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# Diesel imports dependence in Brazil: A demand decomposition analysis

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ABSTRACT

Brazil became self-sufficient in volume of crude oil. However, this has not reduced the dependence of foreign oil products. Brazil imports finished diesel, since its refineries lack hydro-refining units to produce the low-sulfur diesel needed. This paper uses an index decomposition approach to investigate the Brazilian import dependence on petroleum products from the demand side, focusing on today's most relevant oil product in the country: diesel. The three major diesel end uses in the country are decomposed, showing that freight transport is the most vulnerable end use, given Brazil's reliance on cargo movement to drive economic activity. This is, in turn, related to the large economic dependence on the export of primary products, including agricultural products. The demand side drivers for diesel consumption in Brazil analyzed in this paper, help direct demand-side policies to reduce the country's vulnerability to diesel imports.

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## 1. Introduction

Analyses of fossil energy dependence usually emphasize the vulnerability to oil imports1 [1,2] particularly from OPEC countries [3–7], sometimes also accounting for the military costs in the Persian Gulf [8,9]. Several studies also focus on possible ways to reduce the vulnerability of net-import oil countries [10–13].

In fact, the issue of energy dependence normally leads to discussions about total proven and probable crude oil reserves [14–16]. It also raises concerns about expansion strategies of production capacity in OPEC countries [17,18] or even the adherence to the quotas established by these countries [17–21].

Thus, in general, the dependence of oil-importing countries, and especially their vulnerability as described in Percebois [22], is a main subject of analysis in the geopolitics of oil [23] from the perspective of political science. This approach allows a better understanding of major geopolitical movements, as well as their determinants – see, for example, Morse and Richard [24] and Favennec [25].

Several studies have used different approaches to empirically and systematically analyze the vulnerability of oil-importing countries [11,26,27]. Few studies, however, have used index decomposition techniques to analyze oil-vulnerability concerns [2,28,29].

Brazil is an interesting case to examine because it became self-sufficient in terms of crude oil volume in April 2006. However, ten years later, it still relies on imported oil to achieve a higher quality blend for oil refining processes [30]. Also, Brazil remains an importer of specific oil products such as naphtha and diesel [31,32]. Diesel imports are expected to increase due to, mainly, two reasons [31]: the demand for diesel is projected to increase in the medium-term; and the more rigorous specification of metropolitan diesel to a maximum of 10 ppm of sulfur (S10), after 2015, should affect the performance of the Brazilian installed refining capacity in terms of diesel production.

The final consumption of diesel in Brazil accounts for half of all oil products consumed for energy purposes in the country [32]. Furthermore, a part of the diesel consumed in the country is imported (around 20% in 2014 [32]), which makes it the oil product on which Brazil depends the most internationally. This dependence can be related to both demand and supply factors. The latter has already been well explored in the literature [30,31,33–37], and is associated with limitations of the oil refining infrastructure in the country. More specifically:

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- First, the still insufficient capacity in delayed coking units (or bottom of barrel units). Actually, Brazil's refining system lies between a cracking and a coking mode [30].
- Second, and more importantly, the hydro-refining capacity in Brazil accounts for 19% of the total primary capacity [37]. For instance, in 2014, only 36.9% of the diesel produced in Brazil were hydrotreated, and only 26.5% of these units were severe [30,37].

According to GTZ [38] and Cavalcanti et al. [39], diesel consumption in Brazil does not directly follow international prices due to government price regulation. Given the high import dependence on diesel, it is, therefore, important to investigate the drivers for diesel consumption in the country and assess how it relates to the country's foreign dependence.

Indeed, the vulnerability from the demand side of oil products, in general, and of diesel particularly, have not been well explored in the scientific literature. This paper aims to contribute to this discussion by analyzing the demand factors that influenced Brazilian diesel imports dependence in the 1996–2014 period, using the Log-Mean Divisia Index I (LDMI I) decomposition method [40–42]. By doing so, it contributes to the understanding of an important part of the country's fossil fuel vulnerability, so as to guide future energy policies to deal with the issue in Brazil.

This article is structured as follows. In Section 2, the Brazilian diesel imports dependence is described to provide the context in which the vulnerability in diesel is analyzed. The decomposition method and the governing functions, which allow the quantification of the factors explaining the changes in diesel imports dependence and its demand side drivers in Brazil, are presented in section 3. Section 4 shows and analyses the results. Finally, section 5 presents some concluding remarks.

## 2. The vulnerability to diesel imports in Brazil

Technological innovation, advances in biofuels production and policies encouraging domestic exploration and production of oil and gas have led to a sharp decrease in net oil imports and a rapid increase in oil and gas reserves over the past decades. This has significantly impacted Brazil's net energy imports dependence and security. As a result, the ratio of net oil imports to consumption has decreased over the past decades, falling from 83% in 1980 to 43% in 1990 and, in 2006, the country became a net exporter of oil [32]. However, Brazil exports heavy acid crude oils, which are discounted[1] when comparing to light imported crude oils (mainly from Saudi Arabia and Africa [43]). In the last ten years, Brazilian oil export prices have been, in average, around 20% lower than imported oil prices [44]. As a result, although Brazil became a net oil volume exporter in 2006, it only became a net oil exporter in monetary terms in 2009 [45]. In sum, Brazil still relies on imported oil to achieve a higher quality blend in its oil refining processes. Therefore, the country's dependence on oil is more a question of quality than of quantity, or even a question of refining conversion capacity [36,46].

However, the reduction in crude oil net volume imports was not followed by the reduction in the imports of some oil products, especially naphtha for petrochemicals and diesel [32,35]. In the case of diesel, Brazil was an exporter in the 1970s and 1980s, when part of the truck and bus fleets was fueled by gasoline [47]. The sharp increase in the sales of diesel-fueled heavy vehicles (trucks and buses) during the 1990s led the country to become a net importer of diesel. According to EPE [32], between 1970 and 2014 the total consumption of oil rose more than three times while diesel consumption increased by more than eight times, becoming the main oil product consumed in Brazil. As of today, diesel is widely used in agriculture and both passenger and freight transport (Fig. 1). In 2014, the transport sector accounted for 78% of total diesel consumption in the country [32]. Buses accounted for 15% of total diesel consumption, and freight transport, mostly performed by trucks but also, to a lower extent, railway and waterway, accounted for 60% of that total.

Between 1996 and 2014, diesel consumption in the country increased 110%, exceeding GDP growth which increased 70% over the same period [32,48]. In 2014, diesel consumption in Brazil reached 49.9 Mtoe and diesel imports 9.6 Mtoe [32]. The spending on diesel imports in 2014 exceeded 8.7 billion dollars [44]. The total cumulative diesel balance of trade deficit over the period 1996–2014—more than 52.9 billion dollars – represents a little less than the estimated construction cost of a new diesel-optimized refinery in Brazil[2] [31].

Changes in international oil prices have a large influence on the oil imports bill of Brazil. For instance, although diesel import price spiked between 2003 and 2008, following the movements of benchmark crude oils [49], consumption of diesel in the country was not severely affected. Two reasons explain this fact: first, diesel in Brazil is used mainly for essential services without a short-term substitute. Therefore, as pointed out by Azevedo [50] and Brafman [51] diesel price elasticity is low in the country. Second, domestic diesel prices at the pump have not strictly followed international price parity [38]. As shown by the statistical tests performed by Cavalcanti et al. [39], the correlation between Brent spot prices and Brazil's light and mid oil products ex-refinery prices indicated that a variation in the former does not automatically affect the latter. According to the authors, that evidence suggests that Petrobras, although it does not determine the ex-refinery price of light and mid oil products on an *ad hoc* basis, does adjust it in relation to variations in the spot market price of Brent crude with a time lag.

In 2009, the Brazilian oil regulatory agency (*Agência Nacional do Petróleo* – ANP) increased diesel specification from 500 to a maximum of 50 ppm of sulfur in diesel fuel (S50). On one hand, the use of diesel S50 improved environmental quality in Brazil. On the other hand, some refineries faced difficulties to meet the new specification requirements, which imposed additional restrictions on diesel production and, eventually, led to a need for additional imports of high-quality diesel. As a matter of fact, in the metropolitan areas of Rio de Janeiro, São Paulo, Curitiba, Recife, Fortaleza and Belém higher-quality diesel (S10, with 10 ppm of sulfur) has come into use for the purpose of improving local air quality. However, apart from that consumed in Rio de Janeiro, all high-quality diesel is imported [52].

Given the limited capacity of the Brazilian oil refining infrastructure to produce high-quality diesel, after 2009, when the S50 diesel specification came into effect, a sharp increase in imports has occurred [32,52]. It should be noted that this result occurred together with the large increase in diesel consumption observed in 2010 (Fig. 1). Then, in 2012, diesel imports decreased due to either the start of operation of severe hydrotreating[3] units capable of producing S50 diesel[4] or the fact that most diesel consumption

[1] A specific crude oil price has premium or discounts when compared to a benchmark crude, such as Brent. See, for instance, Bacon and Tordo [80].

[2] Considering the inside battery limits (ISBL) investment cost of a 600 thousand barrels/day.

[3] According to the specification of the oil product and quality of the feedstock, the hydrotreatment in oil refineries should be more or less severe. This affects the hydrogen pressure, the type of reactor and the catalysts used in the reactions.

[4] Particularly, three gasoil hydrotreating units in the largest Brazilian refinery, Replan, started operation in 2012 adding up more than 10 thousand m3 of S50 diesel.

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