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Economic impact of legal stability on the Galician wind energy sector

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Abstract

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The energy sector depends heavily on public regulation and it is required to guarantee a minimum remuneration, because of its capital-intensive condition. Renewable energies sources are not an exception and they could make easier the industrial diversification and job creation. Hence, the stability of the regulation framework, especially in the case of new energy sources, is essential due to its positive impact on the emergence and consolidation steps. As several studies show, instability could cause a reduction, or even a shutdown, in their development and economic contribution. Then, it is crucial to quantify the socioeconomic costs of common changes in regulation.
The main aim of this paper consists of analysing the economic impact of wind energy regulation instability on the Galician economy. The wind energy sector was one of the most important drivers in the regional economy and there are no quantitative studies focused on this issue. Galicia is a Spanish north-west region with the highest wind energy installed capacity, with roughly 3.300 on-shore MW in 2012, but in a steady state from 2008 due to a legislative shutdown. Wind energy and hydroelectric power represent the main renewable sources. This paper underlines the importance of long-term policies and clear guidelines in the development of wind energy in terms of its economic impact. Concerning the theoretical framework, it is based on the National System of Innovation (NSI) approach. We also use the input-output analysis by means of the examination of the value chains in the wind energy. In addition, we update the productive structures through a variation of the RAS procedure (biproportional matrix balancing technique) which uses efficiently the available data within the period 2000-2010. The data was gathered from official institutions and completed with qualitative interviews with private and public stakeholders. The main results show significant negative effects on the macroeconomic variables throughout the same period when the instability in the regulation framework became more evident.

Keywords: wind energy, regulation stability, economic impact, input-output, Galicia

Key references:

Blanco, M.; Rodrigues, G. (2009): Direct employment in the wind energy sector: An EU study, Energy Policy, nº 37, pp. 2847-2857.
Borup, M.; Gregersen, B.; Madsen, A. N. (2007): Development Dynamics and Conditions for New Energy Technology seen in an Innovation System Perspective, DRUID Summer Conference 2007. Copenhagen.
Cooke, P. (2009): Origins of Regional Innovation Systems Thinking and Recent Advances from Analysis of Green Innovation, Ekonomiaz, nº 70, pp. 60-80
Gregersen, B.; Johnson, B. (2010): Stimulating emerging sustainable energy technologies through policy learning, 13th Conference of the International Joshep A. Schumpeter Society: Innovation, Organisation, Sustainability and Crisis, Aalborg, Denmark.
Lambert, R., & Silva, P. (2012): The challenges of determining the employment effects of renewable energy, Renewable and Sustainable Energy Reviews, vol. 16, pp. 4667-4674.
Lema, R. et al. (2011): Competitition and Cooperation between Europe and China in the Wind Power Sector. (Working Paper 2011-377). Brighton: Institute of Development Studies (IDS).
Llera, E. et al., (2010): Local impact of renewables on employment: Assessment methodology and case study, Renewable and Sustainable Energy Reviews,vol. 14, pp. 679-690.
Gregersen, B. (2010): The Public Sector as a pacer in National Systems of Innovation, in B. Lundvall [ed.]: National Systems of Innovation. Toward a Theory of Innovation and Interactive Learning. 1sted. Londres: Anthem Press.
Miller, R. E.; Blair, P. D. (2009): Input-Output Analysis. Foundations and Extensions. 2nd ed. Cambridge: Cambridge University Press.
Pereira, X., Carrascal, A., & Fernández, M. (2013): Advances in updating input-output tables: its relevance for the analysis of regional economies, Revista Portuguesa de Estudios Regionais, vol. 33, pp. 5-14.
Sousa, W.; Fernandes, A. (2012): Global Wind Energy Market, Industry and Economic Impacts, Energy and Environment Research, nº 1, vol. 2, pp. 79-97.

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The energy sector depends strongly on public regulation and it is required to guarantee a minimum remuneration, because of its capital-intensive condition. Renewable energies sources are not an exception and they could make easier the industrial diversification and job creation. Hence, the stability of the regulation framework, especially in the case of new energy sources, is essential due to its positive impact on the emergence and consolidation phases. As several studies show, instability could cause a reduction, or even a shutdown, in their development and economic contribution. Then, it is crucial to quantify the socioeconomic costs of frequent changes in regulation.

The main aim of this paper consists of analysing the economic impact of wind energy regulation instability on the Galician economy. The wind energy sector was one of the most important drivers in the regional economy, but there are no quantitative studies focused on this issue. Galicia is a Spanish north-west region with the highest wind energy installed capacity, roughly 3.300 on-shore MW in 2012, but in a steady state from 2008 due to a legislative shutdown. Wind energy and hydroelectric power represent the main renewable sources. This paper underlines the importance of long-term policies and clear guidelines in the development of wind energy in terms of its economic impact.

Concerning the theoretical framework, it is based on the National System of Innovation (NSI) approach. We also use the input-output analysis by means of the examination of the wind energy value chains. In addition, we update the productive structures through a variation of the RAS procedure (biproportional matrix balancing technique) which uses efficiently the available data of the period 2000-2010. The data was gathered from official institutions and completed with qualitative interviews with private and public stakeholders. The main results show significant negative effects on the macroeconomic variables throughout the same period when the instability in the regulation framework became more evident.

Keywords: wind energy, regulation stability, economic impact, input-output, Galicia

1. Introduction

Legal stability constitutes a necessary condition in order to make easier the emergence and development of a capital-intensive sector as the case of wind energy. This kind of processes triggers industrial diversification, the possible creation of industrial agglomerations as well as the emergence of new technological paths. However, instability could cause temporal disruptions and even a permanent shutdown with crucial effects on the regional economy, especially, in some cases with a significant amount of accumulative installed capacity. Thus, it is important to analyse and quantify the stability phenomenon from the economic-regional perspective.

The main aim of this paper is to analyse the economic impact of wind energy regulation instability on the Galician economy. Galicia is a Spanish regional leader in terms of wind energy and hydropower installed capacity. Then, renewable energies would play a role of economic driver with essential positive socioeconomic effects on the whole economy. However, legal framework is a continuous concern since 2007.

The theoretical approach is based on the systemic perspective of National Systems of Innovation (NSI). We also use the input-output analysis by means of the examination of the wind energy value chains. In addition, we update the productive structures through a variation of the RAS procedure (biproportional matrix balancing technique) which uses efficiently the available data within the period 2000-2010.

Concerning the structure, first of all, we analyse the role of institutions and, especially, the legal framework, in the emergence and consolidation phases of the wind energy sector. Later, we describe briefly the main characteristics of the wind energy sector in Galicia at the present. Afterwards, we explain the methodology features regarding the value chain and the input-output analyses. The matrix updating procedure is also described. Finally, we show the main results.

2. The role of institutional framework in the emergence and consolidation of wind energy

The emergence of new sectors is not an automatic process in which a combination of market-led forces as well as public-led forces should collaborate in order to build a comprehensive structure. Some kinds of externalities, related to the "self-discovery" (information externalities) and the need of simultaneous investments in different sectors (coordination externalities), do not enable an automatic emergence based only on market-led forces (Haussman & Rodrik, 2003; Rodrik, 2004). For these reasons, background and pre-emergence conditions are crucial because of their effects on the initial inertias, critical mass and interactions.

Concerning the emergence and consolidation phases of new sectors, innovation constitutes a key factor in the process of creation and diffusion of new knowledge and techniques. The concept of innovation is closely related to the set of stakeholders and institutions which play an active role in the sector maturation. In that point, the concept of National System of Innovation (SNI) arises; this refers to a combination of "*elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge*" (Lundvall, 2010, p. 2). A systemic approach should emphasize the role played by institutions in a broad sense, that is, a set of formal (legislation, standards and so on) as well as informal institutions, such as habits or routines. These institutions are playing an essential role in the creation and diffusion of innovation (Edquist, 1997; Edquist & Hommen, 2008).

Public sector plays gradually an active and central role, not only as a supplier of formal institutions; but also as a source of new policies and strategies (Sánchez, 2007; Gregersen & Jonhson, 2008; Gregersen, 2010). Concerning its role in the innovation process of renewable energies, public policies could be horizontal market-friendly programs without specifying any sector, or targeted programs which are focused on a particular sector or technology (Avnimelech & Teubal, 2007, 2008). Both kinds of programs could enhance the renewable energy development by means of science support or demand (del Río, 2007).

Science support polices (technology push) are mainly concentrated on the technological infrastructure. These programs involve basic and applied research, demonstrations activities as well as diffusion issues. Energy legislation constitutes an essential tool in order to boost the diffusion through several instruments like feed-in tariffs schemes, green certificates, or quotas (Couture & Gagnon, 2010; Söderholm, 2008; Campos & Klagge, 2013)[1]. The main aim of these instruments is to increase the installed capacity and, therefore, a unit cost reduction because of a progressive movement in the learning curve. Nowadays, the final goals refer to environmental issues, industrial diversification, national energy security and economic growth. Albeit, diffusion could be foster through demand side policies, such as direct financial promotion of private demand (Edler, 2006). Additionally, feed-in tariffs, quotas and green certificates could be classified as demand side policies (Lewis & Wiser, 2007; Campos & Klagge, 2013), because they are also considered as indirect subsidies which enhance the consumption of energy from these sources by means of a reduction in prices. Then, these policies also increase the market size.

Other kinds of supply policies are the local content requirements (nowadays widespread in Europe, China and Latin America), quality certification or the implementation of standards in the manufacturing or installation processes (Campos & Klagge, 2013). A good example of standards implementation in wind energy is the Risø National Laboratory (Technical University of Denmark). The implementation of standards from the public sector or private sectorial organizations is crucial due to its positive effects on triggering incremental innovations.

Demand-side support policies (demand pull) depend on learning by doing processes within the value chain, with suppliers, customers or competitors; and the role of environmental standards and mandatory renewable energy targets. Financial and tax incentives represent essential support mechanisms in the wind energy deployment (Campos & Klagge, 2013). We also add the aforementioned case of the feed-in tariffs scheme and green certificates.

Given the central role of institutions and public sector in the innovation process and the emergence of renewable energies, it should not be underestimated the importance of institutional stability (Pavitt, 1984). This stability combined with clear guidelines and institutional learning processes constitutes a key factor to enhance public policy design

[1] Concerning wind energy deployment, feed-in tariffs schemes have achieved a significant success in Europe, especially some modified versions in Spain (del Río & Unruh, 2007; Söderholm, 2008; Schallenberg-Rodríguez & Haas, 2012).

(Gregersen & Jonhson, 2008). The learning policy process refers to a conscious evolutionary progression in which policy makers and experts develop competences, called direct policy learning, and another indirect way linked to “learning by doing” or “learning by accident” (Ib.). Then, it is necessary a minimum level of institutional capability as well as a long-term definition of policy goals in order to provide enough financial support and stability, especially in wind energy in which there are high fixed costs (EWEA, 2009)[2]. Long-term policies which foster renewable energy diffusion by means of financial support and the creation of market demand are essential to reduce the level of uncertainty and increase the financial turnover especially throughout the early steps of development. Some successful development lessons in wind energy show us the importance of keeping clear guidelines and social consensus over time (Lindgaard, 2010).

The lack of institutional stability causes important shutdowns in the deployment of industrial agglomerations, such as peripheral clusters (Gorenstein & Moltoni, 2011). In those kinds of agglomerations, the macroeconomic and institutional volatility, in a broad sense, and the shortage of critical mass, technological and human capital capabilities hinder the emergence and consolidation of the cluster. In these development steps, public policies make easier to overcome initial inertias and barriers. Some dynamics in peripheral clusters represent vicious cycles, in which there is a lack of regulation and also a wrong design. The uncertainty about future trends hampers innovation processes and the creation of interactions and critical mass.

In addition, these negative effects have significant impact on the regional economy through the decrease of the final demand (decline in investment, consultancy, financial and maintenance services and so on). They reduce the economic impact in terms of production, backward and forward linkages or employment as well as energy and industrial diversification. Thus, there is a direct relationship between legal instability and economic impact mainly when one single region has a significant amount of renewable energy production.

[2] For instance, the European Wind Energy Association (EWEA) has estimated a cost around 1,2 million euros per on-shore MW installed.

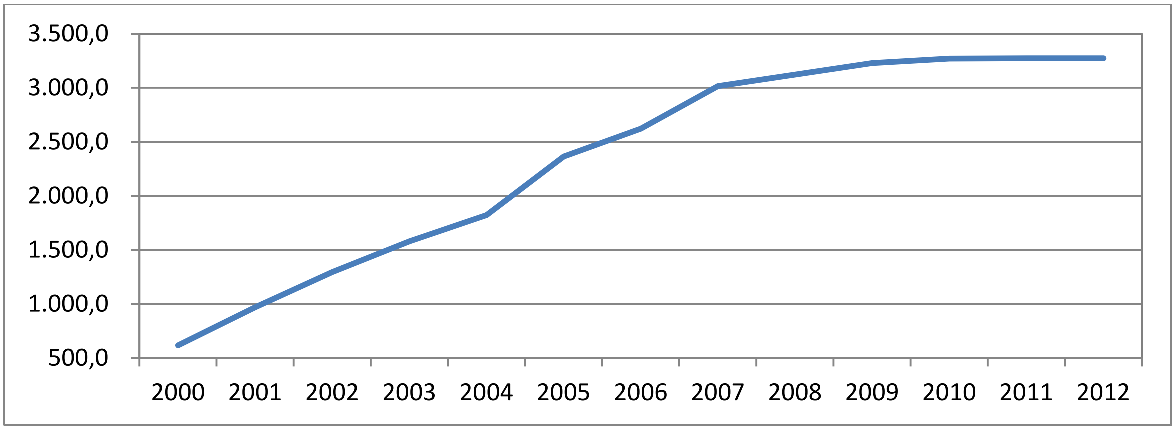
3. The Galician wind energy sector: evolution and current situation

In Spain, the power of legislative development and implementation of the special regimen[3] of electrical production were assumed gradually by the Autonomous Communities (Spanish regions). Central Administration retains the competencies related to the coordination and planning of energy policies and the basic legislation of agreements and administrative authorisations. Likewise, the central government retains the legislative power over remuneration models (Bacigalupo, 2010). The regional government is in charge of the regulation competency of the electricity power installations, transport and distribution set in Galicia (a Spanish north-west region). In this sense, the regional government is also in charge of spatial planning of wind energy, organisation and solution of controversial issues about wind energy and the approval of new installations. Besides, regional governments could also implement local content requirement policies through industrial plans.

The commercial development of wind energy in Galicia began around the mid-90s, when large conglomerates, such as *Endesa*, were interested on using the existent wind resources. Nevertheless, this exploitation was previous to the first Galician Wind Energy Sectorial Plan (PESG), which was approved in 1997. In spite of that normative delay, wind energy developed in Galicia significantly from 2000 until 2008, turning into the Spanish region with more installed capacity. Graph 1 shows two completely different trends between 2000 and 2012 in Galicia. The first one goes from 2000 until 2008, characterising by a continuous growth of installed capacity, higher than 50% in some years. In 2008, normative instability increased due to the fact that official allocation of new wind energy capacity was appealed and there were several regulatory decrees in the sector. The economic crisis and the gradual reduction of premiums to renewable energies of the special regimen also triggered a strong reduction in the installation of new capacity, characterising a new phase of slow growth. Nowadays, Spain does not allow register new installations in the special regimen, then wind farms owners do not have right to perceive a premiums by the electrical production generated[4].

[3] The special regimen includes renewable energies like wind or solar energy. Some installations of renewable energies when they exceeded a particular installed power capacity they became part of the ordinary regimen.
[4] Royal Decree 1/2012 eliminates the procedures of pre-allocation of premiums and economic incentives for new installations of electricity production of renewable energies. Nowadays, Royal Decree 9/2013 into this path, deleting the remuneration system.

Graph 1. Evolution of the accumulative wind energy installed capacity in Galicia (MW, 2000-2012)



Source: (INEGA, 2012)

Table 1 shows the main regional legislations and official allocation of power capacity in Galicia. The first decree (1995) introduces the concept of industrial plans and the local content requirements. The main aim was to enhance an industrial sector related to wind energy, but the lack of administrative control hampers this goal (Simón et al, 2010). In the next regulation (2001), the figure of the singular wind farms arises. This kind of installations enables local stakeholders (such as municipalities, landowners and so on) to participate in wind farms. However, the success was really limited in terms of the number of stakeholders and power capacity.

The aforeomentioned instability arose after several radical changes in the regional legislation. In fact, Table 1 shows that between 2007 and 2010, there were two complete different legislations and two official allocation of power capacity. The former decree (2007) highlights the public interest in wind energy which enables public sector to participate in the wind energy development. There was also an official allocation of power capacity linked to this decree but it was appealed in 2008. The new regional government developed another legal framework in 2009 which abandoned the idea of public participation in wind energy farms. Albeit, one of the most crucial factor which makes easier the shutdown was the total change of stakeholders between the two official allocations of power capacity.

Table 1.Main regional regulations and official allocations of power capacity in Galicia

	Main characteristics	Duration
Decree 205/1995	Most important legislation in terms of power capacity installed[5]. Industrial plans and local content requirements.	1995-2001
Decree 302/2001	Singular wind farms.	2001-2007
Decree 242/2007	Public sector participation in wind farms. Environmental protection of special areas.	2007-2009
Official allocation of capacity	Allocation of 2325 MW. Official allocation appealed.	2008
Law 8/2009	No chance of public sector participation in wind farms. New taxes per wind turbine. Environmental Compensation Fund.	2009-at present
Official allocation of capacity	New stakeholders. Allocation of 2325 MW. No progression.	2010- at present

Source: Own elaboration

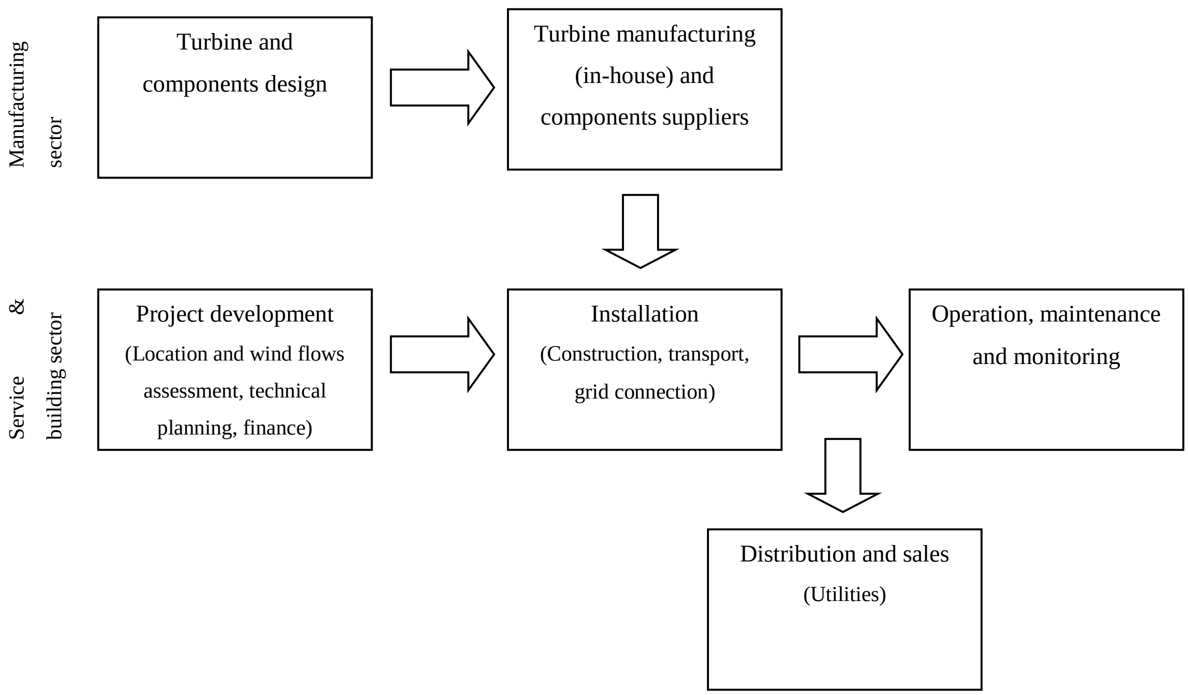
The role played by public administrations in order to regulate Galician wind energy sector and foster its development was focused only on increasing the installed capacity, setting aside industrial or environmental aims such as the protection of special green areas (Simón et al., 2010). Likewise, the lack of administrative control of the fulfilment of the industrial plans and environmental controls reduced substantially the positive impact of the wind energy development on the socioeconomic framework (Ib.).

Diagram 1 shows the basic value chain of wind energy. Its inquiry is crucial to design the analysis of the economic impact by means of input-output analysis. In the first element of the industrial chain there are firms and technological institutions which design and develop new models of wind turbines and components. These stakeholders are those who have industrial designs and patents. The same companies which design the wind turbines could also manufacture directly them or externalise this activity to component manufacturers which would work on request, using the plans of the manufacturers and designers. In general, the activity of component manufacturing on request has a low value added and it constitutes a worldwide standardised activity, such as manufacturing nacelles or towers. Likewise, the innovation performance tends to be limited (Varela & Sánchez, forthcoming).

[5] Many megawatts installed after 2001 were in the shelter of the Decree 205/1995.

Nevertheless, it is possible a learning path if the component manufacturing activities achieve international innovative standards.

Diagram 1. Basic value chain in the wind energy sector



Source: Adapted from Lema et al. (2011)*; EWEA* (2009)

4. Analytical methodology

The empirical methodology is based on the input-output approach and the analysis of the wind energy value chains (Varela et al, 2013). The economic impact diagnosis has to keep in mind the regional special features as well as the distinctive characteristics of value chains (Llera et al, 2010). The analytical methodology is depicted in following sections, particularly, the data used and the branches selected. Moreover, we examine the matrix updating process in order to accomplish more accurate results by means of the quantification of the annual productive structures.

4.1 Analytical framework and data

The analytical framework consists of two parts due to the necessity of analysing separately the temporal economic impact linked to the installation of wind energy farms; and the permanent one, related to the activities of operation and maintenance and the production of electricity. This methodology solves the essential problem of tailoring the temporal and permanent economic impacts of wind energy at regional level (Lambert & Silva, 2012; Llera et al, 2010), increasing the analytical and descriptive capacity. Most seasonal activities depend, greatly, on the economic cycle and the normative framework, as well as on internal dynamics such as the expected profitability, among other factors. Likewise, the investment evolution does not show a stable trend and it presents a moderate volatile evolution. However, branches related to daily operation of wind farms follow a positive evolution trend, because operation and maintenance activities and electricity production depend on the accumulative installed capacity and the meteorological conditions.

Concerning installation activities, we select seven branches following the NACE-Rev1.1[6]. Table 2 shows these branches related mainly to component manufacturing activities, construction, consulting and financial sector. The selection of branches is based on the wind energy sector value chain, interviews with the main stakeholders in Galicia (component manufacturers, consultancies, business associations, wind farms owners and electricity companies) and previous studies, such as Aixalá et al. (2003) and Blanco & Rodrigues (2009).

The quantification of the final demand vector (Δf_i) arises since the annual data of installed capacity published by the Galician Energy Institute (*INEGA*) and the average cost of the investment by megawatt in Spain in 2006[7] (EWEA, 2009). Likewise, this investment is shared between the branches based on the installation cost distribution of wind farms (Hau, 2005; EWEA, 2008, 2011). Afterwards, we allocate an investment percentage which means the share of the total investment implemented by Galician stakeholders. This allocation is

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[6] We select the classification NACE-Rev1.1 due to the fact that we realise the updating of domestic symmetric tables for the period between 2000 and 2010. Given the existence of two input-output frameworks (years 2005 and 2008), it was necessary to keep a same level of homogeneity for all the branches and over time. Thus, we merge several initial branches from input-output structures. The final intermediate consumption matrices (X^d) are 51x51.

[7] These values are reduced by the amount of the historical average VAT rate (16%) for the period of analysis. The same occurs with the costs of operation and maintenance activities.

based on quantitative and qualitative information gathered combining the mentioned interviews and census data from the Galician Wind Energy Association (*EGA*) and the Spanish Wind Energy Business Association[8] (AEE, 2011). Hence, we obtain the value of the final demand vector which will have a temporal multiplier impact on the regional economy.

Table 2 Wind energy sector branches with temporal effects on the economy

Branch codes	Elements
28	Production of metallic elements, with the exception of equipment and machinery
29	Production of machinery and metallic equipment
31	Production of electrical equipment
45	Building
65	Financial services, with the exception of insurances
52-72	Retail trade, with the exception of motor vehicles; computer activities and reparation of personal belongings and domestic instruments
74-85	Health and veterinary activities. Social services and other business activities

Source: Own elaboration

The analysis of the permanent activities is accomplished by means of the selection of the branch 40 (production of electricity) and three branches which represent the impact of operation and maintenance activities. These three branches develop repairing tasks in the NACE-Rev1 but branch 33 is in charge of them in NACE-Rev2. Table 3 shows the aforementioned branches.

To quantify the impact of electricity production, we gather the data of electricity generation of wind energy published by INEGA. Based on these data, we quantify the value of the electricity production by means of the price that the producers receive, thanks to the information offered by the Spanish National Commission of Energy (*CNE*)[9] . Nevertheless,

[8] In relation to the branch 65 (financial services), we chose the Galician saving banks market shares in domestic private loans as an allocation parameter (Fernández, 2011) in 2000-2010. Galician saving banks had a more active role in the credit business to the industrial sector in comparison to the bank system (Vasallo, 2001). The direct quantification of the percentage of loans of the Galician financial firms to the wind energy sector constitutes a complex task, due to the fact that it is usual the underwriting of syndicated loans with several financial firms and the confidentiality clauses.

[9] This value encompasses the price negotiated in the energy market plus incentives and premiums. Until 2004, there was no direct negotiation in the energy market; therefore, the initial value came from the sale to the distributor. Since that, more than 90% of the production is commercialised in the energy market. The producers who choose the option of regulated price are residual.

this value does not still constitute a final demand vector; therefore, it is necessary to filter the data in order to obtain the final demand vector for the branch 40, disregarding, the intermediate production.

Table 3. Wind energy sector branches with permanent effects on the economy

Branch codes	Elements
40	Production and distribution of electricity, gas, vapour and hot water
28	Reparation and maintenance of metallic elements with the exception of equipment and machinery
29	Reparation and maintenance of machinery and metallic equipment
31	Reparation and maintenance of machinery and electrical equipment

Source: Own elaboration

Concerning the quantification of operation and maintenance costs, we use the estimations of EWEA. These estimations refer to the costs in relation to the kWh produced[10]. Likewise, we also need to filter the resultant value, due to the fact that EWEA asserts that only 60% would be properly costs of maintenance and repair. As in the case of electricity production, it is necessary to screen the results to obtain the final demand vector and allocate the final value among the three branches in charge of operation and maintenance activities. This allocation is based on the weight of each branch in the final demand in the annual symmetric matrices.

Finally, there are two final demand vectors, one for activities related to the installation of wind farms and another for permanent activities. Following the process of the Leontief inverse, we will be able to quantify diverse multipliers, as well as the economic impact of the sector in terms of GDP and employment.

[10] EWEA estimated, in 2006, costs between 1,2 and 1,5 cents of € per kWh for wind farms in Spain, Denmark, United Kingdom and Germany. Our study takes the average value.

4.2 Updating matrix coefficients

The last two input-output tables available for Galicia correspond to 2005 and 2008. Apart from the differences of aggregation criterion and the effect of prices[11], these tables will serve as a base to carry out a matrix series of the productive structures from 2000 to 2010, because of the existence of annual information of some macroeconomic variables[12]. It seems reasonable to realise the corresponding estimation in order to avoid focusing only on the data from 2005 and 2008, especially if there are sufficient elements to apply methods of matrix updating. In addition, we avoid a weakness related to quantify the economic impact in input-output models, which refers to the existence of static technical coefficients (Lambert & Silva, 2012).

If we know the production and value added growth rates and the total imports, such as in this case, it is possible to update the symmetric domestic table. The basic RAS is not suitable with this information, because we do not know the row sums of the intermediate consumptions matrix. Regarding with this, it is important to keep in mind that the RAS is a biproportional technical of matrix adjust that consists of multiplying successively form the rows and the columns elements of a basic matrix by some parameter until accomplishing a converge solution. This iterative procedure was proposed by Stone & Brown (1962) and, over time, their foundations and extensions have considerably increased; see for example Bacharach (1970), Allen & Lecomber (1975) or Szyrmer (1989).

In spite of not knowing the vector of intermediate demand, we have decided to adapt the basic RAS. To implement the extension of the RAS, in accordance with the available information, it is necessary to act jointly on the intermediate consumption and final demand domestic matrices, because we know the margins of this combined matrix. In those cases in which we have input-output tables in the base years, we could carry out contrasts among

[11] In this study we did not deflate input-output tables. Diverse authors (Miller & Blair, 2009; Eurostat, 2008) examined the disadvantages of deflation. They stand out mainly the need of a high level of sectorial breakdown and homogeneity by groups, due to the fact that all the elements of the row of the intermediate consumptions matrix should be deflated by the same index. In addition, the interindustrial prices can vary in a large extent among them. The effects of the level of prices will be mitigated in the technical coefficients matrix, because there will be an inflationary or deflationary effect on the numerator as well as on the denominator. A preferable alternative to the deflation are the biproportional methods of adjustment such as the RAS (Miller & Blair, 2009).

[12] Previously, the Galician Statistic Institute (*IGE*) has published an incomplete input-output framework in 1998 (methodology ESA-95), but due to diverse reasons, it is not recommended to use it.

the estimations and the real data. In principle, we do not know the evolution of the totals components of the final demand (public and private final consumption, gross capital formation and exports), but if we adds them in a single vector we could know their total by difference between magnitudes. It is necessary to guarantee the accounting equilibrium in the input-output framework.

Concerning the matrix combined, it is essential to include several sub-matrices. In particular, there are the domestic intermediate consumption matrix X^d and the intermediate import matrix X^m. Additionally, we have the domestic final demand matrix Y^d as well as the import final demand matrix Y^m.

Therefore, analytically there is a combined matrix:

$$(X \vdots Y) = \begin{pmatrix} X^d & Y^d \\ X^m & Y^m \end{pmatrix}.$$

In general, the matrix $(X \vdots Y) \in \mathrm{M}_{2n \times n+f}(\Re)$, where n is the number of industries and f is the number of components of the final demand.

If the aim is to update the matrix of domestic intermediate consumptions, as it is the case, we recommend adding the import flows in a single row vector and the final demand in a vector column. Then

$$(X \vdots Y)_{combined} = \begin{pmatrix} X^d & Y^d i \\ i^T X^m & i^T Y^m i \end{pmatrix} \in \mathrm{M}_{n+1 \times n+1}(\Re),$$

where i is a column matrix of ones and i^T is its transposed.

As the vector of imported intermediate consumptions is known, $i^T X^m$, and the total imports to final demand, $i^T Y^m i$; the extension of the RAS can be applied on the matrix $(X^d \vdots Y^d i)$.

5. Impact of legal stability on wind energy development and regional economy

The main empirical results derived from the application of the input-output analysis to the Galician wind energy sector are the output multipliers, the additional output increase and the weight of the wind energy sector in the regional GDP[13].

Given the matrix updating in order to quantify the annual economic structures, we obtain the output multipliers in the next step[14]. These multipliers estimate the initial direct effect caused by the increase of the final demand as well as the indirect effect that affects the remaining economic sectors to be able to satisfy the demand of intermediate consumptions triggered by the initial stimulus. The quantification is valid both for the temporary and the permanent activities.

The multipliers quantification allows analysing the additional output increase which constitutes a magnitude that shows the relationship between the increase triggered by the final demand and the initial stimulus. It enables to quantify the total outcome per euro of final demand.

Table 4 shows the additional output increase encouraged the wind energy, breaking down for temporal and permanent activities. The evolution of operation and maintenance activities and electricity production are also depicted. As shown, the evolution is relatively stable over time. Regarding temporal activities, there is a generation of an extra production per each euro invested in the installation of wind farms that goes from a range of forty-three cents in 2000, until forty-seven in 2007. In this year it accomplished the higher impact in terms of production.

[13] The effect on the employment also constitutes an essential aim for the complete quantification of the sector. However, it will form part of future extensions of the study. Likewise, the crowding-out effect is postponed for future analysis: It is caused by the progressive replacement of the conventional energies by renewable energies. It constitutes a possible employment loss in these sectors. Some authors studied these effects, such as Cansino et al. (2013) or Lambert & Silva (2012).

[14] The output multiplier $m(o)_j$ is the sum of the elements of the matrix Δx; in mathematical terms $m(o)_j = i^T \Delta x = \sum_{i=1}^{n} l_{ij}$; since l_{ij} the elements of the Leontief inverse.

Table 4. Additional output increase in the wind energy sector

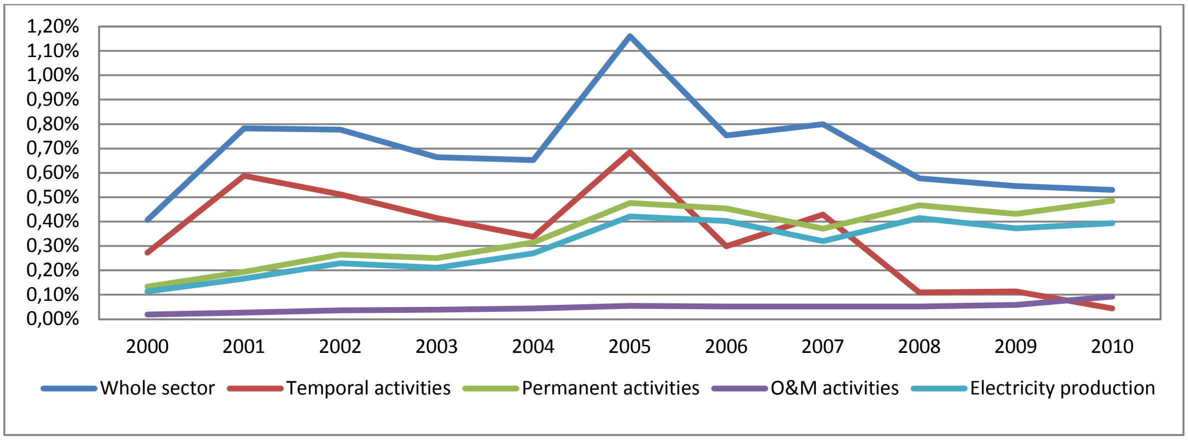
	Temporal activities	Permanent activities	Operation & Maintenance	Electricity production
2000	42,94%	52,99%	37,51%	55,96%
2001	43,45%	56,97%	37,55%	60,73%
2002	45,08%	50,50%	38,68%	52,52%
2003	45,45%	49,38%	38,37%	51,60%
2004	46,54%	50,64%	39,43%	52,68%
2005	46,07%	54,42%	39,05%	56,66%
2006	46,83%	57,04%	39,59%	59,64%
2007	47,11%	54,02%	40,57%	56,47%
2008	45,45%	56,41%	39,40%	58,84%
2009	45,96%	52,06%	38,28%	54,49%
2010	46,10%	48,83%	39,92%	51,09%

Source: Own elaboration

Permanent activities, in a broad sense, reach a higher additional output increase than temporal ones. Throughout the analytical period, permanent activities increase in more than 50% the effects generated by the stimulus in final demand (indirect effects in the production). Nevertheless, observing its breakdown between the generation of electricity and the effects derived from operation and maintenance (O&M) activities, we could check that the former presents some slightly higher effects. For instance, in 2001 the total production increased more than 60% from the generation of electricity for final demand. Therefore, it shows that both the investment in wind farms and its daily activities have some significant effects in the Galician economy. Most of the value chain generates an extra production of almost the half initially invested or even more.

Graph 2 shows the weight of the wind energy sector and of each of its different components in the regional economy. This quantification is crucial in order to measure the size of the sector in relation to the whole economy. It also emphasises the importance of public policies which boost the sector, as well as its potentialities. Equally, it can check the impact of the economic cycle and normative changes on the sector. Besides, the breakdown based on the value chain stands out the relative importance of each subsector.

Graph 2. Estimation of the wind energy sector in terms of the Galician GDP (2000-2010)[15]



Source: Own elaboration

The weight of the wind energy sector in the Galician economy changes substantially over time. In 2005 reached the highest value (1,16% of the GDP) due to the installation of new wind farms (supposed almost 0,69%) and the electricity production (0,42%). That year constituted the moment with more new installed capacity, with 540 MW. However, it also reached lower figures, such as at the beginning and at the end of the decade (0,40 and 0,54%, respectively). Between 2001 and 2007, the contribution to the economy was above 0,70%.

It should be also emphasised the contribution of the installation of new wind farms to the GDP until 2007. During this year, it was always above 0,3%, therefore, it constitutes the main driver in the wind energy sector and with an essential additional output increase in the economy. This evolution reflects the large sector peak, with installed capacity annual growth rates higher than 10% and even reaching 57% in 2001. Since 2007, there were two complete different sectorial legislations with opposite guidelines and the shutdown of the wind energy appeal in 2008. Likewise, it is necessary to emphasise current changes in the remuneration regimen and the new context of economic crisis. The result was a crucial shutdown in the installation of new capacity, what blocked the sectorial development. The dependence on the installation of new capacity highlights the harmful effects that the paralysis of wind energy appeals triggered in the Galician economy.

[15] It includes direct plus indirect effects. The data of the GDP are in real terms on base 2005, corrected of seasonality and calendar effect. Likewise, the production to final demand of each subsector was deflated by means of the implicit deflator on base 2005.

At the end of the decade permanent activities play a palliative role in contrast to the unfavourable evolution of the annual installed capacity, because their contribution to the GDP has increased. This fact is mainly justified by the contribution of the electricity production with the exception of meteorologically bad years. The special regimen has preference in the energy market; therefore, it is not affected by the fluctuations of the energy market. Likewise, the contribution of operation and maintenance activities is insignificant (underneath 0,1% of the GDP). Consequently, it does not constitute an economic driver. Hence, there is no sufficient wind turbines stock in order to reach an important contribution to the economy. The permanent component of the sector has not still significant size to sustain a repair market.

Given the current sectorial stagnation and its capital-intensive feature, a positive development would go through a growth in the onshore or offshore installed capacity, or by repowering the current wind farms. In this last case, it is necessary a legislative reform, especially in the remuneration regimen[16], in order to increase the expected profitability.

6. Conclusions

Legal stability constitutes a key factor to provide financial security as well as it plays a role of enhancing innovative processes. This stability is essential, especially, in the case of emerging sectors which have to face technological and institutional inertias and barriers. Experience teach us the necessity of implementing clear and long-term guidelines which make easier the emergence and consolidation of any new sector. These policies should combine supply-side as well as demand-side measures in order to take into account the systemic features of innovation processes. Then, instability has an important impact on both the sectorial development and the economy through the investment and production channels.

In some wind energy peripheral clusters, instability hinders the sectorial development and the potential chance of industrial diversification mainly in the case of regions with high level of wind energy installed capacity. In these situations, the economic quantification of

[16] Nowadays, Royal Decree 9/2013 increases the uncertainty through modifying the previous remuneration regimen. It is necessary to mention other development barriers such as the Galician wind energy tax stipulated in the Law 8/2009 and the state tax to electricity production.

instability is crucial due to its effect in terms of linkages, output as well as the measure of its potentialities.

The analysis of the Galician wind energy sector, by means of the value chain approach the input-output analyses, shows us an important loss of total output (as a sum of direct and indirect effects) because of a decisive legal shutdown in 2008. This shutdown was a consequence of two totally different legal contexts within two years and the paralysation of the public allocation of installed capacity. In fact, we could quantify this loss in more than 0,5% of GDP within its peak reached in 2005 and 2008. The economic crisis also sharpens that trend. This legal instability affects seriously the wind energy sector because it is a capital-intensive sector and it needs more than 1 million of euros per onshore MW.

The role played by legal framework is due to the sectorial dependency on new installed capacity. Temporal activities were the most important in the wind energy value chain and for this reason, the sector it is very sensitive to normative changes. Thus, there are few options available and all of them go through repowering wind farms or installing new onshore or offshore capacity.

7. Bibliography

AEE. (2011). *Eólica 2010*. Madrid: Asociación Empresarial Eólica.

Aixalá, J., Sanaú, J., & Simón, B. (2003). El desarrollo de la energía eólica en Aragón: Estimación de los efectos en la producción y el empleo regionales. *Economía Aragonesa*(22), 55-80.

Allen, R., & Lecomber, J. (1975). Some Test on a Generalized Version of RAS. En R. Allen, & W. Gossling, *Estimating and Projecting Input-Output Coefficients*. London: Publishing Company.

Avnimelech, G., & Teubal, M. (2007). *Innovation and Technology Policy (ITP) for catching up: a Three Phase Life Cycle Framework for Industrializing Economies*. Santiago de Chile: CEPAL.

Avnimelech, G., & Teubal, M. (2008). Evolutionary Targeting. *Journal of Evolutionary Economics*(18), 151-166.

Bacharach, M. (1970). *Biproportional Matrices and Input-Output Change*. Cambridge: Cambridge University Press.

Bacigalupo, M. (2010). La distribución de competencias entre el Estado y las Comunidades Autónomas en materia de energías renovables. *REAF*(10), 286-329.

Blanco, M., & Rodrigues, G. (2009). Direct employment in the wind energy sector: An EU study. *Energy Policy, 37*, 2847-2857.

Campos, P., & Klagge, B. (2013). The Evolution of the Wind Industry and the Rise of Chinese Firms: From Industrial Policies to Global Innovation Networks. *European Planning Studies*, *21*(9), 1341-1356.

Cansino, J., Colinet, M., González-Limón, J., & Ordóñez, M. (2013). Towards a cleaner energy mix in Spain. Crowding-out effects when biomass replaces Combined Cycled Plants. *V Jornadas de Análisis Input-Output* (págs. 1-15). Sevilla: SHAIO.

Couture, T., & Gagnon, Y. (2010). An analysis of feed-in tariffs remuneration models: Implication for renewable energy investment. *Energy Policy, 38*, 955-965.

del Río, P. (2007). Políticas públicas, creación de industria e innovación en energías renovables. Una reflexión sobre el caso español. *Economía Industrial*(384), 75-84.

del Río, P., & Unruh, G. (2007). Overcoming the lock-out of renewable energy technologies in Spain: The cases of wind and solar electricity. *Renewable and Sustainable Energy Reviews, 11*, 1498-1513.

Edler, J. (2006). Demand Oriented Innovation Policy. *ProACT Conference*, (pp. 1-30). Tampere (Finland).

Edquist, C. (1997). Systems of innovation approaches –their emergence and characteristics. In C. Edquist, *Systems of innovation: Technologies, Institutions and Organizations* (pp. 1-35). Londres: Pinter.

Edquist, C., & Hommen, L. (2008). Systems of innovation approaches. Their emergence and characteristics. In C. Edquist, & L. Hommen, *Small Country Innovation Systems. Globalization, Change and Policy in Asia and Europe* (pp. 1-28). Northampton: Edward Elgar.

Eurostat. (2008). *Eurostat Manual of Supply, Use and Input-Output Tables.* Luxembourg: European Communities.

EWEA. (2008). *Wind at Work. Wind Energy and Job Creation in the EU.* European Wind Energy Association.

EWEA. (2009). *Wind Energy- the Facts: A Guide to the Technology, Economics and Future of Wind Power.* European Wind Energy Association. Londres: Earthscan.

EWEA. (2011). *Wind in Power. 2010 European Statistics.* Londres: European Wind Energy Association.

Fernández, J. (2011). O impacto das Caixas de Aforro na dinamización do tecido produtivo de Galicia. *Sistema Financeiro post-crise e Innovación: Repensar a Banca Pública*. Santiago de Compostela, España.

Gorenstein, S., & Moltoni, L. (2011). Conocimiento, aprendizaje y proximidad en aglomeraciones industriales periféricas. Estudio de caso sobre la industria de maquinaria agrícola en la Argentina. *Investigaciones Regionales*(20), 73-92.

Gregersen, B. (2010). The Public Sector as a Pacer in the National Systems. In B. Lundval, *National Systems of Innovation. Toward a Theory of Innovation and Interactive Learning* (pp. 133-150). London: Anthem Press.

Gregersen, B., & Jonhson, B. (2008). A policy learning perspective on developing sustainable energy technologies. *IV Globelics Conference.* México.

Hau, E. (2005). *Windturbines: Fundamentals, Technologies, Application, and Economics* (2 ed.). Berlin: Springer.

Haussman, R., & Rodrik, D. (2003). Economic development as self-discovery. *Journal of Development Economics*, *72*, 603-633.

INEGA. (2012). *Parques eólicos no réxime especial en Galicia*. (I. E. Galicia, Editor) Recuperado el octubre de 2012, de http://www.inega.es/enerxiagalicia/listaxecentrais.html

Lambert, R., & Silva, P. (2012). The challenges of determining the employment effects of renewable energy. *Renewable and Sustainable Energy Reviews*(16), 4667-4674.

Lema, R., Berger, A., Schmitz, H., & Song, H. (2011). Competition and Cooperation between Europe and China in the Wind Power Sector. *IDS Working paper*, 1-45.

Lewis, J., & Wiser, R. (2007). Fostering a renewable energy technology industry: an international comparison of wind industry policy support mechanisms. *Energy Policy*(35), 1844-1857.

Lindgaard, J. (2010). Science, engineering and people with a mission. Danish wind energy in context 1891-2010. *The International Schumpeter Society Conference*, (pp. 1-22). Aalborg (Denmark).

Llera, E., Aranda, A., Zabalza, I., & Scarpellini, S. (2010). Local impact of renewables on employment: Assessment methodology and case study. *Renewable and Sustainable Energy Reviews*(14), 679-690.

Lundvall, B. (2010). *National Systems of Innovation. Toward a Theory of Innovation and Interactive Learning.* Londres: Anthem Press.

Miller, R. E., & Blair, P. D. (2009). *Input-Output Analysis. Foundations and Extensions* (2º ed.). Cambridge: Cambridge University Press.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy, 13*(6), 343-373.

Rodrik, D. (2004). Industrial Policy for the twenty-first century. *Discussion Paper 4767* (pp. 1-57). Cambridge (MA): CEPR.

Sánchez, M. C. (2007). *A privatización da empresa pública española.* Vigo: A Nosa Terra.

Schallenberg-Rodríguez, J., & Haas, R. (2012). Fixed feed-in tariffs versus premium: A review of the current Spanish system. *Renewable and Sustainable Energy Reviews, 16*, 293-305.

Simón, X., Montero, M., Giménez, E. L., & Castro, F. (2010). *Os plans eólicos empresariais no sector eólico galego. Unha análise do seu grado de desenvolvemento.* Vigo: Consello Social.

Söderholm, P. (2008). The political economy of international green certificate markets. *Energy policy, 36*, 2051-2062.

Stone, R., & Brown, A. (1962). *A Computable Model of Economic Growth.* London: Chapman and Hall.

Szyrmer, J. (1989). Trade-off between Error and Information in the RAS Procedure. En R. Miller, K. Polenske, & A. Rose, *Frontiers of Input-Output Analysis* (págs. 255-278). New York: Oxford University Press.

Varela, P., & Sánchez, M. C. (forthcoming). Estado de desarrollo del sector de la energía eólica en Galicia desde una perspectiva de clúster. *Revista Galega de Economía*.

Varela, P., Sánchez, M. C., & Pereira, X. (2013). Impacto económico del sector de la energía eólica en Galicia. *Smart Regions for a Smarter Growth Strategy: New challenges of the regional policy and potentials of cities to overcome a worldwide economic crisis.* Oviedo: Spanish Regional Science Association.

Vasallo, A. M. (2001). Sistema financiero y desarrollo empresarial desde la perspectiva gallega. *Revista Galega de Economía*, 1-24.