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DISSERTATION PROJECT

The role of Public Policy and Regulation in the transformation of the Electricity Sector: The case of the Germany Energy Transition

O papel de Politicas Publicas e da Regulação na transformação do Setor Elétrico: O caso da Transição Energética na Alemanha

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Motivation

Among economic historians there exists a consensus that an essential pillar of the economic transformation which took place during the 19th century, often referred to as the industrial revolution, was exploiting new sources of energy (Goldstone, 2002). The boom of renewable energy generation in the 21st century marks the beginning of a new fundamental shift which in its disruptive force will rival the industrialization nearly two centuries ago. Just like the industrial revolution, which transformed transportation, energy generation and production, we are witnessing a similar tectonic shift in these three fields. E-mobility, renewable energy and the internet of things are all key elements in this transformation.

On the other hand, growing environmental concerns, including global warming, have brought governments together in an attempt to curb global CO2 emissions. An important part of the answer to this challenge will be found in the energy sector. As a consequence, there can be little doubt, that renewable energy generation will play an important role.

Thus, as a response, more and more countries pursuit the ideals of an innovation-led and sustainable economic model. Together with the notion of the dawn of a "third industrial revolution", there remains little doubt over the structural shifts we are witnessing. In this context, a wider discussion is re-emerging over what role the state should play in light of this paradigm change.

Confronted with these challenges a growing number of scholars discuss the importance of the state in pioneering, incentivizing and supporting this transformation. One of these scholars who has risen in prominence over the past decade has been Marina Mazzucato. For her argumentation, she draws on established ideas such as the developmental state, national innovation systems, evolutionary economics and mission oriented policy to elaborate on her vision of an "entrepreneurial state". With her theory of the "entrepreneurial state", she has

come to define the role of modern Government as being "... about identifying and articulating new missions that can galvanize production, distribution, and consumption patterns across sectors" (Mazzucato, 2015:14). In other words, the state is not restricted to the role of a facilitator, but in fact plays an important part in shaping and driving this process.

In this respect, the German policy framework emerging over the past 20 years is particularly interesting. The country has articulated a vision for what its future economy will look like. "The Energy Transition", "Industry 4.0" and "National Development Plan - E-Mobility" are examples of policy papers, which set the ambitious goal of transforming the German economy, through the adoption of new technologies, making it digitalised and sustainable. Just like the industrial revolutions in the past, this transformation is based on three pillars; transportation (in this case e-mobility), energy (in this case renewable) and production (in this case Internet of Things).

In particular, the German experience demonstrate several characteristics of such a proactive state. The case of the rise of renewable energy generation is emblematic of this entrepreneurial role of the state. The country has played a pioneering role in the research and diffusion of renewable energy sources, especially in the fields of wind and solar energy. The speed and quantity of installed solar power generation has been tremendous and the role of public policy in this process attracts little controversy today.

Within an incredibly short period of time, the country has been able to generate, accumulate and apply incredible levels of know-how to the field, ultimately fostering one of the worlds most advanced industries in renewable energy technologies. Germany "ranks among world champions in the deployment of renewable technologies, being the second country in the world with total renewable power capacity per capita" (WWF, 2016). On May 8th 2016, renewable energy generation reached a new record high, providing 87.6 % of domestic electricity consumption[1] (WWF, 2016). As a result, Germanys electricity mix has

[1] On that given day, wind and sun conditions were particularly favorable.

been dramatically transformed in the past 25 years with renewable energy going from representing 3.4% of gross electricity consumption in 1990 to 32.6% in 2015.

Of course, this incredible transformation did not occur in a political vacuum nor was it solely the result of market forces. The monopolistic nature of the energy sector at the time, created an additional barrier for the market integration of these renewable technologies. Thus, Germany has played a pioneering role in articulating and implementing a vision for the future of its economy. Emblematic of this has been the "Energiewende" (Energy Turnaround, in German), a concept and policy action plan for transforming the German economy, emphasizing the transition towards a carbon free economy.

Thus, the speed and quantity of installed solar power generation has been tremendous and the role of public policy in this process has been central. Yet, today's outcome was by no means self-evident and as a result, an analysis of the contributing factors to this success can be very relevant for understanding the trajectory of renewable energy in Germany, and in particular, the role of the state.

A particular milestone for the deployment of renewable energy technologies (RET) was the "Renewable Energy Sources Act" (EEG) which was signed into effect on the first of April, 2000. Particularly, the feed-in tariff (FIT) introduced through this law, has turned out to be a crucial policy mechanism to incentivize investment in RET and thus fits into what Mazzucato describes as the "catalytic role for Government in creating and shaping markets through dynamic public private partnerships (Mazzucato 2016)." This means, that public policy was able to shape and direct private investment into creating a robust market and demand for RET.

The feed-in-tariffs together with subsidies such as the "100.000 roof-tops-Program" greatly helped the diffusion of renewable/solar energy production while also nurturing an infant market. Especially in this aspect, the German energy transition is a particularly interesting example of "the entrepreneurial State" because the state plays a key, active role in inducing a larger technological paradigm shift.

In this context, analysing the diffusion of photovoltaic energy (or renewable energy as a whole) and the challenges that need to be overcome in this process, are

emblematic for the economic transformation. In other words, the efforts of driving the renewable energy market forward, have crucial spill over effects into other important areas. To exemplify: renewable energy greatly benefits from better energy storage technologies (i.e. batteries), which are a crucial component of e-mobility (i.e. electric cars) which on the other hand depend on energy production (specifically CO2 neutral); on the other hand greater renewable energy diffusion necessitates and benefits from a smarter grid of which a key element is smart-meter technology (i.e. Internet of Things, devices which monitor and communicate with each other) which in itself represents a key component of future industrial production. This is important to understand, because it shows how the dissemination of renewable energy is a figurehead for the greater transformation of the economy.

In addition, there is a particular merit in analysing the case of Germany and the case of photovoltaic. The former, because of its pioneering role in renewable energy policy, emanating from both an economic rationale and an interesting political dynamic (first Green Party in Europe, strong anti Nuclear energy movement) and because of its explicit formulation of policy goals ("The Energy Transition", "Industry 4.0", "National Development Plan - E-mobility").

In summary, there can be little doubt, that Germany is on its way of fundamentally transforming its economy. A great part of this transformation will necessitate innovation and political clout on the part of public policy, in order to guarantee its success. This transformation process has already reached a relatively advanced stage in the electricity sector, through the increased diffusion of renewable energy technologies. Thus, an analysis of the trajectory of these technologies over the past 15 years, paying particular attention to the role of public policy, can contribute to understanding the driving forces behind such a change.

Theoretical Framework

National Innovation System

The important role of technological progress and innovation in stimulating economic change has been recognized for a long time. Yet a more dedicated field of

studies surrounding innovation and technological progress only arose during the second half of the 20th century. Thus the study of innovations began to emerge as a separate field, differentiating itself from economics, in the 1960s (Sharif, 2005).

None the less, many of the origins of innovation studies today, have been largely inspired by the works of Joseph A. Schumpeter and other research traditions outside the economics mainstream, such as institutional economics, development economics, and, most notably, evolutionary economics. Yet while Schumpeter recognized the central role of innovation in economic progress, he made little effort to understand the process itself. Thus, a central concern of innovation studies has been to explain technological growth in an economy more effectively.

Initial theories describing the process of innovation, conceived it as a linear process following certain "stages". These successive stages were usually identified as basic research, applied research, development, production and diffusion (Cassiolato and Lastres, 2005). In this sense, the discussion involving the driving forces behind the innovative process revolve around two conceptualizations, the science push, which emphasizes the importance of scientific advances in "pushing" innovation, and demand pull, affirming the relevance of pressure through demand for new technologies in "pulling" the innovation process.

In the following decades, scholars began to analyze innovation not merely as an isolated act, but as a cumulative, non-linear process, with local and institutional specificities. This revision, was initiated by two prominent empirical research programs, the SAPPHO Project coordinated by Chris Freeman at Sussex University and the Yale Innovation Survey. These two empirical studies first time demonstrated the importance of formal and informal innovation networks. For many, including Cassiolato and Lastres (2005), these two works, among many others, represent the basic pillar upon which most of the innovation theory of the past 30 years has been build.

The 1980s witnessed the emergence of a more holistic systemic approach to innovation, through the contributions particularly of Chris Freeman and Bengt-

Åke Lundvall. Curiously enough, these advanced originated as much from policy as from academic institutions. In this sense, the Directorate for Science Technology and Industry (DSTI) of the OECD made significant contributions through its publication of "Technical Change and Economic Policy" (OECD, 1980), the "Sundquist Report" (OECD, 1988) and "Technology and the Economy: The Key Relationships" (OECD, 1992b). Simultaneously, in the world of academia, works such as Freeman (1987), Lundvall (1985,1992), Dosi et al. (1988) further propelled the development of innovation theory. At this point it is worth examining some of the origins behind these efforts of understanding innovation.

Going back to Schumpeters, The Theory of Economic Development (1912) to Capitalism, Socialism, and Democracy (1942), he argued against the prevailing trend among economists to define the core subject matter of the discipline as firm behavior, prices, and quantities under conditions of equilibrium. Schumpeter was clear that the most important feature of capitalism was that was an engine of economic progress (Nelson 2004). Taking this as their cue, both Freeman and Lundvall said that they felt dissatisfied with the lack of attention mainstream economic theories accorded to knowledge, technology, and technical change (Sharif, 2005). Influenced by Schumpeter's earlier analysis, Freeman, Lundvall, and other contemporary economists studying technological advance agreed that innovation, technological or otherwise, could not be understood within the confines of a theory that assumed stable equilibrium. Consequently, As Sharif (2005) points out, Lundvall affirmed that his own motivation for doing the NIS work was dissatisfaction with standard economics. That explains as well, why in some policy circles, the ideas brought forward by Freeman were perceived as "too much trouble" (Sharif, 2005). Sharif (2005:13) explains that the conflict arose because "Freeman had identified a role in the process of technological change to be played by factors outside of the classical neoclassical framework". Deriving from this was not only a necessity to provide an alternative explanation of the innovation process, but to recognize the key role that innovation plays in explaining the appearance of new technological paradigms which drive the evolution of capitalism (Cassiolato and Lastres, 2005).

Thus, the systemic perspective of innovation, offers an overarching conceptualization, or an underlying framework, for the different innovation studies areas which emerged over time. Some of the characteristics these have in common, is that on the one hand the innovation journey is a collective and cumulative achievement that requires key contributions from entrepreneurs in both the public and private sectors (Van de Ven et al., 1999: 149). On the other hand, since the initial works on national innovation systems, such as Freeman in 1987 in his book on Japan, had a strong emphasis on public policy and governance, much of the literature which evolved from then, recognizes the importance of an active contribution from public institutions.

As a consequence, today, there are a variety of different approaches to innovation systems, which vary according to the subject and the perspective of analysis. For the purposes of analyzing the contribution of public policy to the innovation process, the "national innovation system" seem particularly adept. This is partly due to the fact, that its inception occurred somewhere in between the spheres of academia and policymaking. On the other hand, scholars such as Freeman are of the opinion that the "national" domain is particularly adequate to accommodate the policy dimension of the concept (Sharif, 2005). As such, while the national innovation systems approach incorporates all the systemic conceptualizations of the innovation process, recognizing the multiplicity of contributing factors, it offers itself well for analyzing in more detail, the contribution of public policy. This is not to say, that the innovation systems cannot be conceptualized at still other levels. Other approaches have emphasized the technological, regional, sectoral, or transnational level. Depending on the subject of investigation, these different approaches can be more useful. Malerba (2004) offers some conceptualizations sectoral innovation systems, while Carlsson & Jacobsson (1997) focus on technological innovation systems.

The definition used in this work will be the one created by Chris Freeman, who defines National System of Innovation as, " .. the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987).

Mission Oriented Policy and The Entrepreneurial State

Another theoretical pillar of this analysis will be the hypothesis of the "Entrepreneurial state" presented by Mazzucato[2] (2013) together with the concept of mission oriented policies. In essence, these two approaches focus on shedding light onto the role of states within economic progress and the innovation process.

Mazzucato in her writings emphasizes the importance an active state and public policy plays in achieving a transformation of the economic landscape. This state sees its role no longer restricted to the traditional areas of innovation policy: (1) to support basic research, (2) aim to develop and diffuse general-purpose technologies, (3) develop certain economic sectors that are crucial for innovation, and (4) promote infrastructural development (Freeman and Soete, 1997).

Instead, the state plays a more active role in directing resources towards a previously identified mission, in order to lead and structure the necessary transformational changes (Mazzucato, 2016). This mission oriented approach seem particularly adequate when tackling "grand societal challenges" (Mowery, Nelson, and Martin 2010), of which global warming and environmental protection is certainly a good contemporary example. In addition, Foray, Mowery, and Nelson (2012) contrasted missions of the past, such as putting a man on the moon, with such contemporary missions as tackling climate change. They identified that the due to the nature of contemporary missions of addressing broader and more persistent challenges, they require long-term commitments to the development of technological solutions. Maastricht Memorandum (Soete and Arundel 1993) reiterates this, by providing a detailed analysis of the differences between old and new mission-oriented projects, when it states that:

> "older projects developed radically new technologies through government procurement projects that were largely isolated from the rest of the economy, though they frequently affected the structure of related industries

[2] The Entrepreneurial State: Debunking Public vs. Private Sector Myths.

> and could lead to new spin-o technologies that had wide- spread effects on other sectors. In contrast, [contemporary] mission-oriented environmental [and other] projects will need to combine procurement with many other policies in order to have pervasive effects on the entire structure of production and consumption within an economy. (50)"

Consequently, Mazzucato identifies that a crucial role of modern states, has to be its willingness to take risks and invest in markets and technologies which venture capital deems too risky. Thus for her, the entrepreneurial state agenda has sought to challenge the notion of the entrepreneur being embodied in private business, and policy-making being an activity outside of the entrepreneurial process (Mazzucato 2013a). She goes further to describe her ideas:

> "Historically, such technological and market opportunities have been actively shaped by government investment – what Mazzucato (2013a) refers to as "the entrepreneurial state"; that is, a willingness to invest in, and some- times imagine from the beginning, new high-risk areas before the private sector does…. Business has tended to enter new sectors only after the high risk and uncertainty has been absorbed by the public sector, especially in areas of high capital intensity" (Mazzucato 2016:149).

Interestingly enough, the case of the energy sector also, that the energy industry has tended to develop by favoring the stability and reliability of the energy system over the rapid adoption of new technology (Chazan 2013). In other words, established systems and stakeholders, tend to favor the status quo and thus are not necessarily inclined naturally to adopt innovative new technologies (which usually have a disruptive effect on the sector). The case of renewable energy technologies plays particularly well into Mazzucatos example of a transformative process which can benefit from mission oriented policy making and an active, participating state.

Short overview of the German Innovation System:

Continuing with Freemans definition of innovation system in mind, Germany presents a very interesting case. Its national innovation system is

renown today for its effectiveness in having helped the country become a leader in industry and technology. In particular, the institutional framework that has evolved in Germany, created a network of agents which nurture an environment which stimulate the technological innovation. In the following, it will be mentioned some of the key institutions which have shaped, and supported the emergence of the renewable energy industry. It should be noted that, because of Germany's Federal political structure, many policies at the national level are influenced by the concerns of the governments of the Federal states, known as Länder. These Länder can supplement national-level policies with their own at the regional level.

On a federal level, several institutions have had a Strong impact on the innovation landscape of the country as a whole, and on renewable energy technologies, in particular. It is of little surprise that the Federal Ministry of Research has been influential in driving R&D initiatives forward. In particular, the ministry has concentrated on funding and organizing basic research. This has also been true, in the case of renewable energy technologies. At the same time, the *Ministry of Economics (BMWI)* has played a crucial role in funding and supporting application-oriented research and the introduction of new technologies to the market.

With growing political awareness of environmental protection, the 1980s saw the creation of an independent institution, the *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUB)*. This ministry has become the main political body for implementing and formulating policy initiatives to manage and promote renewable energy technologies.

This separation of institutional responsibilities has enabled the German innovation system to incorporate and create synergies among diverse policy approaches and initiatives. Beside the political institutions, which have been very influential in this process, the country is host of a multitude of organizations which have been important drivers of research and development initiatives. The most important of these research institutes are the *Hermann von Helmholtz Association of Research Centers*, the *Max Planck Society*, the *Fraunhofer Society*, the *Leibniz Science Association*, and the *Centre for Advanced European Studies and Research (CAESAR) Foundation*. Similar to the ministries, their activities are very diverse and very often concentrated on specific stages of the innovation process. The Max

Planck Society for example, focuses on basic research, while the the Fraunhofer Society concentrates on applied research and development.

Most of these institutions are publicly funded, whereby both the state and federal government contribute financially. This allows for greater diversification and decentralization of research efforts, besides a greater independence of regional governments to pursuit and support the progress of particular technologies. As a counterpart to these institutions, the Germany boasts a multitude of private R&D centres, which in most part cooperate with their "public" counterparts. This interaction helps facilitate the gap between market demand for certain technologies, and the actual R&D decisions made.

Another aspect of the German innovation system that has been heralded as remarkable and important, has been the education system and the Ministry of Education and Research (BMBF). While higher education and universities have always played an important role, the case of Germany is particularly well known for its effective system of vocational and technical training. Together with the Ministry and the Federal Institute for Vocational Education and Training play a key role in conjunction with employer and employee representatives, in establishing the broad parameters within which employers, training providers, and employees operate. That is to say, that the process of technical and vocational training, is created and supervised by the government institutions, together with the private sector. Ultimately, this aims at diminishing the gap between theoretical learning, and practical application.

While we have concentrated on outlining some of the key institutions which contribute to the innovation process in Germany, a closer investigation into the specific parts of the system would reveal a much broader spectrum of active contributors. Financial institutions such as the KfW, the German Development Bank, play an important role in financing and investing into new technologies. On the hand, federal policies and technology agendas, have articulated roadmaps and trajectories for technological development goals which have been crucial in directing and bundling some of the different innovation efforts.

Thus the German Innovation System, is composed of a great many stakeholders and institutions, which work together in creating and fostering an innovative environment.

Research Questions and Aims

The purpose of this study is to analyse and discuss the contribution made by public policy and regulation to the transformative process in the case of the German energy transition.

The intention of this work is to demonstrate the importance of creating dynamic and innovative policy and regulatory frameworks for promoting the "Energiewende". In this sense, by using a combination of the mission-oriented policy approach and "the Entrepreneurial state" in order to evaluate the systemic role of regulation and public policy, this paper will analyse the importance of an adaptive policy/regulatory framework to promote and accompany a transformative national project, such as the "Energiewende".

The main question which this will try to address is:

"What role does public policy and regulation play in the Energiewende?"

More specifically, this thesis will investigate the role the Renewable Resource Act (EEG) (as initially introduced in 2000) has played in the German Energy Turnaround ("Energiewende"). In other words, how has this policy mechanism contributed to attaining the goals of the energy transition and how has it evolved over time in order to adapt to the changing techno-economic landscape. Consequently, this discussion will necessitate a broader evaluation of the role/nature of government intervention and public policy.

Breaking down the main research goal stated above, this dissertation aims to answer the following specific questions:

1. *How has the FIT contributed to attaining the energy transition in Germany?*
2. *What is the role of public policy when dealing with accelerated technological progress?*

3. *What is the importance of creating dynamic and innovative policy and regulatory frameworks for promoting the energy transition?*

4. *How can the idea of the Entrepreneurial state help explain the important role public policy has played in enabling the success of Germany energy transition?"*

There exists ample literary discussion on the different facets of renewable energy, energy market transitions, the German Energiewende, and German energy policy among others. Thus, while at the same time as this thesis hopes to contribute to the wider discussion on the role of the state in economic development, it also aims to contribute to lesser debated/explored field of research which is an analysis of the importance of a flexible and adaptive policy/regulatory framework for promoting the progress of a techno-economic paradigm shift (such as the Energiewende).

Additionally, the thesis will offer a more in-depth analysis of the benefits and advantages of such policy tools like the FIT as mechanisms for creating markets through state investment incentive.

Methodology

This thesis is primarily based on qualitative research methods. Its main focus will be an intensive literature review and government publications in order to evaluate the use of renewable energy policy instruments, its implementations and success. The main sources that will be utilized comprise of research papers, government publications and grey literature such as technical reports, conference papers and internal reports.

Additionally, some empirical data will be utilized in order to quantify the success of renewable energy technology diffusion. The data will particularly focus on data related to renewable power generation, renewable power capacity and renewables share in electricity output in %. This data will be used to make an evaluation of the impact that specific public policy decisions have had on the deployment of these technologies.

Timeline

Stages	September	October	November	December	January	Febuary	March
Complete identifying the main literature and resources	■						
Defend Project	■						
Complete a first draft of the theoretical sections		■	■				
Complete mapping out the trajectory of the EEG			■	■			
Complete a first draft of chapter IV				■	■	■	
Review previous chapters, collect conclusions.					■	■	
Prepare final draft							■

First stage: Complete identifying the main literature and resources which will be used in this paper. – Finish until **30/09/2016**

Second stage: Complete a first draft of the theoretical sections (Chapter 1+2). - Finish until **14/11/2016**

Third stage: Complete mapping out the trajectory of the EEG, identifying the different stages and adjustments over the past 15 years. - Finish until **31/11/2016**

Fourth stage: Complete a first draft of chapter IV. - Finish until **13/01/2017**

Fifth stage: Review previous chapters, collect conclusions. - Finish until **30/01/2017**

Sixth stage: Review previous chapters, write conclusion and refine work in order to prepare a last draft. - Finish until **30/02/2017**

Final stage: Incorporate last comments and adjustments to produce finished paper. – Finish until beginning of **March/2017**

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