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A Diagnosis Methodology for Urban Goods Distribution: A Case Study in Belo Horizonte City (Brazil)

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Abstract

Currently, one of the main problems related to freight delivery is the lack of adequate infrastructure for operations in urban areas. In this sense, this paper presents a diagnosis methodology to identify issues relating to urban goods distribution. To undertake the diagnosis, we used interviews with logistics operators, research of loading and unloading places and traffic counts in the study area. The methodology was applied to the central area of Belo Horizonte (MG), and among the results highlight that the loading and unloading places regulated by public authorities on urban roads are occupied mostly by private vehicles. The results indicate the main issues relating to urban freight distribution in Belo Horizonte and the need for effective public policies to improve the activity and the reduction of negative externalities on the urban environment.

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Keywords: Diagnosis; urban goods distribution; methodology

1. Introduction

The discussion referring to urban mobility has become important with the increase of the number of vehicles and the limitation of the urban space in cities. Urban distribution also fits into the context of reduced mobility, as a consequence of economic development, that is, the development and the dynamism of an economy results in a
greater flow of goods and, consequently, of freight vehicles in a city. Seeking solutions to improve distribution in cities, the concept of urban logistics, whose objectives are to support the sustainable development of cities and seek solutions to the problems caused by these distribution centres, arose.

Among the solutions adopted to regulate the flow of freight vehicles in urban centres, stands out the restriction of traffic, measure that can, also, reduce through traffic, besides the regulation of places for loading and unloading. In different Brazilian cities this problem is recurrent, and the irregular occupation of vacancies for loading and unloading provokes the questioning whether these are idle; if there is disrespect to the current law, or who are responsible for the problems caused by urban freight distribution.

In this sense, the paper intends to present the results of a diagnosis that aims to demonstrate the importance of loading and unloading spaces for urban freight distribution, through the evaluation of the occupation of public urban parking space by freight operators. After this introduction, the paper shows the importance of on-street loading and unloading spaces for urban freight distribution, the methodology proposed for the study, and the results for Belo Horizonte city, ending with conclusions of the work.

2. The Urban Distribution of Goods and the On-street Loading and Unloading Spaces

The efficiency with which logistics operations are conducted at the urban level can increase mobility, not only of freight vehicles, but also of passenger cars circulating in the city centre. Increased mobility implies not only reduced congestion, but also on the proper functioning of the commercial sector. For commercial sector, the receipt of goods on schedule and in good condition is essential to economic activities.

Urban freight distribution causes great inconvenience in the urban perimeters. Besides reducing mobility, this causes discomfort due to high noise and increased air pollution. For example, in Europe, freight vehicles are responsible for 10% of traffic (Civitas, 2010). Since they are larger and heavier, the freight vehicles have difficulty to circulate among the high number of cars that travel through urban centres. These difficulties are aggravated by the absence of an adequate infrastructure for this activity. The lack of space for the loading and unloading of goods transfers the operation to the traffic lanes and causes congestion (Dablanc, 2009). The prefecture of Paris requires that there be a loading/unloading bay every 100 meters on city streets. In Tokyo, part of a parking lot was reserved for the loading-unloading operations. Despite this, in Tokyo, for example, 83.1% of deliveries use the road to perform the same operation (Taniguchi, 2012).

In Brazil, one of the main problems faced by transport operators is the difficulty of finding a regulated area in the central regions to park and load / unload their goods. Compared to Paris, where there are 10,000 regulated areas for urban distribution operations, and Barcelona (8,000), Latin American cities have few regulated areas (Dablanc, 2009). For example, in Buenos Aires, there are 750 areas, and in Belo Horizonte are 550 areas in the central region of city. This forces operators to move through the region, which affects the capacity of the surrounding roads and traffic safety (Aiura and Taniguchi, 2006). This context reflects the importance of the issue, which has received little attention, as indicated by McLeod and Cherrett (2011).

The concept of city logistics emerged for seeking solutions to improve distribution in cities. Thus, city logistics solutions are aimed at reducing urban diseconomies to make the whole system more effective through innovative solutions that reduce logistical problems generated by distribution in urban areas and improving the quality of service (Oliveira, 2012).

In this sense, solutions that improve urban goods distribution are essential to ensure the dynamics of the economy, improving urban mobility and quality of life in the region. This objective is closely connected to the concept of city logistics that is a process optimization of logistics and transportation activities undertaken by public and private companies with support of advanced information system in urban areas, considering congestion, safety and energy conservation in the dynamics of market (Taniguchi, Thompson, Yamada & van Duin, 2001). In Brazil, experiments involving solutions of city logistics are still rare, being limited to restricting freight vehicle traffic in urban spaces and regulation of loading and unloading spaces for freight distribution. Regarding the last solution implemented in Brazilian cities, there is a high occupancy of irregular spaces for loading and unloading, that raises the serious concerns regarding the provision and management of these places and current legislation.

In Brazil, by law, the operation of loading and unloading is done on urban roads. However, space for the movement and "sidewalk" intended for pedestrians should be respected, since in conducting this operation it is essential that the vehicle "park." In this case, the road being designed for "traffic" that corresponds to the movement of vehicles, people and animals, its obstruction to the operation of loading and unloading impedes the free movement and therefore characterizes traffic violation. Thus, planning and management of areas reserved for loading and unloading is essential and the responsibility of the municipal government, and that these areas must be sited away from the roadway.

However, ensuring the existence of space for activities is not enough. The results of the work of Correia (2011), which interviewed retailers and logistics operators, emphasizes that parking for the operation of loading and unloading of goods as one of the main problems of city logistics in Belo Horizonte. Thus, to ensure that the operation of urban distribution occurs efficiently and effectively goes back to the appropriate use and occupation of on-street loading and unloading spaces of goods in urban centres.

3. Methodology

According to Tedesco (2008), diagnosis is present in all planning activities, but is not discussed in a systematic manner. Furthermore, diagnosis is a tool to identify problems and find appropriate solutions. Created as part of medicine, the concept is universal and the fundamentals are valid for applications in other fields of study (Tedesco, 2008). Tedesco & Yamashita (2008) propose a methodology for developing diagnostics in the transportation system consisting of seven steps: (1) definition of the object of study, (2) defining the study area, (3) characterization of the object of study, (4) field research, (5) definition of benchmarks, (6) comparison data parameters and analysis of results, and (7) elaborate the diagnosis. Holquin-Veras & Jaller (2012) consider this type of structure also important to understand the type of travel in urban areas. The methodology proposed by Tedesco & Yamashita (2008) was adapted to make a diagnosis of urban freight distribution, although the analysis stage of the benchmarks were not undertaken. The structure is shown in Fig. 1.

![Fig. 1. Methodology to applying a diagnosis in city logistics (Adapted from Tedesco & Yahashita, 2008)](image-url)

Applying the methodology proposed by Tedesco & Yamashita (2008), the object of study is urban freight distribution in Belo Horizonte. It is intended to diagnose the problems of urban freight distribution in the central
area of Belo Horizonte, which is the area study. The structure of the variables in distribution urban is shown in Fig. 2. Applying the concept developed by Villela & Tedesco (2011), urban freight distribution is the result of five key variables: (1) vehicle, (2) delivery, (3) commodities, (4) route, and (5) stakeholders. For the definition of the vehicle, you must know the type, capacity and year of manufacture. For the definition of delivery, you must know about the parking, operation, frequency, type and support equipment. The package includes the type and weight. The route includes origin, destination, road system and travel time. Those involved include logistics operators who transport the goods to retailers and the public authority that regulates the operation of parking for loading/unloading of goods in urban areas. These variables were the key elements for making the questionnaire applied to logistics operators in the emerging area of the study.

This methodology was applied in Belo Horizonte city, the capital of Minas Gerais State. It has a population of 2.4 million inhabitants, a motorization rate of 1.7 inhabitants per vehicle, and presents typical problems of urban mobility. From 2009, the BHTRANS, regulatory traffic agency of Belo Horizonte, implemented a restriction on freight vehicles to reduce the problems caused by urban freight distribution, to reduce the number of freight vehicles in the region.

Drivers of freight vehicles that were operating in the on-street loading and unloading spaces regulated by the agency transit of Belo Horizonte (BHTRANS) were invited to participate in the study. For the statistical consistency of this work, a sample of on-street loading and unloading areas, in the Central Region of Belo Horizonte, was selected. In this region there are approximately 550 loading and unloading spaces, with a total of 1,147 spaces in operation. At total of 491 interviews were conducted with logistic operators operating in the regulated on-street loading and unloading spaces, resulting in a sample with 5% error. The distribution of interviews in regions of the central area are presented in Table 1.

Table 1. Distribution of interviews

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of interviewees</th>
<th>Percentage representativeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hipercentro</td>
<td>356</td>
<td>72.6%</td>
</tr>
<tr>
<td>Savassi</td>
<td>28</td>
<td>5.7%</td>
</tr>
<tr>
<td>Barro Preto</td>
<td>71</td>
<td>14.4%</td>
</tr>
<tr>
<td>Lourdes</td>
<td>21</td>
<td>4.3%</td>
</tr>
<tr>
<td>Hospital Area</td>
<td>15</td>
<td>3.0%</td>
</tr>
<tr>
<td>Total</td>
<td>491</td>
<td>100%</td>
</tr>
</tbody>
</table>
Furthermore, an additional survey was performed: (i) turnover survey in the regulated on-street loading and unloading spaces, and (ii) classified count traffic in two main regions of the Central Area (Hipercentro and Savassi) to evaluate the average number of vehicles entering / exiting the region during the study period. Such research complements the information of the variable route, the process of urban distribution. After collecting data, they were tabulated and analyzed, thus contributing to improving the distribution of goods in this city, ending in the diagnosis of urban freight distribution.


The results of the application of the methodology will be produced in the diagnostic subgroups: vehicle, delivery route and stakeholders.

4.1. Vehicle

Three variables relating to the vehicle were evaluated: (1) type, (2) capacity and (3) the year of manufacture. The results of the interviews indicated that Mercedes Benz (27%) and Volkswagen (24%) are the main manufacturers of vehicles operating in the region of the study. In relation to the vehicle capacity, 92% of the fleet has a capacity of less than five tons, which meets the requirements of maximum weight restriction of freight vehicles allowed in this area. The average age of the fleet is 5.76 years, with 69% of vehicles have an average age below 10 years and 12% of vehicles have aged more than 20 years of manufacturing, as can be seen in Fig. 3. Additionally, drivers were asked if they always drove the same vehicle, with 89% of respondents reporting that they always drove the same vehicle.

![Fig. 3. Year of manufacture of the vehicles of the research](image)

4.2. Delivery

Delivery consists of information about the operation, frequency, parking and support equipment. The operation consists of the average amount of time spent searching for a place to park the vehicle and parking the vehicle, the average idle time, waiting to unloading the goods and, finally, the average delivery time.

In relation to the average time to find a place of loading / unloading and parking the vehicle, 49% of respondents stated that they parked the vehicle as they arrived at the place of delivery, as shown in Fig. 4. Overall,
the drivers took 9.5 minutes (Table 2) to find an on-street loading/unloading place in the Central Region, and this time varies according to time of day, as shown in Fig. 5.

Fig. 4. Average waiting time to park the vehicle in Central Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Average waiting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hipercentro</td>
<td>10.2 minutes</td>
</tr>
<tr>
<td>Savassi</td>
<td>9.13 minutes</td>
</tr>
<tr>
<td>Lourdes</td>
<td>6.9 minutes</td>
</tr>
<tr>
<td>Barro Preto</td>
<td>8.3 minutes</td>
</tr>
<tr>
<td>Hospitalar Area</td>
<td>7.0 minutes</td>
</tr>
<tr>
<td>Central Area</td>
<td>9.5 minutes</td>
</tr>
</tbody>
</table>

Fig. 5. Variation in average wait time to park the vehicle in Central Region
Another important indicator is the time that the driver is idle in the car park, waiting for the release of the commercial establishment for loading or unloading of goods. In the Central Region, on average, the vehicle waits 20 minutes to start this process, however 22% of respondents reported waiting more than 20 minutes. This indicator changes significantly depending on the region, as shown in Fig. 6.

![Fig. 6. Percentage of idleness delivery, by region, in Belo Horizonte](image)

Additionally, a vehicle performs, on average 25 deliveries in one day, and, at each stop, it performs on average three deliveries. The interview with the logistics operator indicated that the frequency of goods delivery is daily, as can be seen in Fig. 7.

![Fig. 7. Frequency of delivery](image)

With respect parking, in the on-street loading/unloading places, the average time of use, the geometry and availability are the important variables for analysis. To determine the average time that a vehicle stays in an on-street loading/unloading place and the availability of a place, a turnover survey was conducted in an on-street loading/unloading place in May 2011, between 06:30 to 20:30, where the plates were recorded for all vehicles that occupied places. These were classified into categories of vehicles in operation or not operation. The vehicles were divided into five groups and the analysis reveals that 57.7% of the places were occupied by passenger cars without load/unload operations (Fig. 8). Freight vehicles occupied 35.7% of these spaces.
Between 9.30 and 18h, the occupancy rates of the places is greater than 50%, as can be seen in Fig. 9. Of the places that are occupied by freight vehicles, on average 7% are operating the loading/unloading of goods, as can be seen in Fig. 10. The use of the places for goods delivery at night (after 18h) is very low and there is no operation after 19:30 hours.

Fig. 8. Groups of vehicles occupying the loading/unloading spaces

Fig. 9. Occupancy percentage of loading/unloading place in the daytime
The Hipercentro is the region that has the highest occupancy rate of on-street loading/unloading places in operation (11%) and Lourdes is the region that has the lowest occupancy (2%), as shown in Table 3. The average time spent by freight vehicles in these places is 66.2 minutes, and Lourdes has the highest time spent (79 minutes) and Hipercentro, the shortest length of stay (58 minutes). Hipercentro is also the region with the highest overall occupancy rate, as shown in Fig. 11.

<table>
<thead>
<tr>
<th>Region</th>
<th>Average Percentage</th>
<th>Average Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hipercentro</td>
<td>11%</td>
<td>58 minutes</td>
</tr>
<tr>
<td>Savassi</td>
<td>4%</td>
<td>71 minutes</td>
</tr>
<tr>
<td>Lourdes</td>
<td>4%</td>
<td>79 minutes</td>
</tr>
<tr>
<td>Barro Preto</td>
<td>2%</td>
<td>54 minutes</td>
</tr>
<tr>
<td>Hospitalar</td>
<td>3%</td>
<td>69 minutes</td>
</tr>
<tr>
<td>Central Area</td>
<td>4.8%</td>
<td>66.2 minutes</td>
</tr>
</tbody>
</table>

To finalize the diagnosis of delivery, 80% of the interviewees said they did not have equipment to assist them in loading / unloading of goods, which may result in an increased length of stay in the places. Among the equipment used for the operation, it is highlighted that 70% of those who use any equipment, make use of a handcart with pneumatic wheels and human traction, with a load capacity from 100 to 300 pounds.
4.3. Commodities

In general, the commodities which are delivered in the Central Area are types of consumer goods, as seen in Fig. 12, especially for the food industry, beverages and clothing totaling, 52%. Most products are transported through boxes to the final destination.

4.4. Routes

Knowing the origin of the goods and the travel time is an important indicator for assessing transport routes and proposing alternative routes to reduce travel time. The goods that have a destination the in Central Area of Belo Horizonte are coming mainly from the cities of Belo Horizonte (39%) and Contagem (35%). To arrive at the Central Area, respondents mainly use Via Expressa (24%), Amazonas Avenue (23%), Antonio Carlos Avenue.
(8%) and Cristiano Machado Avenue (7%), which consist of the main routes to access the region analyzed. In general, the average travel time is less than 60 minutes, as shown in Fig. 13.

![Fig. 13. Average travel time to Central Area](image)

Analyzing the results of the classified traffic counts in Hipercentro (Fig. 14), it is noted that on average 70 vehicles enter the region, in 15 minutes, and 64 vehicle leave, in the same time interval, with a peak input and output at 10:15h. The input peak is explained by movement restrictions in this region. For the peak output of vehicles at the same time, the vehicles arrive in the region before the time restriction to carry out operations at the start of business hours, mainly for goods that are coming from other regions beyond the metropolitan region of Belo Horizonte. Analyzing the Pearson correlation of two variables, it is observed that there is a strong positive correlation with $r = 0.81$, which can be explained by the reduced operation time of loading and unloading, as shown in Table 3.

![Fig. 14. Entry and exit of freight vehicles in Hipercentro](image)

Asimilar situation occurs in Savassi (Fig. 15) where there is an average of 100 vehicles entering and 90 vehicles exiting, within 15 minutes, the entry peak in the range of 16h and exit peak in the range of 11:15 h. These results indicate that there may be a possible route to other regions before arriving at the Savassi, however this was not a focus of this work, it is not possible to test this hypothesis. Analyzing the Pearson correlation for this region, it is
observed that there is a strong positive correlation, \( r = 0.80 \), which can be justified also by the reduced delivery time of goods.

![Graph showing entry and exit of freight vehicles in Savassi](image)

**Fig. 15. Entry and exit of freight vehicles in Savassi**

### 4.5. Stakeholders

In this study it was identified that 52% of drivers are self-employed, and 88% have 1-2 helpers. Importantly, 13% of deliveries are performed by the driver, impacting the total operating time.

### 5. Conclusion

With this diagnosis the main results were:

- The main origins of load flows to the central region of Belo Horizonte is the city of Belo Horizonte and Contagem, being used mainly as access roads Via Expressa (Expressway) and the Amazonas avenue;
- On average, the occupation of on-street loading and unloading spaces is low, with a high percentage of private vehicles parked in these areas. The mean operation time of a loaded vehicle is 61.4 minutes.
- Thus, the offer for on-street spaces is much greater than demand, in other words, there is no need to invest in more areas for loading and unloading;
- The Hipercentro is the region with the highest occupancy of places for loading and unloading operation and Lourdes is the region with the lowest occupancy;
- Vehicles operating in the region have a capacity of less than five tons and, in most cases, have an average age below 10 years.

This way, it appears necessary measures for parking management, horizontal and vertical signaling, beyond the intensive supervision are ways to reduce rates of observed infractions and, rationally use the bays to improve load operations in urban public roads.

The results obtained permit the evaluation of creating new policies for urban logistics, such as areas reserved for loading and unloading operations. Furthermore, as an obstacle for efficient urban distribution, exists the need to change paradigms for all involved in the process, whether they are residents, governments, retailers, shippers and carriers, who need to understand the problem from a social point of view. Therefore, there is no single solution that benefits everyone, but there are alternatives that can reduce the environmental and social problems, which deserve to be disseminated among parties involved. In this context, in conclusion, the concept of urban logistics challenges public authorities, transporters, retailers and residents in their relationships with each other, introducing
a new economic model and operation, requires an understanding of public-private partnerships, as well as collaboration and innovation.

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