Chapter

The Concept of Sustainability in the Brazilian Road Freight Transportation Sector

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Abstract

The road cargo transportation system has significant representativeness in the Brazilian economic scenario. Companies depend on transportation to receive inputs from their suppliers and take their products to consumers. This modal is also the major consumer of fuel oil products in the transportation sector. Thus, it is necessary to act with a focus on sustainability, considering the economic, social and environmental aspects. From this perspective, this study aims to present aspects of the concept of sustainability in the Brazilian road freight transportation sector, with emphasis on the environmental, social and economic dimensions. A qualitative research approach was used with the literature research technique in order to build the theoretical basis for discussion on the dimensions of sustainability in Brazilian road freight transportation. The results show that the road cargo transportation sector is relevant for the country and seeks to fulfill its social role and be economically viable; requires attention to environmental awareness and eco-efficiency; should make efforts to use alternatives to avoid damage to the environment, applying technologies to reduce noise pollution, GHG emissions; and seek to comply with environmental legislation acting in a sustainable manner.

Keywords: Sustainable Transport, Environmental Dimension, Social Dimension, Economic Dimension, Road Freight Transportation

1. Introduction

In the most diverse organizations, the debate on sustainability has been intensely present in a constant challenge to the potential to generate value for customers, shareholders and society in general. Nowadays, sustainability has become a fundamental theme, with evidence to avoid the negative impacts of activities, also reflecting technological advances, population growth and consumption [1].

This comprehensive view of the importance of sustainability being undertaken in companies also has its validity for the cargo transportation sector, in this specific case, the road modal is the most representative one, being responsible for handling more than 60% of cargo in Brazil [2]. The preference for road transportation compared with other transportation systems is marked by factors such as: greater flexibility and easier access by trucks to the most different locations; ability to transport goods door-to-door; simplification of the sending of documentation in relation to the railway modal; and faster delivery of the product [3].

Freight transportation operations between cities and states, as well as between the producer and the distribution centers and between these and the final market, show relevant economic importance. However, this activity, due to the large number of trucks, in view of the need for loading and unloading operations, causes impacts, both on cities and on roads [4].

This dynamic of road cargo transportation operations has its share of contribution to the country's development process, however, on the other hand, it highlights the intense use of an energy pattern based on fossil fuels that strengthens the relationship with the increase in gas emissions greenhouse effect (GHG) of anthropic origin [5]. However, this is an aspect that raises the question of how to undertake sustainability in road freight transportation. From this perspective, this study aims to discuss the dimensions of the concept of sustainability in the Brazilian road freight transportation sector, identifying the main attributes for a road freight transportation to be characterized as sustainable.

2. Sustainability

The organizational posture focused on sustainability has been increasingly valued by stakeholders (shareholders, employees, customers and the community itself). The concept of sustainability is based on the concept of the Triple Bottom Line (TBL), as presented by John Elkington in 1994, composed of the economic, social and environmental dimensions, forming the tripod of corporate sustainability [6]. The interaction and integration between these three pillars bring benefits to the environment and to society, and contribute in the long term to the good economic performance and competitive differential of companies [7–9].

Sustainability has evolved from two sources: the first, in biology, with an emphasis on ecology, highlighting the potential for the recovery and reproduction of ecosystems (resilience), in the face of anthropic actions; the second, in the economy, as a developmental factor, due to the verification of the growth of production and consumption in the course of the 20th century, and which signals the continuity of this rhythm, considering the population increase [10].

Patti, Silva and Estender [11] consider sustainability as a strategy that makes up development, resulting in improved quality of life. From this perspective, an integrated management is projected covering aspects of social development, economic growth and environmental protection. Sustainability is evident as a debate present in the daily agenda of organizations, agencies and government sectors, in non-governmental organizations (NGOs), as well as in the academic environment and in the media in general. Companies have shown interest in the issue, constituting a legal order and government recommendations, projecting environmental and social repercussions.

As for the economic dimension of sustainability, companies need to make products available for consumption, however, this process should provide financial return on the investment made. With regard to the social dimension, the organization needs to offer good working conditions, job creation, social inclusion to combat inequality. In the environmental aspect, the company must have its actions guided by eco-efficiency, being concerned with the impacts caused by the use of natural resources and by the pollutant emissions [12]. An eco-efficient operation is one that manages to produce more and better, with less resources and less waste generation [13].

2.1 Environmental dimension

Usually, the environmental dimension is the first sustainability dimension cited as it concentrates the assumptions that production actions and consumption behavior

are compatible with the material - basis of the economy, as a subsystem of the natural environment. It is constituted in the processes of producing and consuming in order to ensure that ecosystems can evolve in their self-repair or resilience potential [10].

The environmental dimension of sustainability emphasizes the preservation of ecological processes, with special attention to the capacity of physical and biological systems to withstand adversity and to maintain its structure and functions. In the environmental view, sustainability points to the impacts of actions caused by people in relation to the environment. It is a process that establishes policies for the conservation of energy and natural resources, reduces the use of fossil fuels and the emission of polluting substances, substitutes non-renewable products for renewable ones and transforms used products into more efficient ones [14].

The concept of environmental responsibility goes beyond the mere fulfillment of obligations established by legislation. It contemplates citizenship, social commitment, principles, beliefs and values of an organization, their employees and the communities affected [15]. From sustainability centered on the environmental concept, two actions evolve: the ecological balance that ensures living conditions for people, fauna and flora, and the sustainable use of natural resources by organizations. It involves compliance with environmental laws, the elaboration of projects with reduced environmental impacts, the management of liquid and solid waste, the application of clean technologies, recycling and environmental education [16]. Briefly and directly, all these determinations converge to the term eco-efficiency.

2.2 Social dimension

The social dimension represents the concern to provide society with conditions to live properly. A sustainable society is supported by the theory that all its members have the minimum necessary to live with dignity and that no one practices acts that can harm others [10].

In Gomes and Moretti [17], "social responsibility is the ability to give answers or to seek them". The authors emphasize that social responsibility is one of the active elements in the relationship between organizations and stakeholders, thus, the companies involved in this proposal work to offer answers to social needs.

The sociocultural concept highlights sustainability procedures inserted in performance and profit, being attentive to the social and environmental impacts of the actions, with a focus on the quality of life of communities, cultural memory and economic growth. Sustainability under the social view has its activities directed to people, with care for their well-being and quality of life [18].

2.3 Economic dimension

The economic dimension presupposes increasing production and consumption with better use of natural resources, especially fossil sources of energy, water and mineral resources [10]. Sustainability based on the economic aspect supports development and environmental policies in the face of costs and benefits and an economic assessment that supports environmental protection and raises levels of well-being. From this perspective, sustainability includes allocating and managing resources more efficiently and a regular flow of public and private investment. It aims its activities to maximize profit, however, it seeks to sustain competitiveness in the market and seeks to remain aware of environmental and social aspects [19].

Businesses demand the entrepreneur's comprehensive and holistic perspective in order to remain active and with a high level of competitiveness in the segment and in the market. They require the adoption of a management model that has identification with the market in which it operates, seeking to generate profitability

for shareholders and respect and commitment to citizenship and environmental preservation. It is, however, an imposition of the market to apply socially responsible and sustainable management, as well as an advantage for obtaining profit, which is the guarantee factor of longevity of the business [15].

3. Overview of road cargo transportation in Brazil

Road transportation is a complementary modality *par excellence* in different situations of cargo transposition, since it is through trucks that different loads leave the production source and reach the railways, airports or ports [20].

The statistics from the National Transportation Confederation [21] shows the road modal with a composition of more than 2.6 million trucks, 600 thousand mechanical horses, 1.3 million trailers and 900 thousand semi-trailers. This structure handled 485 million tons of useful kilometers (TKU), representing 61.1% of the total transportation cargo. It is worth mentioning that the national fleet has more than 63 thousand autonomous drivers. However, the CNT [22] points out that of the 103,259 km of roads analyzed, 58.2% have some type of problem, whether in the conditions of the pavement, signage or road geometry. Regarding the pavement, 48.3% of the stretches evaluated received a regular, poor or very bad classification.

According to the National Land Transportation Agency [23], the average age of the Brazilian fleet is 13 years, with 16.8 years for autonomous vehicles, 9.5 years for companies and 12.6 years for those who belong cooperatives. Vehicle age is an important factor and is reflected in the type of engine and installed emission control technology [24]. The largest concentration of trucks is in the South and Southeast regions due to the greater economic activity, but they operate throughout the national territory on urban and intercity roads of variable quality [25].

The transportation sector consumes about 30% of the country's total energy, with 92% of that consumption taking place in road transportation. Still, transportation consumes 51% of oil products spent in Brazil [26].

Road freight transportation has its typical body type established in Ordinance 96/2015. It is a wide variety of body types defined to suit different goods. The bodies are: open, tipper, chassis, closed, van, board, tank, among others [27].

Cargo transportation is part of an organization's product distribution logistics system and is represented by three players. The first one is the user: units from the industrial, trade and agribusiness sectors. The second are companies that operate in a cooperative manner such as: Road Cargo Transportation (TRC), Logistic Operators (OL), Multimodal Transportation Operators (OTM) and Logistics Service Quarters (4PL). Municipal, state and federal governments form the third player. Their role is to provide infrastructure for roads and terminals suitable for transportation services, in addition to regulation of operation through regulatory agencies. The decisions to optimize the logistics transportation networks, based on improvements in infrastructure, are objects of the political sphere and, therefore, difficult to influence isolated or cooperated by operators and/or users of the system [28].

Thus, road freight transportation is representative in the country's economy and has great historical and current significance in development. It integrates the Brazilian transportation scenario in a relevantly. However, it needs improvements, both in equipment and infrastructure to carry out operations. One way to achieve sustainable development is to put pressure on national transportation sectors to become more sustainable. The transportation sector is an important field for implementing sustainability strategies as it causes many environmental, social and economic problems, such as air pollution, gas emissions, demand for land and infrastructure, among others.

3.1 Sustainable transportation

Sustainable transportation is motivated by three considerations: 1) the concern with cargo transportation and the direction to the operational structure, mainly with regard to roads; 2) recognition for the reduction of vehicles in circulation; and 3) the growth of sustainability awareness. These are connotations that seek to highlight sustainability to ensure business [29].

In Rodrigue [29], sustainable transportation is one that: allows the basic demands of access by society in general to be carried out safely and without damage to human health and ecosystems, and with balance; if it is consolidated as accessible, it acts efficiently, it has options of type of transportation and it sustains a growing economy; limits emissions and waste within the planet's absorption capacity, reducing the consumption of non-renewable resources, and limits the consumption of renewable resources to the levels of sustainable yield, with recycling and reuse of its components.

Companies that work with cargo transportation, following the logic of competitiveness, are increasingly committed to incorporating technological innovations as an alternative to differentiate themselves from competitors and improve customer service. Putting new technologies into practice is a situation endogenous to the capitalist and globalized system, in which consumption determinations and marketing, sales and customer relations are based on consumer opinion and trends [30].

The ability of an organization to grow in a scenario of strong competition is directly associated with the ability to develop some kind of differential. This factor represents, above all, the development and adoption of innovations for the best relationship with the customer, to generate new products or to be able to establish more efficient processes [30]. In this panorama of the performance of road cargo transportation, the highlights are the innovations of a sustainable character, responsible for directing actions for the preservation of the environment, and also sufficient to optimize resources and reduce costs.

4. Materials and methods

The methodology adopted for the development of this study, according to Prodanov and Freitas [31], is: by the qualitative approach of the problem, since it has a dynamic relationship between the real world and the subject, through interpretation without representation numerical; for its exploratory objective, since it intends to familiarize itself with the problem and present hypotheses; and by the technical, bibliographic procedures, when its elaboration uses material already published in the most varied media.

According to Gil [32], literature research is developed from material already prepared, consisting mainly of books and scientific articles. In qualitative research, the natural environment is the direct source for the search for information. The researcher has direct contact with the environment and the object of study in question. The data are observed in their study environment, without the need for manipulation or the application of statistical methods or techniques. The information collected is descriptive, representing the largest possible repertoire of elements existing in the studied reality [31].

For the collection of articles, we used the databases Ebsco, Scopus and Web of Science for article collection of those aligned with the core of this research, the following keywords were adopted: "Transportation" and "Energy Use" and "Environmental Impacts"; "Sustainable Economy" and "Best practices"; "Sustainable Development" and "Business Strategies"; "Sustainable" and "Supply Chain Management"; "Sustainability" and "Road transportation".

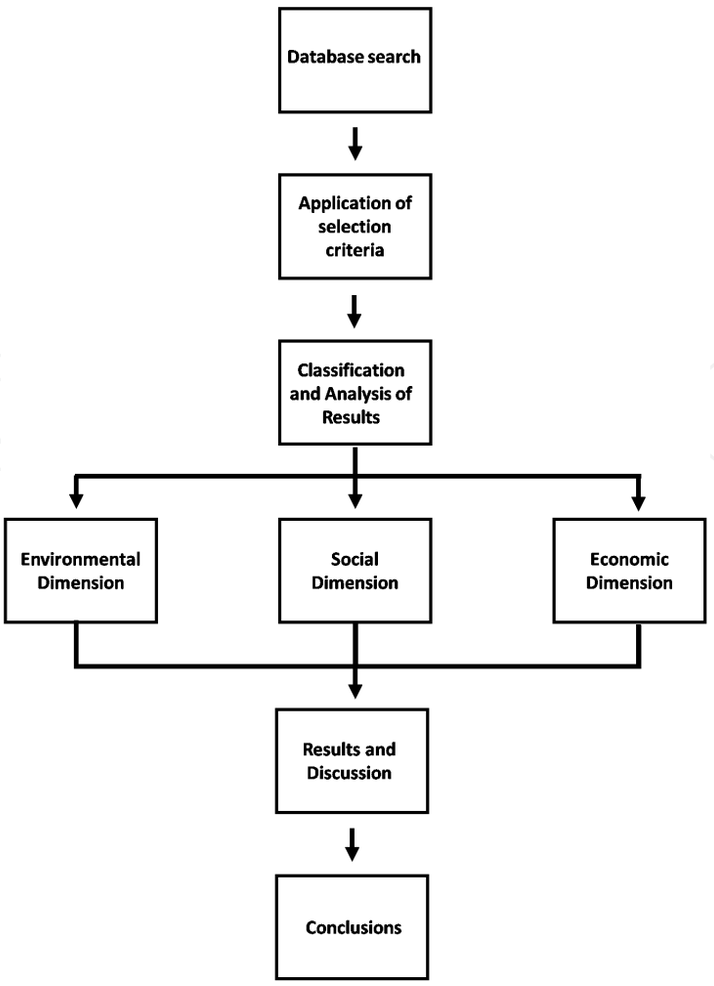

Figure 1.
Methodological Diagram. Source: Author (2021).

These words were used in all defined databases and the filters adopted for the inclusion of articles in the bibliographic portfolio were: the language (English and Portuguese), research area (engineering, administration, logistics), and the articles should have, or in the title, or in the abstract, or throughout the text, any of the keywords used. In this study, only articles available in full text were selected from the database to which they were linked.

Through the pre-selected documents, bibliographic references were searched for other approaches in order to insert them in the research. In total, 58 relevant approaches to the theme were identified, after this survey the research was subdivided into showing the classification, and the relationship with the information available and contributions to the discussion on aspects of sustainability in road freight transportation, as shown in **Figure 1**.

5. Results and discussion

Throughout the researches, a gap was noticed in terms of sustainability in road freight transportation in its most comprehensive definition, that is, from the economic, environmental and social aspects. When it comes to sustainability in transportation, the association with atmospheric emissions is inevitable. However, the other aspects are also of great importance for the well-being of society and many are associated.

The configuration of the transportation system, the performance of its activities, as well as the implementation of actions to achieve sustainable efficiency, require a foundation in the three pillars of the TBL: the economic, with emphasis on the efficiency of the performance of activities, costs of interiorization and compatible price; the environmental, with observation for the prevention of pollution, protection and conservation of natural resources and environmental management; and the social, with attention to people's safety, health and quality of life [29].

A company to be within the parameters of sustainability must be much more concerned than with atmospheric emissions. It is important to be concerned with optimizing the load, the better it is done, the fewer trucks will be needed to transportation the goods, although for this, it may be necessary to increase the waiting time of the goods which would cause a trade-off, increase waiting time and have fewer trucks circulating, or make quick deliveries with trucks circulating below capacity [33].

By reducing the number of trucks, the company reduces the gases emitted, the noise on the roads, the congestion and the number of accidents. By having better infrastructure, land use and truck access, smaller trucks can be placed to circulate in urban areas at times with less vehicle circulation with suitable locations for loading and unloading. This would generate considerable social well-being by decreasing congestion, noise and emissions within urban centers [34].

The number of road accidents can also be reduced through improvements in infrastructure and in the adjustment of the drivers' working hours so that they do not drive under the influence of substances or in conditions of extreme tiredness. Accordingly, in Brazil, Law/2015 was enacted in 2015, which defines rules for road transportation drivers, whether cargo or passengers. It is known as the Driver's Law. It came about in order to ensure the rights and establish the duties of the driver. Therefore, there was a reformulation of some rules, required safety measures, in which the main ones were the readjustment in the workday, waiting and rest periods, toxicological medical exams, fees and fines [35].

The challenge for logistics professionals when embracing sustainability is how to link and balance environmental performance and good business practices. That is, how to identify appropriate approaches or solutions that balance environmental and economic aspects. One of the main objectives of logistics is to increase the efficiency and economic performance of companies. However, the implementation of actions that contribute to changes in other social aspects, such as environmental and social responsibility, depends on the simultaneous fulfillment of short-term economic goals. However, research shows that several benefits generated for companies by adopting environmental policies, such as reducing costs due to resource savings, increasing sales by improving the company's image and adapting to future government regulations [36–40].

5.1 Environmental dimension in cargo transportation

As for the environmental aspect of road cargo transportation, two phenomena stand out: emission of greenhouse gases and noise pollution. Road freight transportation is a major cause of air pollution. The emission of gases has a negative effect on air quality and the health of people and animals. The level of toxicity of the gas emission depends on the fuel used. Although alternative fuels such as biodiesel already exist, the main fuel in use in Brazil to transportation goods is still diesel. This energy source is unsustainable, as it is a finite resource, with potential to damage public health and the environment, through particulate emissions, carbon monoxide (CO), nitrogen oxide (NOx), organic compounds volatiles (VOCs) and

greenhouse gases [41]. Noise pollution comes from the operationality of road traffic, resulting from the speed undertaken, which emits noises through propulsion (engine), pneumatic and aerodynamic [42].

5.1.1 Energy consumption

For the National Transportation Confederation [25], the infrastructure used for transportation in Brazil is inadequate. Due to the large territorial area of the country, the use of the road modal causes inefficiency, since this mode is not the most suitable for cargo with low added value and long distances. Still from an economic perspective, the lack of efficiency in Brazilian transportation logistics reduces the country's competitiveness [43].

In Brazil, in 2010, the transportation sector spent 31% of the total energy, of which 91.7% were consumed by road transportation. The energy source of the Brazilian cargo transportation is constituted in a great majority of fossil fuels, showing the potential of environmental impacts of the sector [44]. However, according to the National Petroleum Agency (ANP), renewable sources, especially biofuels, are increasingly being improved with the proposal to increase supply. Biofuels come from renewable biomass, with the potential to replace fuels from oil and natural gas in combustion engines [45].

Diesel oil represents a high consumption rate of the energy matrix that serves the cargo transportation sector in Brazil. However, its use as a fuel, evidencing combustion and exhaust, constitutes a significant element of emission of particulate material and polluting gases that affect the atmosphere [46].

5.1.2 CO_2 emissions

In view of the energy consumption at a level above the world average, the transportation sector in Brazil stands out as a problem with regard to GHG emissions, mainly of CO_2 gas. Transportation emissions - which mainly involve road, rail, air and sea transportation - accounted for more than 24% of global CO_2 emissions in 2016 [47].

The combustion process of diesel oil releases hundreds of chemical compounds in both liquid and gaseous form. In exhaustion, the main elements released are: carbon dioxide, oxygen, nitrogen, water vapor, carbon monoxide, particulate matter and volatile organic compounds, such as hydrocarbons, the latter of high toxicity, among them the most harmful to health are benzene, toluene, ethylbenzene, xylene and polycyclic aromatic hydrocarbons (PAHs) [48].

In summary, the main pollutants that impact the air quality emitted by the combustion of diesel oil are: carbon dioxide (CO_2), particulate matter, nitrogen oxides (NOX), sulfur oxides and other pollutants [49].

CO_2 emissions have been a target of concern and actions to reduce them, so much so that CONAMA Resolution no. 18/1986 created the Air Pollution Control Program for Motor Vehicles (PROCONVE) with the objectives of: reducing the levels of emission of automotive pollutants; promote national technological development; create inspection and maintenance programs for vehicles; promote public awareness of the issue of air pollution by motor vehicles; establish conditions for evaluating the results achieved; and promote the improvement of the technical characteristics of liquid fuels [50].

Encouraging the use of biofuel for road freight transportation in Brazil has been one of the recommendations for reducing CO_2 emissions. Another observation refers to the readjustment of the fleet and vehicle models in order to increase the efficiency of operations, reduce energy costs and increase the competitiveness of

Brazil [45]. Policies for GHG control, in particular the reduction of carbon emissions, the use of new technologies for more efficient and less polluting engines, have been objectives of manufacturers and vehicles, with significant changes in production patterns. The more restrictive emission limit has contributed to environmental awareness with energy efficiency [51].

5.1.3 Noise pollution

The sound is originated by a mechanical vibration that propagates in the air reaching the ear. Noise is just a type of sound, but a sound is not necessarily a noise, subjectively, noise is an unpleasant and undesirable sound. Noise is the physical vibratory phenomenon (in the case of air) as a function of frequency, that is, for a given frequency, there may be, at random, over time, variations in different pressures [52].

The concern with noise and its effects started at the beginning of the Industrial Revolution due to the appearance of powerful machinery both in factories and in construction, as well as new modes of transportation. The development of industry and the growth of cities has now resulted in an essentially urban world. In Brazil, according to the 2015 population census, about 84% of the population lives in an urban environment [53]. This urban expansion eliminated the silence of much of the planet and, today, noise is one of the most harmful contaminating agents to human health.

Road traffic is the main cause of local environmental noise. The maximum amount of noise that human beings can be exposed to continuously, ensuring acoustic comfort and not harming their health is 65 dB, a value ensured by preventive medicine. Exposure to noise of values above this can cause different impacts on the body, such as, for example, disturbed sleep, decreased work performance, hypertension, interference with cardiovascular diseases, among others [54].

Noise tolerance limits set maximum exposure times for certain levels. However, it is known that there is not a single and perfectly constant level of noise during a journey, including, in the Road Freight Transportation there are great variations, mainly with regard to background noise, such as, for example, the passage through the same via trucks, automobiles, motorcycles and, close to rural areas, even tractors [55]. To quantify these exposures, the dose concept is used, which gathers the acoustic variations according to the exposure time and the maximum time allowed during the journey [56].

The three main sources of truck noise on the roads, according to McKinnon et al. [57], are: (a) propulsion noise (engine), which dominates at low speeds (below 50 km / h); (b) pneumatic (contact noise with the road) which is the main cause of noise at speeds above 50 km/h; (c) aerodynamic noise, which increases when the vehicle accelerates.

The National Environment Council (Conama), in its Resolution 001/90, when disposing about criteria of noise emission standards resulting from any industrial, commercial, social or recreational activities, including those of political propaganda, determines that the values and noise emission limits established in the ABNT NBR 10151 standard, with the objective of ensuring public peace and the health of the population [58].

ABNT NBR 10151: 2019 - Acoustics - Measurement and evaluation of sound pressure levels in inhabited areas - General purpose application, Brazilian Association of Technical Standards [58]. In a table, ABNT NBR 10151: 2019 presents the levels of daytime and nighttime noise allowed, in different types of areas possible to exist in a city, such as, for example, strictly residential, urban, hospitals or schools; the mixed with a commercial vocation; the mixed with recreational vocation; and the predominantly industrial one.

5.1.4 Trucks with alternative technologies

All automakers present in America and Europe, and also in Brazil, have been working on vehicle designs with hybrid technology, 100% electric or gas. There are also several startups around the world that also have projects to develop cleaner commercial vehicles [59].

In addition to sustainable issues, trucks with alternative technologies to diesel have low maintenance costs, emit less noise and, therefore, can travel at times or places of greater restriction and, even with the largest initial investment, in a few years, the trucks are pay. Much because of the lower operating cost than diesel guaranteed by the manufacturers [60].

The electric truck is a response from manufacturers to the increasingly strict rules on pollutant emissions. The need to reduce CO_2 levels is such that it has attracted new companies to the transportation sector [60]. This is the case of the Swedish Volta, with the recently introduced HGT, and the American Tesla, with the Semi.

Several tests and attempts to introduce the electric truck in Brazil were made before BYD arrived. The brand started operations in the country in 2015. Currently, according to information from the Chinese company itself [61], it offers the eT7 11,200 and eT8 21,250 models in the Brazilian market for garbage collection operations, and the eT3 van for the urban transportation. BYD's electric truck has lithium iron phosphate batteries. According to the brand, this solution can last up to 30 years and its autonomy is 200 km [61].

JAC Motors is the second brand to bet on electrification. In September 2020, the brand launched the iEV1200T in Brazil. The model is the second electric truck in the country, but the first focused on urban collection and distribution operations. Unlike BYD eT3, which has a load capacity of 720 kg, the JAC model has a Total Gross Weight (PBT) of 7.5 tonnes. The truck's autonomy is up to 250 km, if the truck runs with 2 t of net load. If traveling with 4 t of net charge, the JAC iEV1200T can travel 180 km between battery recharges [62].

Volkswagen Caminhões e Ônibus (VWCO) started production of the e-Delivery electric truck in October 2020. The model, which was developed in Brazil, is being produced at the Resende plant (RJ). Sales will start in the first half of 2021. The e-Delivery electric truck will hit the market with two Total Gross Weight (PBT) models: 11 and 14 tons [63].

The tests started in 2018, after Cervejaria Ambev announced that it will have more than 1/3 of the fleet composed of at least 1,600 Volkswagen electric trucks by 2023, the largest ad of its kind in the world [63].

In about two years of testing, more than 22 tons of CO_2 are no longer emitted into the atmosphere and, so far, e-Delivery has stopped consuming more than 6,500 liters of diesel. The electric truck is recharged with 100% electric energy from clean sources, and 43% of its energy comes from the vehicle's own regenerative brake system. The e-Delivery electric motor generates up to 260 kW (equivalent to 348 hp) of power and its torque is around 233 mkgf [63].

Like e-Delivery, in addition to being supplied with electricity, some models have a braking system that also produces electricity to be stored in the same batteries that supply power to the engine. All of them are non-polluting, both in relation to the emission of harmful gases and in relation to noise [64].

The main application of these vehicles in the near future is in urban traffic, in short and light cargo logistics operations. With the current battery technology, urban vehicles are the most suitable, as they travel short distances and do not need as much energy to operate [65]. Because of their low autonomy and load capacity,

electric trucks depend on an operation that prevents, for example, the vehicle from getting stuck in traffic jams. In addition to autonomy, other issues to be addressed to make electric trucks feasible are cost and battery recharge. As with cars, electric trucks also cost more than conventional models. This is mainly due to battery packs, which make up 50% of the vehicle's value [66].

5.2 Social dimension in cargo transportation

In this study, two important points stand out in the social aspect of road cargo transportation: accidents and congestion. Accidents can cause deaths and injuries to those involved, as well as inconvenience to other drivers on the roads. In general, the number of accidents with the participation of heavy vehicles considering the distance covered is lower when compared to automobiles, however, the probability of a truck being involved in a fatal accident is great [26].

5.2.1 Accidents

According to data from the Institute of Applied Economic Research [67], in 2014 the total cost of traffic accidents on federal, state and municipal highways reached an approximate value of R $ 40 billion, with an average cost of R $ 647 thousand by fatal accident. Santana et al. [68], point out that, although road cargo transportation (TRC) is a strategic sector for Brazil, it presents several structural problems, with high social cost, including high mortality due to Work Accidents (AT) with truck drivers.

Every day, Brazil records 14 deaths and 190 accidents on federal highways. In 2018 alone, there were 69,206 accidents, of which 53,963 were victims. These accidents resulted in 5,269 deaths in the year [69]. In the 12 years analyzed by the CNT [69], Brazil had 1.7 million accidents on federal highways, with 751.7 thousand with victims and 88.7 thousand deaths. The highway with the highest number of accidents in 2018 was BR-101, where a total of 8,896 accidents with victims were recorded. Most of the occurrences on Brazilian federal highways have the presence of automobiles (64.6%), followed by motorcycles (44.4%) and trucks (23.4%) [69].

According to Silva et al. [70], drowsiness, physical and mental tiredness, drug use and payment for production are among the main factors that lead to accidents at work with professional drivers. In spite of this, the cargo transportation sector has been organized in such a way as to favor productivity, generally linking drivers' remuneration to the number and extent of trips, which leads them to make long journeys with little rest, a combination considered as one of main factors that contribute to the occurrence of accidents.

5.2.2 Traffic Jams

Urban congestion is one of the main problems generated by the use of road transportation for goods transportation, since the speed is relatively low, compromising the flow of vehicles through the streets and avenues. This situation significantly interferes with the city's routine [26]. It is, therefore, a great challenge to be solved, ensuring the economic development of cities and reducing the negative impacts of congestion.

The National Confederation of Transportation [25] developed the study "Urban Logistics: Restrictions on Trucks?" which presents the current panorama of restrictions on the circulation of trucks and loading and unloading operations in seven Metropolitan Regions of Brazil: São Paulo (SP), Belo Horizonte (MG), Curitiba (PR), Porto Alegre (RS), Goiânia (GO), Recife (PE) and Manaus (AM). To this end,

a survey of the laws governing the circulation of trucks and loading and unloading operations was carried out in these municipalities.

The results show that the accelerated urbanization of Brazil, in the last decades, has brought complexity and challenges to the supply logistics of cities where 84% of the Brazilian population lives and 96.7 million motor vehicles circulate. The study found a variety of rules and restrictions on the circulation of trucks in urban centers, added to problems of infrastructure, signaling and inspection, among other deficiencies that have an impact on the transportation activity [25].

The problems found by CNT [25] make it difficult to plan cargo transportation, increase operating costs and decrease the quality of supply services in cities, namely:

- Increase in the operational costs of road cargo transportation. In some cases, the barriers encountered by carriers have generated extra fees that affect the price of freight. Two examples are the Delivery Difficulty Rate (TDE), negotiated from a floor of 20% on the value of the freight; and the Traffic Restriction Rate (TRT), calculated at 15% of freight.

- Low predictability of delivery of goods. In addition to congestion and traffic restrictions, the carrier's planning is often changed in an unpredictable manner due to the lack of clarity and transparency about the restrictions on cargo transportation.

- Increased emission of pollutants and noise. Poorly planned restrictions can lead to congestion, discharge queues, increased number of trips, longer and inadequate routes and other disorders that increase noise produced by traffic and the emission of polluting gases into the atmosphere.

- Risk of accidents. Poor signage or even lack of signage, night time windows and other restrictions are factors that increase the risk of accidents.

The main solutions identified by the study [25] are: to improve public policies and planning, including cargo transportation in urban planning and traffic policies, integrating all municipalities in metropolitan regions; carry out democratic management and expand social control of all interested sectors: transportationers, shippers, buyers, manufacturers, distributors, transportationers, logistics operators, wholesalers, retailers and final consumers; improve traffic signs and inspection, giving more clarity and visibility to restrictions on cargo transportation, publicizing alternative routes and expanding inspection, especially in the areas of loading and unloading; expand the supply of loading and unloading spaces and hourly windows for deliveries and collections; increase security, expanding the offer of rest and rest places associated with goods distribution centers; and expand investment in infrastructure, carrying out maintenance and expansion works on urban infrastructure, especially in highway rings.

The complexity of urban distribution stems mainly from the great variety of demands for goods (at different locations and times), the reduced capacity to expand the road infrastructure and the insufficient offer of routes and alternative modes. In addition, the increase in the total vehicle fleet, congestion, restrictions on the circulation of trucks, the inadequate supply of loading and unloading spaces and the reduced hourly windows are some of the factors that condition the performance of the freight transportation activity in the middle of the country, urban transportation, increasing the costs of road transportation and reducing the predictability of goods delivery.

5.3 Economic dimension in cargo transportation

The economic aspect of road cargo transportation, in addition to focusing on obtaining profits, highlights some significant factors: the configuration of infrastructure for operationalization, access opportunities, cargo optimization and adequate land use. These determinants aim at better organization and distribution of cargo, mainly in the movement in urban centers, with definitions of areas for loading and unloading.

When it comes to infrastructure, access, cargo consolidation and land use, the best organization and distribution of cargo in urban centers is sought. An example of measures related to land use is to reserve areas in urban centers for loading and unloading. When talking about access, it refers to spatial and temporal restrictions and, in the case of public infrastructure, the use of transfer points to improve the load factor of vehicles, that is, the load consolidation centers [71].

According to Novaes [72], in Brazil the occupancy rate in road cargo transportation is only 43%, which results in an excess of trucks on the roads. This is because there are customer demands on specific routes, but the demand does not complete the capacity of a cargo vehicle, nor can it be deactivated due to low demand, as it is necessary to serve the customer.

In an attempt to achieve these economic attributes, Vidal, Laporte and Matl [73], report the use of Information Technology (IT) to achieve some objectives, such as: promoting the exchange of information between interested parties; vehicle routing and scheduling according to the degree of congestion in the transportation network; allocate loads in the compartments, efficiently, for the loading and unloading process; and increase the vehicle occupancy rate. The use of IT to help aggregate freight is of great importance to avoid trips below capacity. In addition, vehicle routing and scheduling systems for using the loading and unloading zones can result in savings in travel time between 10% and 15%, according to the authors.

Some urban centers and cities that are on the side of the roads have tended to build road loops to divert the flow from city centers [74]. Another way to reduce the impact of trucks on urban centers is access restrictions, which are the most common regulations in Europe. These access restrictions can be according to the size restriction of the truck or the time allowed for traffic [75].

5.3.1 Last mile delivery

In freight transportation logistics, the final step "Last-Mile" refers to the transportation in which the goods leave the distribution center for the final destination, that is, for the customer, both B2B and B2C, who purchased a certain product [76].

In terms of innovation, Last Mile Delivery, in addition to transforming the methodology commonly used by the transportation sector, which prioritizes the quality and efficiency of delivery, started to take into account issues such as sustainability [77].

Because of this, it has become increasingly common among companies to use bicycles and scooters to make deliveries, whether on short or large routes. The alternative is quite feasible, since it provides the improvement of urban mobility and does not pollute the environment [78].

The investment in technologies allows for faster delivery, which will not only make the final consumer more satisfied, but will also help the company to gain more time, streamlining processes [79]. Geolocation enables the optimization and improvement of other tools used in the transportation process, being essential for the integration of the company's system with the Google Maps API (Application Programming Interface).

A geolocation tool contributes to the definition of more viable routes, which helps to save time and fuel, directly impacting the maintenance of the means of transportation used. In addition, geolocation allows control of delivery in real time, taking into account the company's particularities. With this, the entire delivery process is streamlined, optimizing material and human resources [79].

According to Joerss et al. [80] the business model conventionally applied to the last mile should be replaced due to the new technologies that reach the market. For these authors, the traditional model that uses light diesel vehicles will be responsible for only 20% of deliveries in the last mile in urban areas, being progressively replaced by autonomous vehicles and delivery services by bicycles, more energy efficient. There is a potential for new technologies to transform deliveries in the last mile, which can lead to a new transportation infrastructure and delivery models [81].

6. Conclusions

The road cargo transportation sector has its representativeness in the country's economic scenario and, however, in order to obtain sustainable gains, attention must be paid to the negative effects that its performance can cause to the environment and establish a reduction in the levels of CO_2 emissions. This is done through logistical planning and the choice of more eco-efficient modes, that is, less polluting, such as the railway. Biofuels, as well as electric trucks, may also help to minimize the serious problems of road transportation in the country, especially urban ones.

The current transportation matrix has proved to be inadequate, since the high dependence on the road modal intensifies the problems of urban mobility, enhances environmental problems and negatively affects people's quality of life. Thus, it is understood that the improvement in the country's economic and environmental results is directly related to changes in the transportation sector. The current model is contrary to the search for a better quality of life for society and to the increase of Brazilian competitiveness in relation to the foreign market.

Organizations around the world have faced the challenge of making their operations more sustainable. In logistics, the focus for the coming years will be on reducing carbon emissions and reducing production waste. Technology and logistics go together, mainly with regard to the development of solutions that help to optimize processes, make the results more satisfactory and guarantee higher quality for companies that are served by companies in the sector.

In the case of logistics, innovation is considered an extremely strategic factor for the success of a business in the sector. In this sense, among the main trends identified in this study in Brazilian road freight transportation, are: the greater use of ecological fuels, which are less polluting and provide less noise, the popularization of hybrid or fully electric vehicles, the growth in use of small vehicles for last-mile deliveries, in addition to the use of transportation management tools, which allow to select and better manage the partners that offer these differentials.

Society faces a challenging time for economic growth and public welfare. The environmental problems resulting from unrestrained progress are already reaching great proportions, becoming the subject of discussions and mobilizations worldwide. In this reality in which sustainability is no longer just a competitive differential, it is indispensable for the future of the planet, the Brazilian transportation sector adopts socio-environmental responsibility as the basis for its performance. Promoting social and environmental responsibility in the Brazilian cargo transportation sector and, thus, collaborating to the preservation of life and the environment, constitute the main contribution of this chapter to the book Urban Agglomeration.

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