UNIVERSIDADE ESTADUAL DE CAMPINAS

Faculdade de Engenharia Civil, Arquitetura e Urbanismo

RODRIGO BARROS CASTRO

CITY LOGISTICS E BOAS PRÁTICAS EM LOGÍSTICA URBANA: O CASO DE SÃO PAULO

CITY LOGISTICS AND URBAN LOGISTICS BEST PRACTICES: CASE OF SÃO PAULO

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Dissertação de Mestrado apresentada a Faculdade de Engenharia Civil, Arquitetura e Urbanismo da Unicamp, para obtenção do título de Mestre em Engenharia Civil, na área de Transportes.

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Orientador(a): Prof(a). Dr(a). Orlando Fontes Lima Júnior

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FACULDADE DE ENGENHARIA CIVIL, ARQUITETURA E URBANISMO

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RESUMO

A urbanização ocasiona em uma maior demanda por mercadorias, serviços e atividades logísticas de apoio, atividades que geram impactos significativos nas cidades. O conceito de *city logistics* se apresenta como oportunidade para o transporte urbano de cargas. Diversas boas práticas de logística urbana foram desenvolvidas para mitigar seus impactos associados. Porém, cidades têm características diferentes, e políticas públicas ou soluções aplicadas em áreas urbanas distintas só podem resultar em diferentes impactos. Além disso, a melhor escala para se estudar a logística urbana de cargas é no nível distrital, uma vez que permite o desenvolvimento de introspecções relativas à características locais das operações, suas restrições e necessidades.

Neste contexto, esta pesquisa tem como objetivo a melhora na sustentabilidade do transporte urbano de carga em uma área crítica da cidade de São Paulo, Brasil. A primeira etapa deste projeto consiste na identificação de clusters urbanos na cidade de acordo com variáveis relevantes para a logística urbana – concentração de estabelecimentos, população, regulamentações e densidade e capacidade de vias. Este procedimento permitiu o conhecimento do contexto de São Paulo com relação ao transporte urbano de cargas, e ainda a sugestão de políticas públicas gerais que contribuem para a mobilidade na cidade. A segunda etapa fundamenta-se no estudo aprofundado de uma área de um quilômetro quadrado com o envolvimento dos atores impactados pelo transporte urbano de carga. A aplicação de um método multicritério para tomada de decisão permitiu a análise e proposta de uma boa prática apropriada para o contexto do local.

ABSTRACT

Urbanization is responsible for an increase in demand for goods, services and logistics support activities. The concept of city logistics presents itself as an opportunity for urban freight transport. Several urban logistics best practices were developed to mitigate their associated impacts. However, cities have different characteristics, and public policies applied in different urban areas can only result in different impacts. Besides, the best scale for studying urban logistics freight activities is at the district/neighborhood level, since it allows the development of insights into the specific nuances of daily operations, existing constraints and needs driving a specific area.

In this context, this research aims to improve the sustainability of the urban freight transport in a critical area of São Paulo, Brazil. The first step of this project consists on the identification of clusters in the city according to relevant variables for urban logistics – establishments' concentration, population, regulations, road capacity and density. This procedure allowed obtaining knowledge of São Paulo's context regarding urban freight transport, with suggestion of general public policies or best practices that contribute to mobility in the city, besides the identification of critical areas for urban logistics. The second step is based on an in-depth study of a critical area of one square kilometer, with the involvement of the stakeholders affected by the urban freight transport. The application of a multi criteria decision tool allowed the analysis and proposal of an appropriate best practice.

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LIST OF ACRONYMS

GDP: Gross Domestic Product

B2B: Business-to-Business

B2C: Business-to-Consumer

ICT: Information and Communication Technologies

ITS: Intelligent Transportation Systems

AHP: Analytic Hierarchy Process

SUMMARY

1 INTRODUCTION AND JUSTIFICATION

The world is experiencing a transition in its population, migrating from rural areas to cities. The overall growth of the urban population is 65 million people per year, and half of the world population already lives in cities, generating over 80% of the world's GDP (Dobbs et al., 2011). This urbanization is more pronounced in developing countries where, in 2012, the urban population accounted for 79% of its inhabitants (Merchán et al., 2015).

Urbanization in developing countries is confirmed by Ibeas *et al.* (2012), who argues that urban freight transport has an essential role in the development of cities, especially in emerging countries. For the population, it ensures the adequate supply of stores, as well as B2C (Business to Consumer) deliveries. For companies, it is the essential link between suppliers and clients. Besides, the urban freight transport is a major employer (Crainic, 2004).

When compared to the transport of people in cities, urban freight transport generates significant social, environmental and economic negative impacts. Congestion affects the economy of the cities due to the waste of resources and inefficiency they generate. The emission of pollutants, the use of non-renewable fuel and waste products such as tires and oil are relevant environmental impacts. As social impacts, the physical consequence of pollutants emission (diseases), the accidents resulting from traffic, the high noise levels, among others can be cited (Anderson *et al.*, 2005; Behrends et al., 2008; Mckinnon, 2010). According to Oliveira *et al.* (2015), 79% of urban freight transport challenges involve congestion intensification, 76% of its challenges involve space-time restrictions of cargo vehicles, and 52% involve the lack of interaction between the stakeholders.

In this context, the identification and implementation of best practices that contribute to urban freight mobility presents as a great opportunity, especially for developing countries such as Brazil.

1.1 Objective

The objective of this research is to propose a city logistics best practice to a critical area of São Paulo/SP, in order to improve the sustainability of the urban freight transport. The research is based in two main applications: cluster analysis of the city, and KM² analysis of a critical area.

Initially, São Paulo was divided into clusters according to urban logistics relevant variables – population and establishments' concentration, regulations and road density and capacity. This procedure had the purpose of analyzing São Paulo's urban context regarding urban freight transport, providing insights and suggestions of city logistics best practices and public policies according to each cluster.

The second step of this research stands for an in-depth study of a one square kilometer area of a critical cluster, in order to better analyze and develop specific urban logistics solutions for the zone.

2 LITERATURE REVIEW

2.1 Urban logistics challenges

Urbanization induces a higher demand for goods, services and logistical support activities. A large number of different types of goods flows through the urban environment, occupying about a quarter of a typical city traffic. Freight needs loading and unloading zones, warehouses, wrapping and packaging services, among others activities and logistics spaces, requiring greater use of urban space. This change of scenario provides opportunities, such as the increase in productivity through economies of scale (Blanco, 2014; Allen *et al.*, 2008; Dablanc, 2007).

The significant freight volume that is transported in cities tends to increase. Factors contributing to this phenomenon include production and distribution practices based in low inventories and reduced delivery windows, such as Just in Time concept, as well as the change in the urban metabolism, with the growth of e-commerce and its increased associated deliveries (Crainic, 2004).

Logistics operators, however, have to work often with inadequate infrastructure, with congestion and lack of areas for loading and unloading freight - and economies of scale depend on transportation costs. Besides, vehicles used for freight transport are responsible for major negative impacts in cities - economic, social and environmental (Blanco, 2014; Dablanc, 2007).

Despite the negative impacts, cities depend on cargo transportation. Urban logistics plays an essential role in maintaining and retaining industrial and commercial activities, which are essential for major wealth generating activities, and is a major employer. Efficient urban freight transport increases the competitiveness of industry, and is critical to sustain the current life style in cities. Thus, urban logistics creates a conflict between commercial interests and the urban environment (Crainic, 2004; Dablanc, 2009).

Public authorities are aware of the importance of controlling and organizing urban freight transport, but most do not know how. In general, public policies regarding freight are scarce and outdated. The truck traffic is seen as something that should be strictly regulated, whereas the best solution would be to organize it more efficiently (Crainic, 2004; Dablanc, 2007; Sanches, 2008).

Part of the complexity of the urban freight transport occurs due to the presence of different stakeholders with different goals, often conflicting among each other. Taniguchi and Tamagawa (2005) listed and described the main stakeholders in urban logistics:

- Shippers;
- Freight Carriers;
- Administrator;
- Residents;
- Urban expressway operators.

Shippers have as main interest the delivery and withdrawal of goods with low cost, meeting the needs of its customers. Carriers seek to minimize transportation costs and to ensure an adequate traffic flow. Administrators seek to regulate and minimize the impact of the relationship between the cargo and the city. Residents desire the availability of a wide variety of products and still ensure good life quality in the urban environment. Urban expressway operators present as main objective maintaining profitability, but also need to provide a good traffic environment (Taniguchi e Tamagawa, 2005).

The productivity of urban freight transport system depends on joint efforts between the stakeholders involved. The public sector is responsible for the infrastructure, regulation and management, whereas the private sector operates cargo terminals and carries out transport operations (Lima, 2011). However, both stakeholders await initiatives from each other. Public authorities expect companies to create new specific logistics services for the emerging needs of customers and retailers, while the private sector is awaiting initiatives and subsidies from the public sector (Dablanc, 2007). Still, according to Crainic (2009), it is essential to replace initiatives that consider deliveries, companies, vehicles and the urban environment separately by integrated logistics systems.

There is a growing concern regarding urban freight transport, leveraged by its challenging issues. In this context, City Logistics concept was developed with the purpose of reducing congestion and increasing mobility; reducing greenhouse gas emissions and noise, improving the quality of life; and supporting the social and economic development of the city (Crainic, 2004).

2.2 City Logistics and urban planning

City logistics plays an important role in the development of sustainable, efficient, and safe systems for urban freight transport. The most accepted definition for sustainable development states it is a development that meets the needs of the present without compromising the needs of future generations (Anderson *et al.*, 2005).

Taniguchi *et al.* (2001) defines city logistics as "the process of totally optimizing urban logistics activities by considering the social, environmental, economic, financial, and energy impacts of urban freight movement."

Public managers can assist the process of logistics activities optimization in the cities. Solutions such as the implementation of freight consolidation centers, accessibility regulations, and areas of low emissions of polluting gases have been tested and implemented in cities around the world to achieve the objectives of city logistics: mobility, sustainability and life quality (Taniguchi *et al.*, 2014).

Three elements are essential to promote city logistics: (1) Application of innovative technologies - Information and Communication Technologies (ICT) and Intelligent Transportation Systems (ITS); (2) Change in the mentality of logistics managers; (3) Public-Private Partnerships (Taniguchi, 2014).

The application of technologies such as ICT and ITS in urban freight transport allows the precise collection of data with low costs. Digital data can be used to optimize the routing and planning of vehicles dynamically and stochastically. This optimization allows the reduction of logistics costs, the reduction of greenhouse gas emissions and the reduction of the congestion caused by freight vehicles. Both private business and society can benefit from the application of ICT and ITS in terms of efficiency and reduction of negative impacts (Taniguchi and Shimamoto, 2004).

The mentality change of logistics managers is critical for urban logistics, since these managers are important actors in the urban cargo transport operations. Taniguchi (2014) highlights the importance of certifications for the development of sustainable logistics systems, such as ISO9001 (quality management) and ISO14001 (environmental management).

Public-private partnerships are essential to urban freight mobility. They allow all actors involved in the urban freight transport to participate in the development of public policies and solutions. Information sharing between private companies and the public sector also allows a better understanding of the distribution of cargo throughout the city and its associated problems (Browne *et al.*, 2004).

Duin and Quak (2007) classified the three main areas of the city logistics concept as:

- Flow improvements, such as consolidation centers, transport reorganization, routing optimization;
- Infrastructure, such as loading and unloading zones;
- Public policies.

Several projects were developed to propose best practices in urban logistics and to mitigate their associated impacts. However, cities have different characteristics, and policy measures applied in different urban areas can only result in different impacts. Thus, it is essential to include urban form characteristics and all stakeholders' opinions to enhance city logistics planning, and the transferability and sustainability of urban logistics solutions (Alho and Silva, 2015; Dablanc, 2009; Anderson *et al.*, 2005).

There are no global solutions or success formulas for the various problems arising from the cargo transportation in the urban environment. Any strategy chosen to mitigate these problems should be developed according to the characteristics of each region. An agreement should be established between the conflicting objectives of the various actors in the urban environment that participate in the load distribution process, such as retailers, government, carriers, among others (Correia et al., 2010;. Crainic et al ., 2009).

In this context, this research presents a literature review on urban logistics best practices. Then, an overview of Cluster Analysis is presented, research method used for the segmentation of São Paulo, Brazil, into urban clusters. This procedure allowed analyzing specific characteristics of the city, basis suggested for the development and implementation of best practices.

2.3 Urban logistics best practices

Urban logistics best practices are a set of actions with the purpose of minimizing the negative impacts and maximize the efficiency and effectiveness of logistics operations that take place in cities. According to Oliveira *et al.* (2015), 38% of the urban freight transport best practices involve the implementation of urban consolidation centers, 31% use different vehicles for cargo deliveries, and 28% adopt ITS and ICT systems for fleet tracking and monitoring.

The main best practices for urban freight transport can be described as (Merchan and Blanco, 2015):

- Freight consolidation centers;

Cargo consolidation centers allow companies have economies of scale out of cities, with transshipment and/or consolidation of freight for urban transport. These spaces also assist compliance with regulations implemented to reduce the impacts of logistics operations (Allen, Browne, & Leonardi, 2012).

- Loading and unloading zones;

The use of delivery bays for loading/unloading operations are the most cost-effective parking solutions for freight vehicles in congested areas. They are designed and implemented by public authorities, but similar solutions can be developed by private carriers, such as the use of shopping centers parking spaces.

- Automatic Parcel Terminals;

Automatic Parcel Terminals are urban lockers conveniently located to collect orders, and stands out as alternative for home delivery. This solution contributes to the assertiveness of Business to Consumer (B2C) deliveries, eliminating the need for any additional attempts to complete the delivery. Thus, urban lockers appear as good choice for the e-commerce freight transport.

- Alternative vehicles;

With the growth of public policies that restrict the access of heavy vehicles in the center of cities, models that optimize the freight distribution may involve the transfer of cargo for small vehicles such as tricycles and motorcycles. Such vehicles are good alternatives to the Last Mile Distribution. The use of electric vehicles should also be considered, since they provide environmental benefits.

- Mobile Warehouses;

The use of trucks, serving as mobile warehouses for smaller vehicles, is also a solution to the Last Mile Distribution, where vehicles can become micro platforms for freight deconsolidation.

- Off-hour Deliveries;

Night delivery is considered an alternative to reduce the flow of heavy vehicles during peak hours of traffic in cities. For the implementation of this practice, vehicles must be especially equipped to control noise levels, and retailers must be organized in order to receive the deliveries during this period. For carriers, the benefits of night delivery are the use of larger vehicles and less travel times. For the society, there is a reduction of congestion during the day due to the decrease in the number of vehicles operating in the delivery of freight in the city center. Commercial establishments guarantee a more organized operation and minor annoyance to their customers. Moreover, the reduction in travel time contributes in reducing emissions and energy consumption.

- GPS Sensors and Data for logistics.

Global Positioning Systems (GPS) support ITS. The demand for these systems is increasing, and they can be used both to enhance the process of routing vehicles as well as services provided to customers (estimated time of trucks arrival, for example).

The use of best practices is one of the most common procedures to implement a solution in urban logistics. However, due to the differences of the cities, there is no standard procedure for implementing urban freight transport solutions. An important step in this process is to select solutions that can be implemented, taking into account needs, goals, available resources and local infrastructure (Iwan e Kijewska, 2014).

Solutions can be implemented according to three main approaches: development of new and innovative solutions in a co creation procedure - creation; direct copying of an implemented solution - transfer; and transferring proven solutions while making changes that mainly depend on the implementation environment – adaptation. The adaptation of best practices makes it possible to avoid mistakes and to indicate to stakeholders the potential benefits experienced by the cities that have already adopted the solution. Best practices adapted to the specific needs of a city are often combinations of various solutions or complementary solutions (Iwan, 2014; Iwan e Kijewska, 2014).

In this context, best practices handbooks are useful tools in choosing solutions, and several projects have been developed with this purpose. To select and implement an appropriate solution, according to Iwan (2014) a key success factor is the transferability of the best practice, defined as the degree of possibility to transfer a given solution to another place, adapting it according to different needs and requirements of different urban environments and operations.

Several projects can be cited as examples of handbooks in urban logistics best practices, such as: Inter- and Intra- City Freight Distribution Networks (City Freight, 2005); Good Practice Guide on Urban Freight Transport (Allen *et al.*, 2007); Freight Transport for Development Toolkit: Urban Freight (Dablanc, 2009); Debates on Brazilian urban logistics - best practices (CLUB, 2013); City Logistics Best Practices: a Handbook for Authorities (Dablanc *et al.*, 2014); Making Urban Freight Logistics more Sustainable (CIVITAS, 2015). These handbooks present an overview of best practices in urban freight transport, with analysis that aid on determining important aspects for its transferability. These projects (Figure 1) were studied with the purpose of identifying elements in common when analyzing city logistics best practices.

Figure 1: Handbooks of urban logistics best practices

"Inter- and Intra- City Freight Distribution Networks" (City Freight, 2005) approaches problems regarding urban logistics, discussing land use and infrastructure, public policies, sustainability, adoption of new technologies and difficulties on implementing solutions.

The guide "Good Practice Guide on Urban Freight Transport" (Allen *et al.*, 2007) has presents as purpose to identify, describe and disseminate best practices, success criteria and bottlenecks of urban freight transport solutions. The projects focuses on technology, sustainability, public policies and regulations, and difficulties on implementation.

The report "Freight Transport for Development Toolkit: Urban Freight" (Dablanc, 2009) presents an overview of urban logistics main challenges, with recommendations to improve the efficiency and sustainability of urban freight transport operations. The report approaches public policies, governance, logistics practices and sustainability in the distribution of goods.

Brazilian Urban Logistics Center developed the report "Debates on Brazilian urban logistics - best practices" (CLUB, 2013). City logistics best practices adopted by European, American and Asian cities are explored, studying projects from the public and private sector. Most projects were analyzed under the sections logistics practices, technology, sustainability, public policies and regulations, and business model.

"City Logistics Best Practices: a Handbook for Authorities" (Dablanc *et al.*, 2014) covers political issues and defines performance indicators for the characterization of best practices. The purpose of the handbook is to analyse urban logistics best practices in a project composed of seventeen partners from ten countries. It approaches logistics practices according to public policies, regulations, governance, primary obstacles to implementation and business model. The handbook still details useful aspects for evaluating the economic viability of the studied solution.

The report "Making urban freight logistics more sustainable" (CIVITAS, 2015) presents different approaches that may be adopted for enhancing urban freight transport: stakeholders involvement (governance), public policies, market-based measures, land use and infrastructure planning, new technologies, sustainable systems, investments and implementation time.

According to Iwan (2014), an essential condition for the effective adaptation of a best practice is to perform a preliminary analysis of the solution prior to its implementation. Patier and Browne (2010) also emphasize the importance of prior analysis for innovation in urban logistics.

The study of these projects allowed the identification of common elements, listed in Table 1. The importance of this table, with the use of non-academic projects, is the learning the experiences in developing and implementing solutions can provide. Thus, common elements that should be studied and analyzed when planning or developing a new solution for urban freight transport were selected, in order to ensure the transferability of solutions.

Table 1: common elements in urban logistics handbooks.

	City Freight (2005)	Allen *et al.*, (2007)	Dablanc (2009)	CLUB (2013)	Dablanc *et al.* (2014)	CIVITAS (2015)
Logistics practices		X	X	X	X	X
Adoption of new technologies	X	X		X		X
Sustainability	X	X	X	X		X
Public policies and governance	X	X	X	X	X	X
Implementation difficulties	X	X			X	
Business model and economic viability				X	X	X

The elements of Table 1 were selected because and can be described as:

- Logistics practices: reports that describe logistics practices adopted in urban freight transport solutions, such as: freight consolidation, freight transhipment, sustainable vehicles, freight routing and management, unattended cargo reception (i.e. urban lockers), off-hour deliveries, among others (Leonardi *et al.*, 2014; Allen *et al.*, 2007).
- Adoption of new technologies: projects that analyse the adoption of new technologies in the studied solutions. The main applications of ICT consisted of systems with the purpose of collecting, processing and distributing information to its use in the planning, operation and management of cargo transportation. The recent focus has become the creation of Internet integrated applications that enable sharing data with many users, the context in which ICTs have caused a variety of effects on logistics systems. The e-commerce increases the Business-to-Business (B2B) and Business-to-Consumer (B2C) transactions, which leads to an increased demand for transport. The ITS have promoted the optimization of fleet management based on traffic or real-time information, which increases the efficiency of transport (Yoshimoto and Nemoto, 2005).
- Sustainability: reports that study the sustainability of the best practices. Urban freight transport is responsible for social, environmental and economic impacts, such as congestion, atmospheric pollution, high noise levels, security costs, among others (Behrends et al., 2008; Mckinnon, 2010). In this context, studying the sustainability of developed solutions is essential.

- Public policies and governance: reports that evaluate the adoption of public policies or the relationship between the stakeholders. The collaboration between the different actors involved in logistics processes is essential to improving life quality in cities (Crainic et. al, 2009; Dablanc 2007). The use of governance in solving urban logistics problems is challenging, mainly due to the collaborative work necessary between the stakeholders involved in the problems. Each stakeholder has different interests, often conflicting with each other, and so the individual can overlap the collective goal. Muñuzuri *et al.* (2005) states that for local authorities solutions for city logistics may be related to public infrastructure; land use management (i.e. areas reserved for loading/unloading zones); access conditions (spatial and temporal constraints); and traffic management (ITS applications).
- Implementation difficulties: projects that indicate the main difficulties in implementing the studied best practice. Urban logistics is a complex phenomenon due to the presence of multiple stakeholders, such as customers, shippers and receivers with specific transport needs regarding the origin and destination of the cargo. City logistics activities are also related to the local economy, transport infrastructures, environmental and legal conditions (DASBURG e SCHOEMAKER, 2006). Therefore, we see the importance of a prior analysis of the main difficulties in implementing urban freight transport best practices.
- Business model and economic viability: business model adopted in the solution and/or its economic viability. Patier and Browne (2010) highlight the importance of performing an economic analysis to evaluate innovations in urban logistics, proposing economic and commercial indicators.

Paper I, attached in this research, and the paper written by Dias e Garcia (2015) were pilot studies in using these elements when studying urban logistics best practices. After the analysis of the use of satellite platforms for the transhipment of cargo to smaller vehicles for last mile delivery at Campinas/SP downtown (Dias and Garcia, 2015), it was possible to develop a simulating model in order to quantify the resources required for the operation before its implementation (Paper II, attached in this research).

2.4 Cluster Analysis

Several logistics practices have been introduced to address the challenges of city logistics. However, cities have different characteristics, and policy measures applied in different urban areas can only result in different associated impacts. Thus, it is essential to consider urban-specific characteristics to enhance the transferability and sustainability of urban logistics solutions (Alho and Silva, 2015).

A definition of clusters states it as a grouping of similar things, such as geographical factors, type of business, or business relationships along the supply chain (United Nations, 2007). The cluster boundary delineation if often imprecise, and, according to Porter (1998), "a cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities." Cluster analysis facilitates the exploration of natural or hidden data structure and groups commonalities in a set of data objects, aiding on the development of insights regarding the studied area.

In this context, we analyzed and compared different clusters identification methods from the works: Ponce-Cueto et al., 2015; Alho and Silva, 2015; Chhetri et al., 2013, and; Allen et al., 2012. These papers were selected due to their focus on city logistics activities, the relevance of the projects and for being relatively recent studies.

In the work "Segmentation of urban areas from a logistics perspective: comparative case studies in Lisbon, Madrid, Mexico City, Quito, Rio de Janeiro, and Singapore", the purpose is to identify clusters that impact urban logistics activities, to assist urban planning with general recommendations for public policies. The research study is based in four steps: collection and processing information, in which demographic, socioeconomic, regulation and infrastructure data were collected; Statistical analysis, with the development of the principal component analysis and k-means clustering analysis; Logistic cluster identification – a categorization of different areas of the city according to urban logistics characteristics, and; finally, general recommendations for public policy aiming contributions for urban freight mobility (Ponce-Cueto et al., 2015).

The paper "Utilizing urban form characteristics in urban logistics analysis: a case study in Lisbon, Portugal", the author presents the concept of Logistics Profile, which "… suggests homogeneous groups of urban zones with respect to three dimensions, which could be used to analyze freight movement policy: (1) the social and built environment; (2) characteristics of the goods/products being moved; (3) characteristics of the deliveries at the receiver establishment." The study was conducted with two statistical steps: Multiple Classification Analysis (MCA) model and Two-step cluster analysis. The author states the Logistical Profile has the potential to be used as a starting point for urban planning commodities and policy analysis on the subject. In the paper, Lisbon was segmented into four logistic profiles, allowing the city planners to focus on just four separate sets of rules and political action.

The work "Characterizing spatial logistics employment clusters" studied cluster theory with a different approach: an analysis involving logistics employment clusters. The paper identified industries related to logistics in order to quantify its employments, and conducted a statistical analysis (principal component analysis and autocorrelation techniques) to empirically identify and spatially contextualize logistics hubs. The research offers policymakers and practitioners a foundation on which decisions about future infrastructure investment can be evaluated to support cluster development and achieve economies of agglomeration (Chhetri et al., 2013).

The last paper, "Investigating relationships between road freight transport, facility location, logistics management and urban form", investigates relationships between road freight transport, urban form, land use, facility location and logistics management. The main idea is the collection of demographic data, socioeconomic data (area occupied by industries/commerce, area occupied by industries/commerce per capta and per km2) and also Origin/Destination information (trips within the area, from the area and to the area). The work studied specific factors (loaded vehicle kilometers, empty vehicle kilometers, tonnes lifted, tonne-kilometers, and vehicle loading factors) – and provided an analysis to the extent to which the commercial and industrial land use patterns influence the amount, pattern and intensity of road freight transport activity, and whether the suburbanization of warehousing has been occurring (Allen et al., 2012).

We built an abstract of the mentioned methods in Table 2, showing common elements and differences between the different alternatives. The parameters adopted (objective, data collection, statistical analysis, result and conclusion) were chosen due to the following reasons: the objective of each project adopting cluster analysis has a direct impact on the required data for collection; cluster analysis usually requires statistical analysis, and; results and conclusion help quantifying potential and applicability of the method.

We can see that, out of the four methods studied, three work with similar statistical analysis: Principal Component Analysis e Multiple Classification Analysis (Alho and Silva, 2015; Chhetri et al., 2013; Ponce-Cueto et al., 2015). Both statistical tools work with independent variables and look for similarities between them. However, the work of Allen et al. (2012)

makes use of Origin / Destination matrix, and lists the array information with data common to other methods such as demographic and socioeconomic data. Although the methods present some differences, mainly because of distinct purposes, their results have commonalities, with the grouping of regions to contribute to the local assessment.

All methods present contributions in addressing city logistics issues: the papers from Ponce-Cueto et al. (2015) and Alho and Silva (2015) aid on dividing the city so that critical areas can be identified and proper solutions suggested; Chhetri et al. (2013) offers a founded basis that helps identifying lack of infrastructure for logistics activities, and; Allen et al. (2012) analyzes road freight transport and its relation to urban form to assist planners when making transport and land use decisions.

A criticism regarding the cluster theory approach is the lack of uniformity on its existing methodologies, which leads to difficulty when comparing different reports on cluster developments or for policy makers to form an objective judgment (United Nations, 2007; Punj and Stewart 1983). This guides the study to unclear policy implications, as most of the developed solutions turns out to be traditional economic development policies or practices, with its particularity being the application on the cluster area. The lack of assessment of cluster theory approach solutions is a limitation of this quantitative procedure (Wolman and Hincapie, 2015). The necessity of background data for the development of the statistical analysis should also be cited. Furthermore, the studied cluster analysis methods does not provide descriptive report about the segmented areas, requiring additional effort to draw inferences regarding their statistical significance (Punj and Stewart, 1983).

Despite its constraints, there are some contributions from the cluster method that should be highlighted. Clustering procedures are a helpful tool in data analysis when one desires to group objects (or variables) according to their relative similarity. The provision of a conceptual framework allows a better view of the economy, aiding to the direction of the regional economic policies development (Wolman and Hincapie, 2015). The cluster analysis approach then helps on the understanding of the regional economy, and, depending on the variables included on the analysis, its crossing with urban form and infrastructure or demographic data, essential aspects to urban logistics. Castro et al. (2016) confirms the advantages of applying cluster analysis in city logistics researches. Table 3 summarizes the main advantages and downsides of cluster analysis as tool for city logistics planning.

Table 2: methods for clusters identification.

Steps	Ponce-Cueto et al. (2015)	Alho e Silva (2015)	Chhetri et al. (2013)	Allen et al. (2012)
OBJECTIVE	Identification of clusters that have impact on urban logistics	Proposal of a quantitative methodology to define logistics profiles, considered as groups of urban areas with homogeneous characteristics in relation to land use and movement of goods.	Identification of employment logistics clusters	This paper investigates relationships between road freight transport activity, urban form, land use, facility location and logistics management
DATA COLLECTION	Demographic data (area, population and demographic density)	City area features (Commercial density, homogeneity, logistics accessibility)	Industries "explicitly" related to logistics were identified	Demographic data (area, population and demographic density)
	Socioeconomic data (quantity of establishments per industry)	Product Characteristics (Easiness of handling, special conditions)		Socioeconomic data (area occupied by industries/commerce, area occupied by industries/commerce per capta and per km2)
	Infrastructure data (road capacity and road density)	Agents/deliveries profile (Urgency of deliveries, frequency of deliveries, amount of freight to be delivered)	Information about employment in those industries were collected	Road freight activity data (3 types of trips: trips within the studied area, trips to the studied area and trips from the studied area)
	Regulation data			
STATISTICAL ANALYSIS	Principal component Analysis	Multiple Classification Analysis (MCA) model	Principal component analysis	No statistical analysis performed. Paper makes analysis such as loaded vehicle kilometers, empty vehicle kilometers, tonnes lifted, tonne-kilometers, and vehicle loading factors
	K-means Clustering	Two-step cluster analysis	Autocorrelation techniques to measure "spill over" impacts of clustering in neighboring areas	

RESULTS	Segmentation of the city into urban clusters aiding the identification of critical areas and development of insights	Identification of four logistic profiles validated for the study case in Lisbon. The approaches to the logistics management in this city can focus on just four separate sets of rules and political action.	Delineate logistics employment clusters to represent the underlying regional geography of the logistics landscape	Commercial and industrial floor-space composition Warehousing floor-space and changes over the decade Road freight transport activity patterns including its efficiency and intensity
CONCLUSION	General recommendations for public policies	The Logistical Profile (LP) has the potential to be used as a starting point for urban planning commodities and policy analysis on the subject.	The key value of this research is the quantification of spatial logistics employment clusters using spatial autocorrelation measures to empirically identify and spatially contextualize logistics hubs.	The extent to which the commercial and industrial land use patterns influence the amount, pattern and intensity of road freight transport activity, and whether the suburbanization of warehousing has been occurring.
CONTRIBUTION TO CITY LOGISTICS	Segmentation of the city into homogeneous areas identifying critical clusters to urban logistics and allowing similar policies/solutions for the same cluster	Segmentation of the city into Logistic Profiles identifying critical areas and allowing similar policies/solutions for the same zone	The research offers an empirically founded basis on which decisions about future infrastructure investment can be evaluated to support cluster development	It is expected that improved understanding of the relationship analyzed (road freight transport, facility location, logistics management and urban form) will assist planners when making transport and land use decisions

Table 3: advantages and downsides of cluster analysis.

	Cluster Analysis
Advantages	Provision of demographic and economic conceptual framework; Possibility of correlating important variables to urban logistics (e.g. infrastructure, demographic or regulation data) with the cities' economic activities; Insights provision that groups commonalities by use of statistical analysis tools.
Disadvantages	Lack of uniformity; Necessity of background data for statistical analysis; Lack of assessment of cluster theory approach solutions; Necessity of further effort to draw inferences regarding their statistical significance.

3 METHODOLOGY

A preliminary literature review was conducted in order to understand the urbanization and the urban logistics challenges, allowing the definition of the research problem and objective.

The literature review included the study of important urban planning tools, such as the city logistics concept. Projects approaching the dissemination of urban logistics best practices were analyzed, with the purpose of identifying common elements and thus contributing to the transferability on the development of new solutions for freight mobility. This work presents cluster analysis as tool for identification of urban clusters, contributing in the development of public policies and solutions that optimize urban freight transport. The advantages and disadvantages of the approach were listed, as well as four different methods adopted for city logistics planning were described.

The methodology of the research is a stepwise approach: initially, we identified urban clusters from São Paulo, Brazil, adopting one of the studied methods, which is further detailed in the next section. This procedure allowed the segmentation of the city into different clusters, with the development of specific insights according to each zone characteristics and the proposal of general recommendations aiding urban freight transport. This first application consists of two scenarios, where two additional variables where included in the second scenario in order to compare the results and select the most representative map of the city. The second main application of the research is the use of a Multi Criteria Decision tool, the Analytic Hierarchy Process, in a critical area of the city identified by the cluster analysis. With the involvement of the stakeholders, we prioritized and proposed an adequate urban logistics best practice ensuring its transferability and efficiency.

Figure 2 illustrates the steps of this research.

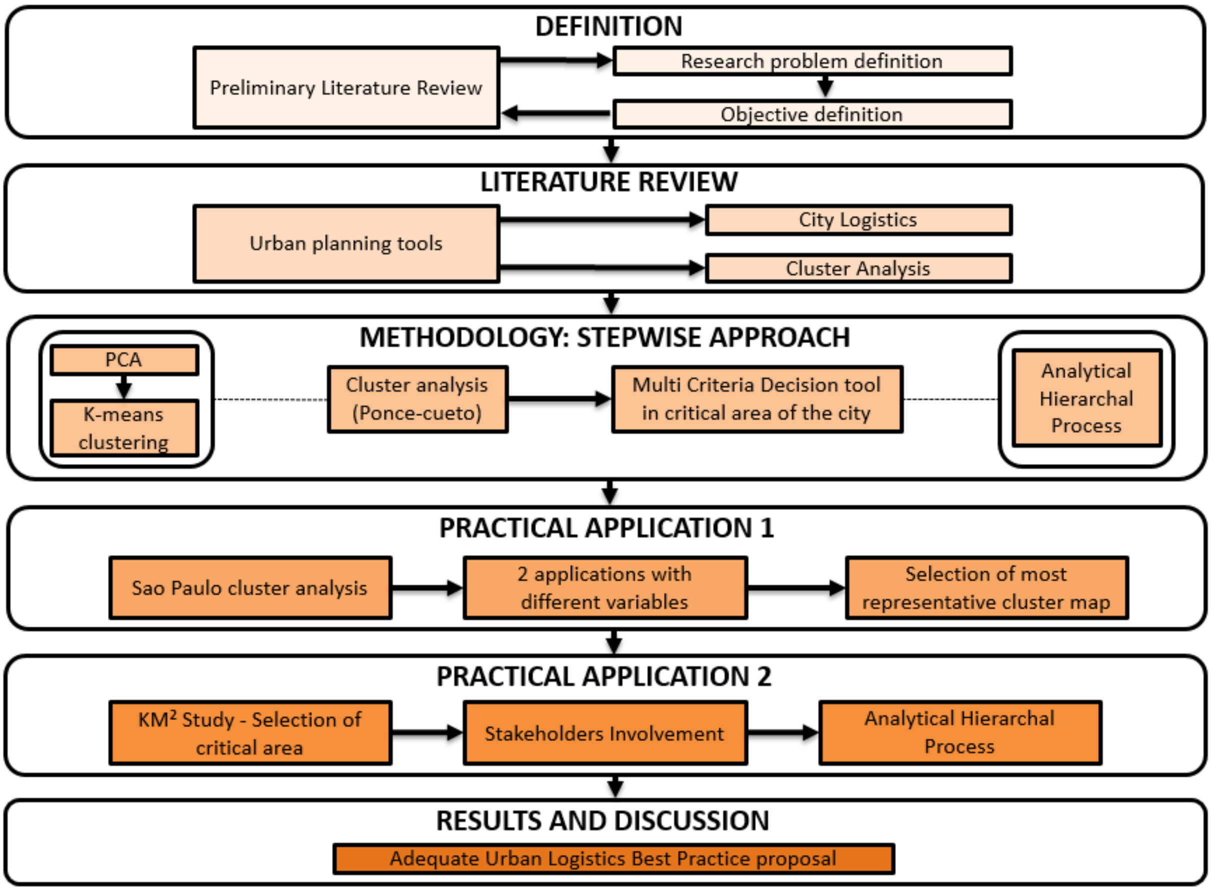

Figure 2: steps of the research.

3.1 Urban clusters identification

The research study follows the methodology described in Ponce-Cueto et al. (2015): (1) Collection and processing information, in which we collected demographic, socioeconomic, regulation and infrastructure data from secondary database and using Geographic Information Systems. (2) Statistical analysis, mainly principal component analysis (PCA) and k-means clustering analysis. (3) Logistics clusters identification – a categorization of different areas of the city according to urban logistics characteristics. (4) And; finally, general recommendations for public policy aiming contributions for urban freight mobility (Ponce-Cueto et al., 2015). Figure 3 represents the data-driven methodology.

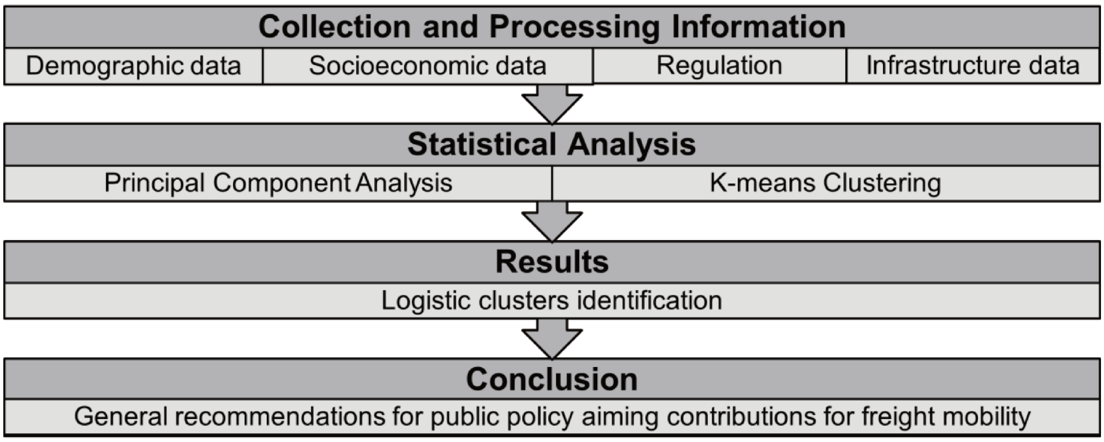

Figure 3: data-driven methodology (Ponce-Cueto et al., 2015).

As aforementioned, the second scenario of the first application adopted two new variables, Human Development Index and percentage of taxes over services, in order to assess the impact of adding new variables in the methodology proposed by Ponce-Cueto et al. (2015) and its contribution to clustering cities from the perspective of urban logistics. Human Development Index includes income per capita, and both variables can help understanding the economic activities that take place in São Paulo/SP. Figure 4 represents its procedure.

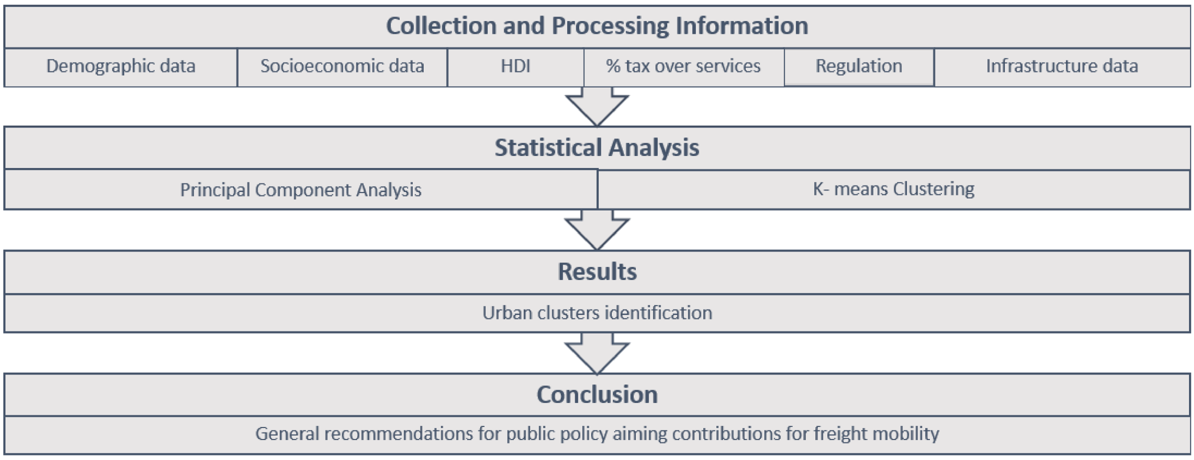

Figure 4: data-driven methodology (adapted from Ponce-Cueto et al., 2015).

We collected all variables following a segmentation of the city into one square-kilometer areas. We gathered the demographic and regulation data from the city's prefecture official website (Prefecture of São Paulo, 2015). The infrastructure variables below were defined and processed using Open Street Maps (Ponce-Cueto et al., 2015). Besides Open Street Maps, Google Street View is a tool that can be used in order to measure the variables.

- Road density, measured by the number of the road's intersection;
- Road capacity, measured by the total road length and weighted with a capacity factor based upon the number of lanes.

Regarding the socioeconomic data, we used secondary databases to identify the number of establishments per industry segment (accommodation and foodservice; wholesale, retail and repair of vehicles; services; and manufacturing), per sub prefecture. Since this is the only variable that did not have the desirable precision (sub prefecture level instead of square kilometer level), we considered two approaches: (1) uniform distribution of the establishments from a sub prefecture level to the square kilometers, and (2) distribution of the establishments weighted by population density. The final selection of the approach was determined based on the results that provided a clearer cluster segmentation.

In summary, the approach of the data-driven methodology allowed the interpretation of urban clusters in São Paulo city, with the segmentation of the city into squares of one square kilometer. With a better understanding of the city's sub-areas, the study provides policy recommendations that match with São Paulo's urban logistics characteristics. The link between the city's specific urban form, population information, economic census, infrastructure data and logistics activities will contribute to design better solutions for urban logistics policy and practice.

3.1.1 Statistical Analysis

- Principal Component Analysis

The purpose of this analysis is to identify the main sources of variability in the dataset, the principal components, between potentially correlated variables (Grus, 2015). This study presents the adoption of multiple variables, which increases the complexity of statistical analysis and results interpretation. This complexity requires separating the correlated data for the cluster analysis to be more transparent, which is achieved through the Principal Component Analysis. This procedure aggregates the correlated data into the principal components, facilitating subsequent analysis.

We adopted JMP software in order to apply the Principal Component Analysis. The purpose of this step is to select principal components that explain 95% of the variation in the dataset.

The first principal component corresponds to the linear combination of the standardized original variables that has the greatest possible variance. Each subsequent principal component corresponds to the linear combination of the variables that has the greatest possible variance and is uncorrelated with all previously defined components.

The input variables of the first approach (uniform distribution) were population, road density, road capacity and establishments' concentration. The establishments' concentration were divided into four segments: Accommodation & foodservice; Wholesale, retail and repair of vehicles; All services, and; Manufacturing. Figure 5 illustrates the report of the statistical analysis, with the selection of three principal components.

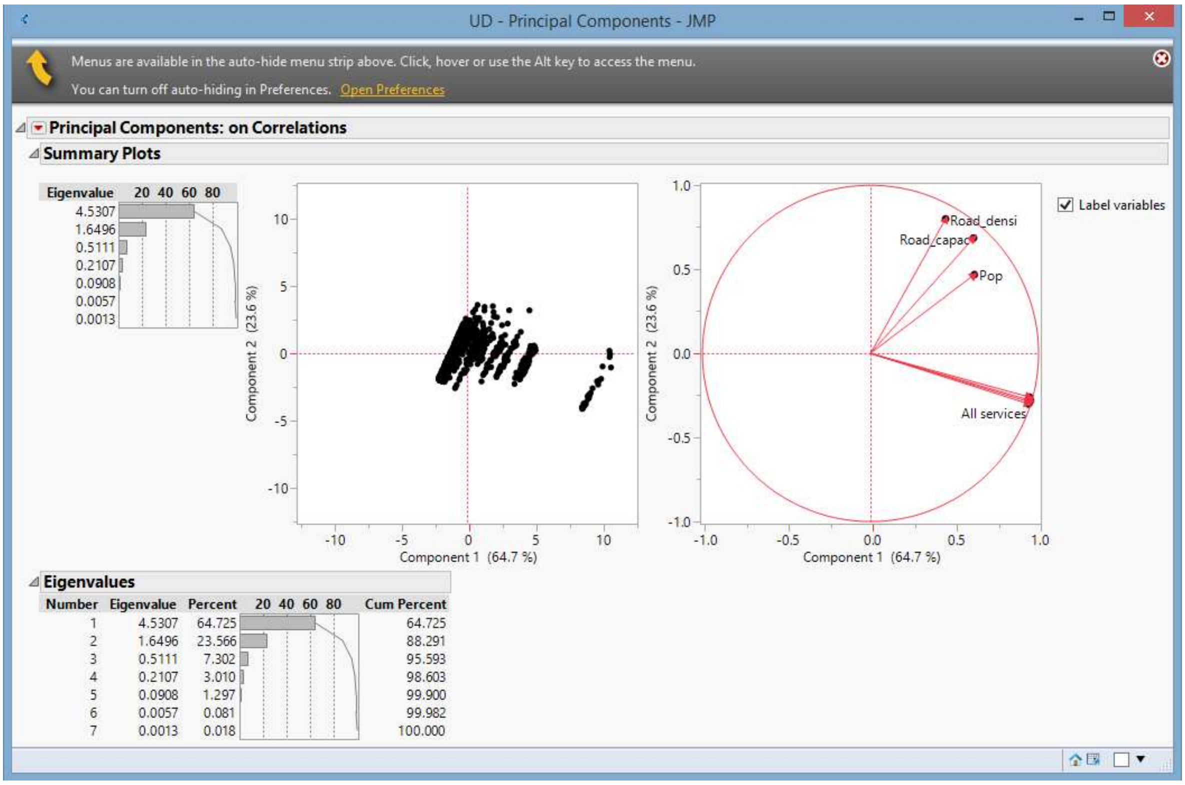

Figure 5: uniform distribution scenario results.

The input variables of the second approach (weighted distribution) were the same from the first approach, with different values for the establishments' concentration. Instead of applying uniform distribution for the division of the establishments from a sub prefecture level to the one square kilometer level, weighted distribution was applied following the correlation between establishments' concentration and population and road capacity. Figure 6 shows the report of the Principal Component Analysis for this scenario, with the selection of three principal components

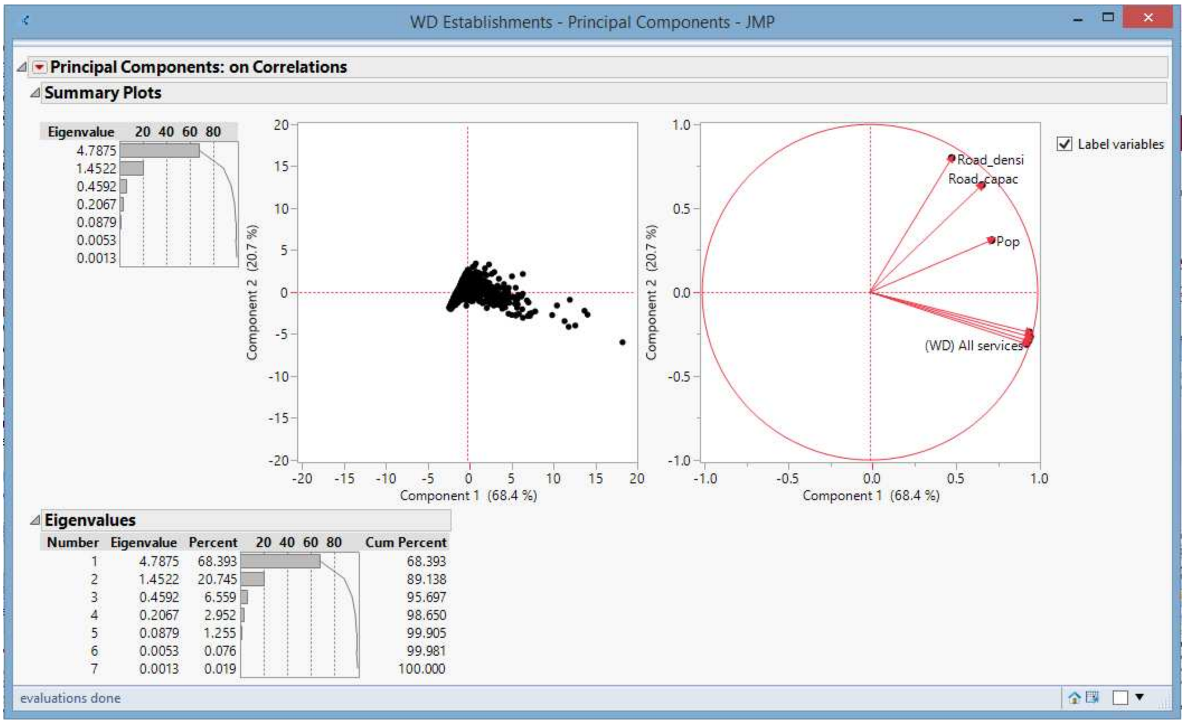

Figure 6: weighted distribution scenario results.

The reports give important information. The eigenvalue in the Summary plots indicate the total number of components extracted based on the amount of variance contributed by each component. The bar chart illustrates the percentage of the variation accounted for by each principal component, information used to select the number of principal components for each scenario. As aforementioned, we required 95% of variation in the dataset, represented by the principal components.

The Score Plot, reports' central graphic, illustrates each component calculated values' in relation to the other, adjusting each value for the mean and standard deviation. The Loadings Plot, graphic located in the right side of the reports, represents the effect of each component on the adopted variables. The closer the value is to one the greater the effect is.

The reports show the establishments' concentration from all four segments are the variables with greater effect on principal component number one. However, they present a low effect on principal component number two. Road density, road capacity and population, in general, are responsible for the greatest effect on principal component number two.

- K-means Clustering

According to Pham et al. (2005), k-means algorithm is a popular data-clustering tool, and gives as output the K optimal number of clusters and its division. We adopted the F-Statistic for selecting the optimal number of clusters. Since the optimal statistical number (K optimal) is not necessarily the best representation of the city, and the code used allows increasing K optimal giving new clustering distributions as output, we tried the following values for k for each scenario: K optimal, K optimal + 1, K optimal + 2, and K optimal +3. After analyzing the cluster map output for each K value, we selected the most representative for each scenario.

The most representative cluster maps chosen for approaches (1) and (2) are almost equal, and have five clusters. Since both maps from the first and second scenarios are similar, and we adopted correlation between variables for the weighted distribution approach, we chose the first approach (uniform distribution) to illustrate the city, as correlations do not necessarily imply a causal relationship.

3.2 Multi Criteria Decision Making

Decision making is a complex activity, since it is necessary to evaluate alternative actions from the perspective of conflicting viewpoints (Freitas, 1999). Multi Criteria Decision Making is "a tool for decision making developed to complex problems" (CIFOR, 2015), such as the context experienced by urban logistics (Anderson et al., 2005; Behrends et al., 2008; Mckinnon, 2010; Oliveira et al., 2015).

Multi Criteria Decision Making assists in the structuring and solving of decision problems and planning involving multiple criteria (Majumder, 2015). In addition, Multi Criteria Decision Making techniques can be used to identify the best solution in a specific context, to sort options, or simply to distinguish between acceptable and unacceptable alternatives (Communities and Local Government, 2009).

Multi Criteria Decision Making methods are classified in two groups: Compensatory Methods and Outranking Methods. Among the Compensatory Methods, the Analytic Hierarchy Process (AHP) was already successfully adopted for prioritizing an urban logistics solution in an important Latin America megacity, (Córdova et al., 2014), and is the approach selected for this research. Awasthi et al. (2012) also used AHP to involve stakholders in the study of a city logistics context and best practice prioritization. In addition, the methodology has also been adopted for transport researches, such as the definition of the best alternatives for urban public transport with the participation of the stakeholders (Silva, 2014). Kunadhamraks and Hanaoka

(2005) use fuzzy AHP for evaluation of logistics performance for freight mode choice at an intermodal terminal.

In addition, the AHP has already been successfully applied in various settings to make decisions. In public administration, the state of North Carolina used it to develop evaluation criteria and assign ratings to vendors, leading to the selection of a best-value vendor acceptable to the decision makers. The Department of Defence in the US uses it frequently and extensively to allocate their resources to their diverse activities. British Airways used it in 1998 to choose the entertainment system vendor for its entire fleet of airplanes. Xerox Corporation has used the AHP to allocate close to a billion dollars to its research projects. In 1999, the Ford Motor Company used the AHP to establish priorities for criteria that improve customer satisfaction. Ford gave Expert Choice Inc, an Award for Excellence for helping them achieve greater success with its clients (Saaty, 2008).

AHP includes and measures all important factors, whether tangible or intangible, approaching to a realistic model. According to Saaty (1994), a benefit of the method is that it can handle quantitative and qualitative aspects of a decision problem. AHP helps the decision makers to find a solution that best suits the goals, avoiding conflicts of interest by involving the stakeholders, and helps the understanding of the problem and its context by building a decision hierarchy (Majumder, 2015).

3.2.1 Analytic Hierarchy Process

The basis of the Analytic Hierarchy Process (AHP) is the decomposition and synthesis of the relationship between the chosen criteria so that the indicators are prioritized, and thus establish a performance measure (Saaty, 1991).

Decision Support Systems Glossary (DSS, 2006) defines the AHP as "a decision making approach that involves structuring multi criteria indicators in a hierarchy. The method assesses the relative importance of these criteria, comparing alternatives for each criteria, and determines an overall ranking of the alternatives."

The method has three main steps:

(i) Hierarchy: this step consists in the identification of the problem and its objectives. The problem is decomposed into a hierarchy of goal, criteria, sub-criteria and alternatives. This is the most creative and important part of decision-making (Saaty, 1994). Despite the need to compute the weights of each criteria, the hierarchy facilitates analyzing the studied problem (Bornia e Wernke, 2001).

(ii) Judgment: paired comparisons for each level of the hierarchy based on the AHP scale of priorities to develop relative weights, called priorities, which differentiate the importance of the criteria (Grandzol, 2005). Saaty (1991) recommends the use of the scale shown in Table 4.

(iii) Consistency of Judgements: Saaty (2000) proposes to verify the consistency of judgments by calculating the Consistency Index and Consistency Ratio. The Consistency Ratio should be less than 0.10.

Table 4: The fundamental scale of absolute numbers (Saaty, 1991)

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	Condition between two settings (1, 3, 5, 7, 9)

4 SÃO PAULO'S URBAN CONTEXT

São Paulo is America's most populated city, with more than eleven million inhabitants according to IBGE (2016) - Brazilian Institute of Geography and Statistics. Increased urbanization directly translates into increased demand for goods and services and their supporting logistics activities (Blanco, 2014), and São Paulo presents a heterogeneous land use, with high concentration of commercial establishments, warehouses and industries (Prefecture of São Paulo, 2015). This context indicates a large demand for cargo transportation and an intense flow of cargo vehicles throughout the city.

According to CET (2016), the city of São Paulo has an almost permanent saturation of its road system. In order to mitigate this serious problem, the City adopted in 1997 a rotation system of private vehicles, which restricts their movement according to its plate final number and the days and times of the week.

According to DENATRAN (2016), São Paulo has a fleet of approximately 7 million vehicles, divided in automobiles (81.7%), motorcycles (12.96%) and trucks (2.1%). Figure 7 illustrates the evolution of the fleet size between 2001 and May 2012. The fleet size had an increase of approximately 67% under the analyzed period. The growth of the motorcycles fleet stands out, with an increase of 323% in ten years.

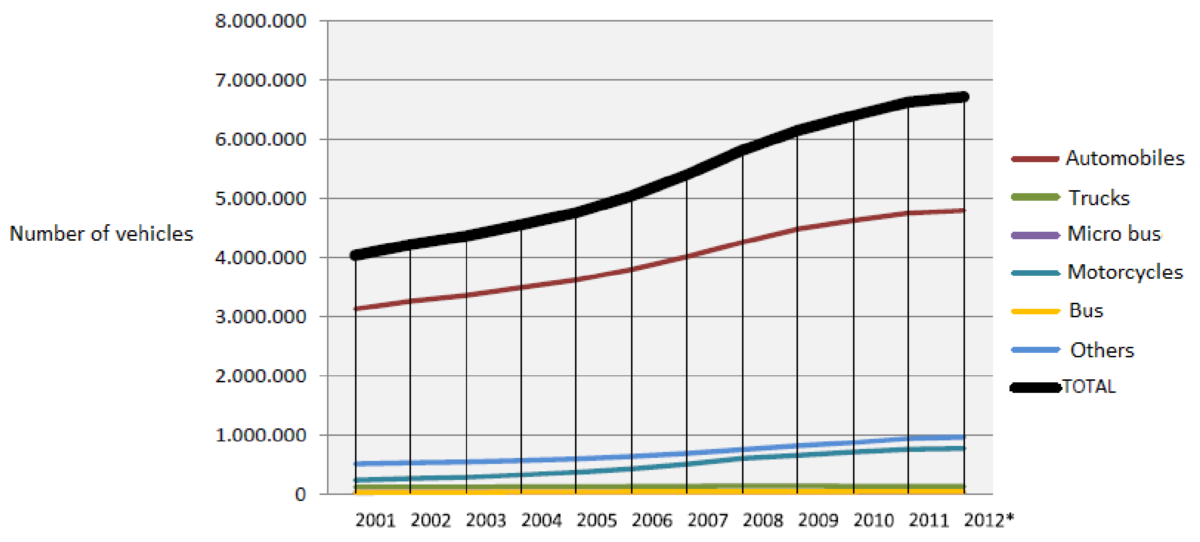

Figure 7: Fleet size evolution in São Paulo (CLUB, 2012)

With these numbers, it is not surprising that the city faces such saturation of its road system. Moreover, the capital is the hub of a metropolitan area that covers 39 municipalities, being also the state capital. These facts aggravate the traffic-related problems, as thousands of people move daily by the city for work, leisure, education, medical services etc.

Figure 8 shows São Paulo in a satellite image, where the green color represents vegetation sites and the purple color represents urban areas. São Paulo presents an environmental Protection area in the bottom of a vegetation site, in the green area in the bottom of the map.

This region of the city was not included in the cluster analysis, and the red line of Figure 8 represents its geographical limit.

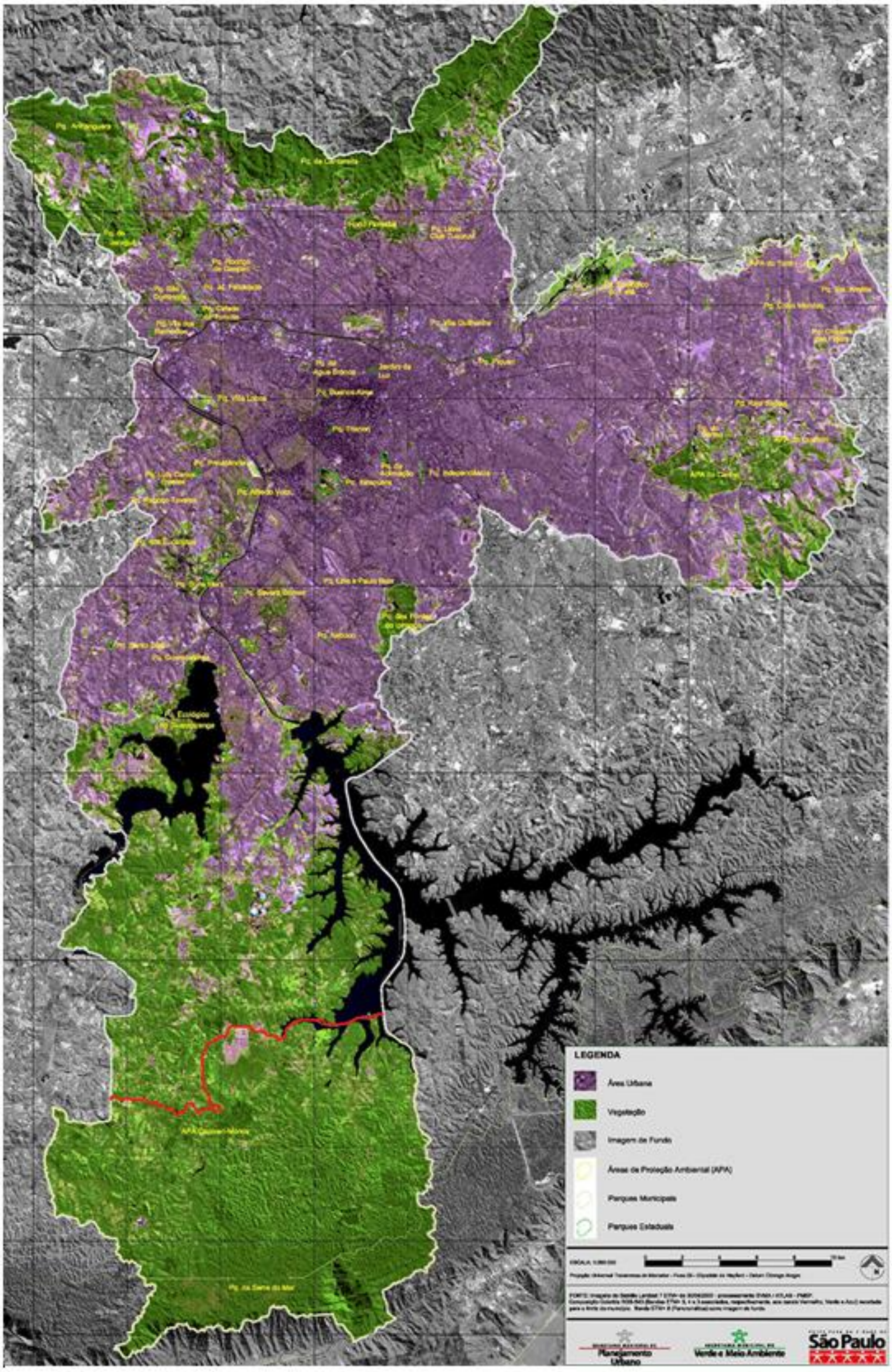

Figure 8: São Paulo satellite image (Prefeitura de São Paulo, 2015)

Brazilian Urban Logistics Center (CLUB) developed several studies regarding urban freight transport in important Brazilian cities. CLUB analyzed São Paulo, and Figure 9 presents its main challenges regarding urban logistics activities. The most important identified problems are related to public policies and congestion, whereas relevant issues such as delivery bays and security were also cited.

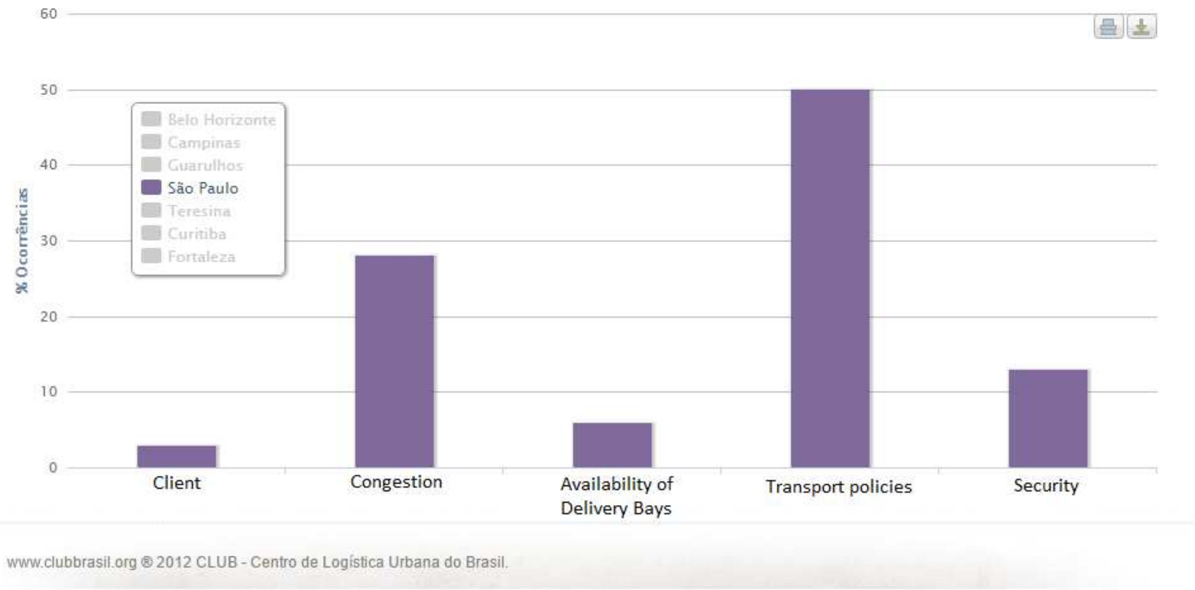

Figure 9: delivery problems at São Paulo (CLUB, 2016)

São Paulo still faces the challenge of urban freight transport in slums. Worldwide, in 2012, 33% of the population live in slums (Lima, 2015). Figure 10 illustrates its distribution in São Paulo, more concentrated in peripherical zones. In addition, as shown in Figure 11, there is a growth in the acquisition patterns in those areas, with an increasing number of middle class families in slums. The higher acquisition power in slums makes urban logistics more critical in those areas, due to infrastructure restrictions combined with a growth in demand for freight.

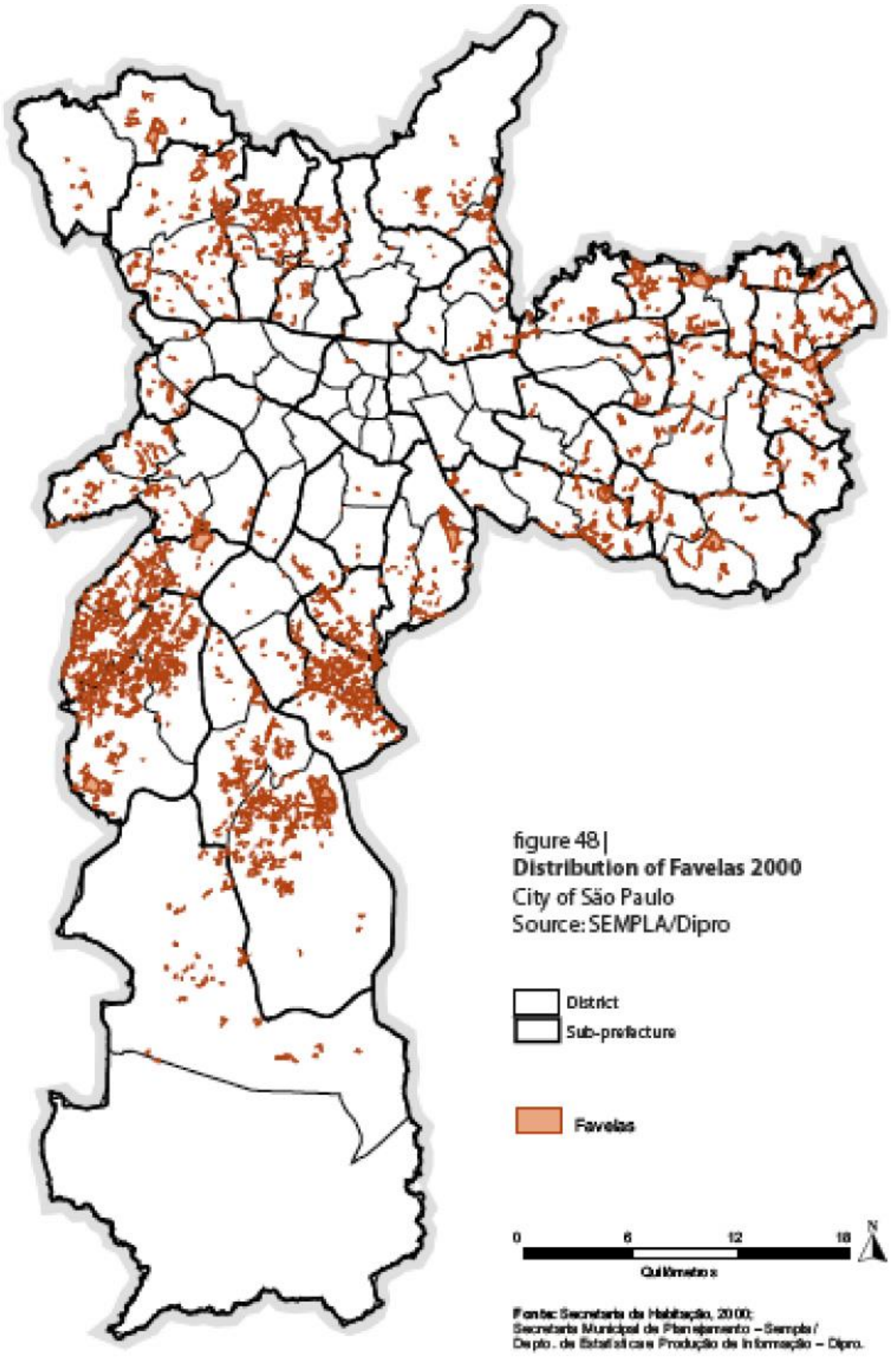

Figure 10: Slums distribution in São Paulo.

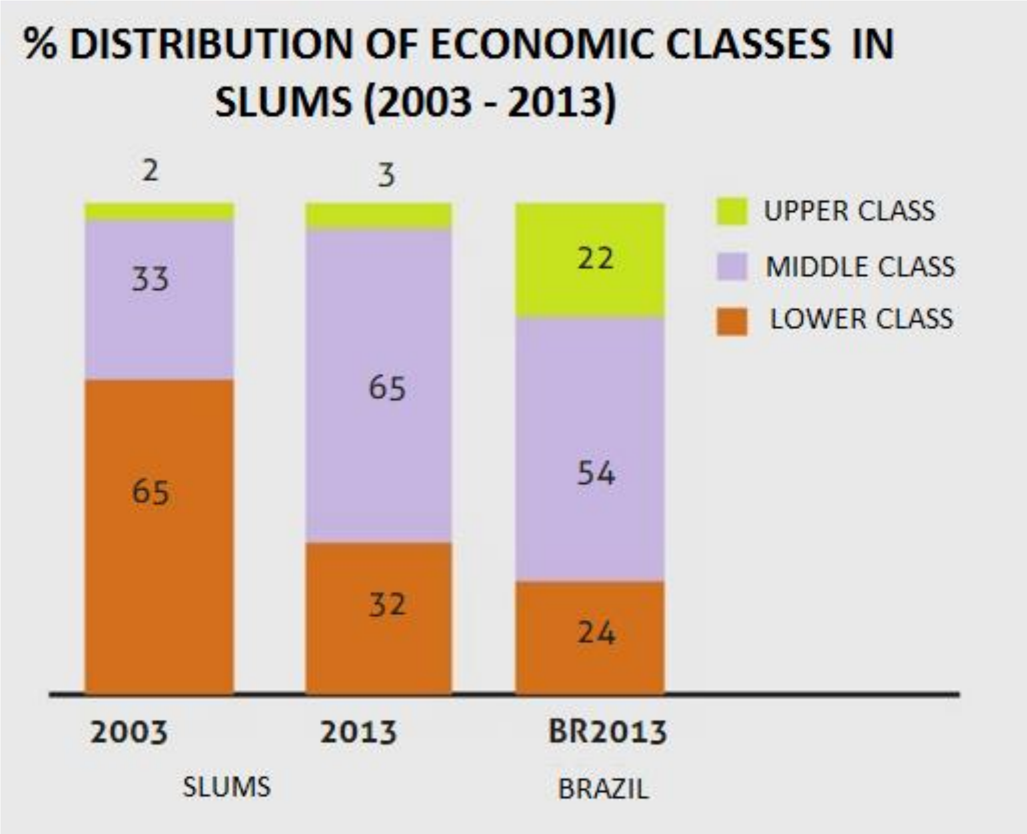

Figure 11: Slums inhabitants profile (Lima, 2015).

This research presents a stepwise strategy in the cluster analysis, with two scenarios, in order to assess the impact of including new variables in the study and with the purpose of selecting the most representative cluster map of the city. In the first scenario, presented in Section 5.1, we adopted the following variables: establishments' concentration (Accommodation & foodservice; Wholesale, retail and repair of vehicles; All services, and; Manufacturing), road density, road capacity, population concentration and regulation data. In the second scenario, shown in Section 5.2, we included Human Development Index and percentage of taxes over services.

5 PRACTICAL APPLICATION 1: SÃO PAULO CLUSTER ANALYSIS RESULTS

5.1 First Scenario

We normalized the data from each cluster, in order to analyze its logistics profile. Table 5 presents the data on the real and normalized scale and Figure 12 illustrates the clusters map.

Table 5: real and normalized clusters' results.

	Cluster	Population	Road capacity	Road density	Wholesale, retail and repair of vehicles	Accommodation & food service	All services	Manufacturing
average	0	29117.88	29.48	99.01	69.85	67.05	289.46	14.09
average	1	15549.04	33.00	101.84	216.48	218.88	995.83	41.16
average	2	3428.88	10.13	28.52	12.28	10.55	42.66	2.33
average	3	10626.66	29.71	120.83	27.75	22.86	93.95	5.53
average	4	23074.57	40.47	112.43	571.00	519.00	2524.00	102.00
	total	81797.03	142.78	462.63	897.37	838.35	3945.90	165.11
normalized	0	0.36	0.21	0.21	0.08	0.08	0.07	0.09
normalized	1	0.19	0.23	0.22	0.24	0.26	0.25	0.25
normalized	2	0.04	0.07	0.06	0.01	0.01	0.01	0.01
normalized	3	0.13	0.21	0.26	0.03	0.03	0.02	0.03
normalized	4	0.28	0.28	0.24	0.64	0.62	0.64	0.62

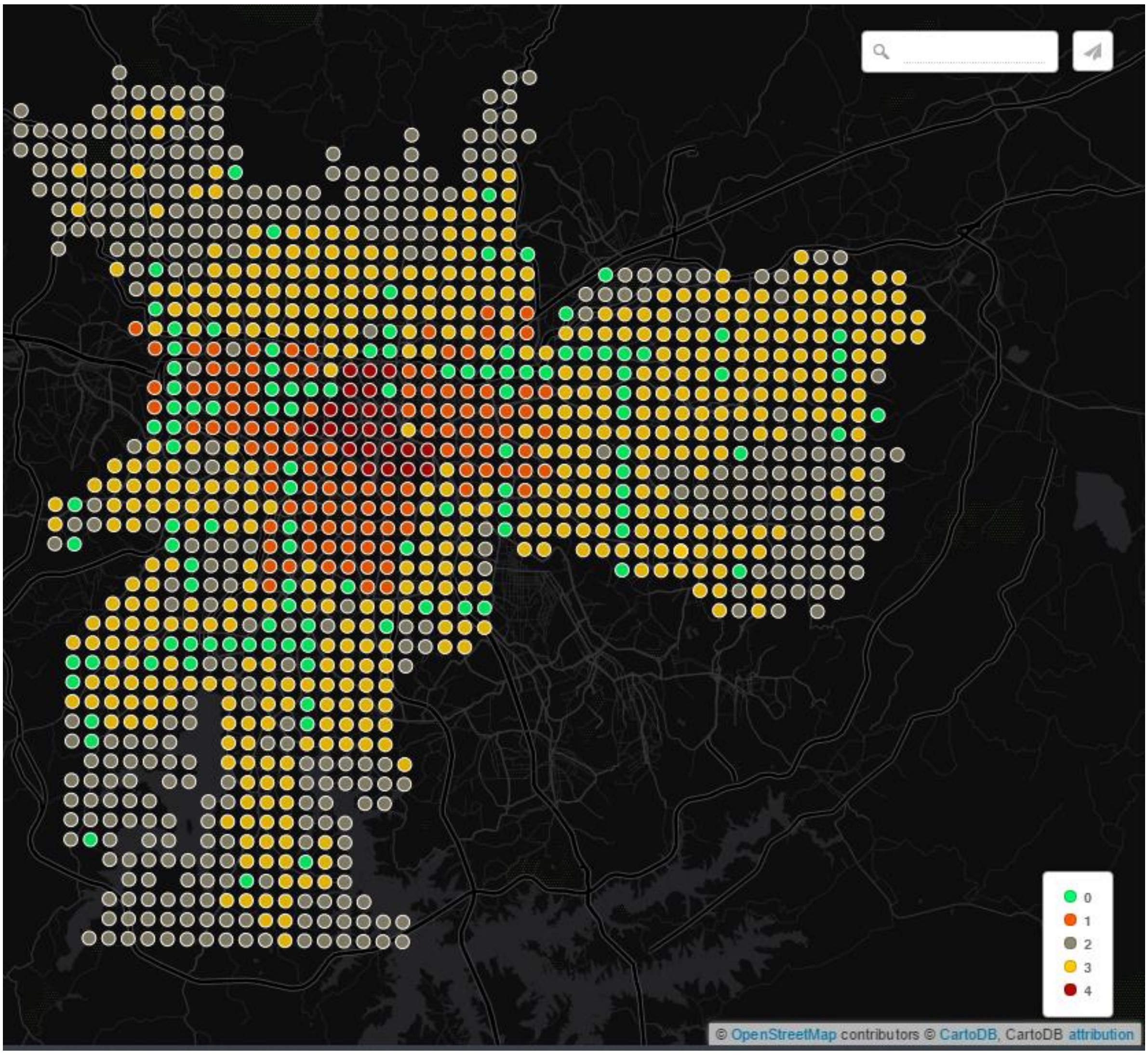

Figure 12: São Paulo clusters map.

- *High-density Residential zone*

Cluster number 0 presents the highest population normalized value, with a demographic density of almost 30,000 people per square kilometer. This cluster has low establishments' concentration (between 0.07 and 0.09 on normalized data) and average infrastructure values for both road density and road capacity. Thus, it is a residential zone.

- *Critical zone for urban logistics*

Cluster number 1 presents an average value for population, with 0.19 as normalized value. It has the second higher establishments' concentration, with normalized values between 0.24 and 0.26. Although presenting similar normalized values, the services segments represent more than half of the establishments. The cluster has average infrastructure data, with normalized values lower than the establishments' concentration, and is inside the restriction zone (urban trucks allowed). Thus, this cluster is a critical zone for urban logistics activities.

- *Peripheral zone*

Cluster number 2 has the lowest normalized values for population, establishments' concentration, road density and road capacity. However, it has the second bigger area, when compared to the other clusters. It is a peripheral zone, with low economic activities.

- *Low-density residential zone*

Cluster number 3 has a low normalized value for population density (0.13) and for establishments' concentration (between 0.2 and 0.3 on normalized data). However, this cluster presents high road density and average road capacity normalized values. In addition to the infrastructure data, it is practically outside the restriction zone, and therefore, represents a zone with high growth potential.

- *Central area*

Cluster number 4 presents a high population density: 23074.57 inhabitants per square kilometer, with a normalized value of 0.28. This cluster contains the higher commercial activity, with a normalized value higher than 0.6 for every studied segment. Despite having its infrastructure values above average, they do not stand out as much as population or establishments' concentration. This cluster is inside the restriction zone (urban trucks allowed).

This cluster represents "Sé" sub prefecture. It corresponds to the oldest occupied area of São Paulo city, initiated on the XVI century, and is known as the "old downtown". The inhabitants' are leaving this region over time, but as the logistics profile shows, it is still a high-populated zone. The cluster concentrates low-income population

Figure 13 illustrates the clusters' characteristics, according to the studied variables.

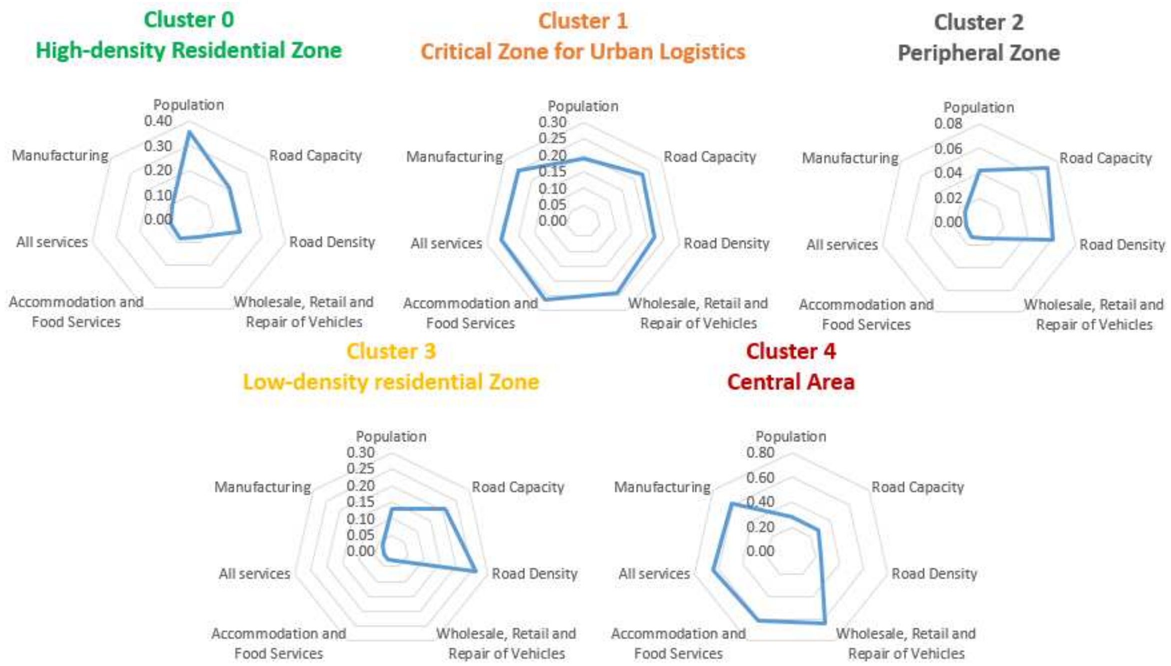

Figure 13: clusters' characteristics.

5.1.1 Public policy and general recommendations

São Paulo's segmentation into five different clusters presents a contribution to city logistics planning, and Table 6 discusses some insights with the presented results, aiding outcomes especially to the last mile delivery.

Table 6: recommendations for each analyzed cluster.

Cluster (0)	High-density Residential Zone	In residential areas, policies providing vehicles speed and noise control are important to ensure adequate levels of life quality and safety. Public policies adequate to this region could also improve last mile delivery assertiveness, specifically B2C deliveries. Further, cluster-specific analyses are suggested for the proposal of specific solutions.
Cluster (1)	Critical zone for urban logistics	There is a lack of accessibility due to low road density in comparison with establishments and population concentration, and for being inside the restriction zone. Investments in infrastructure are essential, and urban distribution centers can aid on freight consolidation. Considering the high adoption of motorcycles for transport, transshipment solutions to smaller vehicles should be studied.
Cluster (2)	Peripheral zone	We recommend public policies aiming the economic and infrastructure development of the region, with focus on ensuring accessibility from logistics centers/industrial zones to residential/commercial areas. Slums concentration – solutions such as Mobile Warehouses and Truck Shops for improving goods accessibility should be further studied. Sustainability must be considered due to high vegetation concentration.
Cluster (3)	Low-density zone	No infrastructure constraints, since establishments and population concentration are low when compared to road density and capacity. The zone has a high potential for economic growth.
Cluster (4)	Central zone	Very high concentration of commercial establishments and population. The cluster is known as “old downtown” and is inside the restriction area. Considering the high adoption of motorcycles for transport, transshipment solutions to smaller vehicles should be studied. A satellite platform can be a great solution for freight forwarding in central areas, as well as the provision of

	infrastructure such as delivery bays for parking VUC's is critical. The use of delivery windows for freight forwarding in this area may also be explored. For companies, night deliveries can be an option to improve operational efficiency levels due to low traffic levels at night. Further studies are needed to development of solutions.

5.2 Second Scenario

The most representative cluster map after completing the statistical procedures is illustrated in Figure 14, while the data regarding each cluster is presented in Table 7. Figure 15 shows the main characteristics of each cluster according to the adopted variables.

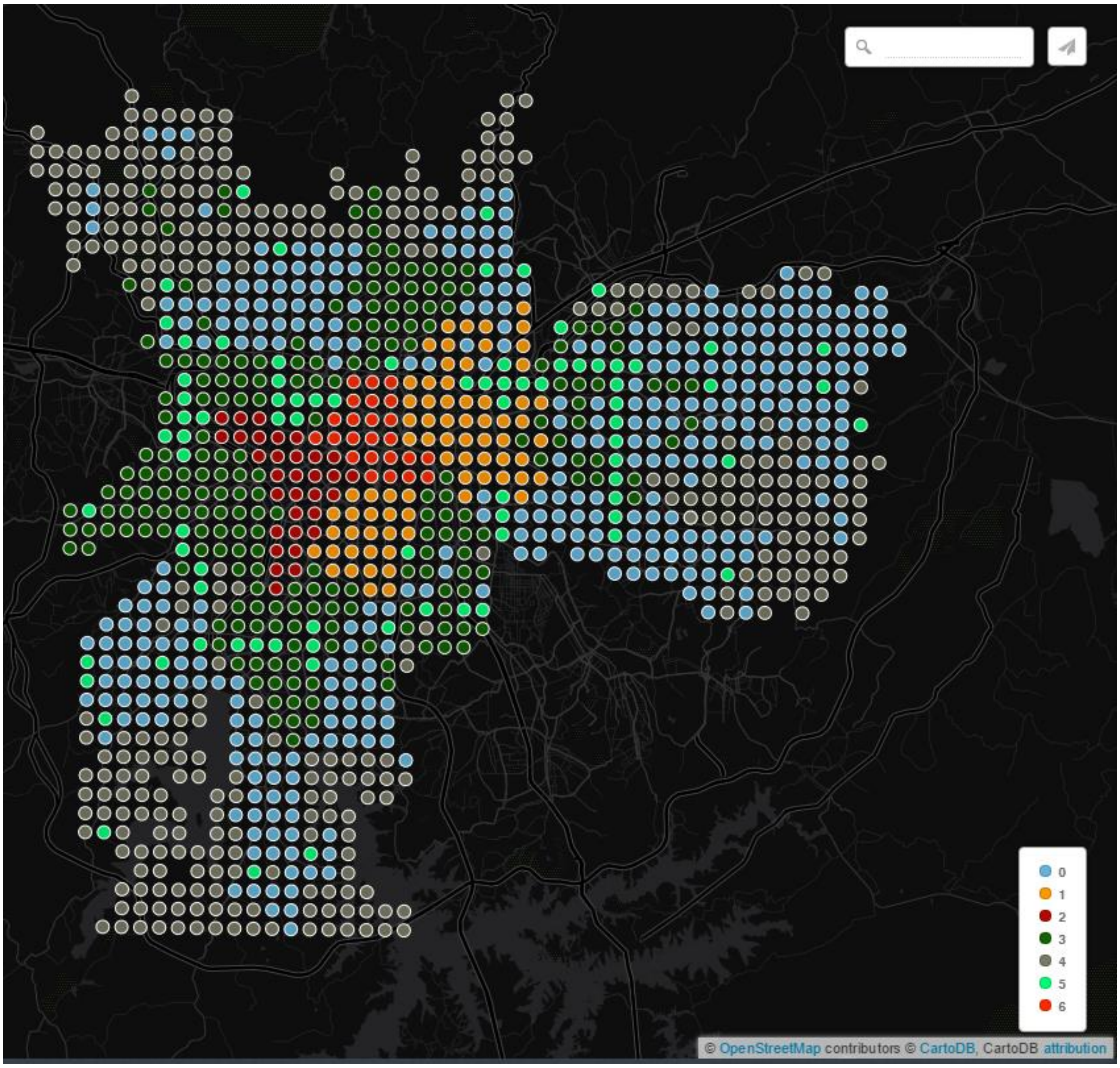

Figure 14: São Paulo cluster's map – second application

Table 7: Real and normalized clusters' results – second application.

		Population	Road capacity	Road density	Wholesale, retail and repair of vehicles	Accommodation & food service	All services	Manufacturing	% tax over services	Human Development Index
média	**0**	10262.81	28.69	123.91	18.54	14.73	57.45	3.77	0.59	0.80
média	**1**	14629.71	33.08	108.88	231.52	191.05	889.01	43.97	4.48	0.91
média	**2**	21945.34	35.02	105.22	219.00	317.00	1389.00	40.00	35.17	0.96
média	**3**	11955.89	28.29	93.20	56.59	52.39	228.93	11.07	3.82	0.89
média	**4**	2763.46	9.07	24.98	7.45	6.03	22.06	1.46	0.52	0.79
média	**5**	30125.71	29.32	99.74	54.70	48.83	205.67	11.65	2.64	0.85
média	**6**	25009.83	40.51	111.83	571.00	519.00	2524.00	102.00	17.29	0.93
	total	116692.76	203.99	667.76	1158.80	1149.04	5316.12	213.93	64.52	6.13
normalizado	**0**	0.341	0.708	1.000	0.032	0.028	0.023	0.037	0.017	0.840
normalizado	**1**	0.486	0.817	0.879	0.405	0.368	0.352	0.431	0.127	0.951
normalizado	**2**	0.728	0.865	0.849	0.384	0.611	0.550	0.392	1.000	1.000
normalizado	**3**	0.397	0.698	0.752	0.099	0.101	0.091	0.109	0.109	0.932
normalizado	**4**	0.092	0.224	0.202	0.013	0.012	0.009	0.014	0.015	0.827
normalizado	**5**	1.000	0.724	0.805	0.096	0.094	0.081	0.114	0.075	0.893
normalizado	**6**	0.830	1.000	0.903	1.000	1.000	1.000	1.000	0.492	0.971

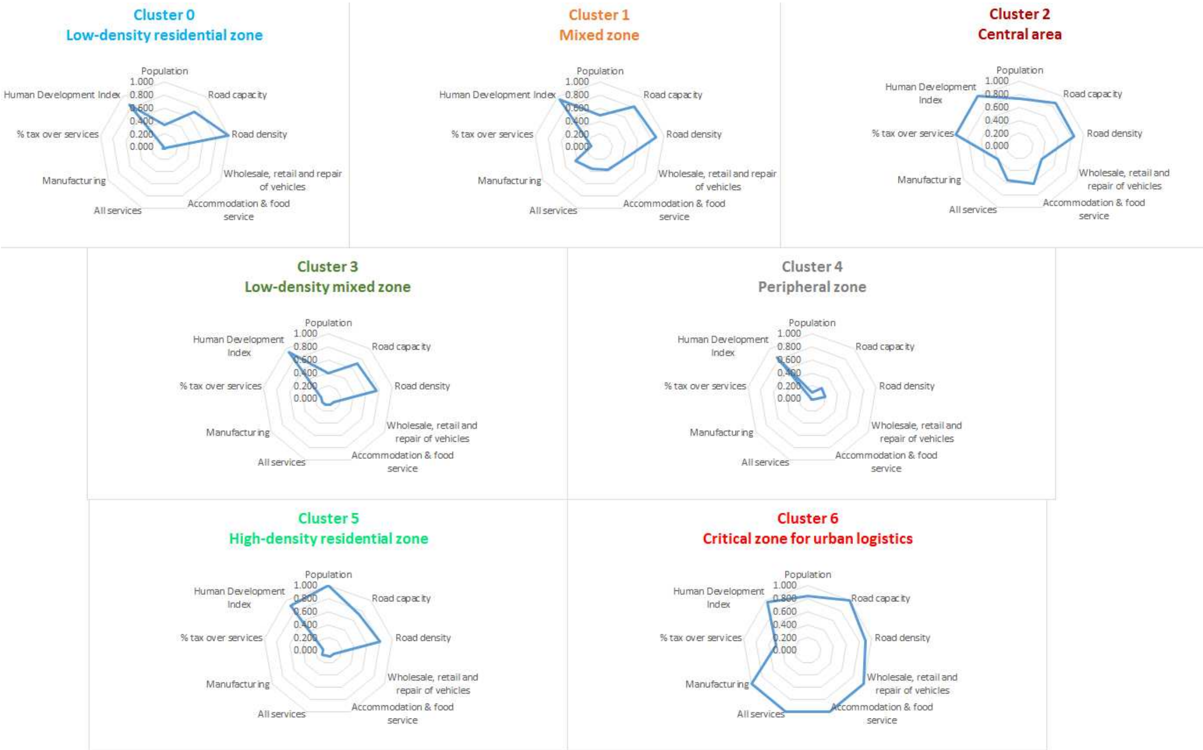

Figure 15: Cluster's characteristics – second application

- *Low-density residential zone*

Cluster number 0 has a low normalized value for population density, and presents almost no establishments' concentration and tax over services. However, this cluster presents high road density and average road capacity normalized values. In addition to the infrastructure data, it is outside the restriction zone, and therefore, represents a zone with high growth potential.

- *Mixed zone*

Cluster number 1 presents average values for all studied variables. It does not present infrastructure restrictions, and a small part of its area is inside the restriction zone for heavy vehicles. This cluster is considered a mixed zone for presenting intermediate values for population and establishments' concentration.

- *Central Area*

Cluster number 2 presents the second highest values for establishments' concentration. In particular a high concentration in the segments "All services" and "Accommodation and Food Services", with over 30% of establishments in these sectors. However, despite not presenting the highest values for establishments' concentration, it is the region with the highest revenue in taxes over services, which can be explained by a greater value in the price of activities in this region, or a higher corresponding aliquot. Thus, this cluster has a high commercial activity, but with lower infrastructure restrictions in comparison with cluster number 6. Nevertheless, it is within the restriction zone for heavy vehicles.

- *Low-density mixed zone*

Cluster number 3 has a low normalized value for population density, establishments' concentration and tax over services. However, this cluster presents average road density and road.

- *Peripheral zone*

Low population and establishments' concentration. Its Human Development Index is the lowest; however, no cluster has a HDI that stands out (average of 0.15 for all clusters).

- *High-density Residential zone*

Cluster number 5 presents the highest population normalized value, with a demographic density of almost 30,000 people per square kilometer. This cluster has low establishments' concentration and tax over services, and also average infrastructure values for both road density and road capacity. Thus, it is a residential zone.

- *Critical zone for urban logistics*

This cluster presents the highest normalized values for establishments' concentration, with more than 50% of the establishments of all segments studied. However, the cluster's tax collection over services does not have a meaningful value as the establishments' concentration, which may suggest a high volume of commercial activities, but low prices or related aliquot. This zone has average values for infrastructure (road density and road capacity), and is inside the restriction zone for heavy vehicles. Therefore, it is considered a critical zone for urban logistics.

5.2.1 Public policy and general recommendations

The adoption of two additional variables allowed the segmentation of the city into seven clusters – with two new homogeneous areas that were not identified in the research performed by Castro et al. (2016). The clusters High-density Residential zone, Critical zone for urban logistics, Peripheral zone, Low-density residential zone, and Central Area were identified in both approaches, while the second application led to the new clusters: Mixed zone and Low-density mixed zone. Table 8 presents general recommendations for the identified clusters.

Table 8: general recommendations for the identified clusters

Cluster (0)	Low-density residential zone	No infrastructure constraints, since establishments and population concentration are low when compared to road density and capacity. The zone has a high potential for economic growth.
Cluster (1)	Mixed zone	This zone presents infrastructure constraints, since its population and establishments' concentration is high when compared to its infrastructure. Since this clusters presents population concentration, policies such as night deliveries would not be appropriate. Solutions that involve B2C and B2B are required for this area. Investments in infrastructure, such as delivery bays, can be explored.
Cluster (2)	Central zone	Very high concentration of commercial establishments and population. The cluster is known as "old downtown" and is inside the restriction area. Considering the high adoption of motorcycles for transport, transshipment solutions to smaller vehicles should be studied. A satellite platform can be a great solution for freight forwarding in central areas, as well as the provision of infrastructure such as delivery bays for parking VUC's is critical. The use of delivery windows for freight forwarding in this area may also be explored. For companies, night deliveries can be an option to improve operational efficiency levels due to low traffic levels at night. Further studies are needed to development of solutions.
Cluster (3)	Low-density mixed zone	This cluster presents no infrastructure constraints, in comparison with its population and commercial establishments' concentration. The zone has a high potential for economic growth.
Cluster (4)	Peripheral zone	We recommend public policies aiming the economic development of the region. Infrastructure development is also required, with focus on ensuring accessibility from logistics centers/industrial zones to residential/commercial areas. Slums concentration – solutions such as Mobile Warehouses and Truck Shops for improving goods accessibility should be further studied. Sustainability must be considered due to high vegetation concentration.
Cluster (5)	High-density Residential Zone	In residential areas, policies providing vehicles speed and noise control are important to ensure adequate levels of life quality and safety. Public policies adequate to this region could also improve last mile delivery assertiveness, specifically B2C deliveries. Further, cluster-specific analyses are suggested for the proposal of specific solutions.

Cluster (6)	Critical zone for urban logistics	There is a lack of accessibility due to low road density in comparison with establishments and population concentration, and for being inside the restriction zone. Investments in infrastructure are essential, and urban distribution centers can aid on freight consolidation. Considering the high adoption of motorcycles for transport, transshipment solutions to smaller vehicles should be studied.

The results allow concluding that the additional variables, Human Development Index and percentage of taxes over services, made possible the development of a map that represents the city better. Despite the scholarship and the life expectancy indexes included in the Human Development Index not directly affecting urban freight transport, the share of gross national income per capita allows an analysis of the socioeconomic distribution of the city. The percentage of taxes over services helps understanding the economic activities developed in São Paulo.

Including new variables does not represent a limitation in the research, since the statistical procedures do not change. It should be noted that the main obstacle to the addition of new variables is the data collection procedure that can be exhausting, as it requires a detailed database.

Thus, both identified additional clusters have a feature not found in the study of Castro et al. (2016): mixed zones, considering city areas where commercial activities are mixed with residential areas. Alho and Silva (2015) argues about the necessity of considering specific urban characteristics to enhance the transferability and sustainability of urban logistics solutions, showing the importance of identifying new areas. Hence, the collection of additional data is an opportunity for better understanding cities, providing more insights about possible solutions for urban logistics. Additional variables can also be set according to the purpose of the study, which allows different segmentation analysis to the city.

6 PRACTICAL APPLICATION 2: SÃO PAULO KM2 STUDY

Urban freight deliveries usually operate on a weekly schedule, serving different zones of the city each day of the week. Therefore, according to Merchan et al. (2015), the best scale for understanding urban freight transport is the neighborhood and/or district level. Instead of analyzing logistics at a wider city level, smaller areas should be selected for studying and collecting data, since it offers insights into the specific nuances of daily operations, existing constraints and needs driving a specific area. The City Form Lab Report (2012) also suggests defining smaller scales for studying cities.

The cluster analysis from São Paulo allowed identifying critical areas for urban logistics and proposing relevant insights, and we selected an area of approximately one km² in order to develop further studies and prioritize an adequate solution. We selected the second scenario as most representative map because it identified two additional zones, with a clear pattern, map that could not be achieved in the first scenario. Pinheiros neighborhood, in Cluster number 2 (Central Area, second application) was selected, since it is located in a region that faces critical challenges to the urban freight transport (Figure 16).

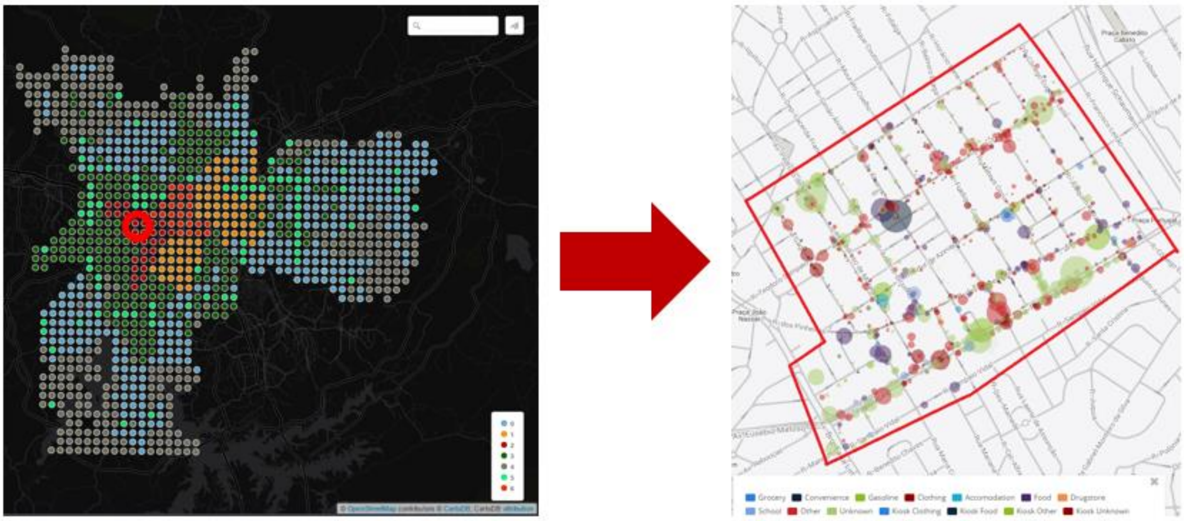

Figure 16: selected area for study

We propose the study of the following best practices suggested in the cluster analysis, in three levels of approach:

- Loading/Unloading zones, dependent on public authorities – planning level;
- Consolidation/transshipment centers, dependent on logistics operators – structural level;
- Night deliveries, mainly dependent on the receivers' organization – operational level.

These urban logistics best practices have consonance with the research performed by the Brazilian Urban Logistics Center (CLUB, 2016), which states that the main problems for the urban freight transport in São Paulo are related to public policies (Figure 9). Night delivery, consolidation and transhipment centers are closely linked to public policies, while investment in infrastructure and consolidation/transshipment centers also act on the availability of places for loading/unloading freight. All alternatives also aim to mitigate congestion in urban freight transport. We selected a Multi Criteria Decision Making approach for studying and prioritizing one out of the three suggested solutions.

Since we adopted the neighborhood level for this project, it is important to highlight that the results presented are local. In addition, the context of the analyzed district may change over the years, and therefore we present short-term solutions for the city.

6.1 Decision Context

This study aims to apply a Multi Criteria Decision Making method, AHP, for prioritizing the best opportunity for improving the sustainability of urban logistics activities in an area of approximately one km², located in Pinheiros neighborhood, São Paulo. This Section helps understanding Pinheiros urban context, and is essential to validate it as a critical zone for urban logistics for further analysis. If the analysis did not point the site as challenging for the urban freight transport, another area would be selected.

Pinheiros neighborhood originated as a wholesale center. It is one of the most sophisticated regions of Sao Paulo, with large and diverse commercial network (clothes, shoes, furniture, food and drink, banks, among others) and an intense cultural life (libraries, bookstores, nightclubs and bars, arts fair and antiques, dance academies, among others). Pinheiros had a fast development after the Independence of Brazil, and factors to this development are the construction of a tramway car reaching the district center and the inauguration of the Municipal Market of Pinheiros (Prefecture of São Paulo, 2015). Nearby neighborhoods include "Jardins" and "Vila Madalena". Jardins and Vila Madalena are noble areas of São Paulo. Jardins stands out for the quantity and quality of the services and commerce present, while Vila Madalena has plenty of establishments for leisure and entertainment.

The atlas proposed by Merchan et al. (2015) contains information on the distribution of commercial establishments in the region, as well as information on deliveries and location of delivery bays (http://lastmile.mit.edu/km2). The two sectors with the highest commercial establishments' concentration are Food (13.98%) and Clothing (10.07%). Pinheiros neighborhood has some establishments with large areas such as gas stations, supermarket and gallery. It has 13.11 kilometers of parking lanes extension, with only seven specific areas for loading and unloading freight (total length of 301.85 meters).

When analyzed to other neighborhoods, from other megacities, the solutions proposed by the cluster analysis show synergy with the Atlas proposed by Merchan et al. (2015) (Table 9). The studied area in Madrid, for example, has a similar concentration of stores per km², but approximately three times more space for dedicated loading/unloading zones. The adoption of a satellite platform would also benefit São Paulo's studied area, since the space for parking smaller vehicles is much larger (11.13 km of regular parking lanes). Figure 17 shows a traffic count in a specific street from Pinheiros neighborhood, confirming the smaller traffic of vehicles during the evening, which confirms the opportunity of adopting night deliveries for increasing the operation efficiency of the last mile delivery. Figure 18 also confirms the smaller disruption of traffic in operations that avoid peak hours of traffic.

Pinheiros neighborhood also presents a high concentration of nanostores. Blanco and Fransoo (2013) studied the features of this retail activity, and classified nanostores as having less than 15 square meters of store, among other characteristics. According to a survey conducted at Pinheiros, approximately 25% of the commercial establishments of the studied area have less than 4 meters of front length, which indicates to the presence of nanostores. Blanco and Fransoo (2013) state that the physical distribution of goods to this type of stores is much more complex. The number of delivery points is larger, with smaller drop sizes, since nanostores do not have space to stock large quantities of freight, which leads to more frequent deliveries.

Table 9: São Paulo compared to other megacities (Merchan et al., 2015)

			Loading/Unloading areas	
	Density (pop/km²)	Stores/km²	Public (mts)	Dedicated (mts)
São Paulo	7.7k	1.38k	11.13k	301.85
Santiago	9.5k	1.8k	415	360
Rio de Janeiro	5.3k	2.62k	1.86k	260
Mexico City	5.9k	2.58k	584	0
Madrid	5.4k	1.42k	10.74k	1.17k
Kuala Lumpur	6.4k	585	1.87k	47.68
Bogotá	1.6k	733	5.8k	5.8k
Beijing	11.5k	836	12.23k	0

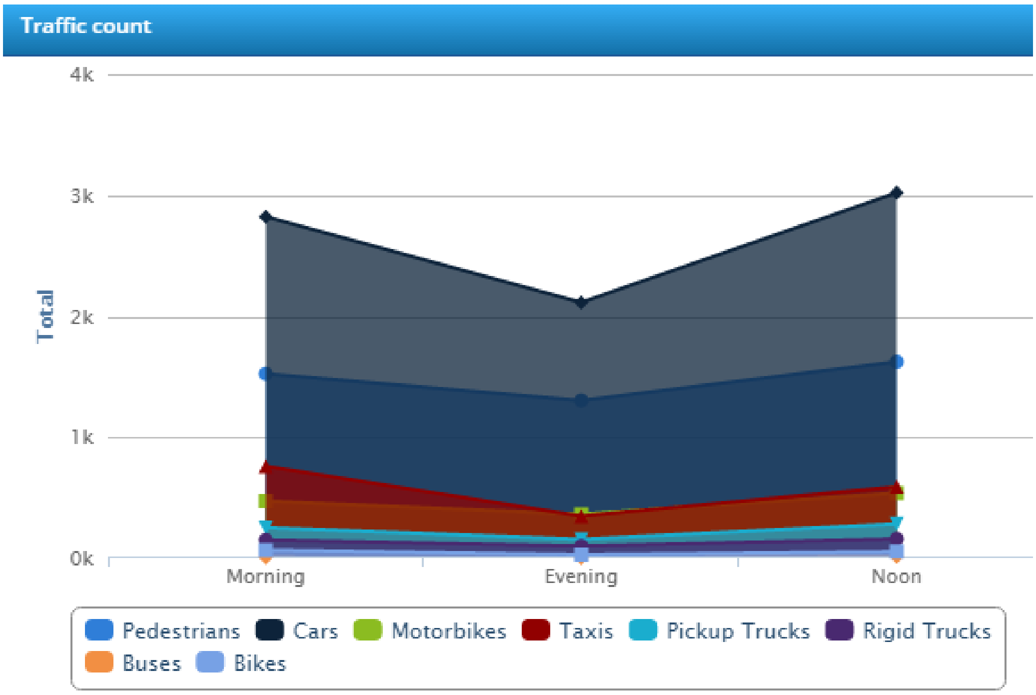

Figure 17: Traffic count in specific street of Pinheiros neighborhood, São Paulo. Source: http://lastmile.mit.edu/km2/show/brazil/sao-paulo/sao-paulo

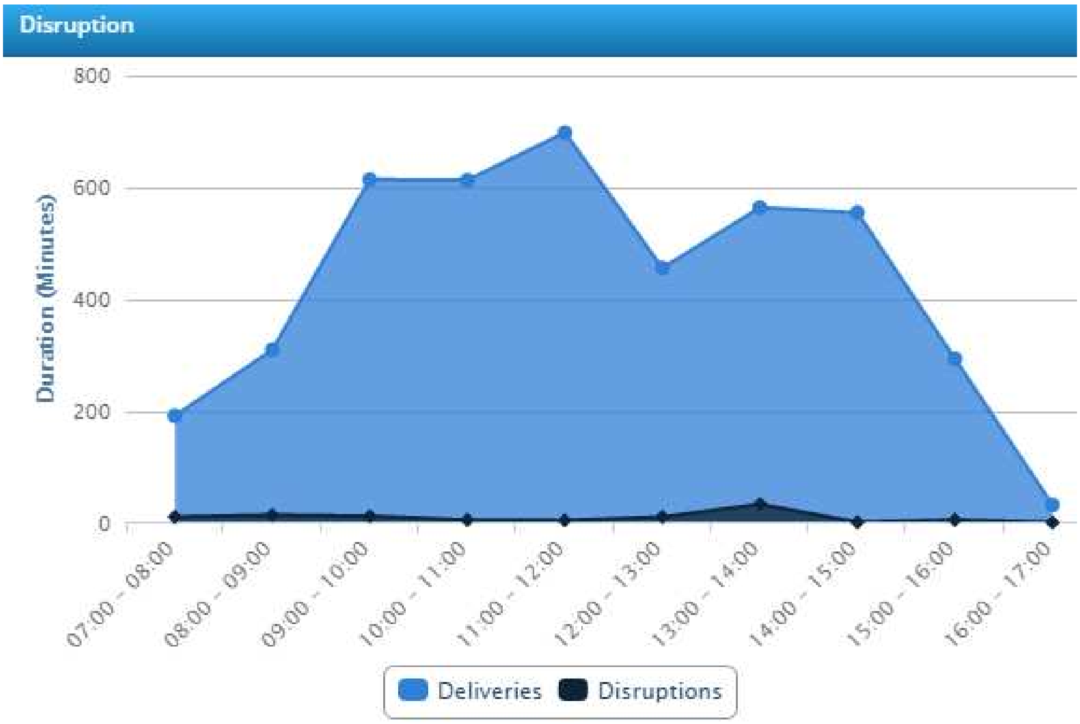

Figure 18: Deliveries disruption in specific street of Pinheiros neighborhood, São Paulo. Source: http://lastmile.mit.edu/km2/show/brazil/sao-paulo/sao-paulo

This project includes three levels of decision - planning, structural or operational, according to the alternative/solution proposed. Taniguchi and Tamagawa (2005) defined the actors involved in the urban freight transport, and the decision-maker actor depends on the solution prioritized in this project. If delivery bays are selected, public authorities are the decision-makers; for consolidation/transshipment centers, logistics operators; and for night deliveries, the recipients (last link in the supply chain before the final consumers).

6.2 AHP objectives

As mentioned in Section 2.1, urban logistics has different actors, often with distinct and conflicting objectives among each other. However, even though distinct, they are directly related to the sustainability of urban freight transport operations.

This research aims to improve the sustainability of urban freight transport in Pinheiros, São Paulo. According to Nykvist and Whitmarsh (2008), impacts on sustainability are categorized into the environmental, social and economic pillars. Thus, through literature review based on the indicators proposed by Quak (2008), on the research performed by Souza et al. (2013), on the impacts described by Quak (2007) and on the objectives of each actor, the hierarchy of objectives of this research was built (Figure 19).

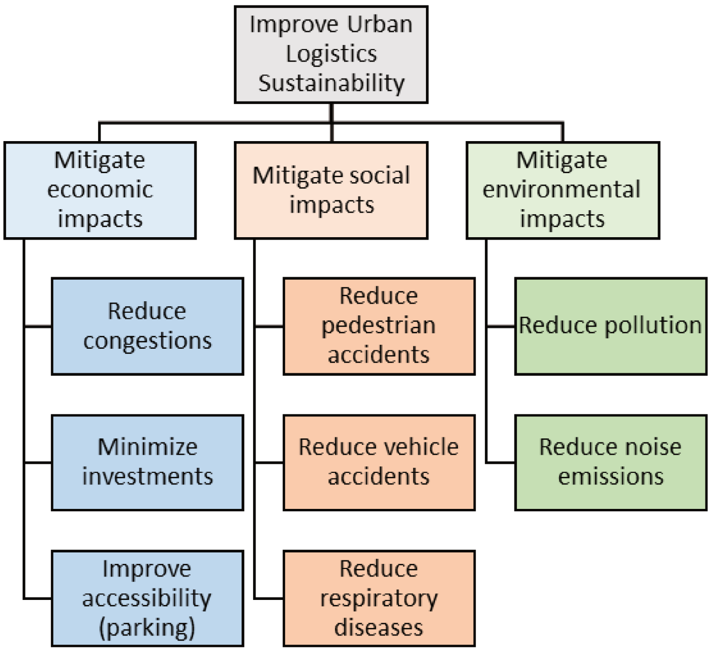

Figure 19: hierarchy of objectives

6.3 AHP criteria

The criteria definition is an essential activity for structuring the context of the study, as it helps in defining the objective of the research, improving communication between the actors of the decision process, can contribute to generating new alternatives, helps the development of an evaluation model and allows evaluation of alternatives (Souza et al., 2013).

These criteria must be attributes that can be measured or assessed, as well as contributing to the decision-making context. The criteria can be classified into two types (Zamboni et al., 2005):

- Factor: variables that enhance or diminish the suitability of a particular alternative;
- Exclusion/restriction: variables that can limit the alternatives under consideration, excluding options of the solution set.

The previous definition of the objectives allowed establishing the criteria used for assessing the decision alternatives. The criteria proposed for this project, classified as a factor, are illustrated in Figure 20.

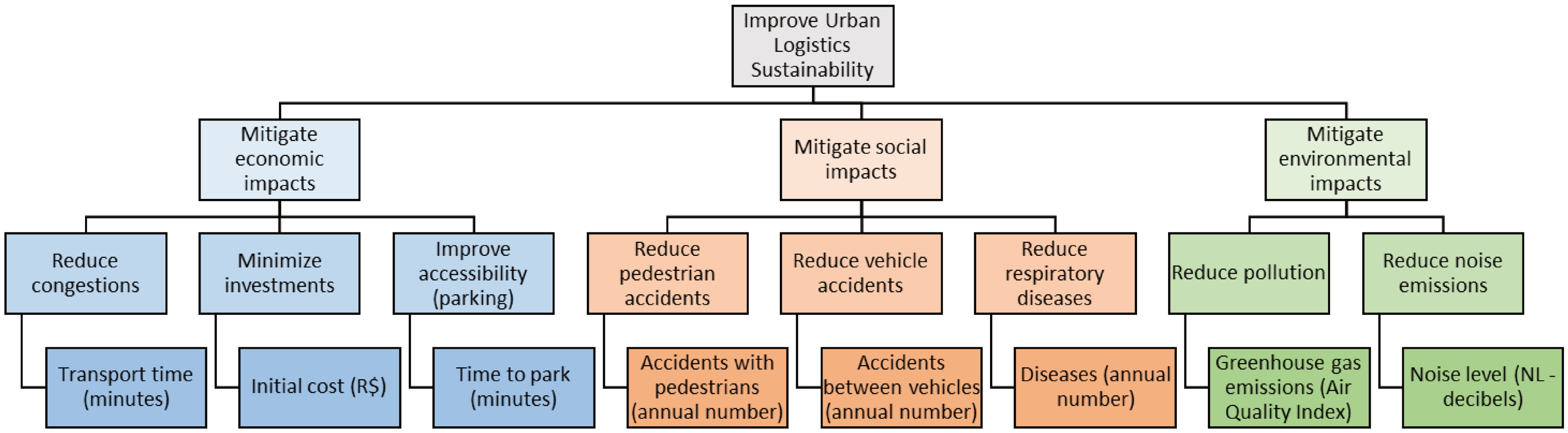

Figure 20: criteria hierarchy

6.4 AHP decision alternatives

As aforementioned, the study conducted by Castro et al. (2016) defined three possible urban logistics best practices, represented by Figure 21:

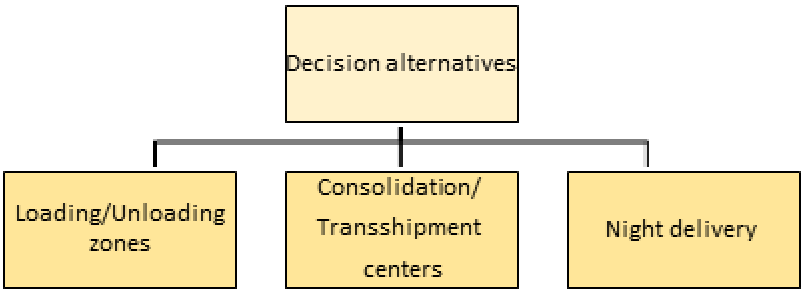

Figure 21: decision alternatives

6.5 AHP application and discussion

Crainic (2009) states an agreement should be established between the conflicting objectives of the various actors in the urban environment that take part in the urban freight transport activities. The actors involved in the urban freight transport in Pinheiros were interviewed in order to identify their vision regarding the importance of each criteria and how each alternative would affect the environment in which they live. This procedure allows the prioritization of the solution alternatives of this research. The interviews were conducted with the Commercial Association of São Paulo - Pinheiros District, a relevant logistics operator, Traffic Engineering Company of São Paulo (CET - Companhia de Engenharia de Trafego de São Paulo) and six residents of the study area. The consistency of judgements was measured for the results of each interview, and the consistency ratio of only one resident was higher than 0.10, not considered in the research. The decision matrices are presented in Tables 10, 11, 12, 13, 14, 15, 16 and 17.

Table 10: AHP Results – Pinheiros Commercial Association

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.333			0.333			0.333		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.234	0.065	0.701	0.485	0.323	0.192	0.500	0.500	
A1: LOADING/UNLOADING ZONES	0.083	0.633	0.106	0.333	0.333	0.143	0.143	0.429	0.239
A2: TRANSSHIPMENT CENTER	**0.193**	**0.106**	**0.260**	**0.333**	**0.333**	**0.714**	**0.714**	**0.429**	**0.404**
A3: NIGHT DELIVERY	0.724	0.260	0.633	0.333	0.333	0.143	0.143	0.143	0.357

Table 11: AHP Results – Logistics operator (DHL)

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.333			0.333			0.333		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.333	0.333	0.333	0.333	0.333	0.333	0.500	0.500	
A1: LOADING/UNLOADING ZONES	0.078	0.619	0.083	0.333	0.333	0.083	0.083	0.455	0.260
A2: TRANSSHIPMENT CENTER	**0.234**	**0.096**	**0.193**	**0.333**	**0.333**	**0.724**	**0.724**	**0.455**	**0.409**
A3: NIGHT DELIVERY	0.688	0.284	0.724	0.333	0.333	0.193	0.193	0.091	0.331

Table 12: AHP Results – Local Authority (CET)

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.082			0.682			0.236		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.455	0.091	0.455	0.633	0.106	0.260	0.750	0.250	
A1: LOADING/UNLOADING ZONES	0.143	0.653	0.286	0.333	0.200	0.200	0.200	0.429	0.276
A2: TRANSSHIPMENT CENTER	**0.143**	**0.096**	**0.140**	**0.333**	**0.200**	**0.600**	**0.600**	**0.429**	**0.408**
A3: NIGHT DELIVERY	0.714	0.251	0.574	0.333	0.600	0.200	0.200	0.143	0.317

Table 13: AHP Results – Resident 1

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.333			0.333			0.333		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.331	0.120	0.549	0.633	0.106	0.260	0.250	0.750	
A1: LOADING/UNLOADING ZONES	0.074	0.633	0.455	0.143	0.143	0.106	0.106	0.455	0.284
A2: TRANSSHIPMENT CENTER	**0.283**	**0.106**	**0.091**	**0.429**	**0.429**	**0.633**	**0.633**	**0.455**	**0.379**
A3: NIGHT DELIVERY	0.643	0.260	0.455	0.429	0.429	0.260	0.260	0.091	0.337

Table 14: AHP Results – Resident 2

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.200			0.600			0.200		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.128	0.312	0.560	0.633	0.106	0.260	0.750	0.250	
A1: LOADING/UNLOADING ZONES	0.083	0.633	0.106	0.333	0.333	0.143	0.143	0.429	0.267
A2: TRANSSHIPMENT CENTER	**0.193**	**0.106**	**0.260**	**0.333**	**0.333**	**0.714**	**0.714**	**0.429**	**0.429**
A3: NIGHT DELIVERY	0.724	0.260	0.633	0.333	0.333	0.143	0.143	0.143	0.305

Table 15: AHP Results – Resident 3

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.333			0.333			0.333		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.429	0.143	0.429	0.669	0.088	0.243	0.500	0.500	
A1: LOADING/UNLOADING ZONES	0.088	0.724	0.143	0.333	0.333	0.187	0.187	0.455	0.274
A2: TRANSSHIPMENT CENTER	0.243	0.083	0.143	0.333	0.333	0.579	0.579	0.455	0.362
A3: NIGHT DELIVERY	**0.669**	**0.193**	**0.714**	**0.333**	**0.333**	**0.234**	**0.234**	**0.091**	**0.364**

Table 16: AHP Results – Resident 4

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.143			0.429			0.429		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.467	0.067	0.467	0.333	0.333	0.333	0.500	0.500	
A1: LOADING/UNLOADING ZONES	0.143	0.778	0.633	0.429	0.143	0.158	0.158	0.455	0.295
A2: TRANSSHIPMENT CENTER	**0.429**	**0.111**	**0.106**	**0.429**	**0.429**	**0.655**	**0.655**	**0.455**	**0.491**
A3: NIGHT DELIVERY	0.429	0.111	0.260	0.143	0.429	0.187	0.187	0.091	0.215

Table 17: AHP Results – Resident 5

Criteria/Alternatives	Economic Impacts			Social Impacts			Environmental Impacts		Priority
	0.200			0.600			0.200		
	Congest.	Investment	Accessibility	Pedestrian acc.	Vehicles acc.	Diseases	Pollutants	Noise	
	0.455	0.091	0.455	0.333	0.333	0.333	0.500	0.500	
A1: LOADING/UNLOADING ZONES	0.468	0.669	0.574	0.333	0.333	0.106	0.106	0.331	0.305
A2: TRANSSHIPMENT CENTER	**0.210**	**0.088**	**0.140**	**0.333**	**0.333**	**0.633**	**0.633**	**0.549**	**0.412**
A3: NIGHT DELIVERY	0.322	0.243	0.286	0.333	0.333	0.260	0.260	0.120	0.283

The data presents a large consonance and suggests that the implementation of consolidation/transshipment centers, in the view of most respondents, would improve more effectively the sustainability of the urban freight transport at Pinheiros, São Paulo. The result of only one resident points to another solution, night delivery. However, the priority of this resident for night deliveries is very close to consolidation/transshipment centers, with values of 36.4% and 36.2% respectively.

We compiled the residents' results according to the guidelines suggested by Saaty (2008) in order to elaborate only one decision matrix for each stakeholder group involved in the research. According to the author, the use of the geometric mean is the most appropriate procedure. We consolidated the priorities perceived by residents regarding the decision alternatives in Table 18. Delivery bays and night delivery present similar values, whereas consolidation/transshipment centers have a larger priority, 41.2%.

Table 18: Residents' decision alternatives priority.

RESIDENTS – DECISION ALTERNATIVES PRIORITIES	
A1: LOADING/UNLOADING ZONES	0.284
A2: TRANSSHIPMENT CENTER	0.412
A3: NIGHT DELIVERY	0.296

According to Saaty (2008), there are two options for group decision making: to aggregate individual judgments and generate only one result for the group, or to build the decision from the individual results. This second option can be held with experts, such as the case of this research in which the stakeholders are directly inserted into the study environment and impacted by the urban freight transport. The priorities of the decision alternatives to improve sustainability in urban logistics are presented in Table 19. Table 20 also shows the relative importance of each impact - economic, social and environmental - for each stakeholder group.

Table 19: Alternative decision priorities for each stakeholder group.

DECISION ALTERNATIVES	COMMERCIAL ASSOCIATION	LOGISTICS OPERATOR	CET	RESIDENTS	GEOMETRIC MEAN
A1: LOADING/UNLOADING ZONES	0.239	0.260	0.276	0.284	0.264
A2: TRANSSHIPMENT CENTER	0.404	0.409	0.408	0.412	0.408
A3: NIGHT DELIVERY	0.357	0.331	0.317	0.296	0.324

Table 20: Economic, social and environmental impacts' priorities.

SUSTAINABILITY	COMMERCIAL ASSOCIATION	LOGISTICS OPERATOR	CET	RESIDENTS
ECONOMIC IMPACTS	0.333	0.333	0.082	0.229
SOCIAL IMPACTS	0.333	0.333	0.682	0.443
ENVIRONMENTAL IMPACTS	0.333	0.333	0.236	0.286

Table 19 confirms the consonance in the results, in which the implementation of consolidation/transshipment centers is the best alternative to increase the sustainability of urban logistics, according to the answers of the stakeholders directly involved and impacted by the urban freight transport. It may be noted that for residents and public authorities, represented by the CET, the social impacts are the most significant to be mitigated. The logistics operator and Pinheiros District Commercial Association, on the other hand, classified the economic, social and environmental impacts with the same importance. This can be explained by the fact that they are private institutions, with profit operations being essential. The priorities of the criteria for economic, social and environmental impacts are presented in Tables 21, 22 and 23.

Table 21: Priority of economic impacts.

ECONOMIC IMPACTS	COMMERCIAL ASSOCIATION	LOGISTICS OPERATOR	CET	RESIDENTS
Congestion	0.234	0.333	0.455	0.329
Investment	0.065	0.333	0.091	0.126
Accessibility	0.701	0.333	0.455	0.489

Table 22: Priority of social impacts.

SOCIAL IMPACTS	COMMERCIAL ASSOCIATION	LOGISTICS OPERATOR	CET	RESIDENTS
Pedestrian accidents	0.485	0.333	0.633	0.495
Vehicle accidents	0.323	0.333	0.106	0.162
Respiratory diseases	0.192	0.333	0.260	0.284

Table 23: Priority of environmental impacts.

ENVIRONMENTAL IMPACTS	COMMERCIAL ASSOCIATION	LOGISTICS OPERATOR	CET	RESIDENTS
Pollutants	0.5	0.5	0.75	0.472
Noise	0.5	0.5	0.25	0.472

There is an agreement in terms of the necessity of improving the accessibility at Pinheiros, São Paulo. The criteria with less importance, except to the logistics operator, is the investment to implement the solution. This difference in values can be explained by the fact that the logistics operator is the most affected stakeholder with regard to investments in the case of the studied solutions. Night deliveries require investments in equipment to reduce noise and satellite platforms require investments in new vehicles (motorcycles or vans).

In the matter of social impacts, pedestrian accidents is more important, whereas vehicle accidents and respiratory diseases present balanced values. Pollutant and noise emissions have the same importance for the stakeholders, except to the public authorities (CET), who argues that mitigation in greenhouse gas emissions must be a priority.

The social impacts, as aforementioned, present in average a higher importance to the stakeholders group. However, there is a balance in the performance of the solutions in accidents with pedestrians and vehicles without an alternative especially for the mitigation of these impacts. Moreover, there is a perception among stakeholders that the consolidation/transshipment centers have a competitive advantage in the social impacts (respiratory diseases) and thus in the overall context analyzed, since they withdraw heavy vehicles from urban centers, major emitters of NOx and particulate matter. This alternative also presents relatively high values for mitigating the environmental impacts, noise and pollutants emissions. Night delivery presents on average greater relative values for the economic impacts (congestion and accessibility), as well as delivery bays, with smaller investments for implementation.

We conclude that, despite night delivery presents possibilities of efficient operations, being economically advantageous and widely exploited in the international literature as effective urban logistics solution, satellite platforms are more consistent with the Brazilian context at Pinheiros, São Paulo. The social and environmental improvement that this solution can provide for the urban freight transport is decisive to its prioritization. In addition, security is a major barrier for night deliveries, especially for developing countries, the case of Brazil. Besides, the cost per square kilometer in urban centers of developed countries is higher than the cost of emerging countries, barrier to the implementation of satellite platforms.

6.6 Report on Satellite Platforms, Night Deliveries and Delivery Bays

The Sections below present a report on each best practice studied for the analysed context, Pinheiros neighbourhood – São Paulo. It is important to state that the best practices studied consist of short-term solutions, without considering external factors, such as Rodoanel (roadway that encircles São Paulo) and São Paulo’s O/D matrix.

6.6.1 Consolidation/transshipment centers – Satellite Platforms

Crainic (2004) states that significant gains in urban freight transport can only be achieved through a rationalization of distribution activities involving freight consolidation from different shippers and carriers as well as through the co-ordination of operations at the city level. According to the author, such approaches are essential in central areas.

Satellite Platforms are locations where freight is transshipped from normal trucks to smaller vehicles for the last mile delivery. Satellites offer no storage facilities, with trans-dock transshipment being the operational model. The operation requires real-time co-ordination, control, and dispatch of trucks and city-freighters (Boudoin et al., 2013; Crainic, 2004).

The use of Satellite Platforms for the distribution of goods in urban centers can help reducing congestions. According to Castro et al. (2015), the implementation of Satellite Platforms in central zones allow reducing the number of trucks that travel in this area and thus possible congestions. Delivery with smaller vehicles, especially motorcycles, minimize the difficulty of finding loading and unloading spaces, one of the biggest challenges urban freight transport faces. Dense urban areas need smaller vehicles to transport freight, which can also contribute to lower pollutants and noise emissions. (Crainic et al., 2004). The emission of NOx and particulate matter, the main cause of negative impacts on the health of the population, is predominant in heavy vehicles (CETESB, 2011). The presence of nanostores in Pinheiros neighbourhood, mentioned above, is an opportunity to the use of smaller vehicles for the last mile delivery, since they have smaller orders that could be transported on motorcycles.

The implementation of Satellite Platforms depends not only on the support of public authorities, but relies also on efficient planning for agile transhipment operations and hence the optimization of the Satellite Platform. Investments on adequate last mile delivery vehicles are also required. This solution can be further enhanced with cooperation between shippers, according to the type and quantity of goods, which can further optimize the occupation of the vehicle and reduce their numbers (Loureiro et al., 2015; Muñuzuri et al., 2005).

Dias and Garcia (2015) studied important characteristics for the implementation of Satellite Platforms in central areas, shown in Figure 22.

Logistics practice	Adoption of new Technologies
• Consolidation points with transshipment.	• Routing software. • Order and truck loading programming. • Tracked vehicles via GPRS. • Freight chests for custom motorcycles.
Sustainability	**Public Policies and Governance**
• Fewer heavy vehicles on the streets, with a reduction in emissions (especially NOx and particulate matter) and in traffic.	• Definition of the Satellite Platforms locations (land use). • Definition of access routes to the Satellite Platforms. • Coordination of the use of the Satellite Platforms. • Incentive for the use of clean vehicles.
Implementation Difficulties	**Business Model and Economic Viability**
• Government, local residents and retailers support. • Investment in appropriate technologies.	• Private sector: fixed and variable operation cost reductions and possible gains from improving the service level versus investment in technology, with additional transshipment costs. • Public sector: reduction in roads saturation and in pollution, supplying the city center.

Figure 22: important characteristics for Satellite Platforms. Source: Dias and Garcia (2015).

6.6.2 Night Deliveries

The night deliveries are a solution for carriers and logistics operators to avoid peak hours of traffic. The benefits include increased speed due to the lack of congestion on the roads, availability of places to park vehicles, reduction of time spent at each stop, reduction in traffic fines, reduction in return of goods, and for drivers, lower level stress (Bertazzo et al., 2015). Holguín-Veras et al. (2010) also states that overnight delivery can reduce the cost of delivery in 20% to 30% when compared to the regular schedule. The receivers can rely on the delivery reliability through time schedule, but have the cost of night labor as main impact (Holguin-Veras and Polimeni, 2006).

According to Holguin-Veras and Polimeni (2006), the trade-offs between the receivers and carriers is asymmetric: (1) in the delivery during regular hours, the recipient is benefited, not incurring extra costs, but the carrier has to deal with high route time and congestion. (2) Night deliveries benefit the carrier with low rates of congestion and increased productivity, while incurring extra costs to the receivers.

Thus, many recipients refuse to receive cargo during evening hours, unless the costs are compensated, or in cases of unassisted deliveries. A risk is added to this last option, since the order and integrity of the goods are not conferred upon receipt (Holguin-Veras; Marquis; Brim, 2012; Holguin-Veras et al, 2013).

Figure 23 shows important characteristics of night deliveries.

Logistics practice	Adoption of new Technologies
• Off-peak Delivery.	• Special equipment for noise reduction.
Sustainability	**Public Policies and Governance**
• Cost of delivery reduction of 20% to 30% compared to regular schedules. • Lower environmental impact due to lower fuel consumption and pollutants emission.	• Requires coordination between shipper, carrier and receiver. • Requires government incentive due to restrictions.

Implementation Difficulties	Business Model and Economic Viability
• Establishments open at night. • Investment in equipment for noise reduction. • Increased security costs.	• Private sector: operation cost reductions versus initial investments to adapt vehicles and additional security costs. • Public Sector: congestion reduction and increased accessibility at peak times, as well as lower greenhouse gas emissions due to greater operation efficiency.

Figure 23: important characteristics for night deliveries.

6.6.3 Delivery Bays

The implementation and management of loading/unloading spaces for delivery vehicles is an essential issue in busy urban areas. When its provision is not adequate, delivery vehicles often park in active traffic lanes, negatively impacting road capacity and safety. Passenger cars occupying delivery bays is also an important issue to consider when studying urban logistics. In addition, the lack of delivery bays impact cost and service of freight carriers operations in cities. Drivers are forced to search for vacant spaces if no vacant spaces exist at the desired location (Aiura and Taniguchi, 2005).

According to Allen et al. (2000), a study conducted in London and Norwick showed drivers spend 87% of the total travel time searching for a loading/unloading zone, parking the vehicle and finally delivering the freight. Oliveira et al. (2011) still states, in a research conducted in Belo Horizonte/MG, that 45% of the loading/unloading zones are occupied by passenger vehicles, which makes them inoperative for urban freight distribution.

A survey conducted at Kyoto city showed that more than 85% of drivers surveyed performed on-street loading-unloading routinely, whereas more than 50% of the loading-unloading operations were done in a one-way street or a road with one lane in each direction that tends to cause a traffic jam due to blocking of a car lane. . In addition, parking spaces used by passenger cars represents approximately 54%, while parking spaces used by pickup-delivery vehicles represents approximately 22%. The author of this survey developed a model in order to determine the optimal location of loading-unloading spaces by minimizing the total cost that is comprised of delay penalty, fixed cost, operation cost, parking fee and waiting cost of both pickup-delivery vehicles as well passenger cars. Using a test road network the model developed by the authors was able to determine a configuration of parking spaces that achieved a cost reduction of approximately 16%. (Aiura and Taniguchi, 2005).

Logistics practice	Adoption of new Technologies
• Loading/Unloading.	• Model for optimizing location of delivery bays.
Sustainability	**Public Policies and Governance**
• Possibility of achieviing cost reduction (16% for Aiura and Taniguchi (2005) research). • Less polutants emission due to lower time searching for delivery bay. • Less congestion avoiding on-street deliveries.	• Location definition and implementation of delivery bay sites by public authorities.
Implementation Difficulties	**Business Model and Economic Viability**
• Use of loading/unloading zones by passenger cars (45% for Oliveira et al. (2011) and 54% for Aiura and Taniguchi (2005)).	• Private sector: reduction in operational costs and increase in service level. • Public sector: reduction in congestions due to lower on-street deliveries and lower time searching for a delivery bay, besides lesser pollutants emission because of increased efficiency of the operation.

Figure 24: important characteristics for delivery bays.

7 CONCLUSIONS AND FUTURE WORK

This research presents a cluster-based data-driven methodology applied in São Paulo city, in order to identify urban clusters related to city logistics and select a critical area to be studied. Based on the results, we can conclude the quantitative methodology is efficient to analyze urban centers, since the provided clusters are a good representation of the city with important insights for studying freight mobility. Further studies were conducted focusing on evaluating the feasibility of the proposed solutions to the selected critical area, by involving the stakeholders and applying a multi criteria decision tool, the AHP. The scale adopted in this second practical application of the project, at the neighborhood level (Pinheiros, São Paulo), allowed the development of insights into the specific nuances of daily operations, existing constraints and needs driving a specific area. This results confirm the statement of Merchan et al. (2015) adopted in this research, who argue the neighborhood or district level are the most appropriate for studying the last mile delivery. The involvement of the stakeholders in the project still provided the opportunity of better understanding the Brazilian and Pinheiros/São Paulo context regarding urban freight transport, essential to ensure the transferability of the urban and city logistics best practices developed in the international literature and to avoid conflict of interests between the actors when implementing a solution.

Furthermore, the integration of quantitative and qualitative methods presents as a great opportunity of research. We integrated a data driven methodology, the cluster analysis, with a qualitative tool, interviews, in order to select a critical area of the city and understand the specificities of the site to propose an adequate urban logistics best practice. Bryman (2006) states that there are relatively few guidelines about how, when, and why the integration of method should occur. Greene (2008) also argues that integrated mixed methods analysis has not yet cohered into a widely accepted framework. Besides, Maxwell and Loomis (2003) confirm the complexity of actually integrating qualitative and quantitative approaches in any particular field of study. This leads to the opportunity of further studies into the development of a framework on how to integrate these methods when addressing urban logistics issues. The integration of other qualitative or quantitative methods, such as survey or focus groups, should also be further explored.

The results of this research will be compiled and delivered to the involved stakeholders in a report. The report includes information regarding the characteristics of the selected cluster, that includes Pinheiros neighborhood, a summary of the results of the AHP application, with the most important impacts to be mitigated and the most appropriate solution to be implemented according to the stakeholders, as well as a short report concerning the three studied urban logistics best practices.

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ATTACHMENTS

- Paper I

  Castro, R. B., Santos, L. S. (2016). Estudo do impacto do e-commerce e de Sistemas Inteligentes de Transporte na logística urbana (Study of the impact of e-commerce and Intelligent Transportation Systems in urban logistics). Mundo Logística, n. 50.

- Paper II

  Castro, R. B., Lima Jr, O. F., Dias, M. L. F. C., Loureiro, S. A., Noletto, A. P. R. (2015). Ponto de apoio como solução para distribuição de cargas em centros urbanos (Satellite platform as solution for urban logistics). XXIX ANPET, Ouro Preto.

- Paper III

  Castro, R. B., Merchan, D., Lima Jr, O. F. (2016). Identifying clusters to implement urban logistics best practices: the case of São Paulo. 2016 MIT SCALE Latin America Conference.

- Paper IV

  Castro, R. B. Loureiro, S. A., Lima Jr, O. F., Noletto, A. P. R. Cluster analysis and Focus group: integrating Qualitative and Quantitative approaches on addressing city logistics challenges. Working paper.

Study of the impact of e-commerce and Intelligent Transportation Systems in urban logistics - Estudo do impacto do e-commerce e de Sistemas Inteligentes de Transporte na logística urbana

Case “Entrega Delivery” e “Já Tá Chegando”

Foto do autor Deve ser enviada também, separadamente em arquivo gif ou jpg de	**Rodrigo Barros Castro** é Engenheiro Civil pela UNICAMP, e realiza mestrado sobre Logística Urbana na universidade. Atualmente cursa especialização sobre Logística e Gestão da Cadeia de Suprimentos no MIT, e é pesquisador no LALT/UNICAMP. **Lilian da Silva Santos** é doutora e mestre em Transportes pelo Programa de Pós-graduação em Transportes da Universidade de Brasília (PPGT/ UnB), e Bacharelado em Turismo pela Universidade Federal de Ouro Preto (UFOP). Atualmente é pesquisadora do LALT/UNICAMP, vinculada ao PPPD - Programa de Pesquisador de Pós-doutorado, junto ao Departamento de Geotecnia e Transportes (DGT).

Abstract

The diversity of information shared with consumers raises their requirements regarding service level. In addition, the e-commerce growth caused impacts on urban logistics, such as the increase in B2C transactions leading to increased demand for transport. The use of technologies such as Intelligent Transport Systems also influence freight delivery operations, contributing to increase competitiveness. In this context, due to the high competitiveness required, collaborative alliances between companies started to be developed, such as between the companies "Entrega Delivery" and "JáTá Chegando". The purpose of this article is to analyze the impact of e-commerce and Intelligent Transportation Systems in urban logistics, from the study of these two companies. In-depth interviews were performed in order to collect data.

1. Introdução

As principais aplicações de Tecnologias de Informação e Comunicação (TIC) nos anos 90 consistiam em sistemas com finalidade de obtenção, processamento e distribuição de informações para o melhor uso no planejamento, operação e gestão do transporte de cargas. Com a chegada do século XXI, o foco tornou-se a criação de aplicações integradas à internet que possibilitam o compartilhamento de dados com muitos usuários, contexto no qual as TICs têm causado uma variedade de efeitos nos sistemas logísticos. A popularização da Internet aumenta as transações Business to Business (B2B) e Business to Consumer (B2C), o que leva a uma demanda maior por transporte em função do e-commerce. Além disso, os Sistemas Inteligentes de Transporte (SITs) têm promovido a otimização da gestão de frotas baseado no tráfego ou em informações em tempo real, o que aumenta a eficiência do transporte (Yoshimoto e Nemoto, 2005). Com isso, essas tecnologias desenvolvidas e disponíveis comercialmente também estão mudando a cara do transporte de mercadorias em centros urbanos (Giannopoulos, 2009).

O e-commerce, traduzido como a realização de negócios pela Internet no mercado, é um negócio rentável e em plena expansão. No Brasil estima-se que no ano de 2014 existiam mais de 50 milhões de e-consumidores com uma média de crescimento de 30% ao ano (E-commerce News, 2014). Alterações no ciclo de pedido dos e-consumidores afetam vários aspectos da cadeia de suprimentos: cadeia de distribuição, tamanho de carregamento, tipo de transporte, número de entregas por rota, locais de entrega, falhas na entrega, frequência de entrega, janelas de tempo e tamanho de veículo, entre outros (Rotem-Mindali & Weltevreden, 2013;. Xing et al, 2011).

A internet é uma grande influenciadora na decisão de compra do consumidor brasileiro. Segundo pesquisa divulgada pelo E-commerce Brasil (2012), mais de 90% dos entrevistados já são e-consumidores, o que demonstra a importância deste novo segmento. De acordo com a pesquisa, comodidade, variedade de produtos, facilidade de pagamento, busca de informações e dicas de outros consumidores são os principais motivadores para a compra online.

A diversidade de informações compartilhadas com os e-consumidores eleva a exigência destes em relação aos parâmetros de oferta de bens e serviços, tais como preço, qualidade do serviço, inovação tecnológica e confiabilidade de entrega (Govindarajan e Gupta, 2003). Assim, a alta exigência em relação à capacidade de resposta ao cenário externo leva a alianças colaborativas entre empresas de forma a adquirir habilidades e competências cruciais à sobrevivência e ao crescimento (Dyer *et al.*, 2001).

O aumento de competitividade do mercado leva a uma necessidade de corresponder à demanda de e-consumidores com maior capacidade de resposta. A gestão de frotas com uso de Sistemas Inteligentes de Transporte (SIT) pode contribuir para a eficiência destas operações. O segmento de operação de cargas de SITs pode ser definido como sistemas de TIC avançados destinados a simplificar e automatizar as operações de transporte de mercadorias, tanto a nível de eficiência operacional, como a nível institucional. Os SITs desenvolvidos para o transporte de carga têm sido, até agora, em grande parte guiados pela introdução de sistemas sofisticados e tecnologias que podem coletar enormes quantidades de dados e apoiar o planejamento e funcionamento de sistemas de transporte de carga, com a transmissão destes dados para centros de controle e/ou banco de dados geridos por autoridades ou empresas intermediárias (Giannopoulos, 2009).

O uso de SIT permite a localização de veículos comerciais e carga com uso de GPS, e essa informação pode ser aplicada na otimização de rotas e disponibilização de tempos de entrega. Se por um lado os e-consumidores têm o interesse de pagar menos na compra de produtos, por outro lado esses também estão dispostos a aceitar preços mais altos a fim de obter seus produtos em tempo hábil. Há uma demanda crescente por serviços como entrega programada, controle de temperatura e rastreamento de carga em operações logísticas (Yoshimoto e Nemoto, 2005). Além disso, o e-commerce e os SITs causam impactos na Logística Urbana, assunto que é detalhado a seguir.

1.1. Alguns impactos do E-commerce e das SITs no contexto da Logística Urbana

O acesso à informações de tráfego aumenta a precisão na previsão de chegada de veículos de entrega, e melhora a sua capacidade de responder rapidamente e com precisão às solicitações dos clientes. A possibilidade de rastrear o produto pela Internet ou conhecer o estágio de produção em que se encontra aumenta o nível de serviço provido ao consumidor (Yoshimoto e Nemoto, 2005). Contudo, o aumento na demanda de entregas frequentes de pequenas encomendas oriundas do e-commerce representa desafios significativos para prestadores de serviços logísticos. Este novo metabolismo leva a um aumento em locais de entrega e número de paradas de entrega (Lim e Shiode, 2011). Cada veículo serve até 200 clientes por dia, o que significa que cada veículo tem de chegar a cerca de 200 locais em um dia (Marco *et al*, 2014). Neste contexto, empresas intermediárias com possibilidade de otimizar estas atividades podem apresentar grandes contribuições para a logística urbana.

Redes interorganizacionais podem agregar valor aos consumidores finais, aumentando a competitividade no mercado. As redes de relacionamento com clientes, fornecedores e subcontratados são necessárias para o aumento da competitividade, possibilitando o conhecimento de necessidades em toda cadeia produtiva (Porter, 2005). É necessário estabelecer relações em toda a cadeia de valor, abrangendo os consumidores e a tecnologia neste cenário. Alianças entre organizações com foco em redes de fornecedores e clientes têm maior facilidade para cooperar e sobreviver em ambientes competitivos. O uso de tecnologias auxilia a otimização dos processos de coleta e entrega de mercadorias, e sua união pode resolver vários problemas referentes à movimentação urbana de mercadorias (Dutra *et al.,* 2004). A competitividade advém do poder de inovação baseado em novas tecnologias e em processos que priorizem vantagens com foco em práticas de excelência mundial (Murdick et al. 2000). Neste contexto, algumas empresas foram criadas no sentido de compartilhar informações e estabelecer relacionamentos mais estreitos com os clientes, fornecedores ou subcontratados, com uso de tecnologia.

Assim, esse artigo teve como propósito avaliar o impacto do e-commerce e de SITs na logística urbana, em casos reais. Duas empresas relacionadas a esses segmentos foram analisadas, a “Entrega Delivery” e a “JáTá Chegando”. Fundada em 2011, a “Entrega Delivery” é uma plataforma online, que trata basicamente do processamento e acompanhamento de pedidos de alimentos e bebidas. Segundo o COO Dalker Walter, a inspiração para criar a “Entrega Delivery” veio de sua própria experiência enquanto consumidor, que já sofreu com diversas falhas no atendimento por telefone e nas entregas de pedidos. Idealizada por ele e por seus sócios, a plataforma da empresa auxilia o consumidor no momento da escolha do pedido, indicando quais estabelecimentos registrados entregam para o endereço desse consumidor via CEP cadastrado no sistema (Figura 1). Além e identificar quais restaurantes entregam para o endereço cadastrado, o consumidor também tem acesso ao andamento do seu pedido em tempo real, e ainda acesso a informações de satisfação de outros consumidores a respeito de qualidade do produto e preço de frete. Os restaurantes, em sua interface, alertam quando o pedido é recebido, quando está sendo montado, quando já foi despachado para entrega e o tempo estimado.

Figura 1: Plataforma permite verificação de restaurantes que entregam na localização do consumidor

Mais nova no mercado, a “JáTá Chegando” foi fundada em 2014, e possui mais de 6 mil clientes finais cadastrados em seu banco de dados. Segundo o co-founder Ivan Bonomi, a plataforma fornece para empresas que realizam entrega de pedidos funcionalidades como otimização de rotas, gestão de frota, através do monitoramento de localização e velocidade de circulação, envio de SMS para clientes no momento em que a entrega é iniciada e quando está próxima ao local final, além da prova de entrega, com possibilidade de entregadores tirarem foto do local. Consumidores podem monitorar a localização de seu pedido e donos de estabelecimentos comerciais ainda podem monitorar a dirigibilidade dos entregadores, evitando curvas rápidas no caso de transporte de comida, por exemplo. Assim, contribuem para o desafio do Last Mile Delivery, aumentando a assertividade da entrega e a redução de seus custos. Os benefícios da plataforma estão ilustrados na Figura 2.

Figura 2: benefícios da plataforma “JáTá Chegando”

As informações apresentadas foram coletadas mediante a entrevistas realizadas diretamente com os responsáveis por cada empresa, durante o mês de setembro de 2015.

2. Case: “Entrega Delivery” e “JáTá Chegando”

A análise das informações coletadas por meio das entrevistas feitas com os responsáveis pela “Entrega Delivery” e “Já Tá Chegando” foi feita mediante a verificação de seis aspectos: Prática Logística; Tecnologia; Sustentabilidade; Políticas Públicas e Governança; Modelo de Negócio e Viabilidade Econômica; e, Dificuldades na implementação. Estas variáveis foram selecionadas após análise de três projetos de relevância que abordam boas práticas em logística urbana de forma que um padrão no estudo destas práticas seja alcançado, e permitem que os aspectos mais importantes das operações sejam considerados. Essas práticas logísticas estão detalhadas nos itens seguintes.

2.1. Prática logística

As melhores práticas logísticas podem ser encontradas em empresas de diversos setores, em qualquer posição da cadeia de suprimentos, como fabricantes, varejistas e atacadistas (Bowersox *et al.*, 1989). Além disso, de acordo com Dantas (2000), práticas logísticas e desempenho estão estritamente ligados.

A "Entrega Delivery" atua como intermediária entre estabelecimentos comerciais – restaurantes – e consumidores finais, influenciando as práticas logísticas envolvidas no processo de delivery. As práticas logísticas envolvidas pelas atividades da empresa têm sinergia com as atividades descritas por Ballou (2006) como manutenção de informações e processamento de pedidos. Com relação à primeira atividade, a plataforma da "Entrega Delivery" permite a manutenção de um extenso banco de dados, com informações importantes para o planejamento de operações da cadeia de suprimentos. O banco de dados contém a localização e contato dos clientes, quantidade de pedidos, além de informações relativas aos restaurantes, como tempo de entregas e qualidade.

Ressalta-se que a atividade de processamento de pedidos é essencial em um processo logístico, pois um bom gerenciamento desta operação auxilia a empresa a atingir um nível de serviço eficaz oferecido aos clientes. Problemas relativos ao processamento de pedidos podem ser minimizados com sistemas de informação (Ballou, 2006; e Fleury, 2006). Neste sentido, a plataforma da "Entrega Delivery" oferece a possibilidade de consumidores realizarem seu pedido, acompanharem o status do mesmo, além de receberem uma estimativa do tempo de entrega. Ainda, a plataforma separa automaticamente os restaurantes que atendem na área do consumidor, de acordo com seu CEP. Há duas possibilidades para realizar pedidos utilizando a plataforma: o uso de sites personalizados, atrelados à página do restaurante, que são transmitidos para a página da "Entrega Delivery" apenas na etapa de finalização do pedido, ou realizar os pedidos diretamente com o site da plataforma. O uso desta tecnologia para processamento de pedidos diminui a demanda de pedidos via telefone, contribui para a diminuição de erros no mesmo, além do ganho de tempo por parte dos operadores do restaurante.

Por sua vez, a empresa "JáTá Chegando" também atua como intermediária entre os estabelecimentos comerciais e consumidores finais, provendo serviços que agregam valor às práticas logísticas desempenhadas na distribuição de mercadorias em centros urbanos. A plataforma permite a otimização das rotas realizadas pelo entregador, contribuindo para as atividades de transporte da cadeia de suprimentos. O algoritmo estabelece a melhor ordem de entrega para que a menor rota seja realizada.

Os serviços desempenhados pela "JáTá Chegando" também possibilitam a manutenção de informações ao longo da cadeia de suprimentos, atividade essencial para o correto planejamento e controle logístico. Uma base de dados com localização de clientes, rotas, padrões de entrega e velocidade dos entregadores, por exemplo, possibilita uma administração eficiente das atividades desempenhadas para distribuição de mercadorias em centros urbanos.

2.2. Tecnologia

Tecnologias podem contribuir na competitividade de empresas, além de auxiliar na mitigação de problemas oriundos da logística de cargas (Barbosa et al., 2007).

Nesse contexto, cabe destacar que a plataforma desenvolvida pela empresa "Entrega Delivery" apresenta grande sinergia com o uso de tecnologia no aumento da competitividade de empresas e com o aumento na demanda de transações B2C gerada pelo e-commerce (Barbosa et al., 2007; Yoshimoto e Nemoto, 2005). A sua plataforma permite a verificação do desempenho de entregas, uma vez que fornece informação de tempo e custo de entrega para os consumidores. Além disso, os consumidores recebem uma notificação, por uma tela de acompanhamento, informando que o entregador chegará ao local dentro instantes, e já podem se preparar para receber o pedido contribuindo para a eficiência no tempo de entrega. Ainda, na avaliação de entrega realizada pelo consumidor após utilizar a plataforma, um dos pontos considerados é o desempenho da entrega. O outro ponto considerado é a qualidade do produto.

Quando se discute tecnologia relacionada à logística urbana, deve-se também analisar aspectos relativos à informação e comunicação, influenciados por sistemas de telecomunicações e de gerenciamento de informações (Barbosa et al., 2007).

Pode-se destacar o sistema de telecomunicações da “Entrega Delivery”, uma vez que os clientes são avisados quando o pedido é processado, quando está sendo produzido, quando é despachado e está a caminho. O responsável pelos pedidos do restaurante ainda recebe uma mensagem automatizada de SMS caso o primeiro status do pedido não seja alterado após determinado período, indicando que seu preparo foi iniciado. Isto diminuiu em 70% a ocorrência de interação humana de suporte para resolver problemas operacionais.

O sistema de gerenciamento de informações da “Entrega Delivery” age de forma positiva na eficiência das operações de delivery, pois tanto usuários quanto restaurantes são avaliados pelo sistema. Esse permite a tomada de decisão quando há avaliações negativas ou críticas em relação ao restaurante, problemas na atualização de status de pedidos ou problemas no pagamento por parte de consumidores, por exemplo. Restaurantes mal avaliados podem ser inativados de acordo com os feedbacks recebidos. O gerenciamento de informações também trabalha no sentido de auxiliar as vendas dos restaurantes, pois podem informar os hábitos de procura dos consumidores de cada bairro.

Por sua vez, a plataforma desenvolvida pela empresa “JáTá Chegando” também permite a análise do desempenho de entregas, devido à possibilidade de monitorar o entregador e verificar a velocidade de circulação do mesmo, além do tempo de entrega. Outro serviço que contribui com o desempenho de entregas é o otimizador de rotas, que fornece ao entregador o melhor traçado entre os pontos de entrega. A funcionalidade de envio de SMS para os clientes quando a entrega é iniciada e quando o entregador está próximo ao local também aumenta a assertividade dos deliveries, contribuindo para a eficiência do *Last Mile Delivery*. O sistema de monitoramento e envio de mensagens SMS também deve ser ressaltado como um sistema de telecomunicações que apoia as atividades logísticas, permitindo a comunicação de dados relevantes entre clientes e estabelecimentos comerciais.

Apesar de já realizar algumas atividades de gerenciamento de informações, esta operação se apresenta como uma oportunidade para a “JáTá Chegando”, devido à grande quantidade de dados obtidos. Além das transportadoras, um dos maiores nichos atendidos por essa empresa é o sistema de bike courier. Empresas que utilizam este tipo de entrega computam a quantidade de quilômetros pedalados por mês de forma a ressaltar a redução na emissão de CO_2. O gerenciamento de informações também apoia a contabilidade de pedidos monitorados com a plataforma. Uma nova funcionalidade, solicitada por transportadoras, permite que a prova da entrega seja realizada, possibilitando o gerenciamento de pedidos não completos.

2.3. Sustentabilidade

Estratégias sustentáveis podem não só atuar na redução de custo, mas também se apresentar como vantagem competitiva por aspectos de marketing (Boudoin *et al.*, 2013). Ao se estudar sustentabilidade no transporte de cargas, três variáveis são essenciais: impacto ambiental, impacto social e impacto econômico (BESTUFS, 2007).

A “Entrega Delivery” fomenta modelos sustentáveis de entrega com modelos híbridos, devido à ganhos no impacto ambiental e mobilidade, de acordo com a região. Entregas próximas podem ser realizadas via bicicleta, e entregas com distâncias maiores com veículos motorizados. Com esta prática, pode-se reduzir a emissão de CO_2, NO_x e material particulado, que são os principais responsáveis por problemas causados na saúde de indivíduos e preponderantes de veículos de carga, impacto social importante (CETESB, 2011). A “JáTá Chegando” também gera valor em atividades de bike courier, serviço de transporte que também contribui para o meio ambiente com a redução na emissão de gases, em função da menor quantidade de veículos pesados circulando nas cidades.

Como impacto econômico deve-se observar a sinergia das plataformas com o e-commerce, e sua relação com o aumento na demanda de entrega de mercadorias em centros urbanos. Segundo Yoshimoto e Nemoto (2005), a internet ocasiona em um aumento nas transações B2C, o que leva à uma demanda por transporte.

O novo metabolismo urbano, abordado por Lima (2011), também é importante para as operações da “JáTá Chegando” e “Entrega Delivery”. Há um aumento na quantidade de entregas fracionadas, compras em menor escala, e que consequentemente exige um melhor planejamento de transporte.

2.4. Políticas Públicas e Governança

A colaboração entre os diferentes atores envolvidos na logística de cargas contribui para a melhora na qualidade de vida em centros urbanos (Crainic et. al, 2009; Dablanc 2007).

A empresa “Entrega Delivery” estabelece um relacionamento entre consumidores e restaurantes. É um sistema colaborativo, pois os restaurantes ajudam a validar os dados dos clientes, evitando assim trotes, por exemplo. Consumidores são beneficiados com as avaliações de outros consumidores pois podem consultar o desempenho dos restaurantes. Através de seu gerenciamento de informações, a empresa ainda pode contribuir com as campanhas de promoções fornecidas pelos restaurantes, de acordo com a demanda observada na região.

A empresa “JáTá Chegando” apresenta um relacionamento colaborativo com empresas para desenvolvimento da plataforma com solicitação de funcionalidades. O relacionamento com consumidores só ocorre no monitoramento das entregas, com possibilidade de rastreio de entrega e envio de SMS.

Com relação às políticas públicas, há uma lei que regulariza o tipo de moto que deve ser utilizada, além de um curso obrigatório para motoboys, porém a verificação na região não é eficaz. Contudo, a responsabilidade pelo cumprimento desta regulamentação é de quem realiza o transporte, ou seja, não cabe às empresas analisadas.

2.5. Modelo de Negócio e Viabilidade Econômica

Um modelo de negócios tem como finalidade identificar como o negócio pode obter lucro (Betz, 2002). Ainda, Patier (2010) ressalta a importância de se considerar variáveis econômicas na análise de inovações.

Para a “Entrega Delivery”, o custo mais significativo é o custo de suporte aos restaurantes. O modelo de negócio da empresa visa a alta retenção de consumidores que utilizam a plataforma, uma vez que o lucro se dá através de um percentual em relação ao preço da compra na plataforma, e o rápido suporte aos restaurantes é uma importante diferenciação do produto. O modelo é escalável, e não há um limitador significante para adicionar novos restaurantes no sistema.

A “Entrega Delivery” atua em Campinas, Americana, Indaiatuba, Belo Horizonte, Natal, João Pessoa, Manaus e Maringá. As cidades são escolhidas de acordo com os seguintes critérios: população superior à 1 milhão de pessoas; ao menos 20% da população da cidade deve ter pelo menos uma renda-alvo específica, de forma a garantir uma quantidade expressiva da população com acesso à internet; e cidades com uma quantidade de estabelecimentos alimentícios significativa. Apenas a cidade de Maringá foge deste modelo, em função de facilidade comercial, e João Pessoa e Manaus foram adicionadas devido a um requerimento individual de restaurantes da região. O modelo foi validado em Campinas, e expandido para as outras cidades. A maior parte destas informações foram coletadas no banco de dados do IBGE.

Os principais clientes da “JáTá Chegando” são o segmento de Bike Courier, transportadoras, entregas de farmácias de manipulação, padarias e clubes de assinaturas para entregas de produtos orgânicos, e não há limite de capacidade do sistema para o cadastro de empresas clientes e usuários. Novos segmentos visados são transporte escolar com rastreamento de vans; e empresas com serviços para pessoas com dificuldade de locomoção, de forma que a localização da van que realizará o atendimento seja conhecida.

Há a possibilidade de empresas realizarem cadastro no site do “JáTá Chegando”, e a partir disso o contato inicial é realizado de forma a analisar a possibilidade de uso da plataforma. A presença geográfica é significativa, com monitoramento de entregas em Manaus, São Paulo, Recife, Fortaleza e Rio de Janeiro.

Custos de operação e implementação não foram significativos para a empresa “JáTá Chegando”, uma vez que os sócios já possuíam os equipamentos de TI necessários para operação. A empresa adquire lucro através da quantidade de pedidos rastreados pela plataforma. A avaliação de satisfação de clientes ainda não é realizada, porém é um objetivo da empresa.

2.6. Dificuldades na implementação

Inicialmente, imaginava-se que uma plataforma eficiente deveria ser o aspecto mais importante, então seria necessário um determinado expertise para seu desenvolvimento.

Atualmente a plataforma da “Entrega Delivery” é resultado de uma metodologia bem elaborada. O desenvolvimento da plataforma, caso o modelo da mesma já estivesse estruturado, poderia ter sido terceirizado. Assim, o relacionamento com os restaurantes e consumidores foi essencial, para que a estrutura da plataforma atendesse à demanda e necessidade dos potenciais clientes e consumidores e fosse aceita pelo mercado.

Uma das dificuldades encontradas é a falta de valor dado por empresas na importância da melhoria do desempenho de entregas, além da visão do benefício que este sistema pode trazer em relação ao custo de uso da inovação. Além disso, a aceitação de inovação e novas tecnologias se apresentam como obstáculos para “JáTá Chegando”. A falta de infraestrutura de tecnologia no Brasil também foi citada, devido às dificuldades técnicas como perda de sinal 3G ou GPS, que atrapalham o monitoramento em tempo real da localização do entregador. Esta localização não é perdida, e o traçado é realizado pela plataforma após recuperação de sinal.

Considerações Finais

A logística urbana apresenta operações de alta complexidade, principalmente devido às restrições impostas pelo poder público, aos congestionamentos e à alta dispersão de pedidos nas cidades. A maior dificuldade é aliar soluções de operações eficientes, de baixo custo, sem impactos ambientais e sociais. O novo metabolismo urbano, abordado por Lima (2011), tornou estes desafios ainda mais críticos. Dutra et. al (2006) citam o problema da última milha, causado pelo número de viagens extras até a consecução do objetivo de entrega das mercadorias. Essa dificuldade é evidenciada em centros urbanos pois, com o aumento de entregas discorrido por Lima (2011), a quantidade de remessas que não são realizadas com sucesso é maior.

Assim, percebe-se uma dificuldade no atendimento de novas demandas por parte dos clientes, que reivindicam a melhoria dos serviços logísticos. Contudo, o desenvolvimento de novas tecnologias pode auxiliar na mitigação dos problemas oriundos da logística de cargas. É neste contexto que as empresas "Entrega Delivery" e "JáTá Chegando" foram criadas, e possibilitam contribuições nestas operações. Dentre os principais benefícios, pode-se citar o aumento da assertividade em transações B2C, o aumento na confiabilidade de entregas e conveniência, uma vez que permite que o consumidor evite congestionamentos e problemas de acessibilidade nos centros urbanos.

A tabela abaixo apresenta um resumo da análise da prática logística desempenhada pelas duas empresas, que possuem grande sinergia em suas operações.

Prática Logística	**Tecnologia**
• Manutenção de informações • Processamento de pedidos • Transporte – otimização de rotas	• Desempenho de entregas • Qualidade do produto • Sistema de telecomunicações • Gerenciamento de informações
Sustentabilidade	**Políticas Públicas e Governança**
• Redução de emissões – impacto ambiental • Novo metabolismo urbano – impacto social • Aumento em transações B2C – impacto econômico	• Intermediária no relacionamento entre consumidores e empresas
Modelo de Negócio e Viabilidade Econômica	**Dificuldades na implementação**
• Custo: equipamentos de TI • Viabilidade econômica depende da quantidade de deliveries na região de atuação	• Falta de infraestrutura de tecnologia no Brasil – sinal de 3G ou GPS • Levantamento de necessidades de potenciais clientes das plataformas

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SATELLITE PLATFORM AS SOLUTION FOR URBAN LOGISTICS - PONTO DE APOIO COMO SOLUÇÃO PARA DISTRIBUIÇÃO DE CARGAS EM CENTROS URBANOS

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RESUMO
Este trabalho avaliou o impacto da implantação de um ponto de apoio no dimensionamento da frota necessária para a distribuição de bebidas no centro de Campinas/SP. Os resultados demonstram que o uso de duas motos e duas vans para a distribuição dos pedidos de menor volume a partir do ponto de apoio é suficiente. Esta medida reduz em aproximadamente um terço a quantidade de VUCs que circulam no centro da cidade para esta operação, além de atenderem 77,86% dos pedidos diários da região. A grande contribuição desta proposta, com a redução do número de veículos pesados que circulam no centro, é diminuir os congestionamentos causados pelos caminhões, além da emissão de gases poluentes.

ABSTRACT
The purpose of this paper is the sizing of the vehicle fleet required for the distribution of beverages in Campinas/SP downtown from the implementation of a support point. The results show that two motorcycles and two vans are required for the distribution of the smaller orders of beverage. This measure can reduce approximately one third of the trucks required for the operation, and attend 77,86% of the diary orders. The contribution of this proposal, with the reduction of heavy vehicles in Campinas/SP downtown, is to diminish congestion and the emission of pollutants, caused by trucks.

1. INTRODUÇÃO

O transporte de mercadorias em centros urbanos enfrenta grandes desafios. Dois aspectos fundamentais enfrentados nas operações de transporte de carga são os congestionamentos e as deficiências de infraestrutura nos pontos de carga e descarga. A eficiência das operações é prejudicada por congestionamentos, pois muitas cidades possuem sistema viário inadequado. O tráfego de caminhões é visto como algo que deve ser estritamente regulado, sendo que a melhor solução seria organizá-lo de forma mais eficiente (Correia *et al.*, 2010; Sanches, 2008)

A maior dificuldade é aliar soluções de operações eficientes, de baixo custo, sem impactos ambientais e sociais. O novo metabolismo urbano, abordado por Lima Jr (2011), tornou estes desafios ainda mais críticos. Nota-se um maior número de compras em menor escala, o que aumenta o número de entregas a serem realizadas e exige um melhor planejamento de transporte. O novo metabolismo não se restringe às compras, mas também aborda o crescente uso do conceito *Just in Time*, que reduz o armazenamento de produtos e obriga uma maior eficiência na entrega (Dablanc, 2009).

O aumento de entregas em centros urbanos discorrido por Lima Jr (2011) agrava o problema da última milha, pois a quantidade de remessas que não são realizadas com sucesso aumenta. Assim, o número de viagens extras até a consecução do objetivo de entrega de mercadorias é maior. O melhor planejamento de entregas na área estudada é essencial, a fim de evitar tráfegos mais intensos (Dutra *et al.*, 2006).

Dificuldades de acesso também degradam a produtividade, já que os transportadores não conseguem cumprir prazos em função da inexistência de locais adequados para realizar as operações de carga e descarga. Dezi *et al.* (2010) retratam a importância da infraestrutura ao propor métodos para o adequado dimensionamento das zonas de carga e descarga, além de ressaltarem a importância de uma distribuição apropriada de vagas pela cidade.

A produtividade do sistema de transporte de cargas em centros urbanos depende de esforços conjuntos. O setor público é responsável pela infraestrutura, regulamentação e gerenciamento, enquanto que o setor privado desenvolve veículos adequados, realiza o transporte dos produtos e a implantação de terminais de carga. O desafio é aliar o interesse de ambas as partes, criando as condições necessárias para uma operação eficiente (PIARC, 2012; Patier *et al.*, 2010; Dablanc, 2007; Muñuzuri *et al.*, 2005).

Não existem soluções prontas ou fórmulas de sucesso para os diversos problemas oriundos do transporte de cargas no ambiente urbano. Qualquer estratégia escolhida para a mitigação destes problemas deve ser desenvolvida de acordo com as características de cada região. Deve-se estabelecer uma consonância entre os objetivos conflitantes dos diversos atores que compõem o ambiente urbano e participam do processo de distribuição de carga, como os varejistas, o poder público, transportadores, entre outros (Correia *et al.*, 2010; Crainic *et al.*, 2009).

Tendo em vista estes conflitos, a participação de todos os *stakeholders* nos grupos focais que resultaram no uso do ponto de apoio como solução para a distribuição de bebidas foi essencial. A metodologia de *Living Lab* proposta por Dias e Lima Jr (2014) tem se mostrado adequada para lidar com este tipo de conflito.

Pontos de apoio são Espaços Logísticos Urbanos Especialistas, uma vez que têm como finalidade atender regiões específicas e somente a atividade de transbordo é realizada. Esta operação não ocorre dentro de uma área de restrição para veículos de grande porte, e o transbordo é feito a partir de caminhões de maior capacidade. A partir do ponto de apoio veículos menores realizam a distribuição de mercadorias (Boudoin *et al.*, 2013).

O uso de pontos de suporte para distribuição de mercadorias em centros urbanos pode auxiliar na redução dos congestionamentos. Zonas urbanas densas necessitam de veículos menores para o transporte de cargas, que ainda podem contribuir com uma menor emissão de poluentes e ruído (Crainic *et al.*, 2004). A emissão de NOx e material particulado, principais causadores de impactos negativos na saúde dos indivíduos, é preponderante dos veículos pesados (CETESB, 2011).

Dentro deste contexto, o objetivo deste trabalho é o dimensionamento da frota necessária para a distribuição de bebidas no centro de Campinas/SP a partir da implantação de um ponto de apoio inserido no centro urbano. Esta operação foi simulada com auxílio do *software Promodel*, com uso da metodologia de modelagem e simulação de eventos discretos apresentada a seguir.

2. MODELAGEM E SIMULAÇÃO DE EVENTOS DISCRETOS

Simulação de eventos discretos é uma metodologia de simulação dinâmica, em que as variáveis do sistema se alteram em momentos distintos no tempo em função de um evento específico. Seus elementos podem ser descritos como: entidades, atividades, recursos e controles (Loureiro, 2014). A Figura 1 apresenta, através do ponto de vista do método, o sistema em estudo.

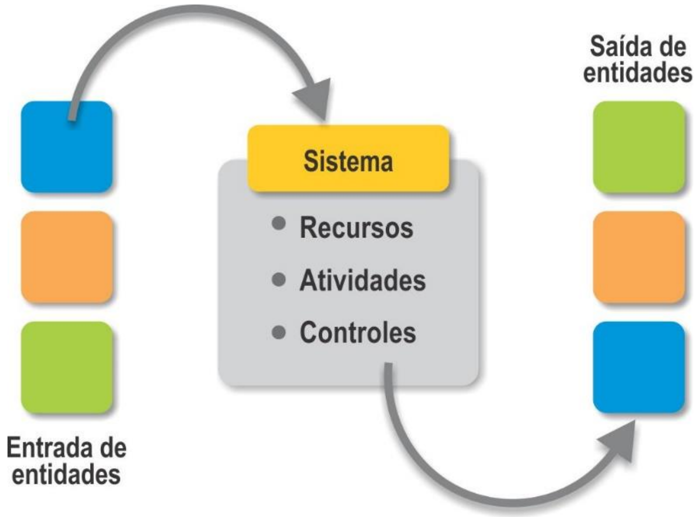

Figura 1: elementos do sistema (Harrell *et al.*, 2004)

Segundo Harrell *et al.* (2004) recursos são utilizados para a execução das atividades, e capacidade, tempo de ciclo, produtividade são suas características associadas. Além disso, modelos de simulação de eventos discretos também possuem elementos como variáveis globais, filas e relógio de simulação.

As características da simulação de eventos discretos o tornam ideal para modelar sistemas que podem ser representados por um processo ou sequência de operações, que apresentem forte variabilidade, definida por uma distribuição de probabilidade. É possível uma representação do modelo através do uso de funções pré-definidas e blocos de construção. Porém, deve-se atentar às limitações relacionadas às dificuldades de representação de processos complexos ou problemas de roteamento dinâmico e de agendamento (Loureiro, 2014).

Uma etapa importante da simulação e modelagem computacional é o teste do modelo em análise. Desta maneira, uma função de produção determinística da operação em estudo pode ser criada, de forma a comparar seu resultado para os parâmetros do contexto com o *output* da simulação através de um *software* adequado. Após o uso da função de produção para o teste do modelo de simulação, é possível alterar parâmetros do modelo de forma a encontrar a melhor solução para o problema analisado.

De acordo com Novaes (1986), a função de produção descreve os esquemas e máxima produção que podem ser definidos a partir de combinações diversas dos insumos. Uma função deste tipo relaciona os níveis de produção de um determinado sistema de transportes com variáveis básicas de natureza diversa: variáveis técnicas, operacionais e insumos diversos.

O estudo da função de produção para um sistema de transportes permite (Novaes, 1986):

- A comparação entre distintas alternativas de oferta de transporte para um determinado sistema;
- A análise dos possíveis ganhos de escala;

- A quantificação dos fatores físicos (insumos e produtos) para uma análise econômica (custos, receitas e valores).

3. METODOLOGIA

Para o dimensionamento de frota na implantação de um ponto de apoio que suporte a distribuição de bebidas no centro de Campinas/SP, optou-se pela metodologia de pesquisa de modelagem e simulação computacional de eventos discretos. A Figura 2 ilustra o fluxograma do procedimento adotado.

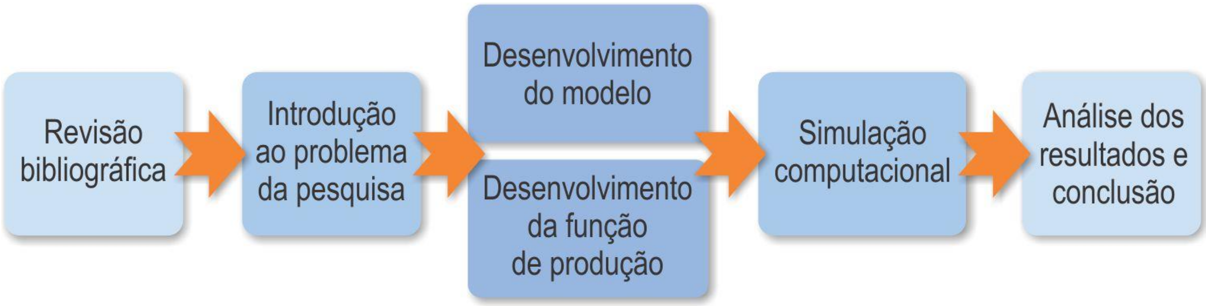

Figura 2: etapas do desenvolvimento da pesquisa

A revisão bibliográfica teve como finalidade identificar trabalhos que abordam o tema de logística urbana e que contribuam para o referencial teórico e motivação da pesquisa, além de definir conceitos básicos de modelagem e simulação de eventos discretos. Após esta etapa, o contexto do desenvolvimento da pesquisa foi descrito. Esta etapa possibilitou o correto delineamento do problema, além dos objetivos a serem atingidos.

A terceira etapa do trabalho é o desenvolvimento do modelo computacional, em que o método de modelagem escolhido foi a simulação de eventos discretos. O processo de desenvolvimento consiste na codificação do modelo conceitual desenvolvido na etapa anterior em uma linguagem computacional. Assim, são realizados experimentos, onde os parâmetros são alterados, o que possibilita que diferentes cenários sejam criados. Isso permite uma maior compreensão do sistema modelado, uma vez que pode-se observar os processos mais críticos do problema em estudo. O modelo foi testado com uma função de produção, para garantir sua aproximação com a realidade analisada.

3.1 Aplicação da metodologia

O setor de bebidas foi escolhido por representar um segmento crítico, com transporte de grandes volumes em uma operação complexa. Nesta operação as cargas se deslocam do centro de distribuição com caminhões toco até o ponto de apoio, a partir de onde são distribuídas por motos e vans, de acordo com o tamanho do pedido feito pelo estabelecimento comercial. Os maiores pedidos ainda são transportados com VUCs, a partir do centro de distribuição. Este sistema foi modelado com auxílio do *software Promodel*.

Para analisar a logística da entrega de bebidas no centro de Campinas/SP, os estabelecimentos comerciais que trabalham com bebidas foram localizados. Uma pesquisa de campo foi realizada, com a finalidade de avaliar as necessidades de melhoria da operação. A Figura 3 ilustra a área de estudo demarcada. Nesta etapa, um questionário foi aplicado de forma a caracterizar os estabelecimentos e suas operações de recebimento de bebidas. Entender a estrutura operacional do processo de carga e descarga foi de suma importância.

Figura 3: área de estudo – região destacada

Os resultados da pesquisa de campo foram apresentados por Castro *et al.* (2014), e estão representados na Figura 4. Um total de 183 estabelecimentos foram mapeados, e destes apenas 144 foram considerados válidos pela pesquisa de campo. Dos estabelecimentos comerciais que responderam ao questionário (45%), aproximadamente 65% recebem de 1 a 3 entregas de bebidas por semana. Evidenciou-se a falta de vagas públicas para descarga de mercadorias, além de demonstrar uma concentração de entregas de bebidas por dois fornecedores. Das oportunidades de melhoria identificadas, as mais citadas foram a falta de horário determinado, a baixa qualidade de atendimento dos entregadores e problemas comercias ou de entrega.

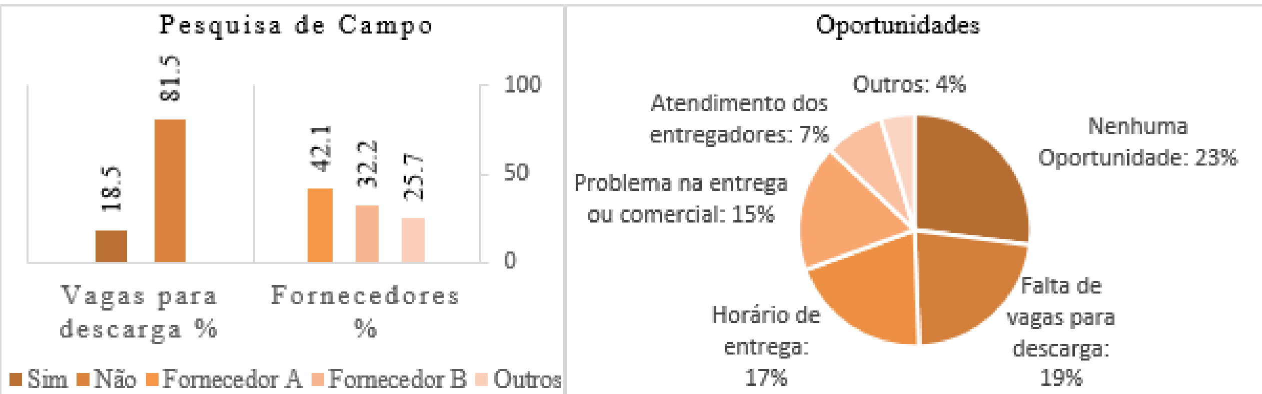

Figura 4: dados referentes à pesquisa de campo (Castro *et al.*, 2014)

Em um projeto desenvolvido por Dias e Lima Jr (2014), com uso da abordagem de *Living Lab*, reuniões focais foram realizadas de forma a identificar o que o usuário valoriza no processo de distribuição de bebidas, explorar suas principais necessidades e estimular ideias construtivas. Fornecedores de bebidas, representantes de estabelecimentos comerciais, duas

empresas de tecnologia e a prefeitura de Campinas/SP estiveram presentes nas reuniões desta etapa, em que os problemas enfrentados na operação e possíveis soluções foram discutidos.
As reuniões focais permitiram não somente uma melhor caracterização da entrega de bebidas, como também sugestões de inovações que devem ser estudadas para futura implantação. Pontos positivos apontados em relação à operação foram praticamente inexistentes. Observou-se um relacionamento deficiente dos estabelecimentos e entregadores com os agentes da prefeitura, expressos em reclamações sobre falta de tolerância dos mesmos. Confirmou-se a falta de padrão nas entregas, sem horário definido, e a falta de infraestrutura da região, com poucas vagas para descarga de mercadorias. O despreparo dos entregadores e de quem atende os estabelecimentos também foi citado. Possíveis soluções foram apontadas, decorrentes de casos de sucesso em outras cidades. Entre elas, a implementação de um ponto de apoio para descarga de caminhões, com posterior distribuição através de veículos menores, solução foco deste trabalho.

4. ATIVIDADES DESENVOLVIDAS

4.1. Função de Produção

O objetivo desta seção é determinar a função de produção da frota de distribuição de mercadorias após o recebimento das cargas no ponto de apoio. Segundo Novaes (1986), os parâmetros e variáveis necessários para a definição de uma função de produção são:

- Q – produção do sistema;
- H – jornada de trabalho;
- N – número de veículos em operação efetiva;
- V – velocidade média de tráfego (km/h);
- A – ano operacional, igual ao número médio de dias de operação efetiva do sistema por ano;
- W – capacidade útil de um veículo;
- Tc – tempo de ciclo.

A variável "A" não será considerada no cálculo da função de produção para que seu resultado possa ser equiparado com o resultado da simulação, o qual considera apenas um dia de simulação. A finalidade do modelo é avaliar quantos veículos são necessários para a distribuição efetiva das mercadorias a partir do ponto de apoio. Assim, as seguintes etapas foram contempladas no cálculo da função de produção:

- Cálculo do tempo de ciclo;
- Cálculo do número médio de ciclos por dia;
- Cálculo da quantidade de veículos necessários, com a produção diária conhecida.

Para o cálculo das variáveis citadas, foi necessária a determinação de alguns parâmetros, obtidos através do contato direto com uma das principais distribuidoras de bebidas da região.

4.1.1. Cálculo do tempo de ciclo

A média dos tempos de carregamento e conferência, deslocamento e entrega foram definidos para o cálculo do tempo de ciclo:

- Carregamento e conferência dos veículos: 14 minutos para motos e 80 minutos para vans;

- Deslocamento total: 23 minutos para motos e 122 minutos para vans;
- Entrega: 12 minutos para motos e 16 minutos para vans.

Assim, o tempo de ciclo é:

$$Tc_{moto} = 14 + 23 + 12 = 49\ minutos \quad (1)$$

$$Tc_{van} = 80 + 122 + 16 = 218\ minutos \quad (2)$$

4.1.2. Cálculo do número médio de ciclos por dia

O cálculo do número médio de ciclos por dia (m) pode ser definido como a razão entre a jornada de trabalho (8 horas) e o tempo de ciclo:

$$m_{moto} = \frac{J}{Tc} = \frac{480}{49} = 9{,}80\ ciclos\ por\ dia \quad (3)$$

$$m_{van} = \frac{J}{Tc} = \frac{480}{218} = 2{,}20\ ciclos\ por\ dia \quad (4)$$

Como a quantidade de ciclos por dia deve ser um número inteiro, considera-se 10 ciclos por dia para motos e 2 ciclos por dia para vans.

4.1.3. Cálculo da quantidade de veículos necessários

Segundo Novaes (1986), a função de produção adaptada ao contexto analisado é:

$$Q = m \times N \times W \quad (5)$$

O valor de produção diária é calculado em função do número de pedidos que cada tipo de veículo é designado, e cada pedido recebe uma distribuição triangular para seu tamanho, ambos os dados fornecidos pela empresa.

Considerando o valor de produção diária e a capacidade dos veículos, além do tempo de ciclo calculado, foi determinada a quantidade de veículos necessária através da Equação 5. Como ambos os valores de N não apresentaram valores inteiros, uma aproximação foi realizada:

$$N_{moto} = 2\ veículos$$

$$N_{van} = 2\ veículos \quad (7)$$

4.2. Teste do modelo

Conforme citado na revisão bibliográfica, é necessário testar o modelo construído de forma a garantir a confiança e efetividade do mesmo. Assim, um modelo para o ponto de apoio foi construído através do *software* de simulação de eventos discretos *Promodel*. Uma das principais distribuidoras de bebidas da região forneceu os dados necessários para a construção do modelo de simulação. Para o teste do modelo, as médias dos tempos também foram utilizadas.

Na situação proposta, os caminhões toco levam a carga do Centro de Distribuição (CD) ao ponto de apoio no começo do dia. Os veículos que fazem a distribuição a partir do ponto de apoio chegam ao local no mesmo horário.

Ao chegar no ponto de apoio, os pedidos sofrem transbordo para os veículos menores, de acordo com o tamanho do pedido do cliente. Os veículos podem sair com um ou mais pedidos, dependendo da sua capacidade.

Para efeito de simplificação para a simulação, os clientes foram agregados em 3 tipos: Clientes Moto, Clientes Van e Clientes VUC, dependendo da quantidade de cubos em seus pedidos. A palavra “cubo” é utilizada pela empresa de distribuição como um pacote de bebidas. Os pedidos que são entregues por VUCs saem do CD e entregam direto aos clientes sem passar pelo ponto de apoio.

Para cada um destes 3 tipos de cliente foram fornecidos dados tratados pela empresa, em que a melhor curva de distribuição encontrada para os tempos de carregamento, deslocamento e entrega foi a triangular. Os dados são apresentados na Tabela 1.

Tabela 1: distribuição dos tempos de carregamento, deslocamento total e entrega por cliente por tipo de veículo de distribuição.

Tipo de Veículo	Tempo	Tempo estimado Carregamento e Conferência (minutos)	Tempo estimado deslocamento (minutos)	Tempo estimado de entrega/cliente (minutos)
	Mínimo	10	20	10
Moto	Moda	10	25	10
	Máximo	20	25	15
	Mínimo			8
Van	Moda	80	122	13.3
	Máximo			25
	Mínimo			25
VUC	Moda	80	105	25
	Máximo			100

A jornada de todos os motoristas é de 9 horas, sendo 8 horas úteis e 1 hora de descanso. Deve-se considerar os tempos de deslocamentos do CD aos pontos de apoio nesta jornada. As Tabelas 2 e 3 demonstram o resultado do teste, em que 2 veículos de cada tipo foram utilizados, quantidade suficiente dimensionada pela função de produção. A variável X representa o número de entregas que deveriam ser realizadas, e o conteúdo atual dos estabelecimentos com o mesmo valor demonstra que todos os cubos foram entregues.

Tabela 2: quantidade de cubos entregues nos estabelecimentos

Resumo do local			
Nome	**Tempo de simulação (horas)**	**Total de entradas**	**Conteúdo atual**
Estabelecimentos	24.00	X	X

Tabela 3: uso dos recursos – motos e vans.

Nome	Jornada de trabalho (horas, pausa excluída)	% de uso
Moto.1	8.04	57.58
Moto.2	8.04	57.58
Van.1	8.04	58.80
Van.2	8.04	29.16

Os dados obtidos na simulação demonstram o mesmo resultado da função de produção, fato que comprova a eficiência do modelo utilizado, uma vez que todos os cubos de bebida foram entregues durante a jornada de trabalho. Como a segunda Van apresentou um percentual de uso baixo, uma nova simulação foi realizada com apenas um recurso para este tipo de veículo, quantidade que não foi suficiente para a entrega de todos os cubos.

O modelo proposto, uma vez testado, permite o dimensionamento com uso das distribuições triangulares, fornecidas pela distribuidora de bebidas. Esta foi a melhor distribuição probabilística encontrada com os dados fornecidos pela empresa. Este processo garante um resultado mais preciso, pois as distribuições apresentam um intervalo de variabilidade alto. A próxima seção apresenta os resultados do uso do modelo para a situação proposta.

4.3. Dimensionamento da frota

Para garantir que a variabilidade dos resultados será analisada, 100 (cem) replicações da simulação foram realizadas. As Tabelas 4 e 5 apresentam o resultado da simulação com uso de dois veículos de cada tipo para a distribuição a partir do ponto de apoio, solução apontada pela função de produção.

Tabela 4: média da quantidade total de cubos entregues nos estabelecimentos, e média da quantidade de cubos transportados pelas motos e vans

Resumo do local (média)			
Nome	**Tempo de simulação (horas)**	**Total de entradas**	**Conteúdo atual**
Carregar moto	24.00	Y	0.00
Carregar Van	24.00	Z	0.00
Estabelecimentos	24.00	X	X

Tabela 5: uso dos recursos (média das replicações) – motos e vans

Nome	**Jornada de trabalho (horas, pausa excluída)**	**% de uso**
Moto.1	8.04	68.55
Moto.2	8.04	62.59
Van.1	8.04	91.91
Van.2	8.04	45.94

Os resultados, com um número maior de simulações, corroboram o resultado do teste e confirmam que a quantidade determinada pela função de produção foi adequada, e os veículos apresentaram um percentual de uso maior. A situação proposta prevê o uso de duas motos e duas vans para a distribuição de pedidos de menor tamanho, com entregas a partir do ponto de apoio, enquanto que os pedidos dos VUCs são transportados a partir do CD. Os locais “Carregar moto” e “Carregar Van” apresentaram a média do conteúdo atual no final do dia de operação igual a zero, o que confirma que em todas as replicações todos os cubos foram entregues.

5. CONCLUSÕES

O uso da função de produção determinística para dimensionamento de frotas é uma solução simples de ser aplicada, com a utilização da média dos tempos necessários. A simulação de eventos discretos, com a função de produção determinística como teste e posterior utilização de distribuições triangulares, possibilita resultados mais adequados à realidade uma vez que a variabilidade probabilística da operação é considerada.

Verifica-se que o projeto de implantação de um ponto de apoio de abastecimento inserido no centro da cidade possibilita a redução do número de caminhões que trafegam nessa área e de possíveis congestionamentos. A entrega com motos ainda minimiza a dificuldade de encontrar vagas de carga e descarga, detectada na pesquisa de campo e reuniões focais. O uso de um ponto de apoio para pedidos de menor quantidade possibilita a entrega de aproximadamente um terço do volume de bebida com apenas duas motos e duas vans. Além disso, 77,86% dos estabelecimentos receberiam seus pedidos em veículos mais leves, que ocupam menos espaço no ambiente urbano, proporcionam uma redução na emissão de poluentes (NOx e material particulado) e no nível de ruído. Assim, integra-se a cidade no sentido de reduzir os congestionamentos e aumentar a mobilidade, sem penalizar as atividades comerciais e a qualidade de vida da população.

O uso da metodologia de modelagem e simulação de eventos discretos se mostrou adequada ao estudo, uma vez que permite analisar facilmente diferentes cenários, com a mudança dos parâmetros do sistema. Além disso, possibilitou o dimensionamento do número de veículos necessários para a operação proposta.

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Identifying clusters to implement urban logistics best practices: the case of São Paulo

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Abstract

Cities have different characteristics, and policy measures applied in different urban areas can only result in different associated impacts. The purpose of this paper is to apply a data-driven methodology to identify clusters to guide São Paulo's urban logistics policy and practice decisions.
The methodology uses relevant variables for urban logistics – establishments' concentration, population, infrastructure (road capacity and road density), and regulation data – in order to perform two statistical analysis: Principal Component Analysis and K-means clustering. The results suggest segmenting the city into five different clusters, as a basis for further cluster-specific analyses and implementation of practices.

Keywords: Urban Logistics, City Logistics, Cluster, Last Mile

Urban Logistics challenges

Freight transport in urban centers generates a variety of economic, environmental and social negative impacts, and an efficient transportation planning system is required to have responsive and viable operations. Congestion affects the economy of the cities because of the waste of resources and inefficiency generated by them. The emission of pollutants, the use of non-renewable fuel and waste products such as tires and oil alter its surroundings, and are relevant environmental impacts. Social impacts such as the physical consequence of pollutants emission (diseases), the accidents resulting from traffic, the high noise levels, among others can be listed (BESTUFS, 2007).
Despite the negative impacts involved on its operations, cities depend on cargo transportation. City logistics plays an essential role in maintaining and retaining industrial and commercial activities, which are essential for major wealth generating activities, and for employing the population. Efficient freight transport operations increase the competitiveness of industry, and are critical to sustain the current life style in cities. Thus, urban logistics activities have to deal with conflicts between commercial interests and the urban environment (Dablanc, 2009).
City logistics faces critical challenges, and the necessity to balance efficient solutions, with associated environmental and social impacts. The new urban metabolism, with changes in consumption patterns and e-commerce penetration, has made these challenges even more critical: there is a higher number of purchases to a lesser extent, which increases the number of required deliveries and needs a better transportation planning (Lima Jr., 2011). This new metabolism is not restricted to shopping, and addresses other supply chain activities, such as the growing adoption of the Just in Time concept, which reduces the storage of products and requires a greater efficiency in services (Dablanc, 2009).
The increase in urban logistics operations approached by Lima Jr. (2011) exacerbates the last mile challenge, because of the increased number on unsuccessful deliveries, especially on B2C (Business to Consumer) operations. Thus, cities are experiencing a higher number of trips to the achievement of freight deliveries, fact that contributes to all negative impacts aforementioned. Therefore, the better planning of city logistics activities in a specific study area is essential in order to avoid more intense traffic (Dutra, 2004).

There are no global solutions or success formulas for the various challenges arising from freight forwarding in the urban environment. To mitigate these problems, the public officials and private sector operators should develop solutions or strategies according to the characteristics of each city and region. To achieve this, they also need to consider potentially conflicting objectives from the various stakeholders that influence the freight distribution process, such as retailers, government agencies, carriers, logistics operators, among others (Crainic et al., 2009).

Several logistics practices have been introduced to address the challenges of city logistics. However, cities have different characteristics, and policy measures applied in different urban areas can only result in different associated impacts. Thus, it is essential to consider urban-specific characteristics to enhance the transferability and sustainability of urban logistics solutions (Alho and Silva, 2015).

The objective of the project is the application of a proposed data-driven methodology in the city São Paulo, Brazil, to identify logistics clusters that could inform the implementation of urban logistics best practices in the city. With a better understanding of the city's sub-areas, it is expected that the study will help to rationalize city logistics planning by identifying solutions that are consistent with São Paulo's urban logistics characteristics.

Cluster Theory Analysis

Clusters are the origin of cities – trade fairs grouped and facilitated the trade of products and provided security, in which cities grown and thrived thereafter. A definition of clusters states it as a grouping of similar things, such as geographical factors, type of business, or business relationships along the supply chain (United Nations, 2007). The cluster boundary delineation if often imprecise, and, according to Porter (1998), "a cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities."

Clustering activities dates back to Aristotle, and is one of the most primitive and important activities of human beings (Jian and Chen, 2009). Cluster theory analysis facilitates the exploration of natural or hidden data structure and groups commonalities in a set of data objects, aiding on the development of insights regarding the studied area.

There is no defined pattern to the dimensions analysed and how to measure these dimensions on cluster theory studies, and researchers developed various methods with the purpose of developing cluster theory analysis. Company's size, its internal structure, transport, communications, other technologies, infrastructure data, demographic data, cultural influences, among others, affect the process of clustering (United Nations, 2007). It is clear that the cluster theory methodology is not new. However, its application in distinct study fields, besides its existence in various regions of the world, with different objectives, highlights the applicability of the study. The next section presents the cluster theory analysis methodology adopted on this project.

Methodology

The research study follows the methodology described in Ponce-Cueto et al. (2015): (1) Collection and processing information, in which we collected demographic, socioeconomic, regulation and infrastructure data from secondary database and using Geographic Information Systems. (2) Statistical analysis, mainly principal component analysis (PCA) and k-means clustering analysis. (3) Logistics clusters identification – a categorization of different areas of the city according to urban logistics characteristics. (4) And; finally, general recommendations for public policy aiming contributions for urban freight mobility (Ponce-Cueto et al., 2015). Figure 1 represents the data-driven methodology.

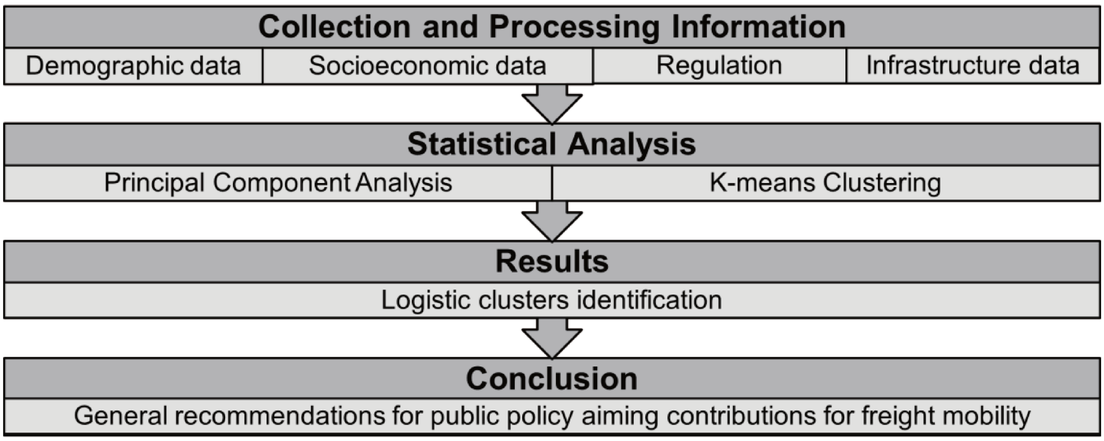

Figure 1. Data-driven methodology (Ponce-Cueto et al., 2015)

We collected all variables following a segmentation of the city into one square-kilometer areas. We gathered the demographic and regulation data from the city's prefecture official website (Prefecture of São Paulo, 2015). The following infrastructure variables were defined and processed using Open Street Maps (Ponce-Cueto et al., 2015):

- Road density, measured by the number of the road's intersection;
- Road capacity, measured by the total road length and weighted with a capacity factor based upon the number of lanes.

Regarding the socioeconomic data, we used secondary databases to identify the number of establishments per industry segment (accommodation and foodservice, wholesale, retail and repair of vehicles; services, and manufacturing), per sub prefecture. Since this is the only variable that did not have the desirable precision (sub prefecture level instead of square kilometer level), we considered two approaches: (1) uniform distribution of the establishments from a sub prefecture level to the square kilometers, and (2) distribution of the establishments weighted by population density. The final selection of the approach was determined based on the results that provided a clearer cluster segmentation.

We processed the collected variables in two statistical analysis: Principal Component Analysis (PCA) and k-means clustering analysis. PCA allows grouping all variables or dimension of a data set in main components, to facilitate subsequent analysis. K-means clustering is a technique used to group observations based on the values obtained for the main components. Each category includes observations that share certain features or similarities, according to the values of its variables or main components (Grus, 2015).

In summary, the approach of the data-driven methodology allowed the interpretation of urban clusters in São Paulo city, with the segmentation of the city into squares of one square kilometer. With a better understanding of the city's sub-areas, the study will inform policy recommendations that match with São Paulo's urban logistics characteristics. The link between the city's specific urban form, population information, economic census, infrastructure data and logistics activities will contribute to design better solutions for urban logistics policy and practice.

Statistical Analysis

Principal Component Analysis

The input variables of the first approach were population, road density, road capacity and establishments' concentration. The establishments' concentration were divided into four segments: Accommodation and foodservice; Wholesale, retail and repair of vehicles; All services, and; Manufacturing.

The input variables of the second approach were the same from the first approach, with different values for the establishments' concentration. Instead of applying uniform distribution for the division of the establishments from a sub prefecture level to the one square kilometer level, we applied weighted distribution following the correlation between establishments' concentration and population and road capacity.

K-means Clustering

According to Pham et al. (2005), k-means algorithm is a popular data-clustering tool, and gives as output the K optimal number of clusters and its division. We adopted the F-Statistic for selecting the optimal number of clusters. Since the optimal statistical number (K optimal) is not necessarily the best representation of the city, and the code used allows increasing K optimal giving new clustering distributions as output, we tried the following values for k for each scenario: K optimal, K optimal + 1, K optimal + 2, and K optimal +3. After analysing the clusters map output for each K value, we selected the most representative for each scenario. The next step consists of a further analysis in order to select the most representative cluster map for São Paulo city.

The most representative clusters map chosen for scenarios (1) and (2) are almost equal, and have five clusters. Since both maps are similar, and we adopted correlation between variables for the weighted distribution approach, we chose the first scenario to illustrate the city, as correlations do not necessarily imply a causal relationship.

Results

We normalized the data from each cluster, in order to analyze its logistics profile. Table 1 presents the data on the real and normalized scale and Figure 2 illustrates the clusters map.

Table 1: Real and normalized clusters' results.

	Cluster	Population	Road capacity	Road density	Wholesale, retail and repair of vehicles	Accommodation & food service	All services	Manufacturing
average	0	29117.88	29.48	99.01	69.85	67.05	289.46	14.09
average	1	15549.04	33.00	101.84	216.48	218.88	995.83	41.16
average	2	3428.88	10.13	28.52	12.28	10.55	42.66	2.33
average	3	10626.66	29.71	120.83	27.75	22.86	93.95	5.53
average	4	23074.57	40.47	112.43	571.00	519.00	2524.00	102.00
	total	81797.03	142.78	462.63	897.37	838.35	3945.90	165.11
normalized	0	0.36	0.21	0.21	0.08	0.08	0.07	0.09
normalized	1	0.19	0.23	0.22	0.24	0.26	0.25	0.25
normalized	2	0.04	0.07	0.06	0.01	0.01	0.01	0.01
normalized	3	0.13	0.21	0.26	0.03	0.03	0.02	0.03
normalized	4	0.28	0.28	0.24	0.64	0.62	0.64	0.62

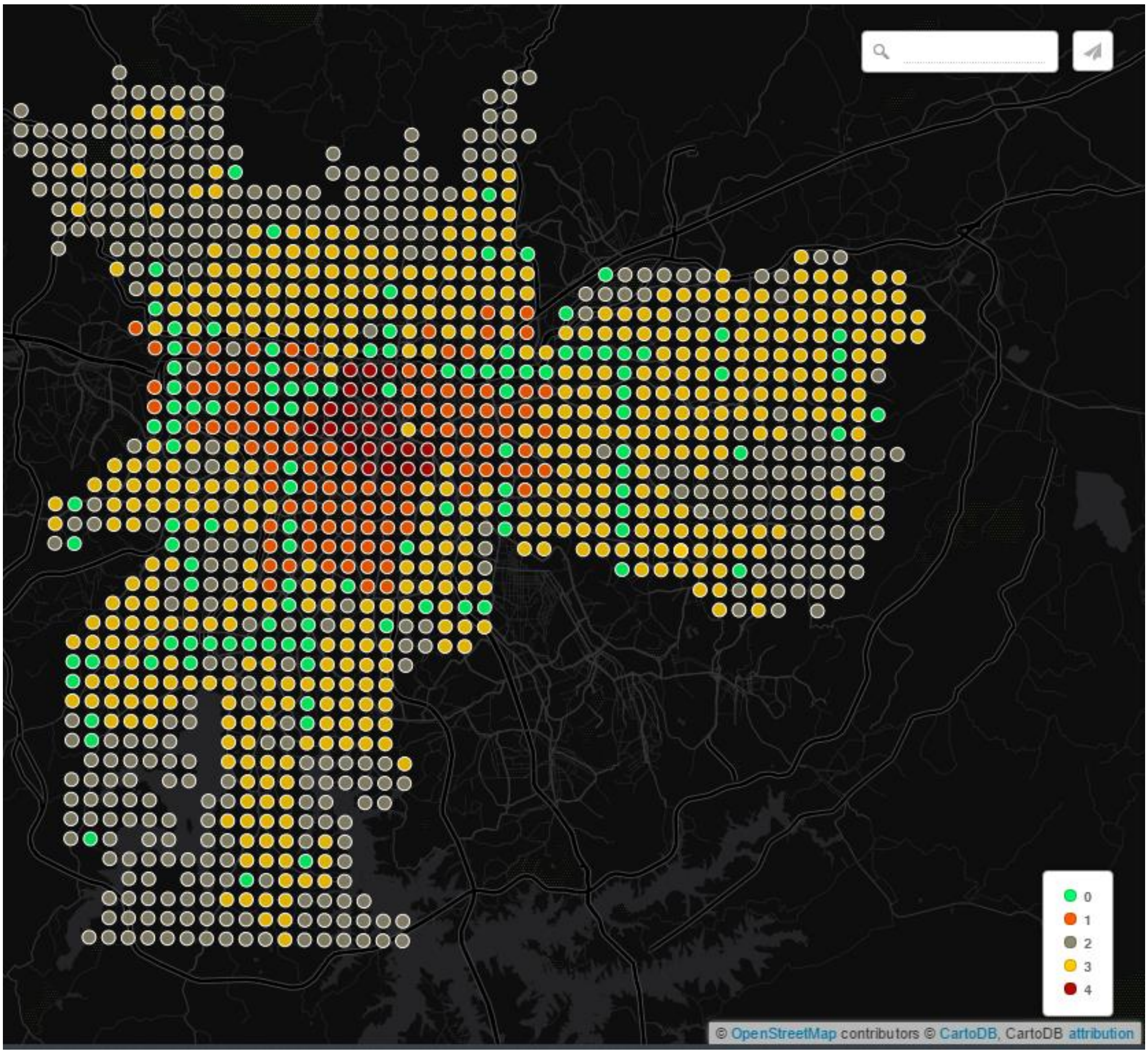

Figure 2: São Paulo clusters map

High-density Residential zone

Cluster number 0 presents the highest population normalized value, with a demographic density of almost 30,000 people per square kilometer. This cluster has low establishments' concentration (between 0.07 and 0.09 on normalized data) and average infrastructure values for both road density and road capacity. Thus, it is a residential zone.

Critical zone for urban logistics

Cluster number 1 presents an average value for population, with 0.19 as normalized value. It has the second higher establishments' concentration, with normalized values between 0.24 and 0.26. Although presenting similar normalized values, the services segments represent more than half of the establishments. The cluster has average infrastructure data, with normalized values lower than the establishments' concentration, and is inside the restriction zone (urban trucks allowed). Thus, this cluster is a critical zone for urban logistics activities.

Peripheral zone

Cluster number 2 has the lowest normalized values for population, establishments' concentration, road density and road capacity. However, it has the second bigger area, when compared to the other clusters. It is a peripheral zone, with low economic activities.

Low-density residential zone

Cluster number 3 has a low normalized value for population density (0.13) and for establishments' concentration (between 0.2 and 0.3 on normalized data). However, this cluster presents high road density and average road capacity normalized values. In addition to the infrastructure data, it is practically outside the restriction zone, and therefore, represents a zone with high growth potential.

Central area

Cluster number 4 presents a high population density: 23074.57 inhabitants per square kilometer, with a normalized value of 0.28. This cluster contains the higher commercial activity, with a normalized value higher than 0.6 for every studied segment. Despite having its infrastructure values above average, they do not stand out as much as population or establishments' concentration. This cluster is inside the restriction zone (urban trucks allowed). Figure 12 presents its logistics profile.
This cluster represents "Sé" sub prefecture. It corresponds to the oldest occupied area of São Paulo city, initiated on the XVI century, and is known as the "old downtown". The inhabitants' are leaving this region over time, but as the logistics profile shows, it is still a high-populated zone. The cluster concentrates low-income population.
Figure 3 illustrates the clusters' characteristics, according to the studied variables.

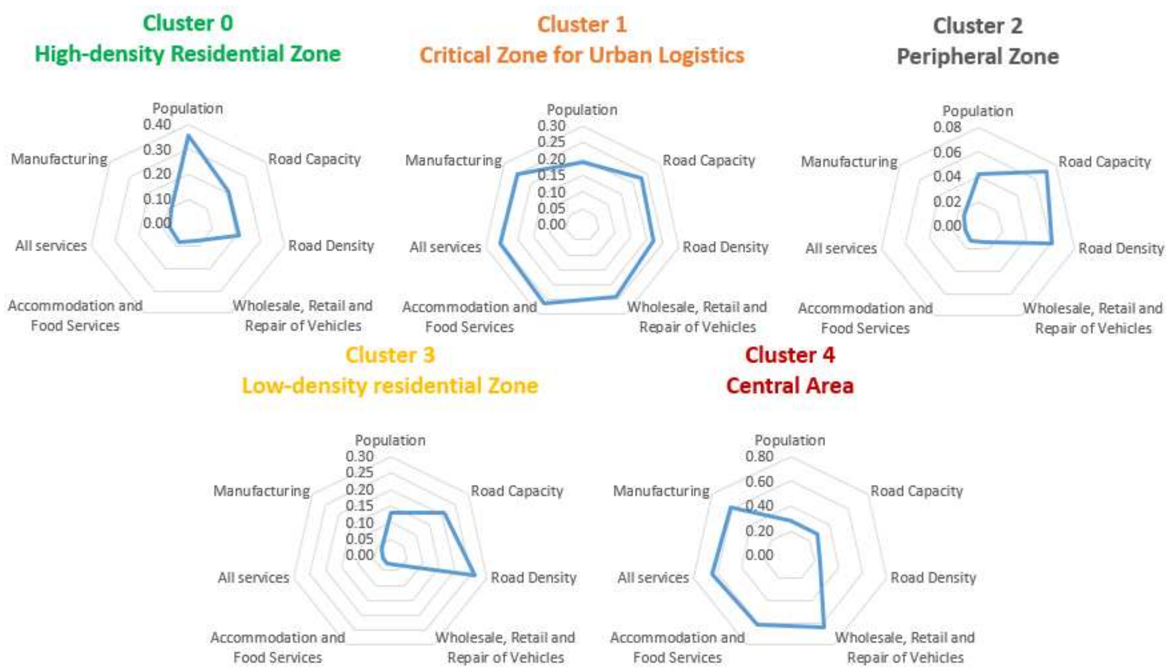

Figure 3: Clusters' characteristics

Public policy and general recommendations

São Paulo's segmentation into five different clusters presents a contribution to city logistics planning, and we will discuss some insights with the presented results, aiding outcomes specially to the last mile challenge (Table 2).

Table 2: Recommendations for each analysed cluster.

Cluster (0)	High-density Residential Zone	In residential areas, policies providing vehicles speed and noise control are important to ensure adequate levels of life quality and safety. Public policies adequate to this region could also improve last mile delivery assertiveness, specifically B2C deliveries. Further, cluster-specific analyses are suggested for the proposal of specific solutions.
Cluster (1)	Critical zone for urban logistics	There is a lack of accessibility due to low road density in comparison with establishments and population concentration, and for being inside the restriction zone. Investments in infrastructure are essential, and urban distribution centers can aid on freight consolidation.
Cluster (2)	Peripheral zone	We recommend public policies aiming the economic development of the region. Infrastructure development is also required, with focus on ensuring accessibility from logistics centers/industrial zones to residential/commercial areas. Slums concentration.
Cluster (3)	Low-density zone	No infrastructure constraints, since establishments and population concentration are low when compared to road density and capacity. The zone has a high potential for economic growth.
Cluster (4)	Central zone	Very high concentration of commercial establishments and population. The cluster is known as "old downtown" and is inside the restriction area. A satellite platform can be a great solution for freight forwarding in central areas, as well as the provision of infrastructure such as delivery bays for parking VUC's is critical. The use of delivery windows for freight forwarding in this area may also be explored. For companies, night deliveries can be an option to improve operational efficiency levels due to low traffic levels at night. Further studies are needed to development of solutions.

Conclusions

The study presents a cluster-based data-driven methodology applied in São Paulo city, to identify urban clusters related to city logistics.

Out of the five identified clusters, two of them are inside the restriction zone for heavy vehicles: the most critical areas for urban logistics. In addition, the cluster with the higher economic activities is on São Paulo's "old downtown", with more than 60% of the city's establishments (all segments). We presented freight consolidating strategies as adequate solutions for both clusters. Solutions such as night deliveries and implementation of delivery windows can also be explored, although further studies are required. Regarding the residential area, strategies aiding B2C deliveries should be adopted, increasing last mile delivery assertiveness. We classified the other regions of the city as low-density zone for urban logistics, due to the available infrastructure, and peripheral zone, with opportunities on ensuring accessibility between logistics centers/industrial zones and residential/commercial areas.

Based on the results, we can conclude the quantitative methodology is efficient on analyzing urban centers, since the provided clusters are a good representation of the city, with important insights when studying freight mobility. Further studies should focus on evaluating the feasibility of proposed solutions in specific clusters as well as including additional variables, such as Human Development Index and percentage of taxes over services, to explore the impact in the cluster generation.

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Cluster analysis and Focus group: integrating Qualitative and Quantitative approaches on addressing city logistics challenges

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ABSTRACT

Freight transport in urban centers is a complex operation due to all the impacts involved, and its planning faces critical challenges. Several qualitative and quantitative data collection techniques have been applied in order to address urban logistics and the last mile challenges, and here we present an overview of four commonly used methods.

The purpose of this article is to study two out of four methods, "the cluster analysis method" and "the focus group method", to identify their advantages and disadvantages. The cluster analysis method presents an interesting contribution to the possibility of spatially correlating important variables to urban logistics in research, whereas the focus group method is a method that ensures that the opinions of the stakeholders have been considered in the project. In addition, an opportunity has been identified: the possibility to integrate the quantitative and qualitative methods on addressing urban logistics issues, which would in turn incorporate their strengths.

Keywords: urban logistics, city logistics, cluster, focus group, methodology

JEL Classification Codes: B40, C18, R58

1. Introduction

The world is experiencing a transition in its population, migrating from rural areas to cities. The overall growth of the urban population is 65 million people per year, and half of the world population already lives in cities, generating over 80% of the world's GDP (Dobbs et al., 2011). In developing countries this urbanization is more pronounced, where in 2012 the urban population accounted for 79% of its inhabitants (Merchán et al., 2015).

Almost all activities in urban centers require transport of any type of cargo. An efficient urban transportation planning system is required, since urban freight transport generates a variety of economic, environmental, and social negative impacts. Congestion affects the economy of cities due to the waste of resources and inefficiency they generate. The emission of pollutants, the use of non-renewable fuel, and the disgarding of waste products such as tires and oil are relevant environmental impacts. The social impacts include diseases as physical consequences of pollutant emissions, also accidents resulting from traffic, high noise levels, among others (BESTUFS, 2007; Crainic, 2004).

Despite the negative impacts, cities depend on cargo transportation. Urban logistics plays an essential role in maintaining and retaining industrial and commercial activities, which are essential for major wealth generating activities, and is also a major agent of employment. Efficient freight transport increases the competitiveness of industry, and is critical in sustaining the current life style in cities. Thus, urban logistics creates a conflict between commercial interests and the urban environment (Ibeas et al., 2012; Correia et al., 2010; Dablanc, 2009).

The greatest challenge is to combine solutions with efficient operations, low costs,and without environmental and social impacts. The new urban metabolism, approached by Lima Jr. (2011), has made these challenges even more critical. There is a higher number of purchases to a lesser extent, which increases the number of deliveries to be made and requires better transportation planning. The new metabolism is not restricted to shopping, but also addresses the growing adoption of the concept Just-in-Time, which reduces the storage of products and requires a greater efficiency in services (Dablanc, 2009).

The increase in urban freight forwarding discussed by Lima Jr (2011) exacerbates the problem of the last mile delivery, because of the increased number of unsuccessful operations. Thus, the number of extra trips in the achievement of freight delivery is higher. Therefore, the better planning of deliveries in the study area is essential in order to avoid more intense traffic (Dutra, 2004).

There are no global solutions or success formulas for the various problems arising from the cargo transportation in the urban environment. Any strategy chosen to mitigate these problems should be developed according to the characteristics of each region. An agreement should be established between the conflicting objectives of the various actors in the urban environment that participate in the load distribution process, such as retailers, government officials, carriers, among others (Correia et al., 2010; Crainic et al., 2009).

Several projects were developed to propose the best practices in urban logistics and to solve their main problems. However, cities have different characteristics, and policy measures applied in different urban areas will result in different impacts. Thus, it is essential to include urban form characteristics and all stakeholders' opinions when enhancing city logistics planning (Alho and Silva, 2015; Dablanc, 2009).

Therefore, an appropriate approach should be selected when addressing an urban logistics issue. Urban logistics presents many reasons for requiring data gathering, such as specific projects to produce national or local estimates concerning vehicle flows, regulation, and environmental impacts; also, it is important to involve the public authorities, to measure and monitor performance, to model and forecast freight transport, and to monitor commercial activities, among others (Ambrosini et al., 2010).

An opportunity has been identified when studying the paper of Zunder et al. (2014). The authors developed a project by adopting a mixed methods approach, combining qualitative and quantitative strategies for collecting data. Bryman (2006) confirms this possibility, stating that mixed method research can be adopted for various reasons. According to the author, by integrating different methods it is possible to incorporate their various contributions.

Bryman (2006) states that this integration of qualitative and quantitative methods has become increasingly common. Two justifications for combining these qualitative and quantitative methods should be highlighted when addressing the city logistics issues: triangulation and expansion. The integration can seek for convergence and corroboration, for example when identifying critical areas for urban logistics (triangulation). Another reason for the above mentioned integration may be to extend the breadth and range of enquiry by using the different methods for different inquiry components, for example adopting the cluster analysis method for the identification of critical areas in urban logistics, and adopting the focus group method for the development of adequate solutions (expansion).

The purpose of this paper is to study data collection techniques that aid in city logistics planning and urban freight transport, and to analyse how they can be integrated. We have selected and studied two methods for data mining, the cluster analysis method (quantitative) and the focus group method (qualitative). The best situation in which each method should be applied, according to its advantages and/or disadvantages), has been suggested. The possiblility of integrating both approaches and thus also incorporating their strengths is also explored.

2. Data collection techniques

In order to adequately address an urban logistics issue a proper approach needs to be adopted. The literature regarding the subject lacks a framework on data collection techniques to identify city logistics challenges, problems, and/or critical areas. However, Bryman (2006) listed research methods employed in social sciences, and we have selected four commonly adopted approaches to address city logistics issues, in which two are qualitative and two quantitative: respectively, focus group and in-depth interviews, cluster analysis and survey. The cluster analysis method is not listed as one of the most common methods used in social sciences, but the potential to spatially correlate urban logistics variables and therefore build a framework of the city according to the adopted variables, along with the application of this method in works such as Castro et al. (2016) justifies its contribution and analysis in this paper. Several works and projects aiming to contribute to city logistic activities have already adopted at least one of those strategies (Castro et al., 2016; Alho and Silva, 2015; BAUDEL et al., 2015; Comi and Nuzzolo, 2015; Ducret et al., 2015; Kijewska and Iwan, 2015; Ponce-Cueto et al., 2015; Castro et al., 2014; Dias et al., 2014; Chhetri et al., 2013; NCFRP 2013; Allen et al., 2012; Ambrosini et al., 2010; Lindholm, 2010; Browne et al., 2007; and Anderson et al., 2005), and have even integrated more than one approach in the same study (CLUB, 2014; Zunder et al., 2014; CLUB, 2012 and Stathopoulos et al., 2012).

One of the main contributions probability-based sample surveys present comes from their statistical potential. Applying questionnaries to a sample of a defined population allows precise estimations of the behaviours and opinions distribution of a larger group of people. The possibility of generalizing with statistical confidence based on probability theory separates surveys from other research methods such as focus groups or in-depth interviews. However, the statistical estimates are subject to a variety of errors, such as sampling error, coverage error, nonresponse error, measurement error, and processing errors (Stern et al., 2014).

Survey types used for transportation planning include: land-use surveys, surveys of the transport system inventory, travel pattern surveys, transport system performance surveys, demographic and socio-economic surveys, and perception and attitude surveys.

Cluster analysis is another quantitative approach. A cluster can be defined as a grouping of similar things, such as geographical factors, types of business, or business relationships along the supply chain (United Nations, 2007). A cluster boundary delineation is often imprecise, and, according to Porter (1998), “a cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities.”

Geography and spatial studies have not sufficiently explored urban freight as a research field, which leads to the opportunity of using cluster analysis. Urban transport activities are affected by spatial factors, such as the city's size and density, layout and urban form, street design, urban morphology, the land use, and the position of the city in the supply chain (Ducret et al., 2015; Allen et al., 2012; Lindholm, 2012; Dablanc, 2011).

Several logistics practices have been introduced to address the challenges of city logistics. However, cities have different characteristics, and policy measures applied in different urban areas can only result in different associated impacts. Thus, it is essential to consider urban-specific characteristics to enhance the transferability and sustainability of urban logistics solutions (Alho and Silva, 2015). Cluster analysis facilitates the exploration of natural or hidden data structures and group commonalities in a set of data objects, aiding in the development of insights regarding the studied area (Jiang and Chen, 2009). Castro et al. (2016) has confirmed that the quantitative methodology is efficient when used to analyze logistics in urban centers, providing a good representation of the city segmented into clusters. Furthermore, Ducret et al. (2015) state that the possibility of bringing urban analysis with spatial studies closer to urban logistics aids in reorganizing logistics more efficiently, meeting city logistics challenges.

On the other hand, the focus group approach– a qualitative method - has as a main concept the involvement of the stakeholders in the project – from the identification of problems to the development of solutions.

A good definition for focus group is stated by Jenkins and Harrison (1990), "A focus group is therefore a free ranging, non-directed, group discussion in which particular issues or items provide an axis or focus for the group." Focus groups are a qualitative research tool, with the objective of a discussion that converges to the participants comprehension according the desirable issues (Dias, 2000). According to Ståhlbröst (2008), focus groups are the main tool in co-creation proceedures, due to its interactive communication between the participants.

Jenkins and Harrison (1990) confirm that the applications of focus groups transcend the identification of challenges or problems in a specific context, such as urban logistics. The main indications for adopting focus groups as a research tool are: during an initial exploration with a small population sample; during deep research in motivations, desires or lifestyle of groups; during the comprehension of the group's perspective; during the concepts and issues testing for future quantitative analysis; during qualitative research monitoring; during the investigation of new concepts or products; and for the comprehension of a specific context (CLUB, 2014).

Moreover, Hopkins (2007) states that spatial research has increasingly benefited from the adoption of focus group analysis. It is essential to highlight then, that this tool allows broader results with the possibility of getting insights about the partiticipants' opinion on how to solve the discussed issues.

Another qualitative strategy are in-depth interviews, which in most cases can help explore issues concerning city logistics activities individually. This approach provides the opportunity to gather insight, probe for additional information, and change the direction of the discussion, according to the circumstances. In-depth Interviews are an ideal mechanism to gain insight from industry leaders, decision makers, and leading researchers (Holguín-Veras et al., 2014). However, interviews are subject to bias and reflexivity – the interviewed might answer according to what they think is the correct answer.

This paper focuses on two data collection approaches used for studying city logistics issues: the cluster analysis method and the focus group method. These methods were chosen due to their potential of spatially addressing urban logistics. Both approaches present an interesting cost-benefit, in addition to depending on a reliable database, or on the participation of all stakeholders respectively. The statistical analysis required by the cluster method are not exhausting, while having the required database and the discussion towards a subject should not be onerous with the presence of all interested stakeholders. Furthermore, this paper presents an innovative strategy: a qualitative and quantivative approach, by combining the two methods. According to Morgan and Spanish (1984), sociological research can benefit from the use of focus groups combined with other data gathering methodologies.

3. Cluster analysis and urban logistics

Researchers have developed various methods with the purpose of developing cluster analysis. However, there is no defined pattern to the dimensions analysed, nor how to measure these dimensions in cluster analysis studies. A company's size and its internal structure, transportation, communications, other technologies, infrastructure data, demographic data, cultural influences, among others, affect the process of clustering (United Nations, 2007). It is clear that the cluster theory methodology is not new. However, its application in distinct fields of study, along with its existence in various regions of the world with different objectives, highlights the applicability of the study.

We analysed and compared different clusters identification methods from the works: Ponce-Cueto et al., 2015; Alho and Silva, 2015; Chhetri et al., 2013, and; Allen et al., 2012. These papers were selected due to their focus on city logistics activities, the relevance of the projects, and for being relatively recent studies.

In the first paper, the purpose is to identify clusters that impact urban logistics activities and to assist urban planning with general recommendations for public policies. The research study is based on four steps: collection and processing information; in which demographic, socioeconomic, regulation and infrastructure data were collected; Statistical analysis with the development of the principal component analysis and k-means clustering analysis; Logistic cluster identification – a categorization of different areas of the city according to urban logistics characteristics; and finally, general recommendations for public policy aiming contributions for urban freight mobility (Ponce-Cueto et al., 2015).

Alho and Silva (2015) present the concept of Logistics Profile, which "… suggests homogeneous groups of urban zones with respect to three dimensions, which could be used to analyse freight movement policy: (1) the social and built environment; (2) characteristics of the goods/products being moved; (3) characteristics of the deliveries at the receiver establishment." The study was conducted with two statistical steps: The Multiple Classification Analysis (MCA) model and Two-step cluster analysis. The author states that the Logistical Profile has the potential to be used as a starting point for urban planning commodities and policy analysis on the subject. In the paper, Lisbon was segmented into four logistic profiles, allowing the city planners to focus on just four separate sets of rules and political action.

The work "Characterising spatial logistics employment clusters" studied cluster theory with a different approach: an analysis involving logistics employment clusters. The paper identified industries related to logistics in order to quantify its employments, and conducted a statistical analysis (principal component analysis and autocorrelation techniques) to empirically identify and spatially contextualise logistics hubs. The research offers policymakers and practitioners a foundation on which decisions about future infrastructure investment can be evaluated to support cluster development and achieve economies of agglomeration (Chhetri et al., 2013).

The last paper investigates relationships between road freight transport, urban form, land use, facility location and logistics management. The main idea is the collection of demographic data, socioeconomic data (area occupied by industries/commerce, area ocuppied by industries/commerce per capta and per km^2) and also Origin/Destination information (trips within the area, from the area and to the area). The work studied specific factors (loaded vehicle kilometres, empty vehicle kilometres, tonnes lifted, tonne-kilometres, and vehicle loading factors) – and provided an analysis of the extent to which the commercial and industrial land use patterns influence the amount, pattern and intensity of road freight transport activity, and whether the suburbanisation of warehousing has been occurring (Allen et al., 2012).

We built an abstract of the mentioned methods in Table 1, showing common elements and differences between the different methods. The parameters adopted (objective, data collection, statistical analysis, result and conclusion) were chosen due to the following reasons: the objective of each project adopting cluster analysis has a direct impact on the required data for collection; cluster analysis usually requires statistical analysis, and; results and conclusion help the quantifying potential and applicability of the method.

We can see that, out of the four methods studied, three (Alho and Silva, 2015; Chhetri et al., 2013; Ponce-Cueto et al., 2015) work with similar statistical analyses: Principal Component Analysis and Multiple Classification Analysis. Both statistical tools work with independent variables and look for similarities between them. However, the work of Allen et al. (2012) makes use of a Origin / Destination matrix, and lists the array information with data common to other methods such as demographic and socioeconomic data. Although the methods present some differences, mainly because of distinct purposes, their results have commonalities in the grouping of regions to facilitate the local assessment.

All methods present contributions on addressing city logistics issues: the papersfrom Ponce-Cueto et al. (2015) and Alho and Silva (2015) aid in segmentating the city so that critical areas can be identified and proper solutions suggested; Chhetri et al. (2013) offer a founded basis that helps to identify the lack of infrastructure for logistics activities; and Allen et al. (2012) analyze road freight transport and its relation to urban form in order to assist planners when making transport and land use decisions.

Table 1

Different methods for clusters identification.

Steps	Ponce-Cueto et al. (2015)	Alho e Silva (2015)	Chhetri et al. (2013)	Allen et al. (2012)
OBJECTIVE	Identification of clusters that have impact on urban logistics	Proposal of a quantitative methodology to define logistics profiles, considered as groups of urban areas with homogeneous characteristics in relation to the use of land and the movement of goods.	Identification of employment logistics clusters	The investigation of relationships between road freight transport activity, urban form, land use, facility location, and logistics management
DATA COLLECTION	Demographic data (area, population and demographic density)	City area features (Commercial density, homogeneity, logistics accessibility)	Industries "explicity" related to logistics	Demographic data (area, population and demographic density)
	Socioeconomic data (quantity of establishments per industry)	Product Characteristics (Easiness of handling, special conditions)		Socioeconomic data (area occupied by industriesá/commerce, area ocuppied by industries/commerce per capta and per km2)
	Infrastructure data (road capacity and road density)	Agents/deliveries profile (Urgency of deliveries, frequency of deliveries, amount of freight to be delivered)	Information about employment in those industries	Road freight activity data (3 types of trips: trips within the studied area, trips to the studied area and trips from the studied area)
	Regulation data			
STATISTICAL ANALYSIS	Principal component Analysis	Multiple Classification Analysis (MCA) model	Principal component analysis	No statistical analysis performed. Paper makes analysis of loaded vehicle kilometers, empty vehicle kilometers, tonnes lifted, tonne-kilometers, and vehicle loading factors
	K-means Clustering	Two-step cluster analysis	Autocorrelation techniques to measure "spill over" impacts of clustering in neighbouring areas	

RESULTS	Segmentation of the city into urban clusters aiding the identification of critical areas and development of insights	Identification of four logistic profiles validated for the case study in Lisbon. The approaches to the logistics management in this city can focus on just four separate sets of rules and political action.	Logistics delineation of employment clusters to represent the underlying regional geography of the logistics landscape	Commercial and industrial floor-space composition Warehousing floor-space and changes over the decade Road freight transport activity patterns including its efficiency and intensity
CONCLUSION	General recommendations for public policies	The Logistical Profile (LP) has the potential to be used as a starting point for urban planning commodities and policy analysis on the subject.	The key value of this research is the quantification of spatial logistics employment clusters using spatial autocorrelation measures to empirically identify and spatially contextualize logistics hubs.	The extent to which the commercial and industrial land use patterns influence the amount, pattern, and intensity of road freight transport activity, and whether the suburbanisation of warehousing has been occurring.
CONTRIBUTION TO CITY LOGISTICS	Segmentation of the city into homogeneous areas identifying critical clusters to urban logistics and allowing similar policies/solutions for the same cluster	Segmentation of the city into Logistic Profiles identifying critical areas and allowing similar policies/solutions for the same zone	The research offers an empirically founded basis on which decisions about future infrastructure investment can be evaluated to support cluster development	It is expected that improved understanding of the relationship analyzed (road freight transport, facility location, logistics management and urban form) will assist planners when making transport and land use decisions

4. Focus group approach and city logistics

Focus groups are a qualitative research method in which a group of individuals are asked to respond to a given policy question with the assistance of a moderator, who probes into different aspects of the subject. This approach emphasizes the collective discussion of a complex subject, where the moderator steers the dialogue into the directions likely to reveal important insights (Holguín-Veras et al., 2014). Examples of the use of the focus group approach as a data collection technique to address urban logistics issues include: CLUB (2014), Dias and Lima Jr (2014), Zunder et al. (2014), NCFRP (2013), Stathopoulos et al., 2012, CLUB (2012) and Browne et al. (2007).

Dias and Lima Jr (2014) present a project with the purpose of improving beverage delivery in downtown Campinas, São Paulo. The authors used focus groups in order to define the purpose and scope of the research, and to confirm the needs of the operation as well as a co-creation technique to propose adequable solutions.

The project developed by Zunder et al. (2014) present as its purpose the development of a local research strategy for city logistics issues. The focus group method was one of the data collection techniques adopted by the authors, which aimed at contesting the relationship between the buying system and freight activities.

The report Smart Growth and Urban Goods Movement, written by the National Cooperative Freight Research Program (NCFRP, 2007), tries to understand the relationship between smart-growth principles and urban goods movement, through the conducting of six total focus groups.

Stathopoulos et al. (2012) adopted the focus group approach in order to identify problems in deliveries in Rome’s limited traffic zone. The authors noticed a large disparity for each group of stakeholders in terms of sensitivity to policy instruments. The results allowed the development of several policy-scenarios for further studies.

In order to measure the impacts of urban freight transport, Browne et al. (2007) developed a study based on an analysis of urban freight operations of seven companies, adopting the focus group technique to discuss and analyze how these operations are likely to change as a result of different future policy scenarios.

The Brazilian Urban Logistics Center (CLUB – Centro de Logística Urbana do Brasil) also adopts the focus group methodology as a data collection technique. The main purpose of those focus groups is to exchange experiences and knowledge among the actors involved in urban logistics problems, aiming at the identification of critical areas and the development of adequate solutions for the studied cities (CLUB, 2014).

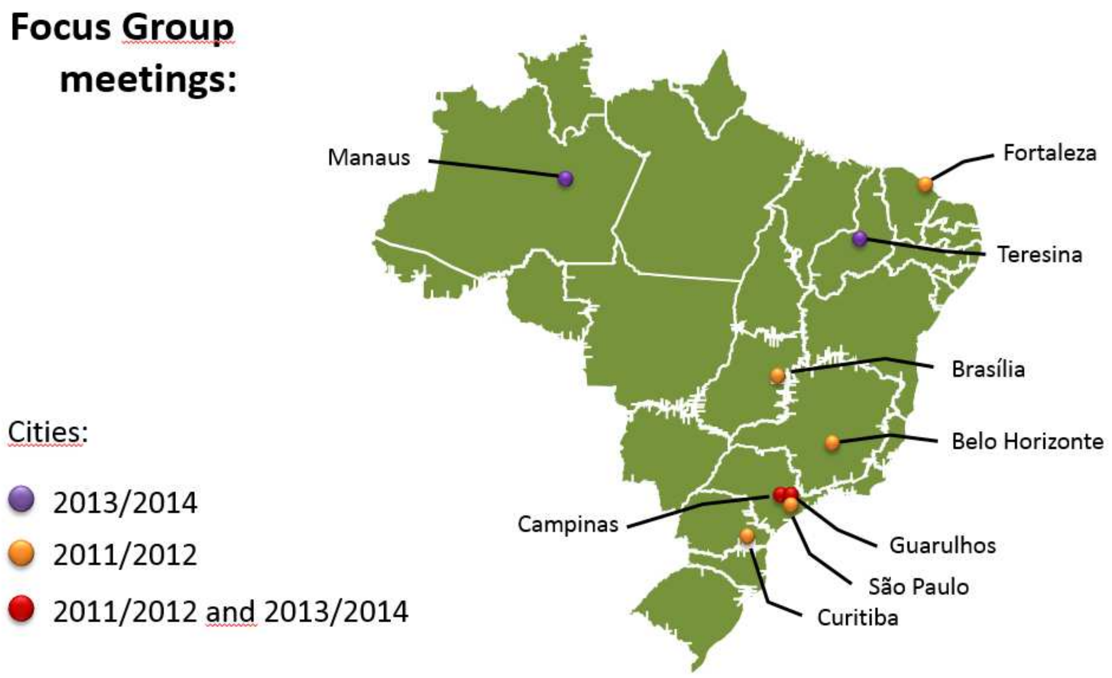

Fig. 1. Focus groups meetings in Brazil by CLUB (CLUB, 2014).

The procedure adopted by CLUB in the study of the aforementioned cities always started with preliminary research with the purpose of characterizing the city's historic development, collecting demographic and socioeconomic data, and also studying the available infrastructure for freight transport. This information aided the discussion between the stakeholders during the focus groups. The questions that guided the meeting intended to determine the cities' main problems for freight transport and its location. After a better understanding of the cities' main issues according to cargo distribution, it was possible to identify solutions or best practices adequate for the observed situations. Fig. 2 illustrates an example of the summary built from the two first questions of the focus group hold in an important Brazilian hub city, Campinas/SP.

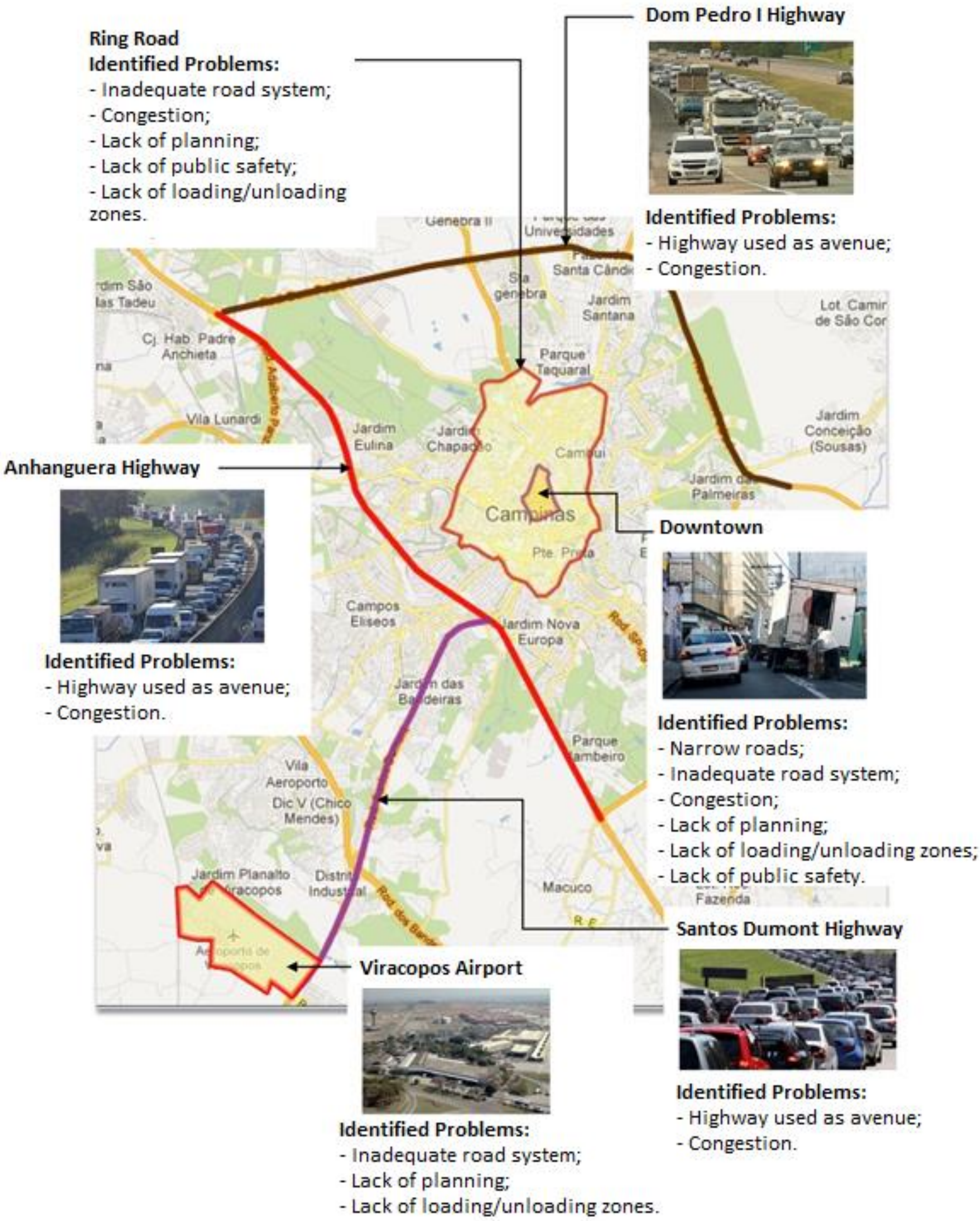

Fig. 2. Summary of Campinas/SP main problems in freight forwarding and its location (CLUB, 2012).

It is clear that the focus group presents contributions when applied as a data collection technique in order to address urban logistics issues. Dablanc (2009) stated that it is impotant to consider all stakeholders' opinions to enhance city logistics planning, and the examples above show the potential of this qualitative approach to gather stakeholders' assessments regarding urban logistics activities.

5. Discussion

It is clear that both approaches - cluster analysis and focus group - contribute as data collection techniques to address urban logistics issues. They can be useful in gathering information regarding problems in urban areas, and also in obtaining important information for development of insights and solutions. In this section we present a summary of the advantages and disadvantages of adopting each method, and of the best situations in which each of them should be applied. This analysis is based on a non-exhaustive literature review and the study of the cases and practical experiences presented on Table 2. However, since this paper focuses on studying applications that impact city logistics, further studies should be performed in order to extrapolate the insights provided to other research fields.

Table 2

Cluster Analysis	**Focus Group**
Identifying clusters to implement urban logistics best practices: the case of São Paulo (Castro et al., 2016)	Use of Living Lab on developing Urban Logistics Innovations (Uso da Abordagem Living Lab no desenvolvimento de inovações em logística urbana - Dias et al., 2014)
	Developing a Local Research Strategy for City Logistics on an Academic Campus (Zunder et al., 2014)
Segmentation of urban areas from a logistics perspective: comparative case studies in Lisbon, Madrid, Mexico City, Quito, Rio de Janeiro, and Singapore (Ponce-Cueto et al., 2015)	Stakeholder reactions to urban freight policy innovation (Stathopoulos et al., 2012)
	Focus Group held in Campinas, Brazil (CLUB, 2014)
	Focus Group held in Guarulhos, Brazil (CLUB, 2014)
Utilizing urban form characteristics in urban logistics analysis: a case study in Lisbon, Portugal (Alho and Silva, 2015)	Focus Group held in Manaus, Brazil (CLUB, 2014)
	Focus Group held in Teresina, Brazil (CLUB, 2014)
	Focus Group held in São Paulo, Brazil (CLUB, 2012)
Characterising spatial logistics employment clusters (Chhetri et al., 2013)	Focus Group held in Curitiba, Brazil (CLUB, 2012)
	Focus Group held in Belo Horizonte, Brazil (CLUB, 2012)
Investigating relationships between road freight transport, facility location, logistics management and urban form (Allen et al., 2012)	Focus Group held in Brasília, Brazil (CLUB, 2012)
	Focus Group held in Fortaleza, Brazil (CLUB, 2012)

A criticism regarding the cluster theory approach is the lack of uniformity in its existing methodologies, which leads to difficulty in comparing different reports on cluster developments or for policy makers to form a clear and objective judgement (United Nations, 2007; Punj and Stewart, 1983). This guides the study to unclear policy implications, as most of the developed solutions turn out to be traditional economic development policies or practices, its main difference being the application in the cluster area. The lack of assessment of the cluster theory approach solutions is a limitation of this quantitative procedure (Wolman and Hincapie, 2015). The necessity of background data for the development of the statistical analysis should also be cited. Furthermore, the studied cluster analysis methods do not provide descriptive report about the segmented areas, requiring additional effort to draw inferences regarding their statistical significance (Punj and Stewart, 1983).

Despite its constraints, there are some constributions from the cluster method that should be highlighted. Clustering procedures are a helpful tool in data analysis when one desires to group objects (or variables) according to their relative similarity. The provision of a conceptual framework allows a better view of the economy, aiding in the direction of the regional economic policies' development (Wolman and Hincapie, 2015). The cluster theory approach then helps in the understanding of the regional economy, and depending on the variables included in the analisys, its crossing with urban form and infrastructure or demographic data, which are essential aspects to urban logistics. Castro et al. (2016) confirms the advantages of applying cluster analysis on city logistics research, on a paper where important variables to urban logistics were correlated providing a demographic and economic framework of the analysed city, São Paulo/Brazil, which in turn lead to identifying critical areas for urban logistics and suggested insights that could be studied in order to develop adequate solutions.

When analyzing the focus groups held by CLUB in important Brazilian cities, there are some advantages of this approach that should be mentioned (CLUB, 2014):

- The interaction between the stakeholders involved in the process of cargo transportation leads to ideas that normally wouldn't be reached by only one person or a part of the stakeholders group;
- The results can be obtained faster;
- Possibility to assess the relevance of explanations and theoretical concepts by the involved stakeholders;
- Allows for the development of innovative solutions.

Furthermore, Stathopoulos et al. (2012) states that city logistics need to identify feasible and acceptable policies, according to the main stakeholders, avoiding potential conflicts. The efficient interaction focus groups provide combined with the fast development of innovative solutions demonstrates the contributions this approach grants when adopted as a data collection technique. The method can be used in order to collect information regarding needs and inefficiencies of operations and also to gather important stakeholders' opinions to develop appropriate solutions (CLUB, 2014; Stathopoulos et al., 2012).

The downside of using this research method lies in group trends that can lead to compliance or a determined bias. The compliance occurs when some participants do not provide essential information that would appear in individual interviews (Morgan, 1988). An important limitation of the focus group analysis relies on the fact that a test with few consumers/stakeholders should not be a reliable indicador for a broader population (Ogawa and Piller, 2006).

Table 3 shows an analysis of the advantages and disadvantages of both approaches on addressing urban logistics issues.

Table 3

Comparative analysis between approaches.

	Cluster Theory	Focus Groups
Advantages	Provision of demographic and economic conceptual framework;	The results can be obtained faster;
		Conceptual or emergent themes can be pursued with the group to shape experiences;
	Possibility of correlating important variables to urban logistics (e.g. infrastructure, demographic or regulation data) with the cities' economic activities;	Originality of ideas by involvement of stakeholders and possibility of solutions development in cocreation process;
		Flexible - possibility of asking open-ended questions;
	Insights provision that groups commonalities by use of statistical analysis tools.	Relatively inexpensive.
		Method ensures stakeholders’ opinion are considered, avoiding potential conflicts
Disadvantages	Lack of uniformity;	Dependent on interviewer's skills;
	Necessity of background data for statistical analysis;	Difficulty on accessing some appropriate people;
	Lack of assessment of cluster theory approach solutions;	Possibility of group trends leading to compliance or a determined bias.
	Necessity of further effort to draw inferences regarding their statistical significance.	

Once an overview of the approaches has been presented, the applications of the methods for addressing city logistics issues have been studied, and their advantages and disadvantages have been identified, one can propose the best situations in which each approach should be applied. This analysis can be performed considering the available resources - complete database for cluster analysis, contact with engaged stakeholders and experienced interviewers for conducting focus groups. Both methods present relevant advantages and disadvantages, and the best option should be analysed according to the observed context.

We can see that quantitative methodologies, such as the cluster theory, depend highly on the disposal of available data, as its results reflect the correlation of the adopted variables using statistical analysis. There is a lack of uniformity in the procedure to perform this type of analysis. Since the cluster theory is directly related to its adopted variables, new procedures can also be developed, as the use of loading/unloading zones for assessing the cities’ infrastructure. Thus, we recommend an extensive study of the methodology before applying this approach, as well as insuring a reliable database.

On the other hand, qualitative methodologies, like the focus group, rely essentially on the participation of the stakeholders involved in the studied issue. The use of the focus group approach can be very flexible, and quickly reach results. However, care must be taken while adopting a qualitative methodology. The interviewer must have a large experience on the studied topic, the involvement of the stakeholders is mandatory, and the group must avoid compliance.

The analysed data collection techniques, focus group and cluster analysis, when integrated, should present a high potential on addressing urban logistics issues. The quantitative approach can ensure that important variables for the project have been considered without bias; the statistical analysis can provide valuable insights regarding infrastructure, land use, demography and economic activities; and that the stakeholders' perceptions can be considered during the focus group in the analysis of the studied issue and in the development of the solution. The toolkit developed by Dablanc (2009) demonstrates the relevance of these aspects, highlighting the importance of using data in urban freight methods and the importance of the stakeholders' opinions when dealing with city logistics. Furthermore, Anand et al. (2015) confirms that city logistics studies should be assessed with respect to the stakeholders' perceptions and elements associated with the demand and supply side of urban movements – parameters covered by focus group and cluster analysis, respectively.

We identified two main reasons for integrating data collection techniques when addressing city logistics issues: triangulation and expansion. CLUB (2014 and 2012) already used this strategy when analysing urban logistics activities across Brazilian cities: their methodology adopted focus groups and surveys to study the same issue by triangulation, converging the results of both methods to produce the final report for each city. In their project, information such as fleet age, average speed, delivery difficulties, fleet composition, among others were gathered through surveys and this data was then compared with the opinions of the stakeholders regarding city logistics activities in focus groups discussions.

Another project that aims to integrate the different methods, but with the purpose of expanding its results, is being developed by Castro et al. (2016). The authors performed cluster analysis in São Paulo, Brazil, and segmented the city into homogeneous clusters. This research helped the identification of the critical zones for urban logistics in the city, and provided insights about possible solutions. Further studies are being conducted by selecting a zone with one square kilometer inside a critical cluster in order to develop an appropriate solution based on the stakeholders perceptions.

6. Conclusions

Urban logistics presents highly complex operations which are mainly due to the restrictions imposed by the Government, and the congestion and high dispersal of orders in those cities. The new urban metabolism, approached by Lima (2011), has made these challenges even more critical. There is also the last mile problem, caused by the number of extra trips to the achievement of the delivery of the goods. In order to study urban logistics main issues, several approaches have already been used. Every procedure has its advantages and disadvantages, and the best option should be analysed according to the observed context.

Both methods studied, cluster analysis and focus group, present important restrictions: the necessity of an active contact with all important stakeholders and the presence of an experienced interviewer to conduct focus groups, and the availability of a complete and reliable database for the statistical tools required in the cluster analysis. Therefore, when selecting one method to address an urban logistics issue the available resources from the reseach should be contemplated. In addition, focus groups may be considered in a situation when results need to be obtained quickly, and the acceptance of the stakeholders is essential. If the study needs to address specific variables, such as loading/unloading zones, presenting or requiring the use of a specific database; cluster analysis may be the adequate option.

Furthermore, the possibility of integrating quantitative and qualitative methods should be explored. Bryman (2006) states that there are relatively few guidelines about how, when, and why the integration of method should occur. Greene (2008) also argues that integrated mixed methods analysis has not yet cohered into a widely accepted framework. Besides, Maxwell and Loomis (2003) confirm the complexity of actually integrating qualitative and quantitative approaches in any particular field of study. This leads to the opportunity of further studies into the development of a framework on how to integrate these methods when addressing an urban logistics issue. The integration of other qualitative or quantitative methods, such as survey or in-depth interviews, should also be further explored.

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