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Utilizing urban form characteristics in urban logistics analysis: a case study in Lisbon, Portugal

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ABSTRACT

Within the realm of urban logistics, Macário (2013) developed a hypothesis, denominated the Logistics Profile (LP) concept that 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 concept was expected to ease the transferability of best practices in city logistics, by analyzing similarities and differences between zones. This research uses a quantitative methodology to apply the LP concept, and assess its potential, using the city of Lisbon as a case study. The analysis is focused on: (a) the extrapolation of freight trip generation per establishment and delivery characteristics from a sample of commercial establishments to the population within the case study, (b) proposing a methodology to test the LPs, (c) testing the existence of proposed LPs. Freight trips have been extrapolated using a Multiple Classification Analysis (MCA) model. Freight delivery characteristics were attributed to establishments from a sample-based probability distribution. LPs were tested using a two-step cluster analysis. Some LPs have been matched with clusters of case-study zones, subject to case study particularities. Profile overlap was not an issue and occurrences were expected. The testing showed that Logistic Profiles have the potential for being used as a departure point for urban freight planning and policy analysis.

1. Introduction

Urban freight operations encompass goods distribution activities (delivering/collecting) in urban environments. These activities influence urban traffic congestion. To enhance planning and policy in city logistics there is potential to include urban form characteristics, expressed in measures of land use, as predictive freight demand variables. Urban form can be defined by the spatial imprint of an urban transport system, adjacent physical infrastructures and socioeconomic activities (Rodrigue, 2014). A particular reason for considering urban form is that local freight outcomes are likely to be dependent on their particular urban context. Hence an understanding of the latter can then be incorporated into policy and/or regulations for sub-areas of a city.

Research in city logistics, which is generally of theoretical nature, can be classed within eleven main areas (Quak et al., 2008):

- *Transport flow improvements:* (1) cooperation between companies, (2) consolidation centers, (3) transport reorganizing, (4) routing improvements and (5) e-commerce.
- *Hardware:* (6) infrastructure, parking and unloading facilities, (7) technological innovations.
- *Policy:* (8) licensing and regulation.
- *Research oriented:* (9) modeling, (10) review/discussion, (11) data.

Despite the fact that Quak et al. (2008) do not recognize research relating land-use and urban freight operations as having the same dimension as other areas, some research has acknowledged the importance of geographical factors/land use characteristics to better understand several dimensions of urban freight operations (TURBLOG, 2011; Allen et al., 2008). As an example of *(9) modelling*, the work Holguín-Veras et al. (2012) analyzed the effects of land use and business size on freight trip generation, and of *(6) infrastructure, parking and unloading facilities* in the work of Alho and de J. Abreu e Silva (2014a) the spatial distribution of commercial establishments versus loading/unloading bays was explored.

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Still, few have incorporated land-use metrics explicitly and some research has even challenged the importance of the relationship between urban form and urban freight operations. Melo (2010) argued that despite the existence of non-ignorable differences in the zones under one study, the revealed good practices by a micro-simulation analysis were similar for all zones. Ambrosini et al. (2010) stated that for French urban areas, economic organization is more important than land use characteristics. It must be noted that the case studies were different, and the range of good practices only partially overlapped.

Assuming that similar policy measures are likely to result in considerably different impacts for different parts of an urban area (Anderson et al., 2005), and considering a common goal (e.g., achieve a higher level of freight operations' sustainability), policy measures should vary, or be adjusted, from one area to the other. The analysis of the impact of urban freight policy on freight operations (e.g., access restrictions or provision of additional parking) is a complex task (Muñuzuri et al., 2005). Hence, understanding how sub-areas in a city relate to policy practice could simplify these approaches and, in turn, provide a basis to ease the replication of successful good policy practice.

This rationale led to the identification of a gap in research, relating policy-supported measures to the more suitable urban form characteristics. One approach that has been developed to expose the links between local areas and logistics issues/solutions is the Logistics Profiles (LP) concept. The LP concept aims to standardize the characteristics of urban zones as seen from their urban logistics needs. It is defined "based on the hypothesis that it is possible to identify, for some well-defined areas inside a city, reasonably homogenous groups of logistic needs, based on three key points" (Macário, 2013). The three key points, or elements, are summarized below and in Table 1:

- The social and built environment, denominated as "City Area Features".
- Characteristics of the goods/products being moved, "Product Characteristics".
- Characteristics of the deliveries at the receiver establishment, "Agents/deliveries profiles".

The LPs can be labeled as theoretical research, with some qualitative application. Also, the concept suggests the need to merge several areas of research such as data collection techniques and modeling under a geospatial analysis framework.

Macário (2013) has expanded these elements by creating three levels of each measure, as shown in Table 1. These elements are representative of the elements defining urban form (Rodrigue, 2014) and go beyond it. City Area Features describes, for example, adjacent physical infrastructures (feature 1.3.1 *Measures considering logistics needs*), socioeconomic activities (feature

Table 1
Logistics Profile elements (verbatim Macário, 2013).

Elements		Classification		
City area features				
1.1	Commercial density	Low	Medium	High
		<30%	30–70%	>70% Commercial
		Commercial face to residencies services/industry		
1.2	Homogeneity	Low	Medium	High
		Several types of services and products	Mix of residential areas with offices and commercial stores	Cluster of one type of service or similar products
1.3 Logistic accessibility		Bad	Reasonable	Good
1.3.1	Measures considering logistic needs	Bad level of access between the shop and the parking (e.g. no loading bays)	Some specific measures considering logistic needs (e.g. loading bays non exclusive)	Transport network suited for the logistic needs (e.g. exclusive loading bays)
1.3.2	Level of congestion	High traffic congestion (commercial speed < 3 km/h)	Reasonable (high on peak hours)	Low (fluid traffic – commercial speed > 12 km/h)
1.4	Restriction applied	Yes (off-peak hours, week days, ...)	No	–
Product characteristics				
2.1 Easiness of handling		Difficult	Reasonable	Easy
2.1.1	Size	Large (wheelbarrow, crane)	Medium (>1 person to carry one unit)	Small (>1 unit per person to Carry)
2.1.2	Weight	Heavy (wheelbarrow, crane)	Medium (>1 person to carry one unit)	Light (>1 unit per person to carry)
2.1.3	Holding conditions	Difficult	Reasonable	Easy
2.2 Special conditions		Special needs (e.g., valuable products and frozen products)	Might have special needs (e.g., open packages, if food handled ambient temperature and chilled)	No special needs
2.2.1	Fragility	Fragile	Might have special needs	No special needs
2.2.2	Perishability	Perishable	Not perishable	
Agents/deliveries profile				
3.1	Urgency of deliveries	Irrelevant	Relevant	Urgent
3.2	Frequency of deliveries	Low	Medium	High
		<once a week	Several days per week	Daily
3.3 Amounts to be delivered		Few	Several	Many
3.3.1	Number of shops	One shop	Several shops	Retail center/big shops
3.3.2	Vehicles weight and size	Light goods vehicle or smaller vehicles	Van/small truck	Heavy goods vehicles
3.4	Planned deliveries	No defined routine	Defined routine (e.g., after hours deliveries, 8–10 a.m., ...)	

"–" stands for "not relevant".