the predictor, criterion and moderator variable as depicted in this chapter are illustrated in figure 1 in order to provide a better understanding.

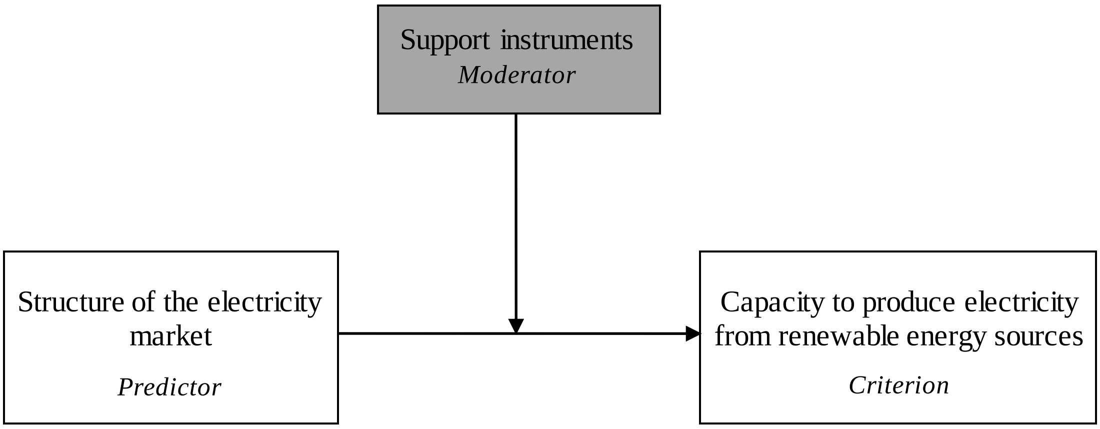

Figure 1: Model of the Moderation Effect between the predictor variable *structure of the electricity market*, the criterion variable *capacity to produce electricity from renewable energy sources* and the moderator *environmental support policies*.

2.2.2 Correlation Hypothesis. As indicated by chapter 2.1.5, little research has been conducted on the correlative linkage between the structure of the electricity market and the capacity to produce electricity in it. This holds true even more when narrowing it down to electricity produced from renewable sources. Studies found in this context present a rather heterogeneous position. For this reason, in addition to the above-formulated hypotheses regarding a moderation effect, the following correlation hypothesis is formulated:

Hypothesis 3: There will be a correlative association between the predictor variable *structure of the electricity market* and the criterion variable *capacity to produce RES-E*.

3 Methods

Within the scope of the paper at hand and by drawing on the data that was used to display the variables (see ch. 3.1.1 to 3.1.3) the influence of the economic organization of the electricity markets (predictor variable) on the Energy capacity from renewable energy sources of the respective market (criterion variable) was tested. The expected association is thought to be moderated by support instruments (moderating variable) implemented in the respective markets. Furthermore, as a result of the theoretical and empirical discordance (see ch. 2.1), the provided data under consideration (see ch. 3.2.2) were tested for correlation between the above presented variable *structure of the electricity market* and *capacity to produce electricity from renewable sources*. In order to quantitatively evaluate the association hypotheses outlined in chapter 2.2 the data of a sample of n = 19 were considered for the hierarchical moderated regression analysis and a sample of n = 21 for the correlation analysis.

Chapter 3.1 describes the research design of the study in the context of the present paper and elaborates on the predictor, criterion and moderator variable. Chapter 3.2 gives a detailed overview of the process of data collection, the sample, it's size, the reason this particular set of units has been chosen and the operationalization of the variable. Subsequently, chapter 3.3 depicts the statistical methods that were applied to test the empirical hypothesis of the study in the context of the present paper (see ch. 2.2) on the basis of the data described in chap. 3.2.2.

3.1 Research Design

The hierarchical moderated regression analysis approach as well as the correlation analysis of the quantitative study in the context of the paper at hand transposes the research question "*Does the structure of electricity markets influence the share of renewables in electricity production and if yes, what is the impact of policy support instruments?"* into a methodic framework. In the process of conducting a hierarchical moderated regression analysis, two regression models are compared: a model containing only the predictor and moderator variable (i.e., a main effects model including the *structure of the electricity market* and *support policies*) and a model that also includes the interaction term (i.e., including the *structure of the electricity market, support policies* and the interaction term *structure of the electricity market* multiplied with *support policies*. As explained in chapter 2.2.2, it is tested for correlation between the predictor variable *structure of the electricity market* and the criterion variable *capacity to produce RES-E* as the scientific literature is discordant regarding this issue respectively entirely lacks information concerning an association (see ch. 2.1.5).

Below the variables are described directly followed by their operationalization.

3.1.1 Criterion Variable. The Dependent variable *capacity to produce electricity from renewable energy sources* is operationalized as the capacity installed for solar energy. *Capacity installed* is preferable over *electricity generated* as it better reflects the investment decision in the given technology. Generation meanwhile purely measures the actual production. Especially in the case of Photovoltaic, the amount of electricity produced heavily depends on external factors such as weather or simply the part of the day and the consequent sun exposure of the PV installation. This could lead to a point, where investments in renewable energy sources respectively PV are taking place but go unnoticed as the installed facilities are not being used to its entirety. The possible influential factors might only result in very slight differences, capacity installed should nevertheless be a more constant measure, as it also reflects the long-term planning that is dedicated to the deployment of solar energy. The data on solar energy capacity was retrieved from a data publication of the European Commission. The so-called 'SHARES'-Tool lists installed capacity measured in Megawatt for each EU Member state. Consistent data was available from 2004 to 2014. Information from earlier years has not been added, as the analysis would already be constrained by data limitations on other variables. By measuring the criterion variable *capacity to produce RES-E* in Megawatt, no index has to be constructed and eventual consequent problems concerning the quality of the data can be diminished. The tool offers data that has been obtained through similar measures for all countries included (see table 1 in ch. 3.2), preventing irregularities that could occur due to varying parameters and guidelines applied for the data collection ("SHARES," 2016). Limited, respectively no data was available for Greece, Cyprus, Malta, Poland, Slovakia, Slovenia and the United Kingdom.

3.1.2 Predictor Variable. The variable *structure of the electricity market* is integrated into the analysis in the paper at hand by means of the Organisation for Economic Cooperation and Development (OECD) sector regulation indicator for the electricity sector (Koske, Wanner, Bitetti, & Barbiero, 2015). In reference to chapter 2.1.3, it is assumed that rivalry within an industry can be taken as an indicator of the structure of a given market as within a rather liberalized market the degree of competition between companies is higher than within a closed, hierarchical market. Based upon four topics – entry regulation, public ownership, vertical integration and market structure – the OECD issues a score that includes indicators relating to regulation in the non-manufacturing (NMR) sector, in case of the study presented in this paper, the focus lies on the electricity sector (Conway & Nicoletti, 2006). Data on the state of regulation of the countries examined was collected for the period from 1975 – 2013 by handing questionnaires with closed questions to the governments of the respective countries. Through pre-defined numerical values for each answer, the qualitative data obtained was operationalized and subsequently normalized over a scale reaching from 0 to 6, where an economic organization of a country reaches from liberal (low score) to hierarchical (high score) (Koske et al., 2015). Before the qualitative answers to the questionnaire were transformed into quantitative information, they were assessed with the government officials, a concerned committee of the OECD as well as the Network for Economic Regulators, consisting of authorities from regulatory institutions (OECD, 2016) and have been discussed and revised various times in order to ensure reliability and significance (Koske, Naru, Beiter, & Wanner, 2016). As the study in the context of the present paper focusses on the regulatory structure that is defining the economic organization of the countries considered, the indicator at hand, assessing the de jure status of the respective structure, meets the requirements regarding a portrayal of the very. As stated in chapter 2.1.4, in the study presented in the paper at hand, Feed-in premiums are treated as part of Feed-in Tariffs (FITs), which is in compliance with the data retrieved from the index. Data was retrieved for the period 2004 to 2012 and no data was available for the countries Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta and Romania.

3.1.3 Moderating Variable. The variable *environmental support instruments* is captured by a sub-indicator of the multi-dimensional Environmental Policy Stringency Index of the OECD that allows for comparison of the environmental policy stringency between countries over the period of 2004 - 2012. The authors define Stringency as the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behavior (Botta & Koźluk, 2014). The main Index was developed as a composite indicator of environmental policy stringency, meaning elements of regulations that each country has implemented, measured on an annual base. As regards trading schemes, in case of green certificates the indicator measures the percentage of renewable energy that producers are obliged to generate per year. In the case of brown certificates, it looks at the price of one CO_2 allowance, as the prices of the certificates depend on the demand of the very, which in turn depends on the amount of greenhouse gasses were produced within one year (see ch. 2.1.4). With respect to FITs, the price that is paid for one kWh produced is examined. In a first step, the approach discriminates between "market-based policies" and "non-market policies". Within the category of market-based policies both measures, namely FITs and Trading Schemes, as introduced in chapter 2.1.4 can be found. In compliance with the literature presented in chapter 2.1., as part of the study presented in the paper at hand, there is no direct differentiation made 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 merged with fixed-price tariffs to represent any price-based policy support.* The Index is measured on a scale ranging from 0 – 6, where 0 means *not existing* and 6 *most stringent*. In order to obtain a measure that can be used for the research of the paper at hand, the values assigned to the feed-in tariffs on the one hand and trading schemes, on the other hand, are added up for each year. This is possible, as the values are standardized across instruments and therefore, the two subcomponents used in the present paper can be aggregated in various ways (Botta & Koźluk, 2014). The index does not provide data for the following countries: Estonia, Croatia, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Romania. For this reason, they will not be considered in the inquiry of the paper at hand (see following ch. 3.2).

As already indicated through the research question, the research is limited to the effect on electricity produced from photovoltaic technology. On that account, any analytical outcome is limited to this technology and cannot be generalized on the basis of hard data to other sources of renewable energies.

3.2 Procedure

The Focus of the study in the present paper is on the Member States of the European Union (N = 28). Ensuing from a lack of information, nine countries had to be excluded from the analysis ($n_e = 9$) for the hierarchical moderated regression analysis resulting in a sample size of 19 countries (n_a = 19). For the correlation analysis, the number of units that were excluded is $n_e = 7$, as the limitations caused by the moderator variable are irrelevant (see table 1).

Table 1: Countries included (n_a) and countries excluded (n_e) from the study

Hierarchical Moderated Regression Analysis		Correlation Analysis	
n_a	n_e	n_a	n_e
Austria	Bulgaria	Austria	Czech Republic
Belgium	Croatia	Belgium	Italy
Czech Republic	Cyprus	Bulgaria	Latvia
Denmark	Estonia	Croatia	Lithuania
Finland	Latvia	Cyprus	Luxembourg
France	Lithuania	Denmark	Netherlands
Germany	Luxembourg	Estonia	Slovenia
Greece	Malta	Finland	
Hungary	Romania	France	
Ireland		Germany	
Italy		Greece	
Netherlands		Hungary	
Poland		Ireland	
Portugal		Malta	
Slovakia		Poland	
Slovenia		Portugal	
Spain		Romania	
Sweden		Slovakia	
United Kingdom		Spain	
		Sweden	
		United Kingdom	

As visualized in Table 1 the Member States of the EU have been chosen as units of analysis as the structure of their electricity markets is based on and the result of the same overarching regulations established through the European Union. Article 194 of the Treaty on the Functioning of the European Union sets the goals and competencies of the EU on this policy field (art. 194 "TFEU,"). The absolute numbers in Megawatt for each year have been standardized with generation as nominator and population of the year 2015 as the denominator, as the population of the respective country serves to relate the capacity to the eventually occurring demand and thereby make the values more comparable between the countries. In the following, the values were divided by 10000 in order to bring them to a more convenient scale to work with. Subsequent, the unit of measurement for the predictor, criterion and moderator variable was aligned by calculating the z-scores so as to be able to compare the data that reflects the different variables.

3.2.1 Sources. Data defining the criterion variable *capacity to produce electricity from renewable energy sources* was obtained from a data publication of the European Commission (see ch. 2.1.1). The SHARES'-Tool provides consistent information regarding installed capacity in Megawatt for each European Member States. The predictor variable *structure of the electricity market* (see ch. 3.1.2) is constructed with the data provided by the OECD's (see ch. 2.1.2). It provides an indicator depicting the *sector regulation for the electricity sector* and serves to classify the markets of the respective countries that are included in the study presented in the paper at hand. Information needed to construct the moderator variable *environmental support policies* also retrieved from the *environmental policy stringency index* that is also constructed by the OECD (see ch. 2.1.3).

3.2.2 Data Description. In this section, the collected data of each variable will be presented and certain characteristics and peculiarities are pointed out. The sample size of the study in the present paper is N = 28 but due to limitations of the sources the data were retrieved from, the number of cases varies between the predictor, moderator and criterion variable (see table 1). If provided, relevant data were collected for each country and each year between 2004 and 2012 (see ch. 3.1.1 to 3.1.3). In order to adequately depict the moderator variable *support policies* in the context of the study in the present paper, the two indices for *Feed-In Tariffs* and *Trading Schemes* have been added up (see ch. 3.1.3). The predictor variable *structure of the electricity market, as well as the moderator variable environmental support policies,* are measured on an ordinal scale whereas the criterion variable *capacity to produce RES-E* is measured on a continuous scale. The variables represent paired observations as the score on each variable for a single unit is reflected.

In the following, the average value over the period 2004 to 2012 for the predictor, criterion and moderator variable have been calculated and standardized by computing the z-scores in order to allow for a comparison. Figure 2 portrays the overall development of the predictor variable *structure of the electricity markets* of the countries analyzed as reflected by the index used in this study (see ch. 3.1.2). The Y-axis represents the arithmetically averaged values of the index, ranging from 2.08 to 2.89 and the X-axis displays each year between 2004 and 2012. The same rationale applies for figure 3, which expresses the development of the criterion variable *capacity to produce renewable energy* of the countries analyzed as reflected by the capacity in Megawatt (see ch. 3.1.1).

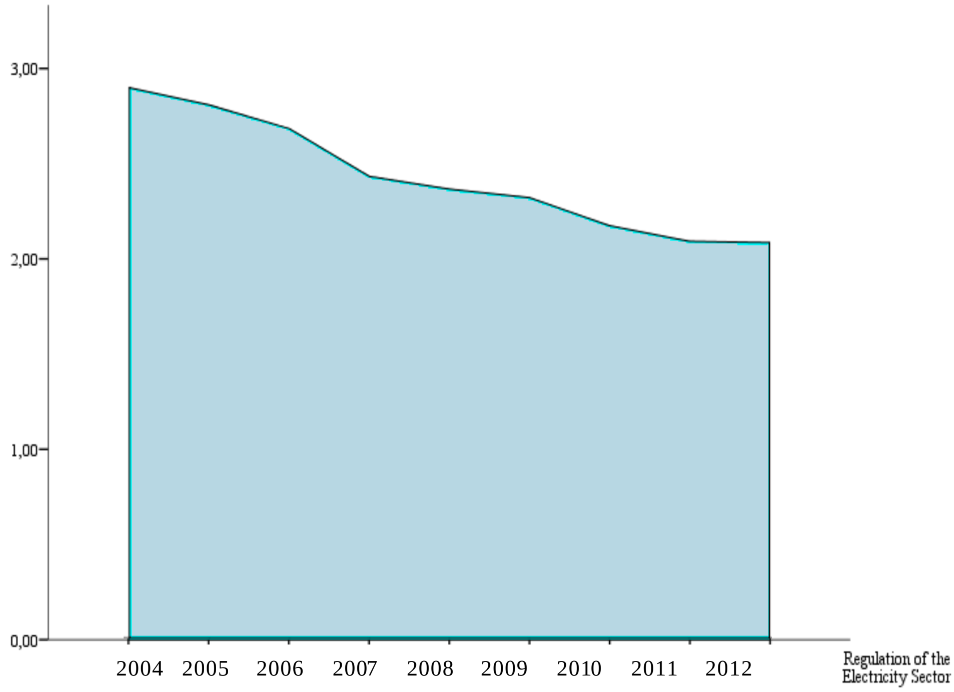

Figure 2. Mean of the predictor variable *overall sector regulation* over the years 2004 - 2012

The processed values range from 0.016 to 0.1185. Figures 2 and 3 serve to give an impression of the temporal progress of the two variables that appear to have an opposing tenor over the period from 2004 to 2012, as the sloping line of figure 2 illustrates what has been described in chapter 2.1.3, namely a general trend towards more liberalized electricity markets, whereas the bars in figure 3 illustrate an annual increase in capacity in the Member States of the European Union.

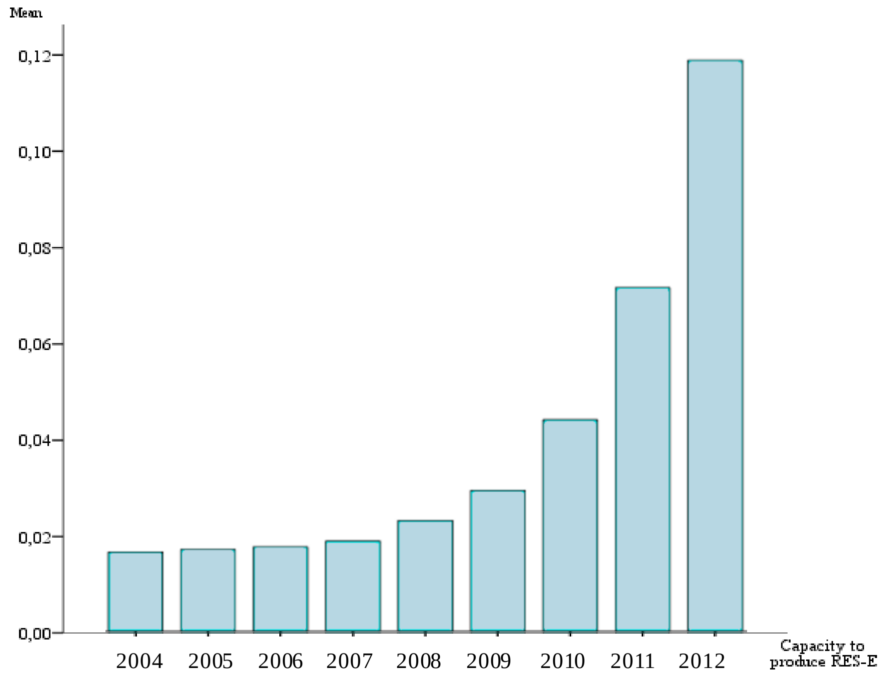

Figure 3. Mean of the criterion variable *capacity to produce renewable energy* over the years 2004 - 2012

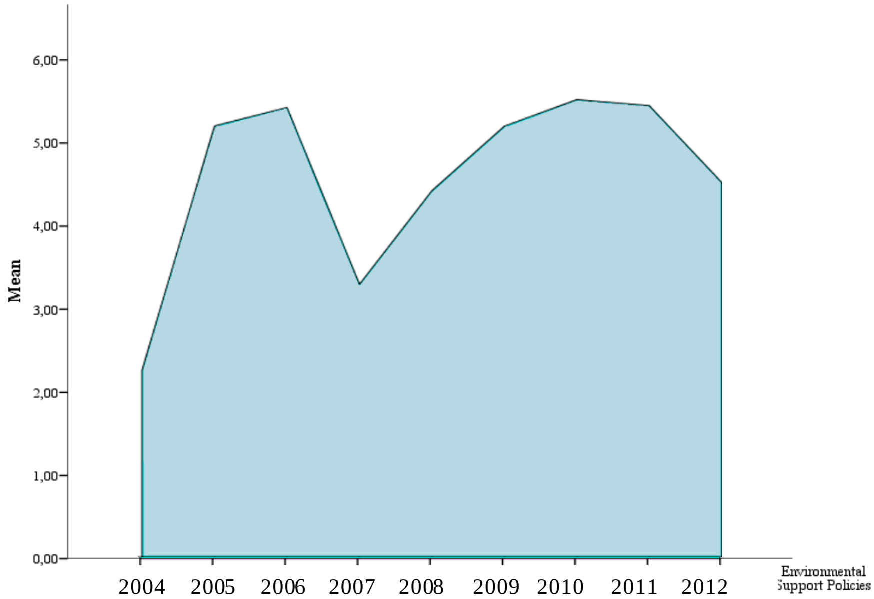

Figure 4. Mean of the moderator variable *environmental policy support* over the years 2004 – 2012

Remark: *Sum EPS* represents the moderator variable *support policies*

In order to depict the moderator variable *support policies*, the values for all countries derived from the index (see ch. 3.1.3) have been averaged for the period 2004 to 2012. Different from the above-described predictor and criterion variable (figure 2 & 3), figure 4 does not indicate a clear tendency. It rather illustrates a fluctuation of the data over the period from 2004 to 2012. Ranging from 2.24 to 5.50, it is noticeable that the data starts in 2004 at the minimum, rises to 5.40 in 2006 and then drops to its second lowest score in 2007, from which point it climbs up again to the maximum in 2010 and subsequently declines until 2012. This peculiar course indicates that starting in 2006 decisions concerning the implementation of support policies have been made that led to a mitigation of their intensity and potential influence.

3.3 Statistical Methods

Hierarchical multiple regression is used to assess the effects of the moderating variable *environmental support policies* on the associated relationship between the predictor variable *structure of the electricity market* and the criterion variable *capacity to produce renewable energy* (see ch. 4.3). In order to test for correlation between the predictor variable and the criterion variable the nonparametric measure Kendall's *tau*-b was used (see ch. 4.2).

4 Analyses

Chapter 4 reports the results of the statistical analyses carried out via IBM SPSS 23. In doing so, first descriptive results (see ch. 4.1), second the results of the hierarchical moderated regression analysis (see ch. 4.2) and third results of the correlation analysis (see ch. 4.3) are presented.

4.1 Descriptive Results and Check for Model Requirements

The mean of the criterion variable *capacity to produce renewable energy* (see ch. 3.1.1) is M = 0.03 (SD = 0.11) and the value ranges from 0.00 to 0.59 (R = 0.59). The mean of the predictor variable *structure of the electricity market* (see ch. 3.1.2) is M = 2.42 (SD = 0.83) and the value ranges from 1.03 to 4.02 (R = 3.00). The mean of the moderator variable *environmental support policies* (see ch. 3.1.3) is M = 3.75 (SD = 1.04) and the value ranges from 3.24 to 6.99 (R = 3.75).

The Kolmogorov-Smirnov test was used to check for a normal distribution of the predictor, criterion and moderator variable. The results of the test are outlined in table C1 and indicate a normal distribution for standardized variables *structure of the electricity market* and *environmental support policies* as the significance is greater than .05. Regarding the criterion variable *capacity to produce RES-E* the Kolmogorov-Smirnov test indicates a statistically significant deviation from normal distribution.

For this reason, it is checked for the steepness as well as the kurtosis of the variables (see table 2). For the predictor variable *structure of the electricity market* the steepness equals 0.37 (SD = 0.52) and the kurtosis -0.803 (SD = 0.101); for the moderator variable *support policies* the steepness equals 0.87 (SD = 0.52) and the kurtosis 0.383 (SD = 1.01) meaning that for both variables steepness and kurtosis are within an acceptable range between ± 1 and thereby still indicating a normal distribution. Nevertheless, the visual inspection of the Q-Q-Plots and the histograms (figures A1 to A4) do provide reason to question the assumption of normality.

Regarding the criterion variable *capacity to produce RES-E*, the steepness equals 2.16 (SD = 0.52) and the kurtosis 5.40 (SD = 1.01), underlining the assumption of non-normal distribution that is also supported by visual inspection of the scatterplot (figure A6).The standardized residuals of the criterion variable *capacity to produce RES-E* (see ch. 3.1.1) are not normally distributed, as assessed by Kolmogorov-Smirnov test. There was no evidence of multicollinearity, as demonstrated by no tolerance values less than .948 and no variance inflation factor greater than 1.055 (see table D1). Following visual inspection of the standardized residuals plotted against the predicted values, the assumption of homoscedasticity has to be contested. Linearity was established by visual inspection of a scatterplot.

Table 2 Descriptive Results

		Average Electricity Sector Regulation	Average Capacity divided by population	Average Policy Support
Number of Cases	Included	21	28	19
	Excluded	7	0	9
Range		3.00	.59	3.75
Mean		2.4280	0.0394	4.5730
Standard deviation		0.83709	0.11224	1.04607
Skewness		0.083	4.717	0.876
Kurtosis		-0.665	23.498	0.382

4.2 Correlation Analysis

In consequence of the non-normal distributed variable *capacity to produce electricity from renewable sources* (see ch. 4.1), the nonparametric measure Kendall's *tau*-b was run to determine the relationship between the predictor variable *structure of the electricity market* and the criterion variable *capacity to produce RES-E* amongst 21 countries (see ch. 3.1). For this analysis, the sample is larger as for the hierarchical moderated regression analysis since the latter was limited by the availability of data for the moderator variable *support policies*.

As depicted in table B1 there was a weak negative association between the predictor variable *structure of the electricity market* and the criterion variable *capacity to produce electricity from renewable sources*, which was not statistically significant, $\tau_b = -.124$, $p = .432$. Therefore, the null hypothesis cannot be rejected and the alternative hypothesis cannot be accepted.

When taking a closer look at the correlations in table 3, there is a significant negative correlation of medium strength between the two variables in the years 2004 until 2008 ($p = 0.02$) from where the value rises into insignificance ($p = 0.26$). Within this timeframe, the significant correlation coefficient ranges from -.367 in 2008 to -.453 in 2006. The strongest correlation between the *structure of the electricity market* and the *capacity to produce electricity from renewable sources* with a high level of significance can be found in the year 2006 for both variables ($\tau_b = -.453$). It is noticeable that the upper left quarter of table 3 shows significant negative correlation of medium strength for the two variables across different timespans. In that regard, the *structure of the electricity market* of the year 2007 is stronger negatively correlated with the *capacity to produce RES-E* in the year 2004 than in 2008. The correlation coefficients steadily decrease until 2011, where they reach the overall minimum of τ_b = -.024 (*p* = .880). For the year 2012, the correlation becomes stronger again with a correlation coefficient of -.067 (*p* = .672).

Tab. 3 Correlation (Kendall's tau) between *structure of the electricity market* and *capacity to produce RES-E from Photovoltaic*

		electricity sector regulation								
		2004	2005	2006	2007	2008	2009	2010	2011	2012
Capacity	2004	-.419*	-.395*	-.426**	-.374*	-.374*	-.313	-.210	-.185	-.185
	2005	-.427**	-.382*	-.453**	-.392*	-.392*	-.322*	-.201	-.166	-.166
	2006	-.407*	-.403*	-.453**	-.392*	-.392*	-.322*	-.201	-.166	-.166
	2007	-.366*	-.382*	-.413*	-.392*	-.392*	-.322*	-.242	-.227	-.227
	2008	-.322*	-.298	-.347*	-.357*	-.367*	-.289	-.259	-.235	-.235
	2009	-.184	-.199	-.228	-.228	-.237	-.179	-.150	-.117	-.117
	2010	-.091	-.087	-.154	-.183	-.192	-.154	-.106	-.043	-.043
	2011	-.053	-.048	-.134	-.163	-.172	-.134	-.086	-.024	-.024
	2012	-.057	-.072	-.138	-.186	-.215	-.177	-.129	-.067	-.067

Remarks:
**. Significance level of the correlation 0.01
*. Significance level of the correlation 0.05

4.3 Hierarchical Moderated Regression Analysis

A hierarchical multiple regression was run to assess the statistical significance of the interaction term between *structure of the electricity market* (see ch. 3.1.2) and *capacity to produce electricity from renewable sources* (see ch. 3.1.1). The interaction term is composed of the criterion variable *structure of the electricity market* and the moderating variable *support policies* (see ch. 3.1.3). As regards a moderating effect, based on the collected data the results presented in this chapter can only be interpreted with reservation since the data does not meet all the requirements necessary (linearity, multicollinearity, homoscedasticity and normality) to conduct a hierarchical moderated regression analysis (see ch. 4.1).

As illustrated by table 4 the variable *support policies* was examined as a moderator of the relation between the variable *structure of the electricity market* and the variable *capacity to produce electricity from renewable sources*. The predictor and the moderator variable were entered in the first step of the regression analysis. Secondly, the moderating variable was introduced and in the third step of the regression analysis, the interaction term between the moderator and the predictor variable was entered.

As evidenced by an increase in total variation explained of 3 % ($\Delta R^2 = 0.03$) which was not statistically significant ($F(3, 18) = 1.44$, $p = .48$), no moderating effect between the variables *structure of the electricity markets* and *capacity to produce electricity from renewable sources* can be asserted. The effect size of the interaction term (β = -.17) itself is very low and when comparing it to the effect size of the predictor variable X (β = -.39) and the moderating variable (β = -.28) it is the weakest of all three. β demonstrates that the predictor variable X has the strongest effect on the criterion variable Y.

Table 4 Results of the hierarchical moderation analysis

		β	s_β	*t*	*p*	ΔR^2
Model 1	*Structure of the electricity market*	-.34	.08	-1.49	.16	.12
	$R^2 = .12$ $F(1, 18) = 2.22$, $p = .16$					
Model 2	*Structure of the electricity market*	-.40	.08	-1.75	.10	.08
	Support policies	-.29	.07	-1.27	.22	
	$R^2 = .20$ $F(2, 18) = 1.95$, $p = .22$					
Model 3	*Structure of the electricity market*	-.39	.08	-1.66	.12	.03
	Support policies	-.28	.07	-1.18	.26	
	Interaction term	-.17	.08	0.73	.48	
	$R^2 = .22$ $F(3, 18) = 1.44$, $p = .48$					

4.4 Decision concerning Hypotheses

Based on the data analyses conducted in the study presented in the paper at hand, hypothesis 1 and hypothesis 2 regarding a moderation effect of *environmental support policies* on the relationship between the *structure of the electricity market* and the *capacity to produce RES-E* from Photovoltaic (cf. chapter 2.2) do not achieve empirical support. The data does not comply with all requirements (linearity, multicollinearity, homoscedasticity, outliers/ influential cases, normality) for a hierarchical moderated regression analysis as presented in chapter 4.1. Consequently, the results of the analysis need to be interpreted with reservation. The results display an effect size of the interaction term that was considerably smaller than the effect size of either of the predictor variable and the moderator variable and moreover not significant (see table 4). As regards the test for correlation (see ch. 4.2), the correlation coefficient indicated a weak negative association that was not significant. Yet, when analyzing the correlation coefficients for each year between 2004 and 2012, a pattern can be detected in which the association is of medium strength and significant. For this reason, hypothesis 3 does achieve empirical support, although only partially.

5 Discussion

The research question of the paper at hand was: *Does the structure of electricity markets influence the share of renewables in electricity production and if yes, what is the impact of policy support instruments?* (cf. chapter 2.2) The theoretical background as presented in chapter 2.1 allowed for the assumption of a moderating effect of *environmental support policies* on the relationship between the predictor variable *structure of the electricity market* and the criterion variable *capacity to produce RES-E*. The criterion variable is reflected by the capacity of each European Member State to produce electricity from Photovoltaic measured in Megawatt and the respective data was retrieved from the SHARES'-Tool of the European Commission. In order to express the predictor variable *structure of the electricity market,* the indicator *sector regulation for the electricity sector* constructed by the OECD was utilized. The OECD also provided the *environmental policy stringency index* that was used to represent the moderator variable *environmental support policies (*cf. chapters 2.1.1 to 2.1.3). The hierarchical moderated regression analysis did not provide significant results and only allows for an interpretation with reservation. Subsequent the correlation analysis was conducted, revealing a significant correlation of medium strength between the predictor and the criterion variable between 2004 and 2008. Since 2008 the correlation coefficient steadily diminishes and the *p*-value indicates no significance (see tab. 3). This pattern allows for assumptions and suggestions regarding follow-up studies to investigate for third variables that exert significant influence on the association between the *structure of the electricity market* and *capacity to produce RES-E.*

In the following chapter the results of the study presented in the paper at hand will be discussed in the context of the preliminary theoretical considerations (see ch. 5.1 and 5.2) and the hypotheses derived from the research question of the present paper (see ch. 2.2.1) Furthermore, potential constraints to the study are reviewed (see ch. 5.3) followed by recommendations for future research relating to the before mentioned limitations. Chapter 5.5 concludes the study presented in this paper.

5.1 Hierarchical Moderation Regression Analysis

The results of the hierarchical moderated regression analysis need to be interpreted with reservation as the requirement for normality could not be fulfilled for the criterion variable *capacity to produce renewable energy* and the assumption of homoscedasticity has to be contested too (see ch. 4.1). The statistical analysis (see ch. 4.3) conducted within the context of the study presented in the paper at hand could not provide any empirical support for the inherently plausible hypotheses for moderation (see ch. 2.2). The non-significant outcome of the analysis (see ch. 4.3) can be attributed to the limitations posed by the failure to fulfill the requirements for a hierarchical moderated regression analysis (see ch. 4.1). Conniving at these restraints, it can be assumed that based on the indicators used, there is no actual moderating effect within the population that was observed. A potential reason for this non-significance could be, that the indicators chosen to operationalize the variables do not reflect the very sufficiently by either omitting critical factors necessary for an appropriate depiction or eventually include confounding information. This would mean that factors differing from the ones included in the study in the paper at hand do actually act a determining effect on the market opportunities for photovoltaic. Therefore, in order to further investigate on this, more indicators need to be included respectively new indicators need to be constructed and subsumed to a scale so as to allow for a more broadly defined depiction of the variables. The data basis must be checked for its quality and thus its appropriateness to describe and allow for analysis of the *structure of the electricity market* and its effect on certain product segments, as in this case *capacity to produce electricity from renewable sources*, as in the case of the study presented in the paper at hand, photovoltaic technology.

5.2 Correlation Analysis

Following the analysis for correlation with Kendall's *tau*-b, there was a weak negative, non-significant association between the *structure of the electricity market* and the *capacity to produce electricity from renewable sources* (see ch. 3.4.2). However, when analyzing table 3 for associations between the predictor and the criterion variable in every single year for the period of interest, it becomes apparent that the negative correlation coefficient for the relationship in similar years is significant until 2008 ($p = 0.02$) and then the value rises into insignificance ($p = 0.26$). Looking at the arithmetic means, a visual inspection of the data (see figures 2 to 4) illustrated that over the course of time, the *structure of the electricity market* constantly changed in one direction, namely towards a more liberalized market while the *capacity to produce RES-E* constantly increased (cf. chapter 3.2.2). The sudden change provides reason to assume that the *capacity to produce RES-E* from photovoltaic ultimately depends on parameters that are not included in the study presented in the paper at hand. Consequently, taking into account the theoretical assumptions and scientific findings that were elaborated in chapter 2.1, it suggests itself that economic factors exert an essential influence on the *capacity to produce RES-E*. In order to obtain an increase in PV-capacity, investments in either innovation or the construction of new plants are necessary. These investments are held back in times of unstable and thus uncertain economic and regulative circumstances. Following this reasoning, it appears logical to check for external economic factors that could have had the effectualness to exert an influence on the *capacity to produce RES-E from Photovoltaic*, strong enough to cause a progress of the very independently from the *structure of the electricity market*. As the association between the predictor and the criterion variable is significant until 2008 and then becomes more and more insignificant, it has to be checked for economic factors arising in that instant of time, that may account for this process. With what began as a credit crunch, these prevailing economic circumstances eventually were carried to Europe in 2007 and until 2008 developed into a global economic and financial crisis that had just the potential to cause a widespread change of agendas and courses of action in various sectors (Fritz-Morgenthal et al., 2009). When taking a closer look at the raw data, it is noticeable, that Luxembourg, a country with a high *capacity to produce RES-E* in relation to its population, was opening its markets like all the European Member States did but starting in 2008, they began aggravating market entrance for new competitors. These kind of changes in the data are not directly reflected when calculating with the mean over the years, but they are when looking at table 3. This crisis posed a major source of uncertainty in the economy and thereby eventually caused an unwillingness to invest. Repayment-periods for loans were shortened respectively obtaining a credit by a bank at all was aggravated which eventually caused cancellation of construction projects. Chapter 5.4 further elaborates on the potential influence of the financial crisis on the *capacity to produce RES-E* as it is a potentially important factor to include into further investigations regarding this matter.

5.3 Constraints

The sample used in this study was inevitable small (N = 28) and had to be reduced even more due to a lack of data (n_a= 19). The external validity is limited as the results are constrained to the countries of the European Union and therefore cannot be applied to countries with a substantially different economic and regulatory basis (see ch. 2.1.1). Furthermore, the quality of the data used in the study of the paper at hand could not be checked in its entirety. The indicators constructed by the OECD, used for the predictor and moderator variable in the study of this paper (see ch. 3.1.2 and 3.2.3) are simplified in order to capture a multidimensional setting of policies. They might contain flaws leading to a devaluation of the results and thus it is necessary to question the content validity. It is questionable whether the indicators from the European Commission and the OECD included in the study of the present paper are the most appropriate and valid to represent the variables of interest or if an integration of different datasets would have led to different results of the analysis. Using these sources might portray the *structure of the electricity markets* adequately but eventually not in its entirety. Competition could lead to cartelization respectively monopolization and a displacement of less established opponents within the electricity market. The market leaders then have the ability to incapacitate niche products such as photovoltaic. These kinds of processes are not captured by an index solely covering the *de jure* situation of a market and could ultimately cause the correlation to go towards zero given the case that the before hypothesized situation is taking place in some countries and in others not. Nevertheless, even with more appropriate data, the sample size is limited to a maximum of 28 countries when exclusively focusing on the European Union. The comparability of the countries poses another constraint. The similar structures of the markets of the European Member States (see ch. 2.1.1) that on the one hand are conducive to the inclusion of the countries into the study limit the very on the other hand in terms of generalizability.

5.4. Future Prospects

As stated in chapter 5.3, the content validity of the study in the paper at hand is needed to be ensured as regards further investigations. In order to obtain convenient results, the commensurability of the 28 European Member States needed to be operationalized by indicators like infrastructure, energy consumption, gross domestic product and other numerical values reflecting the conditions within a national market – at least to be controlled for a statistically significant influence. A following analytical examination of the legislative framework for each country's economic and energy policy could serve to finally conceptualize those into indicators for liberal vs. hierarchically structured markets. The Indicators included would need to portray not only the *de jure* situation of the respective markets but also include the *de facto* situation, eventually depicting deviation from what was envisaged with the introduction of certain regulations. By including the actual state of affairs within a market, potential side-effects that are not explicitly mentioned in the legislation respectively factors that are not directly linked with the particular segment but could wield an influence on the very, are to be captured too. As regards the *de jure* situation, using the policies and regulations concerning competition in a market can only be a part of a larger scale constructed of various indicators covering a broader range of legislation regarding economic, financial, environmental, (supply) security, and other potentially influential factors.

The indicators should put a focus on both regulatory as well as economic factors since the economic situation of a certain market exerts leverage not only on the economical but also on the regulatory agenda. Inconsistencies in the pattern of correlation (see table 3) raise the question for a variable that poses an influence on the *capacity to produce RES-E from Photovoltaic* to the degree that the influence of the *structure of the electricity market* becomes insignificant. Assuming that constant investments are the foundation of an increase in capacity (cf. chapter 2.1.3), it should be checked for factors that may cause an abrupt ceasing in the capital flow in the year 2008. With regard to what has been elaborated in chapter 5.2, the financial crisis, starting in 2007 and increasing in its impact until 2008, is assumed to have caused a direct reduction in investments as well as a reduction in energy demand through the economic recession (Birol, 2010). The crash of numerous financial institutes such as Lehman Brothers and Merrill Lynch caused a rise in uncalculatable risks and distrust in the financial sector. Many banks were socialized by undertaking large expenses – the government of the United States agreed on a bailout package of 700 billion US Dollar in order to clear away uncertainties that hindered investments which in turn intensified the recession (Lewis, 2011). This provides reason to expect the impact of the crisis to account for the shift from significance to insignificance of the correlation between the predictor and the criterion variable. On that account, a variable would need to be constructed that explains the occurrence of the financial crisis as well as the change of association between the predictor and the criterion variable. Indicators used to conceptualize the variable might be drawn from the financial- more precisely, the stockbroking sector, as this is the setting and the origin of the crisis. For each country that is included, the following indicators could be used to depict the situation in the respective market: Key interest rate, government bonds, the configuration of subsidies for the respective sector, stock market structure and the like.

As shown in figure 4 in chapter 3.3.2, the cut in the graph displaying the moderator variable *support policies* can also be associated with the repercussions of the economic crisis. Even though the results obtained from the hierarchical moderated regression analysis do not provide much basis for interpretation, the fundamental assumption of an influential impact of support policies should not easily be negated and therefore also be included in the measurement. As a consequence, the effort needed to construct a scale that is capable of appropriately reflecting the respective energy market segment, as in this case for photovoltaic, requires a larger scope than the study in the context of the paper at hand could be based upon so as to be able to reliably and validly detect a relationship between the *structure* of a market and the *capacity to produce RES-E.*

As explained in chapter 5.3. the external validity could be strengthened by including countries from different continents, with fundamentally different economic and regulatory preconditions. This enhances the generalizability of the study.

5.4 Conclusion

Given the theoretical assumptions presented in chapter 2.1, conducting a hierarchical moderated regression analysis was reasonable. As became apparent, the results do not support the hypothesized associations between the predictor variable *structure of the electricity market,* the moderator variable *support policies* and the criterion variable *capacity to produce electricity from renewable sources* (see chap. 2.2.1). For this reason, it had to be searched for factors that are able to explain the unexpected findings. The correlation analysis conducted for the predictor variable and the criterion variable (see chap. 3.4) indicated a pattern, that was a negative correlation of medium strength for the years 2004 until 2008 when the strength of the correlation decreases and the results become insignificant (see table 3). In turn, as regards the contextual and conceptual level, this suggests checking for influential third variables that are directly linked to the financial crisis in the year 2007 respectively 2008 (see chap. 5.2). Prospective studies can further investigate on this matter by extending the scope to an economy-wide perspective in order to capture occurrences that might not directly have an effect on the capacity but might exert an indirect effect and furthermore cautiously including data of higher quality, as the results of the study presented in the paper at hand can only be interpreted with reservations due to the quality of the data.

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Appendix

Content:

Appendix A

Test for Normality for the Predictor, Criterion and Moderator Variable

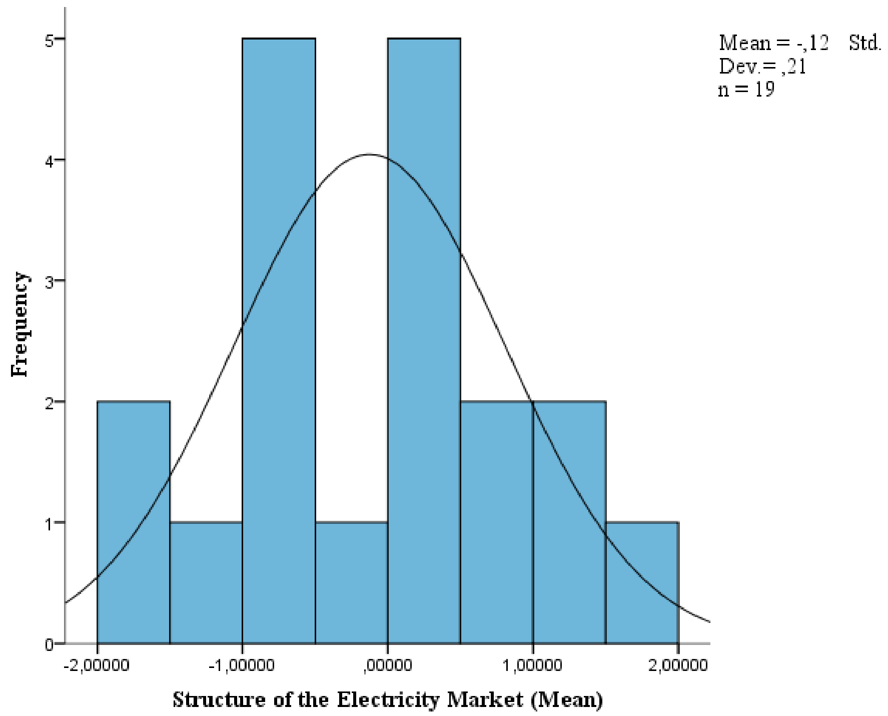

Figure A1. SPSS-Output - Histogram for the variable *structure of the electricity market* with indicated line for normal distribution

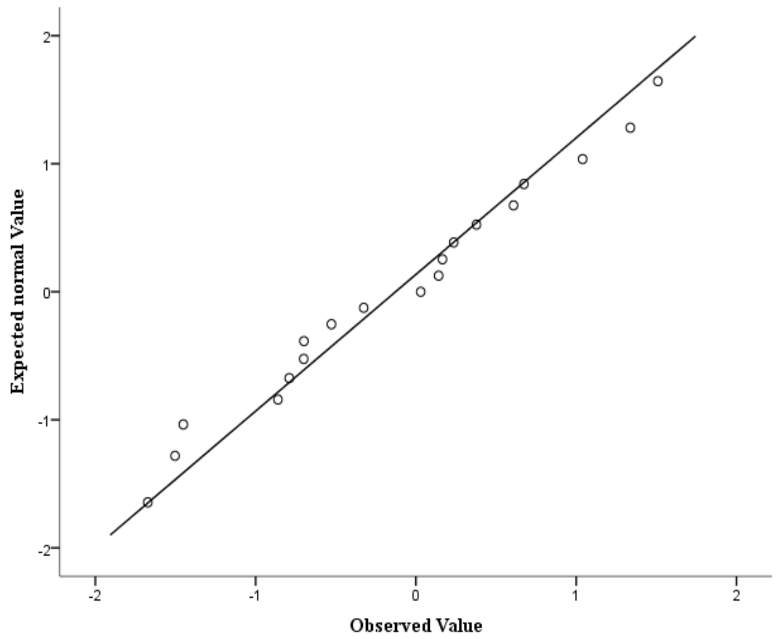

Figure A2. SPSS-Output – Q-Q-Plot for the variable *structure of the electricity market* with indicated line for normal distribution

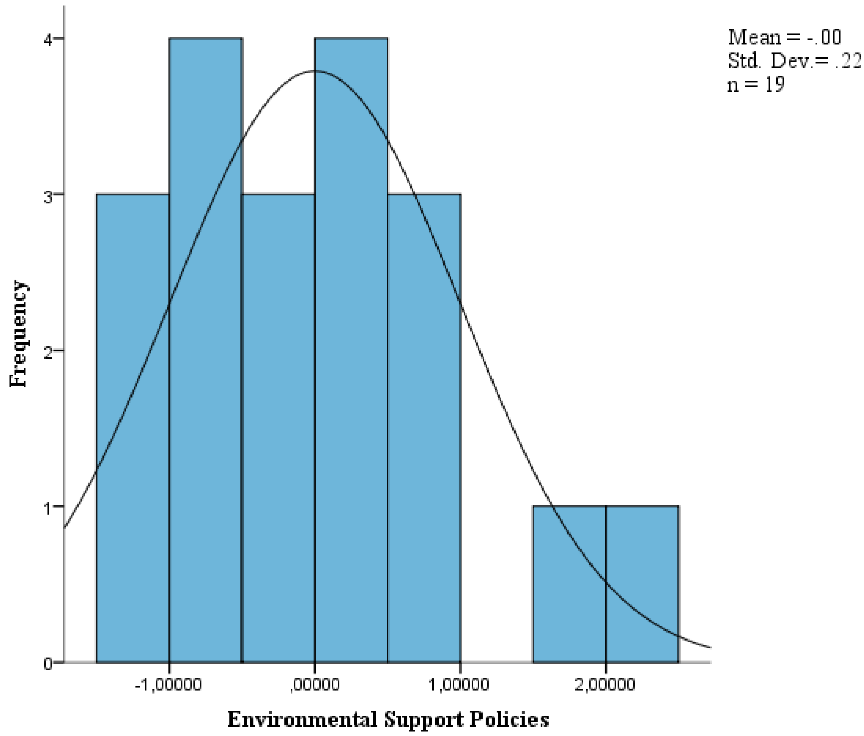

Figure A3. SPSS-Output – Histogram for the variable *environmental support policies market* with indicated line for normal distribution

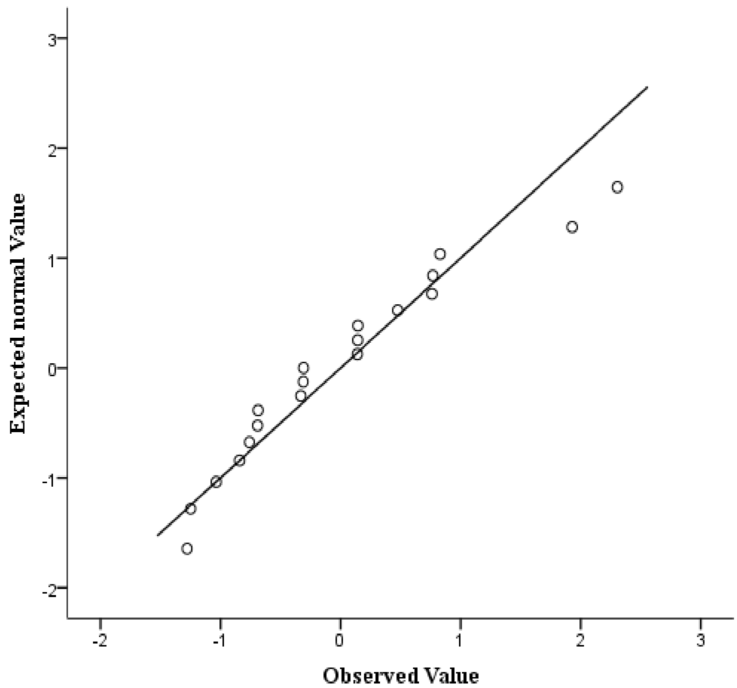

Figure A4. SPSS-Output – Q-Q-Plot for for the variable *structure of the electricity market* with indicated line for normal distribution

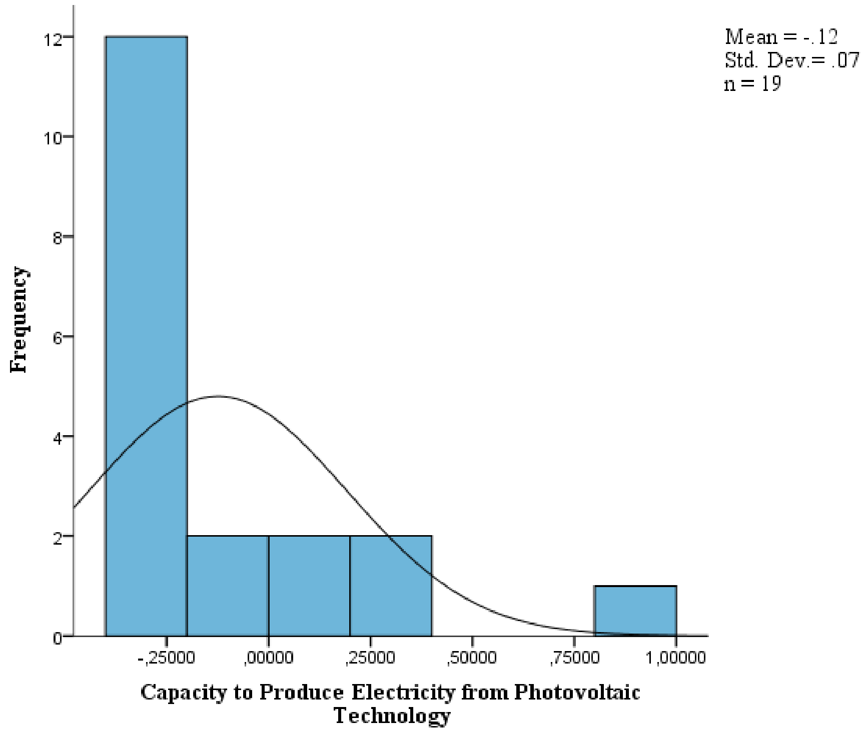

Figure A5. SPSS-Output – Histogram for the variable *capacity to produce electricity from renewable sources market* with indicated line for normal distribution

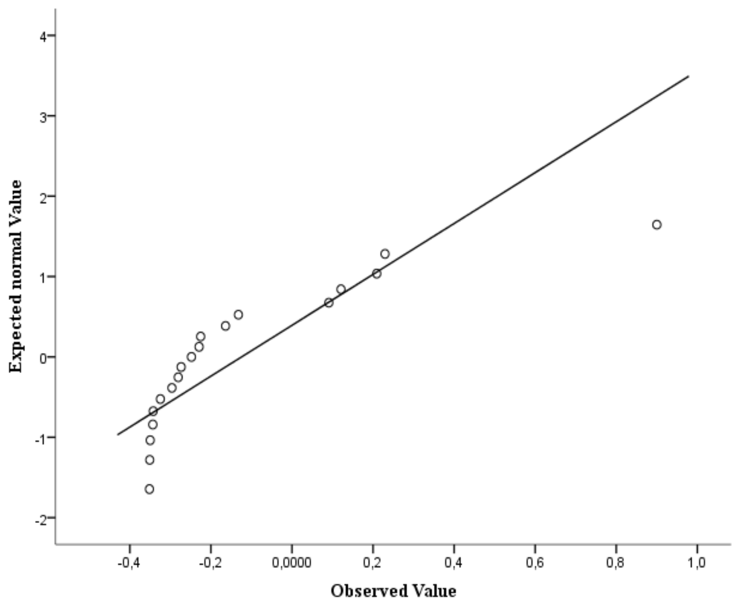

Figure A6. SPSS-Output – Q-Q-Plot for the variable *capacity to produce electricity from renewable sources*

Appendix B

Table Displaying the Results for Kendall's tau-b (τb) Correlation Coefficient

Table B1

			Average electricity sector regulation	Average Capacity
Kendall-Tau-b	Average electricity sector regulation	Correlation coefficient	1.000	-.124
		Sig. (2-sided)	.	.432
		N	21	21

Appendix C

Table displaying the results for the Kolmogorov-Smirnov Test for Normality

Table C1: Kolmogorov-Smirnov Test for Normality

	Kolmogorov-Smirnov		
	Statistic	*n*	*p*
z-score(MW_sec_reg)	.098	19	.200
z-score(MW_cap_pop)	.257	19	.002
z-score(MW_support)	.148	19	.200

Remark:
z-score(MW_sec_reg) represents the predictor variable *structure of the electricity market*
z-score(MW_cap_pop) represents the criterion variable *capacity to produce renewable energy*
z-score(MW_support) represents the moderator variable *environmental support policies*

Appendix D

Table Displaying the Regression Coefficients, Results of the T-test and check for Multicollinearity

Table D1: Regression Coefficients for both predictor and moderator variable

		Unstandardized Coefficients		Standardized Coefficients			Collinearity	
		Regression Coefficient B	Std. Error	Beta	T	Sig.	Tolerance	VIF
Model 1	(Constant)	-.139	.71		-1.960	.067		
	z-scores Sector Regulation	-.115	.77	-.340	-1.489	.155	1000	1.000
Model 2	(Constant)	-.141	.70		-2.032	.059		
	z-scores Sector Regulation	-.135	.77	-.401	-1.749	.099	.956	1.046
	z-scores Support Policies	-.092	.72	-.291	-1.269	.222	.956	1.046
Model 3	(Constant)	-.130	.73		-1.787	.094		
	z-scores Sector Regulation	-.130	.79	-.386	-1.655	.119	.949	1.054
	z-scores Support Policies	-.087	.074	-.276	-1.179	.257	.948	1.055
	Product Term	.060	.83	.167	.728	.478	.987	1.013

Remark: Criterion Variable: *Capacity to produce RES-E from Photovoltaic*

Declaration of Originality

Student Name: David Yannick Pohl	Matriculation Number: 1595806
Date of Birth: 30.09.1992	
Course Title: Bachelor Thesis EPA (2015-2B) Subject of the Study: Change and innovation in energy supply	
Topic of the Work: Assessing the Influence of the Market Structure on the Capacity to produce electricity from Renewable Energy Sources in European Countries	

I declare herewith, that this above-mentioned work (essay, project, thesis etc.) is my own original work.

Furthermore, I confirm that:

- This work has been composed by me without assistance;
- I have clearly referenced in accordance with departmental requirements, in both the text and the bibliography or references, all sources (either from a printed source, internet or any other source) used in the work;
- All data and findings in the work have not been falsified or embellished;
- This work has not been previously, or concurrently, used either for other courses or within other exam processes as an exam work;
- This work has not been published.

I appreciate that any false claim in respect of this work will result in disciplinary action in accordance with university or departmental regulations.

I confirm that I understand that my work may be electronically checked for plagiarism by the use of plagiarism detection software and stored on a third party's server for eventual future comparison.

Signature: D. Pohl

Date: 11.09.2016