Framework for urban freight transport analysis in medium-sized cities

Estrutura para análise do transporte urbano de carga em cidades médias

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Abstract

The urbanization process, especially the diverse aspects regarding size, function, position and growth of cities, significantly affect the Urban Freight Transport (UFT). This paper deals with behaviour of UFT in medium-sized cities. Here we will identify the attributes that characterize the Medium-sized Cities (MC), as well as the influence factors in UFT. In addition, a survey among specialists and public agents of medium-sized cities is presented, about the level of interaction between attributes that characterize MC and the factors that influence UFT. For analysis and validation of the opinion survey is performed non-parametric statistical test, and an analysis of the confidence interval to define the level of interaction between attributes and UFT factors. As a result, we provide a framework that demonstrates the interaction between attributes of MC and the factors that influence UFT. The factors "Projects and measures of local authorities", and "Infrastructure available to the UFT", together with the lack of studies related to freight transport (knowledge, innovation and technological advancement) were identified as the main issues that require attention on UFT in MC. This proposal may contribute to the decision makers regarding urban planning and brings a theoretical contribution to future research in UFT planning studies.

Keywords: Urban freight transport. Medium-sized cities. Brazilian medium-sized cities. Urbanization.

Resumo

O processo de urbanização, em especial os aspectos relacionados ao tamanho, função, posição e taxa de crescimento das cidades, afetam significativamente o transporte urbano de carga (TUC). Este artigo trata do comportamento do TUC em cidades médias. Aqui serão identificados os atributos que caracterizam e diferenciam as Cidades Médias (CM), e os fatores de influência no TUC. Para análise e validação da pesquisa de opinião foi realizado um teste estatístico não-paramétrico para comparação das distribuições das duas amostras – especialistas e agentes públicos, e uma análise do intervalo de confiança para definição do grau de interação entre os atributos e fatores. Como resultado, nós fornecemos uma estrutura que faz a interação entre

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os atributos do MC e os fatores que influenciam o TUC. Os fatores "Projetos e medidas de autoridades locais" e "Infraestrutura disponível para o TUC", juntamente com a falta de subsídios (dados e pesquisas na área) para estudos relacionados ao transporte de cargas (conhecimento, inovação e avanço Tecnológico) foram identificados como os principais problemas que exigem atenção no TUC em MC. Esta proposta pode contribuir para os tomadores de decisão em relação ao planejamento urbano e traz uma contribuição teórica para pesquisas futuras em estudos de planejamento do TUC.

Palavras-chave: *Transporte urbano de carga. Cidades médias. Cidades médias no Brasil. Urbanização.*

Introduction

In the last 50 years, the world has undergone an intense process of urbanization that continues in an accelerated way (Bolay & Rabinovich, 2004), especially in medium-sized cities, where this phenomenon has been occurring more vigorously when compared to large urban centers (Angeoletto et al., 2016; Bolay, 2016; Espindola et al., 2017; Gao et al., 2016).

In Brazil, approximately 36 million people live in cities considered medium-sized according to the classification of the Brazilian Institute of Geography and Statistics - IBGE (100 and 750 thousand inhabitants), equivalent to almost 20% of the Brazilian population (IBGE, 2016).

As the world continues to urbanize, the challenges to sustainable development will increasingly be concentrated in urban centers (Cohen, 2006). Medium-sized cities (MC) have become large urban centers in the near future, the challenges for sustainable development will be greater (UN, 2014; Cohen, 2006). It is noteworthy that MCs present the same problems of large cities, even on a smaller scale (Sathler et al., 2015; Ricieri et al., 2017). These problems refer to the environmental process of urbanization (Bolay, 2016; González et al., 2017), to inequality (Bolay, 2016), to disorderly growth (Bolay, 2016), and, above all, the sustainable development of urban freight transport (UFT) (Pojani & Stead, 2015; Vasconcellos, 2005), especially in terms of ensuring accessibility to goods in expanding urban areas (Kin et al., 2017).

Oliveira et al. (2018a, p. 70) have attempted to establish an analytical framework considering urban logistics solutions by the number of population of the cities. For example, bays for parking and loading/unloading, pick-up points and incentive for using non-motorized vehicles can be appropriate for all the size of the cities; cargo vehicle restrictions and low emission zone may be appropriate for medium-sized and large cities, and off-hours deliveries, urban distribution centers for large cities. However, urban logistics solutions should take into account also other attributes as following: the growth rate of urbanized areas or urban sprawl (Angeoletto et al., 2016); the position of cities in the urban hierarchy (Dias & Araújo (2013) and urban function (Bolay & Rabinovich, 2004). As far as the cities have become larger, these attributes require more complex urban logistics solutions (for instance, the implementation of a UDC, road pricing system).

Considering these challenges and the projections for the future ways of population arrangements and UFT issues, the medium-sized cities (MC) are taking a leading role in addressing the issues of sustainable urban development (Bolay & Rabinovich, 2004; Bolay, 2016). Moreover, CM has greater potential for solving problems compared to larger urban centers (Pojani & Stead, 2015, Schlesinger et al., 2015). In this sense, it is necessary to approach this question in the light of the urban context in which it is inserted (Lindholm & Behrends, 2012).

Therefore, given the importance of urban freight transport (UFT) to consider the complexity and diversity of cities, as well as the prominent role of MC in this discussion, this work aims to identify the attributes that characterize the behavior of UFT in urban centers of medium size. Here we will analyze the relationship between the MC characterization attributes and the factors that influence the UFT, as well as the appreciation of the experts' and public agents' perceptions on the subject.

The main objective of the work is achieved through the following specific objectives:

• Define the attributes that characterize medium-sized cities;

• Evaluate the degree of interaction between attributes that characterize medium-sized cities and the factors that influence urban freight transport through literature review and opinion research with public experts and agents in order to prioritize UFT factors for MC;

• Define a UFT analysis framework for MC.

Urban freight transport and its influence factors

As a starting point for defining the freight transport analysis framework in MC, it is necessary to obtain an overview of the influence factors in the UFT.

In order to understand how and why these factors influence the flow of goods in cities, they are presented here from their social, economic and environmental impacts, respectively, as follows (Allen et al., 2007; Lindholm & Behrends, 2012; Portugal et al., 2011):

• Economic impact factors: they imply consumption of resources (time, money, space/land use and energy) and, consequently, impact on the efficiency of the delivery of goods and their access by the population.

• Environmental impact factors: they produce externalities related to the preservation of the environment, such as maintenance of air quality, soil quality (litter) and/or are related to climate change.

• Social impact factors: related to externalities that affect the quality of life of the population in cities, such as health (e.g. respiratory and hearing problems) and safety (traffic accidents and theft of cargo).

These factors are further classified into six macro blocks: 1) Projects and Measures adopted by Local Authorities; 2) Infrastructure for UFT; 3) Urban Space Configuration; 4) Companies Features, 5) Knowledge, Innovation and Technological Advancement, and 6) Population, as shown in Table 1.

Table 1 - Influence factors in urban freight transport

(To be continued)

Factor	Study	Economic	Environmental	Social
Political-cultural context	Lindholm & Behrends (2012)			X
Degree of stakeholder involvement in the decision-making process	Kin et al. (2017)			X
	Holguín-Veras et al. (2017)			X
Use of alternative fuels encouragement to transportation companies	Kiba-Janiak (2017)		X	
UFT restriction measures	Allen et al. (2007)	X		
	Kiba-Janiak (2017)	X	X	
	Lindholm & Behrends (2012)	X		
	Muñuzuri et al. (2005)	X		
	Quak & Koster (2009)	X	X	
Level of inclusion of the UFT in the city's strategic planning	Kiba-Janiak (2017)	X		
	Lindholm & Behrends (2012)	X		
Public-Private Partnerships	Allen et al. (2007)	X		
	Kin et al. (2017)	X		
Policies with an appropriate focus on the drivers of externalities	Quak & Koster (2009)		X	
	Vasconcellos (2005)		X	
Policies that change the logistics flow in equilibrium to the inefficiency of available infrastructure	Allen et al. (2007)	X		
	Muñuzuri et al. (2005)	X		
Specific regulation for UFT	Portugal et al. (2011)			X
Safety				
Infrastructure for loading and unloading of goods	Alho et al. (2018)	X		
	Muñuzuri et al. (2005)	X		
Infrastructure for intermodal transport	Muñuzuri et al. (2005)	X		X
	Portugal et al. (2011)	X		X
Public facilities and terminals for the UFT	Kiba-Janiak (2017)	X		
	Muñuzuri et al. (2005)	X		
Circulation routes to the UFT	Allen et al. (2012)	X		
	Allen et al. (2007)	X		X
	Lindholm & Behrends (2012)	X		
	Portugal et al. (2011)			X
Access to infrastructure and transport service	Kiba-Janiak (2017)	X		
Allocation of spaces for the logistical operations of cities	Allen et al. (2012)	X		
	Allen et al. (2007)	X		
	Muñuzuri et al. (2005)	X		
Places of concentration of jobs	Boarnet et al. (2017)	X		
Location and extension of facilities and commercial businesses	Allen et al. (2012)	X		
	Lindholm & Behrends (2012)	X		

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(Conclusion)

Size of urbanized areas	Allen et al. (2012)	X	
Specific characteristics of the customer/receiver Type of business segment	Allen et al. (2007)	X	
Data availability	Portugal et al. (2011)	X	
	Rødseth (2017)	X	
Ideas that promote green UFT	Kiba-Janiak (2017)		X
Research on UFT	Lindholm & Behrends (2012)		X
Logistics planning and best practices on UFT	Alho et al. (2018)	X	
	Allen et al. (2007)	X	
	Rødseth (2017)	X	
Applied Technologies in UFT	Allen et al. (2007)	X	
	Muñuzuri et al. (2005)	X	
	Swiatek et al. (2014)	X	
Consumer behavior	Allen et al. (2007)	X	
	Guldbrand et al. (2015)	X	
Conduct of the population towards policies and measures directed to the UFT	Holguín-Veras et al. (2017)		X
Population size	Kin et al. (2017)	X	

Source: Own elaboration (2018)

Medium-sized cities

After identifying the main factors influencing the flow of goods in cities, the next step is to investigate how these factors impact in medium-sized urban centers. In order to accomplish it, it is necessary to establish what would be the definition of Medium-sized Cities.

Studies regarding UFT in Brazilian cities indicate that there is no problem and solution common to all cities (Oliveira et al., 2018b). Therefore, it is necessary to investigate the reality of each city so that it is possible to arrive at solutions that minimize the externalities of the urban transport of loads (Oliveira et al., 2018a). It is important taking into account the demographic and economic parameters of cities, as well as their role in the regional hierarchy.

Although there are studies that bring the characterization of urban transport loads under different approaches, we do not yet see many studies that consider the different realities and scales of urban concentration (Kin & Macharis, 2017; Pojani & Stead, 2015). Perhaps because, in the case of medium-sized cities, there are different definitions for this type of urban agglomeration (Bolay, 2016, Conte & Fresca, 2011, França & Soares, 2014, Sathler & Amorim Filho, Varajão, 2015) and to classify urban logistics solutions according to size of the city it is still a challenge. Although Oliveira et al. (2018a) have pointed out this proposal, to consider only the number of population to implement those urban logistics solutions is at minimal limited. That said, it is necessary first to establish what the definition of Medium Cities would be.

From national and international references, MC can be characterized according to four main attributes: 1) population size; 2) growth rate of urbanized areas or urban sprawl; 3) position of cities in the urban hierarchy; and 4) urban function of cities. Table 2 provides a summary of the studies examined.

Table 2 - Attributes of characterization of medium-sized cities

(To be continued)

Attribute for characterization	Attribute behavior in medium-sized cities	Studies
Population size	Cities with population between 1 and 5 million inhabitants.	UN (2014)
	Cities and/or population arrangements (grouping of two or more municipalities where there is a strong population integration by commuting) with population between 100 and 750 thousand inhabitants.	Salas-Olmedo & Nogués (2012); IBGE (2016)
	Cities with population between 14 and 400 thousand inhabitants.	Amorim Filho et al. (2007)
Growth rate of urbanized areas or urban sprawl	In general, MCs present a more accelerated process of urban expansion	Angeoletto et al. (2016); Bolay (2016); Espindola et al. (2017); Gao et al. (2016)

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(Conclusion)

Position of cities in the urban hierarchy	The MCs, given their function of intermediation in the hierarchy of cities, occupy a position of strategic nucleus in the urban networks.	Amorim Filho et al. (2007); Conte & Fresca (2011); Dias & Araújo (2013); Santos (2009)
	MCs present 4 levels of urban hierarchy: 1) Large Regional Centers, 2) Medium-sized upper-level cities, 3) Medium-sized Cities, and 4) Emerging Urban Centers.	Amorim Filho et al. (2007)
Urban Function	MCs in general have relevant importance in the global economic system.	Bolay & Rabinovich (2004); Conte & Fresca (2011)
	MCs generally present 11 types of urban function that characterize their role in the global economic system (see Table 4)	Bolay & Rabinovich (2004)

Source: Own elaboration (2018).

Based on the studies that describe the different behaviors of such attributes, a characterization model was established to demonstrate if indeed an urban center can be denominated as a Medium-sized City. The model, presented in Table 3, determines how each attribute is presented in medium-sized cities.

Table 3 - Feature model for medium-sized cities

	Attributes that characterize as medium-sized cities			
	Growth rate of urbanized areas or urban sprawl	**Population size**	**Position of cities in the urban hierarchy**	**Urban Function Typology for Medium-sized Cities**
Large Cities	Accelerated	above 750k inhabitants	Metropolis and/or Major Urban Centers	NA
Medium Cities	Very accelerated	between 200k and 750k inhabitants (average point in 400k ponto médio em 400k inhabitants)	Major Regional Centers	Regional market; Service center; Economic locality; Tourist center; Communication hub; Metropolitan suburbs; National/International Interface; Cities in conurbation area; Association of a group of cities; Urban region
		between 70k and 200k inhabitants	Higher-level MC	Regional market; Tourist center; Communication hub; National/International Interface; Cities in conurbation area; Association of a group of cities; Urban region
		between 14k e 100k inhabitants	Medium-sized cities	
		up to 50k inhabitants	Emerging Urban Centers	Tourist center; National/International Interface; Cities in conurbation area; Association of a group of cities; Urban region
Small Cities	Very accelerated	up to 14,000 inhabitants	Small Cities	NA

Source: Own elaboration (2018).

Medium-sized cities and urban freight transportation

In this section, we present the main questions about Urban Cargo Transportation in Medium Cities, considering the classification established in Table 1.

With regard to "Projects and Measures adopted by Local Authorities", four main issues are highlighted in the context of Medium-sized Cities: 1) the UFT Restriction Measures; 2) the level of inclusion of the UFT in the city's strategic planning; 3) the degree of involvement of the stakeholders in the decision-making process; and 4) adoption of policies with an appropriate focus on the drivers of externalities (González et al., 2017; Kramar et al., 2015; Pojani & Stead, 2015; Van Lier et al., 2016).

Regarding "UFT Restriction Measures", which aim to improve the livability of the population with freighters in urban centers, time windows for delivery and collection of goods have been quite restrictive in medium-sized cities (Van Lier et al., 2016). In contrast, low-cost measures such as speed restriction and reasonable parking fees appeared as acceptable and feasible interventions to local MC governments (Pojani & Stead, 2015).

Regarding the "Level of Inclusion of UFT in the Strategic Planning of the City", this issue is not yet sufficiently applied in practice, although their strong impact on the quality of life of the population is recognized by local governments (Kramar et al., 2015). Even in cases where urban logistics are considered in the strategic plan, the strategies adopted has not always proved to be adequate to the reality of MC, since

such adoption has usually been implemented in large cities (Pojani & Stead, 2015). In addition, the local governments of these cities should adopt joint strategies, not only isolated measures (Pojani & Stead, 2015). Regarding this point, there is still a need to define a clear methodology in the definition of city plans (Van Lier et al., 2016).

In relation to the question of the "Degree of stakeholder involvement in the decision-making process", the need for greater stakeholder involvement (Pojani & Stead, 2015; Van Lier et al., 2016) is verified in the MCs. This question directly reflects the divergence regarding the practices adopted by local authorities in MC, especially regarding the positioning of Retailers (Van Lier et al., 2016). A greater involvement would bring less divergence among those involved (Van Lier et al., 2016), as well as awareness raising and education campaigns related to the theme (Pojani & Stead, 2015).

A final aspect concerning the measures taken by local authorities refers to the issue of "Adopting policies with a proper focus on the drivers of externalities". Considering that in MCs, the highest pollution factor comes from the vehicular activity (González et al., 2017), it is important that local governments pay special attention to this aspect.

The "Infrastructure for UFT" is insufficient to urban logistics in Medium Cities. The spaces defined for loading and unloading below the required demand, as well as problematic traffic (congestion), point to the need for more adequate infrastructure (Van Lier et al., 2016). Paying more attention to the maintenance of the current road infrastructure than the expansion or construction of new structures would already bring significant results to the UFT in these cities (Pojani & Stead, 2015).

As for the "Urban Space Configuration", the accelerated process of urban sprawl in the MC is highlighted, and the consequent increase in traffic and air pollution (Espindola et al., 2017). In this aspect, reducing the speed of expansion of the urbanized areas in the MC is not sufficient to obtain positive impacts to the UFT, it is also necessary that the urbanization process takes place in a planned and organized manner (Pojani & Stead, 2015).

Regarding the "Knowledge, Innovation and Technological Advancement" related to UFT in Medium-sized Cities, it is highlighted the lack of data and benchmarking that support applied studies to urban logistics, becoming unfeasible the use of performance analysis tools (Karagiannakidis et al., 2014). In this context, the use of low-cost mobile technologies is a feasible alternative for UFT users in medium-sized cities (Pojani & Stead, 2015). In addition to this type of resource, environments with GIS technology have also shown to be useful in assisting MC decision makers (Gutiérrez-Gallego et al., 2015). In a consolidated manner, the main questions about UFT in MC, regarding the literature review survey, are presented in Table 4.

Table 4 - Main issues about UFT in MC

UFT influence factors		Questions about UFT in MC	Possible solutions	Studies
Projects and Measures adopted by Local Authorities	UFT restriction measures	Time windows for delivery/pick-up have been quite restrictive	Consider adopting less costly and less restrictive measures	Pojani & Stead (2015); Van Lier et al. (2016)
	Level of inclusion of UFT in the strategic planning of cities	It is not sufficiently used in practice, although its importance is recognized by local governments	Inclusion of UFT in strategic plans in more MC, and its practical application	Kramar et al. (2015); Pojani & Stead (2015)
		The strategies adopted do not always prove adequate to the reality of CM	Adoption of joint strategies and not just isolated measures	
	Degree of stakeholder involvement in the decision-making process	Need for greater involvement of stakeholders	Greater involvement would bring less divergence among those involved	Pojani & Stead (2015); Van Lier et al. (2016)
		Divergence between stakeholders regarding practices adopted by local authorities	Awareness and education campaigns on the subject	
	Policies focused on the drivers of externalities	In MCs, the greatest pollution factor comes from vehicular activity	Adoption of more effective measures against pollution causes	González et al. (2017)
Infrastructure availability for UFT		Clearance spaces for loading and unloading below required demand Problem traffic (congestion)	Prioritize maintenance of existing roads than building new ones	Pojani & Stead (2015); Van Lier et al. (2016)
Urban Space Configuration		Urban sprawl in MC occurs in an accelerated manner	It is necessary that the urbanization process takes place in a planned and organized way	Espindola et al. (2017)

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| Knowledge, Innovation and Technological Advancement | Lack of data and benchmarking based on studies of urban logistics | Use of already available and inexpensive mobile technologies Use of GIS technology to aid decision making | Gutiérrez-Gallego et al. (2015); Karagiannakidis et al. (2014); Pojani & Stead (2015) |

Source: Own elaboration (2018)

Method

In addition to the concepts presented so far, a survey was conducted with 10 specialists (researchers) in UFT and 20 public agents of Brazilian MCs to evaluate the level of interaction between the attributes that differentiate the Medium Cities versus the factors that influence the UFT. The cities of the respective public agents are listed in Table 5 and were selected according to the criteria presented in Table 3.

Table 5 - Brazilian medium-sized cities surveyed

City	State	Region	Population
Caldas Novas	GO	Midwest	70,473
Acaraú	CE	Northeast	57,542
Bacabal	MA	Northeast	77,860
Ipojuca	PE	Northeast	91,341
Cascavel	CE	Northeast	296,537
Caraguatatuba	SP	Southeast	55,414
Itu	SP	Southeast	67,875
Januária	MG	Southeast	67,875
Cataguases	MG	Southeast	74,171
Alfenas	MG	Southeast	77,618
Caçapava	SP	Southeast	91,162
Aracruz	ES	Southeast	93,325
Poços de Caldas	MG	Southeast	151,449
Pindamonhangaba	SP	Southeast	164,000
Sete Lagoas	MG	Southeast	229,485
Franca	SP	Southeast	360,544
Juiz de Fora	MG	Southeast	538,764
São José do Rio Preto	SP	Southeast	549,203
Castro	PR	South	67,082
Alegrete	RS	South	78,984

Source: Own elaboration, based on IBGE (2016)

The survey allows inferring how the characteristics attributed to the Medium-sized Cities can affect the influence factors related to the Urban Freight Transport. On a scale of 0 to 10, respondents were asked about the degree of relationship between every factor versus every attribute, for a total of 24 variables.

Prior to the calculation to define the degree of interaction, the Kruskal-Wallis (KW) technique verified whether or not there was a difference between the groups of respondents – Public Agents and Specialists. Since the data did not meet the assumptions of parametric tests, especially the normally distributed data, KW test presented as more suitable for testing differences about two datasets.

The analysis of variance of a Kruskal-Wallis factor consists of a non-parametric method used to decide if k independent samples come from different populations. The technique in this case is presented as appropriate, since it tests the null hypothesis that the k samples come from the same population or from identical populations with the same median (Siegel & Castellan Jr, 2006). If the k samples are indeed drawn from the same population or from identical populations, that is, if the null hypothesis is true, then the sample distribution of the Kruskal-Wallis statistic can be calculated.

After checking the samples, the means were calculated for each of the variables, as well as their confidence interval. The calculation of the confidence interval in addition to the mean becomes necessary, since a point estimate does not inform how close the measure is to the actual measurement. In other words, limits

representing a range of plausible values for a parameter are a good way to arrive at a more accurate estimate (Montgomery, 2012).

The KW calculation for the 24 variables, at a significance level of 5%, showed that for all of them there was no difference between Public Agents and Specialists groups. These results suggest that Public Agents cargo are already filled by Specialists. Thus, both groups were treated as a single sample, and the next step was to define the interaction levels between the UFT factors and the characteristics of the Medium-sized Cities. This analysis was based on the averages of the scores attributed by the respondents. Table 6 shows the 95% confidence interval for the scores assigned by the respondents, for each variable.

Table 6 - Confidence interval of the degrees of interaction between MC attributes and UFT influence factors

| | | Attributes for Characterization of Medium-sized Cities | | |
		Population size	Size of urbanized areas or urban sprawl	Position of cities in the urban hierarchy	Urban Function
Factors that influence UFT	Projects and Measures adopted by Local Authorities	Variable 1 Average ≥ 6,941 Average ≤ 8,126	Variable 7 Average ≥ 6,694 Average ≤ 8,372	Variable 13 Average ≥ 6,375 Average ≤ 8,158	Variable 19 Average ≥ 7,322 Average ≤ 8,678
	Infrastructure available for UFT	Variable 2 Average ≥ 6,440 Average ≤ 7,960	Variable 8 Average ≥ 6,541 Average ≤ 8,059	Variable 14 Average ≥ 6,197 Average ≤ 8,003	Variable 20 Average ≥ 7,030 Average ≤ 8,637
	Urban Space Configuration	Variable 3 Average ≥ 6,720 Average ≤ 8,147	Variable 9 Average ≥ 6,304 Average ≤ 7,830	Variable 15 Average ≥ 6,786 Average ≤ 8,214	Variable 21 Average ≥ 6,504 Average ≤ 8,030
	Companies Features	Variable 4 Average ≥ 5,525 Average ≤ 7,275	Variable 10 Average ≥ 5,140 Average ≤ 7,0600	Variable 16 Average ≥ 6,285 Average ≤ 8,049	Variable 22 Average ≥ 6,171 Average ≤ 7,963
	Knowledge, Innovation and Technological Advancement	Variable 5 Average ≥ 5,519 Average ≤ 7,415	Variable 11 Average ≥ 4,917 Average ≤ 6,750	Variable 17 Average ≥ 6,154 Average ≤ 7,846	Variable 23 Average ≥ 6,037 Average ≤ 7,763
	Population (Behavior)	Variable 6 Average ≥ 6,423 Average ≤ 7,977	Variable 12 Average ≥ 6.379 Average ≤ 8,021	Variable 18 Average ≥ 6,195 Average ≤ 7,739	Variable 24 Average ≥ 6,495 Average ≤ 7,971

Source: Own elaboration (2018).

Results and discussion

From the confidence interval of the degree of relationship between the factors that influence the transport of cargo and the attributes that characterize the Medium-sized Cities, a framework is proposed that describes this relation, as presented in Table 7. The framework for analysis of the interaction between MC attributes and the UFT influence factors, describes the relationship between medium-sized cities and cargo transportation.

Table 7 - Framework for analysis of the interaction between MC attributes and UFT influence factors

| | | Attributes for Characterization of Medium-sized Cities | | |
		Population size	Size of urbanized areas or urban sprawl	Position of cities in the urban hierarchy	Urban Function
Factors that influence UFT	Projects and Measures adopted by Local Authorities	High	High	High	Very High
	Infrastructure available for UFT	High	High	High	High
	Urban Space Configuration	High	High	High	High
	Companies Features	Medium	Medium	High	High
	Knowledge, Innovation and Technological Advancement	Medium	Medium	High	Medium
	Population (Behavior)	High	High	High	High

Average equal to 0 - NO interaction
Average from 0 up to 4 - degree of interaction LOW
Average from 4 up to 7 - degree of interaction MEDIUM
Average from 7 up to 8 - degree of interaction HIGH
Average from 8 or higher - degree of interaction VERY HIGH

Source: Own elaboration (2018).

The framework presented in Table 7 did not have zero-degree variables or low interaction degree variables between MC Attributes and UFT Influence Factors. It means that, size, size of urbanized areas or sprawl logistics/growth of the cities, position of cities in the urban hierarchy and function of cities in urbanization are attributes at minimal important to be addressed in UFT regarding the UFT factors analyzed.

Among the 24 defined variables, 1 presented a "Very High" grade (i.e. at least 80% of degree of certainty), 18 variables presented "High" grade (i.e. at least 70% of degree of certainty) and 5 variables presented "Medium" degree (i.e. at least 40% of degree of certainty) of interaction.

Considering UFT influence factors, the "Projects and Measures adopted by Local Authorities" factor presented the highest degree of interaction with the Attributes for Characterization of Medium-sized Cities, especially with the attribute "Urban Function", which characterizes the economic vocation of the city. This interaction means 80% of degree of certainty or above it to represent how a urban function is important to establish projects and measures by the local authorities. This result corroborates with Van Lier et al. (2016) and Pojani & Stead (2015), indicating that time windows for goods delivery, and speed and parking restrictions are acceptable and feasible urban functions for middle-sized city governments.

The factors "Infrastructure available for UFT" and "Urban Space Configuration" presented a high degree of interaction (or between 70% or 80% of degree of certainty) with all attributes, according to the Public Agents and Specialists. In particular, with regard to "Infrastructure available for UFT", the result found recognized the high importance given to this factor by local governments (Kramar et al., 2015), as well as by the transport specialists. It was verified that the factor "Urban Space Configuration" had a high interaction level with urban sprawl (Espindola et al., 2017), and, as stated by Pojani & Stead (2015), has an urban function in the sense of urban planning for the growth of the city. Besides these, other attributes were identified as relevant, such as the size of the population and the position of the city in the urban hierarchy, whether acting as a major regional center, as a higher-level MC, as MC itself or as an emerging urban center (Amorim Filho et al., 2007).

It is noteworthy that the "Companies Features" factor presented medium-degree interaction with attributes of a demographic nature – "Population Size" and "Size of Urbanized Areas" - and a high degree with the attributes "Position in the urban hierarchy" and "Urban Function".

The "Knowledge, Innovation and Technological Advancement" factor has a high degree of interaction with the attribute "Position of cities in the urban hierarchy", and medium degree of interaction with the others. This indicates the importance that the technological advance represents in the evolution of the cities within the hierarchy of the MC. This advance can be identified through the adoption of mobile technologies already available (Pojani & Stead, 2015) and the use of geographic information systems (GIS) (Gutiérrez-Gallego et al., 2015). However, this interaction is still quite low. It means that at 40% of degree of certainty that population size and urban sprawl do not affect the company features and knowledge, innovation and technological advancement in UFT planning.

The influence factor "Population", which refers to the behavior and conduct of the population, presented a high degree of interaction with all attributes of characterization of the Medium-sized Cities. In other words, education and population awareness, which are factors that directly affect the UFT, can be represented by the size of the population, urban sprawl, the position of the city in the hierarchy and its urban function.

Conclusions

The literature review places medium-sized cities as a potential laboratory for studies aiming to improve the flow of goods in urban centers. As MC have the same problems of the great urban centers, the mid-size arrangements present more opportunities for reversal of the problems compared to the large cities.

The framework for analysis of the interaction between MC attributes and UFT influence factors presented that there is no interaction at low levels with none of the MC characterization attributes. Those results reinforce the idea that the feature of cities, in the whole, is an important variable in the analyses involving urban freight transport.

The factors "Projects and Measures of Local Authorities", and "Infrastructure available to the UFT", together with the lack of subsidies (data and research in the area) for studies related to freight transport (Knowledge, Innovation and Technological Advancement) were identified as the main issues that require attention on UFT in MC. In other words, if a policymaker has an intention to improve any infrastructure available for UFT in MC, for example, these characteristics of the cities should be taking into account in the urban planning. Moreover, this framework may be guidance for any urban logistics solution.

It is noteworthy that the factor "Knowledge, Innovation and Technological Advancement" was the item that received the lowest marks according to the assessment of specialists and public agents, which shows the lack of studies that deepen the theme of freight transportation in cities due to the size of urban centers.

This framework serves as a starting point for future studies and research in urban cargo transportation planning, as well as can help decision makers in their actions and policies regarding the flow of goods in these urban centers.

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