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Technology Transfer and Capacity Building in the Brazilian Shipbuilding and Offshore Industry

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Abstract

The purpose of this paper is to understand the sources and effectiveness of technological transfer in the shipbuilding and offshore sector in Brazil. Technology transfer can be considered as a dynamic and complex process, that occurs in companies or countries to deal with gaps in development and generation of knowledge or the creation of public policies. To achieve this goal, the successes and failures of these technology transfer mechanisms in the shipbuilding industry will be analyzed, observing the geographical distribution and interaction between specific research centers and the naval sector. The exploratory research is result of a study based on secondary data and interviews with field experts. From the collected data, it was possible to build a relationship between yards and their "technological partners" and examine what regions of the country have largest industrial and scientific capacity to develop the shipbuilding industry, the sector in which they specify, observing the interaction paths with a view to technological and productive development of the sector and their influences on the performance of the yards.

Keywords: Technology Transfer, Shipbuilding, Offshore Industry, Capabilities

Introduction

The need to organize industrial sectors requires the development of different knowledge interfaces, ranging from scientific research to its application into productive activities and sales to the end markets. Firms are clusters of capabilities that interact and transact with others in order to solve specific market problems. In this sense, industrial activity is often triggered by governmental incentives to tackle contextual market opportunities to generate economic growth.

Examples of such type of development are best noticed in East Asian countries such as Japan, South Korea, Singapore and China. However, this is not a simple endeavor. Thus, the emergence of new technologies and new areas of industrial activity depends on the transfer of knowledge through the support of academic research and companies (Kergroach, Meissner & Vornotas, 2017). Successful and lasting economic outcomes will depend on how firms develop their capabilities and manage to become autonomous from governmental dependency.

Good relationships between institutions, organizations and governments are necessary for economic development, particularly in developing countries (Osabutey & Croucher, 2018). This is only achieved if firms can find the right configuration of internal capabilities and learn the path from imitation to innovation (Kim, 1997).

Technology transfer plays an important strategic role in this process to facilitate and speed up learning. Thus, is recognized the importance of technology transfer for growth. Recently, Brazil started to put in place national policies intended to engage firms as well as science & technology institutions (STI) in the task of promoting technological and industrial development in the Shipbuilding and Offshore Sector. According to Alonso, Martins and Alves (2015), companies from emerging economies use technology transfer as an alternative to technological capacity building which can result in innovation processes. Moreover, this sector plays also an important in terms of social policies through generation of jobs and income distribution. However, influenced by a political crisis followed by a slowdown in Brazil's economic growth, the shipbuilding sector has been struggling to gain international competitiveness.

Economic development of a country presupposes the existence of industrial dynamics in different sectors. On the basis of this process is the knowledge and the capabilities found in companies and their ability to match their outcome to a market. The interplay of firms and markets is the engine to innovation, “fundamental phenomenon of economic development” (Schumpeter, 1911).

Schumpeter (1942) related innovation to economic development, appointing as impetus for such, new products, new methods of production or transportation, new markets, new forms of organization and new technologies. The diffusion of these new technologies occurs from firms or public policies and can be approached as technology transfer. The transfer of technology is seen as a way to disseminate innovation, mainly from the production capability of firms.

According to Kastelli, Tsakanikas and Caloghirou (2018), technology transfer is a movement of know-how through different actors and external sources that allow an interaction for the technical and technological training and innovative performance of companies. Technology transfer is the process of transmitting the knowledge, be it technical or empirical, of an individual or organization to another. However, evaluating the technology transfer can be considered a complex task, since it is not possible to limit technology or describe your technology transfer process as there are simultaneous processes (Bozeman, 2000).

Cunningham and O'Reilly (2018) assert that it is evident in the studies of technology transfer a dominant focus of North America as object of analysis. Thus, to understand the issue of technology transfer beyond North America, the purpose of this paper is to **understand the sources and effectiveness of technological transfer in the shipbuilding and offshore sector in Brazil.** Moreover, this sector has gone through an intense effort to acquire and strengthen industrial capabilities within national borders to gain competitivity in the global market.

To accomplish this aim, we conducted an exploratory study where evidences of two empirical analyses were collected. Thus, this paper is organized as follows. First we discuss the literature on Innovation and Technology Transfer. Second, we present the research procedures of this study, followed by the discussion and conclusion.

Innovation and Technology Transfer

The quest for knowledge and technology generation is constant and essential to ensure the competitiveness in today's world. Dosi (1982) says that technology is a new combination of factors that, adding to the scientific and technological knowledge, can be considered the mechanism that firms need to keep themselves active in the market. The generation of technology involves the acquisition of qualified knowledge and efficient infrastructure for research and technological development. In developing countries, for example, the use of imported technologies is the guarantee of new knowledge, being able to meet the needs of the innovation process.

For innovation is meant "the fundamental phenomenon of economic development". With innovation being a new combination of factors (Schumpeter, 1942) and also a conditioning mode for economic development, so that, in fact, exists innovation, there must be an economic gain by applying this innovation to market (Zawislak et al., 2008). In addition, knowledge created in generating an innovation arises from research, learning and creativity.

The relationship between development and technology lays an important role for innovation of firms and economic gain. To generate new products, new processes and, with that, new technologies, is part of a dynamic chain that also influences the transfer and adoption of technologies (Gastal, 1989). Corroborating this information, Teece (1977) states that economic growth of a nation from innovation is directly linked to technology transfer mechanisms. Thus, the transfer of technology appears as an effective way of spreading innovation, highlighting the ability to produce a product or process.

There are different ways to define technology transfer, according to the research or for the purpose of investigation (Zhao & Reisman, 1992; Bozeman, 2000). For authors like Szulanski (2000) and Kundu et al (2015), the terms "technology transfer" and "knowledge transfer" may be used interchangeably, since technology is the use of knowledge and information. Roessner (2000) states that technology transfer is the movement of know-how, technical knowledge, or technology from one organizational setting to another. Still, specifically dealing with the broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies (Hedger et al., 2000).

Thus, the transfer of technology can be understood as an exchange ratio between two economic agents. On one hand is the developer agent, who has the technology, holds the knowledge about their routines and processes. On the other hand, is the receiving agent, which own or not the necessary capabilities to produce the technology, being company or country. In this sense, Chais, Ganzer and Olea (2018, p.21) claim that "technology transfer can be explained as a process in which all parties involved share information, knowledge, costs and benefits".

To Caldera and Debande (2010), technology transfer is considered a competitive strategy from the growth of technologies from external partners. In other words, technology transfer is the process of "giving" the knowledge, be it technical or empirical, of an individual or organization to another. This process can only be copied and applied or can be adapted and incremented as the needs of the receiver agent of the technology. However, one must understand that this type of process involves more than just the transfer of hardware components. It is the inclusion of elements that ensure the use, replication, adaptation and improvement of technology to the final environment (Pueyo, 2013). China, for example, encourages the auto industry to acquire new technologies from developed countries.

Technology transfer is a dynamic (Kundu et al. 2015) and complex process, that occurs in companies or countries in an attempt to deal with gaps in development and generation of knowledge or the creation of public policies. Besides that, technology transfer requires significant resources, and involves high levels of uncertainty and risk (Bradley, Hayter & Link, 2013).

So, for the occurrence of transfer of technology is necessary skilled manpower available and that presents technical competence compatible with the technology to be absorbed (Guimarães, 2000). In general, the receiver technology agent, in the means that absorbs knowledge, creates conditions to adapt the acquired technology to local conditions. Thus, it can adapt it or improve it and, finally, innovate it. In other words, is the emergence of technological innovation.

Given the definition of technology transfer, it is necessary to understand how this process actually occurs. Thus, the process generated to reach the transfer of technology (or knowledge) between companies or countries is presented in the literature by different qualitative or quantitative models (Bozeman, 2000; Kundu et al, 2015). However, for Kundu et al (2015) the literature shows a lack of an integrated model that represents the goals of firms, considering the barriers throughout the technology transfer process. Most of these barriers are related to economic issues, such as the cost of the transfer of a technology. Teece (1977) states that this cost is the cost of transmitting knowledge for further absorption of the relevant information. Still, legal, cultural and behavioral issues that influence the process as a whole should also be seen as barriers to transit technology.

Evaluating the technology transfer models in the literature is highlighted the model of developmental stages presented by Szulanski (1996; 2000) as the most widespread model among researchers. According to Szulanski (1996; 2000) four different stages are needed so that the transfer of technology occurs: the initiation, implementation, ramp-up and integration.

i) Initiation: this stage comprises all moments prior to the transfer decision. It is the moment where the knowledge and the need for this knowledge coexists.
ii) Implementation: this stage occurs when resources flow between the receiving agent and the source of knowledge.
iii) Ramp-up: the ramp-up begins when the technology receiving agent starts using the knowledge transferred. At that moment, the receiver uses the knowledge generated inefficiently, but improves its performance gradually.
iv) Integration: this stage occurs when the agent receiver of technology reaches performance levels satisfactory to the knowledge transferred. Gradually the knowledge generated becomes a routine part of the firm or country.

The four stages described by Szulanski (1996; 2000) occur with different agents, being the stage of initiation and implementation a joint force of the developer agent and the receiving agent. At the end of the process, the transfer of technology, expressed by the letter "K", will be complete. However, in front to the transfer process it is necessary to point out that throughout the process many strategic information are transferred and attached. Thus, the methodology used during this process will be the mechanism capable to ensure the complete transmission of knowledge among stakeholders. This process ensures the reduction of the costs of research, development and application of a technology (Teece, 1977).

Knowing how the technology transfer process occurs, it can be determined the types of technology transfer existing. Urban et. al (2015) believes that there are two different types of technology transfer. On one side, a flow of equipment as well as know-how and experience for operating, managing and maintaining the equipment from one firm or country to another, on the other side, a flow of technology- and business-related information from one firm or country to another such as through joint ventures and other forms of technology cooperation. Both usually requires the passing on of hardware and/or skills and experience to the recipient firm or country.

Thus, it is considered that the technology transfer is the transfer of knowledge developed into products, processes and qualified services. Also, it is a necessary tool to explain the innovation initiatives in different industrial sectors, enabling the concept of a technological innovation.

Capability Building and Tech-Transfer in Shipbuilding Worldwide

Shipbuilding is a dynamic industry that follows world's economic cycles (Pires et al, 2007). It can be considered a complex product system (CoPS), that is, “high cost, engineering-intensive products, systems, networks and constructs that involve a number of customized components” (Hobday, 1998). This re-emerging sector can be thought of as a practical experiment on industrial organization dynamics. Expanding economic cycles drive increasing international commerce, which in turn create demands for more maritime transportation. According to Pires et al (2007), the productions cycles can be explained in four different periods.

i) From 1960 to 1975, the world’s production of ships increased due to the growth of developed economies, easiness of financing and a boom demand for Oil Tankers.
ii) From 1975 to 1980, oil crisis led to a chain effect and overall collapse of merchant ships and tankers. The sudden collapse resulted in a rapid drop of prices due to an over-capacity built in previous years. This led to a regime of subsidies, rationalization and supply control.
iii) From 1980 to 1990, the second oil crisis in 1979 and the World’s economic recession in the beginning of the 80s kept production low hitting the lowest level in 1988. Several shipyards in Japan and Europe (the biggest producers at the time) were shut down due to the crisis.

iv) From 1990 up to date, the shipbuilding industry moved to the east as South Korea and China entered and alongside Japan are now responsible for 2/3 of the words book-orders.

According to Pires (2007), these three countries along with other shipbuilders from Asian are responsible for 85% of the world's production of merchant ships. This production is based on developing technologies, labor qualification and tax incentives. Thus, the Global Competitiveness Report (2014) argues that the factors able to leverage the competitiveness are: education and training, technology and innovation.

Technology is not the sole determinant of industrial competitiveness. Institutional (macro) and market factors impacted the entry level of countries into the global arena (Mickeviciene, 2011). A common feature of the leading nations is the strong governmental support of local industrial firms to initiate and expand operations. Market reserves, subsidies as well as strong national goals fostered and directed the efforts of building capabilities and establishing the necessary technological interfaces of the industry. However, the ability of nations to gain the leading position has much to do with the ability to learn and develop technological capabilities to both produce and innovate. As newcomer nations find ways to both master different technological interfaces they were able to exploit market opportunities combined with exploring new technological endeavors. This is the main factor creating their leadership position.

Table 1 shows the development of the shipbuilding and offshore industry around the world, showing the main necessary requirements observed in all recent cases of the leading industries. Parallels between the types of firms, government and technology transfer process can be drawn. Thus, it can be noted that firms comprising that sector in different countries are national, which shows the government encouragement to this development.

Table 1 - Development of shipbuilding and offshore industry worldwide

Source: Adapted from Alves (2015)

	Shipbuilding					Offshore	
	Great Britain	**United States**	**Japan**	**South Korea**	**China**	**Norway**	**Singapore**
Entry	1843	1905	1871	1960	1980	1970	1990
Leadership period	1860 -1950	1941-1945 "economic miracle"	1950-1990 "golden age" after WWII	1990 - 2010	2010 - Today	1980-2000 "70s oil crisis"	2000 - today
Government	-	Intervention WWII	Intervention Revitalization programs	Intervention Nationalization	Intervention Opening + currency depreciation	Intervention NORSOK program: incentives to increase participation in R&D	Intervention
Firms	NATIONALS Industrial Revolution	NATIONALS Great entrepreneurs Henry Kaiser	NATIONALS With tradition	NATIONALS With little tradition in the sector "Chaebols" Fast absorption	NATIONALS With little tradition in the sector Various	NATIONALS Statoil, NPD. Aler and Kvaerner	NATIONALS From the port to the manufacture of offshore vessels
Technology Transfer	-	-	Technology transfer with USA	With Japan, MAN B&W, HDW (Germany), Sulzer (Switzerland) Appledore, Scott Lithgow (Great Britain)	Joint-Ventures (up to 49%), MAN B&W, Wärtsilä, Shipyards of Singapore, Japan and South Korea	International companies of oil Good Will Agreements	Intense programs of technology transfer Agreements with Norway
Technology & Innovation	Introduction of shipbuilding architecture Construction in steel	Standards Technology mastered Construction in scale Prefabrication Weld	Innovation of process Modular construction Automation Weld improvement Advanced finishing Lotus System Gas-cutting machine	Strong adoption of computer systems in the 70s Technology of Membrane ship for transport of LNG gas (higher capacity)	Cost leadership	Condeeps Drilling technology Specialized vessels Organizations by clusters	Condeeps Drilling technology Specialized vessels Organizations by clusters
Decay	Failure to modernize industry Syndication Competition	Demobilization after the war	Aging and rising costs with labor Increase of prices	Rising costs with labor Appreciation of the Korean currency	Dispute of the lead with South Korea	Expertise in several offshore technologies Enhancement of hand labor	Current leader of the offshore segment

Research Design and Method

The aim of this research is **to understand the sources and effectiveness of technological transfer in the shipbuilding and offshore sector in Brazil.** To accomplish this aim, we conducted an exploratory study where evidences of two empirical analyses were collected. According to Yin (2015), a case study research can become reliable from the analysis of more than one case. In this sense, the two companies represent two major processes of technology transfer in the Brazilian Shipbuilding and Offshore Industry. Firm A is responsible for the transfer of technology between firms, whereas, Firm B is responsible for technology transfer of a foreign firm to the labor of a Brazilian firm.

The Brazilian Shipbuilding and Offshore Industry comprises the industrial activity developed for the manufacture of equipment and vessels for navigation, especially medium and large shipyards. According to Jesus (2013), is an industry manufacturer of complex products, considering high investments, long production time, low annual production volume and, especially, its dependence of production by order. These characteristics are typical of industries dependent of generation or technology transfer.

Data collection and analysis

In a first stage, we collected information from secondary sources (public information, internet, firm's websites and open documents, annual reports, and so on). To further complement our analysis, we analyzed several public available documents, such as scientific papers, websites and government reports. From this information it was possible to trace patterns and create maps that facilitated the understanding of the explored environment.

In this sense, the investigation on the research groups was performed by means of data collection at the database at CNPq's (National Counsel of Technological and Scientific Development) website, which has a registration of all the groups in the country. Also, to understand the shipbuilding industry, data collection was made in the ship parts register found at ONIP's (National Oil Industry Organization) website.

In a second step, to complement the surveyed data, interviews (Appendix A)were conducted in depth with employees from two of the representatives companies of Brazilian shipbuilding and offshore industry. That way, the successes and failures of the technology transfer in different yards operating in the country were analyzed critically.

Companies interviewed

Two companies of naval and offshore production were analyzed. Both companies are shipyards working for public concession. The first firm contacted was Firm A. The Firm B was created in 2010 and hired by the E&P company through public auction for building eight bottom hulls for offshore platforms extraction in deep waters. The main components produced by Firm B are hulls, modules and drill ships.

The other firm studied in this paper was Firm B. The Firm B operates in southeastern Brazil since 1999. It is a subsidiary of an international company, specialized in repair and construction of ships, oil platforms and drilling to offshore industry, being responsible for over than 40% of Brazilian oil production platforms.

Results

The analyzed data were explored according to the literature review on technology transfer. First, the secondary data collected will be analyzed and, then, the two companies explored will be analyzed. Each company will have its specificities discussed, as well as their relations presented.

Shipyards and Research Groups

From the database of the National Union of the Industry of Naval and Offshore Construction and Repair (SINAVAL) it was possible to map the main naval and offshore construction sites that are operating in the country. 42 shipyards were identified scattered throughout Brazil (Figure 1). After that, since the shipyards that compose the Brazilian shipbuilding and offshore industry were identified, it was sought, by CNPq's database, to map the existing research groups in Brazilian Universities. It was identified 323 research groups whose work is related to Brazilian shipbuilding and offshore industry, direct or indirectly, according to their field of study (marine and ocean engineering, social sciences, oceanography, geosciences and chemistry) registered at CNPq's database. (Figure 1). From this mapping, it was possible to indicate on the national map the location of these shipyards and groups in order to facilitate understanding.

By analyzing the main national shipyards, it was realized that the greatest number of yards of shipbuilding at Brazil are found concentrated in the Southeast. Specifically in the state of Rio de Janeiro are found twenty shipyards, that is, nearly half of the total number of the country shipyards. Still, stands out the states of São Paulo, Santa Catarina and Rio Grande do Sul, creating the most significant areas of the named Brazilian shipbuilding and offshore industry.

In analyzing the research groups who study the Brazilian shipbuilding and offshore industry it was possible to perceive the concentration of these research groups mainly in the Southeast region of Brazil, totaling 145 research institutions, almost half of the total overall. Moreover, it is noted that the location of the main groups coincides with the local places where the Brazilian shipbuilding and offshore industry is further developed or has more concentration of shipyards, setting, as well, one of the necessary features for the establishment of interfaces that contribute to the development of innovation capabilities and knowledge transfer: the interaction between universities and companies. Stands out the University of Rio de Janeiro (UFRJ), for being the one with the largest number of research groups (14), being followed by University of São Paulo (USP) and State University of Campinas (UNICAMP), respectively with 12 and 7 groups (Figure 2).

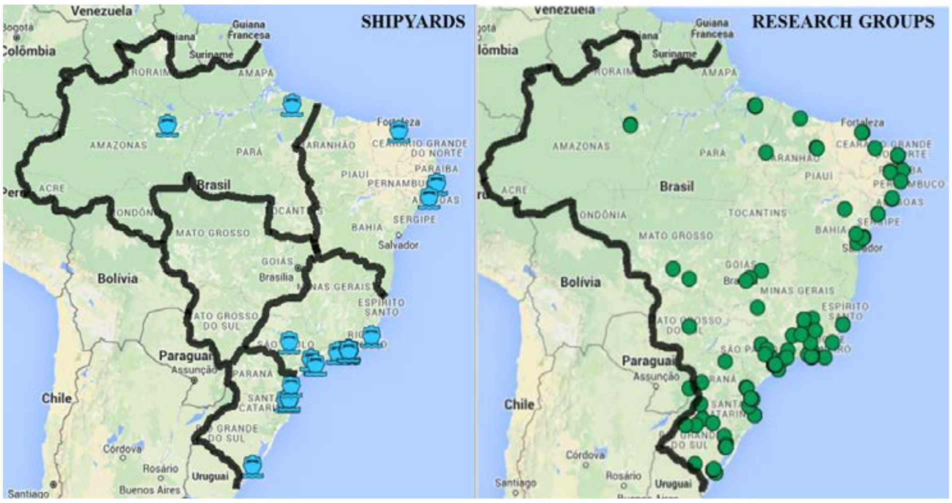

Figure 1 – Main shipyards and active research groups at Brazilian shipbuilding and offshore industry

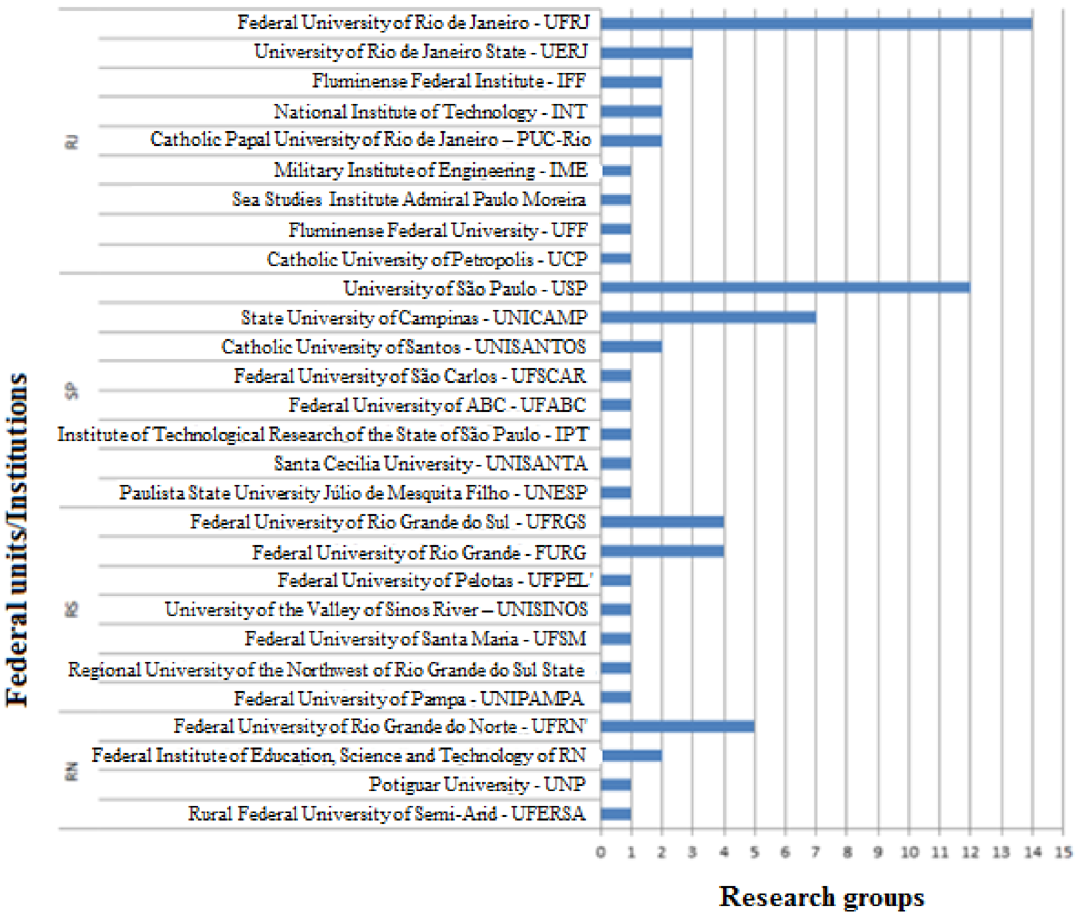

Figure 2 – Institution of the research groups of the main states that interact directly with the Brazilian shipbuilding and offshore industry

Source: Adapted from CNPq's database (2014)

In the north of the country, under developed in this sector, there is the presence of two major shipyards, one in the State of Amazonas, with a production capacity of about eight thousand tons of steel per year, and another in the State of Pará, the largest and most modern in the region. The North has fourteen research groups, eight of them located in the State of Pará, which has no shipyard, and six located in the State of Amazonas. The location of the shipyards coincides with the ones of the research groups but, little significant in the industrial field, the region has one supplier of goods and three service companies.

The Northeast is in more of a structured way, having three shipyards and one under construction; shipyards specialized in the construction of patrol vessels and offshore vessels. In the region there are 83 research groups, with 22 of them being located in the state of Bahia and 17 in the state of Rio Grande do Norte. In contrast, as the least developed region of the sector, the Midwest does not have shipyards, given the unfavorable geographical position. Interestingly, the region has fourteen research groups that engage directly or indirectly with the naval hub, located mainly in the Brazilian capital.

The Southeast region of the country is nationally the most developed of the sector, totaling twenty-seven yards; among them, the top five in the country specialized in the construction of modules and integration. Furthermore, it involves one of the main cases of technology transfer in the sector. In accordance with the location of the yards, the region is also the location of the largest number of research groups involved in the Brazilian shipbuilding and offshore industry, totaling 145 groups. Still, the south of the country has certain expressiveness, with eight shipyards, two of them among the country's majors. In the region there are 74 research groups, mainly in the state of Rio Grande do Sul, specializing mostly in the field of Engineering.

The development of knowledge interfaces applied in industrial sectors requires a balance between science and technology institutions and industry. In the case of the Brazilian shipbuilding industry, the location of the research groups that relate to the naval sector coincides with the main places of focus of this industry and the country's largest shipyards (especially in the Southeast), which sets up this region as the more balanced.

Technology Transfer

In domestic shipyards the technology to be used in the construction of platforms is imported. This occurs not just as an option, but due to the technological requirement necessary in modules and systems that the country does not have available still. Not being possible the development of a technology itself by domestic shipyards, it becomes feasible to create technological relations with other companies. This association permits a productivity gain that translates the incorporation of a technological domain.

To facilitate the understanding, two industrial companies that use the technology transfer process will be presented. It is necessary to mention that, in the shipyards where the company is a subsidiary of foreign firms, the selection process of technological interfaces to be developed in the country respects a coherent technical and economic logic, which takes into account local potential. The participation of foreign firms in its Brazilian subsidiaries is full, working in engineering, production and management as a way to incorporate their technologies in the routines of the companies.

Firm A

The main activity developed by Firm A is to produces the platform’s hull. Firm A was created by and engineering company to compete in the Brazilian E&P Company’s bids for construction of ship hulls for oil extraction. When the interview was taken, Firm B was working with the construction of seven ship hulls. This service is carried out by reproduction, that is, for instance, all the ship hulls must follow the same technical design. The main competitive advantage of the company according to the interviewee is the manpower (technical resources, thus called individual competencies).

The employees' knowledge comes mostly from the remaining companies of the 80’s (first development of the Brazilian naval industry). The coordinator of maintenance engineer said: “the company sought for new employees in the old industries back from the 80s”. But as this decision was not sufficient to meet the needs of the firm, they developed training centers to overcome the training needs of the employees.

The domestic shipbuilding offers direct competitors in the firm level; however, this is not seen as a threat, since management considers its resources able to compete in this market. Moreover, the demand for this type of activity is large, which distributes the service offering. The company believes that there is no innovation in activities; as follows a pattern established by the contracting company.

In the search for better economic and administrative results, Firm A partnered with a Japanese industrial company. The Japanese group had 30% of the yard's shares (US $ 305 million) and performed transfer of technological knowledge, skilled personnel and increase of capital, resulting in significant efficiency and production strategy gains.

Currently the firm has a contract with Sete Brazil for construction of five FPSO hull production platforms (one of which was delivered and the other three will be built in China and two drilling rigs. However, there are uncertainties in the fulfillment of the construction contract of the production platforms of FPSO hulls, as the international partner company formally announced, in early 2016, the end of its partnership with Firm A. The investment is considered as a loss by the Japanese. The delay of Sete Brazil with the shipyard reaches US$ 45 million, and is estimated to reach US$ 250 million. However, a new international partner company has outlined the interest in being a partner in the yard.

Firm B

With the advance of oil exploration in the pre-salt layer, the investment expectations in the naval infrastructure require the creation of an appropriate shipyard to meet the demands of this industry, which requires high technology and quality products for the accomplishment of bold projects. Prominently in the state of Espírito Santo, the Firm B shipyard has partnered with the international partner company, performing a type of unprecedented business mode in the State. It is noteworthy that this are not different companies, but the international partner company is also the parent company of Firm B, having the entire capital of the subsidiary. The technology partner is a publicly traded company, with about one third of the shares belonging to the government of its country, having five high-tech shipyards, whose construction was based on the use of the most modern concepts of naval structures.

The structure offered by the shipyard are prepared to meet not only the demands of Petrobras, but the demands of the world market, in the manufacture of boats and jackets (basic structures of oil platforms), generating business for local suppliers, jobs and income for local workers and foreign exchange for the state of Espírito Santo.

The process of knowledge and technology transfer is carried out through programs that promote the sending of Brazilian workers, hired as trainees, to qualification courses and training in Singapore, which returns already taking functions in the yard, transferring in practice the view of management and production of the parent company.

The Firm B agreed with Sete Brazil the contract of seven drilling rigs, two of which are funded directly by the international shareholder. In addition, there is a FPSO for Libra, in the pre-salt Basin of Santos (at the state of São Paulo, being built directly at the headquarters of the international partner company. The firm operates in Brazil for about 14 years and is responsible for over 50% of Brazilian oil production platforms, among them the P50 (the Brazilian framework of sustainable self sufficiency in oil production). In the current environment, the Firm B is considered one of the few success cases of the Brazilian shipbuilding and offshore industry, which was not severely affected by the crisis of Petrobras and Sete Brazil. The yard was also the one that paid most of the contracted amount by Sete Brazil for the construction of the probes, as there is a more acceptable relationship between the physical progress of the construction and the financial schedule compared with the other shipyards, keeping its productivity.

Discussion and Conclusion

The purpose of this research was to understand the sources and effectiveness of technological transfer in the shipbuilding and offshore sector in Brazil. Based on authors such as Teece (1977), Gastal (1989), Zhao & Reisman (1992), Bozeman (2000), Szulanski (2000), Roessner (2000), Caldera & Debande (2010) e Kundu et al. (2015), two empirical analyses were performed to find how these firms organized their technologies, considering the fact that they are part of an emerging industry in Brazil.

From the analysis of the secondary data, a considerable volume of research groups is found, seeking the development of this industry. According to Chais, Ganzer and Olea (2018), the university has an important role in promoting the culture of innovation, creating internal policies in innovation and mapping transfer processes. The institutionalization of the processes of technology transfer in the university context, especially in the Brazilian case, allowed the existence of different organizational components dedicated to supporting and stimulating this process (Good, Knockaert, Soppe and Wright, 2018).

Through the analysis of the two explored companies, it was possible to draw a comparative analysis of the supply chain and labor of Firm A and Firm B. In the case of A, there is a suppliers chain tendentiously coming from abroad, with 91 companies inside the shipyard, less distributed than the shipyard B and counting with many American suppliers. The shipyard does not manufacture any type of specific equipment, nor materials, which come from suppliers firms (nine countries involved in supplying special materials, equipment or know-how). Brazil lacks a supplier base, causing them to stick with the few big companies there are around. For the construction of vessels, is observed only the purchase of major equipment, but the project is not yet complete and detailed, as a result of the lack of sufficient supplier, lack of key suppliers nearby and lack of an industrial ecosystem of key materials and suppliers. The shipyard has capability to mobilize large contingents or resources like labor and materials, counting with 6.973 employees (October 2015). They use subcontracts for labor to increase capacity. The main challenge for foreign suppliers is the adaptation to local content[1] rules for the supply to the Brazilian market for oil and gas.

It can be noted that the B firm has a chain of suppliers well distributed, allowing the acquisition of the main equipment, resulting that the building design of the probes is 99% complete and detailed. The largest part of the installation is hired from suppliers out of Brazil, with only one Brazilian supplier, proving the lack of capability from Brazilian suppliers to be competitive with the external suppliers. The shipyard counts with approximately 2.000 employees (January 2016), aiming to achieve 5.500 employees. The main challenge considered by the firm B is to develop a strong supply chain and qualify the local workforce

According to the interviews, it was possible to notice a big difference in the **technology transfer** process of the two shipyards studied. In the shipyard of Firm A, the process of transfer of know-how in engineering starts at the detailing engineering and shop drawings, which are more directly related to the concrete construction at the shop floor. The technological partner added a number of advisers (12 of the engineers come from the country of the partner) in the process in order to slowly transfer organizational and technological know-how to give internal coherence to internal and external managerial and technological interfaces firm. There are not enough specialized engineering firms with the necessary capabilities and experience in the type of project that the shipyard needs, as said by the interviewed, “there are many people doing but few people really know”. The engineering teams with the right tools and skills are insufficient, such as specific technical capabilities to deliver what is required, causing low labor productivity, delays and re-work.

On the other hand, the shipyard of the Firm B performs a large project with its technological partner, in which 110 employees are sent to Singapore to be trained and transfer the know-how, aiming to transfer the knowledge in about 10 years, and then directly transfer in Brazil. US$ 4 million was invested for training - equivalent to a postgraduate course - in marine and ocean technology at an esteemed institution of higher learning of Singapore, divided into three courses: the naval expert program for Brazilian students, the immersion program for Singapore students and the “Train the trainer” program, which is a multipliers training program for Brazilian professors. For one year, students go through training in the shipyard of Firm B and can act as multipliers at returning to Brazil. The company also promotes other vocational training courses. In two years, 1,945 people from the community have been trained, with investment of US$ 480 thousand. One of the main differentials of the shipyard performance is the high technology, the facilities and the use of similar resources to the shipyard of the country of the technology partner.

In relation to **production costs**, it is known that 40% of the budget of the shipyard A goes to procurement of items and services from suppliers. The difficulty in competing in economic terms is very severe, which makes the costs of producing anything in Brazil less attractive than imports. The comparative costs are influenced by externalities beyond the capabilities of firms, such as logistics and national infrastructure. There’s lack of operational and organizational capabilities, which have been increasing the overall cost of the projects. Similarly, the Firm B answered that “Brazil has the highest tax burden in the world. It becomes very difficult to compete with the international manufacturer”. A lot of services are brought from Korea, as a result of the lack of technological sophistication from Brazilians companies. The sector has direct dependence on the public authorities, since any change in import policy affects the whole system. Fortunately, the rise in the dollar price made the investments cost less, being more attractive, but still insufficient to be competitive.

Furthermore, the Firm A presents challenges to the capability building process from engineering, construction and labor skills in. The engineering capabilities were bounded in almost all levels and the construction capabilities are not fully ready. 30% of the company and the overall control of the construction process were handed over to the partner to initiate technological transfer. The Firm A aims to obtain the knowledge to one day be able to design a Basic Project, but engineering and construction capabilities are limited in Brazil, with only a few firms specialized in it. There’s also need to outsource industrial services, because specific facilities are required that the firm do not have (like galvanization). At the shipyard of the Firm B, implantation and construction are done at the same time, obtaining gains of productivity. The shipyard of the Firm A has the steel processing capacity of 1.5 thousand tons/month; on the other hand, the shipyard of the Firm B has the capacity to process up to 4000 tons of steel per month.

Table 2 – Features predominance in each interviewed firm

	FIRM A	**FIRM B**
Origin of Capital	Singaporean Firm	Brazilian Firm + International Technological Partner
Mechanisms for Knowledge and Technology Transfer	- Trade. 110 employees are sent to Singapore to be trained. - Training of people, not of other companies.	- Japanese team following each process, with routine meetings. All levels are learning. - From Engineering, management and production.
Issues	- Changes in the administrative body of the firm due to corruption; - Layoffs	- Issues in creating trust between partners.
Results	- Productivity of 1.5 thousand tons of steel per month maintained - One of the few shipyards that is still building the vessels contracted by Sete Brasil.	- Productivity decreased from 3600 tons of processed steel per month in October of 2014 to 3014 tons per month in October 2015 (reduction of 25.6%) - End of its partnership with Firm A Highly costly process.

However, several challenges are impeding the path for capability building which is undermining the continuation of this industry. Considered as a policy of job creation, the reformulation of the shipbuilding industry has neglected industrial policies needed to maintain productivity levels and investments that guarantee their full development. Among the main challenges faced by the shipping industry stand out the petroleum price devaluation due to the growth of world output, the Brazilian economic crisis and corruption, where money laundering charges and tax evasion involves political and national marine sector entrepreneurs.

Thus, faced with these problems, a complex chain is re-emerging, that requires mechanisms for building technological and productive capacities through knowledge transfer. This research suggests that the location of the research groups that relate to the naval sector coincides with the main focus points of the shipbuilding industry and, together, with the country's largest shipyards. There is a strong capacity in research groups in universities for the scientific development of Brazilian shipbuilding and offshore industry, and such groups are established in areas close to shipyards and industry, with each region having a specialized profile in different production fields.

Furthermore, it was possible to build a relationship between shipyards and their technology partners, observing the interaction paths with a view to technological and productive development of the sector and its influence on the performance of the shipyards. With the analysis of the data collected, it was identified two possible paths for this type of industry where it can achieve development: a first case, where technology transfer occurs between domestic company and international partner (Firm A), and the second case, where it qualifies national companies (local workers) from the knowledge of an international company (Firm B).

Two analysis models can be discussed: the short and long term. In the short term, the Firm A is seen as a construction site where the "knowledge holders", that is, the international partner company, is who determines how to operate and develop. To Firm B comes the need for labor exchange, as the transfer of knowledge will be among people and not companies.

In the long run, when analyzing the Firm A can be imagined that this industry will ensure the establishment of domestic enterprises and the development of regions, because the development generated and knowledge created will remain in Brazil. However, the deficiency of domestic enterprises to absorb technology does not allow this to happen. As seen in the description of the firm A, even the management and engineering activities are developing capabilities previously considered ineffective for the development of an industry.

In the Firm B, it can be noted that the knowledge generated and the capabilities created yet remain in international company. The international company is the one who has the power to decide what to pass or not for Brazilian companies, thus, they become dependent on their capabilities, where the tendency is that only the lower-value capabilities are to be transferred to, that is, the operational capabilities. Thereby, in the long term it can be understood that for Firm A there is a generation of knowledge, where development capabilities are created and improved, while, to Firm B, only the operational activities are passed.

That way, institutional partnerships should develop and propose public policies of competitiveness that promote the development of the national shipbuilding industry. The success can come from two alternatives:

i) Construction of basic capabilities to coordinate engineering and production until the capacity development are enhanced and reach levels of competitiveness, or;
ii) Prospect the major players in international shipbuilding to install and operate in the national territory in order to train the local workforce.

Finally, we highlight the limits of this study. It was held at a single moment through interviews. Besides the lack of generalizability capacity, it would be best to analyze this process in different periods of time to see the shifts or changes in technology transfer configurations. Future research is highly encouraged, especially studying the institutional arrangements that allow the transfer of knowledge and the development of the industry.

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Appendix A

Protocol questions:

1. A brief history of the shipyard:

2. Where the firm's knowledge came from?

3. How many employees?

4. What is the steel processing capacity of the shipyard?
5. What are your main activities and projects at the moment?
6. What are the main goals of the shipyard at the moment?
7. What is the strategy to achieve these goals?
8. How does the firm developed the knowledge and techniques to do what it does?
9. How does the knowledge transfer process works with the firms involved in the process? Has it increased the productivity of the shipyard?
10. How could you describe the main competitive advantage of the shipyard?
11. How is the relationship with the chain of suppliers?
12. How could you describe the technology involved in engineering and operations?
13. How could you describe the sophistication involved in design and production?
14. How could you describe the competitiveness in the Brazilian shipbuilding and offshore industry?
15. How could you describe the innovation capability of the shipyard? Is there development of new processes and product-related technology?

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