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Assessing the implications of aggregating data by activity-based categories for urban freight trip generation modeling

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Abstract. This paper studies the implication of aggregating establishments by categories with different levels of detail for modeling urban freight trip generation. To this effect, the authors use a dataset of 2.970 establishments collected in 1998-1999 in France to conduct a formal assessment of FTG patterns homogeneity inside the traditional activity-based grouping (retail, manufacturing, wholesale, etc.). The results shows that, although, for some categories the traditional high-level aggregation includes sub-sectors with homogenous FTG patterns and thus produces appropriate models; in some other cases (e.g., retail, manufacturing), the sub-sectors have different FTG patterns and thus more detailed data is needed to calibrate accurate models. This research can be used to enhance the efficiency of data collection, as it identifies some sub-sectors that need larger efforts for data collection, and some other categories where FTG homogeneity allows for less detailed data collection without hampering the quality of the models.

Keywords: FTG; urban goods transport; accuracy assessment; RMSE.

1 Introduction

Urban freight demand modeling is a popular subject for both researchers and practitioners [1], with a plethora of frameworks and applications. One of the most important stages of demand modeling is demand generation, which takes the form of freight generation (FG) models or freight trip generation (FTG). FG is a measure of freight flow (e.g., tons, volume) that results from the economic interaction between a shipper and a receiver. FTG is a measure of freight-related trips that result from the demand for goods and the logistics decisions of shippers and receivers; FTG includes both freight trip attraction (FTA) manly resulting from deliveries, and freight trip production (FTP) mainly resulting from shipments [2]. This paper focuses on models to quantify FTG using establishments' data.

There are a number of publications in the literature focusing on FTG models [2-11], most of them use either land-use or industry classifications to group establishment that perform similar activities and estimate either constant rates per employee [5, 9, 11] or econometric models for each group [3, 5-7]. The classifications used for modeling purposes can have different levels of detail: models estimated with more aggregated categories have less detail, high risk of heterogeneity within the modeling group, but require less data; while models estimated with more disaggregated categories have a higher level of detail but require a substantial amount of data. The criteria used to group establishments under a certain aggregation level are often based on the premise that similar industries have similar FTG patterns, and on practical reasons, such as, the convenience to use secondary data sources available at higher aggregation levels. However, besides the recent efforts from the authors [1], there is no formal assessment in the literature showing which level of aggregation is more appropriate for FTG modeling. This paper proposes a formal assessment via econometrics to assess the implications for FTG modeling of using different aggregation levels within each industry. The results from this study will be instrumental to design more efficient data collection frameworks, because it will allow to identify industry sub-sectors that require higher level of detail and thus more data, and other industry groups with higher homogeneity that require less data.

This paper extends the results of [1] by proposing a methodology to carry out a heterogeneity analysis with an aim of exploring the needs and opportunities of proposing different aggregations in FTG modeling. In other words, the paper aims to assess if and when aggregated categories have a prediction accuracy that represents well the FTG phenomena without the need of disaggregating data (which can have an interest in terms of costs and resources to deploy) and in which cases a higher disaggregation is

necessary. First, the authors propose the methodological framework to carry out the analysis, the data used and the main hypothesis of the research work. Then, the main results of the analysis are presented and discussed. Finally, as a conclusion, practical implications as well as future developments are proposed.

2 Methodology

2.1 Data description

The first step in the analysis is to define and present the data, as well as the classification system. The authors chose to deploy this analysis framework on the French Urban Goods Surveys of 1995-1998, for a detailed description of the survey, reader scan refer to [13]. That quantitative survey consists of three main parts: the first one describes the establishments' attributes, the second one studies pickup and delivery operations and the third one presents the truck driver's patterns, vehicle rounds and paths. For FTG, the authors use the first two parts of the survey. The data was collected from three cities of different characteristics (Bordeaux, Dijon and Marseille) and includes 2,970 establishments and 11,588 delivery operations (including both receptions and expeditions) without missing data concerning freight transport demand.

Although this dataset is outdated, it provides a unique opportunity to assess the modeling implications of different aggregations of classification systems, because of the number of observations within each sector: 2,970 establishments with at least one operation of any type (i.e., freight trip attraction or production), 2,613 establishments with at least one freight trip attraction (FTA), i.e., reception of a delivery, and 1,500 establishments with at least one freight trip production (FTP), i.e., a pick-up or the expedition of a delivery. Those surveys present information on both FTA and FTP (as shown above). However, this study focuses on FTG, by adding up both FTA and FTP, for the following two reasons: (i) FTG without specifying the nature of the operation can be useful for planning purpose (identification of truck types and mileages for congestion estimation, definition and dimensioning of parking and delivery bay facilities, etc.) and (ii) making no distinction between the type of operations give us a larger dataset, i.e., about 300 establishments more than only FTA and more than 1400 only FTP, which enhances the statistical significance of the results. Moreover, this study focuses only on the influence of the aggregation level of the industry groups (i.e., the typology of establishments) on FTG, and not on other variables such as type of vehicle, city or management mode.

2.2 Aggregation levels and hypotheses

Although the quality of FTG models is, in the literature, often related to the explanatory variables and functional forms, the data aggregation through classification systems is an understudied factor that plays a key role in determining the functional form and quality of the models. Since considering many variables can affect the identification of direct impacts of data aggregation on the model's accuracy and robustness, this paper focuses only on the data aggregation by category of establishments. For the proposed analyses, the authors adapted the classification proposed in the French urban goods surveys analyses [13]. This classification is based on two main elements:

- The type of activity of the firm, eventually coupled with the main function of the establishment (8, 29 or 44 activities distinguished);
- The class of workforce (on the basis of the 44-categories classification, which extends the classification into a 111-category classification).

The authors explain below the rationality underlying the classification systems as well as the technique to obtain the different aggregation levels. The first aggregation level (the most aggregated classification) distinguishes 8 categories of establishments (ST8), which has been set in correspondence with the most aggregated classification of French NAF codes (the French declination of European NACE classification). Then, each ST8 group is divided into one or more sub-categories with more detail on the type of activity taking place in the establishment, resulting in the 28 different categories (ST28). This classification corresponds to a second level of disaggregation in the sampling phase of the surveys. The

third aggregation level, ST44, consists on repeating the ST28 codes and adding a sub-index designing a sub-sector within the ST28 classes. In all three classifications, the only discrimination criterion is the economic activity of the establishment. Table 1 presents these different levels of aggregation.

Table 1: Synthesis of the three first level of aggregation (ST8-ST28-ST44)

ST8 code	Description	ST28 code	Description	ST44 code	Description
1	Agriculture	1	Agriculture	1	Agriculture
2	Craftsmen/ services	2	Craftsmen	2-2	Repair activities
				2-3	Manufacturing or installation
				2-4	Light repair
		26	Services	26Ha	Tertiary services: high flows
				26Mi	Tertiary services: mixed flows
				26Mo	Tertiary services: average flows
3	Manufacturing/ Repair	3	Chemical industry	3	Chemical industry
		34	Construction industry	34-2	Repair industry
				34-3	Construction – Manufacturing or installation
		4	Production and intermediate	4-2	Production and intermediate – basic bulk
				4-6	Production and intermediate – small objects
				4-7	Production and intermediate – bulk
		5	Consumption goods	5-2	Fragile foodstuffs
				5-4	Non-fragile foodstuffs
				5-5	Non-fragile consumer goods, non-food
4	Wholesalers	7	Intermediary products	7-2	Fragile intermediate products
				7-3	Oher intermediate products
		8	Non food	8-2	Non-food fragile consumer goods
				8-3	Non-food non fragile consumer goods
		9	Food products	9-2	Fragile food consumer goods
				9-3	Other food consumer goods
5	Department stores	10	Department stores	10	Hypermarkets and big department stores
				11	Supermarkets
				12	Specialized department stores
6	Retailers	13	Minimarkets	13	Minimarkets
		14	Clothes, shoes, leather	14	Retail trades, clothes, shoes, leather
		15	Butcher's shops	15	Butcher's shops
		16	Small groceries	16	Grocer's shops
		17	Bakery retailers	17	Bakeries – Cake shops
		18	Ho.,Re.,Ca.	18	Ho.,Re.,Ca.: Hotels, Restaurants, Cafés
		19	Pharmacies	19	Pharmacies
		20	Hardware stores	20	Hardware stores
		21	Furnishing shops	21	Furnishing shops
		22	Bookshops	22	Bookshops
		23	Other retail shops	23	Other retail shops
		29	Street trading	29	Street trading (outdoor trading centers and marketplaces)
7	Tertiary/ offices	6	Pure transport	6	Transport (except storage)
		25	Pure tertiary (offices)	25	Pure tertiary sector (offices)
		24	Other tertiary	24Fa	Other tertiary activities with low flows
		27	Offices – not pure tertiary	27-2	Not tertiary offices (agriculture, wholesales)
				27-3	Not tertiary offices (retail, industry, transport, administration)
8	Warehouses/ transport	28	Warehouses	28-2	Warehouses (bulk)
				28-3	Warehouses (of which transport)

2.3 The proposed methodology

The methodology proposed aims to assess the heterogeneity within aggregated categories, i.e., assess the degree at which an aggregated category is able to capture the FTG patterns of its subcategories. The methodology is articulated on the following 4 steps:

1. Data processing and model construction preparation. This includes the choice of the data (the combination of the three surveys' data samples) and justification (table with data variability among cities).

2. Assessment of a model for each category of the three aggregation levels (ST8, ST28, and ST44), obtained by linear regression on each category. The methodology used assesses the specification of the FTG models using an econometric approach. Following the methodology described in [1], the models can take three different forms: (i) a constant number of trips per establishment (does not depend on employment), (ii) a model where the number of trips is directly proportional to the number of employees, and (iii) a combined model where there is a constant number of trips per establishment and a term that shows the increase of the number of trips depending on the number of employees. The criteria used to select the model are the conceptual validity, the statistical significance of the constant and the employment variable, and the Root-Mean-Square-Error (RMSE). These models are not presented in this paper for the sake of brevity, but the results can be found in [1].
3. Estimation of a model for each ST8 category that assesses statistically whether each sub-sector within the ST8 category has a different FTG pattern, i.e., if the ST8 category groups establishment with homogeneous FTG patterns. To this effect, the authors create a binary variables for each sub-sector (identified in ST24 and ST48); and for each sector in the classification ST8 an ordinary least squares model is estimated. In this model, FTG is the dependent variable, while number of employees, the binary variables and the interaction terms between binary variables and number of employees are the independent variables. To identify which sectors have heterogeneous FTG patterns (i.e., one or more sub-sectors have different FTG patterns) only the variables that are conceptually valid and significant at the 5% level are conserved in the heterogeneity model. The resulting models are described using a set of equation where the t-stat is presented under each parameter.
4. Finally, to compare all those models, the models estimated in Steps 2 and 3 are applied to the entire calibration dataset. Then the data are grouped by the most aggregated category (ST8) and the RMSE is computed at this aggregation level for each model. The RMSE provides a good indication of the match between the model's prediction and the observed data. Therefore, the lower the RMSE the better the absolute fit of the model [12]. The results of each RMSE assessment are compared and the suitability of each model is discussed.

This paper presents a detailed description of Steps 3 and 4; for a detailed description of the results from Step 2, refer to [1].

3 Assessment of the homogeneity within categories

This section presents the results from the homogeneity assessment within categories using an econometric approach with fixed effects, as explained in Step 3 of the methodology. For the categories corresponding to agriculture (ST8-1), department stores (ST8-5) and warehouses including transport (ST8-8), no binary variable or interaction is found significant, meaning that the FTG patterns of establishments within these categories are homogeneous. In the case of craftsmen/services, the final model is as follows:

$$FTG_C = \underset{(4.75)}{4.64} - \underset{(-2.47)}{3.24}ST45_{2-3} + \underset{(3.24)}{1.12}E - \underset{(-2.92)}{1.03}E\_ST45_{26Mo} - \underset{(-3.24)}{1.12}E\_ST45_{26Mi} \quad (1)$$

Observations: 375; RMSE: 12.69; R2 adjusted: 0.06

Where, $ST44_{2\text{-}3}$ corresponds to the binary variable for establishments in the manufacturing or installation sub-sector; E represents the number of employees at the establishment; E_ST44_{26Mo} represents the number of employees for establishments in the tertiary sub-sector with average flows; E_ST44_{26Mi} represents the tertiary sub-sector with mixed flows.

As shown, a typical establishment in the craftsmen/services sector has in general 4.64 deliveries per week, plus 1.12 more deliveries per employee. However, this behavior is not homogeneous within the sector, as a typical establishment within the manufacturing or installation sub-sector has 1.4 weekly deliveries (i.e., 3.24 less than other establishments in the sector) plus the same 1.12 per employee. In the case of establishments in the tertiary sub-sectors, the difference is that a typical establishment in that sector tends to produce 4.64 weekly trips, independent from the number of employees. It should also be noticed that the RMSE decreases from 14.92 to 12.69, when the effects per industry sub-sector are taken into account.

Equation (2) shows the equation for the manufacturing and repair sector (ST8-3).

$$FTG_I = \underset{(6.71)}{23.04} - \underset{(-5.20)}{21.10}ST44_{34-3} - \underset{(-5.20)}{21.06}ST28_5 - \underset{(-4.02)}{14.60}ST28_4 - \underset{(-3.12)}{4.59}ST44_{4-7} + \underset{(3.00)}{1.65}E$$

$$- \underset{(-2.71)}{1.49}E\_ST28_3 - \underset{(-2.62)}{1.43}E\_ST44_{5-5} - \underset{(-2.50)}{1.40}E\_ST28_{34} - \underset{(-2.71)}{1.40}E\_ST28_4 \quad (2)$$

Observations: 623; RMSE: 18.57; R2 adjusted: 0.54

Where, $ST44_{34-3}$ corresponds to the binary variable for establishments in the construction and manufacturing installation sub-sector; $ST28_5$ corresponds to the binary variable for industry establishments in the consumption goods sub-sector; $ST28_4$ corresponds to the binary variable for industry establishments in the primary and intermediate products sub-sector; $ST44_{4-7}$ corresponds to the binary variable for industry establishments in the primary and intermediate bulk goods sub-sector; E_ST28_3 represents the number of employees for establishments in the chemical sub-sector; E_ST44_{5-5} represents the number of employees for establishments in the non-fragile consumer goods sub-sector; E_ST28_{34} represents the number of employees for establishments in the construction industry sub-sector; and E_ST28_4 represents the bulk products sub-sector. In terms of the RMSE, there is a decrease from 20.95 to 18.57 when using the pooled model with fixed effects.

For the wholesale sector, the final model is shown in equation 3:

$$FTG_W = \underset{(4.41)}{19.82} - \underset{(-3.23)}{15.65}ST44_{8-3} + \underset{(6.52)}{0.68}E \quad (3)$$

Observations: 414; RMSE: 88.30; R2 adjusted: 0.05

Where, $ST44_{8-3}$ corresponds to the binary variable for wholesale establishments in the non-food non-fragile sub-sector. In this case the model shows that only the non-food non-fragile goods sub-sector, which attracts about 4 trips less per week than other establishments in the sector, has a significantly different FTG pattern.

For the retail sector, the final model is shown in equation 4:

$$FTG_R = \underset{(6.51)}{2.72} + \underset{(2.67)}{3.38}ST28_{21} + \underset{(-4.82)}{3.76}ST28_{17} + \underset{(5.30)}{3.93}ST28_{23} + \underset{(8.06)}{7.45}ST28_{22} + \underset{(8.75)}{17.08}ST28_{19}$$

$$+ \underset{(6.03)}{1.29}E - \underset{(-2.95)}{0.68}E\_ST28_{18} - \underset{(-4.94)}{1.08}E\_ST44_{23} - \underset{(-4.82)}{1.11}E\_ST28_{17} - \underset{(-5.70)}{1.16}E\_ST28_{14}$$

$$- \underset{(-5.47)}{1.18}E\_ST28_{21} - \underset{(-5.77)}{1.27}E\_ST28_{22} \quad (4)$$

Observations: 1080; RMSE: 8.47; R2 adjusted: 0.41

Where, $ST28_{21}$ corresponds to the binary variable for retailers in the furniture sub-sector; $ST28_{17}$ corresponds to the binary variable for retailers in the bakery sub-sector; $ST28_{23}$ corresponds to the binary variable for the other retailers sub-sector; $ST28_{22}$ corresponds to the binary variable for retailers in the books sub-sector; $ST28_{19}$ corresponds to the binary variable for the pharmacies sub-sector; E_ST28_{18} represents the number of employees for retailers establishments in the hotel, restaurants, and cafés sub-sector; E_ST44_{23} represents the number of employees for the other retailers sub-sector; E_ST28_{17} represents the number of employees for retailers in the bakery sub-sector; E_ST28_{14} represents the number of employees for retailers in the clothing, shoes and leather products sub-sector; E_ST28_{21} represents the number of employees for retailers in the furniture sub-sector; and E_ST28_{22} represents the books sub-sector. In terms of the RMSE, there is a decrease from 10.33 to 8.47 when using the pooled model with fixed effects.

In the case of the tertiary and offices sector, equation (5) represents the FTG:

$$FTG_{T/O} = \underset{(3.76)}{6.11} - \underset{(-1.96)}{3.35}ST44_{25} + \underset{(2.46)}{0.02}\mathrm{E} \quad (5)$$

Observations: 322; RMSE: 13.85; R2 adjusted: 0.05

Where, $ST44_{25}$ corresponds to the binary variable for the pure tertiary sub-sector. In this case the model is homogeneous, except for the pure tertiary sub-sector that attracts about 3 trips less per week than other establishments in the sector.

In essence, these results show that for about half of the cases the model used for the higher aggregation level can also be used for more detailed sub-sectors as their FTG patterns do not differ significantly. However, the substantial different FTG pattern from some sub-sectors within the industrial and retail sectors (e.g., manufacturing of construction goods, manufacturing of consumption goods, pharmacy retail) suggests the need to collect more detailed data for those sub-sectors to obtain more appropriate models.

To analyze the implications of implementing heterogeneity models on estimation performance, RMSE are computed and compared for the models estimated in Step 2 of the methodology and the heterogeneity models from Step 3. Table 2 summarizes the results.

Table 2. Root Mean Square Error (RMSE) comparison among models with different aggregations and the heterogeneity model

Category	Aggregation ST8	Aggregation ST28	Aggregation ST44	Heterogeneity
1-Agriculture	4.50	4.50	4.50	n.a.
2-Craftsmen/services	12.97	12.71	12.52	12.59
3-Manufacturing/repair activities	33.11	20.39	18.30	19.64
4-Wholesale	89.36	88.27	87.86	87.98
5-Department stores	44.47	44.47	41.87	n.a.
6-Retailers	14.73	8.43	8.38	8.42
7-Tertiary/ offices	13.89	13.76	13.79	13.79
8-Warehouses/ transport	269.60	177.17	177.17	n.a.

The first salient result is the different magnitudes of RMSE across sectors. While agriculture, retailers, craftsmen/services and tertiary/offices models lead to RMSE of 4.50, 8.42, 12.59 and 13.79 respectively; wholesale and warehouses/transport models lead to RMSE of 87.98 and 269.60. These differences can be the result of both lower performance and higher magnitude (and thus larger deviations) of FTG for some sectors, so instead of comparing RMSE across sectors the analysis focuses on comparing RMSE across models for the same sector. In general, the more disaggregated the categories are, the better the model. However, the results show that for craftsmen/services, wholesale, department stores, and tertiary offices the higher aggregation does not lead to a considerable improvement in the RMSE (always less than 3%) revealing a homogeneity of FTG patterns within each of these sectors.

In the cases of manufacturing/repair activities and retail the heterogeneity model produces considerably lower RMSE than the models for aggregation ST8, and similar RMSE to aggregations ST28 and ST44 (without requiring the same level of detail involved in such disaggregated models). For these sectors, collecting more data for sub-sector to produce models that consider heterogeneity can enhance the quality of the models. However, this is not the case for other sectors, such as agriculture, wholesale, department stores and warehouses, where the FTG patterns seem to be homogenous across sub-sectors, and thus more detailed data on each sub-sector does not improve the quality of the models. These results are not surprising given the similarity in logistics practices within those sectors.

4 Discussion and Conclusion

This paper studies the implications of using classification systems with different aggregation levels to model Freight Trip Generation (FTG). The methodology is econometric in nature and seeks to identify which sectors have heterogeneous FTG patterns as a way to enhance data sampling efficiency. The results show that establishments classified as department stores, craftsmen/services, wholesale and tertiary/offices tend to have homogeneous FTG patterns, and estimating models using more disaggregated classifications (i.e., sub-sector specific models) do not lead to an improvement in the accuracy of the estimates. In contrast, establishments in the manufacturing/repair and the retail sectors have significant heterogeneity, so that estimating sub-sector (ST28 or ST44) specific models or a pooled model that assesses each sub-sector's significance can enhance the quality of the estimates as illustrated by lower

RMSE. The heterogeneity in those sectors has been highlighted in precedent works about the data surveyed, using a qualitative approach [13].
According to the models, in the case of the manufacturing and repair sector a typical establishment generates a base of 23 trips per week plus 1.65 weekly trips per employee. However, if the establishments focus on manufacturing of construction and installation or on consumption goods, it only generates a base of 2 trips per week plus 1.65 weekly trips per employee for consumption goods, or 0.20 weekly trips per employee for construction goods. Similarly, a typical establishment focusing on primary and intermediate products generates a base of 9 trips per week plus 0.25 weekly trips per employee; however, if this establishment focuses on bulk goods it generates a base of only 4 trips per week plus the same 0.25 weekly trip per employee. In the case of manufacturing establishments focusing on chemical products and non-fragile consumer goods, a typical establishment generates a base of 23 weekly trips, plus about 0.2 trips per employee. These results reveal that designing samples with strictly enough observations to estimate a single model for all manufacturing establishments can lead to large estimation errors; instead it is necessary to sample enough observation in the sub-sectors identified in this paper as having particularly different FTG patterns.
Similar results are observed for the retail sector, where a typical establishment generates a base of 2.72 trips per week plus 1.29 weekly trips per employee. However, if the establishment focuses on furniture, bakery, books, or pharmacy the base increase to 6.1, 6.48, 10.17, respectively; and the amount of weekly trips per employee decreases to 0.11, 0.18, and 0.02, respectively. In the case of hotels, restaurants and cafés a typical establishment attracts a base of 2.72 trips per week plus 0.21 weekly trips per employee. A typical retailer of clothing, shoes and leather products generates a base of 2.72 trips per week plus only 0.13 weekly trips per employee. These results show that FTG patterns are very different for establishments in different retail sub-sectors, which is not surprising giving the diversity of logistics decisions and needs across these sub-sectors.
In essence, this paper identifies sectors with homogeneous FTG patterns, sectors having sub-sectors with slightly different patterns and sectors with very heterogeneous patterns. In addition to provide an idea of the different FTG patterns present in urban establishments, the results from this research provide useful insight for an efficient sampling design in which the strata and the number of observations per stratum are designed based on the sector's FTG homogeneity. Although the quantitative analysis does not allow to conclude that these findings are transferable to other cities and across time, the conceptual validity of the results lead to think that the same patterns will be found for different cities and will remain in the medium term. However, this needs to be confirmed in further research endeavors.

References

[1] J. Gonzalez-Feliu, I. Sánchez-Díaz, and C. Ambrosini, "Aggregation level, variability and linear hypotheses for urban delivery generation models," presented at the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., 2016.

[2] J. Holguín-Veras, M. Jaller, I. Sanchez-Díaz, J. M. Wojtowicz, S. Campbell, H. S. Levinson*, et al.*, "NCHRP Report 739 / NCFRP Report 19: Freight Trip Generation and Land Use," Transportation Research Board of the National Academies, Washington D.C. NCHRP Report 739/NCFRP Report 19, 2012.

[3] I. Sánchez-Díaz, J. Holguín-Veras, and X. Wang, "An Exploratory Analysis of Spatial Effects on Freight Trip Attraction," *Transportation,* vol. 43, pp. 177-196, 2014/12/06 2016.

[4] C. Lawson, J. Holguín-Veras, I. Sánchez-Díaz, M. Jaller, S. Campbell, and E. Powers, "Estimated Generation of Freight Trips Based on Land Use," *Transportation Research Record: Journal of the Transportation Research Board,* vol. 2269, pp. 65-72, 2012.

[5] J. Holguín-Veras, M. Jaller, L. Destro, X. Ban, C. Lawson, and H. S. Levinson, "Freight Generation, Freight Trip Generation, and Perils of Using Constant Trip Rates," *Transportation Research Record: Journal of the Transportation Research Board,* vol. 2224, pp. 68-81, 2011.

[6] J. González-Feliu, M. G. Cedillo-Campo, and J. L. García-Alcaraz, "An emission model as an alternative to OD matrix in urban goods transport modelling," *Dyna,* vol. 81, pp. 249-256, 2014.

[7] R. Ducret and J. Gonzalez-Feliu, "Connecting demand-estimation model and spatial modeling for urban freight: first attempt and research implications," in *City Logistics IX*, Tenerife, Spain, 2015, pp. 142-156.

[8] P. T. Aditjandra, F. Galatioto, M. C. Bell, and T. H. Zunder, "Evaluating the impacts of urban freight traffic: application of micro-simulation at a large establishment," *European Journal of Transport & Infrastructure Research,* vol. 16, 2016.

[9] M. H. E. Iding, W. J. Meester, and L. A. Tavasszy, "Freight Trip Generation by Firms," presented at the 42nd European Congress of the European Regional Science Association, Dortmund, Germany, 2002.

[10] A. Alho and J. de Abreu e Silva, "Freight-Trip Generation Model: Predicting Urban Freight Weekly Parking Demand from Retail Establishment Characteristics," *Transportation Research Record: Journal of the Transportation Research Board,* pp. 45-54, 2014.

[11] D. Beagan, M. Fischer, and A. Kuppam, "Quick Response Freight Manual II," Department of Transportation. Federal Highway Administration, Washington, D.C.September 2007 2007.

[12] W. H. Greene. (2014, 07/31/2014). *Econometric Analysis (7 ed.)*. Available: http://pages.stern.nyu.edu/~wgreene/Text/econometricanalysis.htm

[13] C. Ambrosini, D. Patier, and J. L. Routhier, "Urban Freight Establishment and Tour Based Surveys for Policy Oriented Modelling," *Procedia-Social and Behavioral Sciences,* vol. 2, pp. 6013-6026, 2010.