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**INNOVATIONS IN THE BRAZILIAN OFFSHORE SUPPORT VESSEL CHAIN:
A CONTENT ANALYSIS APPROACH**

**INOVAÇÕES NA CADEIA DE APOIO MARÍTIMO BRASILEIRA: UMA
ABORDAGEM POR ANÁLISE DE CONTEÚDO**

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ABSTRACT

This work discusses innovation in a traditional oil chain industry in Brazil, the offshore support vessel. To sustainably increase production, innovation is a mandatory strategy. This paper approaches the Brazilian offshore support vessel industry from an innovation perspective by a content analysis method and thus provides several contributions from both

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academic and managerial perspectives. From academic standpoint, there are several unanswered questions and vast research opportunities, such as improvements in academic-firm relationships to enhance knowledge sharing and contributions to the literature. From a managerial perspective, this study reflects on maturity level of companies' innovation and the needs of developing explicit strategies to achieve better innovation results.

Keywords: Innovation; Maritime support vessels; Offshore supply chain; Oil and gas; Supply networks.

RESUMO

Este trabalho discute a inovação em uma indústria tradicional da cadeia de petróleo no Brasil: o segmento de apoio marítimo. Para aumentar de forma sustentável a produção, a inovação é uma estratégia obrigatória. Este trabalho aborda a indústria brasileira de embarcações de apoio *offshore* a partir de uma perspectiva de inovação através de um método de análise de conteúdo e, assim, fornece várias contribuições tanto da perspectiva acadêmica quanto gerencial. Do ponto de vista acadêmico, existem várias perguntas não respondidas e vastas oportunidades de pesquisa, como aperfeiçoamento nas relações acadêmico-corporativas a fim de melhorar o compartilhamento de conhecimento e contribuições para a literatura. De uma perspectiva gerencial, este estudo reflete sobre os níveis de maturidade de inovação das empresas e a necessidade de desenvolver estratégias explícitas para alcançar melhores resultados de inovação.

Palavras-chave: Inovação; Navios de apoio marítimo; Cadeia de suprimentos; Offshore; Óleo e gás; Redes de suprimentos.

1. INTRODUCTION

This work discusses innovation in maritime support activities in the Brazilian offshore oil and gas industry. Offshore oil exploration and production, known as offshore exploration, requires many maritime support activities, and it is necessary to analyse several types of vessels and support services. For support activities to be performed in the best possible manner, it is necessary to have an optimised plan for employing resources (QUEIROZ; MENDES, 2012). In addition, the companies involved in this market make different decisions every day at various levels of complexity, trying to optimise their operations and return on capital.

The Brazilian National Petroleum Agency (AGÊNCIA NACIONAL DO PETRÓLEO – ANP, 2016) highlights the Brazilian oil production in 2015, when the offshore modality comprised 93.4% of the total oil produced. The average of barrels processed per day was 2.4 million, totalling 889.7 million barrels. The oil reserve/production (R/P) ratio decreased from 19.6 years in 2014 to 14.6 years in 2015, owing to a decrease in proven reserves. The most productive company was Petrobras, accounting for 83.5% of total oil and natural gas production. Brazil ranked 12th in the world ranking of oil producers. To achieve these production levels, it is necessary a set of vessels to perform a large number of tasks.

The four main types (according to fleet size in 2016) of support vessels in the Brazilian offshore oil industry are the following:

1. Anchor Handling Tug Supply (AHTS) – acts as a tugboat for anchor handling and transportation of supplies such as pipes, fresh water, oil, mud, brine, cement, and parts.
2. Platform Supply Vessel (PSV) – used as an oil platforms support and also for transporting cement, tubes, mud, brine, fresh water, oil, bulk, etc.
3. Line Handling (LH) – a type of vessel used to mooring rope activities.
4. Oil Spill Recovery Vessel (OSRV) – used for combating oil spills.

The logistics flow of exploration and production in oil and gas offshore industry is known as upstream or upstream logistics and involves a set of companies in supporting oil production at offshore platforms (CUESTA et al., 2017). The logistics activities that connect oil and gas to the end customers are called downstream logistics (AAS et al., 2007). The vessels involved in supporting platform installations require large investments



and consequently represent high costs in upstream chain (AAS; HALSKAU-SR; WALLACE, 2009). Support vessels that provide logistical support can be called offshore service vessels, maritime support vessels, offshore support vessels and offshore support and supply (BORCH; BATALDEN, 2014). In this business the usage of these terms are interchangeable. Due to the need for large investments and costs, innovation should be a driver for these companies. The remainder of this paper is structured as follows: literature review will be presented in the next section followed by the method utilised and its results, and finally closing with discussion and conclusions.

2. LITERATURE REVIEW

2.1. INNOVATION IN OFFSHORE VESSEL INDUSTRY

There are few papers about innovation in the support vessels industry (JENSSEN; RANDØY, 2002, 2006; AAS; HALSKAU-SR; WALLACE, 2009; BORCH; BATALDEN, 2014). Oil companies do not consider logistical activities as core activities; consequently, the relevant literature is very limited (AAS; HALSKAU-SR; WALLACE, 2009). Identification of the factors that promote innovation could be critical for supporting vessel companies, but there is pressure to optimize their costs.

In the Brazilian context, innovation has received attention; however, we have to improve our position in international rankings regarding to innovation. The World Economic Forum's Global Competitiveness Report 2016–2017 rated Brazil 100th out of 138 countries in their innovation ranking. Some of the most problematic factors include an inadequately educated workforce, insufficient capacity to innovate, inefficient government bureaucracy, restrictive labour regulations, and limited access to financing (WORLD ECONOMIC FORUM, 2016). In order to generate innovation in maritime context, one important step is to develop explicit strategies to promote innovation (JENSSEN; RANDØY, 2002). In the Brazilian support vessel industry, this situation should be improved.

To maintain continuous production in an oil platform installation, several types of vessels are required. Most services provided by maritime logistics are developed in complex environments (BORCH; BATALDEN, 2014), which means that there is a high degree of

volatility and complexity. The combination of these variables presents a challenge not only to support vessel players but also the entire supply chain (BORCH; BATALDEN, 2014). The challenges can be mitigated via innovation strategies. A study about the factors that promote innovation in shipping companies (JENSSEN; RANDØY, 2002) discussed product/service innovation, market innovation, and process innovation variables. Their main discovery is that new services/products and new markets influence innovation more strongly than the others. Moreover, measuring the relationship between innovation and performance is important once the highest level of differentiation can help achieving the highest growth (JENSSEN; RANDØY, 2006). The authors noted that market relationships and productivity slack have a positive influence on innovation.

In recent years, sustainability in offshore oil industry has been discussed more extensively (KAISER, 2015). Policies and technologies for offshore oil spills (LI et al., 2016) represent one of the most complex issues in this industry. Oil spills can generate opportunities for innovation in firms, including support vessel companies. Offshore oil companies are challenged to produce large volumes of oil every day in a hostile and hazardous environment (SILVESTRE; GIMENES; NETO, 2017); thus, developing innovative processes and services is a fundamental issue from a sustainability perspective.

The largest oil company in Brazil, Petrobras, designed a Health, Safety, and Environment Management System (HSEMS) in order to generate greater sustainability. The tool comprises fifteen dimensions:

1. Leadership and accountability.
2. Regulatory compliance.
3. Risk evaluation and management.
4. New projects.
5. Operation and maintenance.
6. Management of changes.
7. Acquisition of goods and services.
8. Training.
9. Information management.
10. Communication.
11. Contingency.



12. Community relations.
13. Accidents and incidents analysis.
14. Product stewardship.
15. Assessment and continuous improvement.

Those dimensions are connected to innovation and, as a consequence, it is necessary for the entire supply chain to develop explicit strategies in order to generate innovation (JENSSEN; RANDØY, 2002).

2.2. STRATEGIES TO DEVELOP INNOVATION IN THE OFFSHORE SUPPORT VESSELS INDUSTRY

Innovation is not a trivial activity. However, there are strategies that can improve the innovation process. Generating ideas can be considered as the first step in the innovation process. A set of ideas generates idea collections, and those collections can establish a link between creativity and innovation according to Gilson and Litchfield (2017). The authors highlight the importance not only of ideas but also an understanding of creation, shaping, development, and the usage of these ideas. New ideas tackled in isolation rarely contribute to innovation. Creative ideas are the key to the innovation process (LITCHFIELD; GILSON; GILSON, 2015).

In the offshore support vessel industry, significant effort is focused on techniques involving the modelling and implementation of sophisticated algorithms for vessel routing (CUESTA et al., 2017; KAISER, 2015; AAS et al., 2007), fleet capacity, and configuration (AAS; HALSKAU-SR; WALLACE, 2009). Business-process management ideas can contribute to innovation in offshore service vessels (BORCH; BATALDEN, 2014) and signal that to overcome complexity and volatility innovation in business process management is crucial. Borch and Batalden (2014) discussed about the factors from nature, society, and operations that contribute to complexity and volatility in an offshore service vessel.

Some important factors regarding to complexity are associated to sea conditions, long distances, transport infrastructure shortcomings, excessive government rules related to operation, safety, environment, an excessive ratio of jobs to vessels, and coordination between the supply chains. Factors that contribute to volatility include low polar



compounds and ice, emergency and rescue plans, environmental activist groups, inexperienced operators, and human factors.

Strengthening the relationships between firms and universities is another strategy that can be essential for generating innovation in the offshore service vessel industry. Boundary organizations (PERKMANN; SCHILDT, 2015) integrate firm and academic researchers to collaborate on their survey problems and attract potential innovators. Academic engagement (PERKMANN et al., 2013), which is defined as knowledge collaboration between academic researchers and firms, represents a strong method to transfer knowledge between academic innovators and companies.

The Brazilian National Petroleum Agency (Agência Nacional de Petróleo – ANP) and Petrobras have a program to develop a specialized workforce for the oil and gas industry in universities. The initiative has granted scholarships to graduate, masters, and doctoral degree students, but some improvements are necessary as the amount of knowledge transfer to the industry is low. In a study (HUYGHE et al., 2016) about technology transfer offices (TTOs), it was concluded that only a minority of researchers were familiar with the TTO at their university.

More interactions between students and the offshore supply chain industry can yield more innovations for firms and contribute to literature growth. These interactions must have strong collaborative relationships (KHORSHEED; AL-FAWZAN, 2014) as the main variable in developing knowledge and innovations for the industry. The model proposed by the authors is based on industry-oriented problems and innovation. The authors highlighted the TIC (Technology Innovation Centers) program in Saudi Arabia, which aims at creating university-based centres to promote collaborations between universities and industry researchers.

3. METHOD

This paper uses a methodology based on content analysis. This research method has a large application in supply chain and logistics problems (CULLINANE; TOY, 2000; SPENS; KOVÁCS, 2006; MAHPULA et al., 2013).

3.1 SAMPLING

To use content analysis technique, one of the main steps to follow is the documents analyses (CULLINANE; TOY, 2000; SPENS; KOVÁCS, 2006). Due to the goal of this study and few literature publications about the Brazilian's innovation maritime industry, the database covering this purpose was the magazine: *Portos e Navios* (Rio de Janeiro: Editora Quebra-Mar).

This magazine is considered one of the most traditional in Brazilian maritime context, including publications about ports, logistics, naval industry, and offshore oil and gas. The magazine has more than 58 years with approximately 670 editions published. To analyse the innovation in a maritime support vessel industry it has been selected 36 editions covering the years 2014, 2015, and 2016. Every context that the word innovation or its variation has been shown, those were counted and their purposes analysed.

3.2 CODING SCHEME OR CATEGORY CONSTRUCTION

To develop a reliable theoretical framework a category construction is necessary. Thus, it is important to develop patterns to analyse information, facilitates information reporting and generates objectivity, validity and reliability (CULLINANE; TOY, 2000; GUTHRIE et al., 2004; SPENS; KOVÁCS, 2006). The following table reports the coding scheme categories and their definitions.

Table 1 Coding scheme categories.

<i>Category</i>	<i>Description</i>
Edition	Edition of the magazine
Innovation	Innovation word count
Context	Context of the innovation

Source: Elaborated by the authors

4 RESULTS

The Table 2 summarizes the main findings, establishing a comparison between the innovation quotation per year and month from 2014 to 2016.

Table 2 Coding scheme categories.

Month	2014	2015	2016	Averages	SD
	Word count	Word count	Word count		
Jan	7	29	8	14.7	12.4
Feb	4	9	1	4.7	4.0
Mar	3	5	4	4.0	1.0
Abr	7	8	3	6.0	2.6
May	6	6	1	4.3	2.9
Jun	23	5	6	11.3	10.1
Jul	8	4	5	5.7	2.1
Aug	7	20	6	11.0	7.8
Sep	15	9	4	9.3	5.5
Oct	6	4	10	6.7	3.1
Nov	9	2	3	4.7	3.8
Dec	9	19	7	11.7	6.4
Averages	8.7	10.0	4.8		
SD	5.4	8.3	2.7		

Source: Elaborated by the authors. Based on Revista Portos e Navios. Rio de Janeiro: Editora Quebra-Mar Ltda. 2014, 2015, 2016

The table 3 emphasizes the main contexts that innovation appeared in the year 2014 in the *Portos e Navios* magazine. The innovation word shows up 8.67 times on average by edition.

Table 3 Main contexts of innovation citation in 2014.

Year	Average Innovation citation	Main contexts
2014	8.67	Advertisement/fair Investments by propulsion manufacturers Exchange between the Brazilian students and foreign universities Equipment investments by terminal container operators Needs for clearer information about National Bank of Development (BNDES) Integration between the Brazilian research institute and Portuguese university Software that innovates the vessel maintenance process Investments in laboratories by paint companies Need for incubators in universities Petrobras Logistics Technology Program develops new solutions for the pre-salt

Source: Elaborated by the authors. Based on Revista Portos e Navios. Rio de Janeiro: Editora Quebra-Mar Ltda. 2014

The Table 4 presents the contexts in the year 2015 about innovation. The average of words citation increases from 8.67 to 10.0 if compared with the previous year.

Table 4 Main contexts of innovation citation in 2015.

Year	Average Innovation citation	Main contexts
2015	10.00	Advertisement/fair Crane companies using simulator for training Needs for clearer information about National Bank of Development (BNDES) Lack of government support for innovation Investments in infrastructure and software by terminal operators Pre-salt and demand for qualified suppliers Federal University of Rio de Janeiro (UFRJ) tries to attract companies to its technological park Doubts on the transfer of oil companies to universities due to Brazilian crisis Paint manufacturer develops innovative fire protection system Cooperation between Financier of Studies and Projects (Finep) and Nordic companies with operations in Brazil

Source: Elaborated by the authors. Based on Revista Portos e Navios. Rio de Janeiro: Editora Quebra-Mar Ltda. 2015

In Table 5, the contexts in the year 2016 regarding to innovation are highlighted. The average of word citation decreased from 10.0 to 4.83 if compared to the previous year.

Table 5 Main contexts of innovation citation in 2016.

Year	Average Innovation citation	Main contexts
2016	4.83	Advertisement/fair Foundation for Research Support of the State of São Paulo (Fapesp) and BG Group establishes a partnership to create natural gas research and innovation center at University of São Paulo (USP) Maritime manufactures start project to develop smart ships Partnership between Brazil and Rotterdam Port to develop innovative port in Brazil Drones study for emergency response Federal University of Rio de Janeiro (UFRJ) tries to attract companies to its technological park Manufacturer presents solution that avoids failures in hydraulic circuits of vessels and equipment Investments by propulsion manufacturers Investments in infrastructure and software by terminal operators Logistic operator has received investments to generate innovation

Source: Elaborated by the authors. Based on Revista Portos e Navios. Rio de Janeiro: Editora Quebra-Mar Ltda. 2016

5. DISCUSSION AND CONCLUSIONS

This present study concentrates on a discussion about innovation in maritime support activities, especially in the Brazilian context. There are several gaps to improve innovation in this industry. A content analysis was utilised to map the innovation word context in a traditional Brazilian magazine named *Portos e Navios*, considering a period of three years (from 2014 to 2016), covering 36 editions. The results pointed out how many times the word innovation has appeared by edition and year, including its related context. In 2015, the average shown was 10 citations per edition, but in 2016, the performance dropped down to 4.83. This reflects the worsening crisis in Brazil.

During the main contexts analyses, the findings indicate an excessive advertisement/fair in several editions. The fairs are important, especially when it holds forum to discussion with the entire supply chain, but related to advertisements approach for itself, the innovation has little significance. Few companies have investments planning in innovation and there are several gaps about information provided by innovation national agencies. It is clear that the necessity in relations among universities and the entire supply chain increases so as to develop new products and services.

In order to design better results for the middle and short terms, we propose several actions. The first one is the identification of Critical Success Factors (CSFs). The CSF approach has not been applied to maritime support activities. The main idea of the CSF is to address a few factors that are critical to the company's success and competitive performance. These factors represent the activities that should be focused on. The CSFs have been demonstrated to adhere to the strategic planning of organizations, thus helping managers to focusing on the critical aspects of the business (JALONEN; LÖNNQVIST, 2011; YEOH; POPOVIČ, 2016).

The second recommended strategy is strengthening the relationships between academy and the companies involved in this market (PERKMANN; SCHILDT, 2015; PERKMANN et al., 2013; KHORSHEED; AL-FAWZAN, 2014). As previously discussed in this paper, there is integration between academics and researchers in the Brazilian context, but it is necessary to develop new strategies to transfer knowledge throughout the entire supply chain. Models based on industry-oriented problems and innovation (KHORSHEED; AL-FAWZAN, 2014), could lead to an interesting TICs adaptation to the Brazilian context. A very important policy for firms' innovation is developing explicit strategies that contribute to innovation processes (JENSSEN; RANDØY, 2002) and sharing them with the entire company and, if possible, with the supply chain.

Another strategy is based on the growth of partnerships with incubators that can yield great results, help the innovation process for firms, and improve the academic-firm relationship to accelerate knowledge development, knowledge sharing and contributions to literature. The maritime support vessel industry is a complex market, and generate innovation can be difficult. To overcome this difficulty, we suggest using a framework (DOUGHERTY, 2016) for complex innovation systems from which is divided into four interdependent



problems based on projects: new products, knowledge systems, strategy, and ecological connections.

Dougherty (2016) emphasizes the focus on project discoveries problems once those are the main points of innovation. More recently, George and Lin (2016) have presented a stylistic model, which combines analytics with innovation. The authors modelled a 2 x 2 matrix, with dimensions of innovation focus x analytics focus. The first quadrant (analytics as innovation) has a managerial focus on analytics implementation in the innovation process. The second one contains innovation and analytics, which drives innovation in analytics, products, and methodologies. In the third (analytics on innovation), firms perform analytics on innovation related tasks. Finally, in the fourth dimension (innovation through analytics), the innovation process supported by analytics represents the most challenging dimension for the organizations. We suggest the analytics perspective as a complementary tool in the companies' innovation process.

From an academic point of view, there are several open-ended questions and vast opportunities for researching. To the best of our knowledge, this paper is the first one to address the Brazilian maritime support vessel industry from the innovation perspective. Research to analyse maturity level, innovation generation and knowledge transfer between universities and industry (PERKMANN et al., 2013; PERKMANN; SCHILDT, 2015; KHORSHEED; AL-FAWZAN, 2014) is a great method to measure and remodel strategic policies and relationships between academia and firms. Works regarding modelling CSFs are necessary and important because there should be some factors that are more closely related to innovation processes and others, more distantly.

An extension of the CSF could be a mapping of factors (JENSSEN; RANDØY, 2002) that promotes innovation in maritime support vessel companies. Developing models and frameworks for measuring and associating productivity and innovation from the same standpoint is interesting. Due to high costs involved in this market and its high turbulence (BORCH; BATALDEN, 2014), especially related to environment and tasks, studies about business processes can contribute to both perspectives: companies cost savings and opportunities for innovation in processes.

Studies about demand patterns in offshore installations (AAS; HALSKAU-SR; WALLACE, 2009) could be an important contribution to understand maritime companies'

behaviour in prioritizing their schedule, investments, and workforce training. Other emerging content that has been connected to the offshore oil industry and maritime support vessels refers to 'industry 4.0'. Some points, including knowledge and competence challenges (HECKLAU et al., 2016), strategic management of human resources, a sustainable approach (STOCK; SELIGER, 2016) to create value, improvement in reverse supply chain using the Internet of Things (IoT) approach (PARRY et al., 2016) and innovations helped by IoT (ANDERSSON; MATTSSON, 2015), directly affect the maritime support vessel industry.

From a managerial perspective, an important implication of this study is to ponder upon companies' innovation maturity level. Historically, the offshore oil and gas segment has been complex, and the largest oil company in Brazil, Petrobras, holds technology and has developed innovation to explore oil in deep water and pre-salt. The daily oil output from pre-salt increased from approximately 41,000 barrels per day in 2010 to 1 million barrels per day in mid-2016.

However, it is necessary to innovate the entire supply chain, including maritime support vessels in order to maximize the results. Hence, for managers who want to foster innovation in their companies, we recommend identifying the factors that promote innovation in shipping companies (JENSSEN; RANDØY, 2002) and developing an environment that encourages creativity and innovation process (GILSON; LITCHFIELD, 2017; LITCHFIELD; GILSON; GILSON, 2015).

This study also suggests that maritime support vessel companies in Brazil develop strategic frameworks based on CSFs (that have been previously identified and studied) to help decision-makers in answering complex questions. The ideas about business-process management discussed in Borch and Batalden (2014) could be used to optimize value creation and consequently yield collaboration in the innovation process. A question emerging here is about the industrial policies, which have an important role. Policies are necessary to improve company's integration and its supply chain. It has been possible to observe that new ideas can be shared in an easy manner and consequently generate benefits to all companies.

Finally, a mandatory variable for firms is to achieve leadership in innovation market. As previously recommended, strong collaborative relationships (KHORSHEED; AL-

FAWZAN, 2014) are a valuable step in innovation direction. It is also important to consider and reinforce university–industry collaborations (KHORSHEED; AL-FAWZAN, 2014; PERKMANN; SCHILDT, 2015) and ideas as starting point of innovation (GILSON; LITCHFIELD, 2017).

Most of the challenges remain difficult and enhance every day; pressures to achieve high-level services require new and sustainable solutions with minimum costs. However, the workforce represents a gap, not only in the maritime support vessel industry but also in the offshore chain. Training and education should be continuously (SILVESTRE; GIMENES; NETO, 2017) incentivized to help workforce achieving and improving its performance.

Furthermore, for a world-class industry, innovation is the key and increases competitiveness. As mentioned previously in the Global Competitiveness Report 2016 – 2017 (WORLD ECONOMIC FORUM, 2016), the Brazilian ranking in terms of innovation is very poor. Innovation occurs primarily through a workforce that influences the capacity for innovation. Consequently, it is clear that there is a close link between innovation and the workforce. Innovation can be a driver for any company, not only at a strategic level but rather at all levels of the company, whichever operational or tactical.

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