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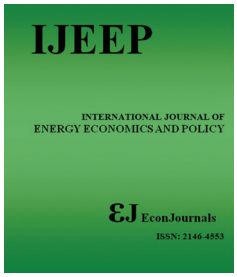

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The Role of Public Policy in the Development of Technological Capabilities of Companies in the Wind Energy Sector and the Impact on Social and Environmental Performance

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ABSTRACT

The object of this study was to analyze the role of public policies in the development of technological capacities in firms of the wind energy sector and the impacts of this development in social and environmental performances of these firms. The investigation was organized through semi-structured interviews with ten professionals of political policies in different Brazilian states and seven professionals of wind energy corporations in Brazil. The main implications in the field of public policies reveal they were fundamental for the sectors development, but were inefficient regarding the transfer of technology to Brazil, training and qualification of the workforce, development of the infrastructure to the wind energy sector, and the development of technological capacities of the firms.

Keywords: Wind Energy Policy, Technological Capacity, Social and Environmental Performance
JEL Classifications: Q42, Q48, Q55, Q56

1. INTRODUCTION

The large-scale wind energy generation trajectory in the Brazil's energy matrix and the development of the local wind energy industry have been largely influenced by the country's government, mainly by program creations and subvention offers which leveraged the sector along the years. This led to the installation of factory plants from major multinational companies on the country, in-turn enabling the development of the Brazilian wind energy industry and the local technology capabilities with a direct impact on these organization social and environmental development.

Junfeng et al. (2006) and Junfeng et al. (2010) indicate that, in direct labor generation terms, the social impact of the development of these wind energy companies no Brazil in 2009 was about 13,500 workers, and they highlight the importance of this sector to help promote a deeper social inclusion. Furthermore, Simas (2012) forecasts that until 2020 the wind energy industry will create 330 thousand direct and indirect jobs. In the environmental sphere, it should be highlighted the reduction of pollutant emission through fossil fuels uses to generate energy and the small environmental impact of wind farms, the preservation of the region which the plants has been installed, and the use of a power supply complementary from hydraulic energy, considering the potential of Aeolian produced energy during the drought seasons (Nascimento et al., 2012).

Several studies have evaluated the public policies and the political and environmental scenarios in which the wind energy has emerged (Abreu et al., 2014; Balibrea-Iniesta et al., 2015; Camillo, 2013; Costa, 2006; Dutra, 2007; Dutra and Szklo, 2008; Ferreira, 2008; Gwec, 2014; Regueiro-Ferreira and García, 2013; Silva, 2006; Nogueira, 2001; Podcameni, 2014). Nevertheless, studies dealing with the role of public policies on the development of wind energy companies technological capabilities and this development impacts on these companies social and environmental performances in

developing countries like Brazil has been scarce. Nascimento et al. (2012) agree and propose the development of studies establishing analytical categories to better understand policies, wind energy sector technological development, social demands and environmental impacts. These studies would expand the knowledge of the sector and the innovation role in its recent development.

Therefore, the current study aims to analyze the role of public policies in the development of technological capabilities of companies in the Brazilian wind energy sector and this development impacts on the social and environmental development of these companies, and presents the specific objectives: (i) Identify and classify Brazilian public policies to the wind energy sector; (ii) analyze how public policies to the wind energy sector influence to the development of technological capabilities; (iii) identify the technological capabilities level of the wind energy companies; and (iv) analyze how these capabilities impact the social and environmental performance of the sector companies.

Next section presents the study's theoretical framework including public policies, technological capabilities and social and environmental performances, as well as the public policies impact on the development of technological capabilities and the latter's impact on social and environmental performance. Also, the analytical categories to be used on the analyses and discussions of the results are defined.

2. RESEARCH FRAMEWORK

It should be highlighted the importance of studies dealing with the interaction between policies and technological capabilities and their influence on social and environmental performance has been consolidated by Bell and Pavitt (1995), Dutrénit (2000) and Lall (1992). These authors consider that public policies strengthen firm's path on the development of technological capabilities, resulting in their knowledge and abilities build up, as companies adapt and develop technologies with a direct impact on their performance, especially social and environmental ones.

The framework presented in Figure 1 is going to be used to analyze the relation of public policies on the development of technological capabilities, and of these capabilities on social and environmental performance of the wind energy companies on Brazil.

The considered analytical framework's constructs are: (i) Public policies, herein addressed as actions taken by the government to create rules and conditions aiming the country development (e.g.: Rua and Romanini, 2013; Secchi, 2014); (ii) Technology Capabilities, addressed as technical conditions, knowledge, skills, experience, and institutional structure, capable of generating and manage change and development (e.g.: Bell and Pavitt, 1995; Dutrénit, 2000; Figueiredo, 2009; Lall, 1992); and (iii) Social and Environmental Performance, herein considered as passive categories of measurement originated from internal and external actions from the companies, which direct impact to the society (e.g.: Branco and Rodrigues, 2006; Husted, 2000). Afterwards, the study's theoretical description and the relation of the constructs are presented.

Figure 1: Research framework

Source: Adapted from Bell e Pavitt (1995), Dutrénit (2000), Figueiredo (2009) and Lall (1992).

2.1. Public Policies and Technological Capabilities

Public policies, formulated and implemented by governments and complemented by societal participation, are a set of decisions and actions required to the State development, in a result of technical and political knowledge process, and which tries to balance social actors' goals and means. Therefore, these policies ought to be coherent to direct these social actors to common goals (Evans, 1995; Heidemann and Salm, 2009; Howlett et al., 2013).

Directed towards the development of technological capabilities, public policies develop and encourage public and private investments which support the assembly of development infrastructure, capable of promoting positive effects of technology exchange between universities, research institutes, firms, training of labor force, and market development (Avellar, 2009; Kim, 1993; Zucoloto, 2009). This device enables organizations to compete with the market major players worldwide through the assimilation of knowledge developed in other countries, and affecting the development of technological paths which, in turn, influence competitive environment, society, institutions and public policies (Bell and Figueiredo, 2012; Bell and Pavitt, 1993; Câmara and Brasil, 2015; Dosi et al., 1994; Kim, 1993; Lall, 1992; Mazzucato, 2014; Teubal, 2002).

Human resource and tax incentive policies are also indicated by Zucoloto (2009), Corder and Salles-Filho (2009) as important government actions which can directly affect the development of technological capabilities. Concerning Multinational Companies installation, human resource qualification plays an important role in the country's appeal to these companies, since they are specially sensitive to the existence of qualified engineers and scientists. On the other hand, tax incentives aid in the firm's operational costs, in import taxes' reductions, in the reduction of corporate income taxes, and improving organizational competitive advantage through R&D investments and business training. Nevertheless, the problems of these kind of device are the difficulty of direct impacts measurement of technological capabilities advancements.

Therefore, considering that countries, specially the developed ones, use these devices to develop their competitive policies and that international commerce guidelines are permissive to that end, the advancement and use of these mechanisms must be developed and understood on Brazil (Corder and Salles-Filho, 2009).

2.2. Technological Capabilities and Social and Environmental Performance

The organizational technological capability has been consolidated as a primary strategic resource and possibly that most valued one

to the maintenance of the competitiveness required by sectors of the society. It also enables companies keeping themselves competitive into the current turbulent markets. The technological capability cumulatively advances, is adapted, and is shaped by the acquired knowledge and expertise, and the surrounding social and environmental contexts (Bell and Pavitt, 1993; Camillo, 2013; Figueiredo, 2009; Lall, 1992; Zhou and Wu, 2010).

The literature presents several definitions of technological capabilities. Bell (1982), Bell and Pavitt (1993), Bell and Pavitt (1995), Lall (1992) and Dutrénit (2000) support technological capability to be the set of resources required to generate and manage technical change, including abilities, knowledge, experience, and institutional structure, through capabilities and knowledge intrinsic to human activities. This set of resources aims to change not only manufacture, but also design, development and innovation management techniques, via a systemic effort to create something aiming to acquire even more knowledge in the manufacture level.

Technological capabilities constantly induce the firm's environmental variables through social relationships. These variables directly affect the accumulation of capabilities process and the way and frequency of the interaction of company and environment might develop benefits in terms of innovation performance through knowledge accumulation and manufacture processes (Franco, 2014). The outcome of this technological evolution process directly effects social and environmental performance of companies. Performance can be viewed as a set of measurable structural categories operationalized inside and outside of organizations. Furthermore, the organization behavior must be socially and environmentally approved and recognized by society, possibly leading to competitive advantage and approaching society (Branco and Rodrigues, 2006; Husted, 2000).

Corazza (2003) considers that the concept of cleaner technologies does not translate into final solutions to social and environmental problems, instead, it has evolved along with technological dynamic and environmental quality patterns. Fankhauser et al. (2013) draw attention to the importance of expanding the universe of analysis of the cleaner technology subject, since the current trend has been to analyze only the production of clean energy, as wind power, or hydrogen powered cars and electric energy. These are important areas, mas there is a lot more to be explored in the manufacturing industry, such as: Machines, consumer goods, resource efficiency and waste management.

Technological capabilities and socio-environmental performance relationship can be considered through the perspective of the shifting behavior of companies, that start adopting preservation practices, and introducing more environmental friendly new manufacture technologies. Besides, the shift from unsustainable consumption patterns to more sustainable ones can lead to a paradigm shift in the business competition, and contribute to firms competitiveness, to sustainable performance and to social and environmental performances, which are long-term goals needed to be more discussed by the society (Freeman and Soete, 2008, Tahim, 2008).

3. METHODOLOGY

The current study presents the results of descriptive and qualitative research performed in the empirical field of the Brazilian wind energy sector. The study focuses on public policies directed to the sector, technological capabilities and social and environmental performance. The sample was selected by accessibility and is of non-probabilistic type. As stated by Vergara (1998) this is a sample type that doesn't use statistic procedure to select the subjects, and use their location to find people with the aimed characteristics, and this choice has been made considering accessibility and relevance to the study.

The data was collected by formal and semi-structural interviews performed between September 2015 and November 2015. Seventeen actors were interviewed, ten of then were from public policies and seven from companies of the wind energy sector. All the most important companies currently operating on Brazil have been interviewed. Afterwards, a triangulation strategy was used regarding commonalities between interviewees' speeches and their comparison with the analyzed theme literature. The interviews were recorded with the authorization of the interviewees, which are described in the Table 1. The interviews were then fully transcribed and analyzed with the Content Analysis technique (Vergara, 2012; Bardin, 2009). The interviewees and their companies were properly nicknamed to preserve their identity.

For public policies, the classification criteria used to analyze the speeches were: (i) Regulatory: Establishes patterns of behavior, compulsoriness, proscription, and conditions to public and private actors; (ii) distributive: Allocates goods and services to certain portions of society; (iii) redistributive: Distributes goods and services among some types of actors through resources from other groups of actors; and (iv) constructive and structural: Reinforces political game through norms and procedures, and through these, formulates and implements other political policies. This formulation and implementations are performed by defining competences, jurisdictions, rules of disputes, rules about power

Table 1: Interviewees detailed information

Participant's sector	Location	ID	Role
Government	CE	PP1	Municipality secretary
Association	DF	PP2	Chairman
Bank	RJ	PP3	Capital goods manager
Bank	RJ	PP4	Project manager
Environment agency	CE	PP5	Industrial chemistry
Bank	CE	PP6	Technical expert
Sector chamber	CE	PP7	Sector chairman
Sector chamber	RN	PP8	Sector director
Government	DF	PP9	Project consultant
Government	CE	PP10	Secretary of science and technology
Alfa	CE	E1	Chairman
Beta	BA	E2	Electrical engineer
Gama	CE	E3	Maintenance technician
Delta	CE	E4	Project manager
Epsilon	CE	E5	Technical director
Zeta	CE	E6	Production supervisor
Sigma	CE	E7	Engineering manager

Source: Prepared by the authors

branches and rules about rules (Rua and Romanini, 2013; Secchi, 2014).

For technological capabilities, the analysis was structured in four levels: (i) Assimilative capability: Actions focused on training and learning related with operationalization and usage of technologies; (ii) adaptive capability: Construction of an initial design base of knowledge, and the introduction of more formal, and deliberate learning activities; (iii) generative capability: Independent R&D activities, more comprehensive knowledge base, scientific knowledge on relevant disciplines, and technologies; and (iv) strategic capability: The generation and implementation of new technologies capable of conducting the company to the international technology frontier (Dantas and Bell, 2011).

Finally, the social and environmental performances of the wind energy companies were analysed. This social performance analysis was structured by: (i) Job creation; (ii) community relationships; and (iii) social impact of the product. Social impact of the product deals with the social contribution of goods and services to the population welfare, fairness and satisfaction of basic needs. The environmental performance analysis was structured by: (i) Use of materials: Types of materials used; (ii) energy consumption: Type of energy used or generated; (iii) production residues: Types of residues generated before recycling, treatment or elimination; and (iv) pollutants release: Types of pollutants released in the environment. This indicator includes solid residues, toxic chemical products and other pollutants. Both the social and environmental performance analysis were based on the taxonomy developed by Ranganathan (1998).

4. RESULTS AND DISCUSSIONS

This section presents the results and a discussion of the findings of the research. Firstly, the Brazilian public policies for the wind sector are identified and classified, Secondly, their impacts on the technological capabilities are presented. Finally, the technological capabilities and the social and environmental performances of the wind energy companies are discussed.

4.1. Identification and Classification of the Main Brazilian Wind Sector's Public Policies

The insertion of the large-scale wind energy generation into the Brazilian energy matrix and the national wind energy industry development have been strongly influenced by the government, through the creation of programs and subsidies that leveraged the sector along the years. According to the public policies interviewees and the wind energy companies, three policies should be highlighted as the most important for the Brazilian wind energy sustainability: PROINFA, FINAME and the design of auctions (Table 2).

According to the typology in study, the wind energy public policies can be classified as multiple types. Pase (2012) states that the multiple classification of public policy types sometimes happens because it oscillates according to the adopted theoretical focus and the political, social and institutional contexts. Souza (2011) contends that policies can shift to another when projects flow from regulatory to redistributive or the other way around. In this changing process, the public policy can receive more than one classification due to definition limitations of its actions threshold. Furthermore, these policies are related with decisions and actions that encompass several social players from multiple public and private organizations (Bucci, 2006).

Table 2: Identification and classification of the main Brazilian public policies for the wind energy sector

Public police	Characteristics	Classification
PROINFA	Establishes rules for energy purchasing	Regulatory policy
Auction Model	Stablishes mandatory rules, behaviour patterns, and commercialization and disputes rules	Regulatory and constructive policy
FINAME	Stablishes rules for nationalization obligations, and allocation of resources from the society to equipment funding	Regulatory and redistributive policy

Source: Research data

4.2. Public Policies Impacting Technological Capabilities

In technological development terms, the chairman (PP2) and the secretary of science and technology (PP10) note that the PROINFA policy paved the way for the wind energy investments, and generated attraction of companies, and the development of lighter and more resistant materials and new equipment models. These developments have been evolving over time through a consistent technological development. At the time of the launch of PROINFA, the current Brazilian technology just allowed the production of equipment with low wind to electric energy processing power (Camillo, 2013; Dutra, 2007).

The FINAME policy had heavily impacted the local technological development because it forced foreign companies to manufacture in Brazil so they could fund their goods with financing from the Banco Nacional de Desenvolvimento (BNDES). The capital goods manager (PP3) credited this policy to be the most important factor to the Brazilian industry because of the imposed equipment nationalization index. This is evidenced by the emergence of a supply chain, that had to be developed and adapted over time to support the supply of national parts and inputs to the manufacture of wind turbines (Abreu et al., 2014).

In market development terms, the public policies professionals and the companies converge their narratives: Public policies, designed and applied to the wind energy sector by the Brazilian government, had been indispensable to the country's market development. The chairman (PP2) highlighted the Brazilian public policies has been suitable, and prime, for the development of the market and to attract multinational companies. The industrial chemistry (PP5) believes the public policies has probably been central to wind energy sector, to the point that without them many companies would not invest in the sector.

About infrastructure, the public and private actors assert infrastructure is a week point of the wind energy sector, and it is a convergence of logistics and electric energy transmission lines. In

relation to logistics, the public actors and the companies state that the public policies have not included the necessary safe production flow. This lack of road structure impacts competitiveness of the Brazilian wind blade production companies. According to the production supervisor (E6) and the engineering manager (E7), wind blades could be easily marketed but transport of these delicate parts involve high risks which, conjunction with the bad conditions of the Brazilian roads, discourage their production.

In relation to energy transmission lines, the interviewees considered the government has been inefficient to prepare the necessary structure to the generated energy distribution from the wind energy farms to the consumption centres. There is a reason to the concerns of the public actors, for as argued by Camillo (2013), there have been delays in the expansion of the electric energy transmission lines which are delaying the start-up of wind energy farms that have been ready on Bahia and Rio Grande do Norte, for example, because they could not be connected to the national electricity transmission network.

About the link between companies, universities and research institutes to benefit the development and technological transfer to the wind energy sector, the actor opinions show that this link is still being built. Such a judgment is corroborated by Camillo (2013) which stated that Brazil did not stablish a deliberate learning and innovation strategy, or even local technological incorporation, to the wind energy sector. The sector chairman (PP7) highlighted that the research and development effort have been made by the entrepreneur themselves, to develop their technological capabilities. The same is noted by the chairman (E1) of the service company Alfa and the engineering manager (E7) of the wind blade industry Sigma, that stated that the government did not intervene to link companies, universities and research centres.

4.3. Phases of the Wind Energy Sector's Technological Capabilities and Social and Environmental Performances

The service company Alfa designs electric energy generation farms to the wind energy sector. It's not in an advanced technological capability level though. According to chairman (E1), Alfa works with projects of wind energy farms but does not develop technology, just absorbs technology developed by others and introduce in its projects. Therefore, Alfa is in an assimilative capability level in technological terms. In social performance terms, (E1) stated that Alfa works by project, does not usually misplace employees or generate new jobs. The company doesn't have any relationship with the community, and its product doesn't have any perceived social impact, for the company only designs the farms and their building process and the community interaction in the constructor's hand. In relation to environmental performance, (E1) notified that Alfa only uses office supplies in its project design processes, thus production waste and pollutants emissions doesn't happen. Finally, the electric energy needed by the company comes from the local electric energy distributor, the self-sufficient energy consumption is not part of the company's plans.

On the other hand, according to the electrical engineer (E2) the service company Beta develops its own technological capabilities. Beta has its own R&D department that generates and offers electric energy management, transmission and commercialization solutions to the market. One of the Beta's differential is the development of long-term series to prospect suitable areas for the assembly of wind farms. On environmental performance, (E2) noticed that Beta only uses office supplies in its project design processes, thus production waste and pollutants emissions doesn't happen. Finally, the electric energy needed by the company comes from the local electric energy distributor, the self-sufficient energy consumption is not part of the company's plans.

In relation to the Gama Company, the maintenance technician (E3) stated that it owns a wind turbines factory in another country where the products are developed towards the international technological frontier, and in Brazil just markets O&M services. The Gama company's turbines are exported to Brazil where are assembled and receive wind blades that are bought from national suppliers. According to (E3), the maintenance technicians work with knowledge obtained from the headquarters, apparently nothing is locally developed. Therefore, the Gama's Brazilian subsidiary is in an assimilative capability level in technological terms. In social performance terms, (E3) noticed Gama is also stable, does not usually misplace employees or generate new jobs, and works by project as well. The company doesn't have any relationship with the community, although the product's social impact is considered positive by (E3), because the wind turbines contribute to the pollutants emission reduction of the electric energy production.

According to the project manager (E4), the Delta Company develops its own technological capabilities with internal trainings offered to some employees and internally spread afterwards. The company works by project and its professionals are hired according to the needs along the time. There is no worry to develop a technological base, and knowledge is mainly acquired in events, fairs, and conventions of the wind energy sector. As such, Delta probably is in the assimilative capability phase technology-wise. In relation to social performance, according to (E4) Delta is a company that presents considerable job creation because, although the employees allocated to the project are dismissed when its finished, every new project demands the new labor. The relationship with the community only happens in the contracting of local labor to its project constructions and there's no social or environmental recovery projects, in a direct reflection on the social impact of the product.

In the case of the Epsilon Company, new knowledge development, new products, new services, and the learning process are all based on a more solid technological knowledge. The technical director (E5) highlighted that Epsilon partnered an international company to help developing projects that demand more technological knowledge. To develop new tools and procedures, (E5) stated that Epsilon partnered a Portuguese company and internalize the developed tools and procedures through training. Therefore, Epsilon probably is in the assimilative capability phase technology-wise. About social performance, (E5) said that Epsilon keeps a stable jobs demand. Its community relationship doesn't exist, as well as the product's social impact, for the company just

design the project and the construction itself and the community interaction are done by other companies.

As explained by (E6), the Zeta company is limited reproducing the wind blades projects, previously prescribed by the Germany headquarters, and though the product and the project are set, there are daily updates that demand assimilative capability to manage the manufacture process. In the past, as reported by (E6), the manufacture process-were adapted by sending professionals to the headquarters, but this process is in decay nowadays, unless specific issues arise. An example provided by (E6) was the replacement of the wind blade model for a new one that required a more specialized training and sending professionals to the headquarters. Therefore, Zeta is in the assimilative capability level in technological terms. About social performance, (E6) stated that Zeta job demand is stable in the management level, and presents an acceptable turnover rate in the factory level. Currently, the company maintains a relationship with the community by renovating crèches and nursing homes. The product's social performance is considered positive because helps on the electric energy generation reduction of pollutants emissions. About environmental performance, (E6) explained that Zeta uses resin, fiber glass, balsa wood and dye, thus its main production residues are sent to recycling companies. The release of pollutants is controlled by sprinkling and filters installed in the production sheds of the wind blades. This system removes airborne particles preventing external pollution.

In the Sigma Company, according to the engineer (E7), the technological capability is developed by tacit knowledge dissemination. An employee takes a course, and pass it on to the other employees. Therefore, Sigma probably is in the Assimilative and Adaptive Capability stage in technology. About social performance, (E7) informed that Sigma currently presents high job generation because of a new supply contract of wind blades to a multinational company which led to duplication of the company's production. About community relationship, (E7) noted that Sigma carries out social programs around the factory, and no contact is maintained in the wind farms locations. The social impact of the product, though, is considered positive, for it aids the reduction of pollutants emission of electric energy generation. About environmental performance, according to (E7) Sigma uses resin, fiber glass, balsa wood and dye, thus its main production residues are sent to recycling companies. The release of pollutants is controlled by sprinkling and filters installed in the production sheds of the wind blades.

The Table 3 presents an overview of the research process results.

5. FINAL CONSIDERATIONS

Wind energy has been the world's fastest growing energy source in the last decades. In Brazil, it's usage has evolved through the years with an important role on its development been assumed by the government. Public policies like the PROINFA, auctions, and the FINAME have been responsible for the industry creation, development and maintenance during its evolution. Nevertheless, evidence has been found that public policies for the wind energy sector have not actually created conditions to promote the development of the sector. No evidences have been found that public policies helped developing proper infrastructure and manpower. The results reveal insufficient availability of logistics, transmission lines and capable professionals. These professionals have been trained by the companies themselves. The same scenario has risen for the technological transfer between universities, research centres and companies, with results revealing that companies from the wind energy sector have developed their own technology or by their interaction with other sector's companies and customers.

About the technological capabilities phase of the wind energy companies, the research results support that most of the companies are in the assimilative capability phase and present actions focused in training and learning third-party technologies. Among these companies, only one has been identified to be in the assimilative and adaptive phases for it focuses in training and use of technologies and introduction of formal ways of learning. In general, only one company has been identified to be in the generative capability phase. It presents independent R&D activities, comprehensive knowledge bases, and developing projects with scientific knowledge of relevant disciplines and technologies. Furthermore, this description reveals that public policies to the sector have not been effective in attracting and developing endogenous technologies in the wind energy sector, and Brazil is still dependent of technologies developed by multinational companies.

In social performance terms, the research results show that energy wind companies has presented satisfactory job generation performance and product's social impact, with a contribution to the wind farms location's communities development, and with a contribution to the energy security and pollutants emission reduction through the electrical energy generation from wind energy. Albeit, results show that some companies keep no community relationship, others keep low frequency relationship and limit themselves to a few welfare activities in the wind blades factories. Only one service company has shown close interaction with communities.

About environmental performance, the wind energy companies have shown a satisfactory performance, for they avoid using pollutants supplies and they properly discard production residues. It should be emphasized that none of the researched companies are self-sufficient in electric energy generation.

The major limitations of this research are the geographical limitation. Albeit all the most important companies currently operating in Brazil have been interviewed, the research has been limited to employees, come communities and public agents located on Ceará from Brazil, presenting a view of the facts from the perspective of these agents and employees. Therefore, future studies should include agents from other states of Brazil which might be able to consider other factors and impacts of the public policies for the wind energy sector.

Table 3: Overview of the research results

Public policies				
PROINFA, auction model and FINAME				
Public policies impacting technological capabilities of the wind energy companies				
Technology	**Market**	**Infrastructure**	**Labor**	**Technology transfer**
National product development allowed by the facilitated attraction of multinational companies	Responsible for the market creation, development and maintenance.	Ineffective in developing logistic, construction of suitable road structure, and implementation of energy transmission lines	Ineffective, leaving the training to the companies	Ineffective, for the technology hard core keeps been developed in the countries of origin, and failed to create interaction channel between companies, universities and research centres stablished in Brazil, for the development of endogenous technology
Identified technological capabilities				
5 Assimilative – 1 generative – 1 assimilative and adaptive				
Technological capabilities impacting social and environmental performances of the wind energy companies				
Enable investments in information technology systems and processes reorganization, sustainable projects development, specialized labor hiring, proper destination of replaced materials, decrease in deforestation, impact minimization of within wind farms installation and movements of equipment, effective management of production's solid residues, pollutants emission reduction				
Performance				
Social			**Environmental**	
Employment	**Community**	**Product**	**Utilized supplies**	**Energy consumption**	**Production residues**	**Pollutants emission**
Stable labor demand in service companies and high labor demand in wind blade manufacturers due to the recent company growth and the high consumption of the final product caused by the market expansion	Almost nonexistent interaction with communities in service companies. Wind blade manufacturers focus their interaction with the community to the factories surroundings	Contribute to job creation, reduce power rationing risk in the national electricity system, and pollutants emission	Office supplies in service companies. Wind blade manufacturers use resins, fiberglass, dye, balsa wood and cork	None of the companies are energy self-sufficient and depend on local energy distributors	There are no production residues from the service companies. The wind blade manufacturers recycle their production residues	No polluting processes were identified in the research companies

Source: Prepared by the authors

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REFERENCES

Abreu, M.C.S., Siebra, A.A., Cunha, L.T., Santos, S.M. (2014), Fatores determinantes para O avanço da energia eólica no estado do Ceará frente aos desafios das mudanças climáticas. Revista Eletrônica de Administração, 20(2), 274-304.

Avellar, A.P. (2009), Impacto das políticas públicas de fomento à inovação no Brasil sobre o gasto em atividades inovativas e em atividades de P and D das empresas. Estudos Econômicos, 39(3), 629-649.

Balibrea-Iniesta, J., Sánchez-Soliño, A., Lara-Galera, A. (2015), Application of real options theory to the assessment of public incentives for onshore wind energy development in Spain. International Journal of Energy Economics and Policy, 5(3), 791-800.

Bardin, L.A.C. (2009), Análise de Conteúdo. Lisboa: Edições 70, LDA.

Bell, M. (1982), Technical Change in Infants Industries: A Review of the Empirical Evidence. Brighton: SPRU, University of Sussex.

Bell, M., Figueiredo, P.N. (2012), innovation capability building and learning mechanisms in latecomer firms: Recent empirical contributions and implications for research. Canadian Journal of Development Studies, 33(1), 14-40.

Bell, M., Pavitt, K. (1993), Technological accumulation and industrial growth: Contrast between developed and developing countries. Industrial and Corporate Change, 2(2), 157-210.

Bell, M., Pavitt, K. (1995), The development of technological capabilities. In: Trade, Technology and International Competitiveness. Washington: The World Bank. p69-101.

Bucci, M.P.D. (2006), Políticas Públicas: Reflexões Sobre o Conceito Jurídico. São Paulo: Saraiva.

Branco, M.C., Rodrigues, L.L. (2006), Corporate social responsibility and resource-based perspectives. Journal of Business Ethics, 69(2), 111-132.

Câmara, S.F., Brasil, A.A. (2015), Coevolução entre políticas públicas/instituições e o desenvolvimento tecnológico: O caso da petrobrás biocombustível. Revista de Administração Pública, 49(6), 1453-1478.

Camillo, E.V. (2013), As políticas de inovação da indústria de energia eólica: Uma análise do caso brasileiro com base no estudo de experiências internacionais. Tese (Doutorado) - Instituto de Geociências, Universidade Federal de Campinas, Campinas.

Corazza, R. (2003), Economia, tecnologia e meio ambiente: Comentários sobre aspectos positivos e normativos da economia do meio ambiente. Ensaios FEE, 24(2), 479-498.

Costa, C.V. (2006), Políticas de promoção de fontes novas e renováveis

para geração de energia elétrica: Lições de experiência europeia para o caso brasileiro. Tese (Doutorado) - COPPE/UFRJ, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Corder, S., Salles-Filho, S. (2009), Aspectos conceituais do financiamento à inovação. Revista Brasileira de Inovação, 5(1), 33-76.

Dantas, E., Bell, M. (2011), The co-evolution of firm-centered knowledge network and capabilities in late industrializing countries: The case of petrobras in the offshore oil innovation system in Brazil. World Development, 39(9), 1570-1591.

Dosi, G., Freeman, C., Fabiani, S. (1994), The process of economic development: Introducing some stylized facts and theories on technologies, firms and institutions. Industrial and Corporate Change, 3(1), 1-45.

Dutra, R.M. (2007), Propostas de políticas específicas para energia eólica no Brasil após a primeira fase do PROINFA. Tese (Doutorado) - COPPE/UFRJ, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Dutra, R.M., Szklo, A.S. (2008), Incentive policies for promoting wind power production in Brazil: Scenarios for the alternative energy sources incentive program (PROINFA) under the new Brazilian electric power sector regulation. Renewable Energy, 33, 65-76.

Dutrénit, G. (2000), Learning and Knowledge Management in the Firm: From Knowledge Accumulation to Strategic Capabilities. Cheltenham: Edward Elgar Publishing.

Evans, P.B. (1995), Embedded Autonomy: States and Industrial Transformation. Princeton: Princeton University Press.

Fankhauser, S., Bowen, A., Calel, R., Dechezleprêtre, A., Grover, D., Rudge, J., Sato, M. (2013), Who will win the green race? In search of environmental competitiveness and innovation. Global Environmental Change, 23(5), 902-913.

Ferreira, H.T. (2008), Energia Eólica: Barreiras a sua Participação no Setor Elétrico Brasileiro. Dissertação (Mestrado) - Programa Interunidades de Pós-Graduação em Energia, EP/FEA/IEE/IF, Universidade de São Paulo, São Paulo.

Figueiredo, P.N. (2009), Gestão da Inovação, Conceitos, Métricas e Experiências de Empresas no Brasil. Rio de Janeiro: LTC.

Franco, C. (2014), Relação entre Subsidiárias de Energia Elétrica e Pequenas e Médias Empresas (PMES) nos Estados do Rio de Janeiro e Ceará: Fatores Determinantes das Capacidades Tecnológicas. Dissertação (Mestrado) – Centro de Estudos Sociais Aplicados, Universidade Estadual do Ceará, Fortaleza.

Freeman, C., Soete, L. (2008), A economia da Inovação Industrial. São Paulo: Editora da Unicamp.

Gwec, G.W.E.C. (2014), Global Wind Report: Annual Market Update 2014. Available from: http://www.gwec.net/wpcontent/uploads/2012/06/Annual_report_2014_lowres.pdf>.

Heidemann, F.G., Salm, J.F. (2009), Políticas Públicas e Desenvolvimento: Bases Epistemológicas e Modelos de Análise. Brasília: Editora Universidade de Brasília.

Howlett, M., Ramesh, M., Perl, A. (2013), Política Pública: Seus Ciclos e Subsistemas: Uma Abordagem Integradora. Rio de Janeiro: Elsevier.

Husted, B.W. (2000), A contingency theory of corporate social performance. Business and Society, 39(1), 24-48.

Junfeng, L., Jingli, S., Hongwen, X., Yanqin, S., Pengfei, S. (2006), A Study on the Pricing Policy of Wind Power in China. Brussels: GWEC.

Junfeng, L., Pengfei, S., Hu, G. (2010), China Wind Power Outlook 2010. Bélgica: GWEC.

Kim, L. (1993), National system of industrial innovation: Dynamics of capability building in Korea. In: Nelson, R.R., editor. National Innovation Systems: A Comparative Analysis. New York: Oxford University Press.

Lall, S. (1992), Technological capabilities and industrialization. World Development, 20(2), 165-186.

Mazzucato, M. (2014), O Estado Empreendedor. 1. São Paulo: Portifólio-Penguin.

Nascimento, T.C., Mendonça, A.T.B.B., Cunha, S.K. (2012), Inovação e sustentabilidade na produção de energia: O caso do sistema setorial de energia eólica no Brasil. Cadernos EBAPE.BR, 10(3), 630-651.

Nogueira, L.P.P. (2001), Estado Atual e Perspectivas Futuras para a Indústria Eólica no Brasil. Dissertação (Mestrado) - Programa de Pós-Graduação em Planejamento Energético, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Pase, H.L. (2012), Políticas públicas e infraestrutura: A agenda do setor elétrico brasileiro. Revista Debates, 6(2), 107-127.

Podcameni, M.G.B. (2014), Sistemas de inovação e energia eólica: A experiência brasileira. Tese (Doutorado) - Programa de Pós-Graduação em Economia, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Ranganathan, J. (1998), Sustainability rulers: Measuring corporate environmental and social performance. Sustainable Enterprise Perspectives. p1-11. Available from: http://www.wri.org/sites/default/files/pdf/sustainability_rulers.pdf[3].

Regueiro-Ferreira, R.M., García, X.R.D. (2013), The Wind Employment in Spain (1995-2010): A Theoretical Approximation Applied to the Region of Galicia. International Journal of Energy Economics and Policy, 3(1), 75-86.

Rua, M.G., Romanini, R. (2013), Para Aprender Políticas Públicas: Conceitos e Teorias. Available from: https://www.pt.scribd.com/doc/221805146/eBook-para-Aprender-Politicas-Publicas-2013-LIVRO-COMPLETO>.

Secchi, L. (2014), Políticas Públicas: Conceitos, Esquema de Análises, Casos Práticos. São Paulo: Cengage Learning.

Silva, N.F. (2006), Fontes de energia renováveis complementares na expansão do setor elétrico brasileiro: O caso da energia eólica. Dissertação (Mestrado) - Programa de Pós-Graduação em Engenharia, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Simas, M.S. (2012), Energia eólica e desenvolvimento sustentável no Brasil: Estimativa da geração de empregos por meio de uma matriz insumo-produto ampliada. Dissertação (Mestrado) – Programa de Pós-Graduação em Energia, Universidade de São Paulo.

Souza, L.M. (2011), Comentando as classificações de políticas públicas. Cronos. Natal-RN, 11(3), 161-197.

Tahim, E.F. (2008), Inovação e meio ambiente: O desafio dos arranjos produtivos de cultivo de camarão em cativeiro no Estado do Ceará. Tese (Doutorado) – Instituto de Economia, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Teubal, M. (2002), What is the systems perspective to innovation and technology policy (ITP) and how can we apply it to developing and newly industrialized economies? Journal of Evolutionary Economics, 12(1), 233-257.

Vergara, S.C. (1998), Projetos e Relatórios de Pesquisa em Administração. São Paulo: Atlas.

Vergara, S.C. (2012), Métodos de Pesquisa em Administração. Atlas: São Paulo.

Zhou, K.Z., Wu, F. (2010), Technological capability, strategic flexibility, and product innovation. Strategic Management Journal, 31, 547-561.

Zucoloto, G.F. (2009), Desenvolvimento Tecnológico por Origem de Capital no Brasil: P and D, Patentes e Incentivos Públicos. Tese (Doutorado) - Instituto de Economia, Universidade Federal do Rio de Janeiro, Rio de Janeiro.