The development of wind energy in Galicia: public policies, effects on the economy and international comparison

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Abstract

Nowadays energy constitutes a very important concern of policy and public debate. It is justified by the effects of climate change and the national strategies to be self-sufficient in the supply of energy. Renewable energies are the alternative to these problems, and therefore public policies could play a key role in their development. Furthermore, those energies have potential to contribute to the endogenous development.

In this paper we study the development of wind energy in Galicia, where it is the most important renewable energy in terms of contribution to the energy balance, as well as the role of public policy in promotion of this type of energy. Its development is a recent phenomena but with a growing relevance, because of their impact in the regional economy. Hence, we analyze the effects of this sector in the economy (employment, manufacturing production, exports, imports...) Moreover, we also compare the Galician model with the Denmark and the British ones, because they have a truly known successful integrated framework, in which, all the economical agents collaborate to build a competitive and innovative sector with several spill-over effects.

1. Introduction

In the early stages, renewable energy policies had a singular goal to achieve some aims such as the reduction of energy dependence or greenhouse emissions, and increasing the weight of renewable energies in the energy supply. However, it is possible to add another outcome for the implementation of coordinated industrial and energy policies: the generation of a manufacturing sector related to windmill construction.

In addition, energy policies constitute a good chance to diversify the regional economies, specially, the industrial sector. This diversification is related to higher income ratio per capita (Rodrik, 2004). Both variables have a relationship with an inverted U-curve form. Hence, the positive effects and externalities which arise from the wind energy development can be spill over the society in terms of industrial production, employment, exports and firm investment. Nevertheless, these effects are not automatic and depend on the policy implementation.

Following this idea, there are several illustrations of different development models and consequences for the related industrial sector in Europe. For this reason, we analyse these models

and their implications in three European economies with different dynamics: Denmark, United Kingdom and Galicia (Spain).

2. Historical evolution of the wind energy in Denmark, United Kingdom and Galicia. Origins and progress

a. The Danish case

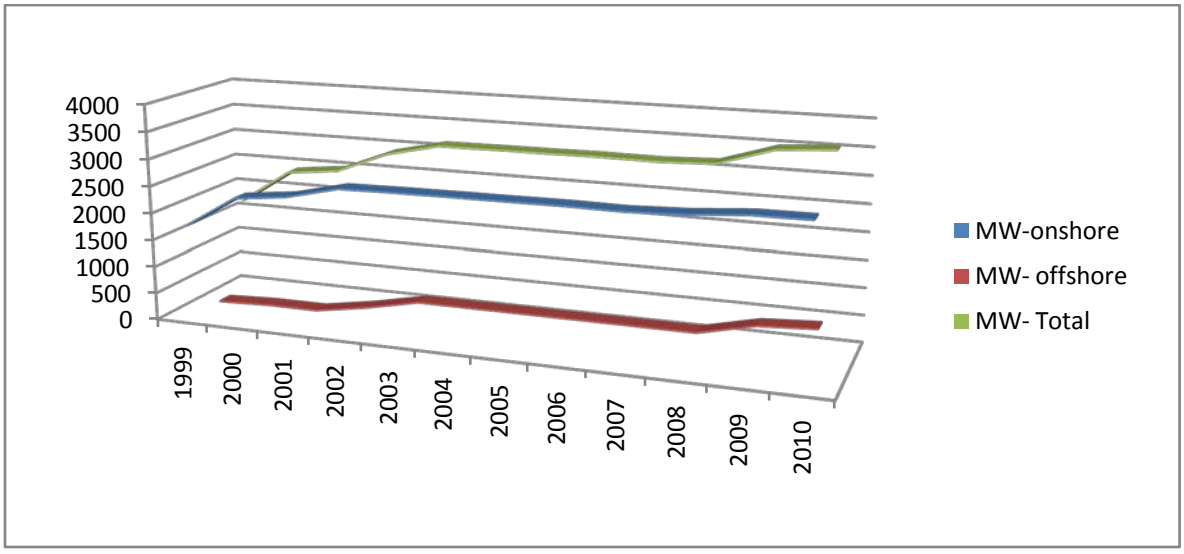
Denmark was the first European country where wind power could develop a deep energy and industrial framework with endogenous roots. The origins come from the end of 1970's, when the Danish society, after a severe oil crisis, preferred an energy system based on renewable energies rather than nuclear power. This process causes an evolutionary "path dependence" in the sector with strong implications in the technological and industrial fields.

Hence, the origin of the wind energy was social, with several interactions among all the agents in the national system. For this reason, it is most typical the mix of *bottom-up* policies and the *top-down* (Gregersen and Johnson, 2008, 2010), as one of the main characteristics of the wind energy development, specially, in early steps. In the opposite side, the Mediterranean model, with countries such as Spain, Italy or Portugal, consist of central decisions taken by the government and energy companies, with a low level of interactions with landowners or local communities.

Following the evolution of the wind energy power, the Graph 1 describes a moderate progress throughout the last decade. In fact, Denmark was the first country which develops offshore wind energy, but nowadays United Kingdom has a higher proportion with 1341,20 MW (Renewable UK, 2011). Moreover, offshore wind energy has a lot of opportunities in the North and the Baltic Seas.

In addition, there is certainly no doubt about the lack of progress between 2003 and 2008, because the government stopped the advancement of renewable energies during this period (Gregersen and Jonhson, 2008). It induces a reduction of the Danish world share of wind energy power and a lost chance to enhance the national industrial production of windmill components, reducing the dependence of exports.

Graph 1. Evolution of the Danish wind energy installed capacity (1999-2010).



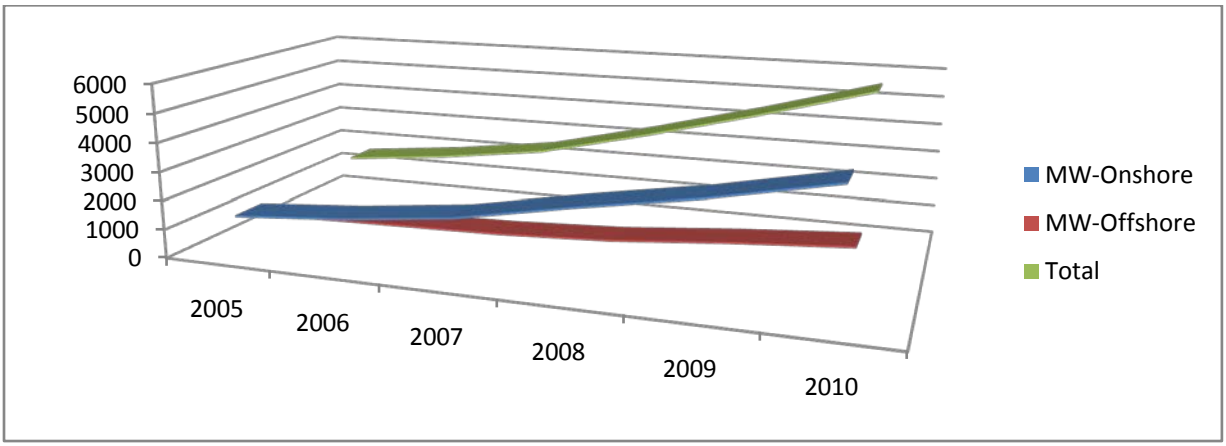
Source: Danish Wind Industry Association and Danish Energy Agency, 2011.

b. The British case

United Kingdom was not a traditional wind energy leader in Europe. In fact, the whole set of policies developed in the last years have played a role as follower of the Nordic ones. Moreover, until 2005, the total wind energy installed capacity was marginal whether we contrast it with others energy sources, such as coal, nuclear or hydropower.

Nevertheless, the interest to analyze the British development model is linked with the exponential increase of off-shore installed capacity during the last decade. From 2005 to 2010, the total amount of MW grew a 473%. This is a product of the implementation of specific active policies in that field, which are focused solely on the off-shore maturation. The Graph 2 shows this spectacular dynamic.

Graph 2. Evolution of the British wind energy installed capacity (2005-2010)



Source: Department of Energy and Climate Change and Renewable UK, 2011

The recent British wind energy development is a consequence of the mix between good resources and a policy adaptation which came from Denmark. The aim of joining all agents affected by this renewable energy cause a great social consensus in order to create common goals. We will be able to examine this last issue more deeply in another section.

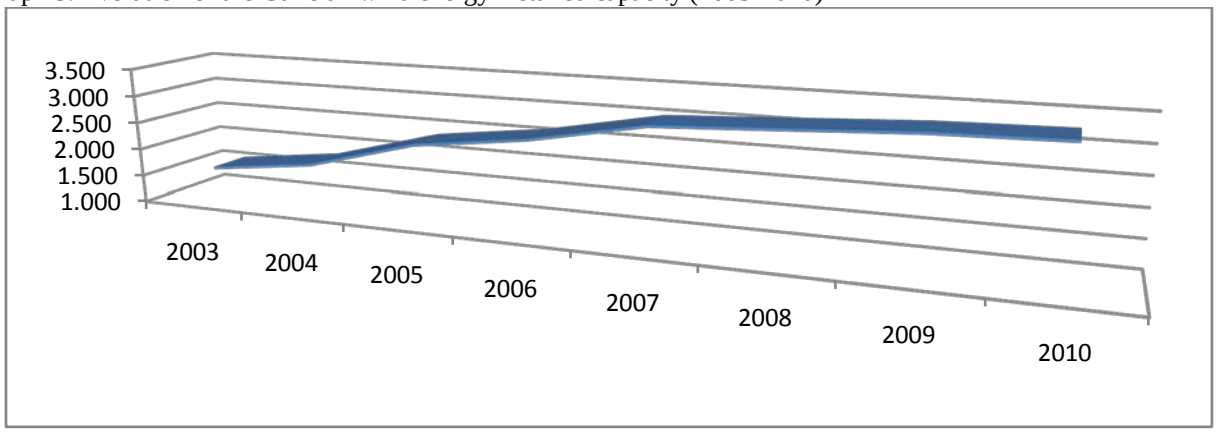
c. The Galician case

Traditionally, Galicia is the Spanish region with the highest proportion of the total wind energy installed capacity. In fact, at the end of 2010, it reached 3272 MW, almost the same capacity than Denmark. Nevertheless, the similarity ends here, because Galicia had been had neither off-shore wind energy[1] nor the same policies. In fact, it is the typical top-down model in which the regional government and the energy firms take part in the policy development with low level of interaction with local communities.

The wind energy development began in the 1990s, motivated by the great wind resources which were exploited by the large national energy and engineer societies like Endesa or Acciona. It is important to notice that in this case, there is not any social debate about the emergence of that renewable energy like the Danish one. Essentially, it was a result of a mix between governmental and business strategies.

In its origins, the evolution was characterized as a strong and continuous increase of the capacity and its electric generation in the Galician energy balance. Reflecting this situation, the Graph 3 shows an important installed capacity elevation throughout 2003-2007.

Graph 3. Evolution of the Galician wind energy installed capacity (2003-2010)



Source: Instituto Enerxético de Galicia (INEGA), 2011

[1] There is a state regulation which permits off-shore wind energy installations (Decree 1028/2007). However, actually, there is not any off-shore wind farm in Spain.

Nevertheless, during the next period (2007-2010), we can appreciate a steady state which has had important side effects in the sector and the auxiliary industry in Galicia. The main cause of this state of affairs is an institutional problem derived from a lag in the regulatory context after the derogation of the last setting by the new regional government elected in 2009. From this year, there are few new wind turbines because the regulation is not clear. There is no coordination with other administration levels such as the national, as well as a lack of consistency.

3. Main characteristics of the sectorial system context. Dynamics and their effects on the sector

In this section, we examine all the factors, which have an important outcome in the wind energy development, in each country. First of all, we focus on the Danish model with its integrated framework. Secondly, we study the British case with a high potential degree in the off-shore field and, finally, the "top-down" Galician model.

- **A history of success: The Danish wind energy sector.**

It would seem that the relative early beginnings of the wind energy could help in order to build a coherent structure, where the accumulative learning is the central piece in the design and implementation of the different policies (Gregersen and Johnson, 2010). This process is characterised as a system, where the interactions among all the agents, such as public sector, landowner, energy firms, local councils or windmill components industry; can enhance a progress with several positive externalities which spill over the society. For instance, there is a new law, called *Renewable Energy Act*, which established various agreements, based on social consensus, with landowners, central government and energy firms in order to install 150 MW on-shore. The result of this kind of policies is a high level of renewable supporters and a socialization of the wind energy benefits. This last issue is the clearest difference between this model and the southerly one.

The specific network in the wind sector constitutes another strength. Universities (Aalborg, Aarhus or Copenhagen), central government, public agencies, public laboratories (such as Risø Research Laboratory), manufacturing companies, partnerships (Megavind), or landowners and turbines owners associations, are working together in the educational and research area and the testing-demonstration fields in order to introduce new innovations to the market (Ministry of Foreign Affairs of Denmark and Danish Wind Industry Association, 2010). As main consequence, the Danish sector is the most competitive worldwide and a good case study to apply

others energies such as solar cells (Cooke, 2009) or marine energy industry (Aqua Marine Power Ltd., 2010).

Moreover, coordinated policies in the energy and industry fields have generated an endogenous windmill manufacturing sector which represents the 8,5% of the Danish in 2009, and more than the 70% of the total energy technology exports (Danish Wind Industry Association, 2010). In 2010, 25.000 employees were working in the sector.

In addition, it is important to underline the evolution of the own qualities in the area, because the wind sector developed from the naval sector in the north of Jutland after the 1970s (Cooke, 2009). This clearly illustrates the evolution of a Jacobin's cluster. Perhaps, which represents a good lesson to learn from Galicia, area with high relative important naval sector and with a significant amount of wind resources.

As a result, Vestas, the worldwide leader in that manufacturing sector come from Denmark as well as the fifth company, Bonus-Siemens, a Danish-German merger (Lewis and Wiser, 2007).

- **A follower model: the British wind energy sector**

There is certainly no doubt that the British case is a good illustration of the adaptation of the Danish policies in order to build an integrated framework. In fact, the most recent strength, off-shore wind, was developed by Danish from 1997 in their cost with own technology.

The main headlines of this process are established on the social dialogue, societal consensus and accumulative learning process, such as the Danish example. A good example is constituted by the *Best Practice Guidelines* (British Wind Energy Association, 2002). It based on some rules for the consultation and stakeholder dialogue. These guidelines are a set of tools to manage the social conflicts which arose in the on-shore development (a lack of local linkages and environmental policies). The effectiveness of this formal rule consists of the participation of different agents such as public agencies and departments, energy companies, turbines owners associations and also ecological associations. This provides an extent social base.

Another interesting analogy was the creation of an extent industry-academia collaborative network, called OWEN (Off-shore Wind Energy Network), which promotes researches in the off-shore area (Renewable UK, 2011). The main goal in this network is to encourage the interactions and cooperation among commercial organizations and researchers. OWEN was financially supported by the Engineering and Physical Sciences Research Council (EPSRC).

In contrast to the Danish case, the windmill manufacturing sector is least important than the Danish one. In spite of the recent home market size increase, there are few significant British firms which operate in the world markets. The main reason is that the domestic demands are important in the early steps of every technology, but the wind energy development develops later in UK in comparison with Denmark, Spain or Germany, for instance. Hence, they must compete with the international established competition.

- **A *top-down* model: the Galician wind energy sector**

The Galician wind energy development model is characterized by central decisions which arise from state or regional government and the energy firms.

The spectacular increase of installed capacity has not generated endogenous capacities with important positive externalities in the manufacturing sector, because it has been an exogenous development with few local linkages.

Traditionally, there were not any communication channels among the different agents such as landowners, local municipalities, manufacturing companies and regional government. In fact, there is a lack of sectorial networks or integrated associations, which do not work, solely, as a particular lobby.

In addition, the level of governmental control of the wind energy planning was low (Simón et al., 2010). Therefore, energy companies have not fulfilled their goals, when they achieve the administrative concessions.

Moreover, recent changes in the regional energy laws are not coherent with the central government energy incentives and they provoke a restriction for the installed capacity expansion (Varela and Sánchez, 2010).

In the next sections, we focus on the consequences for the business dynamics in the Galician manufacturing sector. We underline the aftermaths in the human capital, research and innovation fields.

3. Energy, business and social development of wind energy in Galicia

- **Methodology of the Galician case**

A survey based on personnel questionnaires was carried out in order to analyze the business and innovation dynamics of components manufacturing firms. It was directed to the whole sector of components, conformed by eight companies. The census was elaborated using the data of manufacturers of the Galician Wind Association (EGA). This first source was updated, because

of the extinction of two companies, the takeover of other three, and several companies do not devote to the manufacturing, but to activities of components storage and maintenance and control of wind farms. In this sense, the questionnaire was aimed at whole census, obtaining the answer of four companies (50% of the population). It should stand out the varied composition of the sample, in which the distinct types of companies are present: an indigenous Galician company of average size (51 employees devoted exclusively to these tasks) and an average size (120 employees) subsidiary of a Spanish multinational. On the other hand, two companies, which occasionally carry out activities of this subsector, also include in this empirical study. One is a company owned by Galician capital with important foreign presence (250 employees) and another company owned by the Spanish capital (with 100 employees). Therefore, the sample could be considered representative of the whole sector, following quantitative as well as qualitative criteria.

The questionnaire is based on the criteria of the Manual of Oslo and the INE[2] Survey on Business Innovation. It consists of different sections, such as financing sources, human capital, internal R&D activities, product innovation, process innovation or cooperation.

With regard to the human capital, the Table 1 was carried out by means of personalized questionnaires directed to the manufacturers of windmills included in EGA and other companies suppliers. The average was calculated using a weighted average depending on the workers of each company devoted to these tasks and on the weight on the total sample. The graduates with ESO[3] or high school diploma are considered as "no specialized" due to the fact that they do not have an academic or technician knowledge oriented to a certain field.

Finally, the data referred to R&D, innovation and cooperation were result from the answers and assessment of the personalized questionnaires.

- **Analysis of Human capital**

The group of agents that form and retrain the human capital, and the interactions among them, are extremely important to describe the tendency and the patterns of innovation in a territory. The selection of knowledge (academic and technician) areas to be fostered in a region determines the subsequent industrial, technological and scientific policies. This is due to the fact that the human capital supply constitutes a primary input to develop any industrial/technological pole, except for

[2] National Statistics Institute
[3] Obligatory Secondary School

the case of considerable foreign workforce participation. However, this would cause fewer positive effects in the social environment of this territory and lower possibilities of demonstration effects and endogenous growth. It would seem that in underdeveloped regions the hiring of high-skilled workforce is a key strategy in order to increase the innovation level (Vence, 2007).

- ✓ **Quantitative and qualitative characterization of the human capital in the manufacturers of windmills in Galicia**

Within the companies grouped in the Galician Wind Association (EGA), we focus on the segment of manufacturing for windmills and any another company of civil construction, that during some time devoted to manufacturing components such as power station and even researching in the towers manufacture. The aim is to stand out several structural characteristics derived from the nature of the sector where carry out their main activities.

A large part of the medium and small size (which ranges from 40 to 200 workers) do not devote exclusively to the manufacture of wind turbines, which derives from one of the outstanding characteristic of the Galician wind market: high dependence on the public tenders to power allocation. Thus, it is necessary to filter the professional profiles of each company to examine who are the responsible of the production linked to this field in each staff. Likewise, the sudden stop that suffers the sector because of the contesting of the regional tender corresponding to 2008 and the delay and uncertainty that even surrounding that of 2010, also caused the change of many companies profile and even the closure of others. This involves the need to analyze historical data that comprise the period 2000-2010, with special attention to the first four years, where the greater increases of production had taken place.

In this way, analyzing the quantitative and qualitative characteristics of the human capital related to the manufacturing of windmills, two significant phenomena could be pointed out. They contrast with several guidelines established by the decrees that regulate the wind planning and, particularly, the industrial plans of the contract-winners of Business Wind Farms during the last ten years. In this sense, as governmental sources as different authors (Varela and Sánchez, 2010) emphasize the necessity for setting the percentages of the wind turbines purchase that should execute in Galicia, because of being a sector of high added value (specially, if it is compared with the civil construction in strict sense). In this way, fostering the sector construction of wind turbines would cause the creation of quality employment, with high requirements of human capital. Nevertheless, the data show that the percentage of workers with Professional Training

within small and medium size enterprises devoted exclusively to the wind field is clearly higher than the university graduates, since the former reach more than a half staff. Apart from being the less large group, the university graduates are characterized by having a very different presence in the sector, due to the fact that in some companies reach almost 20% and in others there is not any graduate. On the other hand, in most of the cases the percentage of the staff that does not have any professional specialization is higher than the university graduates. This shows that there is a possible burden to execute the tasks of internal research and innovation within the companies, because they have not skilled personnel. It is also worrying that almost 40% of the staff have not specialized studies, because of innovations (product or process one, derived from the acquisition of machinery or services, purchase or use under license of patents, internal training, etc) will not be so frequent as in the case of more trained human capital. We can observe in the Table 1 an average for the sector firms.

Table 1. Distribution of employment by educative level in the companies devoted to manufacturing/assembly and installation of wind turbines

	Percentage of workers
With university studies	10,6%
FP (level higher and medium)	57,4%
Without specialization	32,0%
TOTAL	100%

Source: Own elaboration.

This factor is being aggravated when it is confirmed that hardly exist specialization of the human capital in the wind market within this type of small and medium size companies. Most of the workers were relocated in the sector in the prosperity time of this market niche, but nowadays they return progressively to the former activities. This last factor causes that the personnel and the company could not benefit neither from the processes of learning and innovation inherent to the accumulation of the production (learning by doing) nor from the own unitary average costs reducing due to the internal economies.

In this same way, the short-term tendency is to keep this composition, due to the fact that 66% of the companies interviewed expect to hire a greater number of workers with professional training than university graduates during 2011 and 2012. The rest of companies have not thought to contract, because of the strong reduction of activity; in fact, they are firing personnel. Following the same previous guidelines, 50% of the companies that want to hire personnel, will tend to choose only the professional training profile.

- **Intensity of R&D and innovative activities. A qualitative approach.**

In this section we examine the research and innovation dynamics of the sector companies, as well as their cooperation patterns with the other agents of the system of R&D&I.

- ✓ **The internal R&D activities in the Galician windmills sector**

The Galician sector of windmills is characterized by low internal R&D intensity. In this sense, only one surveyed company of the four that conform the sample, states that executes internal R&D activities periodically, what means a quarter. Besides, the active company in this field based its research on a prototype of tower for wind turbines with new materials, novelty that have not still entered in the market. Its market niche is not specifically the manufacture of wind or assembly secondary installations of wind farms, but also a secondary activity that becomes important around the middle of the last decade because of the peak of the wind sector in Galicia. On the other hand, the main activity of two companies consists of this renewable energy, but they do not carry out any type of R&D, because they work basically by request. The own customer provides the different plans to the manufacturer and the necessary technical requirement, but anyway, it deals with some standardized products and services to the European and national levels.

Another very significant factor is that the company that devotes substantial resources to R&D in this sector presents the same dynamics in its more traditional activities, which are the civil construction. In fact, this company has an engineering/design and R&D consolidated department, where is common practice to conduct experimental designs and pilot trials. Therefore, we can assert that the own activity of manufacturing (inserted in the market routines) and its development model did not give incentives to execute tasks of basic or applied research or experimental development, but when this happens is due to firms internal routines, caused by other activities that are their main ones.

These results are consistent with the structure of the human capital previously analyzed. The low level of personnel with university studies (around 10%) involves a low research and development capacity. However, the relatively numerous proportion of technicians with professional training provides an important help so that the processes carry out properly, and that they are sources of process innovations.

Finally, we should point out that when asking the companies if they purchased R&D services by contract, agreement or another modality; the answers reflect a similar situation to the case of the internal R&D. In this way, the companies that did not execute this last activity, neither acquired

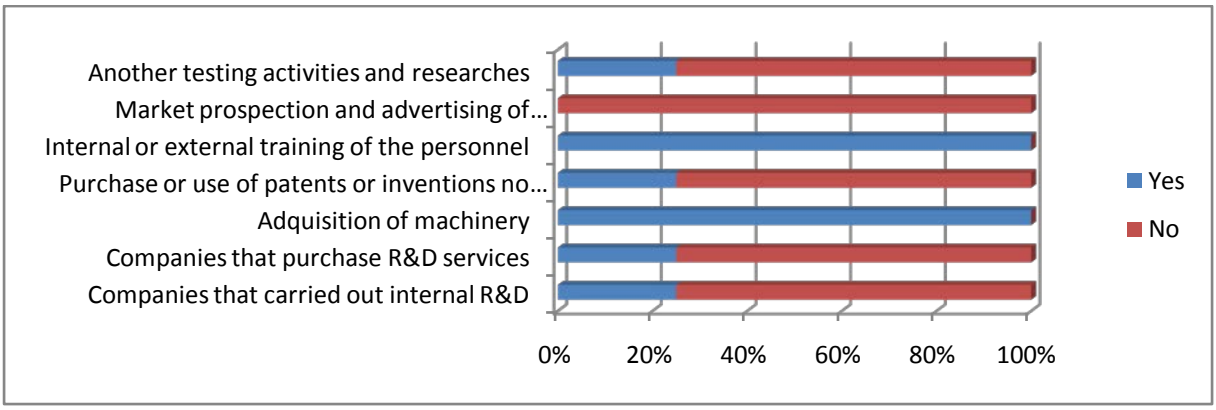
nor contract R&D. In the case of the active company on the research field, it acquired these services from companies of the group and one close university, what indicates a significant level of collaboration with universities. Nevertheless, the applications of the new material that is being tested in the company have multipurpose functions, with secondary effects in the activity of manufacture/installation of windmills.

- ✓ **Innovation in the windmills sector: origins and determinant factors in Galicia**

Innovation can constitute the result from the research and development of new products, services or processes (the model called as "science-technology-innovation"), which reach the market. Now then, it could also mean the process itself by which new or improved services or processes are introduced into the market without need to be supported by a process based on the science; thus we would be in the case of a "doing-using-interacting" model. In this way, the previous section proved that only one company carried out R&D tasks systematically, while most of the companies did not execute such activities. This does not involve that the company that carried out these tasks was innovative and the other no, since there are different ways of incorporating the knowledge, which differs from the traditional one based on the science.

Focusing on the analysis of the sample, we can observe in a first examination that all the companies innovate, included those that do not devote resources to R&D, giving particular importance to the process innovations. In this sense, analyzing the Graph 4, it could be appreciated a clear bias in the sector by the incorporation of knowledge through the acquisition of machinery, equipment, hardware or software devoted to the production of new or significantly improved products, due to the fact that this action is executed by the 100% of the surveyed firms. Likewise, this kind of equipment acquisitions needs some specialized skills, different from the usual ones for the personnel. The same companies point out that it was necessary to carry out formation and retraining tasks of the employees for the operation of the new equipment. In the case of the company that carries out internal R&D tasks, it stressed on the continuous retraining of the workers in the new computer applications that were introducing in the company; although its main purpose was not the design or production of windmills or its installation.

Graph 4. Ways to obtain new or significantly improved goods, services and process based on the science, technique or other kind of knowledge in the last three years.



Source: Own elaboration.

With regard to the rest of activities for the incorporation of knowledge to the productive chain with the purpose to produce new or significantly improved goods, services and processes, the companies hardly are present, and the channels diversification of the incorporation of this input mainly concentrated on the company that has a dynamic research and innovation. In this way, the only company that purchased R&D services to different entities also purchased and used patents or not patented inventions, and other technical knowledge, and carried out internal R&D activities. Thus, this company shows the most complete profile related to its research activities. Nevertheless, one of the companies that incorporated knowledge through equipment purchase conducted trials and studies in the field of the manufacture of wind turbine towers.

- ✓ **Conclusions of the innovation channels of the windmills sector in Galicia**

The manufacturing sector in Galicia present some marked innovation patterns that could be inferred from studying the sample of four sector companies. In this sense, three of the four companies can be inserted in an innovation pattern dominated by the providers, according to the Pavitt's taxonomy (Pavitt, 1986), since the greater source of innovation (product, service or process) consists of the incorporation of new specialized machinery. Moreover, the incorporation of machinery is combined with the internal or external training of the staff to develop new tasks and methods. However, a fourth company would not include in any of the innovation patterns, since, on the one hand, has a method based on the science, but also incorporates new equipment and machinery to the production process. This last case is assimilated to that of a company that has several different production lines, with distinct target markets niche and different technical needs and working dynamics. Likewise, the pattern of specialized suppliers could not be ruled out in the whole sample, due to a large part of its business model consists of personalized and by request manufacturing of many pieces and machinery for the wind turbines. In this way, a

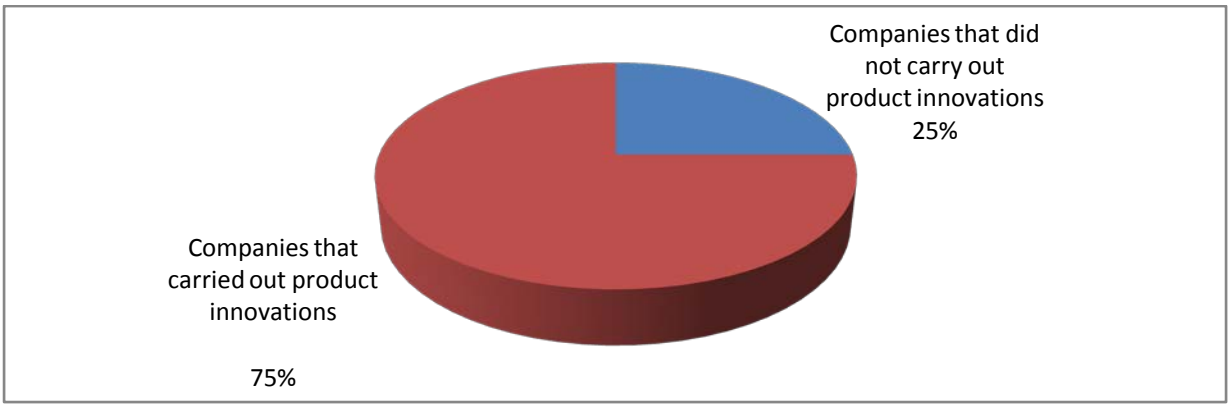
customer demands some components with some certain technical specifications and, these companies manufacture them custom-made. Nevertheless, this innovation pattern is not very clear because the manufacture is carried out on the basis of plan and the learning resultant from the experience with different customers is reduced, because the own companies assert that they have to discuss with the customers if they execute some no stipulated modification in the request, which are not very usual. Even so, it is a channel that would not have to disregard, as it will be appreciated in the cooperation section, the customers represent a decisive way for the incorporation of knowledge to the productive activity.

- ✓ **Innovation activity and importance**
  - *Product Innovations (goods and services)*

According to the Manual of Oslo (OCDE and Eurostat, 2005, 58) a product innovation consists of "the introduction of a new good or service, or significantly improved regarding its characteristics or the use to that allocates. This definition includes the significant improvement of the technical characteristics, the components and the materials, the integrated information, the ease of use and other functional characteristics". Following this definition, product innovation comprises as goods as services and not only new, but also substantially improved, what can originate an additional profit derived from its utilization.

In this sense, although the companies of the sector have very concentrated the channels to carry out innovations in some models very dependent of the equipment suppliers, it must be pointed out that they are very active in the field of the product innovations. As it can observe in the Graph 5, three of each four companies carried out product innovations in the last three years. In the majority of the cases, the innovations consisted of improved products, because of process changes derived from the acquisition of machinery and new equipment, and changes in the interactions with customers and other entities that form a continuous learning framework. Therefore, it does not deal with radical product or service innovations neither for the market neither for the own company.

Graph 5. Percentage of companies which carried out product innovations in the period 2007-2010

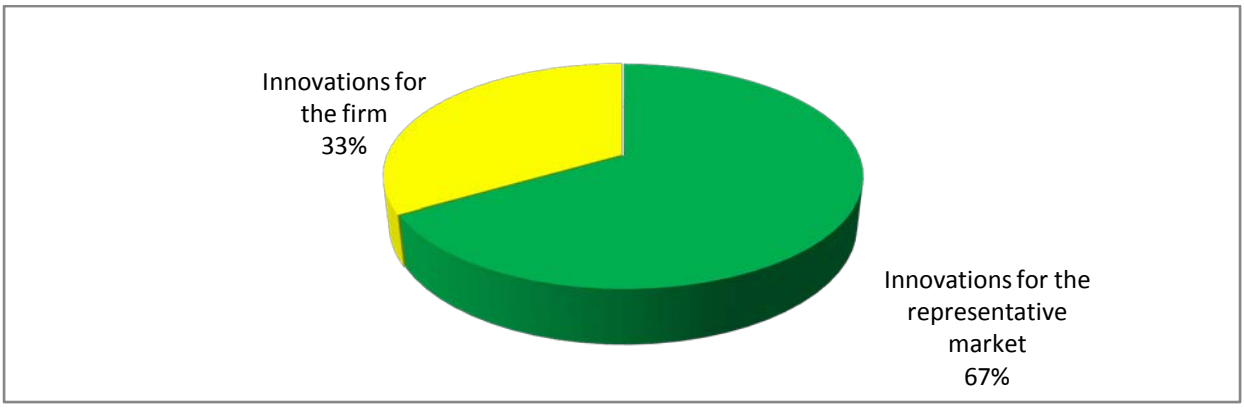


Source: Own elaboration.

Although the Manual of Oslo (3rd edition) considers innovation regardless if it was only for that company or for the market, it is also decisive to analyze the innovations scope. This is because these two kinds of innovation have not the same effect. In this way, the consequences in the turnover as well as the competitiveness of the company and the sector are of different intensity. Likewise, the ways to achieving an innovation only for the company or for the representative market also differ.

Within this same argument, three companies of the sample that introduced some innovation in the last three years were selected to prove the scope of their innovations. The data presented in the Graph 6 show that two companies executed product innovations that reach the market and the remaining company only introduced a standardized product for the majority of the companies. One of the innovative companies had introduced two years ago a new product for the companies settled in Spain and Portugal, but the dynamics of technological advance in that it is immersed all the wind sector caused that it extended in all the sector. Finally, in the case of the remaining company, the product innovation that is executing at present and that has not yet reached the market could be considered as breakthrough, because of the utilization of an entirely new material in the manufacture of towers.

Graph 6. Scope of innovations introduced by the companies of the wind components sector in the period 2007-2010.



Source: Own elaboration.

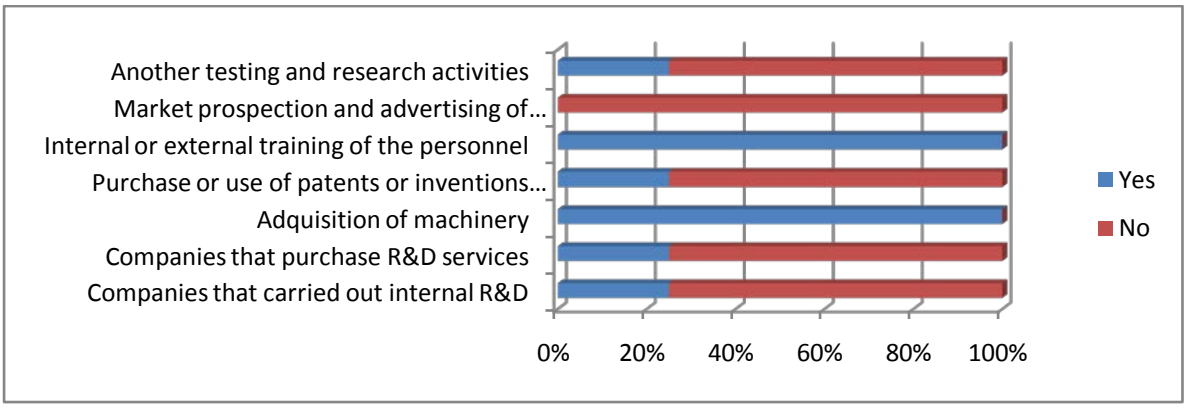
- *Process Innovations*

According to the Manual of Oslo (OCDE and Eurostat, 2005, 59), innovation process is "the introduction of a new, or significantly improved, production or distribution process. This involves techniques, materials and/or computer programs changes". The process innovations are fundamental in the sector, because the main channel to introducing innovations consists of the equipment acquisition that has a direct implication in the production processes. They are sectors dominated by suppliers, according to the Pavitt's taxonomy (Pavitt, 1986). The process purposes could be the reduction of unitary costs, improving the quality or producing new or improved goods and services.

A certain bias to the process innovations focused on the manufacturing method and, not so much to the rest of typologies of process innovations, can be guessed within this sector. Once again, the company that carried out all types of innovations in this field is a multinational that shows better behaviours regarding human capital, internal research and product innovations.

On the other hand, a company that only was five years (2000-2004) in the sector of windmills did not carry out any type of innovation in this period, because of the temporary character of this activity.

Graph 7. Percentage of companies that carry out the different typologies of process innovation in the period 2007-2010.



Source: Own elaboration.

- **Collaboration among windmill companies in Galicia and other economic agents to create, diffuse and apply new knowledge**

The cooperation is another determinant element that can contribute to the formation of research capacities of an agent of the national innovation system (for example, a company, a university or a technological centre) and in the construction of the innovative capacities. Moreover, it can generate some virtuous dynamics and cycles, when getting in touch with different elements inserted in different realities. In this way, one advantage of the worldwide cooperation, in addition to resulting in an increasing need due to the greater demand of incremental specific and multidisciplinary capacities; is represented by the chance of being in close with different creative frameworks and processes dynamics.

In a more concrete way, the innovation cooperation consists of the active participation among not commercial organizations and/or institutions, involving some closer links than the own sporadic contact caused by the productive activity among customers, competitors, etc. Likewise, the cooperation can be formal, through contracts or agreements of active collaboration among all the participants; or more informal collaboration, but continuous and active, that can be established among customers, suppliers or competitors to improve or create new products and services.

The cooperation can happened integrating supplies with customers in the supply vertical chain (OCDE and Eurostat, 2005), or also could be horizontal, being constituted among companies and public research centres.

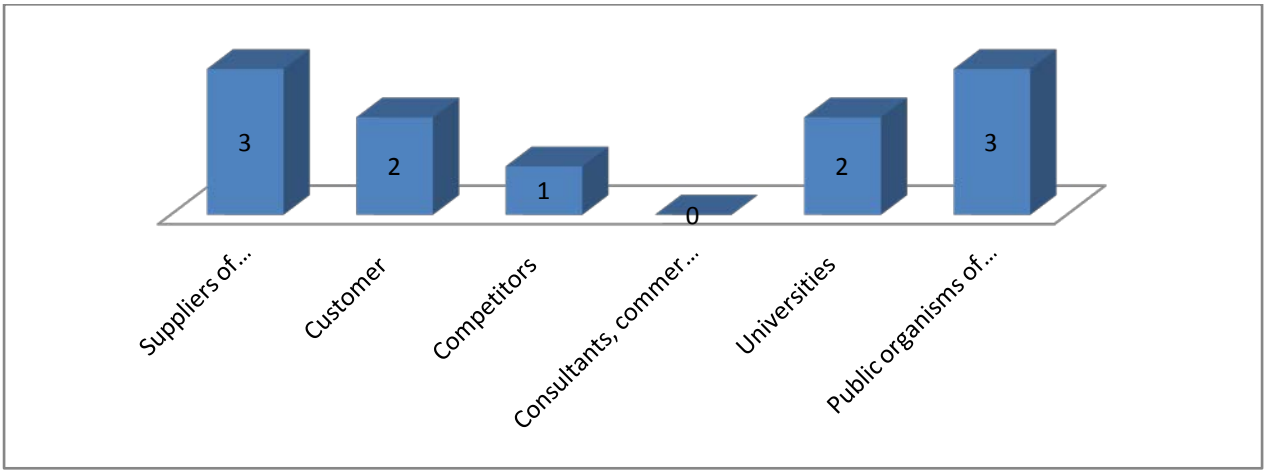
In this sense, because of the characteristics of the sector, a priori it would be more common the vertical cooperative links, when manufacturing on the basis of plan and request, whereas the horizontal collaborations would be minor, given the low research dynamic of the own companies

and the shortage of qualified personnel. On the other hand, 100% of the sample carries out some kind of cooperation.

However, showing the data of the sample in the Graph 8, we find a very similar weight of the vertical (suppliers of equipment, components and software; and customers) and horizontal (public research organisms and technological centres, universities and competitors) cooperation. In some way, it must turn in relative terms some relations of horizontal cooperation. In some cases, they were a necessary condition to conduct trials on new processes, that could not carry out in the own installations of the company, public research organisms or technological centres. Thus, a more passive role to the company is conferred, approaching to the concept of outsourcing that would not enter in this category.

On the other hand, within the horizontal collaboration the universities stand out, with a similar weight to the suppliers and higher than the customers, but that it is necessary also to turn in relative term due to two facts: the low percentage of personnel with university studies (three out of the four companies present values about 10% and another asserts that there is not any employee with university studies, devoted to manufacturing windmills) hinders notably these active relations. On the other hand, two of the three companies that indicated that the universities are important agents to their collaboration, do not carry out any activity of internal R&D, neither purchased neither subcontracted R&D services. They also affirm that their main innovation ways were the equipment purchase. Therefore, it does not obviously show an enough background to carry out an active collaboration among academic entities and research and the own companies.

Graph 8. Number of companies that include any way of cooperation among the three former by importance.



Source: Own elaboration.

Regarding the competitors, and consultants and private R&D laboratories must be pointed out their atony. In the case of the competitors, their scarce importance is reflected in the fact that three of the four surveyed companies indicate specifically that their competitors represent a threat, because of existing an excess of productive capacity according to the level of existent activity. This phenomens is the one that explains the low importance.

Finally, the importance of the vertical cooperation (of suppliers) is reflected indirectly by the business dynamics, as in the field of the internal research as in the innovation one.

4. Conclusions

There is certainly no doubt that the institutional context influences the potential development of whatever sector and public intervention play an important role in these dynamics; sometimes it creates new opportunities for emerging sector and others functions as a restriction.

The history of the wind energy sector in Europe is an illustration of this purpose. Some models, specially the Nordic ones, serve as a good policy intervention tool in order to generate a minimum organizational and technology base supported by a global social consensus. Following this idea, the main advantage of the Danish wind energy sector is to be the historical leader from 1970s. From this reason, they have enough time in order to establish a domestic market and international competitiveness for exports.

However, the followers, such as UK, are able to build the same setting for enhancing their energy balance based on renewable energies. The advantages for the manufacturing sector have least importance than the Danish case, because it is a question of accumulative learning in the policy and technological fields. Nevertheless, a set of policies which underline the interactions among all the agents and the continuous learning have positive externalities and effects on the energy development and its socialization.

In contrast to these models, the Galician policies, which arise from the regional government and energy companies which few local linkages, are typical top-down policies. In addition, there is not institutional stability because the normative context is changing frequently, and not only due to government changes. For this reason, the manufacturing sector suffers a clumsy level of activity. Hence, the main consequences of that are a low level of high-skilled labour force and innovation performance. As a result, a region with adequate amount of wind resources has a traditional and small size wind energy manufacturing sector.

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