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TECHNOLOGICAL INNOVATION AND DYNAMIC CAPABILITIES IN THE SPANISH WIND ENERGY BUSINESS [October 2011; APA Style]

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Technological innovation and dynamic capabilities in the Spanish wind energy business

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Abstract Wind energy is a disruptive technological innovation in the production of electricity in which Europe accounts for over half of the world's installed capacity and European firms are worldwide leaders in wind turbines and wind farms. Taking the Spanish industry as a distinctive setting within Europe, a multiple case study shows that mainstream theories of technological innovation have failed to explain the processes by which an aeronautic, a construction and a utility firm have gained leading positions in the world's wind energy business. These processes are instead explained from a dynamic-capability perspective by proposing a distinction between the discovery and development processes.

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1. INTRODUCTION

Technological innovation is a major competitive weapon in the increasingly globalized marketplace. Academicians, practitioners and public policymakers have accordingly paid considerable attention to the factors that promote or hinder technical change within countries, industries and firms. Mainstream theories of technological innovation are focused on the factors that drive the *development* of an innovation once an innovative idea has been identified and assessed, whereas the factors driving the *discovery* of that innovative idea have received less attention (Zahra, Sapienza, & Davidsson, 2006). Mainstream theories similarly assume that established firms perform well in the context of *incremental* technological changes but are badly equipped to cope with *disruptive* technological changes (Raisch, Birkinshaw, Probst, & Tushman, 2009).

The anecdotal observation of some recent cases shows that the *discovery* of *disruptive* products and technologies is gaining momentum in comparison to the *development* of *incremental* innovations. The cases of smartphones (APPLE vs. NOKIA), tablets (APPLE vs. MICROSOFT), low-powered microprocessors (ARM vs. INTEL) or game consoles (NINTENDO vs. SONY) are only some examples of established firms beating top competitors with disruptive products and technologies based on complex processes of entrepreneurial discovery driven by a thorough consideration of marketing issues. Marketing theories of technological innovation have always been concerned with aligning technology push and marketing pull in product innovations (Cotterman, Fusfeld, Henderson, Leder, Loweth, & Metoyer, 2009), but failed to explain these cases appropriately using well-known concepts such as technology orientation (Zhou, Yim, & Tse, 2005) or market orientation

(Narver, Slater, & MacLachlan, 2004). A more encompassing view of technological innovation which blends marketing considerations with entrepreneurial, organizational and strategic reasoning is thus needed (Schindehutte, Morris, & Kocak, 2008).

Our paper contributes to existent theory by analyzing the ability of a dynamic capability based view of the firm (Ambrosini & Bowman, 2009; Barreto, 2010; Di Stefano, Peteraf, & Verona, 2010) to account for instances in which an established firm is able to bring a disruptive technological innovation onto the market. The dynamic capability approach is unique in that it simultaneously addresses both discovery and development, and incrementalism and disruption with regard to technological change. This perspective is based on the firm's capacity to exploit emerging opportunities through a root-level transformation of its resources and competences (Teece, Pisano, & Shuen, 1997). Those firms that are able to sense evolving opportunities arising from their base industries or adjacent industries and then adapt their resource base and competence sets to seize those opportunities are said to have dynamic capabilities (Teece, 2007). A combination of marketing, entrepreneurial, organizational and strategic perspectives is evident in the dynamic capability perspective.

In order to test a dynamic capability approach towards technological innovation, we have chosen wind power technology in Europe as being a relatively recent disruptive innovation in the production of electricity when compared to other technological alternatives, such as coal thermal power, gas-fuel combined cycle power, hydroelectric power or nuclear power. The European wind power business offers a unique research setting in which to shed light on the innovation-related factors driving the formation of global champions. Europe has almost half the installed wind power capacity worldwide, and its firms enjoy leading worldwide positions in both wind turbines and wind farms.

Three case studies of leading Spain-based European firms in the wind energy business are discussed for empirical purposes: IBERDROLA, worldwide leader in wind farms;

GAMESA, the third largest producer of wind turbines in the world; and ACCIONA, ranked fourth worldwide in wind farms and seventh in wind turbines. A common feature is that all three firms were established firms in their respective base industries and entered the wind energy business after making considerable transformations to their resource base and competence sets with the aid of technological innovation. Contrary to other lagging competitors, they sensed the opportunity that renewable energies represented very early, through different types of *discovery* processes. They then made massive internal changes to seize that opportunity, thus embarking on different types of *development* processes which were conducive to disruptive innovations in the generation of electricity. In other words, they made use of dynamic capabilities as the cornerstone of their innovation strategy.

Each firm followed unique combinations of discovery processes (opportunity seeker, related observer, mission believer) and development processes (restructurer, renewer, focuser), which were shaped by their origins and previous decisions. These combinations are carefully analyzed by tracking the firms back to their origins and studying each of the relevant decisions made to allow them prosper in the wind energy business. GAMESA transformed itself from an aeronautic firm into a wind turbine manufacturer. ACCIONA changed from construction to renewable energies. Finally, IBERDROLA replaced traditional sources of energy with renewable energies as a major electricity producer.

A major finding from the study presented herein is that technological innovation is used as a tool with which to sense new opportunities, along with seizing those opportunities which had arisen from the business landscape. The firm’s innovation is included in a more encompassing dimension, as is the firm’s dynamic capability. This wide-reaching view of technological innovation based on dynamic capabilities would appear to be a promising avenue in which to undertake future research, and has proved to be successful in the marketplace, as our three case studies of leading European firms in the wind energy business shows. Its merits for the integration of marketing, entrepreneurial, organizational and strategic perspectives are highlighted.

2. LITERATURE REVIEW

Mainstream theories of technological innovation draw on evolutionary and ecological traditions to analyze the dynamics of technology and innovation across populations, industries and firms (Tushman & Nelson, 1990). Although there are considerable differences between evolutionary and ecological perspectives, they all reach the conclusion that established firms outperform start-up firms in settings in which technological changes are continuous and competitive rivalry is based on *incremental* innovations. They similarly share the conclusion that start-up firms are better equipped than established firms to deal with punctuated technological changes and *radical* innovations (Sine, Haveman, & Tolbert, 2005; Tushman & Anderson, 1986). Ecological theorists posit that established organizations are inert and it is not possible for them to adapt to profound changes (Hannan & Freeman, 1984), such as those prompted by changes in the dominant design or the technological base from which the product is obtained (Barnett, 1990). Evolutionary theorists defend that established firms develop organizational routines over time, which are very difficult to adapt to profound changes in technological trajectories (Rosenbloom & Christensen, 1994). It is consequently difficult for mainstream theories of technological innovation to explain cases in which established firms are able to bring radical innovations onto the market or to adapt to radical innovations introduced in the market (Henderson & Clark, 1990). In a parallel view, marketing theories of technological innovation recognize that an overwhelming emphasis on market orientation allows the firm to follow an incremental market-driven behavior at the expense of an alternative breakthrough market-driving behavior according to which the firm is able to create new markets and redefine existing ones (Jaworski, Kohli, & Sahay, 2000).

Furthermore, disruptive market-driving firms are more often found among start-ups since market-driving behavior tends to evaporate over time (Kumar, Scheer, & Philip, 2000).

One problem related to these theories is that of their focus on certain stages of the technological innovation process. Any innovation is the result of a *discovery* stage in which creativity and entrepreneurial thinking dominates, and a *development* stage in which technical and organizational issues are fundamental (Freeman & Engel, 2007). The ecological and evolutionary theories of technological innovation are focused on the second stage and overlook the former. The ecological approach provides a lengthy discussion of the organizational rigidities that make established organizations inert (Singh & Lumsden, 1990), while the evolutionary approach gives an extensive description of technology-related routines that place established organizations on an inflexible path (Nelson & Winter, 1982). None of them, however, directly address the discovery stage of technological innovations in which the continuous search for market opportunities and the deployment of an opportunity-seeking behavior are the natural scope of the marketing and entrepreneurship fields.

Various new theoretical attempts to fill in the aforementioned gaps in the study of technological innovation have been made in different fields. In economics, neo-Austrian theorists have produced noteworthy advancements in the analysis of discovery processes in technological innovations (Kirzner, 1997). In organization theory, researchers working in an information-processing tradition have identified the structural mechanisms that allow ambidextrous organizations to cope simultaneously with incremental and radical innovations (Tushman & O'Reilly, 1996), while other scholars working in an organizational learning tradition have introduced the concept of absorptive capacity as a means for firms to deal simultaneously with exploration and exploitation issues (Cohen & Levinthal, 1990). In marketing science, the implications of having a reactive market-driven, proactive market-driven or market-driving orientation for managing both incremental and disruptive innovations are being studied (Schindehutte, Morris, & Kocak, 2008). In the strategy field, the most remarkable contribution has been made by the dynamic capability approach (Teece, Pisano, & Shuen, 1997) inasmuch as firms with a dynamic capability are able to sense evolving opportunities that arise from the environment and to seize them by transforming their resource bases and competence sets (Teece, 2007).

The dynamic capability perspective is especially meritorious because it is able to consider incremental and radical innovations simultaneously, in addition to discovery and development processes. The theoretical approach based on dynamic capabilities first appeared at the beginning of the 90´s when the existence of certain capabilities of a dynamic nature in the firm was tackled (Nelson, 1991). The first formal definition considered dynamic capabilities to be "a subset of competences or capabilities that allow the firm to create new products and processes, answering changing circumstances of the market" (Teece & Pisano, 1994). This approach towards dynamic capabilities based on innovation referred to firms' abilities to develop new solutions. In the new decade, dynamic capabilities were defined as "the ability of organizations to innovate and to adapt to changes in technology and markets, including the ability to learn from mistakes" (Helfat & Raubitschek, 2000). In an effort to clarify this, dynamic capabilities were considered to include "difficult-to-replicate enterprise capabilities required to adapt to changing customer and technological opportunities. They also embrace the enterprise's capability to shape the ecosystem it occupies, develop new products and processes, and design and implement viable business models" (Teece, 2007).

The contributions shown above share an innovation-centered approach towards the definition of dynamic capabilities, but other approaches extend the scope of dynamic capabilities further to include the ability of firms to identify and adapt to any change, technological or otherwise, and the need for firms to modify their resource base and competences set to carry out the adaptation successfully (Eisenhardt & Martin, 2000). In fact, the landmark article on dynamic capabilities adheres to this conception since it affirms that they are “the firm´s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece, Pisano, & Shuen, 1997). In this line of reasoning, dynamic capabilities are “a firm’s behavioral orientation towards constantly integrating, reconfiguring, renewing and recreating its resources and capabilities and, most importantly, upgrading and reconstructing its core capabilities in response to the changing environment to attain and sustain competitive advantage” (Wang & Ahmed, 2007).

All of the above definitions within different traditions allow us to summarize our recognition that dynamic capabilities play the key role in modifying a firm’s resource base and competence set in order to exploit emerging opportunities arising from environmental changes. A major strength of the dynamic-capability approach towards technological innovation is that the *discovery* and *development* processes are dealt with simultaneously. A firm’s ability to discover the opportunity that a technological innovation represents is a *necessary condition*, while the firm’s complementary ability to develop that technological innovation through the corresponding change in resources and competences is a *sufficient condition*.

Wind energy is a technological substitute for coal thermal power, gas-fuel combined cycle power, hydroelectric power or nuclear power for the production of electricity. As will be discussed in the next section, the Spanish wind energy market has provided huge opportunities for firms to prosper, and thus represents an ideal setting in which to study whether or not those firms that were able to prosper have a dynamic capability that encompasses both the discovery and development of wind energy technologies.

3. WIND ENERGY TECHNOLOGY

Since the first oil crisis, renewable energy sources have gained great importance owing to their sustainability, inexhaustibility, ecological awareness and supply of energy security. Renewable energy sources are therefore expected to play a key role in electrical power generation (Akdağ & Dinler, 2009). Countries' governments are looking not only to expand their domestic use of renewable energy, but also to develop accompanying renewable energy technology manufacturing industries to serve the energy demand (Portman, Duff, Köppel, Reisert, & Higgins, 2009). Technologies for the exploitation and conversion of renewable energy sources have now gained a level of maturity that allows the efficient operation of facilities and equipment in many applications.

In addition to the very small environmental impact in terms of carbon dioxide (CO2) emissions, an energy policy based on renewable energy permits sustainable energy supply, thus reducing the consumption of fossil fuels. The use of a wide range of sources supports the security of the energy supply as a result of increased energy diversity. Some other advantages are the long life expectancy of renewable energy facilities, the short time between the moment at which a decision is made and its implementation, the fact that the cost of energy is principally determined by investment, and so on. They are also essential if the requirements mandated by the Kyoto Protocol are to be met, particularly in the aim of reducing greenhouse gas emissions and in supporting the sustainable development of developed and developing countries (Berry, 2009).

3.1. Wind energy in Europe

One important point to consider is that today's discussions about renewable energies mainly concern wind energy, not only because this renewable energy source occupies the first and by far highest position among renewable energies, but also because this share is continually increasing. Global demand for renewable energy is rapidly increasing as a result of climate problems, and also because oil resources are limited (Mostafaeipour, 2010). Wind energy appears as a clean and good solution to cope with a great part of this energy demand (Breton & Moe, 2009). Wind is one of the world's principally increasing renewable energy sources. Wind energy owes its rapid growth to the technological improvements made in recent years (Ozerdem, Ozer, & Tosum, 2006).

The global wind capacity increases year by year. In 2010, the world wind energy capacity was 175,000 megawatts (MW), with important growth rates that have more than doubled every three years. By the year 2020, the predicted world wind energy capacity will be at least 1,900,000 MW (WWEA, 2009). Wind power is growing everywhere. The United States of America (USA) is still the country with the greatest installed capacity. China has moved up two positions from 2009, overtaking Germany and Spain as the second largest country in terms of total installed capacity, while Spain is in fourth place and India is in fifth place. The top five countries (USA, China, Germany, Spain and India) represented 72.9 % of the worldwide wind capacity in 2009, signifying that the level of concentration of wind energy facilities is considerably high.

A look at the share that wind energy represents in total electricity demand highlights the growth potential of this industry in the future. In 2009, wind turbines produced 2% of global electricity demand. In some countries the share of wind power supplied to the electricity grid is higher than in other countries. 20% of the energy consumed in Denmark is provided by wind energy, 15% in Portugal, 14% in Spain and 9% in Germany (WWEA, 2009). It is predicted that wind energy will contribute to at least 14 % of global electricity consumption in 2020.

Europe’s wind energy capacity share reached a peak of 47.8% in 2009 (WWEA, 2009), signifying that half the global share corresponds with one continent worldwide. Europe’s 2009 installations are characterised by a continual strong development in wind power in the mature markets of Spain and Germany, together with countries such as Italy, France, and the United Kingdom (EWEA, 2010). In terms of total capacity, Germany and

Spain were still by far the biggest markets for wind power, with 34% and 26% of shares, respectively.

The European market for wind energy is maturing thanks to a solid and emerging technology in the global energy market. Although wind power is already one of the well-established alternatives to conventional energy sources in electricity generation in markets such as those of Germany, Spain and Denmark, this technology continues to confront the double challenge of competing against other renewable technologies while it should be guaranteed as a solid energy choice for large energy producers that wish to increase and to diversify their portfolios.

3.2. Wind energy in Spain

The analysis of the worldwide and European wind energy markets made so far allows a straightforward implication to be derived: there is something distinctive about the Spanish wind energy market when compared to other countries; something that must explain why a medium-sized economy like that of Spain is one the four largest producers worldwide and the second largest producer in Europe. Moreover, the Spanish wind turbine manufacturers, along with those of Denmark and Germany, dominate many wind markets around the world and are expected to continue in their leading role in the coming years, although new international competitors are expected to emerge from Asia and America. The well-known Porter's diamond is useful in the analysis of country-specific reasons to explain why some countries are more competitive than others (Porter, 1990). A brief application of this to the Spanish wind energy industry sheds light on Spain's competitive advantage in wind energies.

The *related and supporting industries* are automobile manufacturing and aeronautic assembly. A base of qualified engineers, material scientists, software programmers, design specialists and mechanics have enabled the Spanish wind energy industry to focus on higher value added activities such as blade design, software programming and gearbox manufacturing. The Spanish electricity industry has also developed relationships with the utilities and governments of other countries, which has proved useful in the process of importing key complementary technologies (Bolon, Commons, Rosiers, Guzman, & Kukrika, 2007).

The *factor conditions* that were necessary to allow the wind energy industry to prosper were also favorable in Spain. Generally speaking, successful wind farms rely on five key activities: reliable wind turbine design, high-quality manufacturing, good wind resource assessments, professional maintenance and operation, and flexible power grid management. All of these require comprehensive and in-depth wind power technical research and development (R&D) (Zhao, Hu, & Zuo, 2009). Spain has a well-developed electrical grid, high levels of expenditure on wind related R&D and expertise in financing wind power projects, and its public universities are additionally specialized in the field of engineering. Spain has consumed many exhaustible resources for wind energy development such as greenfield sites for the installation of wind turbines. This lack of site availability and the intermittent nature of wind make the scheduling of power flows difficult (Bolon, Commons, Rosiers, Guzman, & Kukrika, 2007). These specialized factors are scarce and difficult for other countries' wind energy industries to imitate, and the creation of these factors requires sustained investments over time.

The *demand conditions* are particularly favorable in Spain as the result of a strong commitment towards promoting renewable energies adopted by successive governments amid a public opinion in favor of green alternatives. Spain consequently has a trusted and flexible incentive scheme. Although the industry may undergo a decline in demand as incentives are phased out, in the long term, global demand is expected to explode in the coming decades as a result of the increasing use of electricity energy and the role that renewable resources must play as certain non-renewable resources are exhausted (Bolon, Commons, Rosiers, Guzman, & Kukrika, 2007).

Finally, the *context for firm strategy and rivalry* is characterized by the Spanish wind energy industry's quest for innovation to improve the adaptability of the land and the overall efficiency. Firms have also sought foreign markets in which to provide their products and services.

The favorable configuration of the Porter's diamond factors, together with the increasing global demand for wind energy sources, have allowed a global industry to flourish in Spain. Despite the fact that the firms within the Spanish wind energy industry are highly internationalized, the domestic market remains an important base from which to expand to other countries.

Starting from the fact that the wind energy markets can be classified in three major categories in accordance with their level of development, Spain's market is at an advanced stage (EWEA, 2010). The *growth markets* category comprises markets with a nascent wind energy sector. In these markets, the gradual creation and implementation of a stable regulatory framework is expected. The total wind power installed in growth markets remains at less than 3% of Europe's total installed power capacity. The *scaling markets* category includes those markets with important remaining resources. Moreover, these markets have a stable regulatory framework. Finally, the *consolidating markets* category is characterized by markets that have matured, since they concentrate more than 10% of national installed generation capacity and the availability of greenfield site opportunities is thus limited. Denmark and Germany are currently located in this group in which there are no new greenfield sites to exploit. In these markets, most projects for the installation of new wind farms have already been authorized or are in the final phase of authorization.

The Spanish market for wind energy has a high level of maturity, which is only surpassed by countries like Germany and Denmark. Spain is on the border of scaling and consolidated markets. 14.4% of total Spanish electricity is produced from wind power, which would situate Spain in the group of consolidating markets, but it has still greenfield sites on which new projects can be developed. In the short term, the consolidating markets will reach a peak in cumulative wind power capacity. This situation will last until offshore markets are developed or wind turbines are repowered (replacing older wind turbines).

3.3. Technology and major players in Spain

The initial development of the wind energy industry in Spain has its roots in small firms which designed their own wind turbines and brought different components onto the market for their assembly in specialized workshops. A closer relation between designers and component manufacturers has arisen over time. Manufacturers gradually began to specialize in the wind energy industry. Spain has an increasingly powerful wind turbine industry which is extremely competitive in the global marketplace.

Spanish wind energy occupies a leading position in every stage of the value chain, which is composed of four main industries: component manufacturers, wind turbine manufacturers, promoters-producers and supporting services (SWEA, 2010). Distribution and transport are carried out by electricity firms.

According to the experience and technical and economic relevance achieved by the Spanish wind industry, it is expected that Spanish firms will play a major role in the worldwide process of infrastructure development (SWEA, 2010). Many Spanish firms have a strong international presence, and leading foreign firms have made the decision to build up a major presence in Spain, including having regional headquarters there.

The most genuine industry within the wind energy sector is that composed of *promoters and producers*, namely, the firms that are responsible for installing and operating wind farms. Although some wind farms are promoted and are then sold to a third-party operator, and some operators produce electricity on wind farms owned by other firms, the reality is that this industry works around a traditional business model characterized by the joint promotion and operation of wind energy facilities. In this industry, a typical firm is the promoter of its own wind farms in addition to being the operator in charge of producing electricity. The top three firms have more than 50% of the installed wind farm capacity in Spain, which is an exceptionally high level of concentration if we consider that this industry is relatively new. The Spain-based firms IBERDROLA and ACCIONA and the Portugal-based firm EDP are the top players in the Spanish market.

The *wind turbine manufacturers* are the wind farms' principal suppliers and are also considered to be part of the wind energy business. In recent years, wind turbine manufacturers have produced turbines of a greater capacity and lower wind speeds, which has greatly improved the wind farms' productivity (EWEA, 2010). The three largest firms account for more than 70% of installed wind energy capacity in Spain. Again, the market concentration is extraordinarily high for a relatively new industry. The Spain-based firms GAMESA and ACCIONA and the Denmark-based firm VESTAS are the top players.

The *component manufacturers* supply the wind turbine manufacturers. They are more distant participants in the wind energy business since many of the firms also manufacture components for other industries. The *service providers* are firms that support certain activities within any of the value chain stages, ranging from consultation to construction, and of which assembly and maintenance are the most important. Finally, the *distributors and transporters* are at the end of the wind energy business value chain since they carry and commercialize the electricity produced to consumers through the power grid (AEE 2009).

Overall, the Spanish wind energy industry is an ideal setting in which to investigate dynamic capabilities, because of the huge opportunity that renewable energies entail for new entrant firms in terms of industrial growth and firm profitability. As is described above, these opportunities are even greater in the Spanish market as a consequence of certain decisions that were made during the early stages of the industrial life cycle, thus providing an almost perfect case for research.

4. METHODS

The dynamic capabilities approach is a relatively new approach, and the evidence accumulated to date is thus still rather scarce (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997; Teece, 2007). Most empirical studies on dynamic capabilities have adopted a case study methodology, whereas quantitative analyses are exceptions. Dynamic capabilities are a concept "which has thus far proven largely resistant to observation and measurement" (Kraatz & Zajac, 2001).

The study of dynamic capabilities and path dependences requires a historical follow-up from the beginning of the industry, which can be achieved with case studies. The studies carried out on dynamic capabilities are in the tradition of longitudinal research, since they attempt to capture historical effect (Helfat, 2000). It is very difficult to collect panel data with which to make longitudinal studies possible (Danneels, The process of technological competence leveraging, 2007). Quantitative methods often involve the use of proxy variables which may only capture the tangible and visible aspects of a phenomenon (Ambrosini & Bowman, 2009) and thus, "it may be necessary to sacrifice some of the generality of quantitative investigation for a more qualitative attention to detail" (Lockett & Thompson, 2001).

Previous studies embracing a qualitative methodology in dealing with dynamic capabilities are common, such as those carried out with multiple case studies in the US bookselling industry (Raff, 2000), the Indian pharmaceutical industry (Athreye, Kale, & Ramani, 2009), the US semiconductor industry (Holbrook, Cohen, Hounshell, & Klepper,

2000) or even single-case studies of prominent firms of the likes of NCR (Rosenbloom, 2000), Polaroid (Tripsas & Gavetti, 2000), IBM (Harreld, O'Reilly, & Tushman, 2007) or Smith Corona (Danneels, 2010). A multiple case study methodology has been used in this study.

The research presented here relies mainly on secondary data, whereas the primary data gathered from meetings with engineers who are knowledgeable in the wind energy business played only a complementary function. The secondary data were collected from a variety of sources, including corporate annual reports, firms' websites, news published in business newspapers and magazines, and stock market advice reports. A set of conversations with engineers from the sample firms complements the secondary information. These meetings provided in-depth and first-hand information on important issues to drive the analysis of the secondary information.

We decided to analyze the largest firms in Spain's wind energy business. As described in the section in which an overview of wind energy is presented, there are two major industries with important differences within the so-called wind energy business: wind turbine manufacturers and wind farm operators. The three largest firms in wind turbine manufacturing account for more than 70% of the Spanish market, whereas the corresponding three largest firms in wind farm operation account for than 50%. There are only two foreign firms amongst the six leading firms: the Denmark-based wind turbine manufacturer VESTAS and the Portugal-based wind farm operator EDP. In order to avoid any confounding effect derived from the fact that these are not domestic firms competing in a domestic market, such as the liability of foreignness issue, these firms were dropped from further analyses .The research presented here is focused on the two most important industries in the wind energy business, namely, wind turbines and wind farms, and the top Spain-based players in these industries: GAMESA, ACCIONA and IBERDROLA.

5. CASE STUDIES

In this section, we trace the evolution of our sample firms back to their origins in order to discover the underlying paths that led them to adapt to the technological innovation that the wind energy business represented. Rather than describing all the events in the evolution of these firms, we focus on the strategic decisions that implied a significant change in their resources and competences, since this type of change may be indicative of the fact that these firms have made use of dynamic capabilities.

5.1. The focusing path of GAMESA

GAMESA is a firm which has been listed in the Spanish stock market since the year 2000 and was included in the stock market index (which comprises the top 35 firms in the Spanish stock market) in 2001. GAMESA is focused on renewable energy technologies, particularly those of wind energy in which it leads the Spanish market, and it is a top manufacturer of wind turbines worldwide. It relies on its own capacity in the design and technological development of wind turbines, an integral production capacity which includes the manufacture of blades, blade roots, molds for the manufacture of blades, gearboxes, generators, convertors and towers, and the assembly of wind turbines at 32 production centers. The commercialization and maintenance of this equipment takes place on a worldwide scale. GAMESA has already supplied wind turbines to the USA, Italy, France, Germany, Portugal, Greece, the United Kingdom, Ireland, China, Japan, Vietnam, Taiwan, Tunis, India, Egypt, Morocco, Argentina, Mexico, Korea, Spain, Hungary and Poland, and has a wide commercial network that includes wholly-owned subsidiaries in Germany, China, Italy, Denmark and the USA, commercial offices in Greece, Portugal, France and the United Kingdom and partially-owned subsidiaries in Mexico, Morocco, Egypt and Tunisia.

From its foundation in 1976, under the name of AUXILIARY METALLURGICAL GROUP, the firm has amassed experience in the manufacture of components for industrial customers, such as automakers and equipment firms. From the outset, it was clear that GAMESA had more ambitious aspirations than that of being a component manufacturer of non-advanced technological parts, and it committed to the development of new technologies for emerging businesses, such as robotics, microelectronics and composite materials. In accordance with this vision, the firm gradually began to focus on renewable energies and aeronautics, a process which intensified in the ‘90s.

In 1993, GAMESA began work on its first aeronautic program consisting of a regional jet for the Brazilian aircraft manufacturer EMBRAER. A year later, in 1994, GAMESA embarked on the engineering, design, manufacture and sale of wind turbines, along with the provision of specialist services to wind energy operators. In the same year, GAMESA obtained a technological license from VESTAS for the manufacture of wind turbines in Spain. The Denmark-based firm VESTAS was the world leader in wind turbines at that time, and the cooperation agreement allowed it to access the Spanish market without committing too many resources. In exchange, VESTAS contributed to GAMESA with technology and brands.

In 2001, VESTAS sold its 40% minority stake in GAMESA WIND to GAMESA for 287 million euros in a financial deal which marked the end of their relationship and included the transfer of intellectual property from VESTAS to GAMESA (to the extent of particular wind turbine models). The termination of this cooperation agreement was prompted by a severe strategic conflict between both partners with regard to the scope of GAMESA operations. The original agreement signified that GAMESA had to restrict its sale of wind turbines to Spain, Latin America and North Africa. At that time, it was clear that GAMESA was undergoing a major corporate restructuring which involved refocusing the firm on the wind energy business. No sooner had GAMESA terminated its cooperation with VESTAS, than it expanded its international footprint, engaging in projects in countries such as Portugal, Italy, France, Greece, Germany, Ireland, the UK, the USA, China and Mexico. It also started up its first manufacturing facility in China. GAMESA did not overlook opportunities to improve its technological know-how with regard to various wind turbine components, and made certain targeted acquisitions, such as that of ECHESA, which manufactures advanced gearboxes.

In 2006, GAMESA sold its aeronautical division (currently AERNNOVA AEROSPACE) to a group of investors. This operation allowed GAMESA to complete its pursued disinvestments in aeronautics and automotives. The need to focus on and finance its international expansion in wind energy-related businesses was the determining factor underlying this decision.

Overall, the path that GAMESA has followed in its 35 years of existence can be regarded as a quest to discover the right place in which to compete. During this process, the firm adopted a de-diversification strategy with divestment in the aeronautic and automotive businesses and a focus strategy within the wind energy business in which, after some trial and error experiences, it has decided to continue concentrating on the manufacture of wind turbines. Another distinctive feature of GAMESA is the entrepreneurial spirit with which it has confronted key strategic decisions. It did not make forced changes as the result of a decline in a particular industry or an unprofitable situation, but rather made changes from strong competitive positions from which it was possible to oversee these changes. It also already enjoyed favorable conditions. The continual quest for business opportunities drove GAMESA into the wind business industry from a related business, this being the manufacture of parts for automakers and aircraft makers. The focusing path followed by GAMESA provided a strong competitive position in the manufacture of wind turbines, in which the firm is ranked first in Spain and third worldwide.

5.2. The restructuring path of ACCIONA

ACCIONA is one of the largest Spanish business corporations listed in the Spanish stock market and included in the Ibex-35 stock exchange index, with operations in more than 30 countries. From 2004 onwards, ACCIONA has had three well-defined business areas based around infrastructures, energy and water, all of which are managed under the principles of sustainable development. ACCIONA ENERGY, the business unit focused on renewable energies, has 20 years of experience in the industry and is present in 20 countries worldwide, employing seven types of clean technologies (wind, hydraulics, biomass, solar, photovoltaic, thermal and cogeneration). It participates in the entire wind energy value chain, ranging from the manufacture of wind turbines to the commercialization of electric power, passing through the promotion of wind farms. ACCIONA ENERGY is a leading firm in the promotion and construction of wind farms, for both for its own operational purposes and those of third parties, whilst it is also a big player in the manufacture of wind turbines through its subsidiary ACCIONA WINDPOWER.

The origins of ACCIONA can be traced back to 1931 when the engineer José Entrecanales Ibarra and the businessman Manuel Távora founded a construction and engineering firm under the name of ENTRECANALES AND TAVORA. Among the most singular works undertaken in the following years were the constructions of the terminals at Barajas Airport, Madrid, or that of the Atazar dam, also in Madrid. In 1970, a planned succession carried out in what was then a family business gave a new impetus to the firm's consolidation in construction and engineering, both in and outside Spain. The firm followed the '80s trend of diversification, and entered real estate, the wine industry and urban services. In the '90s, ACCIONA entered concessional business, first in transport infrastructures and later in telecommunication infrastructures, with a major shareholding in AIRTEL (now VODAFONE in Spain). In 1996, the merger of CUBIERTAS and MZOV and ENTRECANALES involved the creation of a new firm under the name of NECSO, which became ACCIONA a year later. During this formation period, ACCIONA inherited a philosophy based on sustainability, quality, profitability and high engineering standards from the original companies. In the late '90s, the construction and adjudication of new infrastructures stagnated, and ACCIONA adopted the strategy of gradually increasing the weight of the other businesses into which the firm had diversified.

In 2003, the construction business continued to be its major source of income, at almost 84%. In the same year, ACCIONA acquired a 50% shareholding in EHN, a leading Spanish firm in renewable energies with six wind farms under construction in seven countries and a wind turbine manufacturing facility located in Barasoain (Navarra, Spain) which was the origin of ACCIONA WINDPOWER. On the last day of 2003, ACCIONA sold its remaining shareholding in AIRTEL, again with very important capital gains. With a view to the future, the firm continued to seek new areas of growth and diversification in which to invest its available financial resources.

In 2006, ACCIONA ENERGY acquired the firm CEATESALAS, which was, in turn, the owner of 93.1% of CESA, both important promoters of wind farms with a presence in two international strategic markets (Italy and Greece), and ongoing projects for new developments in Portugal and Hungary. This acquisition led to a considerable growth in ACCIONA ENERGY, with an increment of 96% in installed wind power. During that year, ACCIONA ENERGY installed 21 wind farms in ten countries and had projects for new developments in another six. The production of wind power in Spain represented 84% of the total. A further important achievement was the inauguration of the largest wind turbine production facility in China based on ACCIONA's proprietary technology. ACCIONA WINDPOWER almost doubled its production of wind turbines in a context in which the strong international demand for wind turbines surpassed the existing offer. In an important corporate movement, ACCIONA bought a 20% shareholding in ENDESA, the largest electricity utility in Spain and, in relation to this, sold a 15% shareholding in FCC, the second largest construction firm in Spain. The corporate restructuring of ACCIONA was now underway, shifting away from construction and infrastructures to electricity and renewable energies. As a result, the renewable energy business accounted for more than 45% of its net income, whereas the construction business accounted for 25%.

In 2009, the deal to sell the 25% shareholding in ENDESA to ENEL, the largest electricity utility in Italy, included renewable energy assets of 2.85 billion euros worth of MW for ACCIONA, equivalent to 2,080 MW. As a result of this deal, ACCIONA, exchanged non-renewable assets for renewable assets and thus became a renewable energy-centered firm.

Overall, ACCIONA took a path revolving around corporate restructuring in which the firm enters and withdraws from many businesses. This process led ACCIONA to become one of the big players in the wind energy business worldwide. The quest to discover the right place in which to invest the excess cash flows amassed in the construction of infrastructures and some other corporate operations realized with important capital gains (AIRTEL, FCC, ENDESA-ENEL) led ACCIONA into the wind energy business, in which it is now ranked second in Spain and fourth worldwide in wind farms, and third in Spain and seventh worldwide in wind turbines.

5.3. The renewal path of IBERDROLA

IBERDROLA is a large firm whose headquarters are located in Bilbao (Spain) and which generates, distributes and commercializes electricity and natural gas, in addition to other businesses. This firm is the result of the merger between HIDROELÉCTRICA ESPAÑOLA (founded in 1907) and IBERDUERO (whose origins go as far back as 1901), which took place in 1992. IBERDROLA is currently one of the four largest electricity firms in the world, and the top energy corporation in Spain.

In order to understand the path taken by IBERDROLA it is necessary to go back to its origins, as the firms that were successively integrated to form this corporation were originally hydroelectric producers. A tradition of renewable energy therefore lay in the very origins of IBERDROLA. In 1901, HIDROELÉCTRICA IBÉRICA was founded, with a license for the hydroelectric exploitation of the rivers in the main industrial regions of Spain which, at that time, were located in the north of the country. In 1907, HIDROELÉCTRICA ESPAÑOLA was set up to supply the markets of Madrid and Valencia, exploiting the rivers Tajo, Júcar and Mijares. In 1944, HIDROELÉCTRICA IBÉRICA was merged with SALTOS DEL DUERO, resulting in IBERDUERO. In 1957, the first large-scale hydroelectric steam generating station in Spain started operating, with a capacity of 858 MW. In 1962, the second hydroelectric power plant was opened with a capacity of 718 MW. An additional third plant with a capacity of 915 MW was also inaugurated, involving the construction of the largest reservoir in Europe at that time.

In the late ‘60s, it was clear that relying solely on hydroelectric power generation was a highly risky strategy because of the existence of important pluviometric changes from year to year. Rather than adopting technologies that were considered to be more environmentally unfriendly at that time, HIDROELÉCTRICA ESPAÑOLA and IBERDUERO decided to invest in nuclear power generation. Again, the backgrounds of these firms were the key to their taking a very important strategic direction in the future. In 1971, IBERDUERO (in cooperation with ELECTRA DE VIESGO) began to operate a first-generation nuclear power plant with 460 MW (Santa María de Garoña, Burgos, Spain). Ten years later, in 1981, HIDROELÉCTRICA ESPAÑOLA (in cooperation with SEVILLANA DE ELECTRICIDAD and UNIÓN FENOSA) connected a nuclear power plant of 1,860 MW to the grid (Almaraz, Cáceres, Spain). In 1984, HIDROELÉCTRICA ESPAÑOLA started operating a new nuclear plant with 975 MW (Cofrentes, Valencia, Spain). In 1987, HIDROELÉCTRICA

ESPAÑOLA (in cooperation with ENDESA) connected a new nuclear plant of 982 MW to the grid (Vandellòs, Tarragona, Spain). Two additional nuclear power facilities that were under construction (Valdecaballeros and Lemóniz) were suddenly abandoned as the result of a governmental decision not to authorize new nuclear plants in Spain from 1984 onwards (which was, in fact, effective from 1991 onwards). In exchange for abandoning these projects, the government approved a compensation in the promoter firms' electricity bills.

In 1992, IBERDROLA began to operate as a result of the merger between HIDROELÉCTRICA ESPAÑOLA and IBERDUERO, thus obtaining one of the best electricity generation mixes in the world, mainly composed of hydroelectric and nuclear energy sources. What is more important is that these assets were valuable, rare and difficult, if not impossible, to imitate because of the nuclear moratorium in Spain (and in many developed countries) and the scarcity of the river sites needed to produce hydroelectric power. The merger was at that time the best possible merger that could be carried out during the process of industrial concentration that took place in Spain in the eighties and early nineties. In the 7 years after its formal formation, IBERDROLA underwent a significant international expansion in American countries with the important acquisitions of Bolivian, Chilean, Brazilian, Guatemalan and U.S. firms in electricity-related businesses.

From the year 2000 onwards, IBERDROLA decided to invest its excess cash flow in renewable energies by following the path adopted in the past and seeking a green technological substitute for hydroelectric and nuclear power in the face of increasing environmental awareness. IBERDROLA launched its project in renewables in 2001 with the foundation of IBERDROLA RENOVABLES in a corporate move which contrasted sharply with the direction adopted by other electricity firms with huge investments in combined cycle power plants. IBERDROLA RENOVABLES is currently the top wind energy firm in the world when considering its total installed capacity.

As an indication of the valuable assets in renewable energies, when IBERDROLA decided to float 20% of IBERDROLA RENOVABLES on the stock market in 2007, the subsidiary immediately became one of the top ten Spanish firms in terms of market capitalization.

Overall, the path followed by IBERDROLA is that of a renewer since it has constantly searched for renewed environmentally friendly technologies to produce electricity. This renewing path can be traced back to IBERDROLA's origins as a major producer of electricity with hydroelectric technologies. The firm later withdrew from the widespread coal thermal plants and committed to what was, at that time, the emerging nuclear power. After the decision made by the Spanish government not to authorize further nuclear power plants, the firm again overlooked the massive investment of most electricity utilities in combined cycle power plants and committed to wind energy technologies with the commencement of IBERDROLA RENOVABLES. The path followed by IBERDROLA proved to be successful. This firm is the sixth largest electricity utility in the world and the top firm with regard to electricity produced with environmentally friendly technologies. In the wind energy business, IBERDROLA is ranked first both in Spain and worldwide in wind farms.

6. DISCUSSION

The case studies of the GAMESA, ACCIONA and IBERDROLA, which are three leading firms in the wind energy business worldwide, support a dynamic-capability explanation of technological innovation, namely, firms that prosper in technologically changing businesses are those that are able to adapt their resource base and competence set in the light of evolving opportunities. Those opportunities have to be *discovered* as a necessary condition, but they also have to be *developed* for the firms to prosper in changing environments as a sufficient condition. Our case studies show the different ways in which firms may choose to discover and develop opportunities in the form of technological innovations (Table 1).

Table 1: Discovery and development in technological innovation

Firms	Discovery	Development	2010 Worldwide Position
ACCIONA	Opportunity seeker	Restructurer	7th in wind turbines 4th in wind farms
GAMESA	Related observer	Focuser	3rd in wind turbines
IBERDROLA	Mission believer	Renewer	1st in wind farms

GAMESA initially operated in the manufacture and sale of industrial machinery and equipment, with automakers as its major customers. Over the years, GAMESA began to focus its business model on renewable energies and aeronautics. These businesses involved serving large industrial customers, such as the automobile business, but they were more profitable, entailed more advanced technology and promised more growth. As a related observer, *discovery* was driven by the similarities between these industrial businesses, especially those between aeronautics and blade design and automotives and wind turbines. GAMESA then began its *development* process in the wind energy business, namely, enhancing, combining, protecting, and reconfiguring its resource base and competence sets. Most of the resources and competences that GAMESA needed to compete in the manufacture of wind turbines were developed in the process of competing in automobiles and aeronautics, but it was necessary to reconfigure these assets if it was to compete in the new business. This process of adaptation received a definitive impulse with the strategic alliance signed with VESTAS which allowed GAMESA to gain access to key technological knowhow. The exit from automotives and aeronautics which permitted GAMESA to focus on wind turbines marked the end of its development process.

ACCIONA began in the business of infrastructure construction but diversified early into service businesses, such as real estate, urban services, telecommunications, concessions, airport handling and maritime transport, and to a lesser extent into manufacturing businesses. As the traditional business of constructing infrastructures stagnated, ACCIONA looked for other business as an opportunity seeker. The decision to invest in renewable energies was the result of this intended *discovery* process of seeking emerging businesses in which to invest its excess cash flow. Mobile telecommunications and renewable energies attracted ACCIONA's interest, and both were based on major acquisitions: AIRTEL in the first case and EHN in the second. ACCIONA later sold its telecommunications business with important capital gains, thus releasing financial resources for investment elsewhere. Following a restructurer approach to its *development* process, ACCIONA allocated resources away from many businesses toward the wind energy industry, mainly through acquisitions and divestments such as the FCC and ENDESA-ENEL operations.

IBERDROLA began producing electricity with hydroelectric technology, and was later very aggressive both in the implementation of nuclear power as a new means of producing electricity and in the more recent move consisting of producing electricity with wind energy technology. *Discovering* the opportunity that renewable energies represented was consistent with the firm's traditional strategic mission of seeking green technologies in the production of electricity. Along its historical path, IBERDROLA developed valuable competences in the promotion and operation of complex and technologically advanced power stations, regardless of whether these were hydroelectric or nuclear facilities, that were later transferred to the promotion and operation of wind farms. IBERDROLA's *development* process consisted mainly of adapting the knowledge developed in promoting and managing hydroelectric and nuclear stations in order to renew its power generation mix with greener technologies.

Our case studies are particularly valuable, not only because they shed light on the formation of Europe-based global champions in a high-growth, technologically-advanced industry using a dynamic-capability explanation, but also because existent ecological and evolutionary theories of technological innovation find it difficult to explain how the selected firms have achieved leading worldwide positions in the wind energy business. If organizations are inert and become routinized, as is defended by ecological and evolutionary approaches (Barnett, 1990), the explanation of the process by which an aeronautic firm (GAMESA), a construction firm (ACCIONA) and a utility firm (IBERDROLA) have come to be leading firms in the wind energy business is beyond the scope of these theories. Their documented abilities to discover the opportunity that wind energy technology represented, and the corresponding development processes deployed to adapt their resources and competences to the new technology, are exogenous to those theories (Tripsas, 1997). Even in the case of IBERDROLA (an established producer of electricity), ecological and evolutionary approaches would be not very optimistic with regard to its willingness to cannibalize other power generation technologies with wind energy technology owing to inertness and competence-destroying considerations (Henderson & Clark, 1990; Tushman & Anderson, 1986).

The case studies findings are also distinctive from a marketing perspective. Previous research into the role of the marketing function in the management of technological innovations has focused on either the ex-ante introduction or ex-post adoption of product innovations. The ability of the marketing department to bring breakthrough product innovations into the market (Moon, 2010) and to reduce the so-called time-to-takeoff once those product innovations are in their process of adoption (Vowles, Thirkell, & Sinha, 2011) is the focus of most research in this field. However, neither introduction nor adoption considerations contribute to explain our findings. Wind energy technology was not pioneered by Spanish firms nor is Spain a country where the adoption of technological innovations was expected to be particularly quick (Chandrasekaran & Tellis, 2008), so the traditional marketing explanations fail to account for the unprecedented success of Spain-based firms devoted to wind turbines and wind farms. Our paper calls for the role firm-level dynamic capabilities might play in the explanation of the success some firms enjoyed in managing disruptive technological innovations, like wind energy technologies in the production of electricity. Our work reached parallels findings as those achieved by others (Schindehutte, Morris, & Kocak, 2008; Tellis, Prabhu, & Chandy, 2009) regarding the role of firm-level factors in the account for radical innovations; those studies highlight the importance of market-driving behavior and corporate culture, respectively, whereas our paper stress the relevance of dynamic capabilities. The marketing literature on technological innovation and technology firms has always been concerned with marrying technology push and marketing pull in technologically advanced settings. The concept of dynamic capability looks promising in the marketing field to produce that type of integration between technical and market issues.

This work also contributes to existent research on dynamic capabilities by showing the value of the distinction between discovery and development when analyzing this issue. A major problem with the advancement of the dynamic capability view of the firm is that related to the lack of clarity around this concept, which in turn makes its operationalization difficult (Lavie, 2006). Our multiple case study identifies two important dimensions of dynamic capabilities (discovery and development), illustrates that they must appear together (necessary and sufficient conditions) and documents the categorical value that they may have in a specific empirical setting (related observer-focuser, opportunity seeker-reestructurer, mission believer-renewer). The study presented here is thus a step in the direction of delineating the structure and content of dynamic capabilities if this field is to progress.

The two-dimensional conceptualization of dynamic capabilities around discovery and development process has the advantage of highlighting the multi-disciplinary work of the type required to analyze the complexity and subtleties of change and innovation. The process of discovery is the natural scope of marketing and entrepreneurship thinking, while the process of development is amenable to study through organizational and strategic thinking. Mainstream ecological and evolutionary theories of technological innovation have focused on the development process, leaving the discovery process largely unexplored and overlooking the potential of taking marketing and entrepreneurship considerations into account. Recent studies have shown the potential for cross-fertilization between dynamic capabilities and other concepts such as entrepreneurial opportunities (Newey & Zahra, 2009) or customer orientation (Zhou & Li, 2010), while yet other studies have investigated the role of dynamic capabilities in the marketing function (Bruni & Verona, 2009; Fang & Zou, 2009) or in business venturing (Boccardelli & Magnusson, 2006; Zahra, Sapienza, & Davidsson, 2006). Our work points to the direction in which entrepreneurship and marketing concepts may be more fruitfully incorporated, namely, the discovery dimension of dynamic capabilities.

A limitation of the present study is that of generalizability because their findings are derived from a single-country, single-industry case study. Future studies in which more industries and countries are taken into account would improve the generalizability of findings. A second limitation is related to the fact that the sample firms are in different stages of the industry's value chain; IBERDROLA is a B2C company, GAMESA is a B2B company and ACCIONA is both a B2B and B2C company. Consequently, wind energy technology is a source of product innovations for GAMESA and ACCIONA, while is a source of process innovations for IBERDROLA and ACCIONA. Although there are few studies that address radical process innovations in a B2B setting (Vowles, Thirkell, & Sinha, 2011) and thus our study is meritorious in this regard, future studies spanning both types of technological innovations would reinforce our approach. Finally, dynamic capabilities is a concept which is at the heart of the interface between the firm and the environment and hence it is both an inside out and outside in phenomenon; the business opportunity has to be out there and firms has to be ready to exploit it. Accordingly, it is not always clear whether business success can attributed to external exceptional conditions or to internal singular abilities. In this study a question remains as to thumb the context for wind energy in Spain or the dynamic capabilities of focal Spain-based firms as the latent cause of success. Further research is needed to delineate the role played by an industry within a country relative to the role played by the individual firms competing in that context (Tellis, Prabhu, & Chandy, 2009).

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