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# Metropolitan Economies and the Generation of Freight and Service Activity: An International Perspective

José Holguín-Veras, Diana G. Ramírez-Ríos, Trilce Encarnación, Jesús González-Feliu, Elise Caspersen, Carlos Rivera-González, Carlos A. González-Calderón and Renato da Silva Lima

## 1. Introduction

Global urbanization has been growing rapidly in the past six decades. In the 1950s, less than one-third of the world's population lived in urban settlements. In 2014, this had scaled up to 54 percent of the population, and the trend is expected to continue. By 2050, the world is expected to be 34% rural and 66% urban, the opposite of what it was in the mid-twentieth century (United Nations, 2014b). With increasing urbanization, cities face numerous challenges, particularly in regard to the movement of goods in and out of city centres. These challenges will grow as cities do, and as the demand for goods and services are concentrated in urban areas, producing numerous externalities. Congestion, pollution, noise and safety are just some of the issues that cities must contend with on a daily basis in relation to trucks and other vehicles that carry freight. Service activity also contributes to daily vehicle trips in and out of urban centres. An example would be plumbing repair trucks that service both city offices and residents. All service-related vehicles add, in smaller proportions, to the commercial vehicle traffic present in city centres. Estimates from cities across the United States show that service trips represent only 10% of total freight trips generated (Holguín-Veras et al., 2018c); but in terms of parking needs, the effects may be larger. Studies show that service vehicles stay longer in parking spots, limiting curb space for freight vehicles (Campbell et al., 2017).

Understanding urban economies and how these relate to urban freight and service activity is imperative to addressing the key challenges faced in city logistics. Policy makers will need, as a key indicator of this activity, accurate quantification of commercial vehicles that carry freight and services on a daily basis. Yet, data related to the count of trucks, semi-trailers and tractor-trailers may be limited, or unavailable at a city or metropolitan level. At this level, data on the number of trips taken by vans, sport utility vehicles (SUVs), crossovers, and small vehicles, which represents approximately 90 percent of all urban deliveries in some U.S. metropolitan areas (Bronzini, 2008), is rarely available.

The main goal of this chapter is to put in the hands of the transportation community a cogent characterization of urban economies and the freight and service activity (FSA) they generate. Doing so will help transportation planners and decision-makers to understand the interconnections between the economy and FSA, and to gain an idea about the magnitude of the latter. In doing so, the chapter exploits a series of generation models of FSA which have been developed in multiple countries.

To pursue this goal, the authors selected a number of metropolitan areas of different sizes and from countries in different income ranges, analyzed key economic data and generated estimates for FSA at some of these urban centres. The models used correspond to New York and Albany, NY, United States (Holguín-Veras et al., 2017a), Oslo (Caspersen, 2018) and Medellín (Gonzalez-Calderon et al., 2018). Other cities where the models are available were included as well, as with Paris and Lyon (France), for which models have been built from a national rather than city-based database (Gonzalez-Feliu et al., 2016). The estimates provide a sense of the number of freight and service-related commercial vehicles moving daily in the areas considered, and result in FSA rates that can be transferred to other cities where no empirical estimates are available.

The chapter is divided as follows: The first couple of sections provide a brief overview of the selection of the metropolitan areas, and the data and models used to develop the analysis. The third section provides an initial analysis of the urban economies, followed by an in-depth analysis of those economies by industry sector. The

subsequent sections provide the estimates of freight and service generation, and their relationship to urban economies for a subset of metropolitan areas, where FSA rates are provided and analyzed.

## 2. Metropolitan Areas Selected for the Analyses

For the analyses of urban and metropolitan economies and their implications regarding FSA, a selection of metropolitan areas around the world was developed. These urban areas belong to countries with different income ranges located on a number of continents. Based on the United Nations' 2015 ranking for urban agglomerations and metropolitan areas that exceed 300,000 in population (United Nations, 2014b), the selection was developed for three different classes: Class I, with populations between 6 to 22 million; Class II, with populations between 2 and 6 million; and Class III, with populations of less than 2 million. Each class size includes at least a metropolitan area from a high-income country and a middle-upper income country, as defined by United Nations (2014a). Table 1 shows the selected metropolitan areas and their classifications, followed by a brief description of each region represented.

**Table 1: Metropolitan Areas Selected for the Analyses**

Metropolitan Areas	Population	Area (in km2)	Density (Pop/km2)	Country's Income	GDP per capita (in USD)	Number of Establishments	Total Employment
<b>Class I: From 6 to 22M inhabitants</b>							
Sao Paulo, Brazil	21,391,624	7,947	2,692	Upper-Middle	\$ 16,650.00	436,424	6,174,605
New York, NY, USA	20,153,634	21,483	938	High	\$ 70,758.00	575,333	8,285,112
Paris, France	7,020,210	762	9,213	High	\$ 96,845.28	676,090	3,788,321
<b>Class II: From 2 to 6M inhabitants</b>							
Phoenix, AZ, United States	4,661,537	37,723	124	High	\$ 43,602.00	94,568	1,671,907
Medellin, Colombia	3,777,099	1,157	3,263	Upper-Middle	\$ 8,489.00	117,514	1,762,895
Puebla, Mexico	2,941,988	2,392	1,230	Upper-Middle	\$ 5,131.55	134,928	1,049,807
<b>Class III: Less than 2M inhabitants</b>							
Barranquilla, Colombia	1,991,000	520	3,829	Upper-Middle	\$ 6,140.15	49,874	911,529
Lyon, France	1,370,678	534	2,567	High	\$ 45,554.71	105,377	618,205
Oslo, Norway	1,570,000	8,894	177	High	\$ 82,040.00	72,263	763,503
Santiago, Dominican Rep.	577,000	524	1,101	Upper-Middle	\$ 12,626.00	9,541	485,037

Note: Establishment refers to a place of business, which could be local or a branch location of a larger business.

### *Sao Paulo, Brazil*

The metropolitan area of São Paulo (RMSP) is Brazil's largest, with 21 million inhabitants, distributed over 39 municipalities and 7,947 square kilometers (IBGE, 2017). It is the fourth largest urban agglomeration in the world, and concentrates nearly 18% of Brazil's total GDP in its important industrial and commercial complexes (Brookings, 2012). The latest statistics show that there were over 7 million jobs in nearly 450 thousand establishments in RMSP (Brazilian Ministry of Labour, 2016). The RMSP concentrates diversified and specialized services with special highlights in the areas of communications, culture, education, health, transportation and gastronomy. Additionally, it is an important centre for business tourism in Latin America, as well as for numerous multinational companies.

### *New York, NY, United States*

The New York City metropolitan area is the largest in the United States, and includes the cities of Newark and Jersey, and neighboring counties located in the three states of New York, New Jersey and Pennsylvania, with 21

million inhabitants and extending 21,483 square kilometers. It reported a GDP per capita of USD \$70,758 in 2016, a growth of 1.04% from the first statistic recorded in 2001 (U.S. Bureau of Economic Analysis, 2017). The latest statistics show that the number of non-agricultural jobs in the region is over 8 million (US Bureau of Labor Statistics, 2016). It is an important financial centre, and host to many national and international headquarters, particularly in the technology, real estate and insurance sectors. Also known as the “capital of the world,” the city receives an estimated 59.7 million tourists each year (McGeehan, 2016), with very active food and accommodation sectors.

#### *Paris, France*

The metropolis of Greater Paris—which refers to the administrative multi-town structure within the Île-de-France region—includes the city of Paris and the departments located in the “inner ring” of the region: Haut-de-Seine, Seine-Saint-Denis and Val-de-Marne. It has more than 7 million inhabitants, covers 762 square kilometers (Institut National de la Statistique et des Etudes Economiques-INSEE, 2018) and generates a GDP per capita of 97 thousand euros (Eurostat, 2018). It has total employment of 4 million and more than 600 thousand establishments in 2016 for the metropolis of Greater Paris (Institut National de la Statistique et des Etudes Economiques-INSEE, 2018). It is a smaller area within the most populated urban area in France, the Île-de-France region, with more than 12 million inhabitants (Île-de-France, 2018). The main economic activities are retailing and services—excluding public administration, but including transport and logistics (CCI Paris Île-de-France, 2017).

#### *Phoenix, AZ, United States*

Phoenix is the largest city of the state of Arizona and a major economic centre of the southwestern United States. The metropolitan area includes the city of Phoenix plus the cities of Mesa and Scottsdale, spans 37,725 square kilometers, and is home to 4.7 million inhabitants (US Bureau of Labor Statistics, 2016). The most recent GDP per capita measured for the Phoenix metro area (AZ) was USD \$43,602 in 2016, slightly lower than the one reported in 2001 (U.S. Bureau of Economic Analysis, 2017). Employment, on the other hand, has grown faster than the national rate for the past five years, reporting over 1.6 million employees and nearly 95 thousand establishments (U.S. Census Bureau, 2016; 2017). The city boasts a healthy job market with large aerospace and defense companies, as well as a growing market of technological companies, all attracted to Phoenix’s lower cost of living compared with other metropolitan areas in the west.

#### *Medellín (Valle de Aburrá), Colombia*

Medellin is the second largest city in Colombia after its capital, Bogota. Its metropolitan area includes nine neighboring urban areas, known as the Valle de Aburrá metropolitan area. Its area extends to 1,157 kilometers, with a total of 3.8 million inhabitants. The data collected shows a total employment of more than 1.7 million (Área Metropolitana del Valle de Aburrá et al., 2012), and its metropolitan area makes the second highest contribution to the country’s GDP, with nearly USD \$8,500 per capita (Camara de Comercio de Medellín Para Antioquia, 2017). It is an important industrial urban area considering its manufacturing activity, and its international trade is also very active, with an international airport that handles a huge percentage of Colombia’s imports and exports for different industry sectors, particularly the floriculture sector.

#### *Puebla-Tlaxcala, Mexico*

The metropolitan area of Puebla-Tlaxcala is the fourth largest in Mexico, with a total population of 2.9 million, according to the 2015 census (Instituto Nacional de Estadística y Geografía - INEGI, 2018). The city of Puebla, its urban core, represents almost 50% of the population of the entire metropolis, and it reported a GDP per capita of USD \$5,131 (Les Ateliers, 2012). The metropolitan area is composed of thirty-eight municipalities (Consejo Nacional de Planeación, 2010). The metropolitan area reported an employment of 1 million, and 135 thousand establishments (Instituto Nacional de Estadística y Geografía - INEGI, 2018). Puebla’s economy was historically

known for its industrial corridors, which have slowly been replaced by service sectors. This shift, so highly concentrated in its core city, has been accompanied by a reduction of economic activity (Puebla Online, 2018).

#### *Barranquilla, Colombia*

Barranquilla is the fourth largest city in Colombia, and the second largest in the Caribbean Basin after Miami FL. Its metropolitan area includes the city of Barranquilla and the municipalities of Puerto Colombia, Soledad, Malambo, and Galapa (US Commercial Service and Amcham Colombia, 2015). It has nearly 2 million inhabitants, and extends 520 square kilometers (El Herald, 2017). In 2016, it reported over 900 thousand employees and a GDP per capita of USD \$6,140 (Departamento Administrativo Nacional de Estadística-DANE, 2018). It has been acknowledged as Colombia's Golden Gate Way due to its important maritime and river ports, which receive 60% of the metal and 40% of the steel consumed in Colombia (US Commercial Service and Amcham Colombia, 2015). Barranquilla is a dynamic industrial and commercial activity centre, with such important sectors as metal-mechanics, logistics, energy and business services (PROCOLOMBIA, 2018).

#### *Lyon, France*

The Grand Lyon Metropolis is the second largest metropolitan area in France. It includes 59 municipalities, has a surface area of about 538 square kilometers, and counted 1.3 million inhabitants in 2014 (La Métropole de Lyon, 2018). It has a GDP per capita of 43,300 euros, occupying the thirteenth place among European cities (Le Progrès, 2018). The most recent data collected reported more than 600 thousand employees and 100 thousand establishments (Institut National de la Statistique et des Etudes Economiques-INSEE, 2018). The main industrial sectors are chemistry/environment and pharmaceutical production, digital and image industries and automotive manufacturing (Grand Lyon Economie, 2017).

#### *Oslo (Greater Oslo region), Norway*

Oslo is the capital of Norway, and the country's economic and governmental centre, as well as a traffic and cultural hub. The Greater Oslo region includes Oslo and another 45 surrounding municipalities that are both economically and socially connected to Oslo, covering an area of 8,894 square kilometers (Statistics Norway, 2018a). The region was home to 1.57 million people in 2015, which is approximately 30% of Norway's population (Statistics Norway, 2018b) — and was one of Europe's fastest growing in the last decade (Eurostat, 2017). Over 200 thousand establishments and nearly 900 thousand employees were registered in the region in 2015, of which approximately half were registered in the city of Oslo (Statistics Norway, 2018a).

#### *Santiago, Dominican Republic*

Santiago is the second largest city in the Dominican Republic, with a population of 577 thousand with an area of 524 square kilometers. Employment in Santiago has grown significantly in the past decade, as a result of the country's economic growth, with more than 450 thousand employees reported in 2016, and a GDP per capita of USD \$12,626 (Banco Central de la República Dominicana, 2018). The city is located in a fertile region, the Cibao Valley, where cacao, coffee, tobacco, rice, and other agricultural export products are grown. The city's main economic activities are processing the region's agricultural products, as well as manufacturing tobacco products, pharmaceuticals, furniture and leather goods (Oficina Nacional de Estadística-ONE, 2018).

### **3. Data and Models**

#### **3.1 Data Collected**

This section describes the data collected to analyze the economies of the selected metropolitan areas. The data used for the analyses consists of the counts of establishments and employment per industry sector. The main source of these data are listed below, in Table 2.

**Table 2: Sources of Data for Selected Metropolitan Areas**

Metropolitan Area(s)	Source
Sao Paulo, Brazil	Instituto Brasileiro de Geografia e Estatística (IGBE 2017)
New York, NY, United States	US Bureau of Labor Statistics (2016)
Paris, France	Institut national de la statistique et des études économiques (2013)
Phoenix, AZ, United States	US Census Bureau (2016;2017)
Medellin, Colombia	Area Metropolitana del valle de Aburra et al (2012)
Puebla, Mexico	Instituto Nacional de Estadística y Geografía -INEGI (2018)
Barranquilla, Colombia	Dane (2015)
Lyon, France	Grand Lyon Economique (2017)
Oslo, Norway	Statistics Norway (2018)
Santiago, Dominican Republic	Oficina Nacional de Estadística-ONE (2018)

All datasets contain, for the entire metropolitan area, employment and establishment totals, and by industry sector. Given that the industry sectors were different among countries, a cross-referencing of these to the North American Industry Classification System (NAICS) had to be developed as part of the study. As Table 2 also highlights, some of the data is obtained from the census of establishments and business records in the respective Chambers of Commerce, while others were obtained from reports produced or estimates developed from secondary sources. The latter were used only if no primary data was available.

### 3.2 Freight and Service Generation Models

To assess the magnitude of FSA in cities, the authors applied state-of-the-art models to estimate daily freight and service vehicle trips in selected metropolitan areas. Freight Trip Generation (FTG) models were used for daily freight trips, which include daily freight trips produced and attracted to the establishment. Service Trip Generation (STA) models were used to estimate service trips. The limited data available from the service sector only captures Service Trip Attraction (STA), but not Service Trip Production.

The FTG models are available for the following geographical areas: New York and Albany, NY (United States), Paris and Lyon (France), Medellin (Colombia), and Oslo (Norway). The STA models are available for New York and Albany, NY (United States). These were linear and nonlinear Ordinary Least Square (OLS) models, as a function of industry type and employment, as shown in Equations 1 and 2, respectively. In the case where the values were reported per week, respective values per day were calculated, assuming that the firm operates for an average of 5.5 days per week.

Linear model:

$$f(E) = \alpha + \beta * E \tag{1}$$

Non-linear model:

$$f(E) = \alpha * E^\beta \tag{2}$$

Where f stands for FTG or STA. The nonlinear model in Equation 2 is a result of natural log transformation of dependent and independent variables, as given below in Equation 3:

$$\ln(f) = A + \beta * \ln(E) \tag{3}$$

Also for the nonlinear model, the log transformation bias is corrected by considering Mean Squared Error ( $S^2$ ) in the calculation of  $\alpha$ , as given in Equation 4, where ‘exp’ represents exponential function (Newman, 1993).

$$\alpha = \exp\left(\frac{S^2}{2} + A\right) \quad (4)$$

Table 2 shows the summary of the models available.

**Table 3: Functional Forms Available for Freight Activity in the Cities**

Metropolitan Area(s)	Functional Forms Available	Freight Deliveries Received	Freight Shipments Sent	FTG	STA
New York, USA	Linear	x	x		x
	Non-linear	x	x		x
Paris and Lyon, France	Linear			x	
Medellin, Colombia	Constant	x	x		
Oslo, Norway	Non-linear			x	

A brief description of the models used to estimate freight and service trips for the analysis is provided below.

#### *FTG Models for the USA*

Freight Trip Generation (FTG) and Service Trip Attraction (STA) models were developed from survey data collected from establishments located in the New York City metropolitan area, and the New York State Capital District (i.e. Albany, NY and surrounding cities), as part of research funded by the National Cooperative Highway Research Program and the National Cooperative Freight Research Program (Holguín-Veras et al., 2017a). These establishment-level models are solely based on employment, and were developed by industry sector, based on the North American Industry Classification System (NAICS). Specifically, these are estimates for daily shipments sent, and deliveries received, at a two-digit level NAICS for the two US cities mentioned. FTG is the result of the total of daily shipments and deliveries, under the assumption that one freight shipment sent equals one freight trip produced, and one freight delivery received equals one freight trip attracted.

The models were implemented in the Freight and Service Activity Generation Software (Holguín-Veras et al., 2017b), where an aggregation procedure was developed to automatically generate the estimates for any city in the United States, using as input the Census Business Patterns (CBP) database. Through the software, models have been successfully applied to a number of large cities in the United States (Holguín-Veras et al., 2018c).

#### *FTG Models for France*

The FTG models for France are based on the work of Gonzalez-Feliu et al. (2016) and Sanchez-Diaz et al. (2016). Data collected from the French surveys on urban goods (Ambrosini et al., 2010) were used to propose a set of models integrating a statistical analysis (mainly dispersion), and the FTG framework from Holguín-Veras et al. (2011) and Holguín-Veras et al. (2013). The authors examined different levels of aggregation and functional forms. The models are structured in 26 categories, where results from the most robust model were identified by Sanchez-Diaz et al. (2016) in terms of both prediction capacity and heterogeneity caption.

#### *FTG for Medellin*

The FTG models for Medellin were estimated using survey data collected in 2011-2012. The surveys were conducted in 2947 establishments in the urban area (Gonzalez-Calderon et al., 2018). The FTG models were estimated by industry sector. The estimates developed consist of daily shipments (production) and deliveries (attraction) at a two-digit level based on the International Standard Industrial Classification of All Economic Activities (ISIC). The estimates are for both FIS and SIS commercial establishments. Similar to the models for

New York City and Albany, the estimates for FTG assume that one freight shipment sent equals one freight vehicle trip produced, and that one freight delivery received equals one freight vehicle trip attracted.

#### *FTG Models for Oslo*

The FTG models for Oslo were developed using survey data collected from establishments in Groruddalen, an urban area in the eastern part of Oslo, Norway. It covers four of Oslo's boroughs, and a wide spectrum of commercial and private activities. The survey was conducted in 2016, and inquired about the number of freight and service vehicles moving to and from the surveyed establishments during a typical week, as well as establishment-specific characteristics (Caspersen, 2018). Resulting models were similar to the NCFRP 25 FTG models, except only non-linear models were estimated, as this relationship was the most suitable fit for the data, as explained in Caspersen (2018).

## **4. Metropolitan Economies**

To start the analyses of metropolitan economies, it is crucial to get a global picture of the economic activity in metropolitan areas. To develop the analysis, the authors observed key economic data (i.e. GDP, employment and establishments) from the selected metropolitan areas. This section highlights the relationship between population, economic indicators (i.e. GDP per capita) and the size of the economic activity (establishments and employment) at each metropolitan area.

To understand where these metropolitan areas stand in terms of population and economic activity, a ranking was developed for each of the cities, as shown in Table 4. The first three cities in the population ranking are some of the largest cities in the world. In the Americas, for instance, Sao Paulo is the second highest after Mexico City. New York follows as third highest, and is the largest metropolitan area in the United States. These same cities are the top three in the establishments and employment rankings, clearly corroborating what Kötter and Friesecke (2009) mentioned about these cities being the centres and junctions of the global economy.

Based on population ranking, the metropolitan areas that follow are not as large, but fall in the category of cities where a significant proportion of the world's population live. In 2016, 1.7 billion people (23 percent of the planet's population) lived in a city with fewer than one million inhabitants (United Nations, 2016). Also, as shown in Table 4, some of these cities fall naturally in order of employment as well, which suggests that there is a correlation between employment and population size. In terms of establishment numbers, less populated cities such as Lyon have climbed up in ranking. A larger number of establishments is very common in the French context, where cities have a large proportion of small single-employee establishments. Santiago is the smallest of all the cities, but belongs to the category of cities that are expected to increase most rapidly in the next decade, according to the United Nations (2016) report. Also, as expected, it is the smallest in terms of establishments and employment.

In terms of income, GDP per capita clearly separates the cities belonging to high-income countries—i.e. France, Norway, and the United States—and the cities belonging to the middle-upper income countries—i.e. Brazil, Dominican Republic, Colombia and Mexico. There seems to be no clear connection between income and intensity of economic activity, as initially observed by the rankings of number of establishments and employment. Nevertheless, these GDP rankings were important to understand the level of investment that can be made in these cities, particularly in terms of business improvements and the revitalization of city centres.



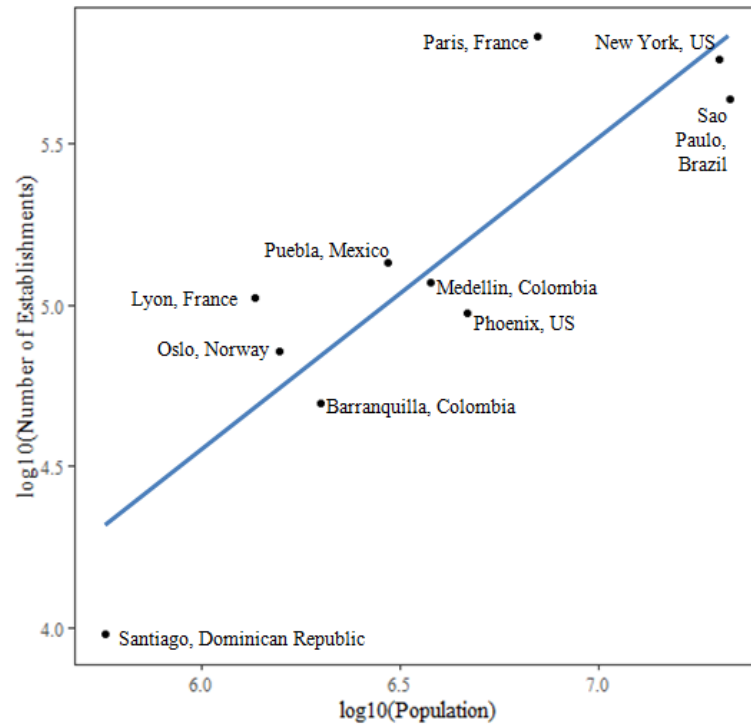
**Table 4: Ranking of Metropolitan Areas**

<b>Rank</b>	<b>Population</b>	<b>GDP per capita (in USD)</b>	<b>Establishments</b>	<b>Employment</b>
1	Sao Paulo, Brazil	Paris, France	Paris, France	New York, NY, US
2	New York, NY, US	Oslo, Norway	New York, NY, US	Sao Paulo, Brazil
3	Paris, France	New York, NY, US	Sao Paulo, Brazil	Paris, France
4	Phoenix, AZ, US	Lyon, France	Puebla, Mexico	Medellin, Colombia
5	Medellin, Colombia	Phoenix, AZ, US	Medellin, Colombia	Phoenix, AZ, US
6	Puebla, Mexico	Sao Paulo, Brazil	Lyon, France	Puebla, Mexico
7	Barranquilla, Colombia	Santiago, Dominican Rep	Phoenix, AZ, US	Barranquilla, Colombia
8	Oslo, Norway	Medellin, Colombia	Oslo, Norway	Oslo, Norway
9	Lyon, France	Barranquilla, Colombia	Barranquilla, Colombia	Lyon, France
10	Santiago, Dominican Rep	Puebla, Mexico	Santiago, Dominican Rep	Santiago, Dominican Rep

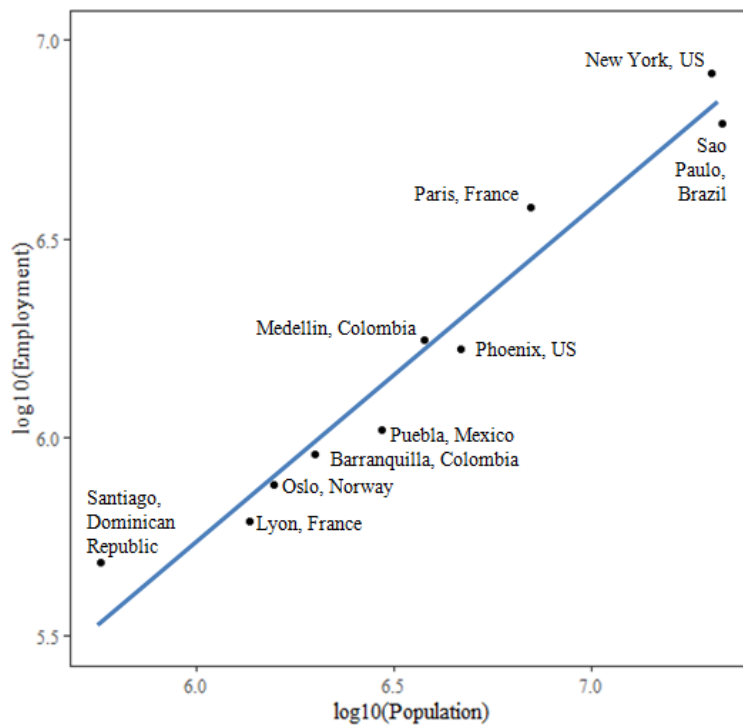
To understand the relationship of population and economic activity, as evidenced by the rankings of the metropolitan areas analyzed, plots for the logarithm of the population with the logarithm of number of establishments and employment were developed, as shown in Figure 1 and 2, respectively. The number of establishments per city has a linear relationship with population, regardless of the level of economic development of the city. As seen in Figure 1, all cities show that as population increases, the number of establishments also increases. In the middle-upper income cities, the number of establishments per person ranges from 0.01 to 0.04, while high income economies show a range of establishments per person of from 0.02 to 0.09. The lowest result for this ratio in high income economies is for Phoenix, in the United States, and the largest value reported is for Paris, France. The difference between these cases is due to the types of businesses located in these urban areas. Paris and Lyon have a large number of small micro-enterprises, which significantly increases the number of establishments per person, while a greater concentration of large businesses reduces this ratio. The relationship between population and employment shows less variability, and does not exhibit significant outliers, as shown in Figure 2. Here, the same correlation is shown between establishments and population. With a median number of jobs per inhabitant of 0.41, these employment numbers reflect the high levels of economic activity concentrated in the metropolitan areas.

Understanding that there exists a correlation in the size of the economic activity with the size of the city can provide city planners with tools to assess the challenges involved in the movement of goods and services to city centres. For instance, more populous cities will have higher demands for freight and services than a smaller city, thus face a more critical situation. Further sections will expand on these opportunities, where estimates for freight and service are compared among cities of different sizes and urban economies.

**Figure 1: Number of Establishments and Population per City**



**Figure 2: Employment and Population per City**



## 5. Freight and Service Intensive Sectors

To grasp the intensity of freight and service activity (FSA), it is essential to get a better understanding of those sectors that generate the most freight traffic, and those that generate the most service traffic. Industry sectors were classified as Freight-Intensive Sectors (FIS) or Service-Intensive Sectors (SIS). The FIS are those industry sectors for which the production and consumption of freight is an important component of their economic activities. The SIS are those sectors where the provision of services is the primary activity. Table 5 shows the resulting classification of the sectors, based on the North American Industry Classification System (NAICS).

**Table 5: Classification of Industry Sectors based on FSA**

NAICS	Freight-Intensive Sectors (FIS)	NAICS	Service-Intensive-Sectors (SIS)
11	Agriculture, Forestry, Fishing, Hunting	51	Information
21	Mining, Quarrying, Oil / Gas ...	52	Finance and Insurance
22	Utilities	53	Real Estate and Rental and Leasing
23	Construction	54	Professional,Scientific,Tech. Services
31-33	Manufacturing	55	Management of Companies /
42	Wholesale Trade	56	Administrative,Support,Waste Manag.
44-45	Retail Trade	61	Educational Services
48-49	Transportation and Warehousing	62	Health Care and Social Assistance
72	Accommodation and Food Services	71	Arts, Entertainment, and Recreation
		81	Other Services
		92	Public Administration

As shown, FIS do not just consist of warehouses and manufacturing facilities. Restaurants, hotels, and retail stores also consume freight on a daily basis. Moreover, the proportion of economic activity in the FIS accounts for half of all of the economic activity. Previous research done on the metropolitan and micropolitan areas of the United States has determined that 45% of all commercial establishments are accounted for in FIS, and 50% of employment is generated in FIS (Holguín-Veras et al., 2018a). This implies that efficiency or inefficiencies encountered in the movement of goods in these sectors will have a direct impact on half of the economy, and an indirect impact on the other half. It is also worth mentioning that these previous studies found that Transportation and Warehousing accounts for only 2.8% of commercial establishments, and 3.6% of employment in the US, while 30-35% of employment is concentrated in the Retail and Wholesale businesses. This suggests that city centres that most likely do not have warehouses or manufacturing facilities are still receiving a lot of freight traffic, given the daily deliveries produced and shipments received in restaurants, hotels and retail stores.

The SIS, on the other hand, consists of all businesses that offer as their primary activity a given service or range of services to their customers. Banks, insurance companies, healthcare facilities, computer service enterprises, attorney offices, management consulting firms, plumbing repair companies, and cable services are all examples of service-oriented businesses. Even though the intensity of freight is not as pronounced for these establishments as it is with FIS, service activity does have a significant impact on passenger and commercial vehicle traffic. On the passenger side, SIS includes the daily commuting of employees to these businesses, and on the commercial side, SIS involves vehicles that are required to get to establishments to perform a given service. The latter has important implications for urban logistics, particularly parking, as these vehicles typically spend extended periods of time at

an establishment while performing a service. Thus, taking into account the number of service vehicles operating on a daily basis is essential for accurate city planning.

To understand the impact of FIS and SIS, total establishments and employment were obtained by industry sector for some of the metropolitan areas of analyses, as shown in Table 6 and 7.

### **5.1 Freight Intensive Sectors**

The first section of Table 6 shows that the percentage of establishments in FIS is significantly lower in metropolitan areas from high-income countries, where these represent typically half or below half of all establishments. In the middle-high income countries, FIS represents the majority of the establishments. This is the case of Sao Paulo (Brazil), Medellin (Colombia), and Puebla (Mexico), where FIS establishments represent 69, 70, and 70 percent of the total, respectively. With regards to FIS employment, the case is similar. For instance, Medellin shows 52 percent of employment in these sectors, and Puebla (Mexico) shows an employment of 81 percent of the total. Table 6 also shows another interesting pattern regarding the estimates in different geographical areas. In European cities, for instance, the average employment per establishment is significantly lower than it is in cities in the United States. This was discussed earlier, for in French cities, as the data shows, there is a higher proportion of smaller establishments, where the average employment per establishment is 5 to 6. This is also reflected in Oslo, which has an average of 8 employees per establishment. In the United States, the value varies between 12 and 20 employees per establishment. As population increases in the high-income countries, the number of establishments per resident increases. In the case of medium-high income cities, there is a consistent pattern of employment per resident. As population decreases, the number of employees per 1000 residents generally increases.

Table 6 also shows a breakdown by industry sector belonging to FIS, where some interesting patterns are observed. The percent of establishments for the consumer-oriented sectors, such as Retail Trade (NAICS 44-45), Wholesale Trade (NAICS 42), and Food and Accommodation Services (NAICS 72), represents a large proportion of the FIS, where the percent of establishments and employments ranges from 44 to 80%. Particularly in the high-income cities, the Construction (NAICS 23) sector is also highly represented, as it accounts for 20 to 30 percent of all establishments in FIS, and 12 to 20 percent of all employment in FIS. In the middle-high income cities there is a higher representation of the Manufacturing (NAICS 31-33) sector, and a lower representation of Construction (NAICS 23) establishments. In Medellin, for example, the Manufacturing sector is 16 percent of the total, while in Phoenix this sector is only 8 percent of total. In the Construction sector, the opposite holds true. In Medellin, Construction is only 6 percent, while in Phoenix it is 21 percent of the total establishments.

**Table 6: Establishments and Employment by FIS**

NAICS	Description	Sao Paulo, Brazil	New York, NY, US	Paris, France	Phoenix, AZ, US	Medellin, Colombia	Puebla, Mexico	Barranquilla Colombia	Lyon, France	Oslo, Norway	Santiago, Dominican Rep
<b>Establishments</b>											
23	Construction	7%	20%	27%	21%	6%	1%	12%	28%	19%	7%
31-33	Manufacturing	15%	6%	8%	8%	16%	17%	13%	11%	16%	18%
42	Wholesale Trade	8%	15%	16%	13%	11%	4%	13%	15%	14%	15%
44-45	Retail Trade	46%	32%	13%	31%	40%	61%	42%	16%	22%	43%
48-49	Transportation & Warehousing	5%	6%	18%	6%	7%	1%	7%	13%	19%	4%
72	Accommodation and Food Services	19%	21%	18%	21%	14%	16%	9%	17%	8%	10%
Number of establishments (FIS)		301,327	250,209	227,995	37,216	82,667	99,774	29,547	35,572	39,049	5,279
Number of establishments (Total)		436,424	575,333	676,090	94,568	117,514	134,928	49,874	105,377	72,263	9,541
% FIS Establishments of Total		69%	43%	34%	39%	70%	74%	59%	34%	54%	55%
<b>Employment</b>											
23	Construction	9%	12%	16%	14%	16%	2%	15%	14%	21%	7%
31-33	Manufacturing	25%	10%	15%	13%	24%	13%	24%	27%	23%	18%
42	Wholesale Trade	9%	14%	16%	10%	12%	4%	10%	14%	18%	15%
44-45	Retail Trade	28%	29%	11%	28%	19%	71%	33%	10%	9%	43%
48-49	Transportation & Warehousing	8%	10%	18%	9%	8%	2%	10%	16%	14%	4%
72	Accommodation and Food Services	21%	23%	24%	25%	7%	7%	7%	18%	10%	10%
Employment (FIS)		3,692,120	3,234,208	1,223,215	781,065	910,914	847,033	600,962	231,690	309,636	268,369
Employment (Total)		6,174,605	8,285,112	3,788,321	1,671,907	1,762,895	1,049,807	911,529	618,205	763,503	485,037
% FIS Employment of Total		60%	39%	32%	47%	52%	81%	66%	37%	41%	55%
<b>Rates</b>											
Establishments (FIS) per 1000 residents		14.09	12.42	32.48	7.98	21.89	36.56	14.84	25.95	24.87	9.15
Employment (FIS) per 1000 residents		172.60	160.48	174.24	167.56	241.17	310.41	301.84	169.03	197.22	465.11
Average Employment per Establishment (FIS)		12.25	12.93	5.37	20.99	11.02	8.49	20.34	6.51	7.93	50.84

## 5.2 Service Intensive Sectors

When analyzing the breakdown by SIS, as observed in Table 7, there are additional patterns that are worth noting. The share of establishments generated by these sectors ranges from 40 to 66 percent in all metropolitan areas, with the exception of Puebla (Mexico), where the representation of establishments in SIS is much lower. The share of employment generated by SIS sectors ranges from 45 to 68 percent, with the exception of Puebla (Mexico) and Barranquilla (Colombia) with a share of 19 and 34 percent of all employment in SIS, respectively.

With respect to those sectors that generate a significant share of the jobs in urban areas in SIS, there is the Health Care and Social Assistance (NAICS 62) sector, which is very well represented in some countries but not as well represented in other countries. For cities in the US, in particular, this sector represents 30 percent of all employment registered in SIS. This is not the case for the cities in France, where the Health Care sector only accounts for 10 to 12% of the employment in SIS. In the Colombian cities, this percentage is much lower, as it represents only 7 to 8% of the employment in SIS.

Other industry sectors belonging to SIS are also well represented across metropolitan areas, particularly those that are related to technological services and sales. The Real Estate (NAICS 53) sector is particularly important in the French cities, as it represents almost half of all establishments in SIS. In terms of employment, the percentage is much lower, which suggests that most of these establishments are composed of single-person employees. The Professional and Technical (NAICS 54) sector is also very well represented in the majority of metropolitan areas, and represents 20 to 38 percent of all establishments, and 13 to 28 percent of all employment in SIS.

**Table 7: Establishments and Employment by SIS**

NAICS	Description	Sao Paulo, Brazil	New York, NY, US	Paris, France	Phoenix, AZ, US	Medellin, Colombia	Puebla, Mexico	Barranqui lla, Colombia	Lyon, France	Oslo, Norway	Santiago, Dominican Rep
<b>Establishments</b>											
51	Information	5%	4%	5%	3%	7%	1%	5%	3%	5%	3%
52	Finance and Insurance	7%	9%	8%	12%	13%	5%	9%	8%	3%	8%
53	Real Estate	26%	11%	48%	12%	5%	6%	2%	50%	11%	8%
54	Prof and Technical Services	34%	22%	2%	23%	27%	4%	23%	3%	38%	22%
55	Management of Companies	0%	1%	0%	1%	2%	0%	1%	0%	0%	0%
56	Administrative and Waste Mgmt	1%	9%	0%	10%	15%	9%	11%	1%	10%	7%
61	Education Services	8%	3%	3%	3%	3%	7%	3%	3%	5%	6%
62	Health Care and Social Assistance	16%	19%	2%	21%	7%	16%	7%	3%	12%	19%
71	Entertainment	3%	4%	4%	2%	4%	2%	3%	1%	4%	5%
81	Other Services	0%	19%	29%	13%	18%	50%	36%	28%	12%	22%
Number of establishments (SIS)		135,097	325,124	448,096	57,352	34,847	35,154	20,327	69,805	33,214	4,262
% SIS Establishments of Total		31%	57%	66%	61%	30%	26%	41%	66%	46%	45%
<b>Employment</b>											
51	Information	6%	6%	9%	4%	5%	3%	9%	8%	7%	3%
52	Finance and Insurance	10%	12%	12%	14%	9%	6%	5%	7%	5%	8%
53	Real Estate	23%	4%	12%	4%	2%	4%	2%	9%	3%	8%
54	Prof and Technical Services	29%	15%	3%	13%	13%	2%	22%	5%	28%	22%
55	Management of Companies	0%	5%	0%	5%	1%	0%	1%	0%	0%	0%
56	Administrative and Waste Mgmt	2%	9%	15%	16%	56%	13%	11%	20%	14%	7%
61	Education Services	11%	7%	8%	5%	1%	25%	3%	13%	12%	6%
62	Health Care and Social Assistance	16%	30%	10%	27%	8%	16%	7%	12%	22%	19%
71	Entertainment	3%	4%	4%	4%	1%	2%	3%	1%	3%	5%
81	Other Services	0%	8%	26%	7%	4%	30%	37%	25%	6%	22%
Employment (SIS)		2,482,485	5,050,904	2,565,106	890,842	851,981	202,774	310,567	386,515	453,867	216,668
% SIS Employment of Total		40%	61%	68%	53%	48%	19%	34%	63%	59%	45%
<b>Rates</b>											
Establishments (SIS) per 1000 residents		6.32	16.13	63.83	12.30	9.23	12.88	10.21	50.93	21.16	7.39
Employment (SIS) per 1000 residents		116.05	250.62	365.39	191.10	225.56	74.31	155.99	281.99	289.09	375.51
Average Employment per Establishment (SIS)		18.38	15.54	5.72	15.53	24.45	5.77	15.28	5.54	13.66	50.84

## 6. Freight and Service Activity

This section presents the estimates for freight and service trips in metropolitan areas in different parts of the world. To accomplish this, the authors selected metropolitan areas where FTG and/or STA models have been estimated, as explained in Section 2. The estimation of daily freight and service trips in the metropolitan areas of New York (United States), Paris (France), Medellin (Colombia), Lyon (France), and Oslo (Norway) were estimated directly from their models, as explained in previous sections. The metropolitan area of Phoenix (United States) used the New York and Albany (United States) models.

Table 8 shows the resulting estimates of FSA, together with the total population, number of establishments, and employment. In addition, the authors decided to include a series of rates that express either FTG or STA as unit rates of population, number of establishments, and employment. These rates provide a pragmatic and very useful mechanism to produce order-of-magnitude estimates of FSA for cities and metropolitan areas for which only approximate estimates are needed, or there are no trip generation models, or the input data are not available. An analyst would only need to decide which metropolitan area from Table 8 provides the best match for the area under study, and then apply the selected rates to the population, number of establishments, or employment.

**Table 8: Key Statistics per Metropolitan Areas**

Description	New York, NY, United States	Paris, France*	Phoenix, AZ, United States	Medellin, Colombia	Lyon, France*	Oslo, Norway
<b>Estimates of Freight and Service Activity (FSA)</b>						
FTG (FIS)	1,924,153	2,221,769	336,115	214,082	357,125	110,462
Freight Shipments (FIS)	1,031,160	1,199,755	157,355	117,139	192,847	52,249
Freight Deliveries (FIS)	892,993	1,022,014	178,760	96,943	164,277	58,214
STA (SIS)	152,758	131,472	34,522	18,750	11,565	14,343
<b>Key Socio-Economic Descriptors</b>						
Population	20,153,634	7,020,210	4,661,537	3,777,099	1,370,678	1,570,000
Area (in km <sup>2</sup> )	21,482.85	762.00	37,723.28	1,157.39	534.00	8,894.00
Density (pop per km <sup>2</sup> )	938.13	9,212.87	123.57	3,263.46	2,566.81	176.52
GDP per capita (in USD)	70,758.00	96,845.28	43,602.00	8,489.00	45,554.71	82,040.00
Establishments	575,333	676,090	94,568	117,514	105,377	72,263
Employment	8,285,112	3,788,321	1,671,907	1,762,895	618,205	763,503
<b>FSA Rates</b>						
FTG per establishment	3.344	3.286	3.554	1.822	3.389	1.529
STA per establishment	0.266	0.194	0.365	0.160	0.110	0.198
FTG per employment	0.232	0.586	0.201	0.121	0.578	0.145
STA per employment	0.018	0.035	0.021	0.011	0.019	0.019
FTG per 1000 residents	95.474	316.482	72.104	56.679	260.546	70.358
STA per 1000 residents	7.580	18.728	7.406	4.964	8.437	9.135

\*Data collected from these metropolitan areas include a significant number of small micro-enterprises, which increases the number of establishments per person and overestimates the values for FTG and STA.



As observed, the magnitude of FSA is evidenced by how large the city is in regards to the population and employment indicators. A large city like New York, which reports over 500 thousand establishments and 8 million employees, generates approximately 2 million freight trips, and 150 thousand service trips daily. For a smaller city, such as Oslo, these numbers are reduced to 110 thousand daily freight trips generated, and 14 thousand daily service trips attracted.

The estimates also show that in some cities, the amount of freight and service generated is much higher when compared to another city of similar size. The city of Paris, with 7 million residents, shows 2.2 million freight trips generated, and approximately 130 service trips attracted; as compared to New York—a city double the size of Paris—which generates approximately 2 million freight trips and 150 service trips. This difference is due to the increased number of establishments obtained from Paris' database, which increases the number of freight and service trips substantially. Even so, both megacities coincide with an average of 3.3 daily trips per establishment. Another example is the city of Lyon, which shows 3.4 daily freight trips per establishment. This rate is much higher than the one obtained in Oslo, which generates nearly 1.5 daily freight trips per establishment.

Different freight rates are also observed among cities with varied income levels. The case of Medellin is an example of this, where FSA is under represented in lower income countries. Medellin shows the lowest freight trips per establishment, approximately 1.8, and 57 daily freight trips per 1000 residents. A city of similar size, Phoenix, shows a higher proportion of freight activity, with 3.5 freight trips per establishment, and 72 freight trips per 1000 residents.

## **6.1 Freight Activity for Freight Intensive Sectors**

To illustrate the importance of freight in metropolitan areas, estimates of daily freight trips were analyzed at each FIS, as shown in Table 9.

As shown, in the largest metropolitan areas, total daily freight trips in FIS range from 1.9 to 2.2 million, which translates to approximately 80 to 110 daily trips per 1000 residents. If internet deliveries are included, using the e-commerce freight rates of 0.12 per resident estimated by the authors using the National Household Transportation Survey, this indicator could climb to 200 daily trips per 1000 residents. With respect to individual industry sectors, cities like Paris have a unique share of establishments, as they have a large share from intermediaries in the supply chain, as observed by the Wholesale Trade (NAICS 42), and Transportation and Warehousing (NAICS 48-49) sectors. These sectors generate approximately 15 daily freight trips per establishment. New York City displays a slightly different pattern, as their larger share of freight trips comes from the local and consumer-oriented establishments, such as Retail Trade (NAICS 44-45) and Wholesale Trade (NAICS 42). Both sectors generate approximately 9 daily freight trips per establishment.

The medium to large cities, as observed from the estimates for Phoenix (USA) and Medellin (Colombia), show similar patterns to each other in terms of daily freight trips in their FIS. The total daily trips are approximately 45-50 per 1000 residents. They both have Retail Trade (NAICS 44-45) as the industry sector with the highest share of trips. They display some differences in their freight patterns in other industry sectors. In the case of Phoenix, the FIS sectors that generate the highest freight trips include other consumer-oriented sectors, such as the Wholesale Trade (NAICS 42) and Accommodation and Food Services (NAICS 72). Together, all three sectors generate approximately 10 trips per establishment. For Medellin, the second place is occupied by the Manufacturing (NAICS 31-33) sector, which is common in a city that hosts 20% of the largest companies in Colombia, particularly the largest textile manufacturers. Both Retail Trade (NAICS 44-45) and Manufacturing (NAICS 31-33) generate approximately 3.6 daily freight trips per establishment in Medellin.

**Table 9: FTG for Selected Metropolitan Areas in FIS**

NAICS	Description	New York, NY, United States	Paris, France	Phoenix, AZ, United States	Medellin, Colombia	Lyon, France	Oslo, Norway
<b>Freight Trip Generation</b>							
23	Construction	8.8%	19.0%	10.5%	5.4%	18.7%	16.3%
31-33	Manufacturing	7.9%	8.0%	10.7%	10.8%	11.7%	7.4%
42	Wholesale Trade	20.3%	27.2%	15.9%	5.8%	26.2%	19.1%
44-45	Retail Trade	35.5%	8.1%	40.4%	67.8%	9.7%	18.9%
48-49	Transportation & Warehousing	14.2%	24.7%	6.1%	3.8%	22.2%	30.5%
72	Accommodation and Food Services	13.3%	13.0%	16.5%	6.5%	11.5%	7.8%
Total Freight Trip Generation (FIS)		1,924,153	2,221,769	336,115	214,082	357,125	110,462
<b>Internet Deliveries</b>							
Population		20,153,634	7,020,210	4,661,537	3,777,099	1,370,678	1,570,000
Internet Deliveries (Ratio=0.12)		2,418,436	842,425	559,384	453,252	164,481	188,400
Total FTG Daily Trips (incl online deliveries)		4,342,589	3,064,194	895,499	667,334	521,606	298,862
<b>Freight Trip Rates</b>							
Daily FTG per 1000 residents		95.474	316.482	72.104	56.679	260.546	70.358
Daily FTG per 1000 residents (incl online deliveries)		215.474	436.482	192.104	176.679	380.546	190.358
Daily FTG per Establishment		3.344	3.286	3.554	1.822	3.389	1.529
Daily FTG per Employment		0.232	0.586	0.201	0.121	0.578	0.145

The smaller metropolitan areas also produce a significant amount of daily freight trips, approximately 110 to 350 thousand. Even though less populated, these cities display higher freight rates than the larger cities (i.e., Phoenix and Medellin), most likely due to the higher economic activity observed in these smaller cities. In both Lyon and Oslo the value ranges between 80 to 180 daily freight trips per 1000 residents. If internet deliveries are included, these values could surpass the 200 daily FTG per 1000 residents estimated for megacities. In terms of the top freight generators, both cities have Wholesale Trade (NAICS 42) and Modal Transportation and Warehousing (NAICS 48-49) at the top, with a cumulative share of 50% of all freight trips in the FIS, and a rate per establishment of 17 daily trips for Lyon, and 4 daily trips for Oslo.

## 6.2 Service Activity for Service Freight Intensive Sectors

To illustrate the importance of service in metropolitan areas, estimates of daily service trips were analyzed at each SIS, as shown in Table 10. The total estimates for daily service trips within SIS vary across metropolitan areas, as shown in Table 10. Larger metropolitan areas, such as New York and Paris, have much higher estimates for STA; typically more than 130,000 service trips on a daily basis. The smaller metropolitan areas show much lower estimates for STA, around 14,000 daily trips. For the majority of cities, service trips typically represent between 4 to 13% of all freight trips. Yet these numbers should not be underestimated, as these trips contribute significantly to the lack of parking in city centres, as service vehicles stay for prolonged periods of time, preventing other commercial vehicles (i.e. delivery trucks) from parking and/or unloading supplies (Holguín-Veras et al., 2018b).

Total daily service trip rates vary across countries. In the cities belonging to the United States, these were approximately 7 daily STA per 1000 residents. In the case of the Colombian city, Medellin, this number was much lower, approximately 4 daily STA per 1000 residents. In the capital of Norway, the rate is 9 daily STA per 1000

residents. In the case of France, this rate varies, as Paris shows 19 daily STA, while Lyon estimates 10 daily STA per 1000 residents.

**Table 10: STA for Selected Metropolitan Areas**

NAICS	Description	New York, USA MSA	Paris, France MSA	Phoenix AZ, USA	Medellin, Colombia MSA	Lyon, France MSA	Oslo, Norway MSA
<b>Service Trip Attraction</b>							
51	Information	6.3%	13.0%	2.7%	7.6%	2.9%	2.8%
52	Finance and Insurance	8.0%	11.4%	17.5%	20.5%	9.9%	3.1%
53	Real Estate	0.1%	0.2%	0.1%	0.1%	20.4%	2.0%
54	Professional and Technical Services	0.5%	0.1%	15.0%	19.8%	7.5%	44.3%
55	Management of Companies	1.0%	0.0%	1.1%	1.5%	0.0%	0.1%
56	Administrative and Waste Management	7.7%	0.7%	5.0%	8.3%	0.5%	4.5%
61	Education Services	0.7%	0.4%	1.9%	2.5%	13.1%	14.3%
62	Health Care and Social Assistance	45.9%	6.7%	41.9%	15.1%	9.1%	18.8%
71	Entertainment	7.1%	11.9%	2.8%	5.7%	1.7%	2.9%
81	Other Services (except Public Admin)	22.7%	55.6%	12.0%	18.9%	35.0%	7.3%
Service Trip Attraction (SIS)		152,758	131,472	34,522	18,750	13,708	14,343
Freight Trip Generation (FIS)		1,924,153	2,221,769	336,115	214,082	357,125	110,462
% Service Trips of Freight Trips		8%	6%	10%	9%	4%	13%
<b>Service Trip Rates</b>							
Daily STA (SIS) per 1000 residents		7.580	18.728	7.406	4.964	10.001	9.135
Daily STA (SIS) per Establishment		0.266	0.194	0.365	0.160	0.110	0.198
Daily STA (SIS) per Employment		0.018	0.035	0.021	0.011	0.019	0.019

In the individual industry sectors that belong to SIS, it seems that the larger proportion of service trips belongs to the Health Care and Social Assistance (NAICS 62) sector. In the US cities, 40% of all service trips typically relate to this sector. In the European cities, approximately 20% of all service trips are within this sector. Yet, in the city of a lower income country (i.e. Medellin) the proportion is lower, as this sector accounts for 15% of the total STA. The only exception is Oslo, which has Professional and Technical Services (NAICS 54) as its largest generator of service trips, representing 44% of total STA.

Besides the Other Services (NAICS 81) sector—which occupies second place in most of the cities analyzed—the second most important sector varies across cities. In the medium-sized cities, Phoenix and Medellin, the Finance and Insurance (NAICS 52) sector accounts for approximately 20% of all service trips. New York also has this sector as the second most important, but it only represents 8% of all service activity in the city. For Lyon, the Real Estate (NAICS 53) sector is the second most important. In Oslo, the second most important is the Health Care and Social Assistance (NAICS 62) sector, followed by the Education Services (NAICS 61) sector.

## 7. Conclusions

This chapter provides an international comparison of metropolitan areas and the relationship of their economic activity to the freight and service generated in these areas. Metropolitan areas in a range of population size, income levels and economic development were selected among countries in Europe and the Americas. The general analyses developed show that growing urban areas are economic powerhouses, which contribute to a large share of the country's economic activity. The chapter also evaluated the contribution of establishments by industry sector to the urban economies, and their connection to FSA. Breaking down the analysis between FIS and SIS provides a better understanding of how urban economies are directly related to the generation of freight and service vehicle trips.

The bulk of the analysis focuses on how the size, income, and economic activity of the cities' FSA. Cities that are among the largest in the world, such as New York and Paris, are generating millions of daily freight trips, and hundreds of thousands of daily service trips. Smaller cities (e.g. Oslo, Norway) are also generating a huge amount of daily freight trips, but the magnitude is only a fraction of the total generated in larger cities. Further, lower income cities show less daily freight activity, but these numbers may merely be underestimates of the freight trips generated from all the informal jobs that are not reported in official databases. Service activity is less critical in smaller cities, but should not be ignored, as it has important implications for city planning for parking and parking facilities, as service trip vehicles occupy parking for longer periods of time.

The analyses reveal that a series of FSA rates provide a very consistent picture of freight and service activity in metropolitan areas: the freight trip generation per establishments (freight trips/ establishment-day) ranges between 1.53 (Oslo, Norway) and 3.55 (Phoenix, USA); the service trip attraction per establishment (service trips/ establishment-day) ranges from 0.16 (Medellin, Colombia) to 0.37 (Phoenix, USA); the freight trip generation per employment (freight trips/employee-day) ranges between 0.12 (Medellin, Colombia) and 0.23 (New York, USA); the service trip attraction per employment (service trips/employee-day) ranges from 0.01 (Medellin, Colombia) to 0.02 (Phoenix, USA); the freight trip generation per 1000 residents per day (freight trips/1000 residents-day) ranges between 56.68 (Medellin, Colombia) and 95.47 (New York, USA); while the service trip attraction per 1000 residents per day (service trips/1000 residents-day) ranges from 4.96 (Medellin, Colombia) to 9.14 (Oslo, Norway). Due to the overestimation of FSA in the French cities, the authors decided not to include them in these ranges.

These analyses are just the beginning of what should be a much deeper discussion about urban economies and FSA across the world. The results provide city planners and practitioners with international FSA rates that must be carefully applied as references for cities where no data on commercial vehicle traffic is available.

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