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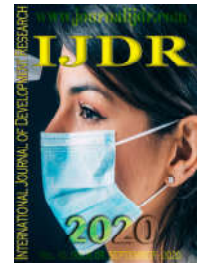
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OIL AND GAS SECTOR IN BRAZIL: AN ANALYSIS OF RECENT ACTIVITY BASED ON THE SCP MODEL

¹Dr. Álvaro Alves de Moura Jr., ²Dr. Joaquim Carlos, R., ³Dr. Pedro Raffy Vartanian and ⁴Vitória Batista Santos Silva

^{1,2,3}Professor of the Stricto Sensu Post-Graduation Program in Economics and Markets of Universidade Presbiteriana Mackenzie; ⁴Economist and Master's Degree in Economics from the Stricto Sensu Postgraduate Program in Economics and Markets of Universidade Presbiteriana Mackenzie

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*Corresponding author:

Prof. Dr. Álvaro Alves de Moura, J.,

ABSTRACT

The discovery of new oil fields in the pre-salt layer in 2005 in the Santos Basin significantly changed the prospects for the oil and gas sector in Brazil. Vast investments have been made by Petrobras to explore these deposits since 2012, in addition to essential changes in the regulatory framework, which now allow the sector to be explored by private domestic and foreign companies. The objective of this work is to analyze the sector in light of the Structure-Conduct-Performance (SCP) model, taking into account all these observed changes, as well as the problems experienced by Petrobras, including the corruption scandals exposed by the Lava Jato operation.

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INTRODUCTION

From 2006 Brazil, with the discovery of oil in the pre-salt layer off the Brazilian coast, Brazil becomes one of the largest oil producers in the world. From 2018, the amount of pre-salt depleted oil surpassed the production of post-salt. However, it was also during this period that one of the biggest scandals of Petrobras (state-owned mixed capital company) broke out, affecting the country's economic and political relations. In this sense, the objective of this article is to carry out a sectoral analysis of the Brazilian oil and gas activity. To this end, an evaluation will be made of its recent activity, using the so-called Structure-Conduct-Performance (SCP) model as a theoretical framework for its approach. Therefore, various sources of information, technical evaluations, and sector studies will be used to carry out the work, most of them based on databases and research, especially those conducted by the Ministry of Mines and Energy, the National Petroleum Agency, and the Energy Research Company.

The article is divided into three sections, in addition to this introduction and the final considerations. The first section will present the Theoretical Framework that underpins this research, the Performance-Conduct-Structure (SCP) model. In the second section, a brief description of the Brazilian oil industry will be made, starting from the creation of Petrobras to the exploration and production from the pre-salt. Finally, the sector will be analyzed based on some of the elements of the SCP model.

THE MODEL

STRUCTURE-CONDUCT-PERFORMANCE MODEL (SCP): Among industrial organization theories, there have been different approaches developed and perfected over the years as a result of technological developments in computing, and this has facilitated the development of models for the interpretation of industries (goods and services) which would previously have been unfeasible. The Structure-Conduct-

Performance (SCP) model is one of these approaches. It aims to understand linearly how the structure of a sector, which depends on underlying conditions such as technology and demand, affects its conduct and how this, in turn, influences its performance (Carlton & Perloff, 1999). Joe Bain (1956 apud Fagundes & Ponde, 1998) is considered the developer of the SCP model. It starts from the essential hypothesis (from the SCP paradigm) that the structure of a market determines the standards of conduct of firms, and this, in turn, affects their performance. According to Farina (1997), the SCP model allows the identification of the forces responsible for the organization of industry and firms and how these have changed over time. According to Scherer and Ross (1990), the main objective of the SCP model is to understand the variables that can interfere in the economic performance of a given sector of activity. Cabral (1994), on the other hand, states that the model is a paradigm that provides a scheme for market analysis that allows the development of a system or scheme with several relevant points for a sectoral analysis. The market structure of the SCP model is based on the analysis of several variables. According to Carlton and Perloff (1994), the main variables are the number of buyers and sellers, barriers to entry, product differentiation, vertical integration, production diversification, etc. According to the theories related to the Barrier to the Entry of New Competitors (Fagundes & Ponde, 1998), with emphasis on the Price Limit model, a market structure should be evaluated by both the performance of already established companies and by potential competitors. The rivalry between competitors already existing in an industry is conditioned on several factors, with emphasis on the degree of concentration each factor exerts concerning several behaviors that maintain or increase the advantages of the largest companies about the market.

On the other hand, competition may be affected by potential entrants who represent constant threats to companies already established in a sector, since they bring additional production capacity, desire to gain market share and, often, resources for investment. It is worth mentioning that the intensity of the threat of incoming companies is generally inversely related to existing barriers and the reactivity of companies already established in the sector. Once the Structure element is briefly discussed, it is followed by the introduction of the SCP Model based on the conceptualization of conduct, which are the actions adopted by companies to operate in the sector, which is why it can be treated as synonymous with competitive strategy. This is the process of choosing between different decision alternatives regarding variables that are under the control of the company. According to Kupfer (1992), the conduct of companies was disregarded in the first versions of the SCP because the structural elements, especially market concentration, were seen as the main elements responsible for performance. However, the most current versions consider the importance of conduct, since they admit that conduct, besides influencing performance, may alter the industrial structure itself. Thus, it is possible to state that business strategies can influence how competition occurs between companies, indicating that firms play an active role in the transformations that occur in a competitive environment.

Depending on the context, companies may even be responsible for changes in the competitive pattern, since instead of merely adapting to the market in which they operate, they may also establish actions capable of modifying it. Thus, the main objective of companies' actions on issues – such as their relationship with pricing policies, investments in research and

development (R&D), or even the differentiation of their products within the same category – is to increase their market share. In addition to these, other business decisions are also recurrent, such as mergers, acquisitions, and investments in advertising, etc. Finally, performance, in pure analysis, can be seen as the result of the previous elements. However, the current model foresees a cycle in which the observed results of "Performance" will function as input for decision making that will influence the "Conduct" and "Structure," feeding back the model. Besides, this revised model also includes an exogenous action towards companies which is carried out by the government through various policies, especially regulation. It is worth mentioning that the revision of the original SCP model presupposes that both the structure of a given industry (of goods and services) can influence the performance of the companies that are part of it, as well as the performance of the firms themselves, which can cause changes in the structure variable. Therefore, the traditional idea of the model, which considered the sense of causality as unidirectional (Performance-Conduct-Structure), has been adapted over the years into more modern versions that are consistent with the reality of firms: the rigidity in thinking about this unique sense of causality is abandoned. It is assumed that exogenous factors can determine the structure but fed back or modified by elements of the model itself, that is, endogenously. This was a significant step for the model in question since it eliminated the possibility of misinterpretations and some of the criticisms previously voiced. Thus, the feedback or return effects are equally crucial for the analysis of the sectors (Scherer & Ross, 1990), whose analytical scheme can be evaluated in the figure that follows.

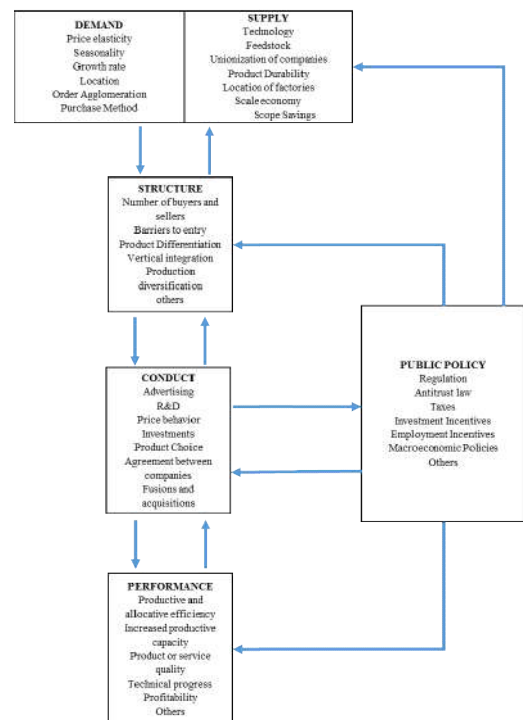


Figure 1. Analytical Scheme of the Revised SCP Model

Some of the elements of the SCP model will be used for the preparation of this sectoral study of the Brazilian oil and gas industry.

The Brazilian oil and gas industry: a brief description of the structuring of the Brazilian oil industry: Throughout Getúlio Vargas' government began with the Provisional Government (1930–1934), was succeeded by the

Constitutional Government (1934–1937) and, subsequently, by the Estado Novo (1937–1945), when it became a dictatorship. The oil issue was at the center of the national political discussion, so much so that in 1934, in line with the Constitution enacted in that same year, the Code of Mines was established to prevent other countries from exercising any influence over national mineral resources. In 1938, the National Petroleum Council (CNP) was created, which was responsible for coordinating the activities of research, exploration, and refining, in addition to the commercialization and distribution of oil. The CNP is considered the first valid attempt to regulate the sector (Nunes, 1980). After Vargas was deposed in 1945, the then President-elect Eurico Gaspar Dutra tried to pass a law that would open up the oil sector to private capital, both domestic and foreign, for exploration. Meeting Vargas' nationalist perspective, the Dutra government argued that the Brazilian state was unable to afford the national oil project financially and technically. However, strong opposition to the project caused it to be rejected by parliament (Paula, 2013).

It was then that the opposition to the Dutra government launched the "oil is ours" campaign, to defend full state monopoly on activities concerning the sector. It is in this scenario that Vargas, who was on the side of the nationalists, returned to the political scenario, electing himself president in 1951. In the same year, he sent the project that created Petrobras, which was approved and sanctioned by Law No. 2,004/53 (Leite, 2009), to the parliament for evaluation. Petrobras began operating in 1954, and except for distribution, the company exercised a monopoly on exploration, production, refining, transportation, and marketing activities (Pinto, 2016). Later, the Target Plan, launched by the Juscelino Kubistchek government (1956–1961), emphasized the energy and transportation sectors, whose activities took up 71.3% of the total resources of the investments provided by the plan, and had in the State one of the main pillars for its development, including the emphasis that Petrobras should be the symbol of the desired national development (Alveal, 1994, p. 71). As a result of investments in these segments, gasoline consumption in the country tripled in just ten years from 2.1 million m³ in 1955 to 6.1 million m³ in 1965, due to the achievement of the goals of the oil and automobile sectors (IBGE, 2019). In 1963, President João Goulart created a Petrobras research center called the Leopoldo Américo Miguez de Mello Research Center (CENPES).

CENPES had the objective of expanding the sector's technological knowledge through research and development and necessary engineering activities, which until then had been developed abroad. It was during this period that Petrobras emphasized the importance of exploring the sedimentary basins of Espírito Santo and Sergipe-Alagoas. And in the early 1970s, with the first drilling in the Campos Basin (Castro, 2013; Lucchesi, 1998). As a result of all these efforts, from the 1970s, Petrobras became the largest state-owned company in Brazil and Latin America, despite the international crisis that had affected the sector, and it should be remembered that in this period, the country was already governed by the military regime (Pinto, 2016, p. 100). After 1975, the equipment and platforms that were previously almost all purchased abroad began to be manufactured in the country. From the 1980s onward, discovering new sources of oil became the military government's main goal because of the oil shocks and the high burden of the Brazilian foreign debt at the time. Since 1985,

Petrobras has gained prominence worldwide for its deep-water exploration activities, especially in the Campos Basin (Morais, 2013). In the early 1990s, after the process of opening of commercial and the deepening of financial relations, the Collor government implemented the National Privatization Program (PND), which promoted the extinction of Petromisa (mining company) and Interbras (trading company), both controlled by Petrobras, and the privatization of assets of Petroquisa (petrochemical company) and Petrofértil (fertilizer company) (Pinto, 2016). In 1997, during the Fernando Henrique Cardoso government, the Petroleum Law was enacted (Law no. 9.478/97), which allowed other companies to explore, produce, refine and transport petroleum. In practice, this meant the end of Petrobras state monopoly. This law also created the National Petroleum Agency (ANP)¹, with the function of regulating the oil industry and the National Energy Policy Council (CNPE), which is an advisory body to the president of the Republic regarding the formulation of energy policies and guidelines.

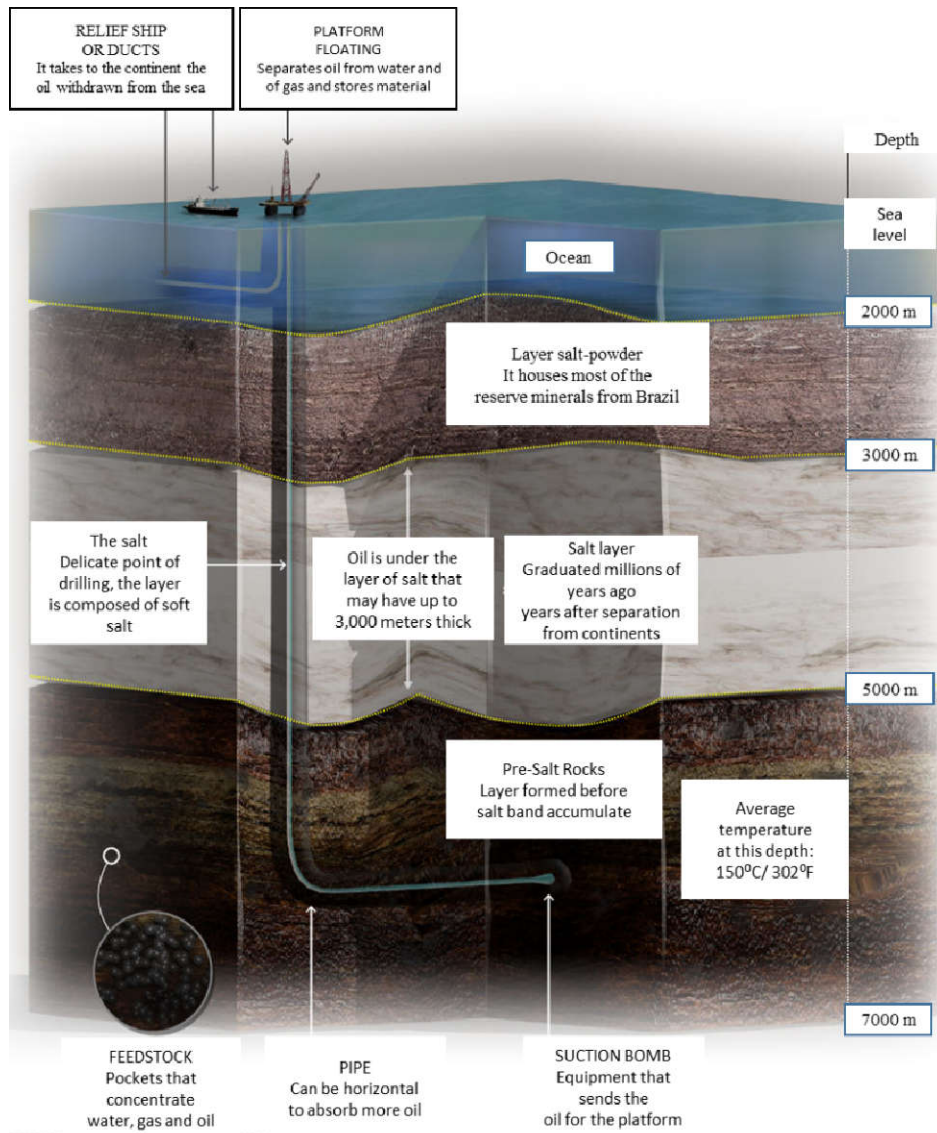
Discovery of the pre-salt: One of the main events that took place in the Lula government, which made essential investments in Petrobras, was the discovery in 2006 of the pre-salt layer, which consists of deposits of oil and natural gas that extend along the coastal strip from Espírito Santo to Santa Catarina, whose characteristics are highlighted in the following figure. The Campos Basin (RJ) contains 70.2% of the pre-salt oil resources, followed by the Espírito Santo Basin (13%) and Santos Basin (12.3%), among others (ANP, 2019). In economic terms, it can be said that the exploration of the pre-salt requires high investments in technology, which significantly increases its production costs. On the other hand, the external dependence on oil has been declining for some decades², but had in the pre-salt a determining factor for obtaining these results, due to the significant increase in its production from 2009, and from 2018, the oil extracted from the pre-salt became predominant, as shown in the figure below. Notwithstanding its economic and social results, the pre-salt also brings environmental impacts, especially deleterious effects on the marine ecosystems of the areas involved, in addition to the emission of pollutants that occur during the production process, and the risks of accidents and leaks (Rocha et al., 2013). The following section will evaluate, in light of the SCP model, the national oil and gas activities.

RESULTS

Evaluation of the oil and gas sector according to the scp model: The theoretical framework brought to light one of the possibilities for evaluating the different market structures, with a logical conclusion that its elements (structure, conduct, and performance) are interconnected but in a non-linear way. Furthermore, governmental policies, particularly the regulatory policies conducted by the National Petroleum Agency (ANP), are essential for understanding the oil and gas sector in Brazil.

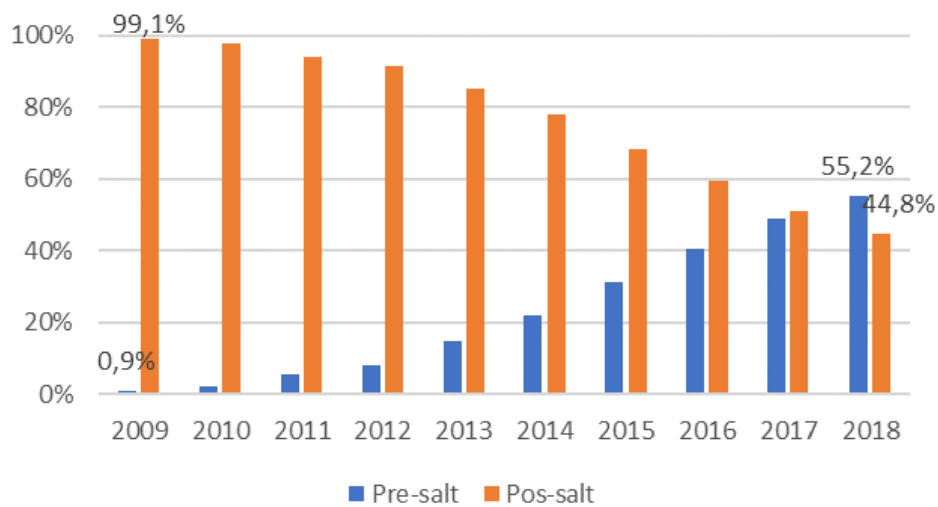
¹ The creation of the National Agency of Petroleum, Natural Gas and Biofuels took place because of the decree No. 2.455 of 1998. For more details, see: <http://www.anp.gov.br/institucional/linha-do-tempo-anp>. The ANP is responsible for regulating and supervising the oil industry in order to guarantee the best conditions for access and quality, as well as to encourage new investments for the viability of the projects.

² In 2015, it reached -8.7%, according to the Statistical Yearbook released by ANP in 2016.



Source: Adapted from: <http://g1.globo.com/economia/pre-sal/leilao-de-libra/platb>.

Figure 2. X-Ray of Oil and Gas Exploration of Pre-salt Reserves in Brazil

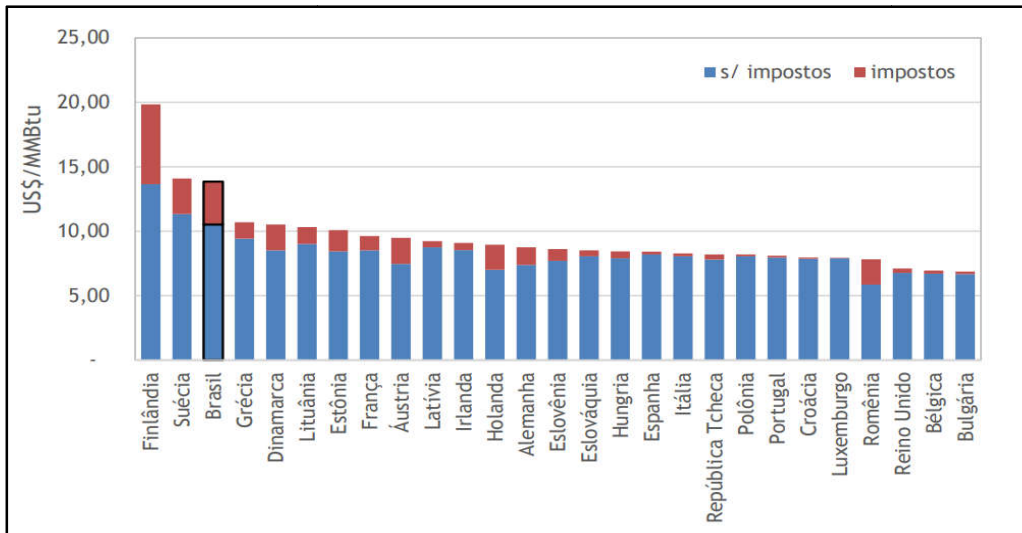


Source: ANP Statist

Figure 3. Evolution of Pre-Salt Production in the Brazilian Total from 2009 to 2018

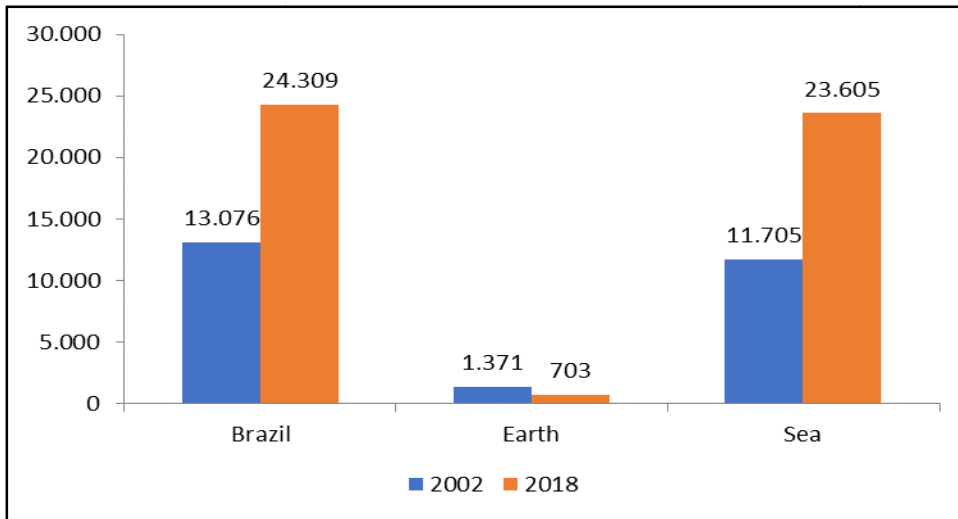
Table 1. Production of Oil and Natural Gas, by

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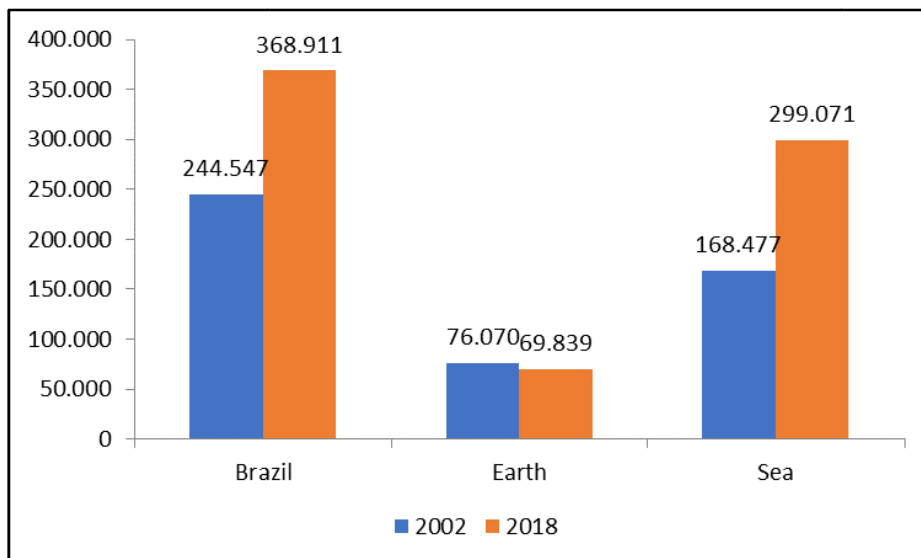
Source: EPE (2019).

Figure 5. Comparison of the Prices of Natural Gas for Industrial Consumers



Source: ANP Yearbooks (2012 and 2018)

Figure 6. Total Oil Reserves in Brazil in Millions of Barrels, by Location (land and sea) - 2002 and 2018



Source: ANP Yearbooks (2012 and 2018)

Figure 7. Total Natural Gas Reserves in Brazil in Millions of Cubic Meters, by Location (land and sea) – 2002 and 2018

Table 4. Results of bids under the Pre-Salt production sharing regime

Rounds	Basin	Block	Companies (operators represented by *)	Percentage	Union Oil Surplus			
1 ^a (21/10/2013)	Santos	Libra	Petrobras	10% ¹	41,65%			
			Shell Brasil	20%				
			Total E&P Brasil	20%				
		Sul de Gato do Mato	CNPC	10%				
			CNOOC Petroleum	10%				
			Shell Brasil*	80%				
			Total E&P Brasil	20%	11,53%			
2 ^a (27/10/2017)	Santos	Entomo de Sapinhoá	Petrobras*	45%	67,12%			
			Shell Brasil	30%				
			Repsol Sinopec	25%				
		Norte de Carcará	Statoil Brasil*	40%				
			Petrogal Brasil	20%				
			Exxon Mobil Brasil	40%				
			Petrobras*	40%	80%			
3 ^a (27/10/2017)	Santos	Peroba	CNODC Brasil	20%	79,96%			
			BP Energy	40%				
			Shell Brasil*	55%				
		Alto de Cabo Frio Oeste	CNOOC Petroleum	20%				
			QPI Brasil	25%				
			Petrobras*	50%				
			BP Energy	50%	75,80%			
4 ^a (07/06/2018)	Santos	Três Marias	Petrobras *	30%	49,95%			
			Chevron Brazil	30%				
			Shell Brasil	40%				
		Uirapuru	Petrobras*	30%				
			Petrogal Brasil	14%				
			Statoil Brasil O&G	28%				
			ExxonMobil Brasil	28%	75,49%			
5 ^a (28/09/2018)	Santos	Dois Irmãos	Petrobras*	45%	16,43%			
			Statoil Brasil O&G	25%				
			BP Energy	30%				
		Saturno	Shell Brasil*	50%				
			Chevron Brasil Óleo	50%				
			ExxonMobil Brasil*	64%				
			QPI Brasil	36%	23,49%			
Campos	Sudoeste de Tartaruga Verde	Pau-Brasil	BP Energy*	50%	63,79%			
			Ecopetrol	20%				
			CNOOC Petroleum	30%				
						Petrobras*	100%	10,01%

Source: ANP Statistical Yearbook (2019)

In this sense, this chapter should list the main components of each element of the SCP model in such a way that it can meet the objectives of this work, which is to analyze the sector. To this end, the following subsections will seek to evaluate each element, always having in mind the interconnection with the regulatory policies of the sector, as well as the primary conditions presented in the previous section. It is worth noting that this analysis will be conducted only for the extraction and production of oil and gas, and not for other links in the chain, since these chains are quite extensive and complex, which requires specific studies on each one of them.

Structure of the oil and gas industry: As discussed in Section 1, the diagnosis of the "Structure" of the SCP model is based on the components that reflect it, highlighting the degree of competition in the sector. Such characteristics tend not to suffer significant changes in a short period. However, recent changes in the regulatory framework of the oil and gas sector in Brazil (Law 9.478/97) have broken Petrobras' monopoly. They have allowed the participation of new national and foreign players in the sector. To analyze this component, the degree of concentration for the two products is evaluated in 2018, the year in which such changes increased the participation of other companies in the sector, despite the maintenance of Petrobras' active presence. The table below lists all the concessionaires that operated in oil and gas exploration in Brazil in 2018, where it can be observed that Petrobras still commands most of the oil production process, being responsible for 73.5% of the total, followed by the

Anglo-Dutch multinational oil company Shell, which produced 12.6% of the national oil. In gas production, Petrobras' participation in the supply is very similar to that of oil, making up 73.4% of the total in the same period, followed once again by Shell, which produced 11.6% of the total supply. All players in the sector, as well as the participation of each one, are shown in the table below. To measure this structural characteristic, two concentration measurements are generally calculated: the Concentration Ratio (CRK) and the Herfindahl-Hirschman Index (HHI). The Concentration Ratio is a simple measure of evaluation which takes into account the relative participation (S_i) of the K largest companies in the analyzed sector for a specific previously chosen attribute. Despite its practicality, the CRK may reveal a severe failure to evaluate the degree of competition because it does not detect any movement of increase or decrease in the degree of competition when there is entry, exit, or a concentration in the n - K segment companies. Because of this, a second indicator was chosen: the HHI, which will be detailed below. The results of the CRK and the HHI were obtained from the barrel attributes for oil production and one thousand m³ for the production of natural gas, whose formula is as follows:

$$CR_K = \sum_{i=1}^K S_i \text{ Being that, } S_i = \frac{x_i}{\sum_{i=1}^n x_i}$$

The x_i corresponds to the production attribute in barrels for oil and thousand cubic meters for natural gas. According to this indicator, the five largest companies in the sector represent 93.34% of the country's oil production, which reflects a high concentration. Regarding this indicator, only Petrobras represents 73.5% of the activity. For the gas sector, the CR_5 is equal to 0.92, i.e., the five largest companies in the sector represent 92% of the total production of the resource, a result that also reflects a high concentration in the sector, the result of which once again is due to Petrobras' 73.4% majority stake. The HHI, which allows the evaluation of the characteristics of the segment as a whole – since it does not only take into consideration the indicators of the K largest companies but also all the companies in the sector – is shown in the formula below:

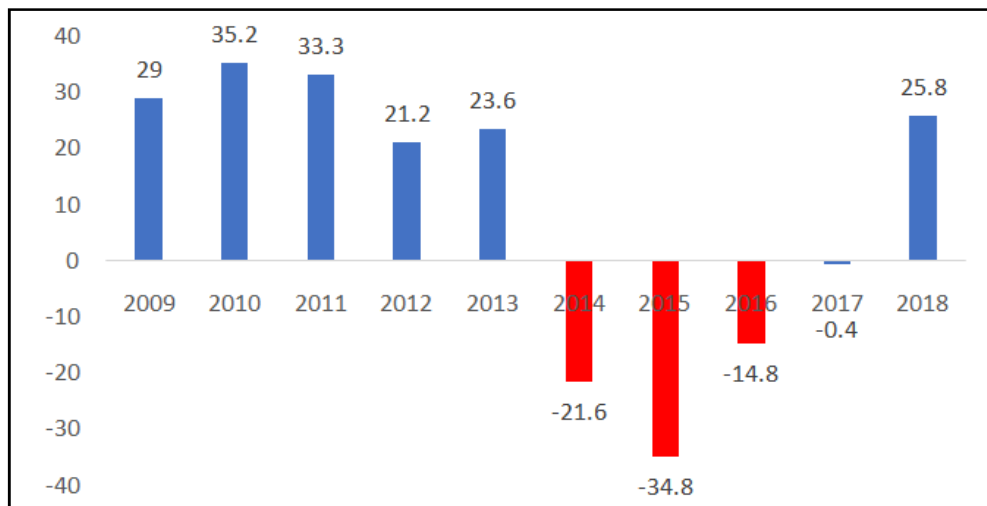
$$HHI = \sum_{i=1}^n S_i^2 \quad (3)$$

The HHI is not as an objective an indicator as to CR_K because its results should always be evaluated in a comparative manner, i.e., over time and within certain standards that are not rigid, since for each sector, the analysis of concentration should be evaluated according to its specificities. Based on the same attributes for calculating HHI, i.e., barrels for oil production and one thousand m³ for natural gas production, the results obtained were as follows: for oil, the HHI = 5,592 and for gas, the HHI = 5,561. These results describe sectors with high concentrations, which is why any merger or acquisition above 50 points would be considered critical for the competitive process. However, it is worth noting that it is Petrobras' participation that causes such results. Therefore, any merger that does not involve Petrobras needs to be considered, taking into account other elements. Another critical component of the structure commonly used to evaluate the sector studied are the barriers to entry for new competitors, which highlights a structural condition that may allow established companies to charge higher prices rather than the competitive one without attracting new competitors.

Table 5. Main Results of Bidding Rounds for Block Concession, by Round – 1999–2018

Bidding Rounds	Blocks granted	Onshore Area Granted	Onshore Area Granted	Offshore Area Granted	National Winning Companies	Foreign Winning Companies	New carriers	Subscription Bonus Raised (R\$ million)	PEM (UT) after a subscription	PEM (R\$ million) after subscription
1	1999	12	-	54.660	1	10	6	322	NA	NA
2	2000	21	10.227	37.847	4	12	6	468	NA	NA
3	2001	34	2.363	46.266	4	18	8	595	NA	NA
4	2002	21	10.620	14.669	4	10	5	92	NA	NA
5	2003	101	697	21.254	2	4	1	27	33.671	364
6	2004	154	2.846	36.811	7	12	1	665	131.137	2.047
7	2005	242	163.272	7.735	14	16	6	1.085	162.591	1.698
8	2007	108	31.910	13.419	20	16	11	2.102	158.036	1.333
9	2008	40	44.954	-	12	5	2	80	100.101	554
10	2013	120	29.085	32.173	12	18	6	2.480	236.060	5.800
11	2013	62	20.371	-	8	4	1	154	99.481	388
12	2015	36	32.000	1.513	11	6	3	120	38.901	210
13	2017	32	16.734	-	10	7	4	3.841	12.958	841
14	2018	22	-	-	2	10	-	8.015	8.045	1.223

Source: ANP Statistical Yearbook (2019)



Source: Petrobras (2019)

Figure 8. Petrobras' Net Profit – 2009–2018 in R\$ billion

In general, the main determinants of barriers to entry are the advantages resulting from product differentiation, absolute cost and scale advantages, and sunk costs (Possas, 1990). However, it is essential, following the SCP model itself, to relate this structural aspect of the sector not only to these possible advantages that may be associated with Petrobras but also to the legislation that regulates the sector itself. In this sense, the main barriers to entry faced in the oil and gas sector are the following: 1) high entry costs, which makes few companies try to establish themselves in the sector; 2) the technology developed – which in the case of Brazil should be highlighted, in view of Petrobras' standard of excellence for pre-salt exploration – that leads even companies with high initial capital to face an immediate operational disadvantage when entering the sector; 3) high fixed operating costs; and 4) local and foreign governments whose legislation requires industry companies to comply with environmental standards strictly. Specifically for the Brazilian case, it is important to highlight – despite the breaking up of the Petrobras monopoly in 1997 – that since 2010, there has been in force in the country a mixed regulatory regime for the exploration and production of oil and natural gas, governed by Law No.

12.351/1997. This law established in the country the regime of production sharing for the areas of the pre-salt polygon and other areas that are considered strategic. For the rest of the territory, approximately 98% of the total area of the Brazilian sedimentary basins is subject to the concession regime established by Law No. 9,478 of August 6, 1997. Two other laws that complement the regulation of the sector should also be considered: Law 12276/2010, which authorizes the federal government to onerously transfer to Petrobras an area equivalent to 5 billion barrels of oil and, in return, allows the federal government to obtain more shares of Petrobras; and Law 12304/2010 that created the state-owned company Pré-salPetróleo S.A. (PPSA) to act on decisions regarding the exploration and production of oil and natural gas under the sharing regime. Despite the changes generated by the current legislation in the sector, the pre-salt sharing regime still prevails, which for many companies may represent a possible barrier, despite the auctions, whose analysis will still be made in the Performance element, which has been occurring since 2013 showing a keen interest in private / state and national / foreign companies participating in this system. In short, barriers to entry into the oil and gas sector are extremely high.

They include high resource ownership, high start-up costs, patents, and copyrights in association with proprietary technology, government and environmental regulations, and high fixed operating costs.

Conduct of the oil and gas industry: It is considered that one of the main components of the conduct element for the oil and gas sector, as well as for any other productive activity, is the investment in the Research and Development (R&D) component. Morais (2013) divides this process, which affects the results of exploration (the discoveries of oil fields) and production (the implementation of innovative production systems in oil fields), into six phases, as shown in the table below. Analyzing the current context of the sector concerning Research, Development, and Innovation (RD&I), the ANP³ points out that about exploration, development, and production in onshore fields of common areas, the new technologies are already duly disseminated. However, there is still a need for further study and drilling of exploratory wells to expand geological knowledge about the so-called unconventional deposits. The sector's main challenges relate to offshore activities (structures located on the high seas), especially in deep and ultra-deep waters.

The new regulatory guidelines that have been mentioned allow other companies, in addition to Petrobras, to operate in the segment in such a way that they are also responsible for essential investments in RD&I. Among them, the construction company Queiroz Galvão stands out, in addition to the foreign companies Shell, British Petroleum (BP), Total, Statoil, Chevron, and ExxonMobil. According to IEL (2018), there is an offshore trend of increasing expansion in the numbers of equipment installed on the seabed, which significantly increases the sub-factories, i.e., the units that aim to develop increasingly complex facilities at hundreds of meters below sea level. In addition, the federal government created in 2016 the Program to Stimulate the Competitiveness of the Production Chain, the Development and Improvement of Suppliers in the Oil and Natural Gas Sector (Pedefor), which is a program to stimulate investment in R&D, with the aim of to improving the complex technological conditions of the chain (Almeida, Losekann, 2016). Another critical point to highlight is that ANP included a clause in the concession and sharing contracts that determines the allocation of a percentage of the gross revenue from the production of a field of high productivity in R&D activities to foster the scientific and technological development of the oil and natural gas sector, in addition to others linked to the energy sector⁴. In the concession contracts, the RD&I clause establishes that the concessionaires must make investments of 1% (one percent) of the gross revenue from the production of the fields that pay Special Participation⁵. The ANP is responsible for analyzing,

approving, monitoring, and inspecting the proper application of these resources. The total accumulated value of investments in R&D in the period from 1998 to the first quarter of 2019 was R\$15.8 billion. The investments based on the obligations generated show a growth trend over the last few years, despite a reversal in the years 2015 and 2016 due to the problems exposed by the jet-washing operation and the economic crisis in the country. In 2018, the sector recorded the most significant volume of resources allocated for R&D, and Petrobras was responsible for 90% of the total amount, as shown in the figure below.

Another essential element to highlight about Conduct relates to the entry of new players in the sector, which, since Law 9.478/97, created the concession regime in Brazil. However, it is worth remembering that the conditions that the country possessed in terms of oil reserves at the time of its promulgation were different from those found since the discovery of the pre-salt. Therefore, it is essential to note that these new proposals are linked to regulatory issues, also provided for in the revised SCP model. Initially, knowledge about oil reserves pointed to insignificant reserves, with a high risk of exploration (Dalla Costa & Souza-Santos, 2009). Besides, there was, at the time, low government financing capacity due to attempted control of public spending. However, with the discovery of the pre-salt, there was a reversal of priorities on the part of the Lula government, which increased Brazil's potential as an energy supplier. This new context required a readjustment of the regulatory framework made in 2010. The enactment of Law No. 12.276 authorized the Union to arduously transfer to Petrobras the control over activities of exploration and extraction of oil, natural gas, and other fluid hydrocarbons. Also, in the same year, Law No. 12,351, known as the Production Sharing Law, was enacted, establishing in Brazil the Production Sharing Regime in strategic areas and pre-salt areas (Zeituone, 2016).

The country currently has three types of oil and gas exploration regimes: concession, onerous assignment, and production sharing. In addition, the latter law created the Pre-Salt Social Fund, which is made up of deposits made with revenues from activities in the oil sector to be kept as reserves for dealing with possible economic impacts generated by activities in the oil sector and also to invest in education, science and technology, and other developmental segments (Machado & Silva, 2015). The new regulatory framework also created "Petro-Sal," Pré-Sal Petróleo S.A., in 2013, a company controlled by the government whose function is to manage production-sharing contracts in order to guarantee the interests of the Union. The company was made possible by Law No. 12,304/10, and it is linked to the Ministry of Mines and Energy (MME, 2014). From 2015, however, it was possible to observe the growth of opinions favorable to the modification of some characteristics of the regulatory framework of the pre-salt in order to reduce the "powers" given to Petrobras through the new framework of 2007. Thus, some changes were made to the regulatory framework, which included the release of Petrobras' participation in all pre-salt exploration blocks, although it still receives from the CNPE (National Energy Policy Council) the preference of participation. Previously, the company was required to participate in at least 30% of all the blocks negotiated under the production-sharing regime, with or without resources to do so. This change was sanctioned after the impeachment of President Dilma Rousseff, with the enactment of Law No. 13.365/16, which created more

³For more details, see: <http://www.anp.gov.br/pesquisa-desenvolvimento-e-inovacao>.

⁴Resolution n° 50/2015. Available at: <https://www.legisweb.com.br/legislacao/?id=310611>.

⁵The individual participation is an excellent financial compensation owed by oil or natural gas exploration and production concessionaires to large production fields. For the calculation of the individual participation in oil and natural gas production, progressive rates, which vary according to the location of the mining, the number of years of production and the respective quarterly production volume monitored, are applied to the net revenue of the Company. Quarterly production of each field, considering the deductions provided for in Paragraph 1 of Article 50 of Law No. 9.478 / 1997 (royalties, investments in exploration, operating costs, depreciation, and taxes). For more details, see: <http://www.anp.gov.br/royalties-e-outras-participacoes/participacao-especial>.

opportunities for private and foreign capital in the exploration of the pre-salt. The evaluation of these changes will be presented based on the Performance element and the results of the auctions for exploration of the pre-salt. The price of oil is also one of the most representative components of the oil and natural gas pipeline. This discussion is even more relevant in the analysis of the sector in Brazil, mainly because of the discussions about the price control policy adopted by President Dilma Rousseff's government. During the Rousseff administration, the practice of controlling and delaying the transfer of international prices to fuels in the domestic market aimed at influencing inflation rates through gasoline and diesel, forcing Petrobras to sell oil at prices that were considered below those in the international market, which for some analysts contributed to causing part of Petrobras' losses, as will be assessed below. With the impeachment of Rousseff and the inauguration of Vice President Michel Temer in June 2016, former government minister Pedro Parente assumed control of Petrobras. He adopted a price policy "guided by the interests of the company" so that political interference should no longer occur, not even to meet the interests of economic policy⁶. Under this new guideline, oil produced and marketed by Petrobras began to be priced according to exchange variations (without lag) and based on the price quotation defined by the international market.

This quotation is now based on the prices of West Texas Intermediate (WTI), North Sea Gross (Brent), and Arabian Light crude oil. Thus, because of the new management, the value of fuels began to follow the fluctuations of the international market in terms of the price of crude oil. However, they also took into account freight costs, internal transportation costs, and port taxes, as well as a remuneration margin for risks inherent to the operation, such as the volatility of the exchange rate and prices, port taxes, profit, and taxes⁷. The new practice coincided with the increase in oil prices in the international market in June 2017, as shown in the table below. Regarding the price of gas, it is considered high when compared internationally. According to EPE (2019), this fact results from the high presence of carbon dioxide (CO₂) contents, which makes the production cost of natural gas very high, especially for fields far from the coast. Also, according to EPE (2019), the distribution margins vary between the local distribution companies and the types of consumption. In the case of the transport tariff, the current contracts include quarterly readjustments based on the IGP-M (General Price Index). PIS (Social Integration Programs)/COFINS (Contribution to Social Security Financing), and ICMS (Tax on the Movement of Goods and Services) taxes are also levied on the sale of natural gas. The PIS/COFINS rate is 9.25%, and the ICMS rate varies from 12% to 25%, depending on the state. The composition of the price of natural gas for the final consumer are: molecule 46%; Taxes 24%; distribution 17%; and transports 13%. Given this composition and the policy adopted, the reference prices for Brazilian natural gas are some of the most expensive in the world, especially when taxes are included, as shown in the figure below. Therefore, the prices of natural gas (molecule) in Brazil are comparable to those in the United Kingdom and Asia, while in the USA, the price of the molecule is significantly lower.

⁶<https://www.valor.com.br/empresas/4581539/pedro-parente-assume-presidencia-da-petrobras-partir-desta-terca>.

⁷ For more details, see: <https://www.estrategia-bolsa.pt/preco-barril-petroleo.html>.

However, natural gas prices in Brazil for industry, when taxes are added, become some of the highest in the world. With the justification of reversing this situation, in June 2019, the CNPE approved the guidelines for liberalizing the natural gas market. These guidelines resulted from the work carried out by the Committee for the Promotion of Competition in the Natural Gas Market in Brazil⁸. The guidelines prepared by the committee aim to act on the structure and conduct of the sector. They are based on four points: 1) promotion of competition; 2) integration of natural gas with the electricity and industrial sectors; 3) harmonization of state and federal regulations; 4) removal of tax barriers. The main objective of this CNPE Resolution is to make the price of gas competitive in Brazil, and EPE will be responsible for monitoring the implementation of these new guidelines, evaluating the results and supporting the states in the improvement of the markets in the sphere of Local Distribution Companies (CDLs) of natural gas. Finally, it is assumed that the recent corruption scandal involving the board of directors of Petrobras, large contractors, political agents, and financial operators is also one of the components of conduct of the SCP model, since it is associated, even if illegally, with the various agreements between companies and agents. It is also based on the hypothesis that such conduct results from Petrobras' concentrated structure, as well as from its connection with the federal government, which allows political use in negotiations between the executive and legislative branches. As a result of this (criminal) conduct, Petrobras has recorded heavy losses, including payments for impairment losses arising from criminal acts, the evaluation of which will be made in the next subsection that analyses the performance of the sector.

The scandal, investigated since 2014 by Operation Lava Jato, involved the payment of bribes to Petrobras executives and other public agents. Several agents have already been condemned, including former president Luis Inácio Lula da Silva. The payment of bribes was made by large contractors who organized themselves into cartels to obtain overpriced billionaire contracts. According to the Federal Public Prosecutor's Office (MPF), the bribe was distributed through financial operators of the scheme⁹. According to the MPF, the contractors also formed cartels that replaced real competition with the apparent competition, which allowed the charging of prices for the services rendered that were calculated in secret meetings. In these meetings, who would be the winners of the contracts and who would decide on the prices. In this scheme, Petrobras' employees participated by allowing the inclusion of unnecessary contract additives and excessive prices. Also part of this scheme was the so-called "financial operators" who were the people responsible for intermediating the payment of the bribe, as well as for making the bribe look like clean money. Finally, the political agents were part of or related to the political parties that formed the bases of the governments of the Lula and Rousseff governments. The consequences of the scheme, as well as the other elements of conduct discussed in this subsection, will be assessed in the next subsection.

⁸ The Energy Research Company (EPE), the Ministry of Mines and Energy, the Ministry of Economy (ME), the National Agency of Petroleum, Natural Gas and Biofuels and the Administrative Council for Economic Defense (CADE) are part of the committee; see Resolution No. 4 of CNPE on April 9, 2019:

http://www.mme.gov.br/documents/10584/126063519/Resolu%C3%A7%C3%A3o_CNPE_4_2019.pdf/229ba7d8-4c7d-411d-893a-84b45e83f1fa.

⁹ For more details, see: <http://www.mpf.mp.br/grandes-casos/caso-lava-jato/entenda-o-caso>.

Performance of the oil and gas industry: One of the main components of performance, which stems from the innovative conduct evaluated in the previous subsection, is the advances in the development of production resulting from the technical progress achieved through activities related to pre-salt that have made Brazil the foremost leader in oil prospecting in deep waters. Therefore, several technological solutions were developed, with emphasis on the robotization of part of the production process, and the use of new materials such as carbon fibers, nanomaterials, composites, nano polymers, and mechatronics. The improvement in the technologies used for the treatment of natural gas, as well as the separation of carbon dioxide, is also worth mentioning.

According to the IEL (2018), such results, among many others, were possible because of Petrobras' knowledge accumulation policy, which can be summarized in three points: 1) training and qualification of human resources, accompanied by the growth of the operational teams of geologists, geophysicists, chemists, engineers of various specializations and researchers at the Research and Development Center (CENPES); 2) expansion of laboratories and facilities of CENPES; and 3) policies for conducting collaborative research with scientific institutions, reinforcing research networks for the development of innovations, in addition to cooperative developments with supplier companies. The main result in terms of performance generated by these advances is the 85.9% growth in proven oil reserves when comparing 2002 and 2018, with sea reserves registering a 101.7% growth for the same period, as shown in the figure below.

As for proven natural gas reserves, the growth recorded for Brazil in the same period was 50.8%, driven by the 8.2% drop in onshore reserves and the 77.5% growth in offshore reserves. It is worth noting that these advances at sea are linked to pre-salt reserves. For more details, see the figure that follows. As discussed above, given the pressures for a new regulatory framework for the sector starting in 2015, which led to the release of Petrobras' participation in all pre-salt exploration blocks, several sharing bids were held. In this regime, the winning companies are those that offer the Brazilian state, from a fixed minimum percentage, the highest percentage of oil and natural gas produced (that is, the highest percentage of surplus in oil). Faced with this new regulatory perspective, a significant part of the pre-salt oil exploration areas has been auctioned, as illustrated in the following table. In the concession regime, the risk of investing in and finding oil or natural gas is the responsibility of the concessionaire who becomes the owner of all the oil and gas that will be discovered and produced in the area granted. Under this contract model, the concessionaire pays government interests, such as signature bonuses, payment for occupation or retention of an area (in the case of land blocks), royalties, and, in the case of large production fields, individual participation. In these bids, the interested companies offer, individually or in a consortium, an amount in signing bonuses and propose a Minimum Exploration Program (MEIP), that is, they commit to performing certain activities in that area, such as seismic surveys and drilling of exploratory wells, among others. The company or consortium that presents the most advantageous proposal, according to the criteria set out in each bid invitation, receives the right to explore that area to verify the existence of commercial oil and/or natural gas deposits. The results of the 15 rounds of bidding already conducted for the concession of blocks, which demonstrate part of the performance of the

sector, are set out in the table below. Analyzing the results of the auctions and the companies acquiring the pre-salt exploration lots, it is possible to state that there is a high interest in the sector. However, one question that arises is: What are the consequences for the country of these interests of foreign companies in the pre-salt areas? On the one hand, partnerships with other companies generate more resources that can be invested in the project and the expansion of innovations in the sector via technology transfer; on the other hand, there is the question of the appropriation of what has been achieved by Petrobras in recent years in terms of exploration in ultra-deep waters, which has made it one of the main world references in the segment due to the technological advances made from its high investments. Another issue that draws attention, when considering the performance of the sector, is that poor management and corruption involving Petrobras substantially damaged the expected results in the exploration of the pre-salt, hurting the company's image and compromising its economic and financial results. After reaching the highest profit in Petrobras' history in 2010, there were significant drops in the financial results, although 2011 still shows a very positive result for the companies in Brazil. One of the main reasons for such results was the high oil prices in the international market in 2011 and 2014, a condition that was only reversed in 2018. The figure below shows the company's net profits between 2009 and 2018.

Considering the criminal conduct discussed in the previous subsection, in terms of performance, the highlight was the billions lost between 2014 and 2017. Specifically, for 2014, this result is explained by the payment for the depreciation of assets (impairment) of R\$44.6 billion, which corresponds to the write-off of expenditures unduly capitalized in fixed assets arising from the scheme of improper payments discovered by the investigations of Operation Lava Jato¹⁰. In 2015, Petrobras recorded the most significant net loss in its history, R\$34.8 billion. Once again, the impairment payment explained these results, and the adjustment in question was R\$33.7 billion¹¹. However, the fall in oil prices and the increase in discount rates, a reflection of the increase in Brazil's risk due to the loss of the investment-grade this year, also weighed on these results. Also, the significant exchange devaluation during the year, resulting from the intense political and economic crisis in which the country found itself at the time, should be highlighted. In 2016, the company recorded its third consecutive year with a loss of R\$14.8 billion. Once again, much of the loss was attributed to impairment, which totaled R\$20.9 billion¹². In 2017, Petrobras began to reverse the results of the previous three years, although it still recorded a loss of R\$446 million. The company maintained its trend of improving its operating results but at high extraordinary expenses, especially the R\$11.2 billion agreement with investors in the United States to close the class action suit and the adhesion to federal debt settlement programs that totaled R\$10.433 billion. These expenses did not allow the company to have a net profit of R\$7.1 billion. Also contributing to the result this year were the efforts of the new managers appointed by the Temer government to reduce the company's net debt, the fourth consecutive year of record production in Brazil of

¹⁰ For more details, see: <https://www.investidorpetrobras.com.br/pt/central-de-resultados/4t14.htm>.

¹¹ For more details, see: <https://www.investidorpetrobras.com.br/pt/resultados-financeiros/holding#topo>.

¹² For more details, see: <https://www.investidorpetrobras.com.br/pt/resultados-financeiros/holding#topo>.

oil and natural gas, the 32% increase in the volume of oil and oil product exports, together with the increase in the Brent price in the international market, and the 18% reduction in imports¹³. Already in 2018, the company had once again recorded positive profits, an impressive result given the trend pointed out by the crisis caused by the jet wash operation. The net profit registered in this last year analyzed by the present research was R\$25.8 billion. It is worth noting that the adjusted EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) this year was R\$114.9 billion, which represented a record for the company's indicator. According to the financial report published by Petrobras, the result is due to the increase in the margins of derivatives sales in Brazil and oil exports, in addition to the increase in the price of oil (Brent quotation) concomitantly with the appreciation of the dollar, a fact that is a consequence of the new pricing policy that began to follow the international market. Once again, the fall in indebtedness, the result of the management policies adopted by the company, also contributed to this result. It should be noted that the result obtained this year was not higher because the company still made adjustments to its equity, due to the agreements made from the jet wash operation, in addition to the agreements signed with authorities in the United States to close the investigations in the Department of Justice and the Securities and Exchange Commission (SEC), which resulted in the spending of R\$3.5 billion. Finally, we highlight the cash inflow of approximately US\$6.1 billion with divestments, as well as new partnerships with Equinor, Total, and Murphy for the development of business in the areas of exploration and production of oil and gas and renewable energies¹⁴. Despite the adverse scenario of Petrobras in recent years, it should be emphasized that the result of the auctions has proven the viability of the pre-salt since significant premiums were paid in the auctions, and there were transfers of significant volumes of surplus oil to the Union.

Conclusion and policy implications

Considering that the objective of this article is to carry out a sectoral analysis of Brazil's oil and gas activity, this research was based on the Structure-Conduct-Performance (SCP) model to evaluate, above all, the recent changes that have occurred in the sector since the discovery of new oil deposits in the pre-salt layer and the successive changes in regulatory frameworks which have broken Petrobras' monopoly in oil and gas exploration and production, thus allowing the exploration of the deposits by national and foreign private companies. In this sense, analyzing the necessary conditions of supply which directly affect the structure of the sector, observed that, unlike what happened in 1998 when only Petrobras carried out oil exploration activities; in 2018 more than 80 concessionaires were doing the same activity, using both national and foreign capital. Regarding natural gas, Petrobras still has absolute control over the production, transportation, and distribution of natural gas in Brazil. However, the most recent governments (Temer and Bolsonaro) have acted to open up the sector to private exploration at all stages of the sector's chain. In terms of structure, the high degree of concentration for both products in 2018 is noteworthy, with Petrobras maintaining its predominance.

And about barriers to entry into the sector, these are still quite high, even with the changes in regulatory frameworks and opening of the sector, because it requires high technological investments, high fixed operating costs, and regulatory policy for the exploration and production of oil and natural gas. In the country, the regime of production sharing in the areas of the pre-salt polygon and other areas are considered strategic. In terms of conduct, it was noted that investments in RD&I, although already widespread, still need further studies and drilling of exploratory wells, to expand geological knowledge about the so-called unconventional deposits related to offshore activities. The price of oil and natural gas, another component of the conduct of the analyzed sector, had a change in price policy. The practice of control and delay in the transfer of international prices to fuels in the domestic market during the Dilma administration was ended in favor of a pricing policy that began to follow exchange variations (without lag) and prices defined by the international market. Concerning gas, the ANP and EPE began to monitor the implementation of new guidelines, to make the price of natural gas, one of the most expensive in the world, more competitive.

Finally, the Petrobras corruption scandal revealed by the Lava Jato operation resulted not only in setbacks for the company in economic and financial terms but also contributed to the deepening of the economic and social crisis in Brazil. In terms of policy implications, it appears that the sector has been undergoing changes both regarding Petrobras' corporate governance, in an attempt to reverse the widespread picture of corruption exposed, and the regulatory framework with the attempt to expand the participation of companies (domestic and foreign) in the oil and gas exploration and production process, starting from new pre-salt layer auctions.

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¹³ For more details, see: <http://www.petrobras.com.br/fatos-e-dados-1/petrobras-melhora-resultado-em-2017.htm>.

¹⁴ For more details, see: <http://www.petrobras.com.br/fatos-e-dados/registramos-lucro-liquido-de-r-25-8-bilhoes-em-2018.htm>.

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