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FREIGHT IN BRAZIL

An assessment and outlook for improving environmental performance

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

ACKNOWLEDGMENTS

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ABBREVIATIONS

ABIQUIM	Brazilian Chemical Industry Association
ABOL	Brazilian Association of Logistics Operators
ANFAVEA	National Association of Motor Vehicle Manufacturers
Anfir	National Association of Trailer Manufacturers and Body Builders
ANTT	National Agency of Land Transportation
BEN	national energy balance
BNDES	National Bank of Social and Economic Development
CNPJ	National Registry of Legal Entities of the Ministry of Finance
CNT	National Confederation of Transport
CO	carbon monoxide
Denatran	National Traffic Department
DNPM	National Department of Mineral Production
EGR	exhaust gas recirculation
EPE	Energy Research Company
EPL	National Planning and Logistics Company
GCW	gross combined weight
GDP	gross domestic product
GHG	greenhouse gas
GPS	Global Positioning System
GVW	gross vehicle weight
IADB	Inter-American Development Bank
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources
IBGE	Brazilian Institute of Geography and Statistics
MMA	Ministry of the Environment
ICCT	International Council on Clean Transportation
MTC	maximum traction capacity
NMHC	non-methane hydrocarbon
NOx	nitrogen oxide
ntk	net tonne-kilometer
tkm	tonne-kilometer
O/D	Origin/ Destination
PAS	Annual Survey of Services
PM	particulate matter
PNT	National Traffic Survey
PROCONVE	Program for the Control of Air Pollution by Motor Vehicles
RAIS	Annual Social Information Report
RNTRC	National Registry of Road Freight Transportation
ROI	return on investment
SASSMAQ	Safety, Health, Environment and Quality Assessment System
SEEG	greenhouse gas emissions estimation system
Sindipeças	National Motor Vehicle Component Industry Union
Smartway	US EPA's SmartWay program
UCV	urban cargo vehicles
UNDP	United Nations Development Program

EXECUTIVE SUMMARY

Road freight plays a major role in Brazil's economy, accounting for around 65% of all freight transported in 2015. By 2019, the total freight truck fleet, estimated at 2 million vehicles, accounted for 76% of all fossil diesel consumed in Brazil and 40% of all greenhouse gas (GHG) emissions from the transport sector.

In this context, initiatives to mitigate GHG emissions from freight are important for Brazil. These include initiatives aimed at improving energy efficiency per tonne transported, actions to improve logistics and promote modal shifts, and public policies related to vehicle technology and the use of renewable fuels. Voluntary "green freight" programs generally include collecting data and benchmarking fuel consumption and emissions, and sharing information on technologies and strategies to increase efficiency and environmental sustainability. Although experience with green freight programs is still limited in Brazil, such a program could be created based on the requirements imposed by the national Rota 2030 program, which focuses on fuel efficiency, safety, and investments in research and development.

This study is an exploratory assessment of Brazil's road freight transport sector. It considers several important characteristics of the agents involved and the particularities of the truck market, including key routes traveled and common cargo, in order to identify opportunities and obstacles for the implementation of a green freight program. Some of the main lessons are:

- Freight transportation involves a wide range of heterogeneous actors, including carrier companies, self-employed carriers, and cooperatives. The high degree of outsourcing, and in many cases the informality of operations, present a major challenge. This is especially true for self-employed carriers, who represent 44% of the truck fleet and often operate under challenging working conditions. This group also operates the most outdated fleets and is least able, among actors in the sector, to make new investments.
- Heavy and semi-heavy trucks are the main GHG emitters and account for 70% of all emissions in this segment.
- Characteristics of the most frequently used trucks and transported load types can help to define fuel efficiency standards for heavy-duty vehicles. This information allows regulators to implement new rules in stages and to avoid the complexity of covering, from the outset, the entire range of vehicles sold.
- Almost all trucks sold in Brazil were produced in the country by just six manufacturers, with Mercedes and MAN/Volkswagen together controlling almost 60% of the market. Despite an uptick in fleet age because of the economic crisis, 61% of the fleet is less than 10 years old.
- Over the last 15 years, the load capacity and number of axles on trucks sold have increased substantially, especially for tractor trucks. Regulatory changes regarding the maximum truck load capacity may explain this.
- General goods represent 73% of all freight transported in terms of tonne-kilometers. Roughly three-quarters of this freight is manufactured products and processed food and beverages.
- The economic crisis of recent years has significantly affected the freight transport sector, with a negative impact on transport operators and on the entire truck production chain. In 2018, strikes and protests by truck drivers against increases in the price of diesel paralyzed the country. This became known as the Diesel Crisis.

» The emergence of mobile apps that support cargo transportation management has grown significantly in recent years, especially those that connect shippers with carriers. These apps have a disruptive potential. They can quickly change the local road freight transport landscape and they contribute significantly to reducing GHG emissions and fuel consumption by reducing operational inefficiencies.

Given the degree of outsourcing in Brazil's freight transportation sector, one of the most important aspects of any green freight initiative will be the identification of a neutral entity to verify the effectiveness of energy efficiency technologies through standardized tests.

Besides green freight programs, initiatives such as energy efficiency standards for heavy vehicles, investment in infrastructure to promote a shift to more energy-efficient modes, and improvement in freight logistics management can significantly reduce consumption of fossil fuels and the associated GHG and pollutant emissions. A significant share of bulk cargo like grains and ores is still transported by highway in Brazil because of the lack of railway and maritime shipping infrastructure. In addition, preliminary surveys suggest that a large number of vehicles circulate empty, revealing the potential efficiency gains to be won from logistics management and integration efforts.

INTRODUCTION

Brazil's freight transportation system handled 1.9 billion tonnes of goods and moved 2.4 trillion tonne-kilometers (tkm) in 2015, according to data from the National Planning and Logistics Company (EPL). Of this total, road transportation handled around 65%, a clear indication of the importance of road freight transportation to the Brazilian economy. The on-road fleet is estimated at 2 million trucks (Sindipeças, 2019), and it consumed 40.5 billion liters of diesel in 2019, which was 76% of all the diesel consumed in Brazil (ANP, 2020).

Because the majority of road freight transportation is powered by fossil fuel, the environmental externalities of freight are large in Brazil, especially compared to less energy-intensive alternatives. In 2019, the truck fleet in Brazil contributed more than 40% of the greenhouse gas (GHG) emissions of the entire transportation sector. (Sistema de estimativa de emissões de Gases de efeito estufa [SEEG], 2020). For decades, government policies have favored investments in highways, and projections suggest this modality will be dominant until 2050 (EPE, 2015).

Initiatives to mitigate GHG emissions from transportation are clearly important, and this study seeks to deepen the understanding of the road freight transportation sector in Brazil. It is aimed at identifying opportunities and barriers for public policies and voluntary initiatives toward energy efficiency and GHG mitigation. Among these voluntary initiatives are "green freight" programs, which are in different stages of maturity in several countries and regions. Such programs generally include collecting data to benchmark fuel consumption and emissions, and sharing information on technologies and strategies to increase efficiency and environmental sustainability.

Experience with green freight programs is limited in Brazil. One effort, Despoluir, a joint initiative of the National Transport Confederation (CNT), Social Transport Service (SEST), and National Transport Learning Service (SENAT), has promoted the environmental inspection of vehicles, among other activities. More recently, it supported the Brasil Verde Logistics Program (PLVB) under the coordination of the Cargo Transport Laboratory (LTC) at COPPE – Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia/ Universidade Federal do Rio de Janeiro-URFJ. The objective is to share best practices and establish a labeling system, Selo Verde (Green Label), for recognizing the adoption of these practices.

Whatever their form, environmental solutions for transportation need to suit the country or region to which they apply, considering institutional peculiarities, the degree of maturity of ongoing initiatives, environmental and energy security needs, and the characteristics of the fleet and the freight transportation sector overall. Many of the operational characteristics of freight in Brazil, including the high degree of diversity and atomization of service providers, add complexity to the implementation of comprehensive and scaled voluntary programs. In 2018[1], there were 668,810 registered service providers, of which 77% were self-employed carriers.

There are also relatively few vehicle technology-related actions to reduce energy consumption in Brazil as compared to other countries. Although the government has made efforts recently to promote energy efficiency policies for heavy vehicles under the Rota 2030 program, the proposed timetable establishes targets only by 2032. This delays change for more than a decade, putting the country well outside of international best practices in this regard. While the program establishes fuel-efficiency labeling for heavy vehicles in 2023, this measure may not occur, as no movement in this direction has begun, nor have the relevant regulatory bodies been designated.

1 RNTRC data in November 2018.

In addition, the economic crisis in Brazil in recent years significantly affected the cargo transportation sector and had a negative impact on transport operators and the entire vehicle production chain. One of the challenges of this crisis and the reduction in demand for freight was to maintain the value of freight service amid the increase in costs. This generated a tense relationship between various entities in the supply chain and culminated in strikes and protests in 2018 against the increase in the price of diesel—the Diesel Crisis, as it became known. This is relevant when analyzing the opportunities for advances in energy efficiency policies, initiatives, and actions. It could mean an opportunity to reduce fuel consumption, but it created a core conflict of interest: who would invest in vehicle technology and who would appropriate the energy efficiency gains: shipper or carrier?

This report has four core sections. The first identifies the main characteristics of freight transportation, in particular road freight. This includes the characteristics of Brazilian freight, the volumes of freight and distances transported, available data on fuel consumption and emissions, and the stakeholders involved. The second section focuses on the vehicle and its parts, and presents the characteristics of the truck market and the overall fleet of trucks in Brazil. The third covers trucking's operational profile, including the degree of outsourcing and fleet profiles by type of carrier and type of goods transported. And the fourth section presents results of an exploratory survey of stakeholders' perceptions—including those of shippers, carriers, trucking associations, and others—of initiatives related to energy efficiency and reduction of GHG emissions, barriers and opportunities, and recommendations and further steps. The conclusion then highlights key lessons and discusses the future outlook for improving the environmental performance of road freight transport.

This study uses publicly available data from publications and websites of industry and government associations, among others, as well as sales data for the automobile sector acquired from marketing consulting firms. The inconsistencies and lack of data and information identified throughout this report are evidence of the need to systematize the collection of robust data on the subject. The appendix summarizes the main sources of information used.

1. FEATURES AND TRENDS ACROSS FREIGHT MODES

Brazil is the fifth largest country in the world by area and the largest country in Latin America. Its longest distances north-south and east-west are roughly 4,300 kilometers (km). Although such long distances would favor high-capacity freight transportation modes with greater energy efficiency like railways and waterways, 65% of the freight transported in Brazil in 2015 was on the road. As shown in Figure 1, rail accounted for another 15%, and inland waterways and maritime cabotage accounted together for 16%.

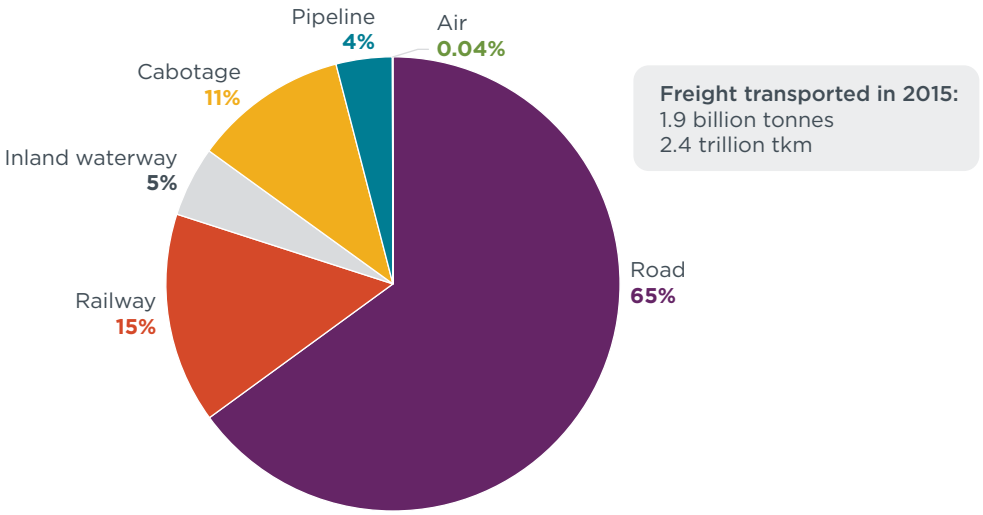
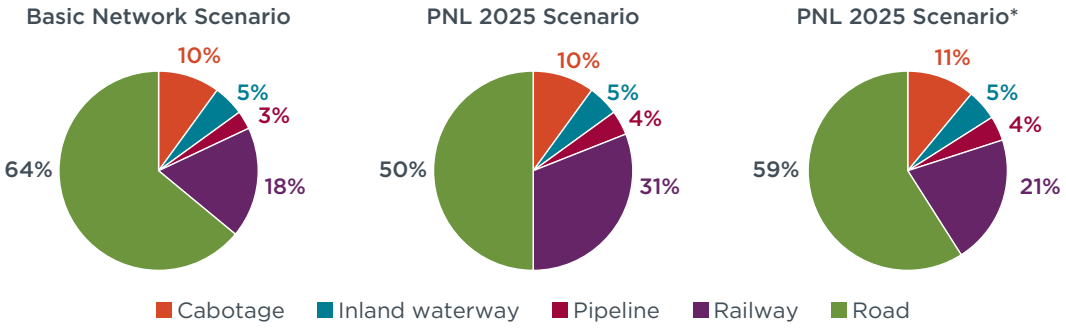


Figure 1. Freight transportation mode shares in 2015 (percentage of total tonnes). (EPL, 2015).

In large part, this composition is the result of the industrialization model implemented in Brazil from the 1950s through the 1970s, which prioritized roadway expansion and associated investments in the automobile industry. That choice led to the scrapping of most of the country's railway infrastructure and the boosting of road transportation as a vector of development. Additionally, the move of Brazil's capital to the Center-West region contributed to the road-dominated model (Goldenstein, Alves, & Azevedo, 2006; Schroeder & Castro, 1996; Ronchi, 2011). This model is firmly established and has changed little over the last four decades.

The 2025 National Logistic Plan (EPL, 2018) includes different scenarios for achieving better efficiency in Brazil's transport matrix. The "Basic Network Scenario" considers the transport network currently in existence and work underway or scheduled to be underway by the end of 2018. A second scenario, called the "PNL 2025 Scenario,"[2] considers also the highways, railways, and waterways that are expected to be under construction or operational by 2025. And finally, the "PNL Scenario 2025 without adaptations of capacity" accounts for the same investments of the previous scenario but without considering the adequacy of capacity in some railroads. This last scenario is meant to isolate the impact of the new investments in railroads already granted. Figure 2, below, illustrates the share of the different modes in each scenario.

2 The PNL scenario 2025 considered projects qualified in the investment partnership program, components of the Programa Avançar, concession obligations in force and capacity expansions in extendable concessions.



** without adaptations of some railroad capacity*

Figure 2. Estimated freight transportation modal share by PNL scenario (% of tonnes). (EPL, 2018)

In each of these scenarios, Brazil continues to depend on roads and highways for at least half of freight transportation in 2025. Therefore, actions to improve the energy efficiency of road transport should be a priority.

1.1. COMMODITY PROFILES

In addition to infrastructure availability, a key determinant of transport mode choice is the type of commodity. This also affects equipment type. In Brazil, general cargo is the most common commodity type, accounting for 73% of all freight transported by road. As shown in Figure 3, roughly three-quarters of general cargo is composed of manufactured products and processed food and beverages. In addition, bulk solid non-agricultural freight (16%), agricultural freight (6%), and liquid freight (5%) circulate on the nation's highways.

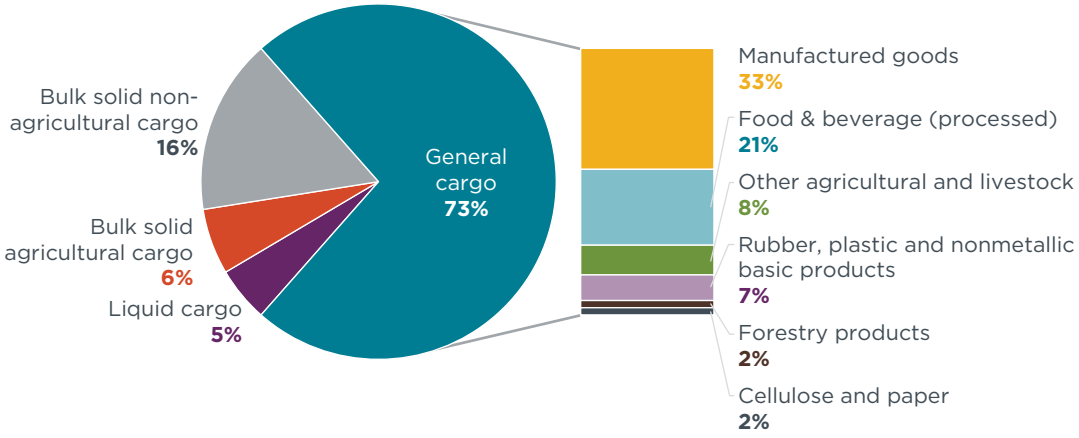


Figure 3. Type of freight transported by road (tkm). (EPL, 2015 and EPL, 2016)

Agricultural solid bulk freight includes things like corn grain, soybean grain, sugar, and coffee, and non-agricultural solid bulk freight includes coal, cement, iron ore, and other minerals. As shown in Figures 4 and 5, although solid bulk represents almost all the freight transported by railways, a significant portion of these products is still transported by road. This highlights the need to explore the potential to reduce Brazil's fossil fuel consumption and GHG emissions through modal shifts to rail or waterways.

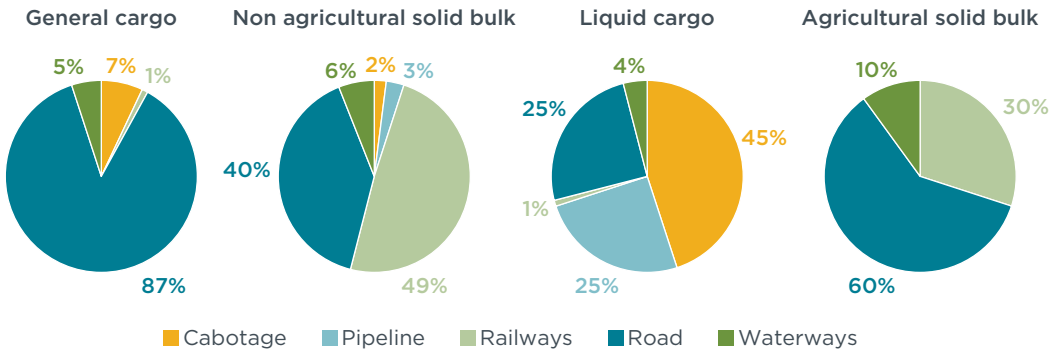


Figure 4. Freight transported, by mode.

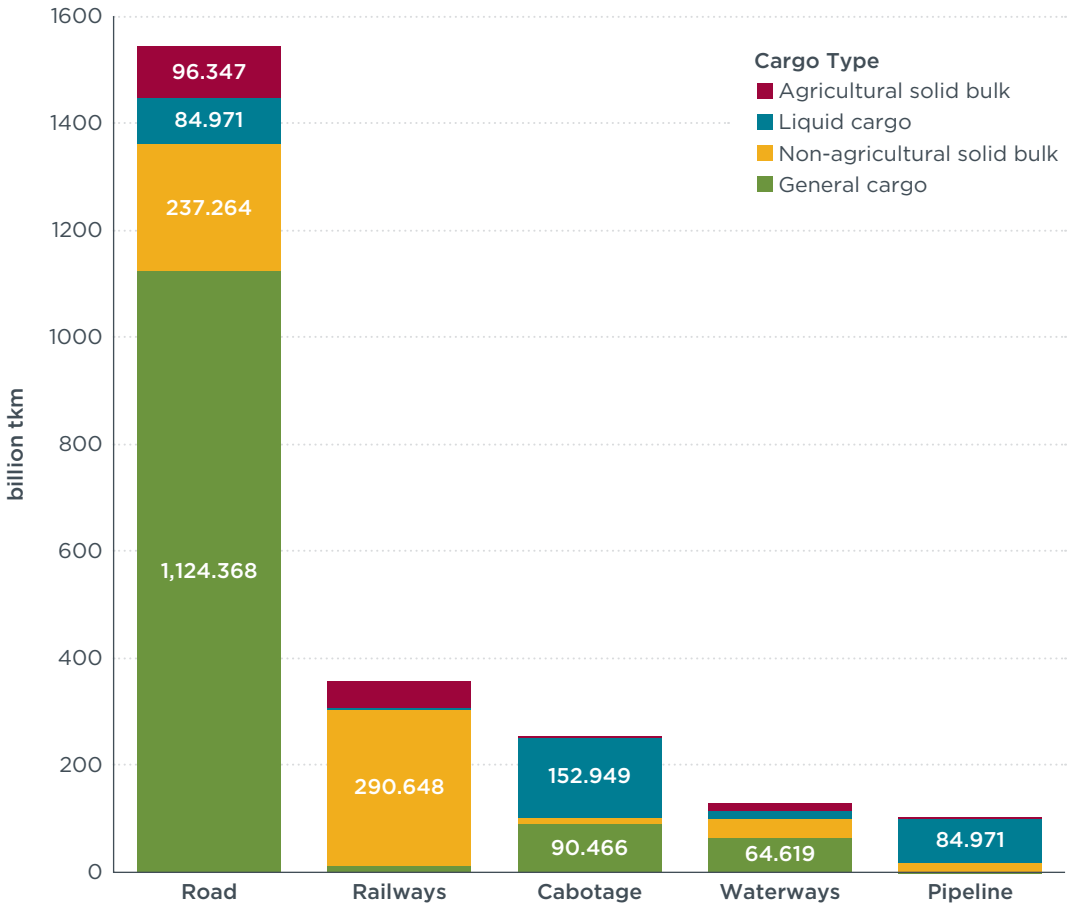


Figure 5. Mode, by type of freight. (EPL, 2016)

1.2. FREIGHT FLOWS

Freight flows in Brazil are concentrated in a few regions, especially the South and Southeast (Figure 6). These regions are responsible for the production of 63% of the freight transported in tonnes and are the destination for 47% of the freight (Table 1).[3] With respect to international flows, exports account for roughly 32% of all freight transported; only 6.8% of the freight transported comes from imports.[4]

3 In this study, data from several sources were used; we present data in tkm (tonne-kilometers) where possible. However, data from the Origin–Destination Survey were made available only by weight (tonnes).

4 As a characteristic of the Brazilian export agenda, more than 60% of the products exported in 2016, by weight, came from the extractive sector, especially iron ore. On a value basis, these products – including ore, oil, and coal – accounted for only 10.8% of the amount exported during this period (FOB value) (MDIC, 2017)

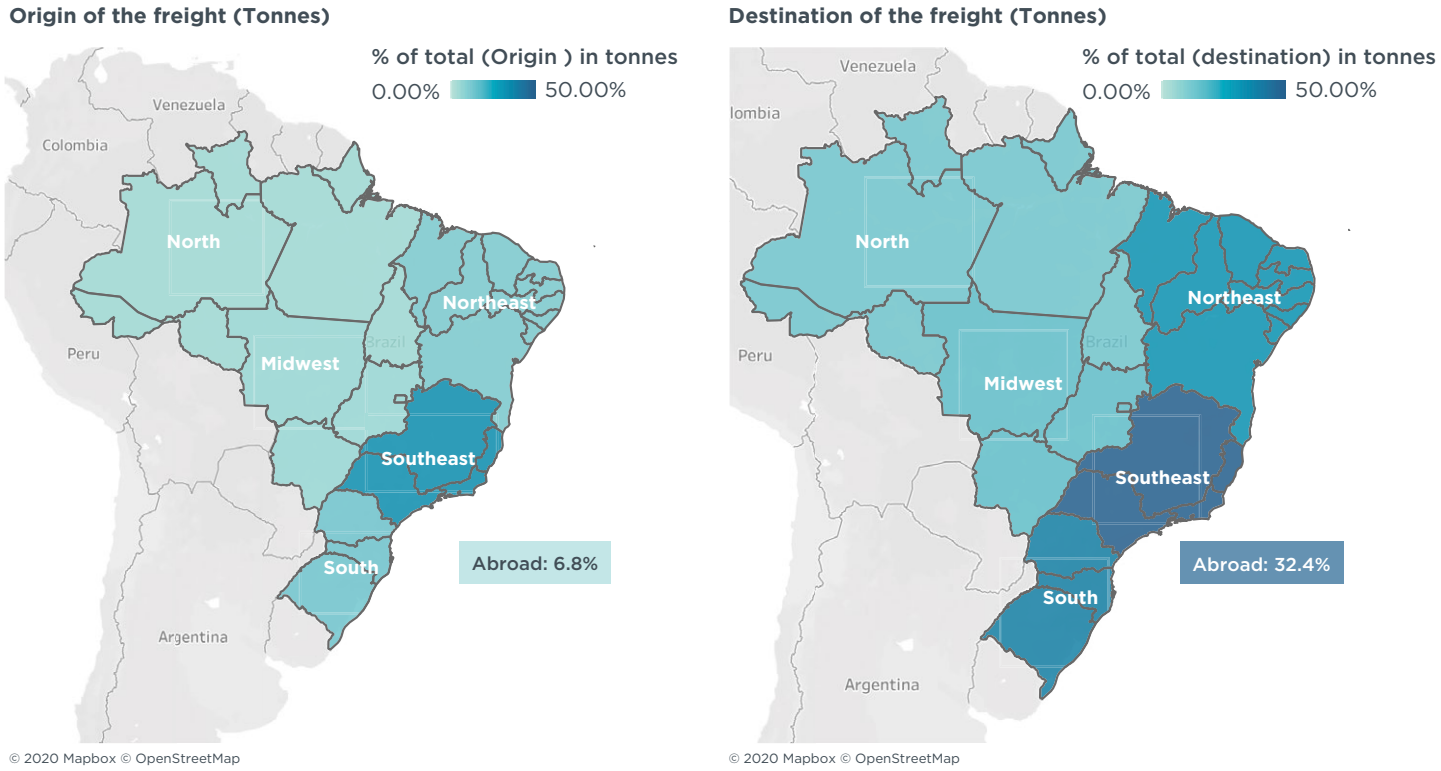


Figure 6. Origin and destination of Brazilian freight, per region (percentage of total tonnes).

Table 1. Origin and destination of freight flows in Brazil per region in 2015 by share of weight transported. (EPL, 2015).

Origin	Destination						Total Origin
	Abroad	Midwest	North	Northeast	South	Southeast	
Abroad	0.01%	0.26%	0.39%	1.12%	1.14%	3.02%	5.94%
Midwest	3.29%	1.55%	0.44%	0.73%	1.23%	2.32%	9.56%
North	11.12%	0.23%	1.58%	1.67%	0.35%	0.74%	15.68%
Northeast	1.97%	0.47%	0.53%	3.59%	0.96%	2.39%	9.92%
South	2.87%	0.76%	0.41%	1.02%	5.14%	3.94%	14.14%
Southeast	13.86%	2.04%	0.91%	2.64%	4.22%	21.10%	44.76%
Total Destination	33.12%	5.31%	4.26%	10.77%	13.05%	33.50%	100.00%

This concentration of flows in certain regions is directly related to Brazil's regional peculiarities and inequalities (EPL, 2016). Only five states—São Paulo, Rio de Janeiro, Minas Gerais, Rio Grande do Sul, and Paraná—accounted for 64% of the GDP in 2014, according to the Brazilian Institute of Geography and Statistics (IBGE, 2020). Moreover, the nation has specific agro-industrial production centers in the Center-West and parts of the Southeast and South regions (EPL, 2016) and mining production centers in Minas Gerais and Pará (DNPM, 2016). This imbalance in freight flows may be one of the causes of trucks making empty return trips, and it impacts both freight costs and emissions per unit of transported cargo.

1.3. FREIGHT GHG EMISSIONS

Total GHG emissions in Brazil reached a peak of 3.82 gigatonnes (Gt) of CO_2 equivalent (CO_2e) in 2003. Efforts to combat deforestation after that year caused emissions from the country to fall by half, although in the last year they have grown, according to the Climate Observatory (SEEG, 2020). Moreover, in the energy sector, which includes transport, the trend is one of increasing emissions (Figure 7).

In 2019, road transport emissions, at 196.5 $MtCO_2e$, constituted 83% of the emissions from the transportation sector; 78.9 Mt CO_2e of that was emitted by road freight transport. These figures are relevant when compared to emissions from other sectors. For example, emissions from burning diesel in trucks were 51% higher than the total emissions from electricity generation in the country in 2019.

Because freight transportation is directly affected by changes in the economy, as measured by gross domestic product (GDP), it is expected that improvement in the Brazilian economy will bring an increase in GHG emissions. Where freight is concerned, significant changes in modal distribution or in emissions per tonne transported via each mode are unlikely in the short or medium term. Moreover, although the road transport sector is still precarious along some routes, it is the mode with the greatest capacity to respond to economic recovery in the short term because of its consolidated and interconnected road infrastructure, flexibility, and low barriers to entry for the fleet.

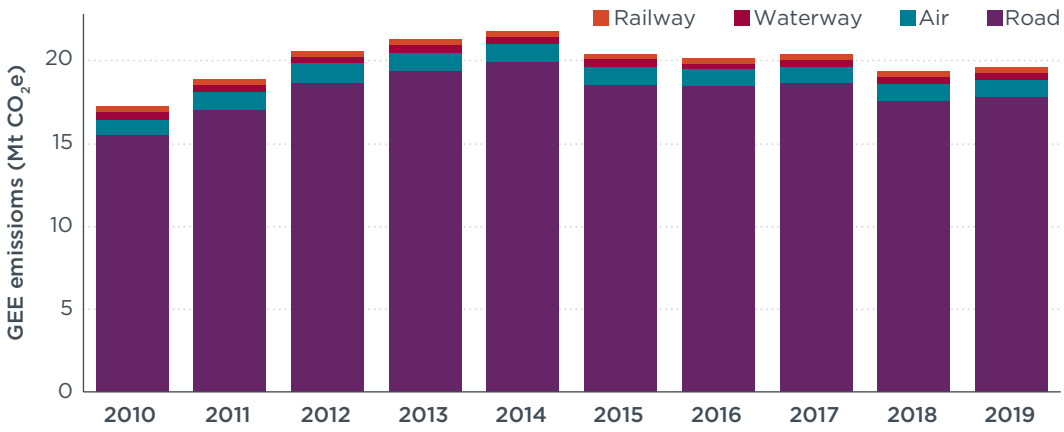


Figure 7. Freight transportation emissions by mode. (Plataforma.seeg.eco.br/sectors/energia).

According to data from the Climate Observatory (SEEG, 2018), CO_2 emissions per tonne- kilometer generated by road transportation are between 4.3 and 12.8 times higher than emissions from rail transport, depending on the product being moved, and may be up to 20 times higher than in short-sea (coastal) shipping (Figure 8).

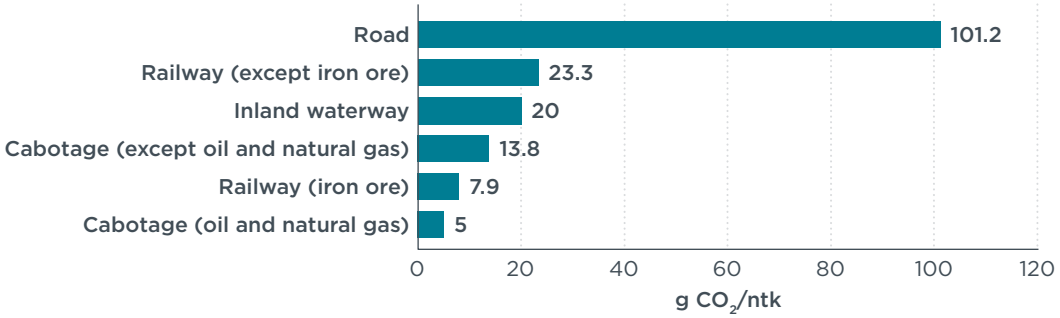
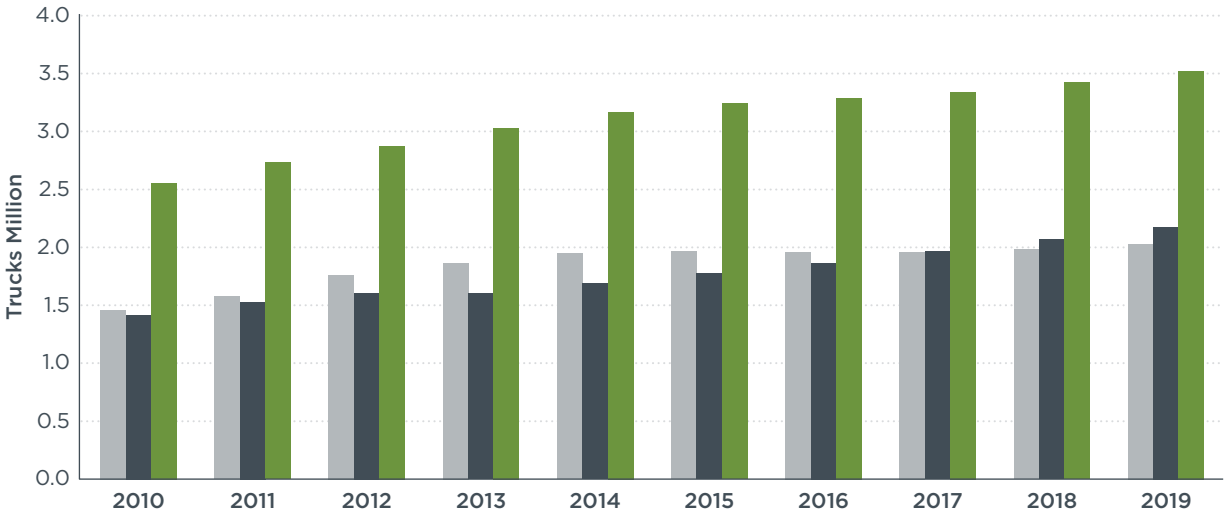


Figure 8. CO_2 emissions by modal share in Brazil. (SEEG, 2018)

1.4. TRUCK FLEETS

Accurate data on the truck fleet (trailers and rigid trucks) does not exist in Brazil because of how the National Traffic Department, Denatran, registers vehicles: New vehicle registrations are entered in the database, but vehicles that are no longer circulating are not removed. Thus, the official data provided by Denatran overestimates the size of the fleet that is circulating.

Given this, our estimates of the current circulating fleet are made based on data about new vehicle registrations and a scrapping curve applied to each vehicle category.[5] An estimate is carried out annually by the National Motor Vehicle Component Industry Union (Sindipeças) and occasionally by the Ministry of the Environment (MMA); in the case of the latter, the most recent data are from the 2014 National Inventory of Road Vehicle Emissions. Although there are small differences between the databases of these two organizations, the fleet registered with Denatran is approximately 58% larger than the estimates based on scrapping curves.[6] Figure 9 compares all three.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Truck fleet (Sindipeças)	1,456,649	1,577,072	1,761,280	1,863,787	1,947,888	1,965,220	1,962,036	1,961,068	1,983,149	2,028,633
Truck fleet (MMA)	1,416,473	1,530,446	1,607,286	1,603,453	1,686,683	1,774,460	1,866,903	1,964,129	2,066,477	2,173,972
Truck fleet (DENATRAN)	2,555,940	2,732,901	2,873,420	3,029,798	3,167,749	3,239,884	3,290,906	3,343,660	3,421,144	3,524,075

Figure 9. National truck fleet comparison by database source. (Sindipeças, 2020; MMA, 2013; and Denatran 2010 to 2020).

The National Association of Motor Vehicle Manufacturers (Anfavea) classifies trucks in Brazil according to gross vehicle mass and maximum traction load, as shown in Table 2. These categories are adopted in this study because the available truck fleet and sales data follow this classification. In addition to this classification by weight, the characteristics of the truck body—rigid trucks and tractor-trailers—are also considered.

Table 2. Anfavea's classification scheme

Categories Type of truck	Limits Weight range
Semi-light trucks	3.5 t < GVWr < 6 t
Light trucks	6 t ≤ GVWr < 10 t
Medium truck	10 t ≤ GVWr < 15 t
Semi-heavy trucks	GVWr ≥ 15 t
rigid trucks	MTC ≤ 45 t
tractor trucks	GCWr < 40 t
Heavy trucks	GVWr ≥ 15 t
rigid trucks	MTC > 45 t
tractor trucks	GCWr ≥ 40 t

GVWr = Gross vehicle weight rating; MTC = maximum traction capacity; GCWr = Gross combined weight rating. (Anfavea, 2020)

5 The scrapping curves adopted in the National Inventory of Atmospheric Emissions were based on the Reference Report of Greenhouse Gas Emissions in the Energy Sector by Mobile Sources of the First Brazilian Inventory of Anthropogenic Greenhouse Gas Emissions, Ministry of Science and Technology –MCTI (2006).

6 The fleet estimated by MMA is based on sales data up to 2009 and sales projected therefrom. In the case of Sindipecas, the fleet was estimated from effective new vehicle licenses. The scrap curve may also be slightly different in these two estimations.

In examining fleet estimates in recent years by vehicle category, we see a marked increase in the share of heavy and semi-heavy duty trucks over 15 tonnes (Figure 10). In 2005, the heavy and semi-heavy fleet accounted for 44% of all trucks, and by 2014, this figure reached 58%. At the same time, there was a significant reduction in the relative share of vehicles with GVW between 10 and 15 tonnes, from 20% to only 12% of all trucks. Although in absolute terms the number of light trucks slightly increased, their relative share decreased from 32% to 25%. These fluctuations are mainly explained by the significant increase in the licensing of new heavy and semi-heavy vehicles, at rates well above the rate of their scrapping.

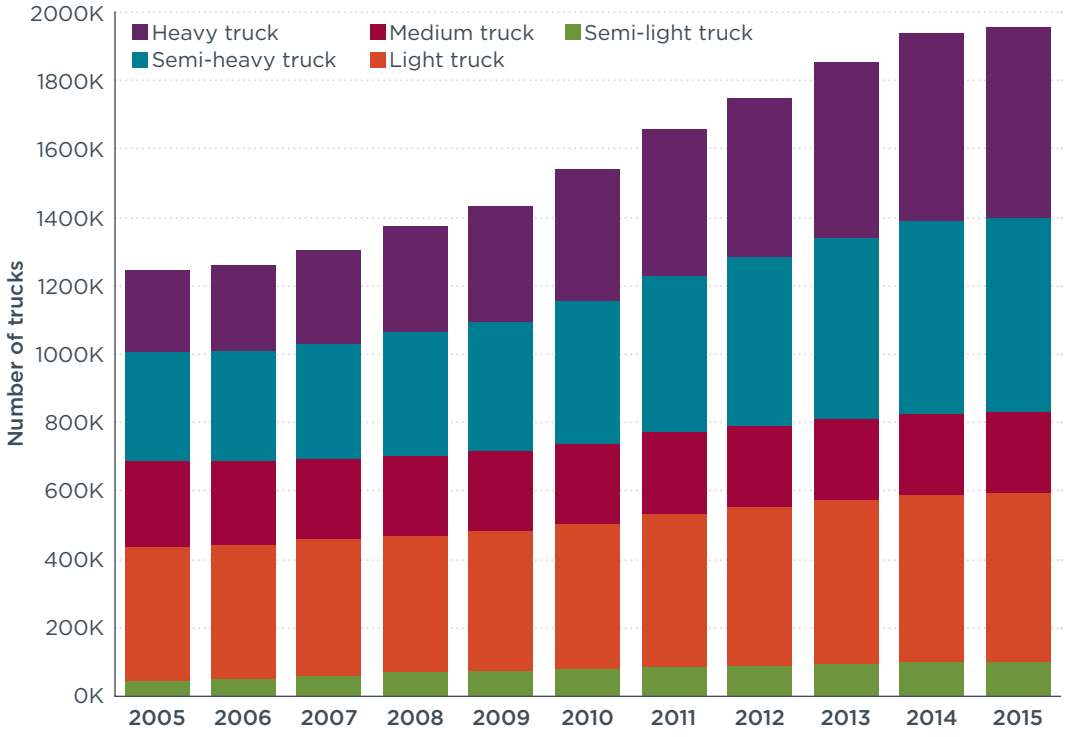


Figure 10. National truck fleet by classification. (Based on MMA, 2011 and MMA, 2013)

In 2015, based on the estimated fleet data, 46% of trucks were less than 5 years old and 13% were more than 21 years old (Figure 11).

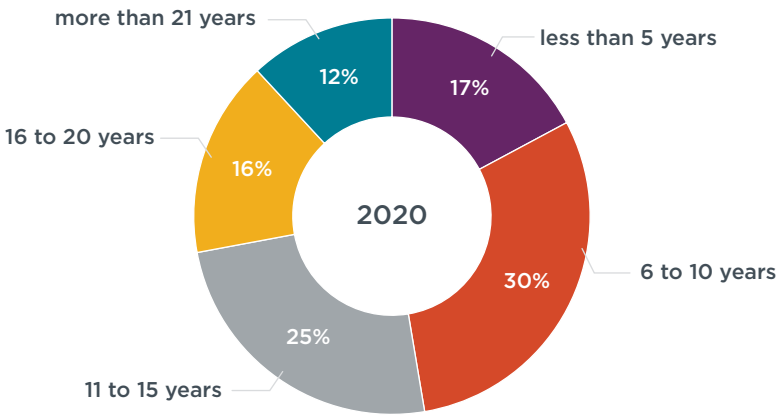


Figure 11. Truck fleet by age range (2015). (Sindipeças, 2020)

In 2020, it was estimated that Brazil had more than 241,000 vehicles that were more than 20 years old (Sindipeças, 2020). Trucks over 20 years old are usually the targets

of accelerated fleet renewal programs. There have been pilot experiences with this already in the country, and the issue is now on the government's agenda again.

As shown in Figure 12, the highest average age of the fleet is among trucks. Over the years, there has been an increase in the average age of all categories.[7]

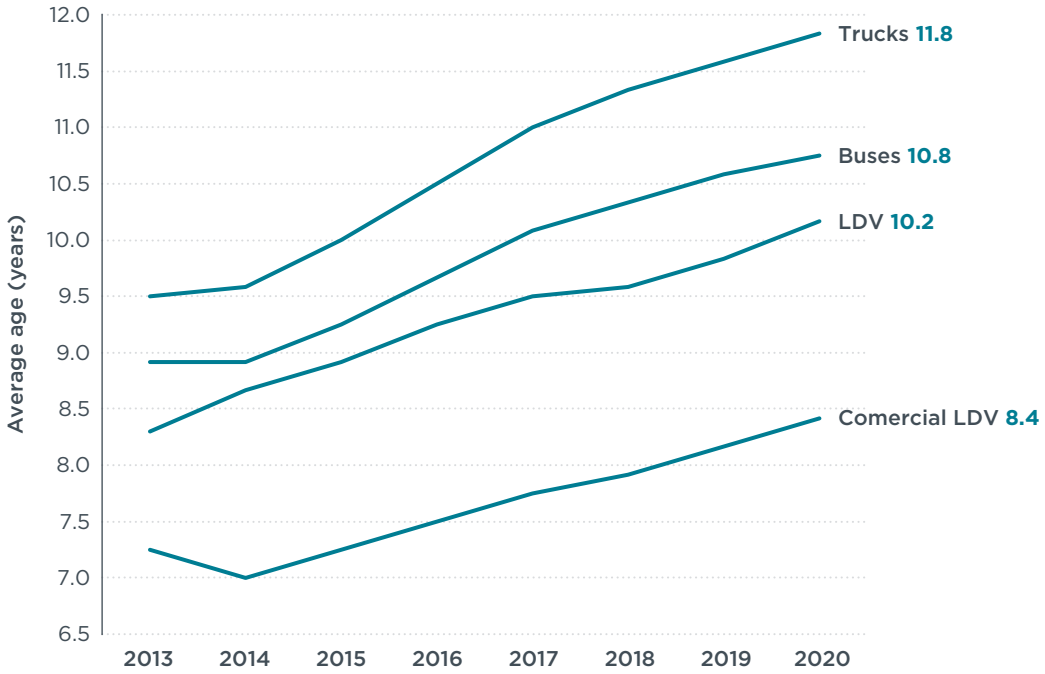


Figure 12. Fleet average age by truck category. (Based on MMA, 2013).

In addition to registering with Denatran, freight carriers engaged in paid activity are required to register their vehicles with the National Registry of Road Freight Transportation (RNTRC), which is part of the National Agency of Land Transportation (ANTT).[8] RNTRC's database covers only a portion of the total trucks in the nation, since it encompasses only the vehicles of service providers who perform paid activity and leaves out company-owned fleets.[9] As of October 2020, 944,489 trucks were registered with the RNTRC, including light-duty trucks (3.5t to 7.99t), single trucks (from 8t to 29t), tractor trucks, and special tractor trucks.

Comparing the RNTRC total with the Sindipeças fleet estimate of approximately 2 million trucks, reveals a difference of approximately 1,105,500 trucks, or 52% of the total fleet estimated by Sindipeças. The Sindipeças total includes its own fleet of shippers and also carriers that did not register in the RNTRC period. There is no data to separate these two groups.

The nationwide distribution of the fleet in 2016, based on data from Denatran, is presented in the map below.[10] Recall that the main flows of freight in Brazil are concentrated in relatively few production centers; the same occurs with the share of the truck fleet, as the South and Southeast regions account for more than 70% of the registered fleet.

7 The fleet data estimated by Sindipeças do not include a breakdown by category. For that, the data estimated in the National Inventory of Atmospheric Emissions by Vehicles (MMA, 2013) was used.

8 This data can be retrieved from the ANTT website: http://portal.antt.gov.br/index.php/content/view/4969.html

9 Although the RNTRC foresees inclusion of the shippers' own fleets, this figure is not being reported. It is likely that this fleet of shippers, when included in the registry, will be overestimated because it will come from the Denatran registry, with the data problems pointed out previously.

10 Although the fleet according to Denatran is overestimated, it is assumed that the distribution of the fleet by state or region is like the distribution indicated by these data.

Nationwide distribution of the fleet

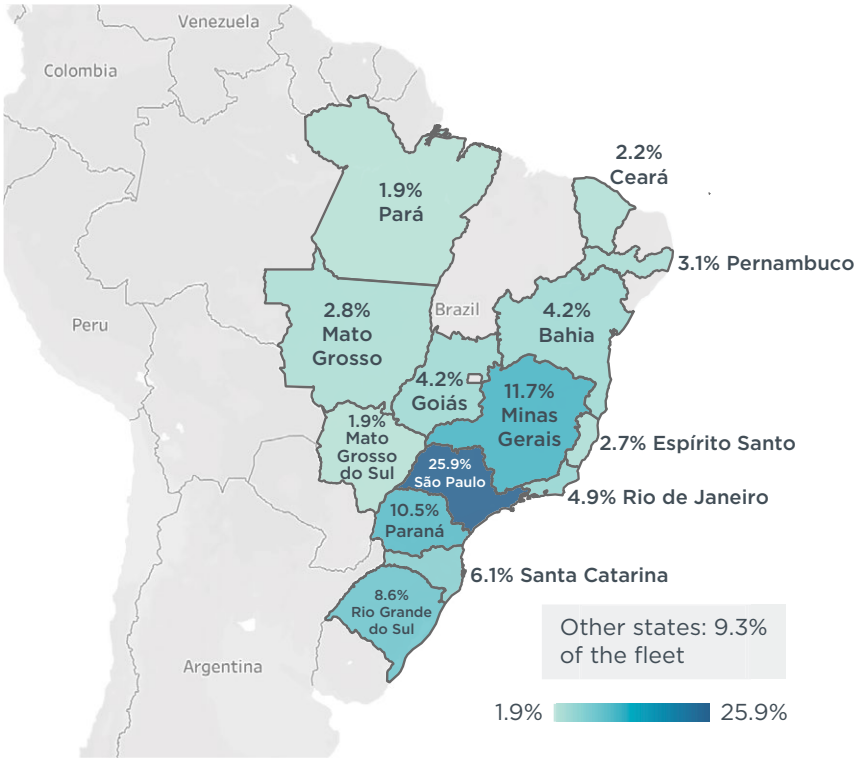


Figure 13. Nationwide distribution of the Denatran-registered fleet. (Anfavea, 2020).

1.4.1 Fuel consumption

Brazil is a net importer of diesel fuel, making diesel consumption an important factor in Brazil's energy security. Brazil produced 21% less diesel fuel than it consumed in 2019, according to National Energy Balance 2020 data (EPE, 2020). Consumption of diesel for road transportation (passengers and freight) has remained steady over the last decade, at around 75% to 80% of the annual total. The Ten-year Plan for Energy Expansion 2029 projects that the country will continue to rely on imports despite the increase in biodiesel production provided for by law. Complicating the energy security situation is the insufficient infrastructure to receive and distribute imported diesel, which elevates the fuel's price. The gap between consumption and domestic production is presented in Figure 14.[11]

11 In the case of diesel, the proportion of biodiesel expected starting in March 2021 is 13% (a mixture known as B13). Law 13.263 / 2016 established the schedule for the mandatory mixing of B15 until March 2023, with increments of 1% per year until that date.

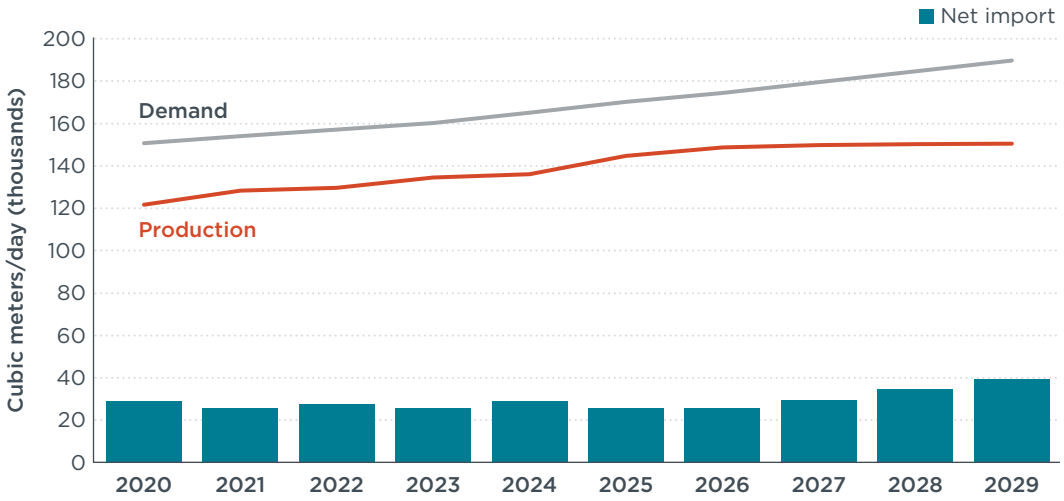


Figure 14. Projected demand, production, and net imports of diesel fuel in Brazil. (Based on EPE, 2020).

Vehicle fuel efficiency has been addressed in public policies, most notably in the InovarAuto programs launched in 2012, which sought to create conditions to increase competitiveness and produce cheaper and safer vehicles. Rota 2030, which replaces InovarAuto, launched in 2018 under the Ministry of Industry, Foreign Trade and Services – MDIC.[12]

InovarAuto set energy efficiency targets only for light vehicles. In Rota 2030, there is a reference to the energy efficiency of heavy vehicles, such as the requirement to implement vehicle labeling by August 2023, and to establish a timetable for the implementation of targets for HDV fuel efficiency.[13] The Rota 2030 program's schedule for setting mandatory targets for energy efficiency is not in line with world best practices.

Green freight programs could be created based on the requirements imposed by the Rota 2030 program. For example, although the Rota 2030 vehicle labeling program does not yet have an established methodology, it could require certification of important parts or components that affect energy efficiency, such as engines, tires, and aerodynamic components. With that, a unified benchmark would be available to assess the energy efficiency gains for different vehicles. This would accomplish one of the main factors for the success of the green freight programs that will be discussed below: verification and certification by a neutral entity. Under Rota 2030, this could be carried out in conjunction with the vehicle labeling program to be established by the National Metrology Institute, Quality and Technology (INMETRO).

1.4.2 Road freight environmental profile

Despite representing only 4% of the vehicle fleet in Brazil, freight transport contributed 40% of the GHGs emitted by the transport sector in 2019 (SEEG, 2020), emitting 78.6 million tonnes of CO_2e. In addition to GHG emissions, heavy vehicles are the main source, in cities, of particulate matter and nitrogen oxides (NO_x), the precursor of tropospheric ozone. They emit up to 85% of local pollutants, and the health effects of these pollutants are known and serious—they increase the risk of cardiorespiratory diseases, cancer, stroke, and other conditions and diseases.

Some public policies to reduce emissions of pollutants have been implemented, and with regard to GHGs, there are few mitigation policies. Among them, though, is the

12 Currently incorporated into the Ministry of Economy

13 Decreto 9.557 DE 8 DE NOVEMBRO DE 2018 and Portaria Nº 2.200-SEI, DE 27 DE DEZEMBRO DE 2018

mandatory addition of certain biodiesel percentages in diesel fuel. In addition, the RenovaBio Program was launched, and it establishes national emission reduction targets for fuels. Although the objectives are clear, this strategy deserves attention because there may be greater climate and air quality risks due to the rapid expansion of soy-derived biodiesel. These risks are a consequence of the contribution of indirect land-use change (ILUC) emissions, which increase the life-cycle emissions from this fuel and can eliminate end-use emission savings (Pavlenko & Araujo, 2019).

Since it was created in 1986, the Program for the Control of Air Pollution by Motor Vehicles (PROCONVE) has guided the technological transition in domestic vehicles to reduce emissions. Pollutant emission limits were established and implemented in phases over the past few decades; the program has acted to control emissions of CO, NMHC, NO_x, and PM from diesel engines. PROCONVE is currently in phase P-7, equivalent to EURO V, and it was implemented in January 2012. The P-8 phase, equivalent to Euro VI, is set to take effect for new type approvals on January 1, 2022 and on January 1, 2023 for all new sales and registrations of HDV vehicles. Table 3 presents the emission standards for each Proconve phase.

Table 3. Brazil and EU emission standards for HD diesel engines (Façanha, 2016)

PROCONVE Standard***	Euro Equivalent	Test Cycle	CO	HC	NOX	PM	NMHC	CH4	PN (no/kWh)
			(g/kWh)						
P-1 (1989)	-	NBR 7026/7027	Only smoke index						
P-2 (1996)	-	R-49	11.2	2.45	14.40	0.60	-	-	-
P-3 (2000)	Euro I (1991)	R-49	4.9 4.5*	1.23 1.1*	9.0 8.0*	0.40 0.36*	-	-	-
P-4 (2002)	Euro II (1996)	R-49	4.0	1.1	7.0	0.15	-	-	-
P-5 (2006)	Euro III (2000)	ESC/ELR	2.1	0.66	5.0	0.10 0.13**	-	-	-
		ETC	5.45	-	5.0	0.16 0.21**	0.78	1.6	-
P-6 (skipped)	Euro IV (2005)	ESC/ELR	1.5	0.46	3.5	0.02	-	-	-
		ETC	4.0	-	3.5	0.03	0.55	1.1	-
P-7 (2012)	Euro V (2008)	ESC/ELR	1.5	0.46	2.0	0.02	-	-	-
		ETC	4.0	-	2.0	0.03	0.55	1.1	-
P-8 (new models: 2022 and all models: 2023)	Euro VI (2014)	WHSC	1.5	0.13	0.4	0.01	-	-	8.0 x 1011
		WHTC	4.0	-	0.46	0.01	0.16	0.5	6.0 x 1011

* Indicates values for corresponding Euro standard.
** For engines of less than 0.75 dm3 swept volume per cylinder and a rated power speed of more than 3000 min-1.
*** Years indicate full implementation of standards for all HDV types.

Based on Sindipeças truck age estimates, Figure 15 shows trucks by Proconve phase in 2020. Note that most trucks are from P-7 (equivalent to Euro V) and P-5 (Euro III), and these represent 40% and 33% of the fleet, respectively. Trucks in the P-4 (Euro II) phase were 13% of the fleet that year. Note, though, that given the problems in the P-7 phase, mainly with regard to fraud in the use of a reducing agent and with sensors that would indicate malfunction of the emission control, the actual emissions from P-7 vehicles are significantly higher than expected (Façanha, 2016). The regulation of the P-8 phase (Res. Conama 490/2018) requires its introduction by 2023 for all heavy vehicles and allows for early introduction.

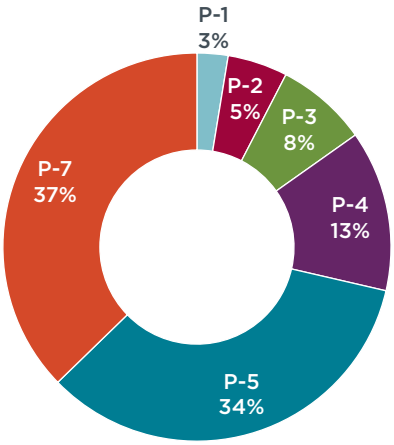


Figure 15. HDV fleet in 2020 by PROCONVE phase. (Based on Sindipeças, 2020).

Regarding emissions by category of truck, in 2012, the main emitters were the heavy and semi-heavy categories, which accounted for 70% of all emissions in this segment (MMA, 2013). In other words, most of the GHG emissions from freight transport occur on highways, considering the long distances traveled (Figure 16).

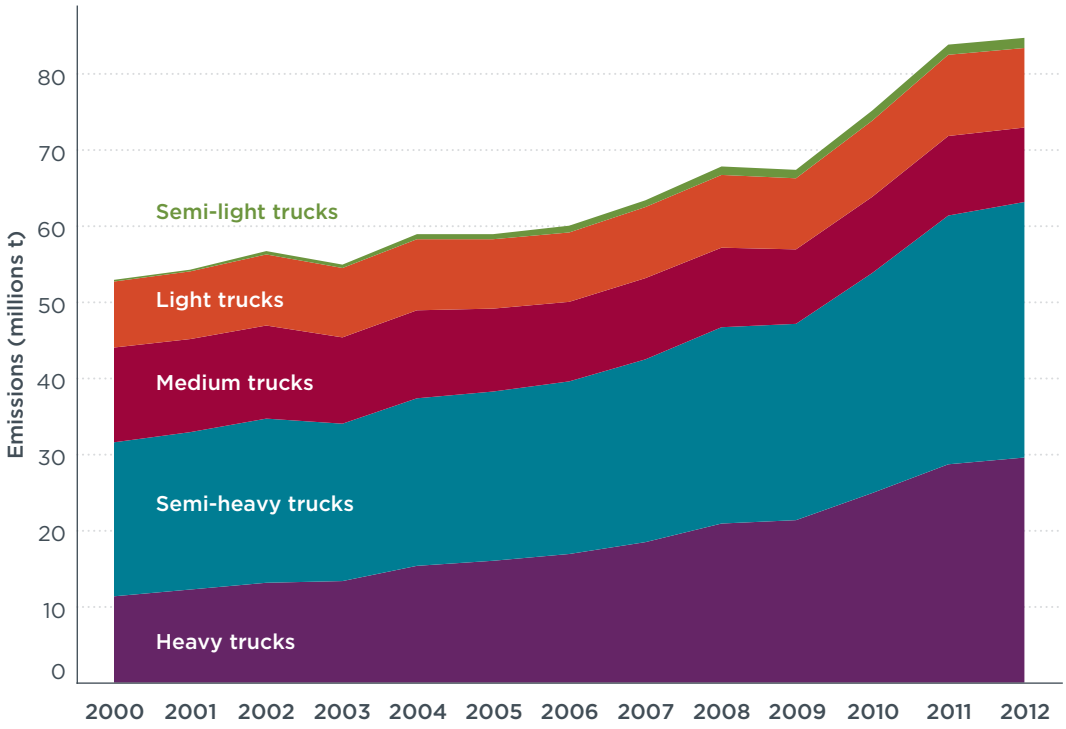


Figure 16. CO_2e emissions in 2012, by truck category. (MMA, 2013).

2. TRUCKING MARKET AND TECHNOLOGY PROFILE

Brazil is among the world's largest vehicle markets. Approximately 2.9 million vehicles, including light- and heavy-duty vehicles, were produced in 2019, and more than 90% of those were sold domestically. That year, trucks accounted for 117,692 units, 3.9% of the total produced.

In 2011, at the peak of domestic production, Brazil's automobile industry produced 223,602 trucks. However, this number has been falling in recent years, especially starting in 2014, when the economic crisis intensified in Brazil (Figure 17). This demonstrates that the road transportation sector is influenced by the level of economic activity in the nation, from the viewpoint of not only the volume of freight transported, but also truck sales to the domestic market. Only in 2018 did the truck market start to recover.

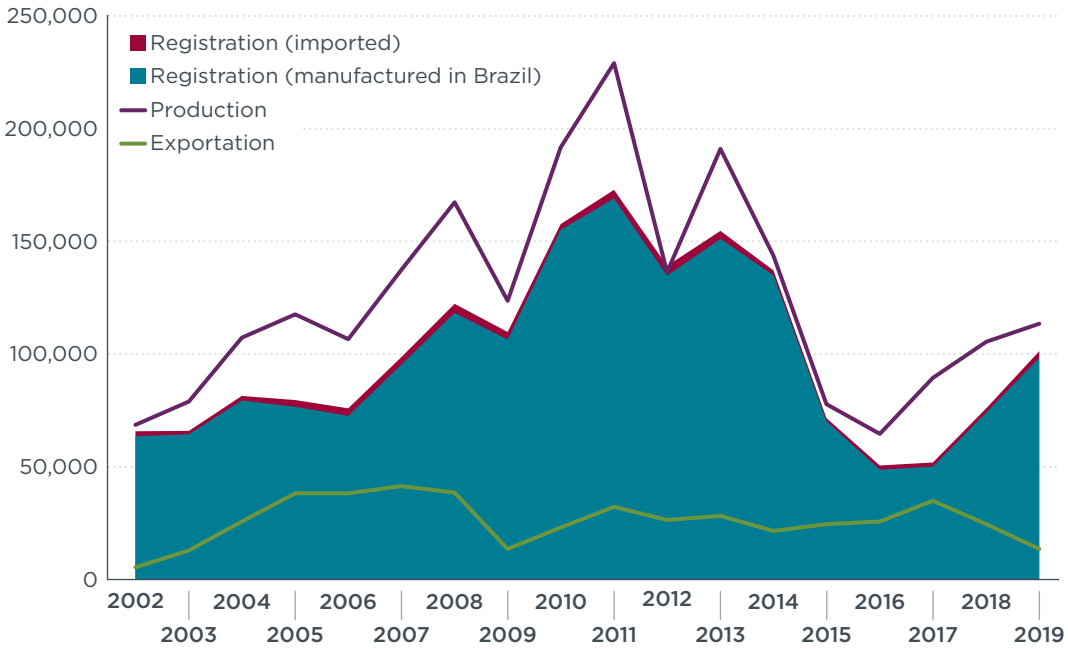


Figure 17. Truck registration, production and exportation in Brazil. (Anfavea, 2020).

Sales to the foreign market, on the other hand, remained constant at around 20,000 units per year between 2010 and 2017. With the slowdown in the domestic market in 2014, exports accounted for almost 40% of national production. In 2019, this percentage dropped to 12%, motivated by the increase in sales in the domestic market and the drop in export sales to around 13,000 units.

Imports, on the other hand, are not very significant. They represent less than 3.1% of the trucks licensed in 2019. This is almost certainly related to the high import tax rates and the conditions for truck financing set by the National Bank of Social and Economic Development – BNDES; this is the main financing bank and offers the most convenient rates. BNDES imposes a 60% minimum national content for financed vehicles.[14] In this context, it is important to note that BNDES is one of the main players responsible for stimulating the production and marketing of trucks, since the abundance of credit lines with low interest rates from the bank was largely responsible for the increase in sales.

14 Percentage changed to 50% in September 2016. The changes are, in general, due to exchange rate fluctuations.

2.1. PROFILE OF DOMESTIC SALES

Figure 18 shows the evolution of sales of the various truck categories from 2002 to 2018. Notice the preponderance of the categories of heavy-duty and semi-heavy-duty trucks, followed by light-duty rigid type. Indeed, when we analyze the profile of sales in 2018, these are the three categories with the largest market share: 50.5%, 21%, and 20.6% respectively.

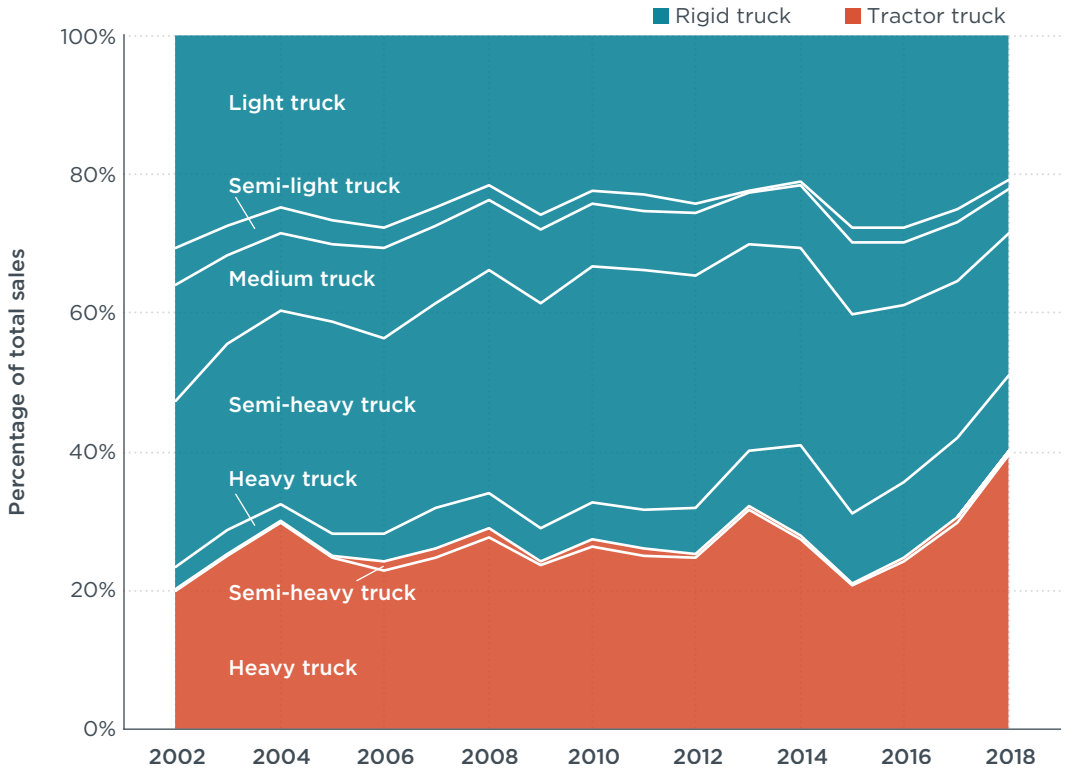


Figure 18. Truck registrations by type and category. (ADK Automotive).

With regard to body, rigid trucks or box trucks are the foremost product and account for 60% to 80% of sales over the past 15 years. The rigid body was preferred in the cases of semi-light, light, medium-duty trucks, and nearly all semi-heavy-duty trucks. Tractor trailers, on the other hand, are two out of every three heavy trucks sold and their share over the years in the period analyzed ranged from 20%–40% of sales. Note that tractor trailers have higher total gross weight and traction capacity than most of the rigid trucks marketed in Brazil.

For the period 2008 to 2018, heavy trucks had an average gross vehicle weight (GVW) of 28 tonnes (t) and heavy trucks had an average GVW of 24.5 t. For rigid semi-heavy trucks, the average GVW was 22 t. Figure 19 shows the GVW distribution by category and type of truck.

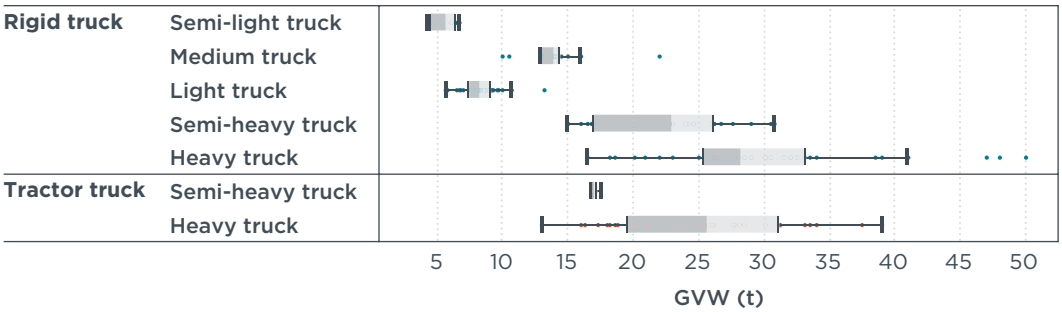


Figure 19. Truck registrations by type, category and GVW (from 2008 to 2018). (ADK Automotive)

2.2. MANUFACTURERS

Similar to several other markets, including Europe and the United States (Sharpe, 2015), nearly all trucks marketed in Brazil are concentrated in only six brands. Indeed, in order of market share from largest to smallest, Mercedes-Benz, MAN/VW[15], Ford, Volvo, Scania, and Iveco have 97.4% of the market.

Analysis of the market share over the 15 years from 2002 to 2018 (Figure 20), reveals slight changes in each manufacturer's share of total truck sales. Importantly, with the economic crisis and abrupt drop in sales from 2014 to 2017, it is likely that the recession has affected the various productive sectors unequally. This leads to a differentiated impact on the production of each brand. The market leaders, MAN/Volkswagen and Mercedes, account for 55%–65% of total sales over the period of 2002 to 2018, with MAN/Volkswagen representing 27.6% of the market in 2018 and Mercedes 27% in the same year. In recent years, the shares of Volvo and Scania have increased slightly. Comparing sales in 2016 and 2018, Volvo increased from 11.7% to 14.5% and Scania from 8.8% to 11.8%. Ford, which represented 12.7% of sales in 2018, ended production in Brazil in 2019.

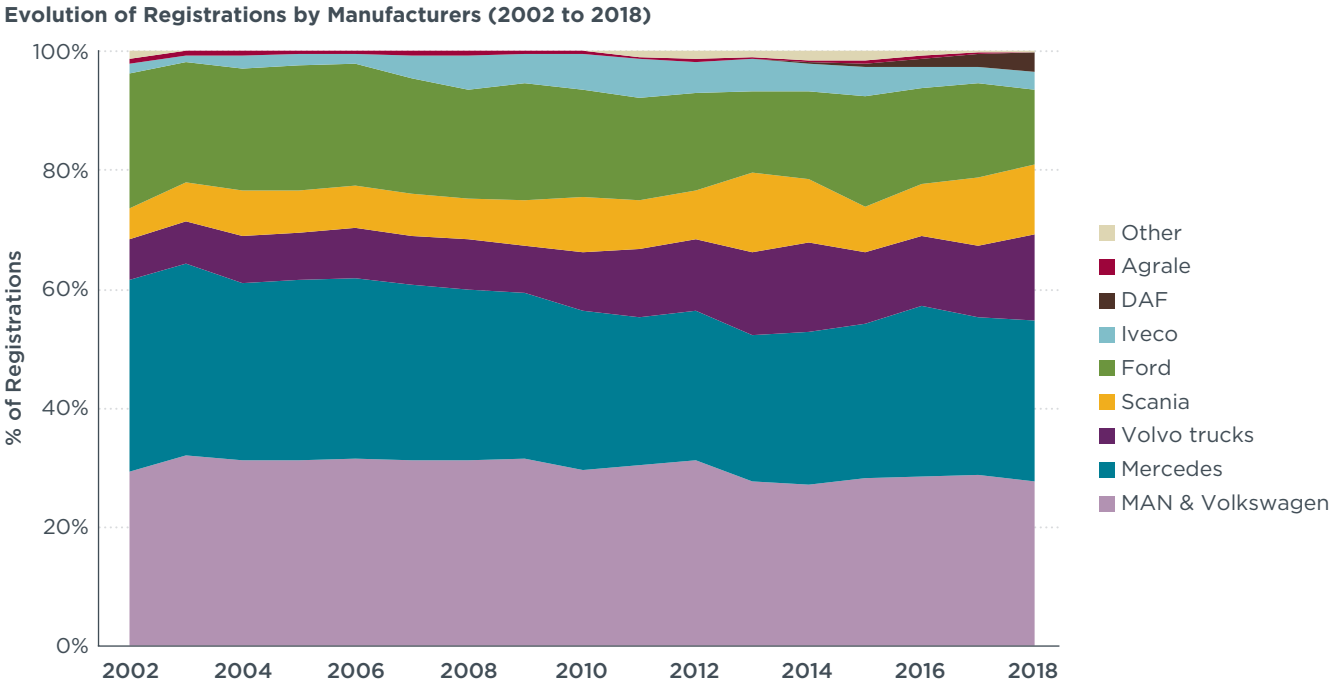


Figure 20. Registrations by manufacturer, 2002–2018. (ADK Automotive).

15 In 2008, the German group MAN bought Volkswagen Trucks and Buses in Brazil and created the MAN Latin America group. To simplify the data analysis, the MAN/VW brand covers both MAN and Volkswagen trucks throughout the study, although both brands have been maintained.

MAN/VW and Scania are controlled by the holding company Volkswagen Truck and Bus.

As for market niche, MAN, Mercedes-Benz, Ford, and DAF predominantly produce rigid trucks, while Volvo, Scania, and IVECO mainly produce tractor trailers (Figure 21).

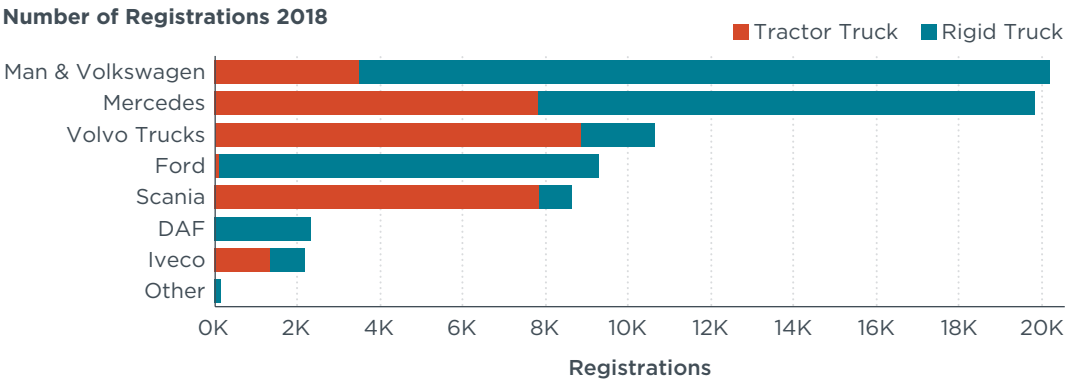


Figure 21. Number of registrations by manufacturer and truck type in 2018. (ADK Automotive).

2.3. ENGINES

The engines of trucks produced in Brazil are either manufactured by the automakers themselves or produced by suppliers like Cummins and MWM, the latter of which is owned by Navistar. In 2016, 56% of the engines marketed in Brazil originated from only two manufacturers which had equal market shares: Cummins and Mercedes. MAN, the third largest truck engine manufacturer (Figure 22), equipped its trucks with both its own engines and Cummins engines in similar proportions. Volvo works in a similar way; it uses its own engines, but also those manufactured by MWM. Mercedes and Scania, on the other hand, work exclusively with their own engines, which makes them exceptions in the market.

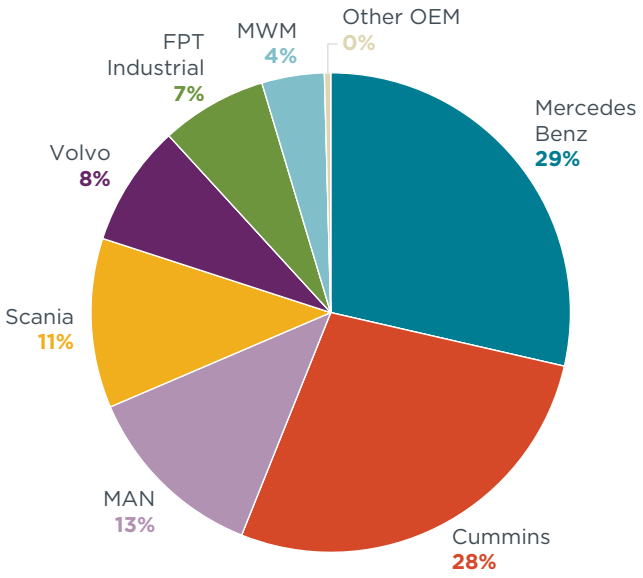


Figure 22. Engine market share in 2016. (Fraga Inteligência Automotiva).

As one would expect, heavy- and semi-heavy-duty tractor trailers are equipped with engines of larger displacement and higher power, mostly in the range of 7 to 13 liters, and 210 to 400 kilowatts (kW). In the 2008 to 2018 period, the best-selling trucks had engines around 300 kW and 12 to 13 liters. (Figure 23.) Rigid trucks, due to their diversity, had a greater variety of engines, sized from 3 to 12 liters. However, sales were strongest for models with power between 100 kW and 300 kW and engine sizes from 3 to 7 liters.

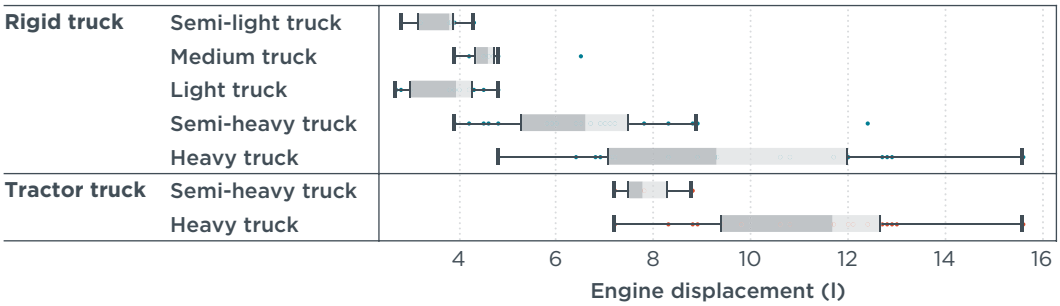


Figure 23. Box plot – Engine displacement by truck category, cumulative registrations from 2008 to 2018. (ADK Automotive).

The detailed analysis of truck sales by engine power and manufacturer (Figures 24 and 25) reveals specific niches for each brand. Volvo, for instance, produces tractors with higher-powered engines, ranging from 325 kW to 425 kW. Scania's sales were also mostly tractor trucks, with power ranging from 250 kW to 400 kW. MAN, on the other hand, mostly marketed rigid trucks in the range of 125 kW to 250 kW; this was also the case with Mercedes, which also sold rigid trucks with power ranging from 100 kW to 325 kW and tractor units in the range of 250 kW to 400 kW.

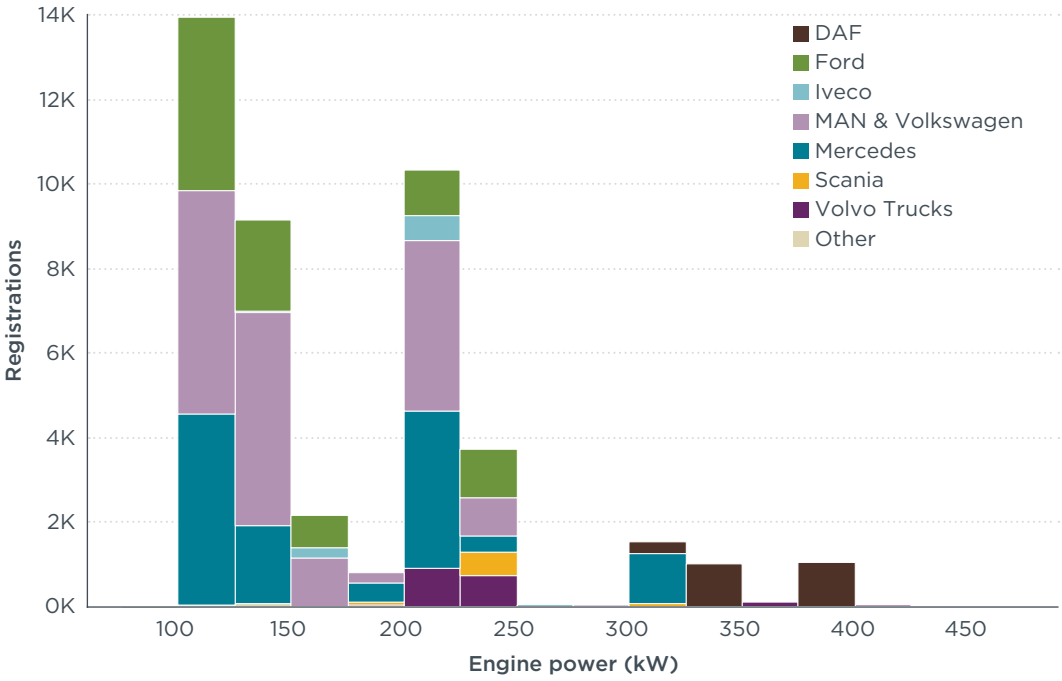


Figure 24. Registrations in 2018 by manufacturer (Rigid truck)

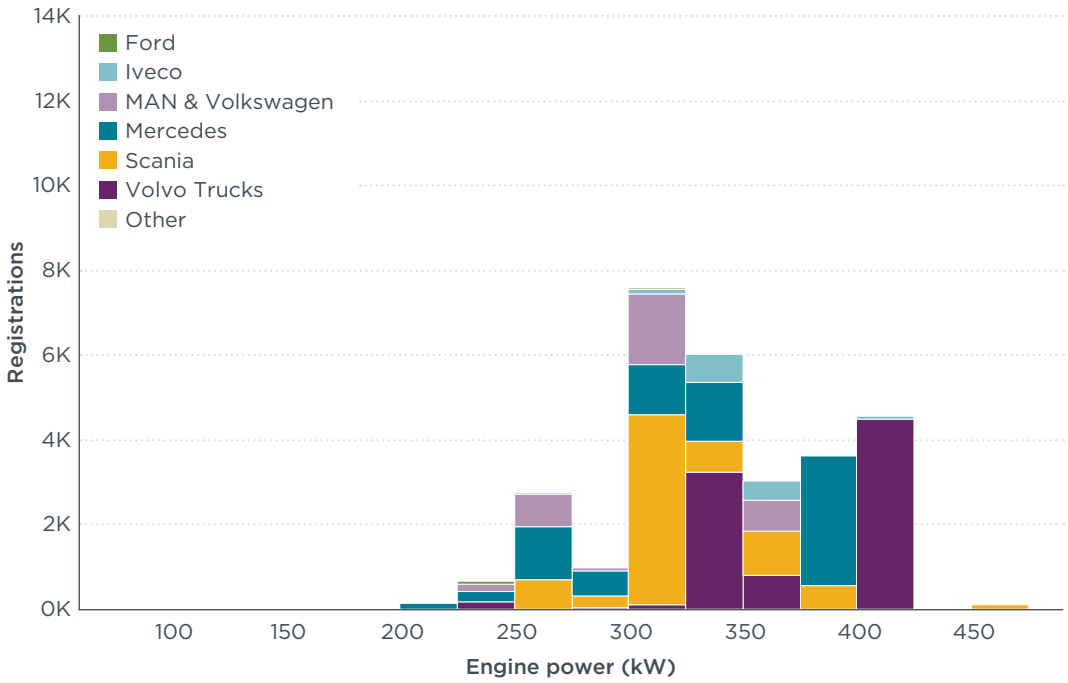


Figure 25. Registrations in 2018 by manufacturer (Tractor truck). (ADK Automotive).

2.4. TRACTOR TRAILERS

Over the last 15 years, there has been a clear trend toward the use of tractor trailers with higher total gross weight and a larger number of axles. While in 2003, around 86% of the tractor trucks sold had a 4x2 configuration, in 2018, the most frequent configuration was 6x4 and the second most frequent was 6x2 (Figure 26),

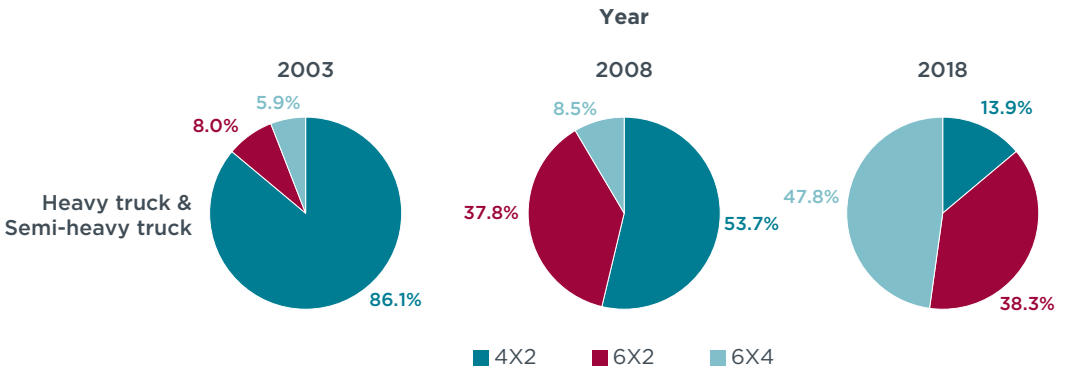


Figure 26. Tractor truck registrations by driveline configuration – 2003, 2008, and 2018. (ADK Automotive).

Changes in regulations concerning the maximum load capacity of trucks allowed in Brazil can explain this non-homogeneous evolution. In 1998, the load limit of 45 t for the transportation of cargo was increased by special authorization, pursuant to Contran Resolution 068/98. During the period in which Resolution 68/98 was in force, there was no regulation for nine-axis b-train, so only 89 units had been licensed. As of 2006, with the regulation of the combination of vehicle of load (CVC) known with the

b-train,[16] the legal limit happened to be 57 t without requiring the special authorization known as AET[17] (Resolution 211/06 of the Contran).

The traditional b-trains are composed of seven axles, the mechanical horse type 6x4 and two semi-trailers with two axles each. The maximum gross combined total weight (GCW)[18] in Brazil is 57 tonnes, with a payload capacity of 38 to 40 tonnes, depending on the weight of the vehicle. The 9-axle b-trains must be driven by a tractor unit type 6x4 and can have up to three axles on each semi-trailer. In Brazil, the maximum GCW for the 9-axle vehicle is 74 tonnes and the length is typically between 25 and 30 meters.[19] The entry into force of Contran Resolution 211/ 2006 also regulated this configuration.

A similar phenomenon can be seen in registrations by GVW in Figure 27, which show a market divided in 2002 between 16 and 20-tonne trucks, on one hand, and trucks over 20 tonnes, on the other. In the decade that followed, sales of trucks with a GVW of more than 20 tonnes started to dominate the market, and their share reached around 90% in 2018.

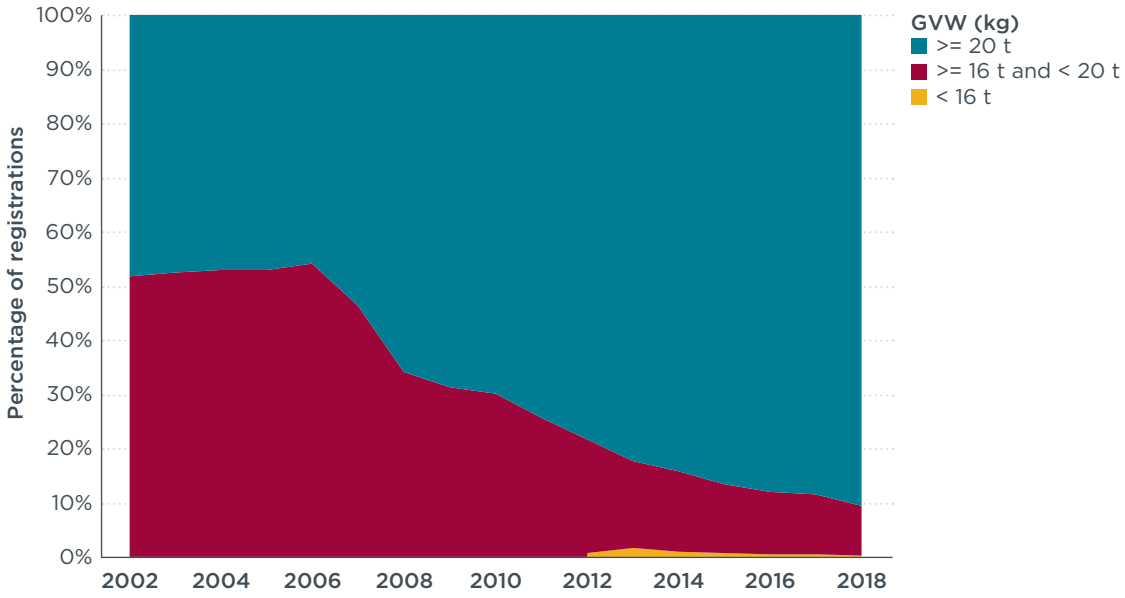


Figure 27. Evolution of tractor truck registrations by GVW. (ADK Automotive).

Regarding market share, the main players are Volvo, Scania, Mercedes, and MAN, which accounted for 95% of the market in 2018. The remaining share is divided mainly between Iveco and Ford. (Figure 28.)

16 The b-train is a combination of two semi-trailers coupled using a fifth wheel located at the rear of the first semi-trailer, driven by a mechanical horse. This conjunction allows, in special cases, the user to transport only a semi-trailer (in this case, the equipment loses the b-train characteristic). In Brazil, the b-trains were developed initially in the bulk carrier version and started to operate in several other segments due to the advantage of higher net cargo transported. Its main application is in the bulk version by the national transport profile.

17 The length is limited between 17.50 and 19.80 meters, for circulation without Special Traffic Authorization (AET).

18 Gross Combined Total Weight- GCW: Maximum weight that can be transmitted to the pavement by the combination of a traction or cargo vehicle, plus its semi-trailer (s), trailer (s), respecting: (i) the ratio power / weight, established by INMETRO - Institute of Metrology, Standardization and Industrial Quality, (ii) the Maximum Traction Capacity of the traction unit, as defined in item 2.7 of the annex to this Resolution and (iii) the maximum limit established in CONTRAN Resolution nº 211/06, and their substitutes.

19 The vehicles with this maximum traction capacity are the TRI TREM (tractor truck + three semi-trailers) or RODOTREM (a mechanical horse pulling two semi-trailers coupled using an intermediate vehicle called a dolly). In this configuration of 9 axles it is necessary to carry the AET.

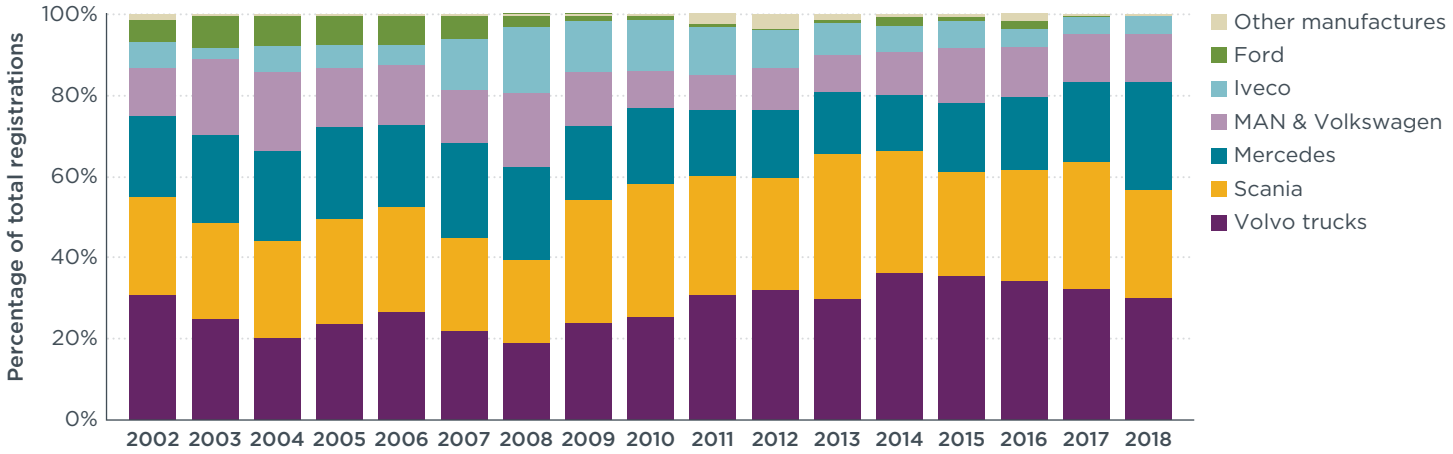


Figure 28. Evolution of tractor truck market share. (ADK Automotive).

2.5. RIGID TRUCKS

As previously shown, rigid trucks belong to several categories and have several ranges of GVW. Around half of the rigid trucks sold in 2018 were light- and medium-duty, predominantly urban and short-haul (UCV – urban cargo vehicles). The other half belonged to the semi-heavy and heavy-duty categories.

The market for rigid trucks is concentrated among three main manufacturers—MAN, Mercedes, and Ford—which jointly accounted for 85.6% of sales in 2018. The remaining share was mainly divided among four others—DAF, Volvo, Iveco, and Scania. (Figure 29.)

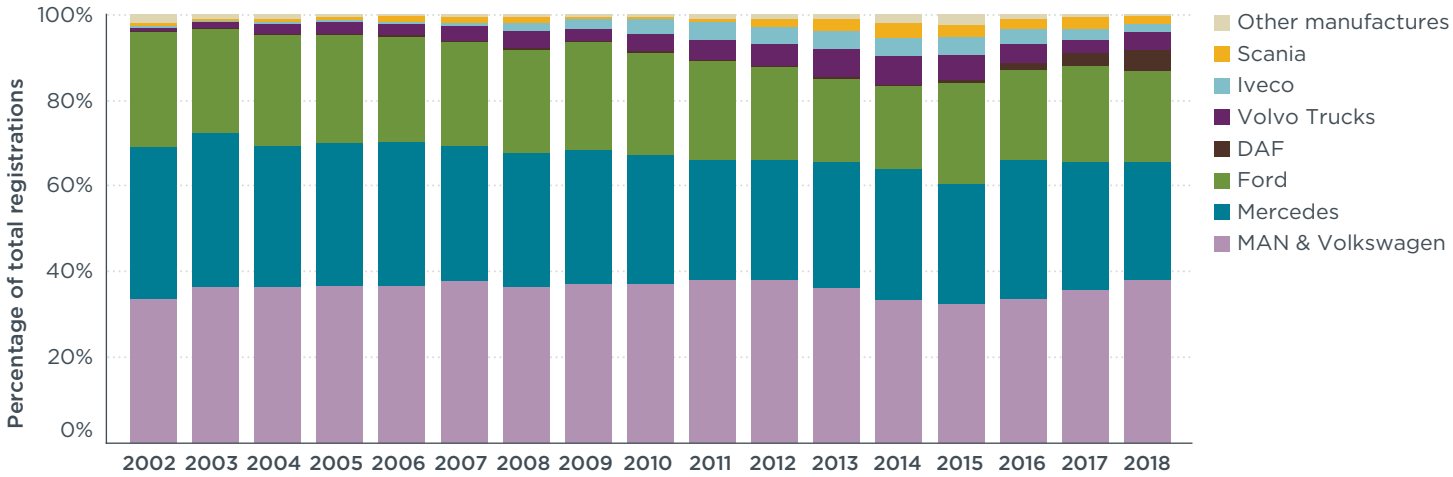


Figure 29. Evolution of rigid truck market share. (ADK Automotive).

Two characteristics are noteworthy regarding the top-selling configurations among light-, semi-light, and medium-duty rigid trucks. First, almost all sales are in the 4x2 configuration. (Figure 30.) Additionally, the vast majority of trucks sold can be classified as UCV (see Box 1).

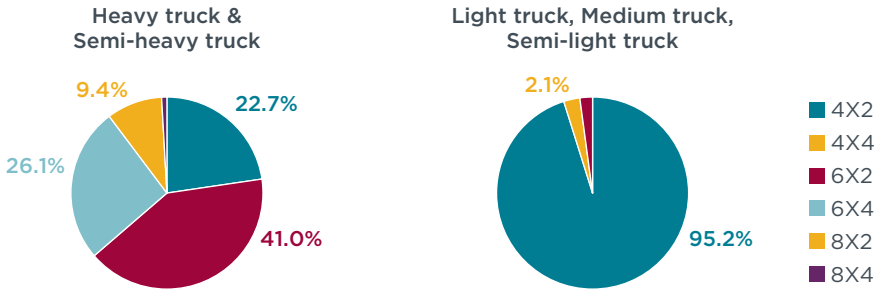


Figure 30. Rigid truck registrations in 2018 by driveline configuration. (ADK Automotive).

BOX 1. URBAN CARGO VEHICLES (UCV)

Several Brazilian cities have imposed restrictions on the operation of trucks with the aim of reducing congestion and air pollution. The measures restrict circulation and loading/unloading in certain areas or routes, or at certain times of day; set limits on parking; provide for alternate-day travel (i.e., road space rationing) and schedules; restrict vehicle size, weight, and age (technology); and restrict load types (e.g., dangerous cargo).

To accommodate these restrictions, an alternative vehicle type, the Urban Cargo Vehicle (UCV), was defined for deliveries to urban centers. In 2016, an estimated 10,000 UCVs were registered with São Paulo City Hall.

In São Paulo, UCVs are defined by the following characteristics (Ordinance No. 31/16-SMT, G):

- maximum width = 2.20 m;
- maximum length = 7.20 m;[a]
- manufacture date: January 2005 or later.

São Paulo's legislation does not limit the maximum capacity of the truck, only its dimensions. In several municipalities, however, there are limitations on GVW. This includes some of the metropolitan areas of Belo Horizonte, where the maximum GVWs range from 3.5 t to 10 t, and some of the metropolitan areas of São Paulo, where GVW limits range from 1 t in Mogi da Cruzes to 23 t in Biritiba Mirim.

Additionally, a recent survey on urban logistics in several metropolitan regions of Brazil, including the metropolitan regions of São Paulo, Belo Horizonte, Curitiba, Porto Alegre, Goiania, Recife, and Manaus, identified a diversity of rules and criteria in relation to these restrictions, even within the same metropolitan region (CNT, 2018). This is because the regulations are established at the municipal level and municipalities within a given region do not always coordinate on these rules. The motivations for the rules are the most varied, and such diversity of rules can bring additional complexity mainly in conurbations. This highlights the need for more in-depth studies to evaluate the impacts of these measures, including whether they increase the number of trips necessary to deliver the same volume of cargo.

[a] Modified in 2016; previously the maximum length was 6.30 m.

2.6. TRAILERS, SEMI-TRAILERS, AND TRUCK BODIES

The trailer manufacturers and body builders who develop and produce bodywork, trailers, and semi-trailers, along with any other accessories for the functioning of the vehicles when transporting freight, are an important part of the sector. Given the economic downturn, it is not surprising that, between 2014 and 2017, the freight sector suffered from reduced truck sales. As of 2018, there was an increase in sales as a result of the market recovery, although still below the levels of 2013. In 2019, according to data from the National Association of Bodywork Manufacturers (Anfir, 2020), 120,962 bodies were produced and licensed (Figure 31).

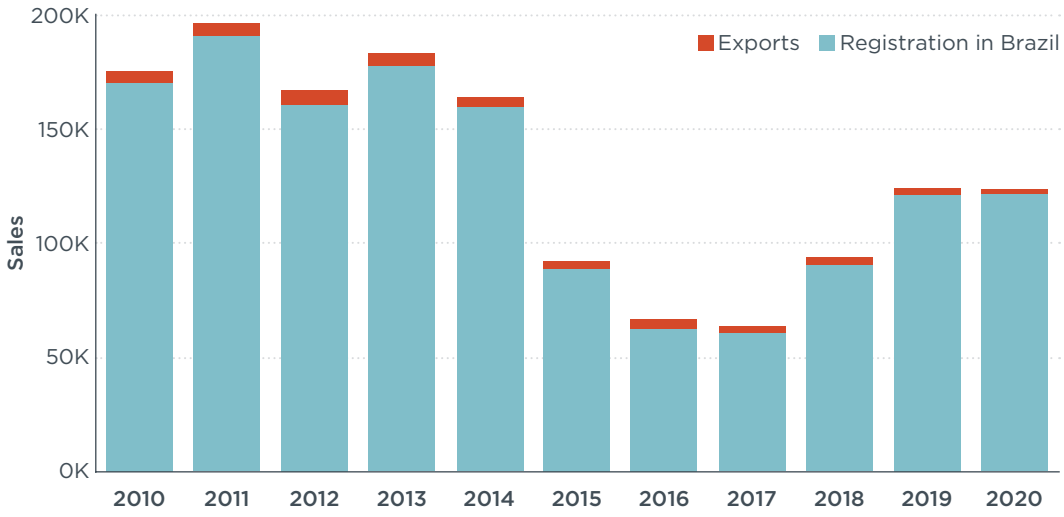


Figure 31. Evolution of registrations in Brazil and exports: Trailers, semi-trailers, and truck bodies. (Anfir)

Unlike truck and engine manufacturers, the trailer manufacturers and body builders' sector is quite fragmented, with 1,142 companies in 2019. These are mostly domestic companies; the first were established in the 1950s. As demand for road freight continued to increase over the following two decades, the sector matured, creating a diversified supply of products to meet the severe conditions of Brazilian roads and highways.

BOX 2. TYPES OF TRAILERS AND TRUCK BODIES

Chassis-mounted bodies complement rigid trucks and are mounted directly on the truck chassis. These bodies do not have their own axles or chassis.

Trailers and semi-trailers have greater length and freight capacity.

Trailers are attached to trucks by means of a draw bar and have a front axle. They are generally used in applications that require agility in the coupling and decoupling of the trailer from the tractor unit, as in mechanized harvesting of sugarcane, or to increase the carrying capacity of a road train combination.

Semi-trailers do not have a front axle and are coupled to the tractor unit by means of a system consisting of a kingpin on the trailer and a fifth wheel in the tractor unit. This gives stability to the set.

There is also diversity in size. The sector is composed of small, medium, and large companies, and the technological level is rather heterogeneous. In some segments, medium and large companies that have a greater degree of technological development dominate, and in others there are a large number of smaller companies that produce less-sophisticated trailer and truck bodies that have few differentiating factors. The asymmetry between companies is also reflected in data from the IBGE, which shows that half of the personnel employed in the manufacture of cabs, bodies, and trailers for motor vehicles are linked to the 12 largest companies. In other words, 50% of the personnel employed in the sector are concentrated in less than 1% of the companies.

The choice of trailer and truck body configuration is based on the characteristics of the freight to be transported and the objective pursued—e.g., flexibility, cost, haul distance, and interaction with other modes of transportation. To meet demand and maximize transportation efficiency, manufacturers produce a very wide range of products. According to data published by Anfir (2020), of the license tags issued for rigid trucks over the last 10 years, most were for aluminum boxes and refrigerated boxes, and that was followed by bulk freight and dry freight (Figure 32). Meanwhile, data on the issuance of license tags for trailers and semi-trailers for the same period showed that bulk freight, dry freight, dumper, and tank trucks were the preferred body types (Anfir, 2020).

The most common bodywork for trailer and semi-trailer categories is open dry freight, equipping not only rigid trucks but tractor trailers (trailers/semi-trailers) as well. The next most common type is closed dry freight. (Figure 33)

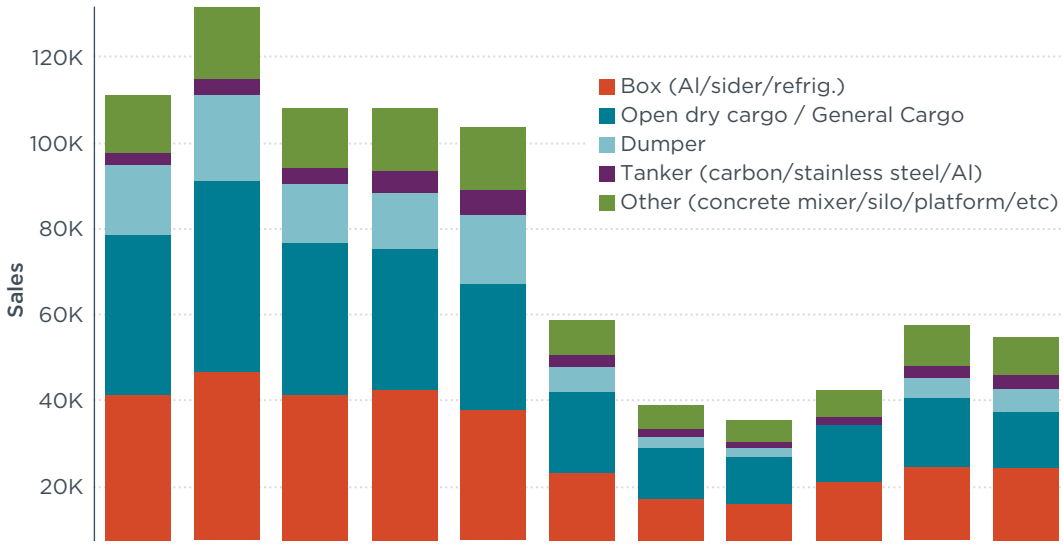


Figure 32. Truck body registrations by type from 2010 to 2020

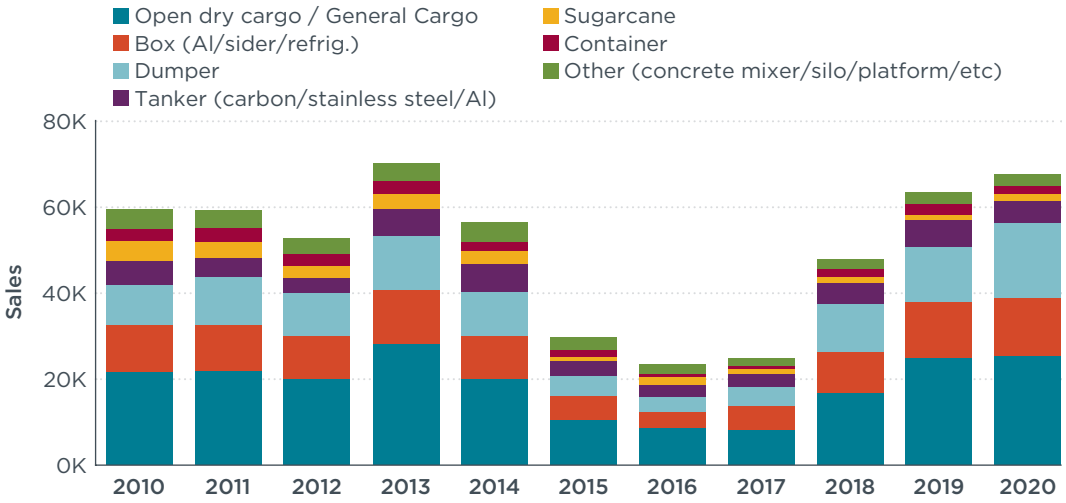


Figure 33. Trailer and semi-trailer registrations by type from 2010 to 2020. (Anfir, 2020)

The RNTRC contains data regarding the most frequent configurations within each category of registered vehicles. Although this database does not represent the entire fleet of trucks because it excludes vehicles that carry their own cargo, the most frequent types are dry, open, and closed load. These figures are compatible with the load profile transported in the country, as there is a predominance of general cargo.

BOX 3. COMMON CONFIGURATIONS OF TRAILERS, SEMI-TRAILERS, AND TRUCK BODIES

PHOTOS BY CARMEN ARAUJO

Open Dry Van

Curtainsider

Open Dry Van

Aluminum Box

Tank Truck

Tank Truck

Tank Truck

Dump Truck

Flatbed Truck

Container Truck

Logging Truck

Auto Hauler

3. TRUCKING OPERATIONAL PROFILE

In Brazil, freight transportation is regulated by Law 11.442, dated January 5, 2007, which sets out the minimum requirements for the profession. The work is carried out by a wide range of very heterogeneous carriers, both in terms of company size and institutional arrangements. These include transportation cooperatives, carrier companies, and self-employed carriers. In some cases, carriers are transporting their own freight, unpaid, and therefore are not obligated to register with the relevant authorities. In the case of paid trucking services, though, and as explained above, registration with the National Registry of Road Freight Transportation (RNTRC), under the National Land Transportation Agency (ANTT), is required. This national registry contains data about the number of carriers and the fleet of vehicles. Periodically, the re-registration of carriers and their fleet is required.

Data obtained from the RNTRC in November 2020 indicated that there were 956,133 registered road freight carriers. Historical data show significant fluctuations between 2010 and 2011, gradual increases up to 2015, and a significant drop of almost 50% between 2016 and 2017 (Figure 34). Since 2018 there has been a gradual increase in registrations again. These fluctuations may be the consequence of several factors, including a reduction of activities or even the elimination of outdated records from the registration database.

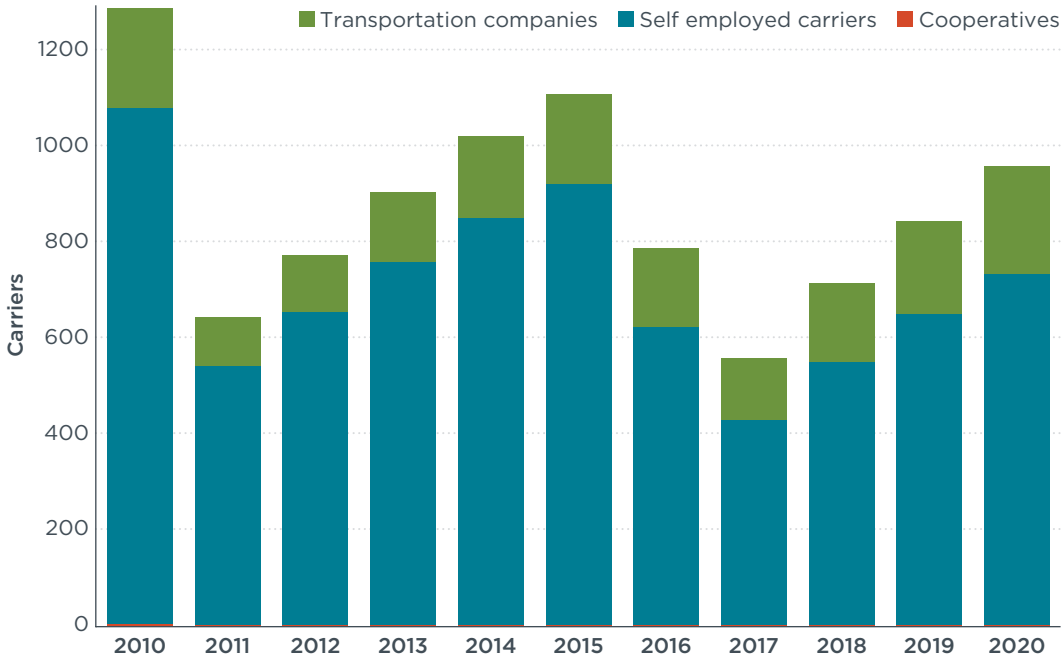


Figure 34. RNTRC-registered carriers by segment. (ANTT, 2020).

In examining the three-year period from 2015 to 2017, we found a 30% drop in the number of registered vehicles. When broken down by type of organization, the data reveal a sharp drop in registrations of self-employed carriers' vehicles, a slight drop in carrier companies, and an increase in the number of vehicles in co-ops (figure 35).

Because this is a period of only three years, it is unlikely that the decrease is related to a scrapping of the fleet of this proportion. It may be related to the reduction of economic activity, which directly impacted self-employed carriers; or to a more precarious type of work that also adversely affected companies, though not to the same extent. An increase in informality in this profession might explain the fleet reduction, or it may reflect inactive trucks that were not re-registered with RNTRC. It is worth noting that road freight transportation is characterized by low barriers to entry and exit; investments are relatively small when compared to other modes of

transportation. When transportation demand decreases, there is usually a drop in the amount charged for shipping and, consequently, there can be a reduction in the number of agents operating the system.

The data of the fleets registered in the RNTRC show an evolution compatible with that observed in the number of transporters, however, with fluctuations slightly less pronounced. The reduction in fleets registered between 2015 and 2017 was 30%. (Table 4.) This difference can be explained by the more pronounced reduction of self-employed carriers, with a smaller fleet when compared to the companies' fleet. From 2018, there is an increase in registrations for all categories of carriers and in the fleet, coinciding with the economic recovery.

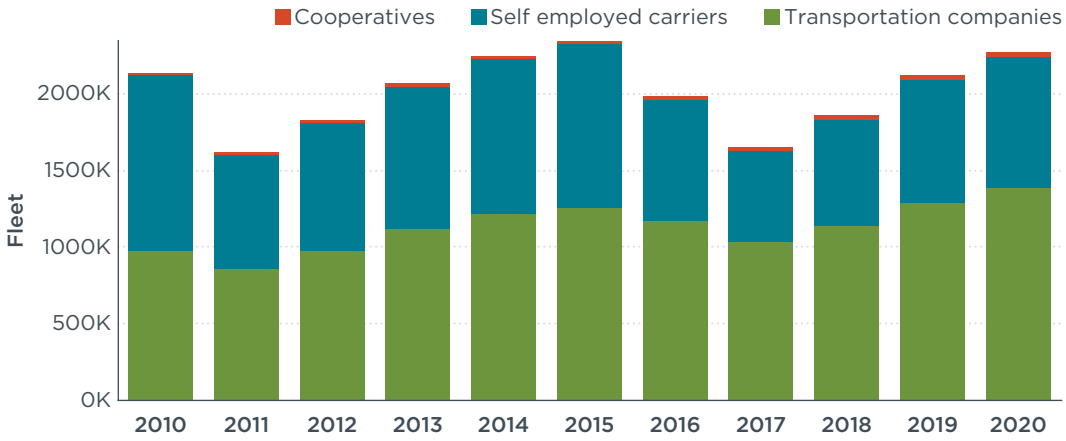


Figure 35. RNTRC fleet by segment. Note: Cooperative registrations represented 1.3% or less of the total registrations between 2010 and 2020.

Table 4. RNTRC fleet detailed by freight carrier segment (ANTT, 2020).

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cooperatives	11,839	11,496	13,000	15,707	17,697	18,800	21,837	22,188	23,955	26,878	28,481
Transport Companies	973,335	854,315	971,653	1,116,722	1,211,601	1,252,811	1,170,378	1,028,229	1,135,538	1,287,422	1,382,651
Self-employed carriers	1,141,952	749,400	838,600	926,437	1,009,860	1,068,092	783,656	597,491	693,916	804,499	856,729
Total	**2,127,126**	**1,615,211**	**1,823,253**	**2,058,866**	**2,239,158**	**2,339,703**	**1,975,871**	**1,647,908**	**1,853,409**	**2,118,799**	**2,267,861**

3.1. OUTSOURCING

Another important characteristic of freight in Brazil is the high degree of transportation outsourcing. This outsourcing takes place at various levels of the value chain, from shipper to carrier companies and self-employed carriers. At the first level, shippers are the agents who are in possession of the freight and hire other agents to transport it, such as carrier companies (77% of the time), self-employed carriers (31%), or co-ops (4%). This is shown in Figure 36 and adds up to more than 100% because the same shipper may hire more than one type of transportation service, depending on the route and commodity.

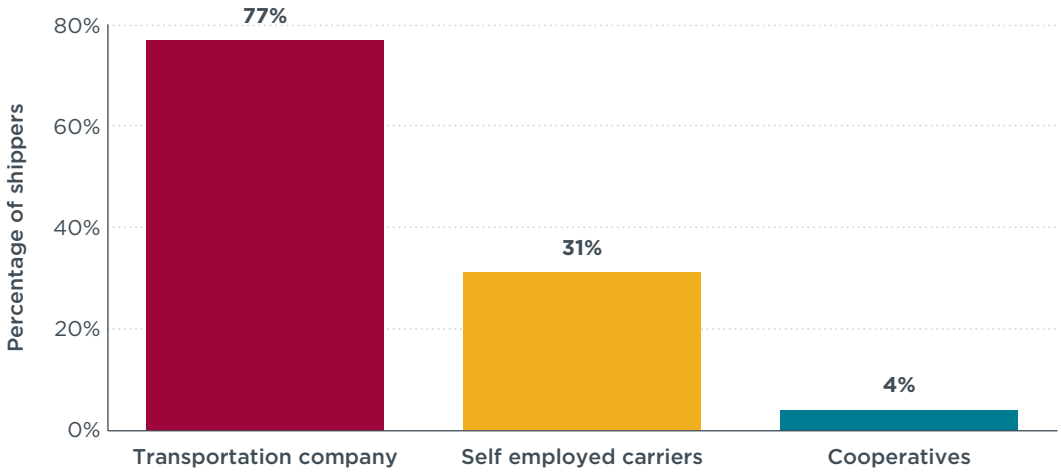


Figure 36. Percentage of shippers that contract each segment of carrier. (EPL, 2015).

Because shippers include an extremely wide range of companies, stores, industries, dealers, and the like, there is no accurate data on their numbers in Brazil. In 2010, EPL (National Planning and Logistics Company)[20] conducted a survey that estimated approximately 780,000 companies fall under the category, out of more than 3 million contained in the Annual Social Information Report (RAIS). According to the same survey, 21% of shippers, around 160,000 companies, fully transport their own freight. At the other extreme, 38%, approximately 290,000 companies, outsource all shipping of their freight.

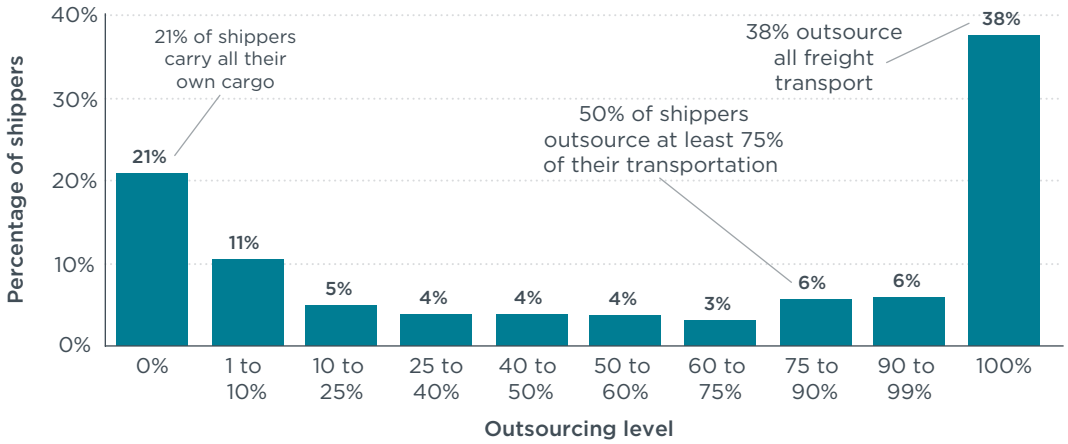


Figure 37. Percentage of shippers by outsourcing level. (EPL, 2015).

According to this survey, which also sought to analyze the profiles of shippers, the most important factors when hiring a carrier company are cost, service capacity, and service level. Quality of the fleet and environmental certification were also mentioned, but by smaller shares of the shippers surveyed.

20 EPL, the National Planning and Logistics Company, is a public company linked to the Ministry of Infrastructure. It provides services in the area of projects, studies and research designed to support the planning of infrastructure, logistics and transport in the country.

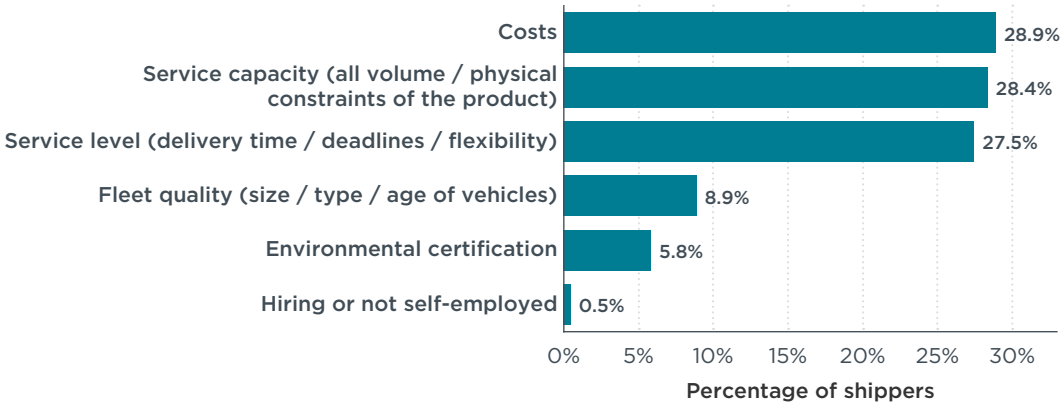


Figure 38. Most important factors when hiring a carrier company. (EPL,2015).

Although the main service of carrier companies is freight transportation, in some cases they also provide logistics services including warehousing, inventory control, order management, and help with distribution. According to a survey by the Brazilian Association of Logistics Operators (ABOL, 2020), in 2014, there were 159 such companies with total gross revenues of R$ 44.3 billion annually.

At the second level of outsourcing, it is quite common for carrier companies to subcontract other companies in the same segment or self-employed carriers to perform part of the route or the complete route. Among the main reasons for this outsourcing by carrier companies is the seasonality of the activity, specializations or local performance of subcontractors, and lower costs. Figure 39 summarizes these relationships.

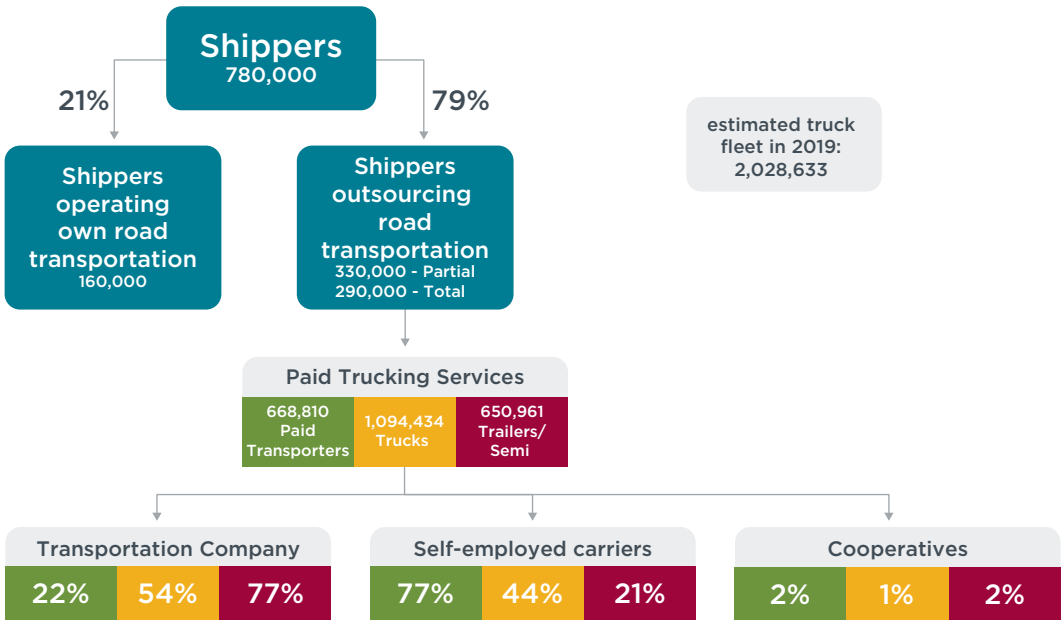


Figure 39. Relationships between different carriers and contractors. (Prepared by the author based on ANTT, 2020 and Sindipeças, 2020).

Law 11.442 / 2007, which regulates the activity of road haulage of remunerated goods, states that the relationship between the carrier and the autonomous company can be "aggregated" or "independent," according to agreement between the parties. "Aggregates" are self-employed carriers that use their own vehicles, driven by themselves or their representatives, in service of the contracting company exclusively and for defined compensation. "Independent" self-employed carriers are those who provide the freight transportation services on an ad-hoc basis and without exclusivity, for shipping fees negotiated for each trip.

According to current labor laws, hiring an aggregate carrier creates an employment relationship and the contracting company is required to pay labor-related charges. Therefore, carrier companies usually hire independent carriers to avoid creating an employment relationship; carriers are also able to pay non-fixed monthly amounts for the hauls they order. Moreover, carriers prefer the engagement of ad-hoc and non-exclusive services, the absence of a relationship of hierarchical subordination, and, preferably, self-employed carriers that organize as legal entities.

3.2. FLEET PROFILE PER TYPE OF CARRIER

According to the RNTRC , registered self-employed carriers outnumbered carrier companies by more than three-to-one in 2017. At the same time, the total fleet of the companies was twice as large as the fleet of self-employed carriers, as there were an average of 9.7 vehicles per company and self-employed carriers had an average of 1.5 vehicles.[21] Regarding the cooperatives, which are a type of association among self-employed carriers, they have a much larger average number, 84.5 vehicles each.

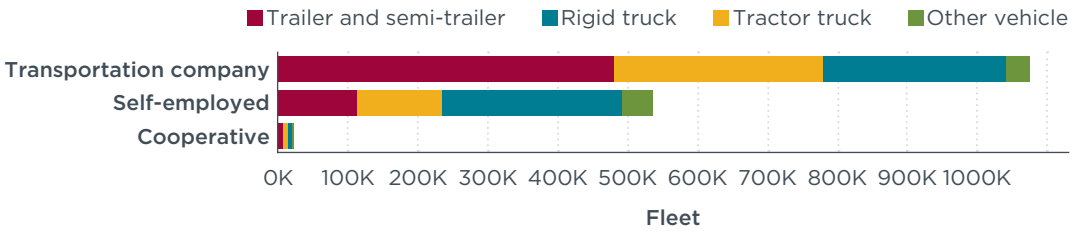


Figure 40. Registered fleet by carrier segment and vehicle group

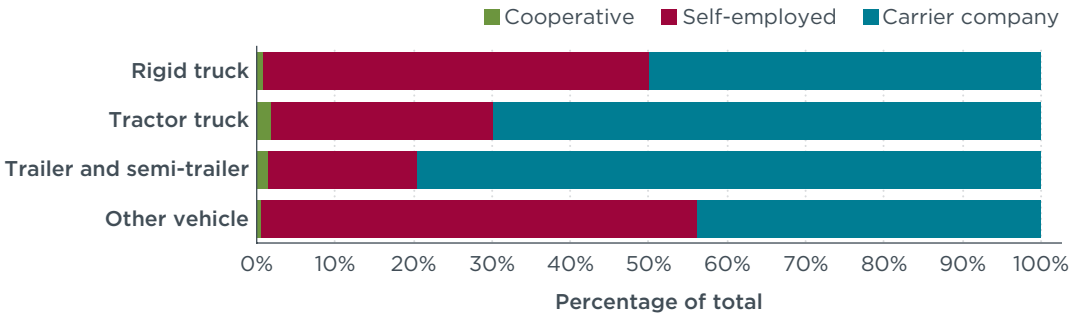


Figure 41. Registered fleet by carrier segment and vehicle group (percentage of total). (ANTT, 2018).

Carrier companies usually have greater financial resources; they own 67% of all tractor trucks in the fleet and 77% of trailers and semi-trailers. In the case of rigid trucks, 54% belong to self-employed carriers and 45% to companies. Companies' fleets have a greater number of trailers and semi-trailers both in absolute terms and in proportion to tractor trucks. In the case of self-employed carriers, rigid trucks predominate compared to tractor trailers. Co-ops have a proportion of vehicles similar to that of self-employed carriers.

Two relatively recent studies coordinated by the National Confederation of Transport (CNT, 2015; CNT, 2016) complement some of this information. The first, CNT's Survey of Energy Efficiency in Freight Transportation, covers the outlook of business owners in the sector regarding efficiency measures and other issues regarding the environmental externalities of freight transportation. The second, a CNT survey called Profile of Truckers, 2016 Edition, presents general information about professional truck drivers.

21 This includes straight trucks and tractor trucks (trailers and semi-trailers).

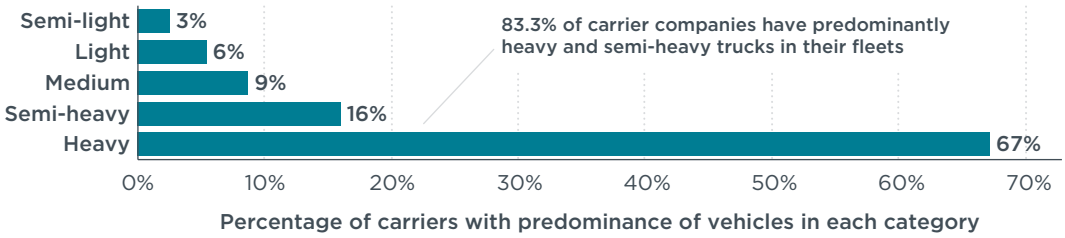


Figure 42. Carrier companies' most frequent truck categories. (CNT, 2015).

The 2015 CNT survey was sent to carrier companies with more than 50 vehicles (own fleet or subcontractor carriers) and 292 responses were received.[22] The results showed a clear predominance of mostly semi-heavy and heavy-duty trucks, and that 83.3% of the companies used these categories most frequently in their truck fleets. In the 2016 trucker profile survey, CNT also investigated the characteristics of the fleets of self-employed carriers regarding GVW and found that 63% were semi-heavy and heavy-duty vehicles.

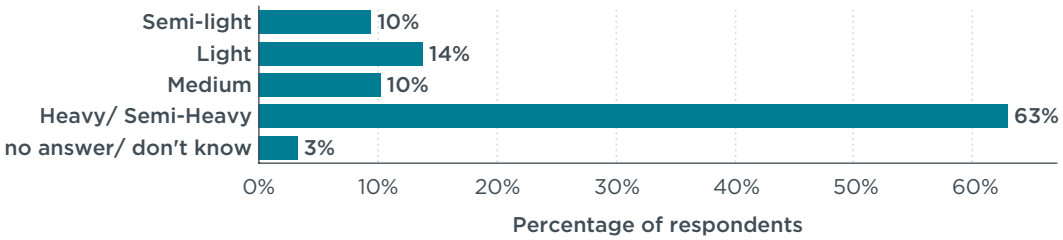


Figure 43. Truck GVW, self-employed carriers. (CNT, 2016).

As one might expect, the more institutionalized the carrier, the newer its fleet is. In many cases, the vehicles of self-employed carriers are two to three times older on average than those in companies. The cooperatives, in this case, are a midpoint between the extremes.

This aspect is relevant to the design of initiatives related to green freight. Representing the majority of registered transporters (77% of registrations, 54% of the fleet) but with less capacity for investment in fleets, self-employed carriers should, in some way, be considered in green freight initiatives. Their fleets, however, are older in general, and they tend to purchase used vehicles that originally belonged to transport companies.

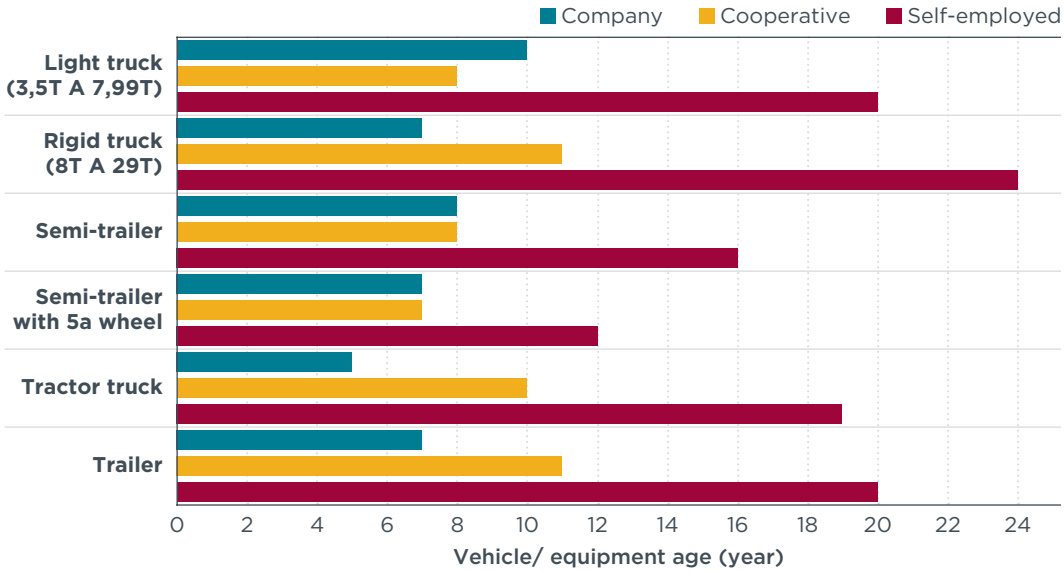


Figure 44. Age of fleet registered in RNTRC by vehicle category and carrier segment. (ANTT, 2021).

22 A caveat regarding this survey: While the sampling method and the form of research offer clues about the reality of the roads, the results are not broadly representative and may not be significant.

3.3. FREIGHT TRANSPORTED PER TYPE OF CARRIER AND VEHICLE

According to the CNT Survey, 40% of carrier companies transport bulk solids. This includes cereal grains, fertilizers, crushed and powdered products, and others. Just over one third of the companies transport breakbulk freight, or various goods of different customers on the same truck.

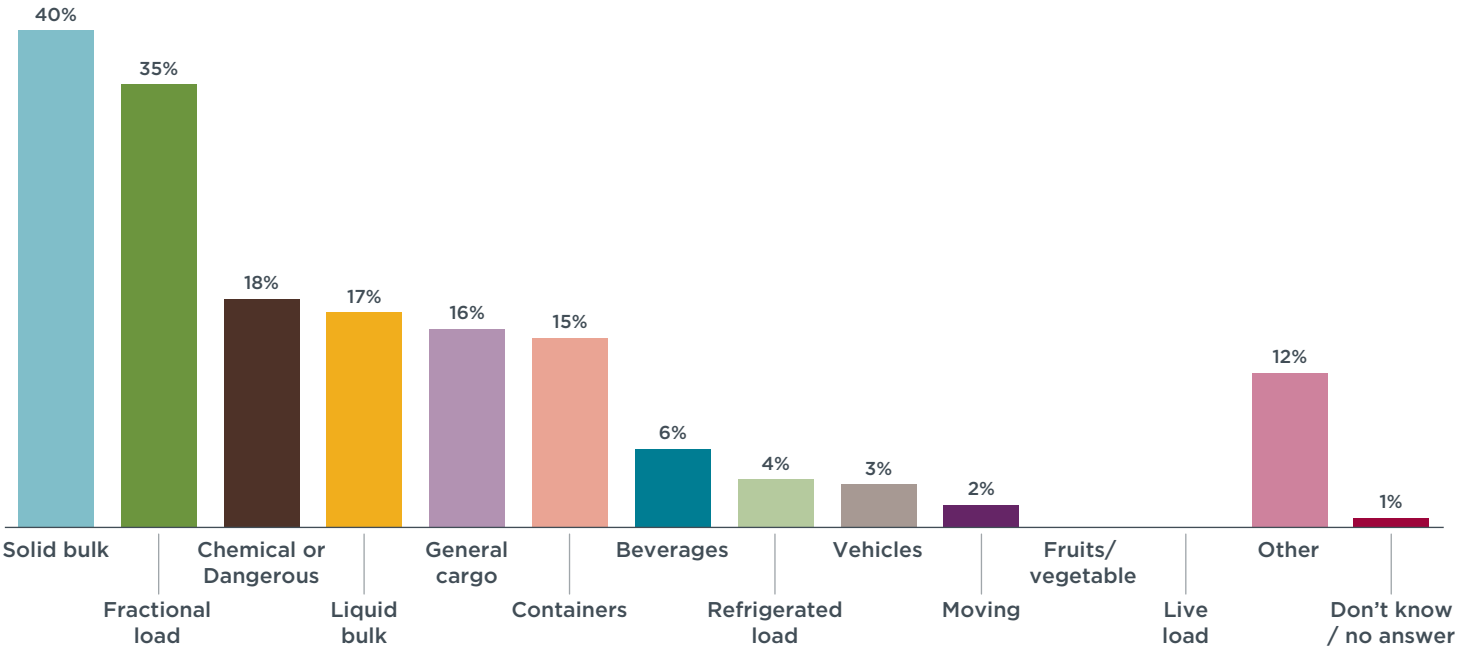


Figure 45. Freight type by carrier segment, CNT survey companies. (CNT, 2015).

Note: Each company could mark up to three types of freight, which makes the total share of responses exceed 100%.

According to the trucker profile survey (CNT, 2016), 33% of self-employed carriers transport solid bulk and 31% transport breakbulk freight. The figures are not mutually exclusive, and the same company or even self-employed carrier may transport more than one type of good. Indeed, that is common.

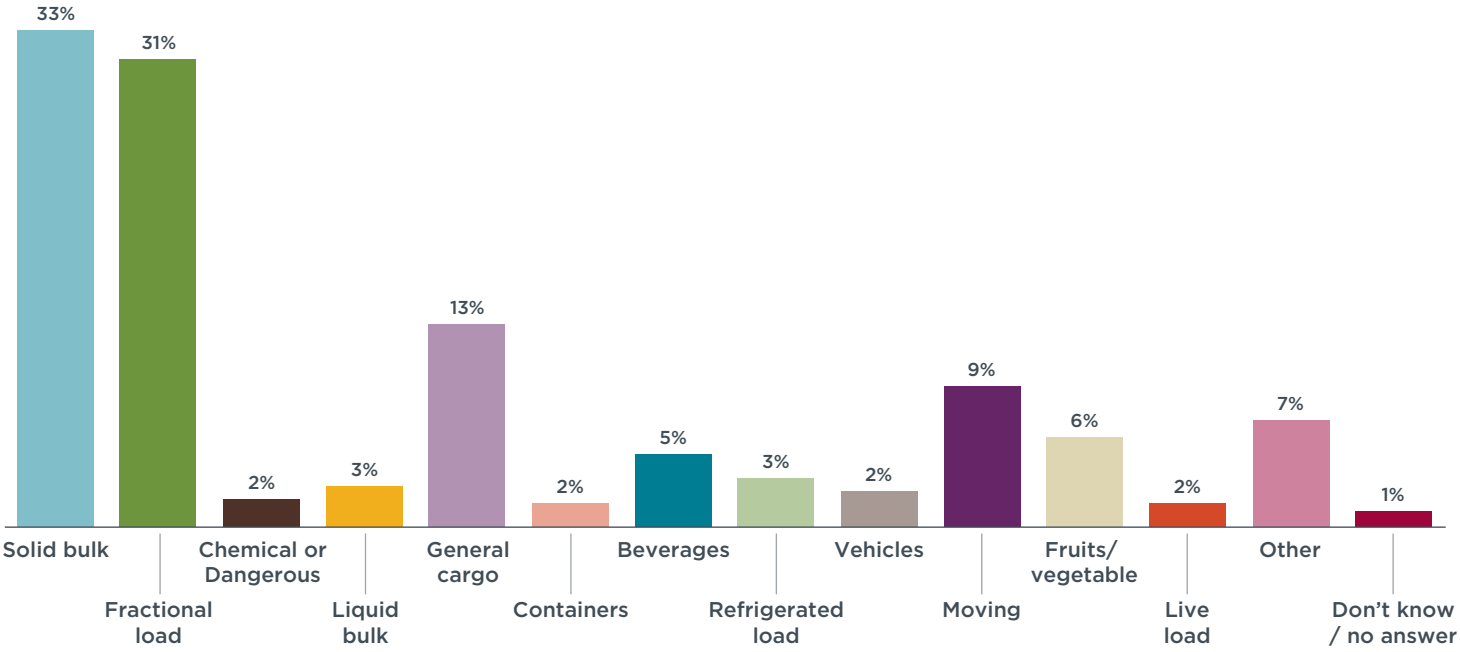


Figure 46. Freight type by carrier segment – self-employed. (CNT, 2016).

Hazardous materials, due to their particular characteristics, are hauled by 18% of carrier companies and only 2% of self-employed carriers. Although these percentages are not directly comparable, since the total number of self-employed carriers is more than three times the total number of carrier companies, it is likely that the higher level of demands and controls required for transporting these products necessitates greater specialization from the carriers, or more highly structured companies with newer fleets.

In 2011, the Transportation Ministry conducted the National Traffic Survey (PNT, 2011), in which teams interviewed drivers and identified the types of vehicles carrying a wide range of freight. According to the survey, agricultural bulk solids represented the majority of hauls, and they were transported by special semi-trailers including combined vehicles such as B-trains and other combinations of road trains. However, the transportation of non-agricultural bulk materials, such as iron ore, coal, and cement, is usually done by tractor truck—heavy and semi-heavy—and semi-trailers, mostly not using combined vehicles.[23]

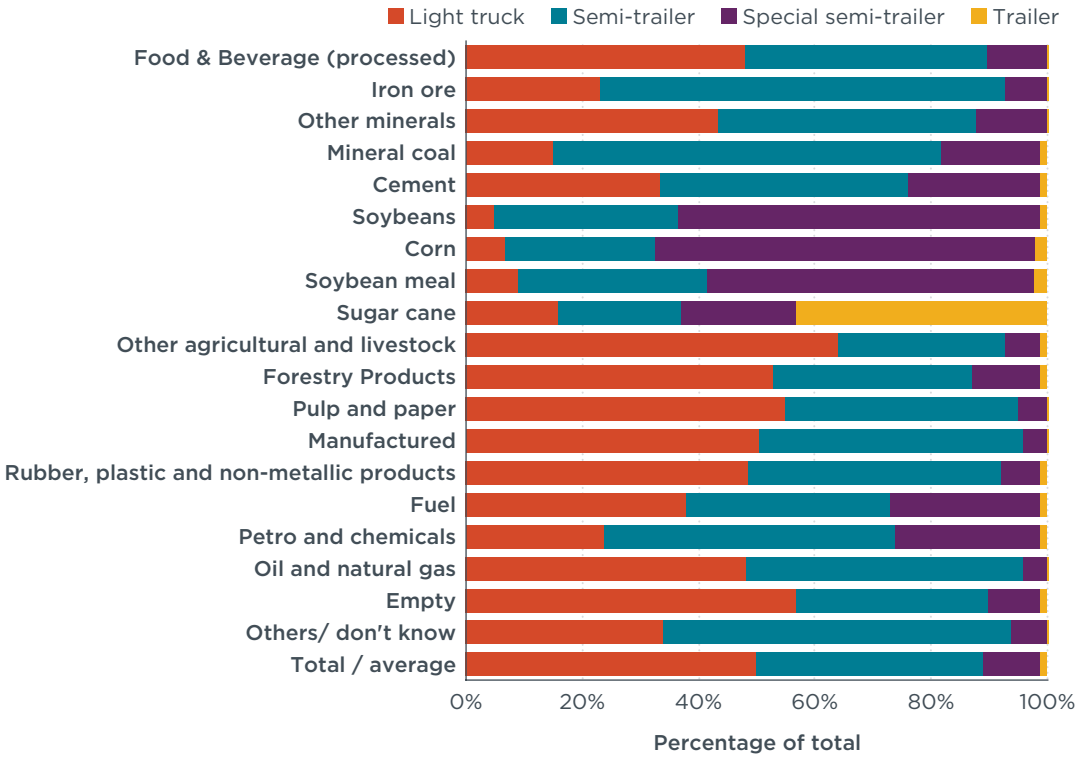


Figure 47. National Freight Survey (PNLT 2011) – Commodity by vehicle category. (MT, 2012).

3.4. AVERAGE DISTANCES TRAVELED

According to EPL's Shippers Profile Survey (2016), for 49% of shippers, the distance covered in the transportation of typical freight (the freight most frequently transported by the company) to its final destination is less than 300 km, and the average distance is about 430 km. For 19% of shippers, the distance of the typical lot is more than 1,000 km. The survey also showed important differences regarding the distances traveled by typical cargo, when analyzed according to logistical vectors.[24] There are states that make up the Northern vector, such as Amazonas, Rondônia, and Roraima, where the

23 Ores generally have a specific weight more than three times greater than grains. Therefore, they require tractor trucks with much greater capacity to pull combined vehicles, often making such transport unfeasible.

24 The Logistical Vectors are Brazilian territorial spaces where there is a more homogeneous socio-economic dynamic from the viewpoint of production, prevailing movements in access to markets and exports, common interests of society, levels of technological and managerial capabilities, and common problems and constraints, which can lead to the construction of a joint effort to overcome obstacles and challenges.

most frequent distances are over 1,000 km; for others in the Southern region, such as Paraná, Santa Catarina, and Rio Grande do Sul, typical distances are 100 km.

According to data presented by the IADB (2017), the average annual distance traveled by truck in Brazil is 56,000 km.[25] Meanwhile, as shown in Figure 48, in Argentina, the second largest country in the region, the average distance is twice that.

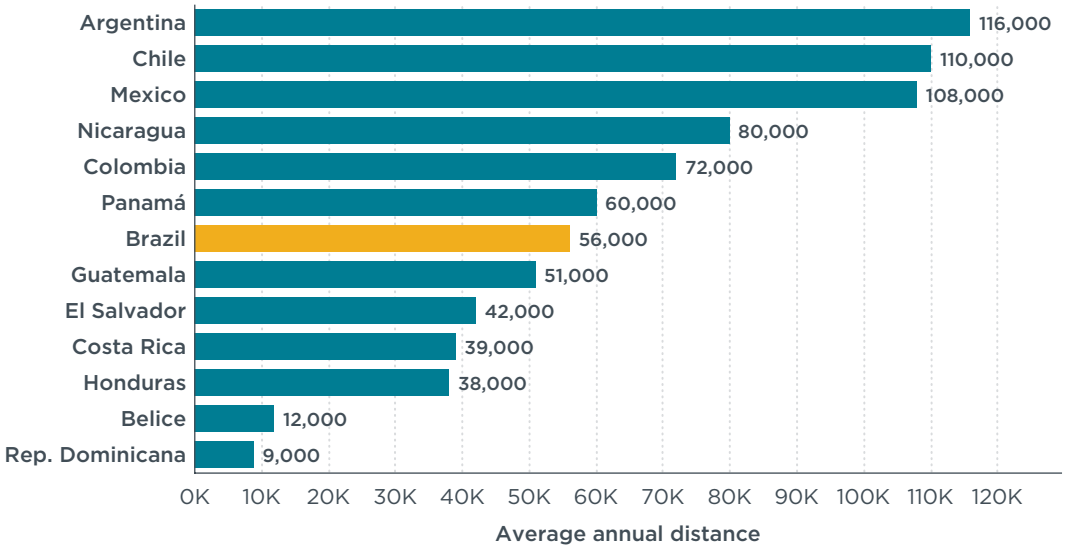


Figure 48. Average annual distance traveled by truck. (IADB, 2017).

Note, however, that the average value presented for Brazil in the IDB report (Figure 48) is significantly less than the values estimated by autonomous carriers or vehicles owned by the company, as shown in Figures 49 and 50. These differences should be better investigated, but may reflect differences in the strata considered (including, or not, shippers carrying their own cargo and cooperatives, for example) or even the unit considered in these estimates (tkm, average values of tonne per truck, etc.).

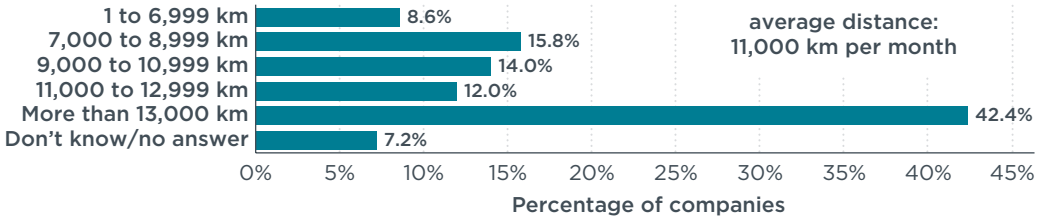


Figure 49. Average distance traveled per month – Companies

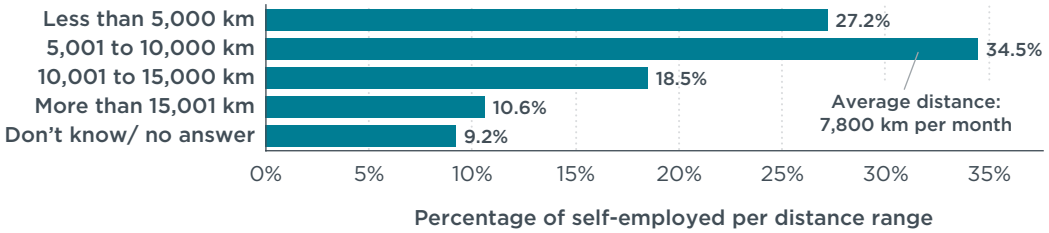


Figure 50. Average distance traveled per month – Self-employed. (CNT, 2015 and CNT, 2016).

25 The data, according to this report, were obtained by consultations with official agencies, specific for the preparation of the IADB document. It is unclear how the data from each country were estimated.

3.5. EMPTY LOADS

The percentage of trucks travelling empty is high in Brazil, according to data from the Origin/ Destination Survey (EPL, 2014), as shown in Figure 51 and Table 5. During 2014, 38% of drivers were traveling with empty vehicles at the time of the interview, and even those traveling with freight would return empty in 60% of the cases. In addition, from the 62% of drivers that were traveling loaded, only 40% of them will also return loaded. Therefore, only 24.8% of all vehicles would have freight on both the outbound and return portions of the trip.

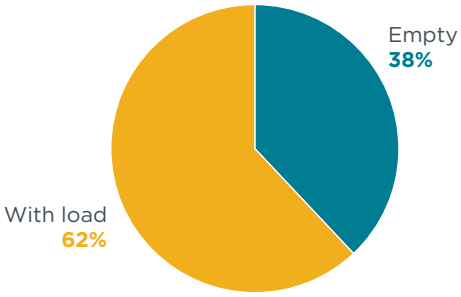


Figure 51. Load percentage by trip, 2014

Table 5. Load percentage by trip (Origin/ Destination Survey, EPL, 2014)

Empty		**38%**
	Outbound empty	**57%**
	Return empty	**39%**
	Don't know	**4%**
With load		**62%**
	Return loaded	**40%**
	Return empty	**60%**

Another survey that had addressed this topic is the CNT Survey (CNT, 2016). This survey showed that 82.5% of interviewed companies indicated that in some stretch of the route, their vehicles circulate without load.

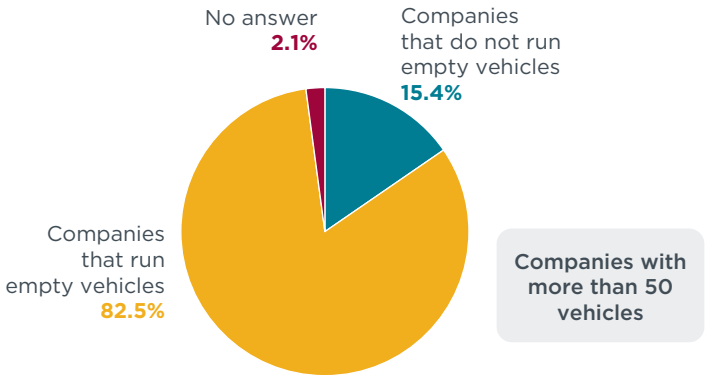


Figure 52. Companies running empty vehicles. (CNT, 2016).

The CNT survey also found that among the companies that run unloaded at some point, 16% said that they circulated with an empty vehicle 30% of the distances traveled, whereas 19.2% drove empty half of the kilometers traveled monthly.

The percentages of vehicles with no load in any section in the CNT survey were higher than those obtained in the O/D survey. Although these surveys are not comparable because the periods, sample sizes, and methodologies are distinct, the CNT survey

numbers reinforce that there are a large number of vehicles that run empty along some part of their route.

Bearing in mind that the trend for increasing domestic productivity was the growth of trucks in both size and freight capacity, the scenario tends to get worse, with increasingly large trucks travelling empty. Part of this low occupancy of vehicles is a consequence of the poor distribution of GDP in the national territory, as previously discussed. In addition, this shows the need to optimize efforts to reduce trucks running empty.

3.6. COSTS OF ROAD FREIGHT

There are several costs involved in road freight, both fixed and variable. Costs that are directly associated with a transportation service and can be identified as such, including for fuel and vehicle lubricants, and wear and tear of tires and parts, are direct costs, and these are variable in the short term. Indirect costs, generally fixed in the short term, include administrative costs, rent, insurance, and wages, among others. Fixed costs are allocated to a particular service by apportionment.

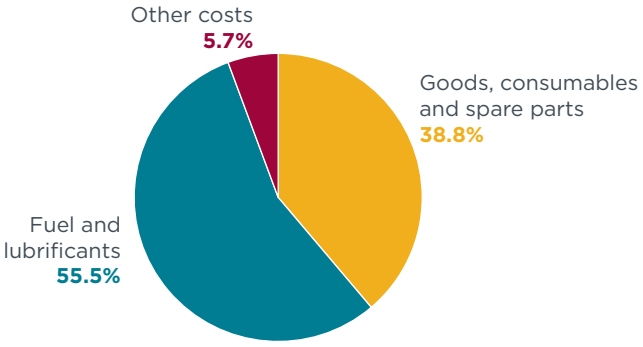


Figure 53. Main operational costs incurred in road freight transportation (2018). (Based on Annual Survey of Services, IBGE, 2018)

Costs vary significantly depending on activity, type of operation, type of freight and truck, distances traveled, operational structure, management, range of services offered, and risks related to the activity. This study does not include an analysis of the cost structure of road freight transportation, but rather identifies the relative importance of fuel in direct costs.

According to the Annual Survey of Services by the IBGE, for the trucking industry as a whole, expenditures on fuel and lubricants represented 55% of operational costs in 2018.

The average costs of distance traveled, and type of freight carried, from a sectoral analysis of freight transportation costs in 2016 (Valdivia, 2017), are presented in Figure 54. The average percentages of fuel cost in relation to total costs are directly proportional to the distance traveled, as expected. The percentages of the cost of fuel for the same distance are similar for full or fractional loading.

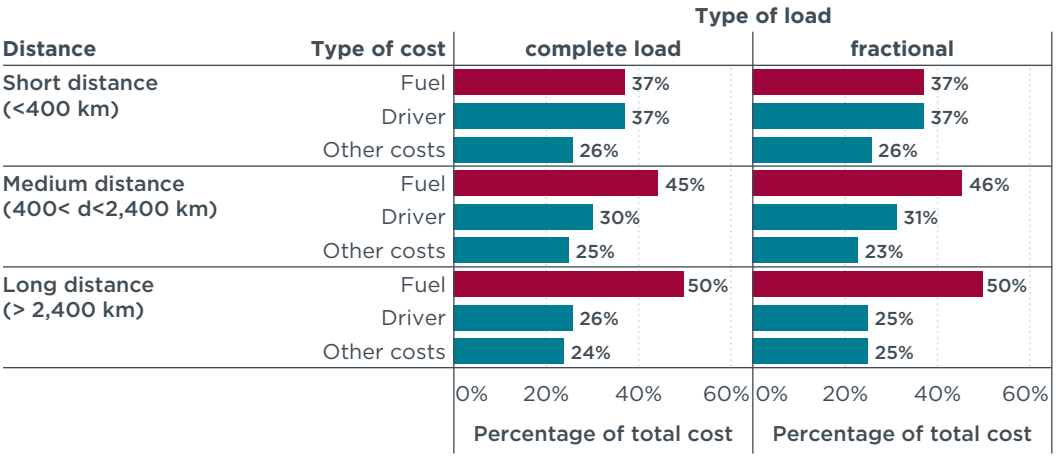


Figure 54. Percentage of cost by distance and type of load. (Valdivia (2017).

According to the CNT survey (CNT, 2016), fuel is the most important item for 94.5% of the self-employed carriers who responded; second most important is tires, indicated by 53.4% of respondents, and maintenance, 34.8%.[26] These results reinforce the importance of energy efficiency actions, as such gains directly impact profitability.

26 More than one cost item could be indicated by each respondent.

4. GREEN FREIGHT AND THE BRAZILIAN REALITY

To complement the data collected from the literature, we interviewed a few important carriers[27] and service providers, including developers of apps, to better understand (1) the sector's priorities and (2) the barriers and opportunities to improving fuel efficiency. These interviews complemented our review of surveys, presentations at seminars and forums, news stories, and information on company websites with a special emphasis on sustainability reports where available.

At the time of these surveys and interviews, in 2016, tension was already apparent among the various agents. This grew out of successive increases in transportation costs, mainly due to the increase in the price of fuel, and, in the opposite direction, the decrease in demand caused by the economic crisis, which pushed down the freight price. This tension led to the truckers' strike, or Diesel Crisis, as it became known, that started on May 21, 2018.[28]

In the summary below, we follow the four dimensions previously highlighted by the ICCT as key to the success of green freight programs, as suggested by the experience reported in several countries (Sharpe, 2015). These key elements are summarized in Figure 55.

Data Collection and Benchmarking	**This element is critical to the Green Freight Program and is present in all its formats. With data systematized and mad e available by the different actors, it is possible to compare energy efficiency metrics of simil ar fleets, allowing carriers to assess and compare their perfor- mance against the competition, and allows shippers to select carriers based on this analysis. In addition to information on greenhouse gas emissions and energy efficiency, it may also contain data on other pollutants, such as particulate matter and nitrogen oxides.**
Guide to Best Operational and Technological Practices	**A shared and integrated reference among the actors, present in most of the programs, allows participating companies to align themselves with the same benchmark and favors the targeting of the entire segment in the same direction, not only in terms of technology employed, but also in terms of emission mitigation strategies and energy efficiency improvement strategies.**
Verification and Certification of Technologies	**An important factor for the success of green freight, the verification of effectiveness of the technologies by an independent entity favors standardization of the analyses and brings a common frame of reference to evaluate the gains in energy efficiency or reduction in emissions of pollutants.**
Visibility	**As the Green Freight Program is composed of voluntary targets to improve environmental performance in road freight transport, it is necessary to ensure visibility to the program and its participants, in such a way that the benefits and incentives for participation are relevant to the actors. A meticulous communication effort should include the level of performance of the technologies that vendors offer or used by fleet owners/operators.**

Figure 55. Key elements of green freight. (Based on Sharpe, 2015)

27 Interviews with three of the main actors from the domestic scenario were conducted by the ICCT's consultant in Brazil, under a non-disclosure commitment. Throughout the text, the most important elements from the interviews are included, although without disclosing the specific actor to which they relate.

28 The strike lasted 10 days and brought serious damage to the country. During the strike, a shortage of fuel caused its price to climb further, public transport was compromised, and flights were canceled. There were also shortages of products in supermarkets, students were out of class, production of vehicles was interrupted, and hospitals were out of some supplies, among other problems. This strike also negatively affected GDP.

4.1. CARRIER COMPANIES' PERSPECTIVES

We interviewed individuals at a leading Brazilian company and at multinational companies who would have contact with green freight programs at their parent companies abroad. Representatives from FedEx,[29] Julio Simões,[30] and Logística e TNT[31] were interviewed.

Data collection and benchmarking

We asked interviewees about possible carrier motivations to implement green freight programs or to join them, and one was customers who are themselves interested in reporting the environmental impacts of their activities and carbon footprint. Such reporting would include GHG emissions throughout the life cycle, and therefore also those generated in the transportation of their products and raw materials. According to the interviewees, although the number of companies concerned about the impact of their activities is increasing, the total number of those seeking more accurate information on emissions in the transportation of their products is still not very significant. There is also no single or integrated method for this accounting. Moreover, different customers might require different data collection methodologies.

Technical support for the selection and dissemination of a standardized methodology was strongly suggested as an opportunity for improvement. This would facilitate reporting and comparison with other carriers. One difficulty would be in obtaining data and information from self-employed carriers, since the monitoring of fuel consumption, distance traveled, and freight carried are usually very simplified. Adding to the complexity is the calculation of emissions at the consignment level or client level. Currently, with several contracts and multiple deliveries, often in the consolidated load modality, apportioning emissions by customer is calculated via an approximate, top-down approach that uses an average emission factor per tonne-kilometer. In general, the characteristics of the vehicles and the route, and even the load's dimensions, are not taken into account.

Interviewees described little integration between the operational and management systems of the company that would provide the data for a green freight program. The companies have most of the data, but they do not use it. Of the missing data, fuel consumption for each trip is most frequently missing. This is because fuel consumption is mainly monitored over longer periods and recorded when filling the tank; for the subcontractors, there is no information. Interviewees felt it would be helpful if the systems were integrated to link information that is isolated in specific applications and create interfaces to provide carriers with integrated information. Future studies and developments related to information systems could consider a more holistic and integrated view of management for the transportation sector.

Verification and certification of technologies

No structured process to verify and certify the effectiveness of energy efficiency technologies was identified by the interviewees, and they highlighted the need to have a neutral entity for both the identification and verification of cleaner technologies. This should be done through pre-defined protocols and in controlled testing conditions.

29 FedEx is one of EPA's 15 Charter Partners who helped this agency develop, launch, and champion SmartWay. FedEx acquired TNT's shareholding control, and at the time of the interviews, they were just beginning the integration process. In 2016, FedEx acquired TNT and started the integration process.

30 Julio Simões is the country's largest logistics carrier in terms of net revenue.It has 1,262 employees and its fleet consists of 442 tractor trucks, 184 trucks, and 686 trailers and semi-trailers, as well as other equipment (data from 2016).

31 TNT is co-founder of the Green Freight Europe (GFE) sector initiative which aims, amongst other things, to reduce carbon emissions of the transportation sector by supporting its members through a standard methodology for monitoring and reporting on carbon emissions. In 2014, TNT was awarded the first Green Freight Europe 'leaf' in recognition of TNT's commitment to report and reduce CO2 emissions from freight transportation.

Meanwhile, the CNT Survey (CNT, 2015) explored specific themes with carrier companies, including the extent of knowledge about technologies for energy efficiency, their dissemination, and future expectations. It was an exploratory survey, and 292 companies with fleets larger than 50 vehicles responded. Although hardly representative in terms of the total number of carriers, the results did shed light on some of the understandings in the sector. First, it was observed that most companies were acquainted with equipment such as light alloy wheels and automatic tire inflation systems (Figure 56).

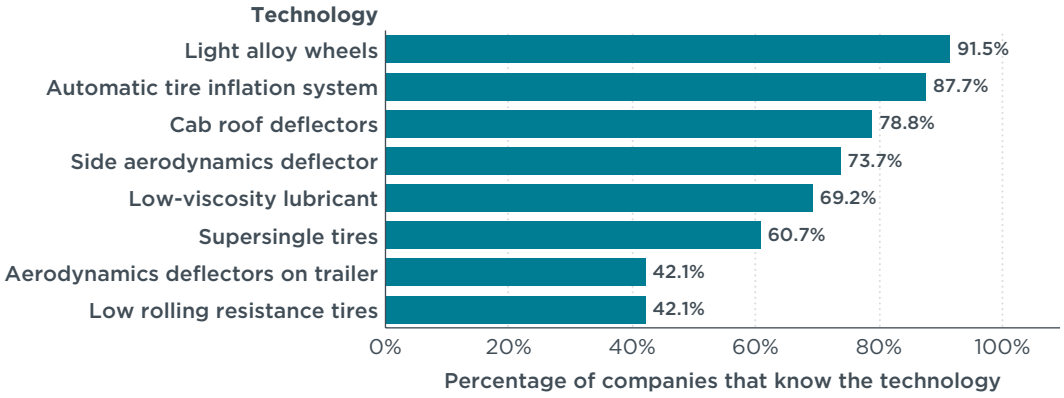


Figure 56. What technologies for energy efficiency are you aware of? (CNT, 2015).

Nonetheless, only one in three survey respondents used these technologies. On the other hand, aerodynamic deflectors on trailers and low rolling resistance tires were known by 42% of companies, and used only by 14% and 17%, respectively. Another item to highlight is the cab roof deflector, known and used by many companies (Figure 57).

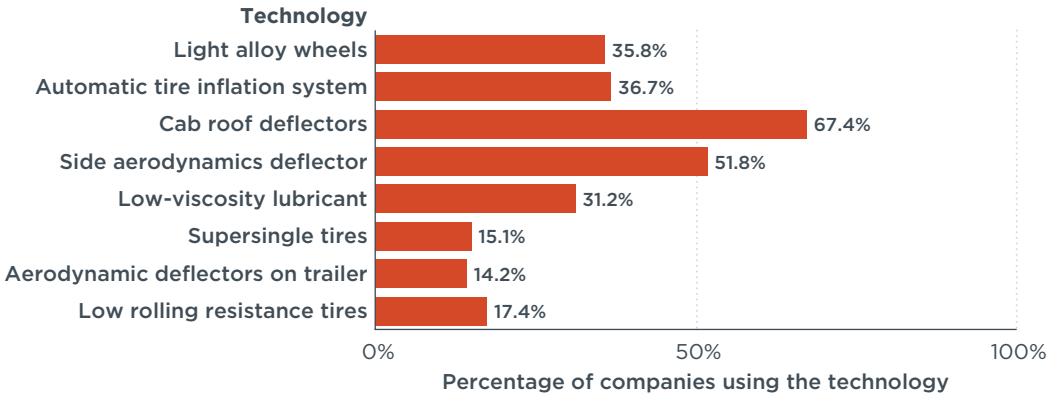


Figure 57. Which technologies for energy efficiency are being used by your company? (CNT, 2015).

As for effectiveness, many companies are suspicious of such technologies. The single tire, for example, is considered not very effective or ineffective by 40% of the survey respondents. Again, the cab roof deflector obtained a more favorable evaluation: It was considered effective or very effective by 66% of the companies (Figure 58). Such findings indicate the need for further investigation and dissemination of the performance results of these technologies. They also reinforce the importance of having a neutral entity that assesses the effectiveness of these systems.

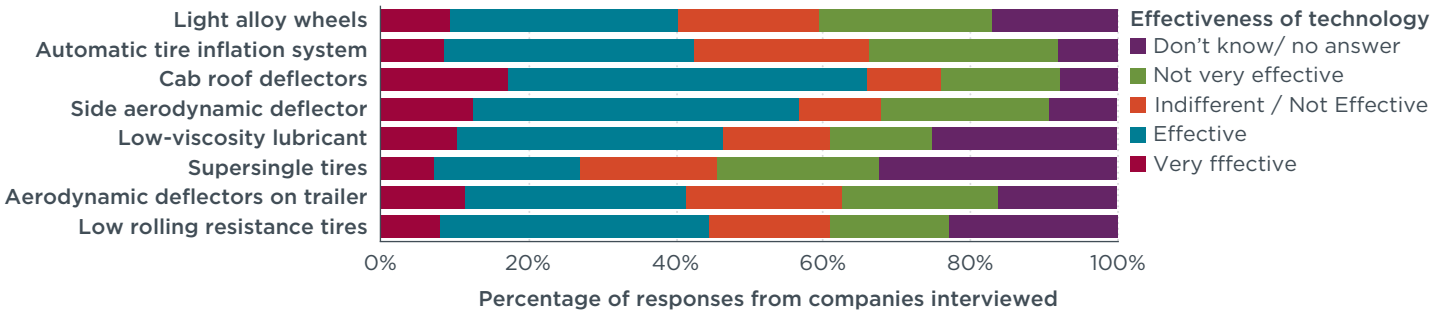


Figure 58. Which technologies are effective? (CNT, 2015).

Synergies

Interviews and other surveys identified some programs that, although not connected to green freight programs, nonetheless offer potential synergies with such initiatives. The identified programs have several aims that range from simple reduction of transport costs to reducing GHG emissions throughout the life cycle of the products transported. Some companies established voluntary socio-environmental targets, including emissions reduction, and other goals that unfolded across the value chain and affected suppliers and service providers, including those that transported the raw material or final product. Some results from these programs are presented in Table 6.

Table 6. A sample of programs or initiatives related to climate change or green freight in Brazil

Plan/ program	Description	Coverage	Comments
Carbon Disclosure Project (Supply Chain)[a]	The Carbon Disclosure Project (CDP) aims to enable organizations to build strategies for supplier engagement by analyzing the risks and opportunities associated with climate change and managing greenhouse gas emissions. Reports of participants of this program were checked, identifying the initiatives related to reducing emissions in transportation.	In Brazil, 301 companies submitted reports in 2016, representing an increase of 57% compared to the previous year. These companies are mainly in the industrial, consumer goods, and basic materials sectors.	Among the companies that submitted results, only 24% reported CO_2 emissions, a figure that is lower than that of other Latin American countries, such as Mexico (42%). Of these companies, few report emissions of their suppliers (scope 3), such as carriers. Therefore, the involvement of suppliers, including carriers, is still an incipient practice among companies in the program.
Brazilian Network of the Global Compact (Energy and Climate WG)[b]	The network seeks to be a center of influence to encourage companies to engage in issues such as mitigation, adaptation, carbon pricing, energy efficiency, and increased participation of renewable energy in the nation.	In Brazil, 747 companies participate in the Network in 16 different actions, with only 12 active in the Climate initiative. Among them are companies in the chemical, mining, and electricity/natural gas distribution sectors.	Some companies aligned with the Climate initiative also take part in other programs, such as the CD-Supply Chain and the Climate Forum. There is no highlighted feature for the involvement of suppliers of these companies in most of the reports submitted, generally following the GRI model.
Climate Forum[c] (Corporate Action on Climate Change)	Corporate action on climate change, a group in which the Ethos Institute serves as the executive secretariat.	In 2016, eleven companies participated, with two supporting organizations. Some of the sectors represented include mining, retail, chemicals, cement, and transportation.	Some companies that participate in the Forum submit their reports of social and environmental responsibility in the other programs mentioned, which can demonstrate proactiveness and leadership on the Climate issue. However, regarding the involvement of their suppliers, specifically carriers, in terms of GHG emission reduction targets, the actions are still incipient.

Plan/ program	Description	Coverage	Comments
Green Logistics Brazil Program[32]	Under the coordination of the Freight Transportation Laboratory (LTC) of the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering – Federal University of Rio de Janeiro (COPPE/UFRJ), this program gathers companies that seek to capture, integrate, consolidate and apply knowledge with the aim of reducing the intensity of greenhouse gas (GHG) and atmospheric pollutants, as well as to improve the efficiency of logistics and freight transportation in Brazil, with an emphasis on road transport.	In 2016, six companies participated in this program. This number increased to 19 in 2017, with prospects of increasing further in 2018.	The good practices presented in the guide are related to shared logistics, densification and reconciliation of cargo, modal changes, location of distribution centers, and economical driving.
Despoluir	The Despoluir program was launched in 2007 as a joint initiative of the National Transport Confederation (CNT), the Social Transport Service (SEST), and the National Transport Learning Service (SENAT) with the aim of promoting improvement in the quality of life of transporters and engaging them in social and environmental responsibility initiatives. Among its initiatives is the Environmental Vehicle Assessment, an environmental vehicle inspection service that also builds capacity for eco-driving, a partnership with Natural Resources Canada and ICCT. The program also includes other initiatives such as conducting and publishing research and surveys related to energy efficiency.	The scope of the program is national. As of October 2019, 2,775,508 vehicle inspections had been carried out, serving 25,666 companies and 28,160 self-employed truck drivers.	This is the most comprehensive initiative related to green freight. Through the verification of vehicle emissions, it contributes to preventive and corrective maintenance actions, consequently inducing a reduction in fuel consumption and emissions.

Notes:

a. CDP is an international non-profit organization that offers a global environmental disclosure system. The CDP Supply Chain is one of five programs offered by CDP, geared toward managing carbon emissions throughout the chain.
b. Founded in 2003, the Brazil Network of the UN Global Compact works in partnership with the United Nations Development Program (UNDP). It is under the management of a committee composed of nearly 40 reference sustainability organizations and leading companies in strategic sectors of the Brazilian economy.
c. The Climate Forum is a private initiative created to follow the commitments of the "Open Letter to Brazil on Climate Change," pursuant to which business leaders have made voluntary commitments to reduce their GHG emissions.

These programs indicate a growing concern among shippers about the environment, and the number of participating members increases every year. Studies that highlight the importance of transportation emissions associated with products or specific sectors create an opportunity for deeper engagement by the industry. Such work would demonstrate that actions to reduce emissions that do not consider transportation are incomplete, since transport can represent significant portions of emissions from various sectors.

4.2. BARRIERS AND OPPORTUNITIES

The transportation market's high degree of outsourcing and the precariousness of the labor of self-employed carriers creates a context of great informality where there is little effective control over how subcontractors transport goods. Restrictions imposed by Brazilian labor legislation futher create obstacles and risks that have caused carriers to interfere as little as possible with their service providers, especially self-employed carriers. There are thus risks associated with any demands for changes in the supply chain, since the request for data or the standardization of ways of

32 In Portuguese, this program is know as PLVB, acronym for "Programa de Logística Verde Brasil."

obtaining such data could be understood as interference and could be characterized as an employment relationship.

This risk was highlighted by all interviewees, which points to the importance of a program managed by a neutral entity to conduct a green freight program. That would avoid harming the existing relationships between freight carrier companies or shippers and self-employed carriers.

Interviews revealed a weak connection between operations, controls, and the calculation of GHG emissions per unit of freight transported or per customer. This may be a consequence of the secrecy with which operational issues are handled. But there is also likely a real lack of coordination between company units responsible for environmental and operational matters. If that is the case, it is also an opportunity to improve the integration of various management systems and the management of fuel consumption and emissions. This would ultimately reduce management costs.

FedEx, whose country of origin is a pioneer in the discussion and implementation of green freight, also recommends a neutral entity for the identification and verification of cleaner technologies. Such verification should be done via pre-defined protocols and in controlled test conditions, and should also be adapted to local conditions.

Regarding possible industry sectors that could undertake pilot programs or induce implementation of a green freight program in Brazil, we believe that the chemical industry is promising, given the risks already involved in the transportation of both raw materials and finished products. According to the Brazilian Chemical Industry Association (Abiquim), the chemical industry moved 132 million tonnes of products in Brazil in 2016. Additionally, the sector already has a supplier management system structured and managed by Abiquim, because carriers of these products are jointly responsible for any problems that occur during transportation.

The Safety, Health, Environment and Quality Assessment System, known as SASSMAQ, was implemented in 2001 to continuously and gradually reduce risk in chemical transportation and distribution operations. This program includes certification of suppliers by an independent entity that assesses the administrative, financial, and social aspects of the supplier or service provider, and specific aspects of each service provider, including its service and operating structure. This starts with a road module aimed at carriers and logistics operators. Although the term “environment” in the system’s name refers to environmental risks in cases of accidents, the structure of the system would allow, with a small amount of effort, the inclusion of topics related to the calculation and reduction of GHG emissions.[33]

In 2016, preliminary contacts with Abiquim and an interview with a certifier of this program revealed that there was no intention at that time to expand the scope of the program to include quantification and monitoring of GHG emissions, or any action associated with green freight. However, doing so could take advantage of the already established structure and is an opportunity to be explored further.[34]

33 This program was based on a similar program in France – the Intervention in Chemical Transport Emergencies (ICE) of the European Chemical Industry Council (CEFIC). It is worth noting that the CEFIC website features a manual to calculate emissions in the transportation of chemicals, by various modalities; this could be an offering of the Brazilian chemical industry as well.

34 It is worth mentioning that concern about the costs of transporting chemicals and the competitiveness of the sector led Abiquim to elaborate the Logistics Strategic Plan, as a contribution to the development of the National Integrated Logistics Plan (EPL). Thus, the motivation to reduce logistics costs may be worth exploring as an incentive for implementation of green freight programs.

4.3. LOGISTICS IMPROVEMENT AND INFORMATION TECHNOLOGY

Although the economic crisis has had a negative impact on the freight transportation sector as a whole, it has also guided some investments made by the sector. After truck sales peaked in 2011, updating the fleet, some companies sought to reduce investments in new vehicles and instead invest in information technology that promotes logistics efficiency.[35] This includes applications and services that reduce operational inefficiency, optimize routes, and control the way drivers drive so as to reduce fuel consumption. These applications and services range from integrated GPS systems provided by truck manufacturers that are capable of analyzing routes, to applications that connect conveyors and loaders efficiently and reduce the likelihood of traveling with an empty load.

Apps such as Truckpad,[36] CargoX,[37] and Rede Frete Fácil,[38] which seek to connect shippers with carriers, have more than half a million registered drivers, and such apps are a strongly growing market.[39] They appear to promote optimized service and reduce inefficiency. These apps have the disruptive potential to rapidly change the local landscape of road freight transportation. Also, while separate from green freight programs, they can contribute significantly to reducing GHG emissions and fuel consumption from transportation.

35 CASTRO, Gleise de. Mais, com menos. Valor Econômico. São Paulo, 27 April 2016.

36 A pioneer in this market, founded in 2013, Truckpad recently had a minority share acquired by Mercedes Benz, which became the third largest shareholder of the company. The application has already had more than 600,000 downloads and more than 50,000 users use the platform daily.

37 A Cargo X was launched in 2016 and has as its focus the transportation of freight from 5 tonnes, with the total profit of the trucks through the freight shippers and their drivers.

38 Easy Freight Network is a startup that was founded in 2014 and received important contribution from the investment fund of Banco Bradesco. Similar to other apps, it connects truckers and shippers but has the advantage of being integrated with the Bradesco Transporte card, a means of payment that brings together, in a single card, the payment of freight transportation expenses.

39 In Brazil, a similar process happened when taxi cabs were organized into cooperatives that served as the intermediate entity between passengers and drivers. With the arrival of apps that replaced the cooperatives' central offices, reducing taxi drivers' costs, the vehicles began to run longer, with passengers, optimizing the trips. The risks these platforms bring to self-employed workers lead them to see their activity as even more precarious. This is worthy of note.

CONCLUSION: KEY LESSONS AND THE ROAD AHEAD

This report is a non-exhaustive, exploratory survey of the truck market in Brazil. We considered the particularities of the road freight transportation system in an effort to evaluate possible obstacles and opportunities for the application of a green freight system similar to the EPA's SmartWay and other initiatives related to energy efficiency and the reduction of emissions from transport. We examined the operational characteristics of freight transportation, recent truck sales and the profile of the truck fleet, and the perceptions of transporters. Given the relevance of road freight transportation in Brazil and the impacts on the economy due to the increase in the price of diesel, there are clear opportunities to advance green freight.

Highlights of key findings and lessons are summarized below.

OPERATIONAL PECULIARITIES

- **Operational profiles:** Freight transportation is carried out by a wide range of actors, with quite varied profiles, including carrier companies, self-employed carriers, and cooperatives. There were more 956,133 registered carriers in Brazil as of 2020. For green freight programs to be scalable, there needs to be a way to aggregate these carriers, potentially by establishing a class association or a neutral entity.
- **Self-employed carriers:** The high degree of outsourcing and, in many cases, informality in the industry presents a major challenge, especially when it comes to self-employed carriers who often face less favorable working conditions. Their difficulties are also exacerbated in periods of declining demand for transportation services. This group has the most outdated fleets and their trucks are 44% of the registered fleet; they also have the lowest investment capacity vis-à-vis others in the sector. Nonetheless, this work brings income to more than half a million people and is therefore of major relevance. A successful green freight program needs to incorporate the specific needs of these carriers.
- **Concentration in the South and Southeast regions:** The most frequent origin and destination of freight transported in the country are the South and Southeast regions. Therefore, these regions also contain the largest number of trucks and carriers and are natural candidates for the implementation of green freight programs.
- **Outsourcing and Brazilian labor legislation:** The high level of outsourcing of transportation services is associated with the restrictions imposed by Brazilian labor legislation. This could be a barrier to green freight programs if the relationship between carriers or carrier companies and self-employed carriers is not dealt with well.
- **Truckers' strike and the consequences:** In addition to the labor question, recent events, including the 2018 truckers' strike, revealed the tensions and imbalances and culminated in the government taking certain measures, including the establishment of the minimum freight price table. These tensions have not yet been fully solved. Many in the productive sector, especially agribusinesses, have questioned the legality of these measures. This is a controversial issue that needs to be considered as part of any green freight program in Brazil.

FEATURES OF THE TRUCK MARKET

- **Tractor and rigid truck:** 60% of the trucks sold in 2018 were rigid and 40% were tractor trucks. Some 46% of the rigid trucks sold in 2018 were lightweight or medium, Urban Cargo Vehicle- UCV, with GVW less than 15 tonne. Almost all of the tractor trucks were heavy.
- **Manufacturers of trucks and trailers and bodies:** Almost all trucks sold in Brazil were produced in the country by only six manufacturers, with Mercedes and MAN/Volkswagen together holding almost 60% of the market. In the case of trailers, the

situation is different, highly dispersed, and there are nearly 1,400 manufacturers. But even here, a few manufacturers hold the largest market share.

- **Load capacity:** There has been an increase in the load capacity and number of axles of trucks sold over the last 10 years, especially for tractor trucks. In 2003, the most common configuration was 4x2 and with GVW between 16 and 20 tonnes. By 2018, more than 90% of the tractor trucks traded had GVW of more than 20 tonnes and a driveline of 6x2 or 6x4.
- **Freight transported:** Some 73% of all freight transported in tkm is general goods. Roughly three-quarters is composed of manufactured products and processed food and beverages.

OPPORTUNITIES FOR GREEN FREIGHT PROGRAMS

- **Performance of technologies:** Neutral entities that study and quantify gains in energy efficiency from different technologies could be important in stimulating adoption of green technologies. HDV labeling under the Rota 2030 program brings certification of parts, components, and vehicles and is to be implemented by 2023. INMETRO, a national certification body, is well positioned to implement this for heavy vehicles, the data from which can serve as a basis for future green freight programs. But there is still no news of efforts in that direction.
- **Emissions in transportation:** The identification and dissemination of a methodology to quantify emissions by transported product or by customer (shipper) would help to incorporate actions to reduce GHG emissions in this stage for companies that have already set reduction targets.
- **Pilot programs:** The number of participants in GHG inventories and green freight programs has grown in recent years. Although still a small portion of the large universe of transporters that operate in the country, these are important as pilots and can be leveraged to form more comprehensive programs.
- **Eco-driving programs:** Among the ways to improve energy efficiency, the ecological management programs stand out. In addition to contributing to the reduction of emissions and fuel consumption, eco-driving programs bring benefits such as the professionalization of the road transport sector and its drivers and greater safety in traffic. The growing interest in these programs makes them relevant to a future green freight agenda.
- **Contribution to fuel efficiency standards policy:** The current pressure on transportation costs and the role of fuel in this equation also bring fuel efficiency standards for HDVs to the agenda. Voluntary green freight programs can provide support for the design of these policies, especially with regard to the possibility of making data available.

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APPENDIX A. MAIN DATA SOURCES FOR ROAD FREIGHT TRANSPORT

Entity	Type of data	Publication	Frequency of disclosure	Primary source
EPL - Empresa de Planejamento e Logística S.A	OD research of cargo, search of perception of shippers, modal participation in the transportation of cargo,	Logistics Bulletin, EPL Research	Quarterly	EPL
		Study of the characteristics of the demand for cargo transportation	Sporadic	EPL
		OD Survey	Sporadic	EPL
		PNLI - National Integrated Logistics Plan		EPL
	Information that characterizes the infrastructure and operation of the transportation sector	National Transport and Logistics Observatory - ONTL	Quarterly	Various
ABCR - Associação Brasileira de Concessionárias de Rodovias	Traffic flow on toll roads Index	ABCR Index	Monthly	ABCR
ANTT - Agência Nacional de Transportes Terrestres	Number of carriers, self-employed and cooperatives; number of registered vehicles, average age of the fleet	RNTRC in numbers	Daily	ANTT
NTC & Logística- Associação Nacional do Transporte de Cargas e Logística	Variation of freight cost, composition of costs	National Cost of Transport Index	Monthly	NTC logistics
Sestcesp - Sindicato das empresas de transporte de SP	Operational costs	Summary of most commonly used operating costs	Monthly	NTC logistics
OC- Observatório do Clima	GHG emissions data by sector	SEEG database	Yearly	Various
MMA - Ministério do Meio Ambiente	Emissions of pollutants, fuel consumption, fleet	National inventory of atmospheric emissions by road vehicles	Latest publication: 2013	Various
Anfavea - Associação Nacional dos Fabricantes de Veículos Automotores	Licensing of new vehicles (aggregated data), production, import, export, international data	Statistical Yearbook; Letter	Yearly; monthly	Denatran, Abeiva, Anfavea
Anfir - Associação Nacional dos Fabricantes de Implementos Rodoviários	Road Equipment Licensing Data	Industry Performance	Monthly	Denatran
Marketing consulting firms (e.g. ADK Automotive, Fraga)	New vehicle licensing detailed by features	Non-public data, purchased	n / a	Denatran, technical specifications by truck manufacturers
IBGE - Instituto Brasileiro de Geografia e Estatística	Economic data	SIDRA - Statistical database	Monthly	IBGE
CNT - Confederação Nacional do Transporte	Surveys and studies of the sector		Sporadic	CNT surveys
	Cnt Transport Director		Yearly	Various
Denatran - Departamento Nacional de Trânsito	Legislation applicable to the transportation of cargo (Contran resolutions, Brazilian traffic code, etc.)	CBT, Resolutions Contran, Laws	When approved	n / a
ABNT - Associação Brasileira de Normas Técnicas	Technical standards applicable to trucks and implements	NBR	When elaborated	n / a

APPENDIX B

ENGINES

Some engine characteristics of trucks sold between 2008 and 2018 are presented below. Figures B1 and B2 show displacement and power of engines by category and type of truck, and cumulative sales volume from 2008 to 2018 (indicated by the size of the circle). As expected, the larger engines are equipped with heavy-duty tractor trucks and the smaller engines are light rigid trucks. This information can be useful in the design of energy efficiency policies for HDVs, which can assist in the segmentation or prioritization that can be considered.

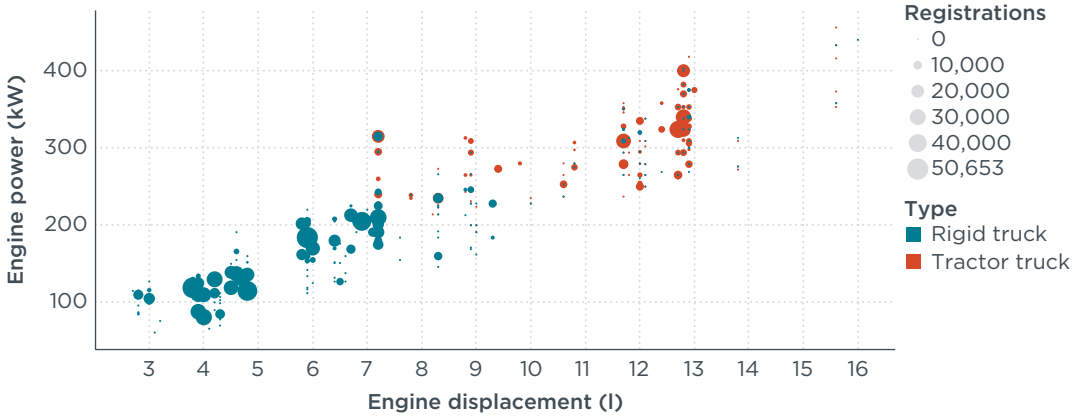

Figure B1. Truck registrations from 2008 to 2018 by motor and type.

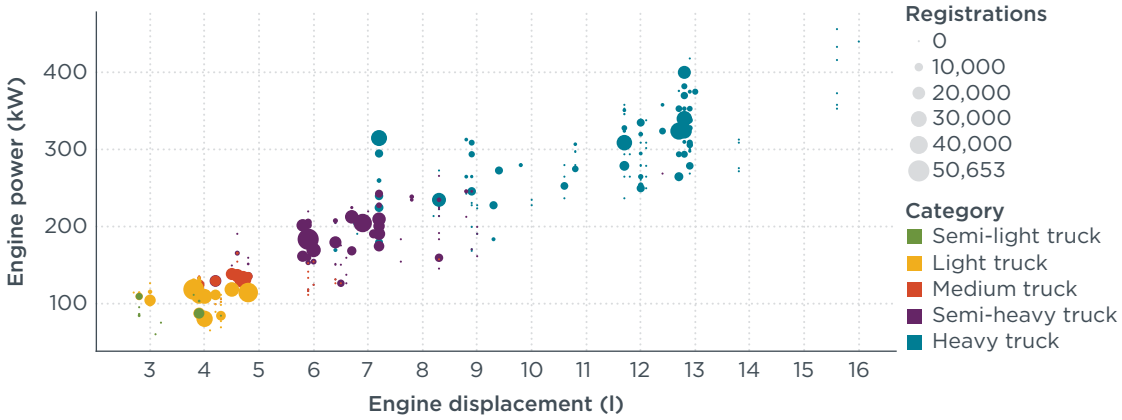

Figure B2. Truck registrations from 2008 to 2018 by motor and category. (ADK Automotive).

Table B1 indicates the origin of engines used by each HDV manufacturer. Note that Mercedes and Scania manufacture their own engines. VWCO and Volvo have part of their engines manufactured by Cummins or MWM in addition to their own production.

Table B1. Number of registrations in 2016 detailed by truck and engine manufacturer

Truck manufacturer	Engine manufacturer	
Mercedes Benz	Mercedes Benz	13,911
Volkswagen	Cummins	6,684
	MAN	6,144
	MWM	112
Ford	Cummins	7,588
	Ford	13
	FPT Industrial	156
Volvo	MWM	1,646
	Volvo	3,897
Iveco	FPT Industrial	4,444
	Iveco	9
Scania	Scania	4,231
MAN	MAN	752
DAF	Paccar	673
Agrale	Cummins	139
	MWM	59
Sinotruk	Sinotruk	180
International	Cummins	29
	MWM	44
Total		**50,711**

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