The Irrationality of the Petrobras Refining Divestments

Cássio Garcia Ribeiro[1]
Guilherme Jonas Costa da Silva[2]
Francielly de Fátima Almeida[3]

Abstract

Petrobras is a Brazilian state-owned company and is one of the largest oil companies in the world. It is an internationally recognized company for being at the technology frontier for the exploration and production (E&P) of oil and gas in deep waters. Moreover, Petrobras is a publicly traded oil company with the largest production of hydrocarbons worldwide. The pre-salt discovery has created a window of opportunity for implementing an export-led growth strategy that targets segments of oil production with a higher income sensitivity. However, since the administration of President Temer, a policy of divesting Petrobras assets in the refining sector has been taking place. Therefore, this paper aims to investigate the strategiesthat Petrobrashas currently adopted in refining, based on an econometric analysis of panel data. The article is pioneering, in the sense that it empirically demonstrates that Petrobras has established its position in E&P while advancing in the aggregation of value in the refining sector. We mayobserve that income elasticityis less than 1 (about 0.6%), whichis positive and significant.However,a sensitivity lower than unity demonstrates that Brazil has broken the barrier for entry into the export sector of oil products. Thus, based on econometric estimates, it is believed that there has been a great misunderstanding in the strategy of divestitures and downsizing in the refining segment.

Keywords: Brazil; Petrobras; Refining; Divestments; Downsizing.

JEL Classification: O38; C33.

1 PhD, Professor of the Institute of Economics of the Federal University of Uberlândia. E-mail: cassiogarcia@ufu.br

2 PhD, Professor at the Post-Graduation Program and Tutor of the Tutorial Education Program in Institute of Economics of the Federal University of Uberlândia. E-mail: guilhermejonas@yahoo.com.br

3 PhD Candidate, School of Economics Business Administration and Accounting at Ribeirão Preto, University of São Paulo. E-mail: franciellyalmeida@usp.br

1. Introduction

Petrobras was created by the Federal Government of Brazilian 1953, with the aim of reducing restrictions on the country's industrialization process, given the limitations regarding petroleum resources. Six decades after its creation, the Brazilian state-owned company is positioned amongst the world's major oil companies and is internationally recognized for its deepwater technology capabilities. The discovery of pre-salt represents unequivocal proof of this capability. Furthermore, it should also be noted that in 2014, Petrobras became the largest oil producer amongst publicly traded companies when it overtook Exxon.For these reasons and because it is located in a developing country, it is a case that deserves special attention in the field of development economics.

Despite the collapse of its monopoly in 1997, Petrobras has maintained its sovereignty on the Brazilian market, with a very significant participation in all stages of the country's oil and gas production chain. In addition to its prominent role in the area of Exploration and Production (E&P), it is the company with the largest participation in the downstream stage. Therefore, following the hegemonic trend among the major oil companies, Petrobras is a vertically integrated company, with an important role in all the links of the oil and gas chain. Thus, it is an authentic case of a well-to-pump.

The literature that focuses on Petrobras places most emphasis on the company's technological capability in the segment of E&P (Furtado and Freitas, 2000; Dantas and Bell, 2011; Mendonça and Oliveira, 2013; Ribeiro and Furtado, 2014; Schutte, 2013; Florencio, 2016). This approach may be seen as understandablesince the company's flagship nowadaysis the E&P segment. However, although this theme is of relevance, this study draws attention to a second theme related to Petrobras,which, despite being insufficiently explored in the literature,isof decisive importance toPetrobrasas well asto Brazil - refining.

Over recent periods, it is possible to identify two opposing strategies concerning the Petrobras refining activity: one before and one after the impeachment of President Dilma Rousseff.Petrobras represented an important mechanism for mobilizing the national economy during the governments of PT (the Workers' Party), - hence, before impeachment. Within this logic and to account for the increased demand for products derived from oil, the Brazilian oil company, during this period, made significant investments to expand its refining park, strengthening the vertically integrated profile of the company, from well to pump. However, a divestment strategy was put into practice after impeachment, by

PresidentTemer's government, mainly focusing on the refining segment. The Petrobras management appointed by the current President, Jair Bolsonaro, has maintained such a strategy.The objective of this study is to evaluate whether the strategy of selling the company's assets in the refining sector is adequate for the development of the country, and for strengthening Petrobras. To achieve this goal, this paper uses an export-led growth approach, which estimates the sensitivity(ies) of the exports of different segments of the oil sector from dynamic panel models via the GMM System. The hypothesis is that the progress of Petrobras in the oil refining segment could create conditions for greater dynamism within the sector, and for a more successful insertion into the global scenario, which would contribute further to the country's growth.

The period analyzed covers the last year of the first term of the President Lula's government (2006) until the last year of President Temer's (2018). The choice of this period is justified since it is possible to observe two diametrically opposite schedules in relation to Petrobras, as highlighted above, particularly with regard to the refining sector.In relation to the variables used in this paper, we have worked with: i) Petrobras investments/divestments in the refining sector with a view to highlighting the treatment granted to the refining industry before and after impeachment, and; ii) income from global partners (to test the elasticity of exportingBrazilian refining products).

The article has six more sections besides the introduction. In section 2, the focus is on the trajectory of Petrobrassince its inception, emphasizing its importance in the Brazilian oil sector, even after the monopoly was broken. Section 3 addresses the performance of the Brazilian oil company in the refining activity. Section 4 aims to expose the recent crisis faced by Petrobras and its consequences on the refining segment. The methodology, database, and results obtained through the panel analysis are presented in section 5. Finally, in section 6, there are some reflections on the main conclusions drawn from accomplishing this study.

2. The Brazilian Oil Industry: the Protagonism of Petrobras

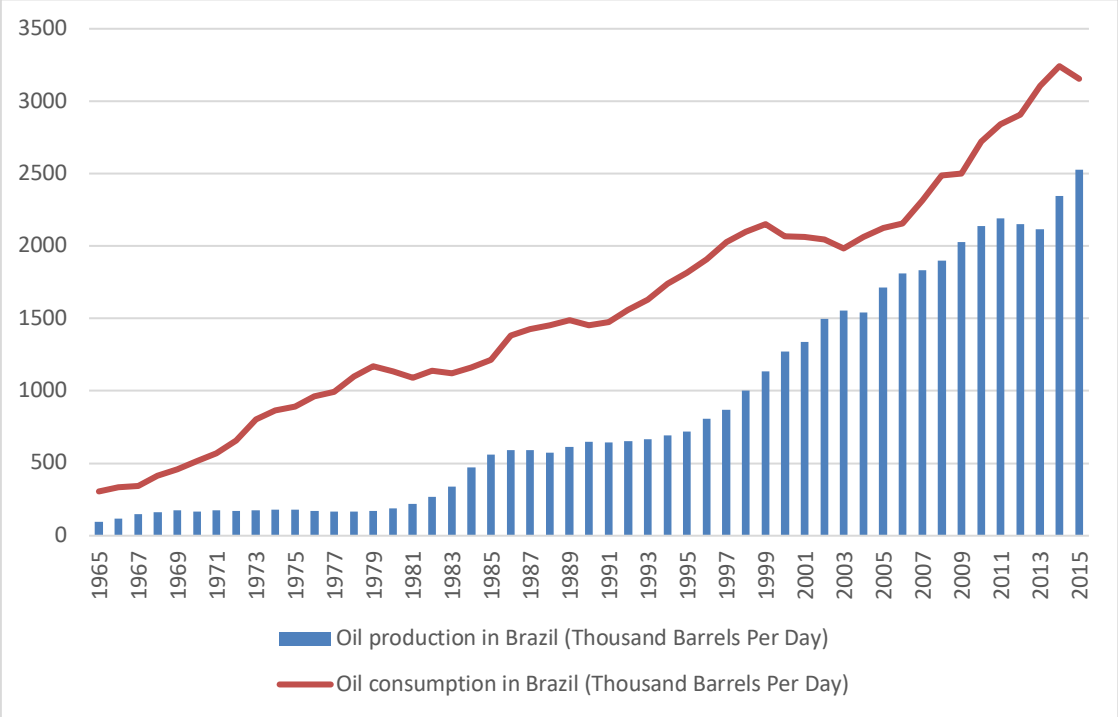
The history of the Brazilian oil value chain is closely linked to the history of Petrobras. The company was created in October 1953, by the government of President Getúlio Vargas, as a mixed-capital corporation with a majority capital controlled by the Brazilian Federal Government, , as a state monopoly for research and mining, refining and for the transportation of oil and derivatives. The aim of

the Brazilian government in creating Petrobras was to reduce obstacles to industrialization, stemming from a reduced base of oil resources.

After the oil crises of the 1970s, Petrobras began to focus on oil exploration and production activities in the Brazilian sea basins, to reduce dependence on imported oil. From that point on, R&D carried out by Cenpes, the company's R&D center, focused on the discovery and delimitation of oil reserves (Furtado and Freitas, 2000; Dantas and Bell, 2011). Besides this, during the same period, the Brazilian government implemented the so-called import substitution industrialization, a strategy based on strong trade barriers and import restrictions. Evidently,during this period, the Petrobras business model was strongly influenced by the development agenda adopted at the time in Brazil. The Brazilian state, therefore, urged Petrobras to pursue self-sufficiency in oil production for the country, as well as to reduce imports of capital goods, since imports of crude oil had a negative impact on the country's trade balance (Lloyd and Wheeler, 1977).

In the second half of the 1980s, when Brazil still imported much of the oil consumed, Petrobras discovered vast reservoirs along the Brazilian coastline. Figure 1 presents the significant jump in oil production in Brazil between the mid-1960s and mid-2010, bringing domestic production and consumption closer together.

Figure 1. Production vs. Oil Consumption in Brazil (1965 - 2015)



Source: British Petroleum Statistical Review (2016).

Since 1997, with the enactment of the Petroleum Law (No. 9,478), there have been significant changes in the Brazilian oil industry. This law stated that any company, other than national companies, could carry out the exploration, production, transport, refining, import and export of petroleum in Brazil, upon authorization, permission or concession fromthe public authorities. The "Petroleum Law" endedthe monopoly held by Petrobras throughout the main stages of the country's oil sector (Ribeiro and Furtado, 2014).

As well as endingthe Petrobras monopoly, the government of President Fernando Henrique Cardoso (1995-1998 and 1999-2002) established the same conditions for the Brazilian oil company as those offered to other companies that wanted to enter the market for oil exploration and production in Brazil. The new regulatory environment gave rise to the participation of other oil companies (national and international) in the exploration and production of oil from the country's reservoirs. Notwithstanding this fact, Petrobras continued to be the main protagonist of the sector (see Table 1).

Table 1. Oil and Natural Gas Production in Brazil: Petrobras vs. Other Concessionaires (2016)

Concessionaires	Petroleum*(barrels)	Production of natural gas (thousand m^3)
Petrobras	748,360,717.7	29,771,797.6
OtherConcessionaires	170,370,299.30	8,118,652.70
Total	918,731,017	37,890,450.3

Source: Adapted from ANP (2017).* Includes condensates.

By 2016, in addition to Petrobras, there were another 45 oil companies in Brazil. Nevertheless, Table 1 demonstrates the prominence of Petrobras in both oil and natural gas production. The Brazilian state-owned oil company accounts for 81% of oil production and 79% of domestic natural gas production. Thus, it may be seen that even after the end of the Petrobras monopoly, the company has continued to be the main player in the Brazilian oil industry.In addition to maintaining a prominent position in the Brazilian oil industry, it is important to emphasize the company's leading role within the international scenario. Petrobras stands amongst the most important energy companies in the world (see Table 2).

Table 2. Ranking IHS Energy 50 (2010 – 2013)

Oil companies	Market Cap ($US billion)	Position in Ranking IHS ENERGY 50			
		2010	2011	2012	2013
ExxonMobil	442.1	1	1	1	1
Chevron	240.2	5	4	4	2
Royal Dutch Shell	233.8	4	3	3	3
PetroChina	229.4	2	2	2	4
BP	150.7	7	6	5	5
TOTAL	145.9	8	8	8	6
Schlumberger	118.7	9	11	13	7
Gazprom	99.2	6	7	9	8
Petrobras	91.0	3	5	7	9
Sinopec	88.2	11	9	11	10

Source: IHS Energy 50 (2012 and 2014).

IHS Energy 50 (formerly PFC Energy 50) is the ranking that brings together the world's leading publicly traded energy companies by market capitalization. Despite the fall, which occurred between 2010 (when it was ranked 3rd) and 2013 (when it was ranked 9th), Petrobras remains among the ten largest energy companies in the world.

However, with regard to the company's performance in the E&P segment, the discovery of the pre-salt in 2006 should be mentioned, in the ultra-deep waters of the Santos basin, "located across three oil basins: Campos, Espírito Santo, and Santos" (Seabra et al., 2015, p. 1). The term pre-salt is used because the hydrocarbon reserves are located beneath a layer of salt two kilometers thick. The pre-salt cluster is circumscribed "heterogeneously, from the southern Santos Basin to the north of the Campos Basin, in an area of approximately 800 km long by 200 km wide, in deep and ultra-deep waters" (Petrobras, 2018).

The confirmed reserves indicate a volume of oil of between 30 and 40 billion barrels. However, based on estimates by Jones and Chaves (2015), taking into consideration the undiscovered, recoverable hydrocarbon resources in the Brazilian pre-salt, the volume is significantly higher: 119 billion barrels of oil and gas (90% probability of occurrence), reaching 217 billion barrels. Thus, the new cluster reveals that it is possible for Brazil to become part of the select club of oil exporting countries.

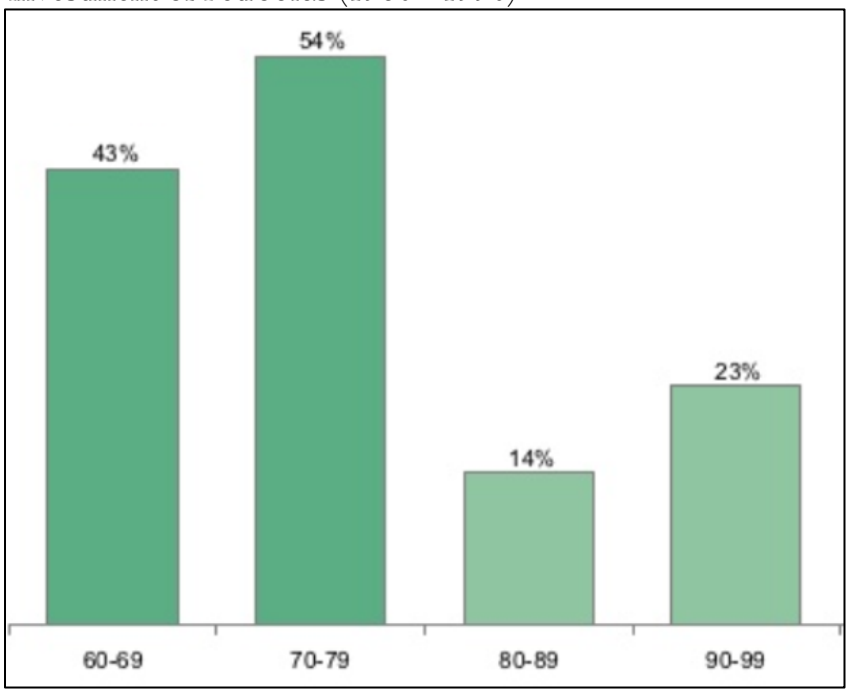
The results of the pre-salt enterprises are currently being harvested by the company. Between 2010 and 2016, there was an almost24-fold growth in the daily

production of petroleum in the cluster, which jumped from 41 thousand barrels per day to 1 million barrels. In January 2017, production reached approximately 1.588 million barrels of oil per day, when pre-salt production accounted for 47% of the total oil production in Brazil (ANP, 2017).

3. The performance of Petrobras in the Brazilian refining segment and the resumption of investments in the sector during the governments of PT

In the refining sector, Petrobras is also the top Brazilian protagonist, since it owns 16 of the country's 18 refineries. The initial focus of the company was on the search for self-sufficiency in oil derivatives to account for the growth of domestic demand in a context marked by the vigorous growth of the Brazilian economy. The construction of several oil plants enabled a significant increase in the hydrocarbon processing capacity of Brazil.

Figure 2. Percentage of investments in downstream/total investment of Petrobras (1960 - 1990)



Source: Costa (2010).

Figure 2 demonstrates that during the 1960s and 1970s, Petrobras investments were predominantly directed towards the refining sector (Perissé, 2007). During this period several refining plants were built, and the company was able to significantly reduce dependence on imported refined products. Therefore, the country's refining capacity increased by 1,000% in 20 years, i.e., an increase in

production capacity from 150,000 barrels per day (bpd) in the early 1960s to 1.5 million (bpd).

Investments in the refining sector aimed to meet the growing domestic demand due to the industrial development and growth of the Brazilian automobile fleet (Ponzoni, 2009). Furthermore, Surrey (1987) reported that the country's oil policy during this period was aimed at achieving self-sufficiency in fuel production to overcome the high import costs of these products.

After the two oil crises, the focus of the company turned to Exploration and Production activities. The discovery of the Campos Basin in 1974 and the first giant deepwater field (Alabacorra) in 1984, reinforced such a focus. More recently, during the PT governments, more precisely between the end of President Lula's first governmentand the last year of the first term of President Dilma's government, there wasa significant growth in the share of investment in refining, both in absolute and relative terms (see Table 3).

Table 3. Petrobras: total investments, investments in oil refining, and investments in refining/total investments (2006 – 2014) in R$ million*

YEAR	TOTAL INVESTMENTS	INVESTMENTS IN OIL REFINING	INVESTMENTS IN OIL REFINING/ TOTAL INVESTMENTS
2006	61.66	7.68	12%
2007	80.36	18.8	23%
2008	90.51	20.38	23%
2009	102.91	26.46	26%
2010	117.46	43.75	37%
2011	105.29	39.35	37%
2012	114.66	39.33	34%
2013	134.1	39.58	30%
2014	105.95	22.2	21%

Source: Petrobras (many years). *monetary values corrected by IPCA (2018 = 100)** There is a gap between 2003 and 2005, as the data were taken from the Petrobras annual reports, which are available on the company's homepage for the period 2006 to 2018.

During the PT governments,the Petrobras investments and procurement policy were key elements in the development agenda. It is within this context that it is possible to observe a strategy of strengthening the integrated profile of the company with substantial investments, not only in exploration and production activities, but also in the refining sector. The resumption of refining investments may be associated with the growth in Brazilian demand for derivatives due to a

more significant growth of the economy and an increase in the country's fleet of vehicles. Additionally, a growth in the production of crude oil may be considered an important stimulus for the expansion of the Brazilian refining capacity.

Investments were made in the implementation of delayed coking units[4] at the Duque de Caxias (Reduc), Henrique Lage (Revap), and PresidenteGetúlio Vargas (Repar) refineries. These investments brought greater flexibility to the Brazilian oil company, allowing it to define the basket of oil derivatives produced from the demand profile and the behavior of market prices. Thus, the implementation of catalytic coking units in some of Petrobras' refineries made it possible for the company to choose between the use of "imported oil - lighter and producing higher value derivatives and the refining of national heavy oil" (Petrobras, 2007).

In addition, with regard to the company's investment strategy to modernize its refining plant, Petrobras implemented hydrotreatment units (HDTs) in nine refineries. Treatment with hydrogen enables a reduction of the sulfur content in oil derivatives. Thus, it is a technology that has made it possible for the company to comply with the stricter Brazilian environmental specifications in force since 2009 andhas allowed the opening of new markets (such as the North American and European) for the export of derivatives (Petrobras, 2006).It maytherefore be stated that the strategy implemented by Petrobras until recently in the downstream, is in line with the two main challenges of the global refining industry, according to Branco, Gomes, and Szklo (2010, p. 3098)

> the first strategy is to increase refinery complexity and versatility; the second is to integrate the refining and petrochemical industries, adding value to crude oil, while guaranteeing the market share to premium oil products.

In addition, with an increase in the demand for oil products in the Brazilian market, and the prospect of increased exports due to an increase in crude oil production in Brazil, especially after the pre-salt discoveries in the late 2000s, Petrobras announced the construction of four new refineries: the Abreu e Lima refinery (or Refinaria do Nordeste - RNEST), Comperj, and the Premium I and Premium II refineries.Initially, the implementation of RNEST was foreseen as a partnership involving Petrobras and PDVSA (the Venezuelan state-owned oil and natural gas company). However, negotiations with PDVSA did not advance, and

[4] According to Botelhoet al., (2015, p. 467), "The delayed coking unit (UCR) under study has the objective of converting heavy oil fractions into light fractions of higher value, through a thermal cracking mechanism" (Citations originally in Portuguese have been translated by the authors).

the project was carried out solely by the Brazilian company. The refinery started its partial operation in 2014 (34 years after the construction of the last Petrobras refinery) with an installed capacity of 74 thousand barrels per day (bpd) of oil. When it is operating at full capacity, it will have the capacity to process up to 230,000 barrels of heavy oil and produce up to 162,000 bpd of diesel, its main product. The refinery will also produce Liquefied Petroleum Gas (LPG), petrochemical naphtha, fuel oil for ships, and petroleum coke.

The Rio de Janeiro Petrochemical Complex, better known as Comperj,the cornerstone of what was considered the largest development in the history of Petrobras, was launched in 2006. This project would involve investments of US$ 13.5 billion, used in the construction of an innovative refinery that would transform heavy oil (produced in the Campos basin) into petrochemical products (Paduan, 2013). In the meantime, there have been some changes to the original projectand two refineries will be built, instead of one; such a complex will be responsible forfuel production and no longer petrochemical products (Paduan, 2013).

In addition to these two projects, Petrobras, in its annual activity report published in 2008, announced the construction of two other refineries: Premium I and Premium II. These refineries were to be installed in the states of Maranhão and Ceará, respectively, for the production of "high quality and low sulfur derivatives from the processing of heavy and acid oil" (Petrobras 2008, p. 44). The processing capacity of the Premium I Refinery would be 600 thousand bpd, while the Premium II Refinery would be 300 thousand bpd.

Recent Petrobras investment in the refining area saw a 17% increase in Brazilian refining capacity between 2007 and 2016, from 2.07 million barrels per day to 2.41 million barrels per day (ANP, 2017). The expansion of its refining capacity allowed the company to reverse its net importer profile of oil derivatives (see Table 4).

Table 4. Exports *versus* imports of Petroleum Products (Thousand bpd) by Petrobras (2002 - 2009)

Year	Exports	Imports
2002	206	216
2003	213	105
2004	228	109
2005	260	94
2006	246	118
2007	262	148
2008	234	197
2009	227	152

Source: Petrobras (over many years).

As may be observed in Table 4, in 2002, Petrobras imported a larger volume of oil derivatives from the rest of the world than the amount exported. However, from 2003 the situation is reversed. Between 2003 and 2009, the Brazilian state-owned company became a net exporter of oil derivatives in a context marked by a reduction in imports of derivatives compared to 2002, and an increase in exports of derivatives in comparison to the same year. The peak occurred in 2005, with a balance of 166 thousand bpd.

In conclusion, during this period, the Brazilian government and Petrobras realized the importance of investing in the refining segment to reduce Brazil's vulnerability in oil and petrochemical products. The purpose was to modernize the installed refining plant and expand production to account for the country's growing demand for these products, as evidenced in the study by Tavares et al. (2005).

4. The change of strategy in the refining segment during president Temer's government

Difficulties faced by Petrobras more recently, as well as a change in the company's direction during President Temer's government, initiated after President Dilma's impeachment, has brought about a drastic strategic change for the company in the refining segment. The net loss in 2014 and 2015 and a revision of its investment plans for the coming years (with a decrease as compared to the original plan) are manifestations and reflections of this crisis.

It should be noted that the investment decisions of Petrobras during the boom period were designed considering the generation of revenues and the use of third-party resources (debt), with the oil barrel expectations of above US$ 80, and

considering the appreciation of the Brazilian currency. A contraction in oil prices and the depreciation of the Real against the Dollar caused a significant increase in the Petrobras debt. The company's consolidated debtgrew from R$ 181 billion in 2012 to R$ 436 billion in 2015 (AEPET, 2017).

One of the repercussions of the crisis presently experienced by Petrobras was the decision made by the board of directors to abandon the projects of the Premium I and Premium II refineries. This decision was made, according to a company press release (Petrobras, 2015)

> because the projects lacked economic attractiveness until this moment, taking into consideration the expected growth rates of the domestic and international derivatives markets, as well as the absence of an economic partner for its implementation, a condition foreseen in the 2014-2018 Business and Management of the company.

The abandonment of Premium I and II refinery projects is in line with the 2017-2021 Strategic and Business Plan, in which the company defined its projects in the area of oil production as the focus of the period. The data in Table 5 reveals the decline in investments in the refining sector in the recent period (from the first year of the second term of President Dilma to the last year of the President Temer's government) in absolute and relative terms.

Table 5. Petrobras: total investments, investments in oil refining, and investments in refining/total investments (2015 – 2018) in R$ million*

YEAR	TOTAL INVESTMENTS	INVESTMENTS IN OIL REFINING	INVESTMENTS IN OIL REFINING/ TOTAL INVESTMENTS
2015	87,20	12,20	14
2016	57,15	6,86	12
2017	49,64	8,04	16
2018	49,37	5,71	12

Source: Petrobras (many years). *monetary values adjusted by IPCA (2018 = 100)

In addition to this, a downsizing strategy has also been adopted by the Brazilian state-owned company, involving a reduction in its activities in the areas of petrochemicals, fertilizers, and biofuels, a reduction in investmentsand the privatization of refining assets. Evidence of this strategy is the divestment program prepared by the management team of Pedro Parente, which provided for the sale of assets to the amount of US$ 21 billion for the 2017-2018 biennium (Petrobras, 2017).

As part of the disinvestment program implemented by the Brazilian oil company, 70% of the Landulpho Alves Refinery (RLAM) located in Bahia, was sold to a multinational company, whose name has not been disclosed. It is important to note that RLAM is the country's second-largest refinery in terms of processing capacity (Pereira, 2017). The next asset on the divestment list was the Pasadena refinery located in the US, in the state of Texas. One of the scenarios discussed internally by the Petrobras management is the sale of shareholdings in at least 6 of the 14 refineries in operation in Brazil. Abreu e Lima (RNEST), Alberto Pasqualini (Refap), PresidenteGetúlio Vargas Refinary(Repar), Duque de Caxias Refinery (Reduc) and, Gabriel Passos (Regap) are on the list. These refining plants have a combined capacity to process around 1,235 million bpd, about half the country's total capacity. According to the Petrobras manager for business restructuring, refining, transportation and commercialization, Arlindo Moreira Filho, the company intends to put up 60% of the refining center of the South and Northeast (Ramalho and Polito, 2018). There are therefore, signs that a Brazilian oil company specialization project is being developed in the production of crude oil.

This logic of divestments has also permeated the current management of Petrobras, under the government of President Bolsonaro. In April of this year, the sale was completed of the Pasadena refining system decided during President Temer's government. The system was sold to US-based Chevron (Moreira, 2019). Further to this, the Petrobras "New Guidelines for Portfolio Management" (Petrobras, 2019) has also been recently approved. In the following extract from this document, the focus of the company's management on the sale of assets, especially in the refining and distribution segments, is evident

> The new guidelines consider the sale of assets, with emphasis on the downstream segment, including the full sale of PUDSA, a network of service stations in Uruguay, eight refineries with a total refining capacity of 1.1 million barrels per day, and the additional sale of the stake in Petrobras Distribuidora (BR), with Petrobras remaining as a relevant shareholder. The downstreamassetsincluded in thisdivestmentprogram are: Refinaria Abreu e Lima (RNEST), Unidade de Industrialização do Xisto (SIX), Refinaria Landulpho Alves (RLAM), Refinaria Gabriel Passos (REGAP), Refinaria Presidente Getúlio Vargas (REPAR), Refinaria Alberto Pasqualini (REFAP), Refinaria Isaac Sabbá (REMAN) and Lubrificantes e Derivados de Petróleo do Nordeste (LUBNOR).

In addition to the divestment strategy in the refining segment, it is important to draw attention to the drop in the utilization factor of the Brazilian refining park over recent years.According to the data presented in Table 6, there was a decrease

in the usage factor of refining capacity installed in the country from 91% in 2007, with a peak of 98% in 2013, to 80% in 2016.

Table 6. Utilization factor of the Brazilian refining plant (2007 - 2016)

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Usage Factor (%)	91,0	89,7	90,9	91,0	92,6	96,1	98,0	94,1	87,0	80,0

Source: ANP (2017).

As from PresidentTemer's government, besides the disinvestments in the sector, Petrobras adopted a policy change in fuel prices. The pricing policy linked to the international price variation and foreign exchange, inaugurated by Parente, was detrimental to both Petrobras and the consumer. In the case of the Brazilian oil company, it lost its market and sales revenue by occupying up to 30% of the Brazilian market to importers of petroleum products, causing the most expensive fuel to run into its refineries. Without being able to dispose of its production, Petrobras refineries needed to limit the oil load and became idle, by up to 30% (Coutinho, 2018). It is important to emphasize that the price of gasoline and diesel are key prices of an economy such as Brazil's, which signifies that they have a high impact on inflation, given that the modal road transport is critical for transporting goods and people. Hence, allowing the price to oscillate to the taste of the market seems to us a misguided governmental attitude. At the end of the truck drivers' strike in Brazil, with a reduction in fuel prices, Petrobras managed to regain its share on the domestic market, which allowed it to substantially increase its refining profit, as demonstrated on the balance sheet for the second quarter of 2018 (Petrobras, 2018). Given this, it is evident that the strategy to follow the oscillations of international prices is inadequate.

According to the Second Bulletin of the Conjuncture of the Petroleum Industry in Brazil, issued by the Energy Research Company (EPE, 2017, p. 11), linked to the Ministry of Mines and Energy (MME), "the perspective is that Brazil consolidates its position of net oil exporter and net importer of oil derivatives in the coming years". Considering the importance of Petrobras to the Brazilian economy and the opportunities that the discovery of the pre-salt brings to the country (including in terms of the increase in the production of oil products), the productive specialization represents a setback.

The results of the pre-salt enterprises are currently being harvested by the company. Between 2010 and 2016 there was a 24-fold growth in the daily

production of petroleum in the cluster, which jumped from 41 thousand barrels a day to 1 million barrels. In January 2017, production reached approximately 1.588 million barrels of oil per day, when pre-salt production accounted for 47% of the total oil production in Brazil (ANP, 2017). Therefore, the decline in investments and in the utilization factor of the Brazilian refining plant does not seem rational, precisely at the moment when the country undergoes an increase in the production of crude oil from production in the pre-salt reservoirs.

Thus, the rationality of this downsizing strategy must be questioned, since, despite the current difficulties faced by Petrobras, the company and the country encounter favorable conditions to carry out a resource-based industrialization strategy (Paz, 2014). This step back has been accomplished at a time when the National Petroleum Company is making a significant jump in its crude oil production, therefore, precisely when it is faced with a promising opportunity to expand its productive chain and strengthen the business model from the well to pump. It should be noted that this model is highly revered amongst the large oil companies.

The reflexes of this scenario may already be observed in the current Brazilian trade balance. In the first ten months of 2017, amongst the main products of the Brazilian import tariff, there wasa significant participation of oil derivatives. During that period, diesel oil was the top Brazilian import, when the country spent US$ 4.4 billion on importating this product (a growth of 90% over the previous year). Another product derived from petroleum, gasoline, also had a significant participation in the Brazilian import tariff. In the first ten months of 2017, Brazil importedUS$ 1.5 billion in gasoline, an increase of 93% compared to 2016 (MDIC, 2017).

The increased imports of oil products over recent years has not only influenced the country's trade balance, but also the Petrobras cash flow. In specific terms, this rise in imports has been disastrous for the company's financial health, since the government hasfrequently obliged the company not to pass on to consumers the total cost assumed with the importation of oil and its derivatives(AEPET, 2017).

It is possible to associate the decisions made by the current management of Petrobras to reduce the utilization factor of its refining plants, the attempt to align domestic and international fuel prices and the incentive to import derivatives (with unfavorable exchange rates) with the shortagecrisis that hit the country. The fuel

price increase, especially diesel, due to the strategies of Petrobras, triggered the Brazilian truckers' strike in the second half of May 2018. As the road modal is neuralgic for the transport of raw materials and goods, and given the importance of fossil fuels for transportation, the truck drivers' strike unleashed chaos in Brazilian society, with severe consequences for the economy. In addition to the importance of diesel, because of the preponderance of road transport, gasoline occupies the first place in the light vehicle market (Silva et al., 2014).The current crisis reveals the importance of the refining sector for the country, which reinforces the pertinence of the research presented in this article.

With regard to the Petrobras strategy of divestment and downsizing in the refining segment, it is important to emphasize that vertical integration represents a dominant strategy amongst the major oil companies. Thus, in spite of outsourcing some upstream activities (such as acquisition, processing and geophysical interpretation, drilling, cementation, and profiling) to oilfield equipment and service companies, the main companies in the oil sector have a strong performance in all segments (Barlow, 2000).

To compensate the high risks and the long maturation of the initial stages of theoil chain, these companies do not lose sight of the role played by the final stages regarding value aggregation and, above all, by the activity of refining. Such an activity is crucial for major oil companies, precisely because oil derivatives represent an important source of revenue and profitability for these companies.According to Patrick Pouyanné, CEO of the French oil company Total:

> Only a few years ago, many experts or advisers were pushing us to divest our downstream business and to focus on upstream only. We were right then not to listen to them and to stick to our model. Because, while it is true that upstream is more leveraged to oil prices than downstream, it is also true that downstream helps to recover part of the added value lost by upstream and may offer less cyclical revenues, which are most welcome in the low cycle (Pouyanné, 2017).

The vision of John Abbott, Downstream Director of Royal Dutch Shell, converges with Pouyanné's perception. According to Abbott, "Downstream is a highly resilient business. It is pretty independent to changes in crude price" (Bousso and Zhdannikov, 2017).The fact that the refining segment (along with other downstream activities such as chemical manufacturing and marketing) provided most of Shell's profits since the oil price collapse occurred in 2014 proves its importance and corroborates the assertion of Abbott.

Vertical integration allows them access to the raw material, dilutes the risks inherent to the E&P area, and maximizes revenues and profits. Instead of pursuing a profit margin for each stage of the chain, vertically integrated companies start maximizing the return of the oil chain as a whole.In this sense, it can be said that the current strategy of Petrobrasof downsizing and divestment in the refining segment is against the hegemonic business model amongst the major oil companies.

5. Methodology

In this work, we intend to use the panel data methodology, since this allows the researcher to combine cross-section with time series. The most straightforward representative of this estimation is the following

$$Y_{it} = \alpha + X'_{it}\,\beta + \delta_i + \gamma_t + \varepsilon_{it} \qquad (1)$$

Where Y_is the dependent variable, X'_{it} is a vector of explanatory variables, andε_are the error terms for i = 1, 2, .., j for the observed transverse units for the periods t = 1,2. .., T. The parameter α refers to the global constant in the model, while δ_i e γ_t are the specific effects of the period.

The panel data model can be estimated statically or dynamically. The main specifications of the static model are: Fixed Effects and Random Effects. In dynamic panel data models, the explanatory variables are endogenous, but this method allows non-biased estimators to be obtained, unlike static models, in which the estimated coefficients are biased when deferred dependent variables are included.

Dynamic panel data models may be estimated via the Generalized Moment Method (GMM), as it makes it possible to calculate the model parameters a minimum amount of momentum conditions. Dynamic models include the lagged dependent variable as one of the explanatory variables, as described in (2). This inclusion is fundamental to control possible sources of bias of the estimators (BALTAGI, 2005).

Given the dynamic model

$$Y_{it} = \alpha + \beta_1 Y_{it-1} + \beta_2 X_{it} + \gamma_i + u_{it} \qquad (2)$$

In this model, Cov $(\gamma_i, y_{it-1}) \neq 0$. From the above, after taking the first difference, we have the following equation

$$\Delta Y_{it} = \beta_1 \Delta Y_{it-1} + \beta_2 \Delta X_{it} + \Delta u_{it} \quad (3)$$

This procedure circumvents the endogenous problems of the model.

It may be said that there are two dynamic panel data model estimators, the GMM Difference, in which it corrects problems of endogeneity with the use of instrumental variables, although these instruments may be weak for a set of variables that are not strictly exogenous if the lags behave like a random walk.

To overcome the problems of bias and inconsistency in the GMM Difference estimator, the GMM System estimator was developed. The authors of this estimator were Arellano and Bover (1995) and Blundell and Bond (1998). The estimator hypothesizes that the variables on the level and the first differences are considered instruments of the model and are not correlated with the fixed effects, which increases the number of instruments and generally improves the efficiency of the estimations (BAUM, 2006).

5.1. Database

The construction of the database was based on the compatibility of two bases for separating exports into three categories considered for analysis of the Brazilian petroleum sector and, eventually, identifying strategies for this sector in a context of progress and anintensification of the fragmentation of world production.Exports from the sector under study were broken down into:

i) Exports of Basic Inputs: this category refers to exports of crude oil only.

ii) Exports of Intermediate Inputs: this category refers to the exports of Intermediate Inputs of Coke and Refined Petroleum Manufactures.

iii) Exports of Finished Goods: includes exports of Manufactured Coke and Refined Petroleum destined for the final consumption of the trading partners.

For the first breakdown, data were separated from the construction of a weighting data compatibility calculated by MDIC/Secex and WIOD (2016). The data source for the other categories was only the WIOD database (2016).

The use of the World Input-Output Database (WIOD, 2016) allows us to evaluate the trade in more disaggregated terms, which provides greater precision in a trade pattern analysis under the context of greater production fragmentation. The WIOD were grouped from national accounts, usage and resource tables, and detailed data on bilateral trade in products and services from 56 sectors classified

according to ISIC Rev. 4 from 43 countries, including Brazil. They also contemplate all the other countries, portraying them by a proxy denominated "Rest of the World" (Row).

A simplification of the WIOD in a scheme with only two countries (country A and country B) and three sectors (s1, s2, and s3) is depicted in Table 1, below. The rows contain pairs of industry and country suppliers and the columns, industry-country pairs as users of intermediaries and final consumers. For the destination of products for final consumption, the matrix specifies four categories of destination: 1) Final household consumption; 2) Final consumption by non-profit organizations serving households 3) Final consumption of public administration; 4) Gross Formation of Fixed Capital.

In each bilateral relationship, the destination of each product is defined as to whether it is used for intermediate or final consumption, and for each country, the origin of the products is identified; whether they are produced internally or imported.

Figure 3. Representation of Input-Output Matrix - Example for WIOD

		Country A Intermediate *Industry*	Country B Intermediate *Industry*	Rest of World Intermediate *Industry*	Country A Final domestic	Country B Final domestic	Rest of Final domestic	Total
Country A	*Industry*	Intermediate use of domestic output	Intermediate use by B of exports from A	Intermediate use by RoW of exports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	*Industry*	Intermediate use by A of exports from B	Intermediate use of domestic output	Intermediate use by RoW of exports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	*Industry*	Intermediate use by A of exports from RoW	Intermediate use by B of exports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
		Value added	Value added	Value added				
		Output in A	Output in B	Output in RoW				

Source: Produced by the authors from Timmer et al. (2012).

All data available in the WIOD are measured in millions of dollars, and the period covers the years 2000 to 2014. The calculations made to separate the variables to be used in the econometric estimations are shown in detail below

a) Brazilian Exports of Crude Oil Petroleum for country i

i) Weight

$$Export\ Crude\ Oil\ of\ Petroleum_{Bra} = \frac{Export\ Crude\ Oil\ of\ Petroleum}{Total\ Export\ Extrative\ Industry}$$

ii) Exports of Crude Oil by trading partner

$$Export\ Crude\ Oil\ of\ Petroleum^{i}_{Bra} = \sum_{j=1}^{56} Mining\ and\ Extraction\ \ {}^{ji}_{Bra} * Weight$$

where i represents commercial partner, and j represents the sector of the country i.

b) Brazilian Exports of Intermediate Inputs of Coke and Petroleum Manufactures Refined by trading partner

$$Intermediate\ Inputs^{i}_{Bra} = \sum_{j=1}^{56} Intermediate\ Inputs\ of\ Coke\ and\ Petroleum\ Manufactures\ Refined\ {}^{ji}_{Bra}$$

where i represents commercial partner, and j represents the sector of the country i.

c) Brazilian Exports of Manufactured Coke and Refined Petroleum destined for final consumption of trading partners

$$Finished\ Goods\ {}^{i}_{Bra} = \sum_{j=1}^{56} C_1^{ji} + C_2^{ji} + G^{ji} + I^{ji}$$

where i represents commercial partner and j represents the sector of the country.

Calculation based on the sum of products exported by the Coke Manufacturing and Refined Petroleum industry from the Brazilian economy to each sector j of partner i that were destined for final household consumption (C_1), final consumption of non-profit organizations (C_2); final government consumption (G), and Gross Fixed Capital Formation (I).

GDP data at constant prices of 2011, made available by the World Bank, were usedto estimatethe income elasticities on each export category considered. Models were also estimated, including the exchange rate, oil price, anddummy for the post-crisis period. For the exchange rate, the annual average of the real effective exchange rate was used, made available by BIS (Bank for International Settlements).

Data on oil prices were obtained from the British Petroleum (BP, 2017) report, using the oil price in dollars (US$)/barrel - Brent $ bbl. All data were deflated by the United States CPI, based on 2011 data, andconverted into logarithmic form.

The specification of the models is detailed, according to the following equations:

Model 1: $ln\ (Export^{h}_{it}) = ln\ (Export^{h}_{i\,t-1}) + ln(GDP_{it}) + u_{it}$

Model 2: $ln\ (Export^{h}_{it}) = ln\ (Export^{h}_{i\,t-1}) + ln(GDP_{it}) + ln(Exchange\ Rate_{it}) + u_{it}$

Model 3: $\mathbf{ln}\ (\boldsymbol{Export^{h}_{it}}) = \ln\ (Export^{h}_{i\,t-1}) + ln(GDP_{it}) + ln(Exchange\ Rate_{it}) + ln(Price\ of\ Petroleum_{t}) + u_{it}$

Model 4: $ln(Export^{h}_{it}) = ln\ (Export^{h}_{i\,t-1}) + ln(GDP_{it}) + ln(Exchange\ Rate_{it}) + ln(Price\ of\ Petroleum_{t}) + Dummy\_Crisis + u_{it}$

On whath denotes exports of crude oil, exports of intermediate inputs of coke and refined petroleum, and exports of final goods made from coke and refined petroleum; i represents a trading partner; t shows the period.

5.2. Results

The results obtained in the econometric estimations of the panel data models by GMM System (Two-Step) are shown in Table 7.

Table 7. Elasticity Results of Exports - GMM System

Dependent Variable (Y): ln(Export of Basic Inputs - Crude Oil of Petroleum)				
Independent Variables	**Model 1.**	**Model 2.**	**Model 3.**	**Model 4.**
Constant	-19.236*	-20.319***	-20.358***	-20.826***
	(10.87)	(7.319)	(6.917)	(0.687)
$\ln Y_{(t-1)}$	0.521***	0.531***	0.498***	0.495***
	(0.041)	(0.448)	(0.056)	(0.060)
ln(GDP)	0.753**	0.804***	0.802***	0.800***
	(0.405)	(0.275)	(0.253)	(0.259)
ln(ExchangeRate)	-	-0,059	-0,145	-0.076
		(0.260)	(0.270)	(0.274)
ln(Price of Petroleum)	-	-	0,125	0 .191
				(0.134)
Dummy_Crisis				-0.130
			(0.090)	0.181
AR(2)	0,082	0,080	0,079	0.065
Hansen	0,311	0,785	0,771	0.738
Diff-Hansen	0,654	1,000	0,968	0.942
Nº of Observations	574	574	574	574
Nº of Instruments	41	55	55	55
Dependent Variable (Y): ln(Export of Intermediate Inputs - Coke and Petroleum Manufactures Refined)				
Independent Variables	**Model 1.**	**Model 2.**	**Model 3.**	**Model 4.**
Constant	-25.529**	-29.844***	-30.208***	-31.55***
	(11.480)	(8.344)	(7.925)	(0.824)
$\ln Y_{(t-1)}$	0.520***	0.493***	0.469***	0.485 ***
	(0.066)	(0.075)	(0.076)	(0.084)
ln(GDP)	0.926**	1.004***	1.016***	1.037***
	(0.430)	(0.325)	(0.311)	(0.334)
ln(ExchangeRate)		0,448	0,391	0.492
		(0.327)	(0.333)	(0.422)
ln(Price of Petroleum)			0,066	0 .178
			(0.104)	(0.230)
Dummy_Crisis				-0.240
				(0.401)
AR(2)	0,217	0,241	0,251	0.234
Hansen	0,400	0,865	0,804	0.849
Diff-Hansen	0,249	0,756	0,874	0.346
Nº of Observations	574	574	574	574
Nº of Instruments	41	55	55	55
Dependent Variable (Y): ln(Export of Final Goods - Manufactured Coke and Refined Petroleum)				
Independent Variables	**Model 1.**	**Model 2.**	**Model 3.**	**Model 4.**
Constant	-17,396	-21.863***	-20.833**	-20.91***
	(13.362)	(7.489)	(0.107)	(0.685)
$\ln Y_{(t-1)}$	0.572***	0.535***	0.517***	0.554***
	(0.107)	(0.086)	(0.107)	(0.106)
ln(GDP)	0,600	0.665**	0.616**	0.596**
	(0.492)	(0.280)	(0.285)	(0.269)
ln(ExchangeRate)		0,527	0,448	0.515
		(0.370)	(0.341)	(0.351)
ln(Price of Petroleum)			0,139	(0.259)
			(0.145)	(0.191)
Dummy_Crisis				-0.225
				(0.363)
AR(2)	0,028	0,027	0,030	0.024
Hansen	0,282	0,846	0,769	0.770
Diff-Hansen	0,873	0,69	1,00	1.000
Nº of Observations	574	574	574	574
Nº of Instruments	41	55	55	55

Source: Produced by the authors based on results obtained in Stata 11.Note (1) Robust errors in parentheses.Note (2): Y_ (t-1) represents the dependent variable lagged in each equationNote (3): Statistical Significance at 1% (***); Statistical Significance at 5% (**); Statistical Significance at 10% (*).Note (4): All estimated GMM models are GMM System Two-Step and include time dummies.

The choice of the GMM System on the GMM Difference is justified by the high p-values for the Hansen difference test. In this case, the GMM System Two-Step was used for all estimates because it was more adequate and efficient. The

table presents the reported p-values corresponding to the statistics of the SecondOrder Autocorrelation tests of Differential Residues (RA [2]), the Hansen Test and the Hansen-Difference Test[5].

The measurement of the income elasticities of each category of oil sector export classification was based on the estimation of four different models, considering the inclusion of control variables: exchange rate, oil price, and the post-crisis period (2008).In the first sets of models in which the dependent variable is the exports of crude oil and intermediate goods, the tests indicated exogeneity and validity of the instruments. However, in a general analysis of the results, it is evident that only the lagged dependent variable, the constant term, and the income in the logarithmic form, were statistically significant to explain the respective categories of exports considered. Brazil, traditionally, is a country that consumes crude oil and its intermediary inputs of this commodity, which explains the constant negativeand high level in all the estimated models.

It is also observed that there is no statistical significance of the price elasticity in any model, both concerning the price measured by the exchange rate, the price of crude oil and its intermediate inputs. In the analyzed period, the exchange rate appreciated continuously, but it was not decisive in explaining the fall in exports of crude oil and intermediate inputs. The price of oil has remained high and cannot be considered a significant determinant of the drop in exports of the commodity over recent years, since it was aroundUS$ 100, which is considered high.

The post-crisis dummy was also not statistically significant in these models. This result shows that the 2008 crisis had no impact on export performance nor the magnitude of the coefficient associated with trade partner income. Thus, the export performance of the sector under analysis is fundamentally related to the economic performance of its trading partners, which was the only statistically significant variable of the model. The result is in line with expectations since the Brazilian performance in the oil sector is mainly concentrated in the exploration and

[5] All estimates were performed using the xtabond2 command, developed by Roodman (2009), in Stata 11. In all estimations, the standard errors were corrected using the robust command, a procedure developed by Windmeijer (2005). In addition, the collapse command was also used. The collapse command can deal with the proliferation of instruments that can invalidate some asymptotic results and specification tests. With respect to this last aspect, before making estimates using the collapse command, the command lag limits were also adopted. However, this procedure did not result in a reduction in the number of instruments enough to purge endogenous components of the variables, with the p-values of the diff Hansen test statistic being equal to 1 for all models.

production of oil. It may be noted that the income elasticities of crude oil exports were significant and close to 0.8%, while the income elasticities of exports of intermediate inputs were significant and close to 1%. Therefore, since crude oil and intermediary inputs are products with low added value, the sensitivities associated with partner income are inelastic or, at best, hypotheses, equal to one. Thus, variations in world income positively and significantly impact exports,although less than proportionately.

In the models in which the dependent variable is oil derivatives exports, the tests indicated exogeneity and validity of the instruments. It should be noted that, once again, the lagged dependent variable, the constant term and the income of the trading partners, in the logarithmic form, were statistically significant to explain the exports considered. Brazil has traditionally been a country that consumes this commodity, which explains the constant negative and high level of the estimates related to petroleum derivatives.

To understand these results, it is important to take into account certain characteristics of the Brazilian oil and gas industry. First, it should be noted that the country's production is predominantly heavy oil. According to Castellar and Feijó (2006), "there are two types of oil: the so-called light oils, of which it is easier to extract gasoline and other noble derivatives, and the heavier ones, denser, good for making asphalt and fuel for machines". The variety of oil produced in Brazilian reservoirs allows gasoline and other fuels to be produced, but at a higher cost. Second, it is important to consider the fact that most of the Brazilian refineries were configured to process light oil since they were installed before the discoveries in the Campos basin, which occurred mainly between the 1980s and 1990s. As in this cluster, there is the concentration of heavy oil; in the old oil refineries, Petrobras has mixed the oil produced in the Brazilian reservoirs with imported oil, lighter and of a superior quality (Lima and Silva, 2012). Finally, from the 2000s onward, there was a significant increase in the Brazilian fleet of vehicles, which represented an increase in the demand for oil products.

When considering the results obtained for the model in which there are exports of petroleum products destined for final consumption as a dependent variable, we may observe that income elasticityis less than 1 (about 0.6%), which indicates a lower sensitivity of exports regarding changes in world income. This positive and significant sensitivity, even smaller than unity, demonstrates that the country has broken the barrier for entry into the export sector of oil products. If

we had found negative or non-significant sensitivities, the hypothesis of the entry barrier would not be confirmed.

Thus, the econometric results demonstrated two things:

i) First, the sensitivity of the final goods production (refined oil) is relatively lower when compared to the other segments;
ii) but it also displayed that this may still be a viable strategy for the company to move up the global value chain and, once again, to be one of the world's leading companies in the oil and gas sector, i.e., the company is within the global value chain of the oil industry.

The sensitivity of the exports of final goods for the world income is less than 1, which is relatively lower than the elasticities obtained for the other segments analyzed, confirming the strategy adopted by Petrobras to concentrate on the production and export of crude oil and input intermediaries. On the other hand, although less than unity, the positive, significant result of the income elasticity of exports is evidence that the company has also been acting as a supplier of final goods in international trade relations. This result indicates that Petrobras is already a supplier of oil derivatives, and there is no longer any barrier to entry, so it has already been broken, in the trade of oil products with higher added value in the period under analysis. The next step would then be to explore opportunities for advancement in the oil production chain. In this sense, we question the divestment strategy of Petrobras currently underway in the refining sector.

6. Conclusions and policy implications

The objective of this study was to evaluate the strategies currently carried out by Petrobras management in refining, in the light of econometric data. From the estimates presented in this article, it is possible to affirm that Brazil has already entered the international refining market. Given the large volume of oil in the Brazilian pre-salt, there is an interesting perspective for Petrobras to increase the production of derivatives, and the consequent sale of surplus production in the international market. The data reveal that Brazil has definitively broken the barrier for entry into this sector, indicating that there is a window of opportunity for Brazil to enter the international derivatives market as a leading player.

Furthermore, the oil sector, and particularly Petrobras, as highlighted throughout this article, is highly strategic for Brazilian growth, and may become a propelling force for structural changes within the country. However, the recent crisis experienced by Petrobras and the downsizing strategy in the downstream

sector indicate Brazil's (and Petrobras') weak positionin the international oil sector: exporter of crude oil and importer of derivatives.

Considering the precariousness of this position and taking into account the data presented in the econometric estimations, it is argued herein that the company should review its asset sales strategy in the refining and petrochemical areas. The divestments carried out in the refining area, and the lack of strategic vision by the current Brazilian government could have disastrous consequences for the country. This strategy, based on a short-term perspective, favoring only animmediate return to the company's private shareholders, severely compromises the sustainability of Petrobras activities in the medium and long-term. At its limit, this strategy may also imply the end of Petrobras as we currently know it, an integrated company that acts from well to the filling station and is internationally recognized as a major player in the industry. The truck drivers' strike and the shortage crisis, which occurred in Brazil in May 2018, practically paralyzing the country for one week, stripped the pertinence from studies that have focused on the policy of the country's government and Petrobras concerning the refining sector.

Vertical integration is a dominant strategy among major oil companies. These companies do not dispose of assets in the refining area, even in a crisis period, since it is from this that they derive a significant part of their profits, as well as counterbalance any upstream losses due to a fall in the price of crude oil. Thus, Petrobras, by reducing the factor of use from its refineries, increasing imports of derivatives and disposing of assets in the refining area is acting contrary to the way in which the big oil companies behave. Based on the preceding, it is imperative that the strategy for the Brazilian oil sector be rethought.

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