

Urban Metrics for Urban Logistics: Building an Atlas for Urban Freight Policy Makers

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Abstract

Recognizing the scant coordination frequently observed between city planning and logistics, this paper introduces a set of metrics and tools for informing city planners about drivers of urban freight efficiency that could be used to design better urban freight policies. We propose a web-based urban logistics atlas to assist the decision making processes regarding urban freight. The pilot of the atlas included an extensive data collection effort in selected one square-kilometer areas in eight metropolises around the world. This paper will review the motivations to create the atlas, the proposed set of urban logistics metrics to characterize each city, the development of the tool and some initial findings that illustrate the value of extending this effort.

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1. Introduction

As of 2012, 52.6% of the world's population dwelled in urban areas. Projections suggest that, by 2030, cities will harbor close to 66% of the world's inhabitants (UN Department of Social and Economic Affairs, 2014). On average, the rate of population living in urban areas grows by 65 million per year. Such rapid urban growth is particularly complex in emerging economies. In 2012, urban population accounted for 79% of the emerging world's inhabitants, and it has been projected to reach approximately 85% by 2030 (Blanco & Fransoo, 2013). According to projections by McKinsey Global Institute, over the next 20 years only four of the top 25 megacities will be located in the developed world (Dobbs et al., 2011).

Increased urbanization directly translates into increased demand for goods and services and their supporting logistics activities. However, as urban population grows, these logistics operations must rely on already congested infrastructures, particularly the road and parking networks, adding layers of complexity to freight activities and worsening city externalities such as congestion, pollution, greenhouse gasses and noise. Freight vehicles account for a small share of vehicle traffic, but a large share of those externalities. Consequently, urban freight is often considered a nuisance from the public perspective (Blanco, 2014).

In spite the vital social and economic role of freight movement, urban planning has not properly considered the intensity of urban freight needs in mobility plans. Reasons for this marginal attention gravitate around the conflict between visions of sustainable urban development and the nature of efficiency-driven modern logistic systems. Still, this planning gap can be resolved with appropriate tools and metrics accessible to city planners. In this paper, we outline some of these metrics and describe the development of the first version of the urban logistics atlas, an open-access platform for capturing and visualizing urban logistics information to support city planning activities that impact freight.

For this first version of the atlas, we collected primary information in selected one-square kilometer areas in eight major cities across Asia, Latin America and Europe: Beijing, Kuala Lumpur, Madrid, Mexico City, Sao Paulo, Rio de Janeiro, Bogota and Santiago. Data collected included: commercial density, delivery operations, traffic and disruptions. The urban logistics atlas, named *km2*, can be accessed using the following link: <http://lastmile.mit.edu/km2>.

The goal of this paper is threefold: 1) to introduce the concept of the urban logistics atlas, including its motivation and development framework; 2) to introduce a set of urban logistics metrics and discuss its applicability to

freight policy and freight solutions analysis; 3) to present the results of a preliminary analysis across the selected case studies as a basis for further work.

2. Motivation

2.1 Incorporating logistics into urban planning

Urban policies and plans have evolved over time to address attributes of city life. With the continual evolution of city form over time, policymakers and planners are tasked with the intentional shaping of the city form and enacting regulation to protect the quality of urban life. As public servants, policymakers and planners are focused primarily on serving the needs of residents and enabling their mobility (Berke et al., 2006). Despite the vital need to move freight into the city, the role of logistics in supplying urban needs has largely been ignored in urban plans and policy (Dablanc, 2009) (Hall & Hesse, 2013). As a result, urban logistics providers adapt and implement ad-hoc measures to operate within increasingly complex and congested cities. These adaptations facilitate the continual delivery of goods to serve urban needs but are not always informed by the urban context or aligned with urban planners, which could improve efficiency, reduce social and environmental impacts, and support long-term coordination. This could also reap similar benefits in urban planners if they were provided with adequate tools to inform future plans.

There are a variety of arguments for why logistics has not been accounted for in urban plans and policies. One major assumption is that freight movement was historically perceived as dirty, noisy and polluting (Hall & Hesse, 2013). Urban planning's historical roots are in aesthetics and beautifying the city (Peterson, 1997), which has long ignored freight movement as a key process in the overall functioning of the city. Modern perspectives on sustainability and environmental protection have further shifted planners' interest away from highly polluting industries like freight movement, despite their centrality to urban life (Berke, Godschalk, & Kaiser, 2006) (Dablanc, 2007).

Furthermore, a conflict exists between ongoing visions in sustainable urban development, which privileges pedestrian mobility, and the nature of logistics systems, which are designed towards economies of scale and freight consolidation in large vehicles. In addition, designing effective and comprehensive regulatory frameworks is a highly difficult task given the diversity of urban freight needs across economic sectors, the variety of urban characteristics among city districts, and the level of fragmentation of

urban freight stakeholders (Blanco, 2014). Lastly, the traditional functional structure of city administrative bodies has not incentivized addressing systemic needs through interdisciplinary efforts (Knoflacher, 2001).

Over the past years, city officials have become more aware of the need to control urban freight flows, but they lack of proper knowledge or tools to do so (Dablanc, 2007). Furthermore, although the need to connect logistics with city planning has been extensively pointed out within the urban freight research community, no data-driven tools have yet been developed. In this paper, our goal is to fill this research and development gap.

To begin to reconcile urban planning and logistics in the city, the tools city planners use should be revisited for supporting planning for logistics. The broadest characterization of a city is the assessment of its physical form. Typically urban form metrics are used to inform planning for residential and business needs in the city and are incorporated into plans and policy for the city. Sometimes referred to as a master, comprehensive, or long-range plan, these plans are long-term policy documents that guide design, density, location, type, and rate of development in a specified area (Berke et al., 2006). An inclusion of freight information and metrics early on in the plan, could better facilitate goods movement in the city while reducing externalities imposed on urban life.

2.2 Primary metrics used in urban planning

Urban form refers to the spatial arrangement within cities. On a conceptual level, descriptors of urban form include location, distance, direction, orientation, linkage and patterns (Herold et al., 2005). These concepts are quantitatively defined by urban metrics that describe urban form. These metrics assess the spatial configuration and local attributes of urban form in its most contemporary condition by serving as summary descriptors of the city (Angel et al., 2011). It is important to note that metrics that characterize the existing urban form are independent from the processes that shape it. Social, environmental, economic, and political processes are not accounted for in urban form metrics. Table 1 presents an overview of the primary metrics used in urban planning.

Table 1. Definition and usage of primary urban planning metrics

Urban Form Metrics		Definition	Use in Planning
Basic			
Size		Total land area	Boundary delineation
Density		Population to total land area	Zoning, long range planning, transit
Land Cover		Total built land in city	Zoning
Pattern-Based			
Complexity		Form of perimeter	Urban growth trends, urban growth boundaries
Centrality		Closeness to an urban center, proximity to CBD	Zoning, transit
Polycentricity		Number of centers, rank size of centers, share of jobs in centers	Transit, long range planning
Compactness		Density of people, jobs and built area	Transit, zoning
Discontinuity		Extent of discontinuous development	Transit
Expandability		Buildable land within urban boundary	Development management, long range planning
Land Use Mix		Types & total area of land use	Zoning, long range planning, transit

To effectively incorporate logistics into city plans, appropriate metrics and tools are necessary. Generating such metrics on the basis on the existing ones will facilitate the integration of logistics and urban planning, by ensuring consistency and applicability.

3. A Framework for Data-Driven Tools and Metrics for Urban Freight Planning

Working from existing studies, we first propose a framework to develop urban logistics tools and metrics and to guide future research. This framework addresses the definition of geographical scale, centrality, and logistics-oriented metrics, as guiding principles to develop an urban logistics atlas.

3.1 Geographical scale for logistics

While many urban form metrics are commonly analyzed at the wider city level, the scale more appropriate for logistics tends to be smaller areas

within the city. Urban freight delivery often operates on a weekly schedule, with each day of the week serving different zones of the city. Therefore, the scale that matters for understanding urban freight is more commonly the neighborhood and/or district level. Therefore, to better tailor urban form metrics for logistics, data needs to be collected and analyzed at these levels instead of citywide. Understanding urban form characteristics at district/neighborhood levels offers insights into the specific nuances of daily operations, existing constraints and needs driving a specific area, as opposed to a more generalized view of the entire city.

Furthermore, large cities are made up of multiple different sectors that may be characterized by higher densities and highly diverse characteristics. By reducing urban form metrics like density to the appropriate scale, planners and logistics providers can better understand more localized urban needs. To more specifically define what scale is appropriate, this proposal draws from the City Form Lab Report (2012). Authors suggest that there should be a common size that metrics draw from in defining smaller scales. One km² is proposed as an appropriate size for subareas in the city.

3.2 Focus on centrality

Although much of the urban form literature has focused on the city as a whole, the greatest complexity of urban freight operations is often concentrated to specific urban areas such as central business districts. Therefore, it is most useful to develop more specific metrics around these city “centers” providing greater detail and in-depth perspectives. Furthermore, many cities have multiple types of centers that drive the movement of people and goods in different ways, as portrayed by the polycentricity urban measure. There are multiple ways to identify “centers”, for instance by focusing on population density or labor statistics. We suggest using International Standard Industrial Classification (ISIC) level data to further refine identification from a logistics perspective. This type of measure allows for estimating good needs based on the type of industrial activity occurring in various areas of the city. Once city centers, relative to logistics, are established, the focus of flows between, from and to these centers is of strategic importance.

3.3 Logistics land use

Urban freight is diffused throughout cities but has specific interactions with various land use types. Therefore, a specific focus should be placed on measuring the road networks, city parking capacity, storage areas, loading & unloading bays, as well as retail and restaurant spaces. There needs to be a greater standardization and quantification of these specific land uses as

they are directly related to logistics impacts. Furthermore, metrics capturing characteristic of logistics operations, as delivery time-windows and vehicle usage, will contribute to tailor policy and solutions to specific urban freight needs.

4. The Urban Logistics Atlas

Using the framework proposed in the previous section, we argue that it is imperative to develop a large-scale atlas employing refined urban logistics metrics to compile case studies of urban areas around the world. This proposal is inspired in the Density Atlas (www.densityatlas.org) completed in 2011 at MIT. The goal of an urban logistics atlas will be threefold. First, will be to better understand what data exists, existing constraints with available data, and which data collection procedures are applicable. Next, by collecting and analyzing data for a broad set of case studies, commonalities and trends between cases will provide insight into how to better plan for logistics. This will allow attaching concrete urban measurements to best-practice manuals such as the one compiled by Dablanc (2011). Finally, once the refined metrics have been established and commonalities across cities understood, companies and logistics providers would also be able to utilize the atlas in the shorter term to have a broader understanding of urban form and how that impacts planning and operating freight movement.

4.1 Selected pilot cities and area of scope

We selected eight metropolitan areas in Asia, Europe and Latin-America as initial case studies, based mainly upon size and availability of local resources. Within each of these cities, a one-square kilometer area was chosen, as proposed in the framework in Section 3. The areas observed were selected considering three major criteria: retail density, area relevance and feasibility to execute the data collection. The selected areas included Chaoyang in Beijing, Modelia in Bogotá, Centro in Rio de Janeiro, Centro in Santiago de Chile, Pinheiros in São Paulo, Zócalo in Mexico City, Jalan Tuanku Abdul Rahman in Kuala Lumpur and Lavapiés in Madrid.

4.2 Data categories

Based upon existing literature and previous data collection experience, an on-site, four-week data collection strategy was designed. Five categories of information were identified for field collection: shop inventory, roads and regulations, delivery operations, disruptions, and traffic. For the first two categories, the information was collected at the square-kilometer level. For

the three remaining categories, data were collected for a relevant street segment, generally one 100-meter block, within the square kilometer. Data was captured using templates, maps and GPS devices.

- *Shop inventory*: The shop inventory consisted of a geo-referenced collection of all commercial activity in the area, including kiosks. Details included type of business, front length, geographic coordinates, store name, and availability of loading area.
- *Roads and regulations*: This information identified the existing road network, parking infrastructure and the corresponding regulations. Details included specific use of street lanes, number of crosswalks, dimension of sidewalks and availability and dimensions of dedicated loading and unloading areas.
- *Delivery operations*: Freight and parcel delivery activities were observed within a street segment for five days. Pickup activities, although less frequent, were also captured. Using the corresponding templates, the following data pieces were collected: vehicle type, delivery equipment, product type, drop size, vehicle-to-store distance and vehicle-to-store number of trips, number of shops served per stop and duration of delivery.
- *Disruptions*: Information on vehicle and pedestrian disruptions was collected, with particular interest in those caused by freight delivery vehicles. The source of the disruption, its duration, the impact on blocked lanes and number of vehicles affected were also captured.
- *Traffic*: The data collection included capturing an estimate of all traffic flows within the segment, from pedestrian to large cargo and passenger vehicles.

4.3 Platform design and development

The online platform for visualizing the information was designed and implemented in the summer of 2013. As the atlas was conceived for practitioners, it was designed as a practical tool with high-visualization interfaces. The data collected across cities were processed and uploaded into the atlas for visualization and further analysis, as described in the next section. The first iteration of the urban logistics atlas, entitled *km2*, can be openly accessed through the following website: <http://lastmile.mit.edu/km2>. Figure 1 illustrates a sample visualization for Pinheiros, in São Paulo, Brazil.



Figure 1. Sample visualization of the urban logistics atlas for Pinheiros, São Paulo

5. Metrics for Urban Freight Policy

Based on the metrics framework and leveraging the urban logistics atlas development described in previous sections we introduce an initial set of metrics that capture different features of the urban logistics system. We illustrate these metrics with the initial results obtained during the pilot data collection.

5.1 Area descriptors

Area descriptions are high resolution land-use and road network metrics that allow for better estimation of logistics activities and impacts in an area of the city. We propose four types of metrics: retail density, city road network factors, road accessibility factors and parking density.

Retail density

Overall, an inventory of retail establishments informs the extent and specific types of retail activities in an area, as a basis for assessing the overall inflow of goods to it. In particular, the retail density metric captures the amount of retail establishments in the urban region. Results for the selected case studies are provided in Table 2.

Table 2. Retail density and predominant retail types per selected areas

City	Area	Retail density (establ/km ²)	Foodservice (%)	Clothing-Fashion (%)	Grocery (%)	Others (%)
Rio de Janeiro	Centro	2,624	14	21	2	63
Mexico City	Zócalo	2,579	13	29	1	57
Santiago	Centro	1,801	21	24	7	48
Madrid	Lavapiés	1,420	24	17	7	52
São Paulo	Pinheiros	1,381	22	16	3	59
Beijing	Chao-Yang	836	20	2	5	73
Kuala Lumpur	Jalan A. Rahman	585	32	34	1	33
Bogotá	Modelia	527	46	5	20	29

The sample of square-kilometer areas chosen for this study included two major types of districts. In Mexico City, Rio de Janeiro, Madrid, Sao Paulo and Santiago, the areas observed corresponded to centric zones with major commercial, governmental or touristic relevance. Consequently, a larger density of retail activities was observed. On the other hand, in Bogota, Kuala Lumpur and Beijing, the square-kilometer areas presented zones of relevant commercial activity, including shopping malls and large markets, along with residential neighborhoods. In those cases, the number of retail establishments was generally lower, nevertheless significant.

Capturing the type of retail establishments is also critical for a comprehensive inventory, as different business activities generate different freight delivery patterns. Fashion stores and food service establishments were the most frequently observed establishments, with varying percentages across the square-kilometers observed (Table 2).

Retail density by type information is particularly useful to estimate the total inflow of goods into a specific area. To illustrate this approach (Table 3), we estimated the average daily deliveries in a selected km² area using multiple classification analysis models (Alho et al., 2015). Based on this approach, on average, close to 4,000 deliveries take place in downtown Santiago every day.

Table 3. Estimation of deliveries for the selected area in Santiago de Chile

Retail categories	Estimated daily deliveries per establishment for each retail category			Average daily deliveries per retail category
	Average - 1/2 Std. Dev.	Average	Average + 1/2 Std. Dev.	
Food service	7	10	14	948
Clothing & fashion stores	1	3	4	267
Grocery stores	6	9	13	834
Others	3	6	8	1,887
Estimated average daily deliveries in the selected km ² area in Santiago				3,936

Road network density and circuitry factors¹

In logistics analysis, trip distances are commonly estimated using analytical approximations and linear coordinate points. Scalar multipliers or circuitry factors, as those proposed by Ballou, Rahardja, & Sakai (2002), correct this estimations by capturing road network features that impact travel directness such as road density, forms and regulations. Existing circuitry factors are most appropriate for inter-city distances and do not capture the highly complex settings of urban areas. Therefore, additional circuitry metrics, at city and district scale, are needed for urban distribution networks analyses.

For district level metrics, we introduce two factors:

- The Road-Network Density (RDF) captures the impact of road network density and topography on travel distance estimations within a city area. It is defined as the ratio between the travel distance using the city road network without any directionality constraints and the Rectilinear (L_1 norm) distance – also known as Manhattan distance – for an n-stop optimal (shortest distance) tour. We use the *Rectilinear* distance, as opposed to the *Euclidean*, as it is more appropriate for grid-like urban structures at district level, usually favored in planned urban developments. Analytically, the RDF defined as:

$$RDF = \frac{1}{m} \sum_i \left(\frac{d_i^F}{d_i^{L_1}} \right) \quad (5.1)$$

¹ Previously known as Urban Form Factor (UFF) and Urban Circuitry Factor (UCF)

where $d_i^{L_1}$ captures for the rectilinear L_1 distance for optimal delivery trip i ; d_i^F represents the real distance for optimal delivery trip i using an undirected (or flexible road network), and m is the total number of trips considered to derive the factor.

- The Road-Network Circuity Factor, RCF, extends the RDF to capture the impact of traffic flow direction constraints (i.e. one-way streets) within urban areas, and it is defined as:

$$RCF = \frac{1}{m} \sum_i \left(\frac{d_i^R}{d_i^{L_1}} \right) \quad (5.2)$$

where d_i^R captures the real distance for optimal delivery trip i using a direction-constrained road network.

To estimate these metrics, we used location of retail establishments provided in the urban logistics atlas to randomly generate 10-stop delivery trips within each square kilometer, and we obtained the optimal trip sequence based on the real and L_1 distances. For the real distances, both over the flexible and constrained road networks, results were obtained from the Google Maps Web Service. In total, for each selected city area, we generated close to 400 delivery trips. Results are depicted in Figure 2. As expected, RCF ratios are larger than RDF ratios, as they capture directionality constraints of the road network. However, we can observe very large differences when comparing different square kilometers. These can be explained by the district types sampled.

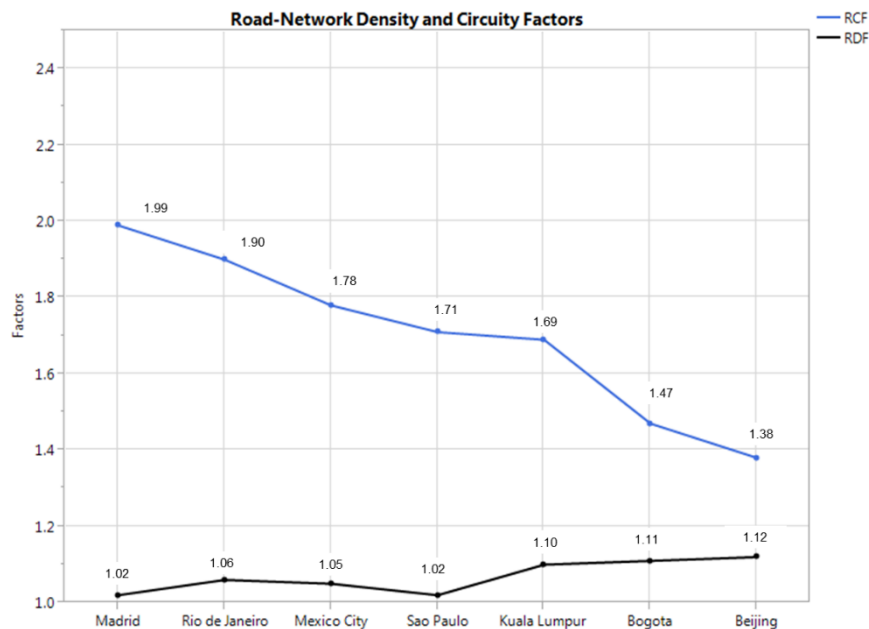


Figure 2. RCF and RDF for selected case studies, alike district types exhibit similar circuity and density factors

As mentioned before, in Madrid, Rio de Janeiro, Mexico City and Sao Paulo, the selected areas were centric and dense zones, mostly having narrow, single direction streets. Indeed, in at least 80% of these street segments, measured by total road length, are one-way streets. Even though the RDF in these areas is close to 1, which implies a convenient grid-like road network, one-way streets significantly increase the real trip distance expected for freight vehicles, as captured by the RCF.

On the other hand, in commercial-residential areas sampled in Bogotá, Kuala Lumpur and Beijing, given the reduced retail density and wider road networks available, the RCF is generally lower, which implies reduced complexities for freight activities. We were able to observe a positive correlation between one way streets and the RCF estimation (see Figure 3).

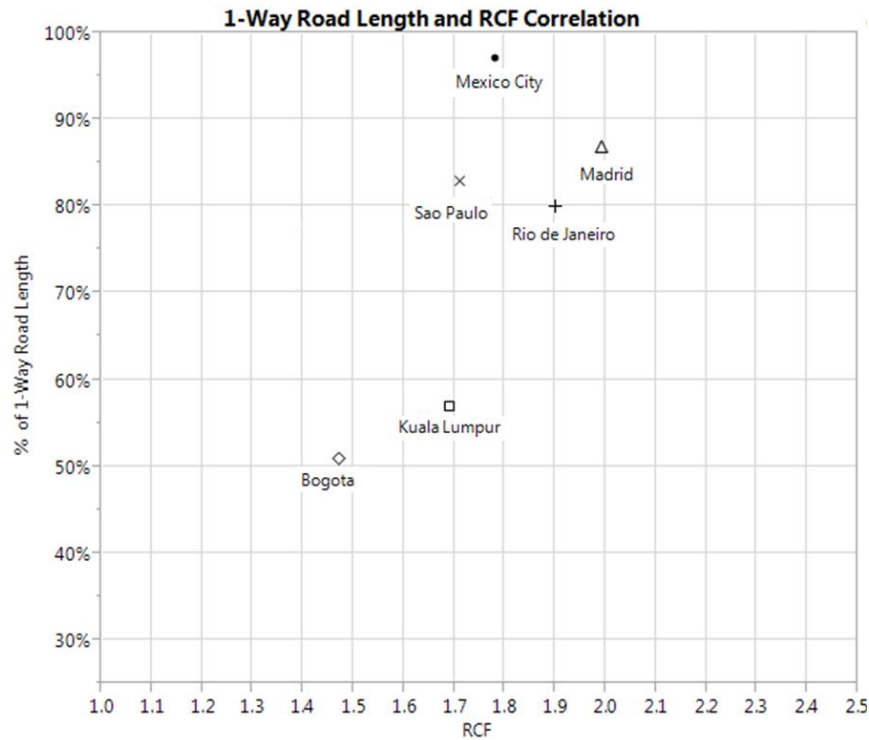


Figure 3. Positive correlation observed between the RCF and the % of 1-way road length

Area accessibility factor

The RDF and RCF capture the impact of the road network at the district level. However, the polycentric nature of most cities and the proper nature of logistics operations demands continuous freight flows between different urban districts on a daily basis. Consequently, it is also necessary to capture the accessibility to urban zones. For this metric, our ongoing developments are inspired by the work of Barbieri da Cunha, Oliveira Arbex, & Yoshizaki (2014), who have introduced a *zone straightness index*, which captures the “difficulty” to reach a specific traffic zone from all other, using the ratio between real and Euclidean distances (L_2 norm). The Area Accessibility Factor (AAF) is defined as:

$$AAF = \frac{1}{m} \sum_i \left(\frac{d_i^R}{d_i^{L_2}} \right) \quad (5.3)$$

where $d_i^{L_2}$ captures for the Euclidean L_2 distance from a point i in the city to the area centroid; d_i^R represents the real distance for this same trip using the city road network, and m is the total number of areas in the city considered to derive the factor. These areas should be selected based on the concentration of warehouses and industrial activities in the urban area.

By combining the AFF metric with the RDF and RCF metrics, we can obtain a comprehensive assessment of the additional distance required to reach and service any area of the city.

Parking density

Simple metrics that capture the provision of parking spaces can directly inform the availability of proper infrastructure for freight activities. These metrics, either in the form of accumulated length or ratios, should include the provision of both, general purpose parking and freight-dedicated parking spaces (delivery bays).

Overall, in the centric areas considered in Mexico City, Santiago and Rio de Janeiro, the inventory of parking revealed a limited number of parking spaces available. In Madrid, in spite of being a centric zone, parking lanes were commonly observed, which facilitates freight activities. However, a common feature across cities was the very limited provision of delivery bays (Figure 4). In general, fewer than 10% of the street segments were equipped with these, signaling the marginal attention given to appropriate urban freight infrastructure.

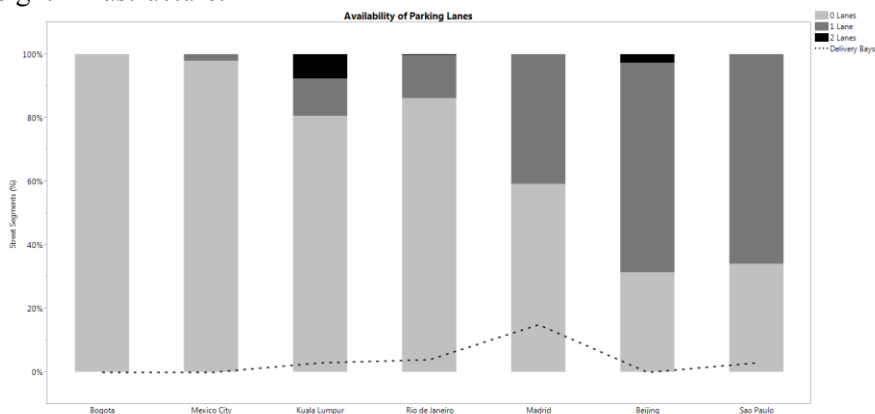


Figure 4. Availability of parking lanes and delivery bays in street segments

5.2 Logistics activity descriptors

The logistics area descriptors of the previous section focus on the physical and industrial characteristics of the city. However, in order to fully develop freight policies, some understanding of the profile of logistics activities is also needed. We propose two basic metrics: the delivery density and the delivery duration. These two metrics are commonly collected as part of freight studies around the world.

Daily delivery density function

The daily delivery density profile captures the average number of deliveries per hour throughout the day. Understanding these freight patterns is instrumental, for example, to design policies involving time windows for freight vehicles access or multi-use parking spaces.

The density functions evidence similar patterns for the street segments observed (Figure 5). In all segments, most deliveries occurred between 9:00 a.m. and 12:00 p.m., as logistics operations are planned to avoid early morning traffic and reach customers, particularly restaurants, before noon. Another delivery-intense period was observed between 2:00 p.m. and 3:00 p.m. Although no detailed information on night deliveries was collected, establishment interviews confirmed that the vast majority of freight operations occurred during daytime.

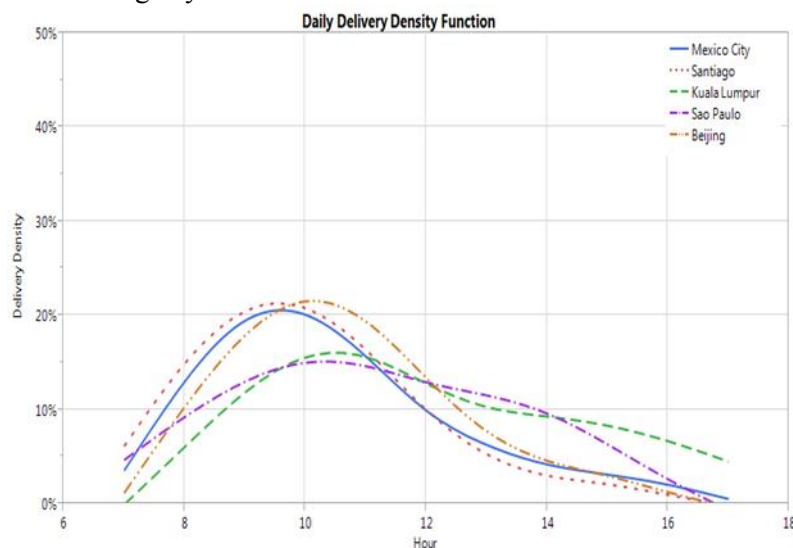


Figure 5. Daily delivery density functions reveal a peak period for freight activities between 9am and 12pm

Delivery duration

To supplement the information about delivery operations, an estimate of the average delivery duration should be obtained. This metric could inform, for instance, the maximum parking time allowed for freight vehicles in dedicated spaces. The differences in delivery duration (see Figure 6) result mainly from the use of different vehicles as well as the type of establishments prevalent in the segments observed. For instance, faster deliveries were observed in Madrid and Rio de Janeiro, where motorcycles or pedestrian deliveries were mostly used.

On average, across all sampled cities, logistics operations last approximately 15 minutes.

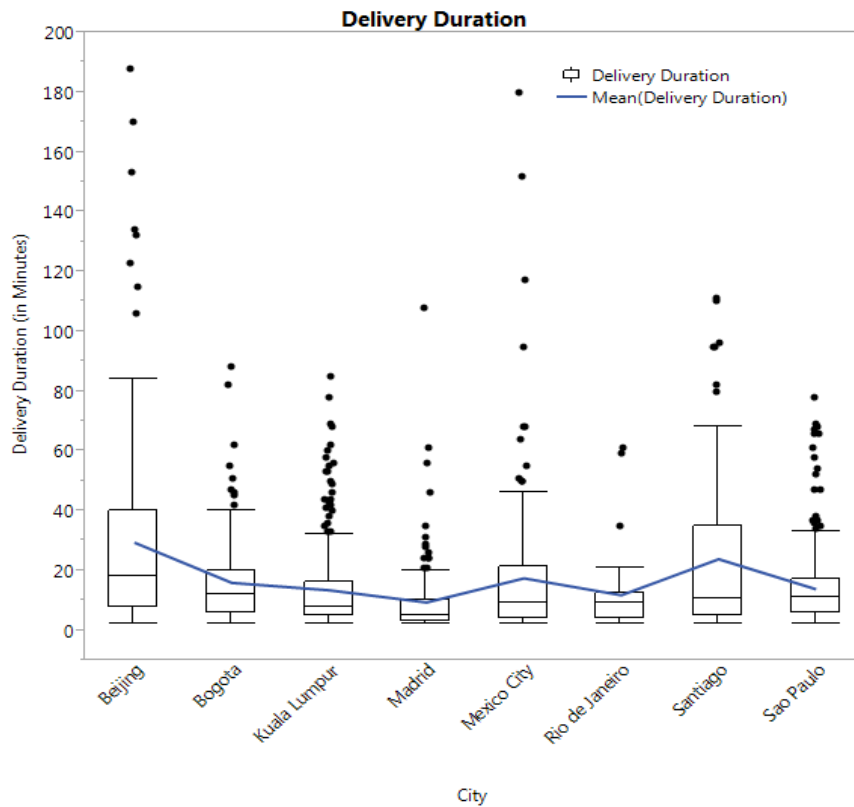


Figure 6. Variability in delivery times driven by vehicles used and retail type

6. Discussion and Further Work

Overall, this first iteration of the urban logistics atlas was instrumental in collecting locally relevant data in major cities around the world and for enabling comparative analyses across differing cities. These data collection also allowed for a concrete validation of our proposed urban logistics metrics. Conclusions from these analyses point to the similarities and differences in urban form, infrastructure and logistics operations. We believe that an effective understanding of the logistically-relevant characteristics of each urban zone, and the similarities and divergences by city and region, which are captured by the proposed metrics, could better inform decisions about the applicability of urban logistics solutions.

Several paths of future work can be pursued using the information captured in the atlas. The retail density and retail type information can nourish freight trip generations models as describe by Alho et al. (2015). The RDF, RCF and AAF, in addition to assessing the complexity of the urban road network, can be used in approximation techniques for last-mile delivery network design and analysis, as those proposed by Daganzo (2005). The provision of parking spaces also captured in the atlas, along with the metrics on specific characteristics of logistics operations in the area, should help assess the sufficiency of proper infrastructure for loading-unloading operations. Additional metrics and techniques are being developed to supplement existing techniques and guidelines, for instance, on the provision of dedicated parking spaces for freight operations (Paris City Council, 2005).

Several limitations need to be addressed in future stages. The data collection process relied on resource-intensive field observations, which could be impractical to replicate at a larger scale. In this regard, data collection options using in-vehicle GPS and mobile phone technology are currently being explored. Alternatively, some of the information needed could be available from local sources, such as government entities. However, the information format may vary across sources, and extensive data processing could be required. Additionally, information from local sources might not capture all the information requirements for a comprehensive assessment of urban logistics operations. Therefore, some level of standardization could be helpful, using, for instance census data and International Standard Industrial Classification code.

We conclude that the urban logistics atlas has the potential for providing useful urban logistics information for city planning purposes, otherwise hardly available. The metrics introduced in this paper provide a generic logistics characterization of each area, and the potential impact on policy considerations has been briefly outlined.

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