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Which Investors Drive the Development of Wind Energy?

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"Which Investors Drive the Development of Wind Energy?"

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Abstract: In order to facilitate the transition to electricity sectors with low CO_2 emissions, it is important to understand which firms invest in new renewable energy technologies, and which firms are responsive to energy policies. This study concentrates on the heterogeneous characteristics of investors in wind power that are embedded in the investors' dynamic capabilities. The paper explores which type of investors display a positive reaction to the undifferentiated policy, and thus build up more assets in wind power. Empirical data is collected on investments in the Swedish wind energy industry in the Swedish tradable certificate system. The findings demonstrate that the cumulative wind power assets are indeed influenced by investors' characteristics. Investors with a greater resource endowment, higher investment experience and a mixed generation portfolio hold higher share of assets in wind. The results also indicate that the investors' age in the wind industry has a negative relation with the cumulative assets in wind, offering evidence on the important role of new entrants in this industry. This study offers insights for policy makers on which investors are responsive to the certificate system and invest in wind. It also implies that a more diversified set of policies could stimulate a greater variety of firms to invest in wind power.

Keywords: Radical change, investors, electricity generation, dynamic capabilities, energy policy, wind power, incumbents, new entrants.

JEL-codes: O310, O330, O380

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1. Introduction

The message is clear; to tackle catastrophic consequences of climate change, an '*energy technology revolution*' is unavoidable (IEA, 2008, IEA, 2009). One potential approach to achieve this technology revolution is through the advancement of technologies for the production of electricity from renewable energy sources (RES-E), and an especially promising technology is electricity production with wind turbines (GWEC, 2013). For this to happen governmental targets are set and massive investments are directed into the energy industry (Norberg-Bohm, 2000). A particularly prevalent target is the aim to reduce CO_2 emissions by half in 2050 in comparison with 2005 levels (IEA, 2008). When it comes to the particular case of wind power, it is expected that its installed capacity increases with 830 GW by 2030 (Bird et al., 2005). This roughly equals the capacity of 1000 large scale power plants and would indeed mean a technology revolution in the electricity industry (Russo, 2003).

The literature on radical innovation argues that the new technology often encounters hostility from incumbents who hold considerable resources in the existing technology (Utterback and Suarez, 1993, Chandy and Tellis, 2000, Wesseling et al., 2013). Consequently, when the new technology prospers beyond expectations, it threatens incumbents' position, and market new entrants start to dominate the transformed market (Christensen, 1997, Chandy and Tellis, 2000). In the case of the electricity sectors, the electric utilities (in this paper referred to as incumbents) had an oligopoly in the electricity market based on centralized power plants. This position is being overtaken in the renewable energy market by new entrants (Bergek et al., 2013). Benefiting from incumbents' lack of capabilities to pursue radical changes (i.e. (Henderson and Clark, 1990, Christensen, 1997, Schaltegger and Wagner, 2011)), the new entrants with their specific characteristics and preferences (Bergek et al., 2013) can manage to transform a market. They do so through increasing knowledge, enhancing resources, filling gaps and meeting new demands (Negro et al., 2007). Though, knowledge on these new market players, with their heterogeneous characteristics is underdeveloped (Masini and Menichetti, 2012, Bergek et al., 2013). This is problematic when forecasts are made about the future electricity sector or when new policy instruments are designed. For good forecasts and policy plans, it is important to understand how the structure of the electricity sector is changing and what the future industry may look like.

Our study's point of departure is therefore the observation that the electricity industry is changing rapidly and massively, though there has been insufficient dialogue on the nature of investors[1] who are changing this industry (Bürer and Wüstenhagen, 2009, Wüstenhagen and Menichetti, 2012, Bergek et al., 2013, Darmani et al., 2014). This paper intends to fill this knowledge gap by shedding light on the characteristics that positively influence investors' decision for investment in wind power assets. To do so, we focus on investors' characteristics that are embedded in their dynamic capabilities, which correspond to the capability of a firm to discover, realize and exploit new opportunities in an existing or a new market (Miller, 1983, Hamel and Prahalad, 1994, Sathe and Drucker, 2003). On the basis of this definition, the amount of dynamic capabilities influence the *ability* and *willingness* of a firm to implement changes into their routines (Penrose, 1958, Zahra et al., 2006). This is the first study that applies the dynamic capabilities literature for exploring the dynamics of the electricity sector.

This paper makes several important contributions to the literature. Firstly, we characterize which types of investors are most likely to invest in wind power thereby shedding light on how the electricity sector is currently changing. In second, we seek to account for variations in the investors' propensity for radical change by bearing in mind the differences between

[1] *In this paper the word firm and investor are used interchangeably.*

incumbents and new entrants, and also among investors having different industrial backgrounds in this nascent market.

To achieve these objectives, the case of wind power in Sweden is chosen for the empirical foundation of this paper. The case is analyzed through 1994-2013, and the results are based on data on investments in wind power by 570 firms. Sweden has implemented a tradable certificate system to stimulate the integration of renewable energy as of 2003. Using statistical analysis, the paper shows which type of investors display a positive reaction to the undifferentiated policy of the certificate system, and thus build up more assets in wind power. This knowledge is highly relevant for policymakers, since it enables them to forecast the future landscape of the electricity sector. Our study enables them to better understand the differences between investors in renewable energy and also the differences in investors' responses to energy policy. The third contribution of our paper is therefore offering results that are relevant for policymakers.

This paper is organized as follows, section 2 explains the theoretical background and proposes the hypotheses of this paper. Section 3 describes the selected methods for data collection and analysis, and the logic for the selection of the case under study. Section 4 presents the results, and the study is concluded in section 5.

2. Theoretical foundation and hypotheses

2.1. Investors of RES-E in the electricity industry

The aim of decarbonization is changing the composition of the electricity market, which in particular can be attributed to the increase in renewable energy technologies. This can be highlighted in the report by the IPCC (2011) in which it is estimated that investments in the production of electricity from renewable resources are to be equal to 2,850–12,280 billion USD in the period of 2011-2030. This recomposition constitutes radical innovation, since it requires different technological competences and endangers an already established technological regime and firms (Markard and Truffer, 2006). For it to happen, several drivers have been introduced into the electricity sectors, among which energy policy is considered as the most promising one (Darmani et al., 2014).

Due to its importance, the advantages and disadvantages of energy policy for accelerating renewable electricity innovations have been assessed in several studies (cf. (Negro and Hekkert, 2008, Jacobsson et al., 2009, Haas et al., 2011)). This topic is explored using different approaches such through system-based approaches (i.e. (Hekkert et al., 2007, Bergek et al., 2008, Negro and Hekkert, 2008, Hekkert and Negro, 2009, Suurs and Hekkert, 2009, Jacobsson and Bergek, 2011, Roald A.A. Suurs et al., 2011)), historical analyses (i.e. (Foxon et al., 2004, Del Rio and Unruh, 2007, Haas et al., 2011, Del Rio and Mir-Artigues, 2012, Darmani et al., 2014)), diffusion-based models and reviews (i.e. (Moon and Bretschneider, 1997, Davies and Diaz-Rainey, 2011, Karakaya et al., 2014)) and even simulation studies (i.e. (Fagiani et al., 2014, Richstein et al., 2014)).

An emerging body of literature has started arguing that what is missing in this debate is a focus on the investors (Agterbosch et al., 2004, Bergek et al., 2013). Investors of RES-E are identified as a heterogeneous group of actors, "*... who invest in renewable electricity production rather than as actors who finance such investments, e.g. banks, funds. […]. The former initiate the idea for a new plant, mobilize resources to realize it and take ownership of the plant once it is in place. Electricity production then becomes a part of their business*" (Bergek et al., 2013 : P. 573). On the basis of this definition, the role of investors in the market in mobilizing capital and advancing RES-E is prevalent, and in particular when investors are considered as actors who can react in different ways to both market and policy changes (Bergek et al., 2013, Darmani et al., 2014). Branzei and Vertinsky (2002) discuss that investors may respond to policies in a reactive or proactive way. The first group, reactive investors, only values an investment when it complies with their competitive advantage or aids them in maintaining their market position. Proactive investors, on the other hand, are more prone to take the risk of making an early investment and turning a new policy or regulation into a competitive advantage.

More recent studies have argued that the different roles of investors in the energy sector are determined by their characteristics. The variety among investors includes heterogeneity in terms of types and motives (Bergek et al., 2013), experience (Bollinger and Gillingham, 2012, Drury et al., 2012, Wüstenhagen and Menichetti, 2012), investment behavior (Aguilar and Cai, 2010, Bollinger and Gillingham, 2012, Drury et al., 2012), beliefs in a technology or market efficiency (Dinica, 2006, Masini and Menichetti, 2012), risk aversion and propensity for change (Meijer et al., 2007, Fagiani et al., 2013) and technological capabilities (Delmas and Montes-Sancho, 2011). A clear case of this variation can be found when looking at incumbents and new entrants in the energy sector. An incumbent is identified as a firm that enters a market in an early stage and has a sizeable market share (Hockerts and Wüstenhagen, 2010). Regardless of their considerable amount of resources, these firms are normally 'locked-in' their established technologies and competences (Unruh, 2000, Negro et al., 2007) and are reluctant to explore new opportunities (March, 2003). On the other hand, new entrants are players who join the market in later stages and own a smaller market share (Hockerts and Wüstenhagen, 2010). Through their entrepreneurial activities new entrants may view investments in the new technology as an effective tool for reaching a more favorable market position (Mensch, 1979, Negro et al., 2007).

In line with this literature, we argue that differences between groups of investors materialize in different responses to changes in the electricity industry and in particular to changes in energy policy. To enhance our understanding of the type of characteristics that lead investors to respond to environmental changes, and thus in our case to invest in renewable energy, we make use of the perspective of dynamic capabilities.

2.2. Investors' dynamic capabilities and wind power assets: Hypotheses

Dynamic capabilities are the capabilities of firms to integrate, build and reconfigure resources, which enable a firm to enter a new market (Eisenhardt and Martin, 2000, Døving and Gooderham, 2008) or to answer to changes in the market (Teece et al., 1997). These capabilities are often referred to as higher-order resources that have an impact on lower-order resources (Niesten and Jolink, 2014). Examples of such higher-order resources include a bundle of factors that are generally managed by firms such as, operational and managerial experiences, expertise, knowledge resources, financial reserves and production capacity (Schumpeter, 1942, Kraatz and Zajac, 2001). The word 'dynamic' in the term 'dynamic capability' refers to intentional changes in or renewal of lower-order resources (Ambrosini and Bowman, 2009). In this paper, the lower-order resources are the investors' assets in wind power.

Given the aim of energy policies to move towards low-carbon technologies, significant changes in the electricity market are required to increase investments in RES-E (Krewitt et al., 2007). As we argued, investors in renewable energy technologies have different characteristics, and we expect that they will also differ in terms of their dynamic capabilities. In compliance with the dynamic capabilities literature, we expect that investors with a greater amount of dynamic capabilities will invest in larger amounts of wind power assets. This paper measures an investor's dynamic capabilities by its resource endowments, owner experience, investment experience, unrelated and related diversification, and firm age in the wind industry. The following sections will illustrate the relation of these characteristics of investors to the technological assets in wind power.

2.2.1. Resource endowment of investors

The dynamic capabilities perspective builds on the resource-based view of the firm and on evolutionary approaches to organization (Teece et al., 1997). The resource-based view argues that important differences exist in the resource endowments of firms within an industry (Kraatz and Zajac, 2001), meaning that firms differ in terms of their access to technological, financial, human and complementary resources (Wesseling et al., 2013). Furthermore, the evolutionary approach to organizations argues that path dependence limits the adaptation options of firms. This leads to the assumption that firms with greater resources face a less narrow and idiosyncratic menu of options to respond to changes in the environment (Nelson and Winter, 1982, Kraatz and Zajac, 2001). On the basis of the resource-based view and the evolutionary approach, Kraatz and Zajac (2001) discuss that resource endowments can act as facilitators of change. They claim that firms with a greater resource endowment, consisting of financial reserves, distinct expertise and experience, research and development capability and, production capacity respond better to environmental changes. To exemplify, Helfat (1997) shows that energy firms with larger amounts of complementary technological knowledge and physical resources are better able at responding to changes in the external environment (i.e. rising oil prices) by investing in larger amounts of R&D on coal conversion. We will therefore argue in this paper that firms with a greater resource endowment in the electricity industry are better able to respond to changes in this industry that demand a larger share of RES-E, and will thus invest more in wind power.

Hypothesis 1: A higher resource endowment of an investor positively affects its amount of technological assets in wind power.

2.2.2. Different types of experience of investors

Dynamic capabilities must be built through experience (Teece et al., 1997, King and Tucci, 2002). By enhancing experience, firms learn to assess opportunities in a more proper way (Masini and Menichetti, 2012) and thereby to adjust their lower-order assets. Experience can be enhanced through repetitive and continuous investments and implementations of a process or a project that contributes to understanding the process meticulously and to performing it more effectively (Argote, 1999). Zollo and Winter (2002) refer to this proposition as the influence of the "*knowledge evolution cycle*", which consists of repetitive routines that enable a firm to augment its process implementation (Zollo and Winter, 2002). With respect to our case, it is expected that two types of experience will positively affect the amount of assets of firms in wind power. First, owner experience refers to the number of firms that one investor has created in the wind industry. The second type of experience is investment experience and refers to the number of years in which a firm has invested a new wind power capacity. We therefore formulate the following two hypotheses in this study:

Hypothesis 2: An investor's owner experience in the wind industry positively affects its amount of technological assets in wind power.

Hypothesis 3: An investor's investment experience in the wind industry positively affects its amount of technological assets in wind power.

2.2.3. Different types of diversification of investors

Ng (2007) makes a distinction between strong form and weak form dynamic capabilities. In strong form dynamic capabilities, a firm introduces new resources without being constrained by its prior knowledge of resource uses, and therefore the firm engages in unrelated diversification (Ng, 2007). An example of firms with strong form dynamic capabilities that display unrelated diversification are the firms that invest in the renewable energy market, but have a different industrial background, such as in the agricultural or real-estate industries. These firms with a different industrial background aspired to search for a new market by broadening their range of products and services. In this paper, we study unrelated diversification by analyzing whether firms from the energy industry or firms from another industry make investments in wind power.

On the other hand, weak form dynamic capabilities draw on a firm's prior knowledge of resource uses to reveal new uses from its existing resource bundle, and these are therefore associated with related diversification (Ng, 2007). Døving and Gooderham (2008) show that firms with dynamic capabilities diversify into related services, and are able to generate an important proportion of their revenue from these services. Related diversification is used as a tool for effective deployment of all the firm's resources, the use of its specific capabilities, and to ascertain its strategic direction and reduce redundancies (Penrose, 1958, Zahra and Nielsen, 2002, Zahra et al., 2006). In the case of the electricity industry, investors in wind power that display related diversification are expected to invest in other types of renewable energy. In this paper, related diversification is therefore studied by measuring whether firms that invest in wind power also have investments in other types of renewable energy, such as solar power, hydropower or biomass.

Hypothesis 4: Unrelated diversification of an investor positively affects its amount of technological assets in wind power.

Hypothesis 5: Related diversification of an investor in renewable energy positively affects its amount of technological assets in wind power.

2.2.4. Age of investors in wind power sector

In section 2.1, we made a distinction between new entrants and incumbents, as one way to characterize the differences between investors in the wind power industry. The new entrants, who join the industry in later stages, have a strong motivation to establish a solid position in the market by taking advantage of all the available opportunities and by meeting new market demands (Negro et al., 2007). On the other hand, incumbents with established market positions have less incentives to radically innovate (Chandy and Tellis, 2000, Wesseling et al., 2013). The incumbents' lack of capabilities to sense new opportunities and to respond to environmental changes (Gilbert, 2005, O'Reilly III and Tushman, 2008) is what provides the new entrants with more options. Consequently, we expect to find that investors who join the wind power market in later stages to be more vigorous in taking advantage of the available opportunities and to be more dedicated to investments in wind power assets when compared to the incumbents. In hypothesis 6, we refer to firm age to indicate that new entrants are the relatively young firms in the industry, whereas the incumbents are firms that have for a long time been part of the industry and have a higher age. Therefore, we formulate the final hypothesis as follows:

Hypothesis 6: An investor's age in the wind power industry negatively affects its amount of technological assets in wind power.

3. Method and research design

3.1. Context

Given the objectives of this study (i.e. to analyze characteristics of investors that invest in wind power and their response to energy policy), the empirical foundation of this research should be based on a market that consists of three main features. First, in order to study investments in an upcoming and competitive source of energy production, we require an energy market in which investors can compete with each other without restriction, regardless of their size and position. Second, we require a market in which an important change has occurred in the regulatory framework. However, to limit interference of exogenous parameters, a market with a limited number of variations, especially in terms of regulation and policies is preferable. Finally, a market with transparency is required to be able to get access to the necessary data.

Considering all the criteria, the case of wind power in the Swedish electricity market is selected as the empirical context of this study. Satisfying all the requirements and considerations, the electricity market of Sweden is an interesting and valid case for this study. First of all, the Swedish electricity industry is liberalized, and thus allows for competition between investors. Second, the Swedish energy market has had only a few but still significant variations in its national regulatory framework for renewable energy over time. The main regulatory change is the introduction of a tradable green certificate system in May 2003.

Third, the Swedish energy agency endeavors to create transparency by publishing a database on the certificate electricity market. It encompasses data on registered power plants harnessing wind, solar, biomass or hydropower eligible for receiving tradable green certificates. The selected database has been used in earlier research (cf. Bergek et al. (2013)) and is proven to be consistent and representative for the case of wind power in Sweden.

Notably, the investors of RES-E in the Swedish electricity industry are divergent and vary from one renewable energy source to another (Bergek et al., 2013). We focus on investments in wind power, because they have the highest potential for advancement of RES-E (GWEC, 2013). This potential can be highlighted in the database under study in which about 70% of the data are on registered wind power plants.

3.2. Data and operationalization of variables

The selected database encompasses data on registered wind power plants in Sweden from 1927 to 2013. While the first registered plant is recorded as early as 1927, the registration of the second plant goes back to 1994, thus creating a 67-year gap. From 1994 until the end of 2013, every year new wind power plants are registered in the database. In order to eliminate the effects of the outlier data (year 1927), the data for this study are restricted to the time span 1994-2013[2].

The dataset of this study includes investors of all the registered wind power plants in Sweden[3]. This includes a total number of 570 investors during the time span under study. The database includes information on the name of the plant, its capacity and yearly production, the owner(s), organizational number of the owner(s), type of electricity sources, first date of registration, last date of registration, electricity region and state. Additional data on each investor are obtained from other data sources. First, through *www.allabolag.se*[4] information on the firms' registration date and founder in the Swedish companies registration office *(Bolagsverket)* are extracted. Second, information on the type of firm and the industry in which the firm is located is found on two websites: www.solidinfo.se and www.proff.se[5].

The database also includes data on private persons whom invest in wind power plants, while no specific data, such as name or registration number is available on this group of investors. Due to this lack of data and since the theoretical framework of this study applies to firms, we have excluded private persons from the analysis. The unit of analysis in this study is the firm, since the investors in our dataset are registered as firms.

The study requires measures of one dependent variable, 6 independent variables and 2 control variables, which are presented below.

Dependent variable. *Technological assets* of an investor in wind are measured by recording cumulative installed capacity (kW) for each investor at the end of the year 2013.

Independent variables. *Resource endowment* of an investor is captured through the average size of the investment made by each investor in the market. This amount is calculated by

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[2] *The database only provides data on wind power plants that are installed, but we do not have information on exits from the market.*

[3] *Notably, since all the energy produced in wind power plants is used for the generation of electricity in Sweden, all of the installed capacity is eligible for receiving certificates.*

[4] *The website belongs to a service agency that gathers business information on all the Swedish companies. The agency collects data from the Swedish companies registration office (Bolagsverket), Tax Agency (Skatteverket) and Statistics Sweden (SCB). According to the KIA index -the official measurement index for Swedish websites- the Allabolag website is the most acknowledged information service for those who need information about firms.*

[5] *Two leading search engines with official financial and business information for all Swedish companies.*

dividing the amount of cumulative installed capacity by the total number of registered plants in the name of the investor.

Owner experience is measured by extracting the name of the founder for each firm and identifying the founders who have founded more than one firm. Thus, the number of firms owned by the same founder is used to measure experience of a firm's owner. This number ranges from 1 to 16.

Investment experience is measured by recording the total number of years in the time span under study in which a firm has made investments.

Unrelated diversification is defined as a binary variable, making a distinction between wind power investors whose primary industry is producing energy (coded as 1) and whose primary industry is not producing energy (coded as 0).

Related diversification taps into the number of renewable energy sources in which an investor has made an investment, 1 indicating only wind and 2, 3, or 4 indicating a more diversified generation portfolio (hydro, solar and/or biomass).

Age of investor in the wind power industry is captured by subtracting the first year that a firm has installed capacity in the wind market from the current year (2014).

Control variable. We introduced two control variables for alternative possible explanations, namely *firm age* and *number of regions*. Firm age is calculated by extracting the firm's registration date in the Swedish companies registration office from the current year (2014). We did not find data on the registration date of 3 firms, which we report as a missing value.

Information on the number of regions is measured by counting the number of electricity regions in which the firm has made an investment. The investment regions are identified and recorded in the Swedish tradable certificate database. Electricity regions of Sweden are distinguished into four groups, ranging from SE1 to SE4.

3.3. Data analysis

Our model with technological assets as the dependent variable and eight independent and control variables was estimated using OLS. We performed a Durbin-Watson test to test for the possible presence of autocorrelation in the model residuals. The results confirmed the assumption of independent errors (Field, 2013). We also checked for multicollinearity and obtained VIF and tolerance scores on the relation between the independent and control variables. Bowerman and O'Connel (1990) suggest that VIF substantially different from 1 and greater than 10 imply a problem in the variables. The VIF values range between 1.072 and 2.188, indicating that there is no multicollinearity problem in our data.

Although we strived to collect complete sets of data, for a few variables we have missing data. The number of missing values is considered as minimal (indicated in Table 1) to make a difference in the analysis. We use pairwise deletion to cope with the missing values in our dataset.

4. Results

This section starts by identifying incumbents and new entrants in the Swedish energy market. Next, we explore the industrial background of different groups of investors in wind power. Finally, we proceed to discuss the results of our model, and thus offer an analysis of the impact of investor characteristics on investments in wind power.

4.1. Incumbents versus new entrants in Swedish energy market

In compliance with the reports of the Council of European Energy Regulators (CEER) and the European Commission, electricity producers are considered as main producers (what we refer to as incumbents) when they produce at least 5% of national net electricity generation. This study therefore identifies five incumbent power producers in the Swedish electricity market, including Vattenfall, Fortum, E.ON, Statkraft and Skellefteå Kraft (Figure 1) (CEER, 2010, European Commission, 2011).

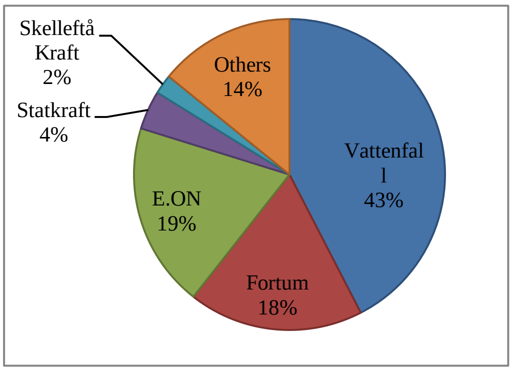

Figure 1 – The five largest Swedish electricity producer in 2010 (CEER, 2010, European Commission, 2011).

Since these five firms are identified as the incumbents in the Swedish electricity industry[6], we classify the other firms in our database as new entrants[7]. A report by the CEER (2010) shows that the incumbents own around 85% of the total electricity market as of 2010 in Sweden, which implies that other firms have less than a 15% market share. In contrast, in the wind power market the incumbents only possess a 15% market share. This indicates that 85% of the wind power market is owned by new entrants, illustrating their dominant role in this market. On the basis of our data, figure 2 shows that the Swedish wind power market has received huge support from the new entrants.

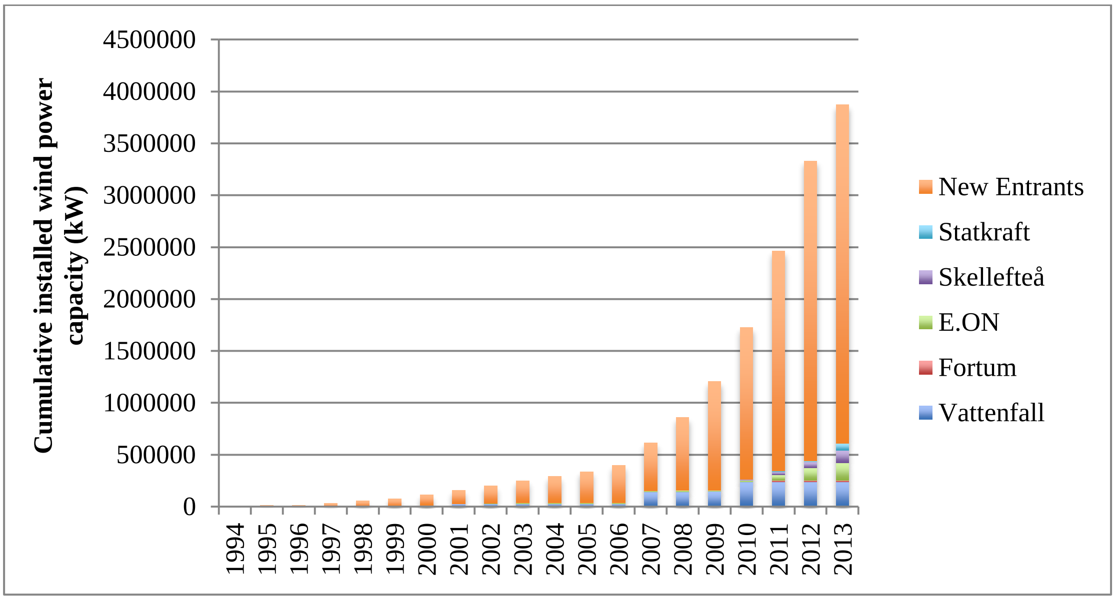

Figure 2 – Cumulative installed wind power capacity of incumbents and new entrants from 1994 to 2013 (Source: Swedish tradable certificate database)

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[6] *These five firms are the incumbents of the Swedish total electricity market, rather than the Swedish renewable electricity market.*

[7] *It could be the case that some of the investors in this category are old players in another industry or hold a relatively large share of wind power assets. However, these firms are not identified as the Swedish electricity market incumbents by the official authorities and reports.*

4.2. Investors' main industry

Investors in RES-E are not only energy firms, but form a rather heterogeneous group of firms with diverse motives behind their investments (Bergek et al., 2013). To analyze this heterogeneity, this paper expands our knowledge on the relation between the investors' industrial background and the amount of wind power assets. We draw attention to the fact that all investors in our study are producing wind energy, but not every firm is registered as a member of the energy sector. For instance, a firm can be registered in the official websites (sources mentioned in the section on methods) as a real estate firm, but the firm also invests in wind power.

To identify categories of investors, the main industry for each investor is recorded. Provided that the number of investors in an industry was more than three, we classified that industry as a separate category. Industries with less than 3 investors are included in the category of 'others'. Notably, we identified several investors that are officially active in more than one specific industry. As an example, this was the case for a firm that is registered simultaneously as a real estate firm, as a farmer, and also as a member of the energy sector. To deal with that, we classified these investors in the category of multi-responsibility firms. While our study is inspired by the classification of investors' types by Bergek et al. (2013), our categorization is different, because we focus on the investors' industries rather than on investor types. The data on investors' industries are summarized in Table 1.

Table 1- Summary of investors' industry

Total number of companies	*570*
Energy producer	439
Farmer	38
Financing	4
Machinery	11
Real Estate	21
Multi-Responsibility	10
Consultancy	10
Municipality	8
Others	26
Not Available	3

When comparing the average firm age between different categories, we noticed that municipalities are the oldest established organizations in the Swedish energy sector, whereas their average age in the wind power industry is among the youngest ones. On the other hand, consultancy firms are quite young, but their initial year of investment in the wind power market in comparison with other groups is considerable. We also observed that real estate firms, farmers and energy producers invest in a more diversified portfolio, while others only invest in wind power. Table 1 illustrates the involvement of different industries in wind power investment, but also shows that the majority of investors in wind power are registered as an energy producer. This category of investors owns a higher share of wind power assets in the market. Therefore, provided that the market grows with the same trends, this category of investors will dominate the future market.

Up to this point, we identified incumbents and new entrants in the Swedish energy market, and explored their industrial background. The remainder of this section will focus on explanations for the differences in the amount of wind power assets on the basis of investors' characteristics by presenting the results of our model.

4.3. Model results

Table 2 presents the descriptive statistics and pairwise correlation matrix. Table 3 presents the results of the model that enables the testing of our hypotheses on if and to what extent characteristics of investors embedded in their dynamic capabilities influence their technological assets related to wind power in Sweden. We note that, referring to R^2, the characteristics of investors recorded in the model explain about 38% of the variation in the dependent variable.

With respect to Hypothesis 1, on the relation between an investor's resource endowments and his investments in technological assets, the results disclose a positive and significant effect of the average size of the investment on the cumulative assets in wind power.

Hypothesis 2 is rejected by the model indicating that the experience of a firm's owner does not have a significant influence on the installed wind power assets, but hypothesis 3 was not rejected. This discloses that investment experience, the repetition of investments between 1994 and 2013, positively and significantly influences the technological assets. Interestingly, the estimation confirms that investment experience has a more substantial impact on the cumulative assets in wind power when compared to the impact of resource endowment captured by the average size of the investment (corresponding to standardized beta's of 0.42 and 0.26, respectively). This verifies our earlier discussion that, whereas incumbents are interested in investing in large-scale power plants, new entrants compensate this by their more frequent investment and thereby their extensive investment-based experiences in the market.

Our findings also show that the initiation of the wind energy market from 1994 onward proved to be the contribution of mainly energy firms. Hypothesis 4 should therefore be rejected, and we cannot conclude that investors' industrial background, as a proxy for unrelated diversification, has an effect on assets in wind power. This implies that although investors with diversified industrial backgrounds join the renewable electricity market, firms whose center their activities on producing energy still invest more in wind power assets.

The results do confirm hypothesis 5, and we can conclude that the investor's related diversification capabilities, tap into investors' diversified generation portfolio, have a positive and significant effect on the technological assets. Firms that invest in other types of renewable energy, such as solar, biomass or hydro power, in addition to wind power, have greater amount of assets in wind power when compared to firms with less diversification in their generation portfolio. This implies that investors, who are more capable of reconfiguring their existing resources, are more responsive to the changes in the electricity market towards sustainability.

Finally, the model confirmed our argument on the lack of propensity to invest in new disruptive technologies by older firms, such as incumbents. Hypothesis 6 is confirmed and demonstrates a significant and negative relation between firm age in the wind power sector and investments in wind assets, meaning that older firms in the wind power sector are less likely to invest in wind assets.

Both control variables were identified as insignificant in model 2, implying no relation between firm age and number of regions on the one hand and the firms' technological assets in wind power on the other hand.

In all, our results have identified a series of causal relationships between investors' characteristics as well as investors' type and their amount of wind power assets. The model results indicated that investors with a greater resource endowment, more investment experience, an industrial background in producing energy who hold diversified generation portfolio are more likely to have a higher share of assets in wind power. Moreover, the result revealed that the new entrants who join the wind power market in later stages invest more vigorously to reclaim their favorable position. As the result, recently these new entrants have managed to predominate older market players, including the incumbents.

Table 2 – Mean, standard deviation and correlations of variables in model 2.

	Variable	*Number*	*Mean*	*St. dev*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	Technological asset *(In wind power)*	570	6796,62	17671,00	1,00								
2	Resource endowment	570	2140,43	3923,69	0,30*	1,00							
3	Owner experience	548	1,91	2,71	0,07*	0,15*	1,00						
4	Investment experience	570	1,30	0,88	0,46*	-0,02	-0,03	1,00					
5	Unrelated diversification *(Industrial background)*	567	0,77	0,42	0,12*	0,10*	0,15*	0,04	1,00				
6	Related diversification *(Generation Portfolio)*	562	1,04	0,24	0,32*	0,00*	-0,06	0,23*	0,03	1,00			
7	Age of investor in wind power industry	570	7,49	4,88	-0,11*	-0,22*	-0,17*	0,27*	-0,02	0,01	1,00		
8	Firm Age	567	13,98	14,30	0,06*	-0,07*	-0,14*	0,18*	-0,39*	0,23*	0,29*	1,00	
9	Number of invested regions	570	1,06	0,28	0,36*	-0,01	-0,05	0,72*	0,02	0,23*	0,18*	0,13*	1,00

**Significant at 0.05 level*

Table 3 – Model results on investor characteristics and investments in wind power

Variable		*Model 1 (Control variables)*			*Model 2 (All variables)*		
		Std. Error	*β (Std. β)*	*Sig*	*Std. Error*	*β (Std. β)*	*Sig*
1	(Constant)	2719,158	-17948,947	0,000	3731,197	-23524,818**	0,000
2	Resource endowment				0,159	1,171** (0,260)	0,000
3	Owner experience				229,760	152,197 (0,023)	0,508
4	Investment experience				1009,725	8615,825** (0,429)	0,000
5	Unrelated diversification *(Industrial background)*				1606,556	3025,832* (0,072)	0,060
6	Related diversification *(Generation Portfolio)*				2638,124	15295,061** (0,210)	0,000
7	Age of investor in wind power industry				137,985	-648,763** (-0,179)	0,000
8	Firm age	49,063	14,240 (0,012)	0,772	49,934	38,955 (0,32)	0,436
9	Number of invested regions	2486,854	2486,854 (0,0356)	0,000	3039,390	2250,363 (0,36)	0,459
	R^2		0,128			0,386	
	Adjusted R^2		0,125			0,377	

*P<0.1**, *P<0.01***

5. Concluding remarks and policy implications

The landscape of electricity sectors is changing radically through investments in RES-E and specifically wind power. Whereas this technological revolution provides opportunities as well as cause challenges for all the investors, evidence suggests that a group of investors with certain characteristics are more dedicated to mobilize capital to support the development of wind power. This will have severe consequences for other investors, such as incumbents, who invest considerably less in these new technologies.

While renewable energy researchers have become increasingly concerned with the effectiveness of energy policies in the promotion of RES-E development, very little research has acknowledged the important role of investors in this development process. As a result, there has been little research on how investors' heterogeneous characteristics may impact their propensity for changes towards a low-emitting electricity sectors. To take a step, we reviewed and integrated work from a wide range of energy research and dynamic capabilities literature. The reviewed literature suggested that investors' characteristics *do* affect their investment behaviors in the context of wind power development as well as the way that they respond to energy policies. We increased the knowledge on this matter by offering *why* and *which* investors' characteristics positively affect the way that they answer to changes in the electricity sectors toward low-emitting technologies. To do so, we identified characteristics that are embedded in investors' dynamic capabilities, the capabilities that enable firms to respond to market changes. We believe this study to be a key contribution in its own right, and also we hope its outcomes orient more future studies towards the investors' perspective.

We improved an understanding of the characteristics of wind power investors through an empirical study in a well-suited context, the Swedish wind power market. On the basis of empirical data on 570 wind power investors in Sweden, we disclosed that there are certain relationships between investors' characteristics as well as investors' type and their amount of wind power assets. We show that investors invest more in wind power assets when they have a greater resource endowment, measured by the average size of the investment, and when they have more investment experience, measured by the number of years in which they made an investment. Interestingly, the results of our model indicate a more significant influence of investment experience than resource endowment. This reveals how the new entrants' small scale but frequent wind power plants have managed to predominate a few incumbents' remarkably larger-scale plants. Moreover, we find that the experience of a firm's owner does not essentially contribute to a higher amount of assets. In addition, the results showed that investors who possess mixed generation portfolios (related diversification), and have industrial backgrounds in producing energy (negative influence of unrelated diversification) have higher amount of wind power assets. Lastly and remarkably, this paper revealed that an investor's firm age in the wind power sector has a negative and significant influence on its wind power assets. This is consistent with our argument that older firms, including incumbents, have less dynamic capabilities, and are thus less able to adapt to changes in the environment.

The findings support our observation that the landscape of the electricity sector is changing massively towards a situation where a certain group of investors, mainly new entrants, will play a crucial role. Forecasts that are derived from these findings imply that this group of investors is more prone to take advantage of the indifferent energy policy. This further suggests that the success of these new entrants can be seen as a potential competitive threat for the existence of incumbents. What follows is that if incumbents do not want to be overtaken by these new market players, they may need to reconsider their generation portfolio and insert RES-E into their mainstream business. Hence, the first important policy implication of this study is that as an alternative to homogenized policy frameworks on national levels, more policies tailor-made for heterogeneous investors should be enforced. These heterogeneous policies could consider stimulating investments by incumbents, who appear to be less prone to respond to green certificate prices. When stimulating investments by incumbents in renewable energy, policy solutions for incumbents' stranded assets in the old technologies are likely to contribute to a more sustainable electricity market.

We further noticed that while investors from other industries such as farmers or real estates are joining the market, still young energy-based firms who only make investments in wind power are the majority. For good policy plans and designs thus it is important to consider this unbalanced competition. Hence, the second important policy implication of this study is that policymakers can leverage cooperation between different types of investors holding different industrial background, offering different services. As one possible approach they can support plants that are owned by multiple owners with diversified backgrounds.

It is noteworthy to acknowledge the limitations of this study. First, there are other important characteristics, such as growth ambitions, profitability, size of firms, and managerial education, that this research did not investigate. Second, with respect to the empirical foundation in this study, we only focused on the investors active in the Swedish wind energy market. Thus it is worthwhile to test the findings of this paper with the integration of more variables in other contexts in future studies.

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