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# Supplying Cities from Abroad: The Geography of Inter-Urban Freight Flows

David Guerrero\*, Patrick Nierat†, Laurent Proulhac‡

Université Paris Est - Ifsttar - †AME-SPLOTT, France

Université Paris Est - Ifsttar - ‡AME-LVMT, France

## ABSTRACT

This article aims to identify the role of urban areas in freight systems. To achieve this goal, the article examines the nature and intensity of inter-urban freight flows in France. It draws on the results of a French survey that describes shipments sent by firms. It paints a simplified picture of the geography of freight flows with regard to the light they shed on economic interactions between urban centers. It shows that the pattern of inter-urban freight flows in France is hierarchical: large urban areas are supplied by smaller ones.

*Keywords: freight transport, city supply, urban hierarchy, France*

## INTRODUCTION

Urban areas rely on freight transportation, which is essential to supply them with goods and to enhance their economic development. The scale and nature of freight flows depend on the size and shape of individual urban centers and also to a large extent on how their activities are structured. This is the purpose of most urban freight transport surveys (Gonzalez-Feliu et al., 2014; Taniguchi et al., 2003), which, however, deal with only a small number of urban areas and do not extend beyond their boundaries. Because urban areas are just very small parts of the global freight system, accurate forecasting of urban freight should integrate larger areas, at least at a national level. Some of these shortcomings can be overcome by exploiting a shipper survey, which provides an insight into national interests and provides a fuller description of the transport flows among urban areas. The aim of this article then is to use the results of this survey to explore the organization of inter-urban freight flows and to determine if a clear pattern can be eventually identified.

Pursuing these two avenues requires conceptualizing inter-urban freight flows. Toward this end, we use the concept of urban hierarchy, which refers to a pyramid-shaped network dominated by very large urban centers whose economies are largely diversified. Formalized in the first half of the 20th century by Christaller (1933), it was mainly developed in the 1950s and 1960s through a number of national studies. In these studies, urban hierarchy is analyzed using two main information sources: stocks and networks. In the analysis from stocks, population and activities in urban centers are studied to identify thresholds that form the boundaries between the different levels of urban hierarchy (Berry & Garrison, 1958). In the analysis from networks, urban centers are distinguished by the size of their catchment areas and/or their position within systems of different kinds. For this article, we narrow our focus to the works about urban hierarchy that are based on networks and flows.

### **Transport Networks Studies: A Partitioned Approach of the Urban Hierarchy**

Transport is a recurrent theme of urban hierarchy. In their quest to investigate the entire urban hierarchy, researchers tackle different means of transport separately. The work by Godlund (1956) in Sweden and by Green (1958) in the United Kingdom shows how urban centers are hierarchically structured by a bus network. Godlund also shows that the position of individual Swedish urban centers within a bus network is strongly correlated with diversity of economic activities present in those urban centers. These two studies, focused on medium-sized and small urban areas, are rich in information about the organization of the lowest levels of the urban hierarchy because they can help to identify the boundaries of regional catchment areas. However, this type of approach has limitations when it comes to analyzing the catchment areas of large urban centers insofar as medium- and long-distance transport increasingly takes place by air. In this respect, the pioneering study by Taaffe (1962) on air links between US urban centers provides an excellent counterpart to the work on bus connections. It shows the growth in direct air links among four big airports and all the other urban centers and demonstrates the dominant role of New York, Chicago, Los Angeles, and San Francisco in air links. This leads to a marginalization of many regional airports, which experience a weakening in their role as intermediaries between large and small airports. The decline of the intermediate level and the growth of the four main airports reveal the changing hierarchical organization of US urban centers.

### **Global City Studies: A Selective Approach of the Urban Hierarchy**

This same hierarchical model of interurban relations reemerged more recently in the research field of “global cities,” focusing less on transport-based approaches and more on the higher levels of hierarchy. Friedmann (1986), for example, showed how the development of multinational firms, with their international division of labor, has increased the gap between urban centers. In his approach, based on the number of headquarters located in each urban center, global cities are those urban centers that concentrate the control functions of multinational firms. Urban centers are then organized in categories depending on their ranking on the different sectors of world economy, mainly on advanced producers and financial services.

The hierarchical approach of global cities has been widely criticized by scholars since the 1990s. Castells (1996) argues that the global city phenomenon cannot be reduced to competition between large urban centers. According to him, non-hierarchical relationships of cooperation between urban centers have become more and more important in the age of cyberspace and cannot be neglected. More globally, hierarchical approaches are criticized by the lack of empirical work specifying how hierarchical ties between urban centers are organized (Taylor, 2004).

Contemporary studies of urban systems focus mainly on the higher levels of urban hierarchy (i.e., global cities) and on control functions of multinational firms (i.e., advanced producers and financial services). Small and medium-sized urban centers and other dimensions of economy, such as manufacturing and logistics, remain clearly underrepresented, except in a few cases that are essentially focused on port-city relationships (Ducruet, 2012).

### **Freight Flows: Toward a More Inclusive and Integrated Approach to Urban Hierarchy**

The purpose of this article is to help to fill this void by analyzing the physical links between the higher and lower levels of urban hierarchy in France. To achieve this goal, it examines the nature and intensity of interurban freight flows in France. It paints a simplified picture of the geography of freight flows with regard to the light they shed on economic interactions between urban centers. However, beyond simply deploying a new indicator to analyze the relations between urban areas, the article

seeks to elucidate the consequences and implications of the location of the system of production on the transport system.

The rest of this article is structured as follows. The next section sets out our hypotheses and outlines the data and methods used. Section 3 describes the distribution of freight flows between urban areas as it relates to their size. It proposes a macroscopic approach to examining the spatial organization of productive systems. The final section offers some concluding remarks.

## **Measuring Interurban City Supply: Data and Method**

In this section, we describe the research methodology employed. Our purpose to analyze freight flows between urban areas requires multiple methodological choices which are discussed here. To ensure reliability and robustness of the findings, the research approach must be adapted to available data.

### **The Urban Area as the Unit of Observation of Interurban City Supply**

Because this article looks at the question of inter-urban freight flows, its aim is significantly different from that of other articles on urban logistics. What we analyze here are not intra-urban movements between urban centers and the outskirts, but the relationship between different urban areas. We therefore felt it necessary to use a wider definition of urban entities to include the urban outskirts, where many of the entities that generate flows are located. The definition of the urban perimeter in this article is that used by INSEE (the French National Institute of Statistics and Economic Studies) and refers to the geographical definition of urban areas established in 1999. The urban area is a unit with more than 10,000 jobs, and a suburb is a unit in which at least 40% of the resident working population works within the central zone or within its catchment area. The principle of definition of the 354 French urban areas is similar to other functional urban regions defined abroad, as for example functional urban areas for Western Europe, metropolitan statistical areas in the United States, or urban employment areas in Japan.

### **Data on Flows**

In this work we use the 2004 national shipper survey (ECHO), conducted by IFSTTAR (French Institute of Science and Technology for Transport, Development and Networks) (Guilbault & Gouvernal, 2010; Guilbault & Soppé, 2009). It provides a tool for observing demand by shippers and by flows leading from the shipper to the end consignee. The sample survey in the study consists of 2,935 plants and 10,462 shipments. The scope of the survey covers all firms in mainland France with ten employees or more, operating in “freight-related activities”: wholesale trade (retailing is not included), manufacturing (excluding the extractive industries and public works), mail-order sales, agricultural cooperatives, warehousing services, and industrial waste processing centers. The ECHO survey is then focused mainly on business-to-business freight flows. In France, these freight-related activities account for 20% of total jobs. It should be noted that that the initial aim of the ECHO survey was not to be statistically representative of the different levels of urban hierarchy. The sampling plan used in this survey is based mainly on the type of activity and size (number of jobs) of firms.

This study is focused exclusively on inter-urban flows between French urban areas, so the data consist of 6,303 shipments and 114,000 tons (56% and 60% of the total sample survey). Intra-urban shipments (1,406) and shipments to foreign countries (2,753) have been excluded. So in all our sample covers some 70,000 plants and estimated transport volumes after adjustment of 641 million metric tons and 490 million shipments.

### **Choice of the Shipment as a Transport Measurement Unit**

The use of the shipment as a transport measurement unit in addition to the conventional units of tonnes or tonne kilometres is an original feature of shipper surveys. The shipment is defined as a quantity of freight that is made available at a given time in order to be transported during a single transport operation from a given shipper to a given consignee and is the natural observation unit for reconstructing transport chains. However, this unit also has conceptual advantages. The shipment is the link between the shipper and the consignee. Likewise, it is a representation of transport that is closely integrated with the production and distribution process that informs us about the economic context of the exchange of goods. In addition, it provides us with a better perception of shipper practices and the logistical constraints that affect them. Shippers develop their transport policy not only on the basis of the tonnages they produce but also on the number and spatial dispersion of their clients and the frequency at which they send out shipments. There is a great difference between sending 1,000 tonnes of freight to a single consignee or 1,000 shipments of 1 tonne at different times to different consignees. The number of tonnes is the same, but the economic rationale and the type of transport differ in every respect. Likewise, by using the shipment as an observation unit, we are able to observe the activity of carriers in terms of the number of operations they perform. Doing so provides a picture of the carrier population, which is close to that based on the total turnover of transport firms.

The results from shipper surveys thus enable us to use a variety of measurement units, not only the number of tonnes or tonne kilometres but also the number of shipments or the number of shippers responsible for the flows in question. Passing from one to the other of these units is highly instructive and provides an understanding of the market that is markedly different depending on the preferred unit: the relative weight of the different sectors of activity in the generation of traffic changes completely, as do the transport modes.

### **Methodological Choices**

#### *Identifying Size: Classes of Urban Areas Based on Population*

The fine stratification of the shipper survey by firm activity and size means that its traffic data are statistically representative at the national level. It lends to economic breakdown into major production types. But, the sampling plan does not include a regional breakdown or origin-destination analysis. This means that the shipper survey does not represent shipments at the level of each urban area. In order to overcome this deficiency, the urban areas where the firms' shipping and receiving freight flows are located were aggregated into five categories (see the appendix): a rural area and four urban area classes by population size: the Paris urban area; 18 large urban areas (400,000 to 1.6 million inhabitants), which include a dozen regional capitals outside the Paris area (i.e., Lyon, Marseille, Nice, Lille, Bordeaux, Toulouse, Strasbourg, etc.); 58 medium-sized urban areas (100,000-399,000 inhabitants); and 274 small urban areas (under 100,000). The total weight of each class was comparable in terms of population and jobs (Table 1). The average distance of urban areas has been calculated for every level of urban area, except Paris and rural areas, for which it cannot logically be calculated. The results show that the average distances within each level of urban area are very similar (Table 1).

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Table 1: Background Data on Urban Areas, Aggregated by Size Class (Source: Authors, 2015)

	Census Data 1999		Freight-related activities, SIRENE 2004		Average distance between urban areas inside the same level
	Population	Jobs	Plants	Jobs	
	millions	millions	thousands	millions	
Level 1. Paris Urban Area	11.2	5.1	16.1	0.8	N/A
Level 2. Large Urban Areas > 400,000 inhab.	12.8	5.0	16.4	0.8	477 km
Level 3. Medium-sized U. Areas 100,000 - 399,999 inhab.	11.4	4.4	14.4	0.8	421 km
Level 4. Small Urban Areas Up to 99,999 inhab.	9.5	3.9	14.1	0.8	426 km
Level 5. Rural Areas	13.4	4.2	17.0	0.9	N/A
<b>Total *</b>	<b>58.3</b>	<b>22.7</b>	<b>78.0</b>	<b>4.1</b>	-

\* Inland France, excluding Corsica and Overseas Territories

© U. Paris Est, IFSTTAR, AME-SPLOTT, AME-LVMT (2014) Source: INSEE, SIRENE (2004)

Definition of freight-related activities (IFSTTAR, 2004)



### Measuring Inter-Urban Freight Flows

In the ECHO shipper survey, the results can be presented with two complementary units: tonnage and shipment. Used alongside tonnage, the shipment provides an enhanced level of observation for reconstituting traffic chains and as a logistical indicator of shipper practices. Both these different levels of information are used in the article. We restricted our analysis of freight flows only to the two ends of the shipping chain, in other words, to consider only the urban area of origin, where the sender is located, and the urban area of destination, where the consignee is located. Intermediate logistics platforms in urban areas through which these shipments may transit are not included because this is a question of logistics rather than production or consumption. Finally, when looking at the results, it should always be remembered that internal flows within urban areas are never included. These intra-urban flows represent 29% of shipments and 17% of tons and are logically more important in larger urban areas. Paris is a special case and calls for some explanations: (1) the surface of the urban area of Paris is very large (much more than the second largest one), so its intra-urban flows, which are not taken into account by our analysis, are important; (2) we find inside Paris several urban entities of different sizes, so the hypothesis of an internal urban hierarchy shouldn't be excluded; (3) because intra-urban flows have been excluded, Paris is therefore underrepresented in the matrix.



Table 2: Scheme Explaining How Flows Have Been Aggregated in Our Analysis (Source: Authors, 2015)

Origin \ Destination	L1. Paris UA	L2. Large UA	L3. Medium-S. UA	L4. Small UA	L5. Rural Areas	Total (Outbnd.)
L1. Paris UA	∅					
L2. Large UA						
L3. Medium-Sized UA						
L4. Small UA						
L5. Rural Areas						
<b>Total (Inbound)</b>						



#### Upward flows


-  Flows to upstairs (from L to L+1)
-  Other upward flows (from L to L ≥ 2)

#### Downward flows

-  Flows to downstairs (from L to L-1)
-  Other downward flows (from L to L ≤ -2)

#### Horizontal flows

-  Diagonal. Flows between entities (urban or rural areas) of the same level
-  Intra-urban flows of Paris UA (out of the scope for this paper)

 Margins of the matrix. Sum of outbound / inbound flows

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Furthermore, freight transport flows are analyzed by the direction: from the origin to the destination of the flows (Table 2). Our research approach consists of a matrix that differentiates the five urban areas of origin and the five urban areas of destination. Thus the survey sample of flows is divided across the 25 classes that are in fact 24 because intra-urban flows of Paris are outside the scope of this research. To assess the shipper survey sample, we grouped the flows into three categories:

- Upward flows regroup flows that are directed to greater urban areas. For example, a flow from a small urban area to a large urban area is an upward flow. Within the upward flows, the methodology used to distinguish flows puts them immediately upward, which means that flows are directed to the level just above.
- Downward flows regroup flows that are directed to smaller urban areas. For example, a flow from a medium urban area to a rural area is a downward flow. Downward and upward flows are referred as the hierarchic flows.
- Horizontal flows aggregate flows between urban areas of the same size of the urban hierarchy. It should not be confused with intra-urban flows, because horizontal flows are not within the same urban area. For this reason, the Paris urban area is excluded from the horizontal flows.

The method used here provides a representative sample of the inter-urban freight flows to ensure reliability and robustness of the findings.

## **The Organization of Freight Flows among Size Classes of Urban Areas**

This third part explores the interrelations, hierarchical or horizontal, between urban areas according to their size class. We try to determine if the jobs and the flows exhibit similar location patterns. The location pattern of economic activities should theoretically be reproduced in the pattern of freight flows by urban areas forming either horizontal or hierarchical networks.

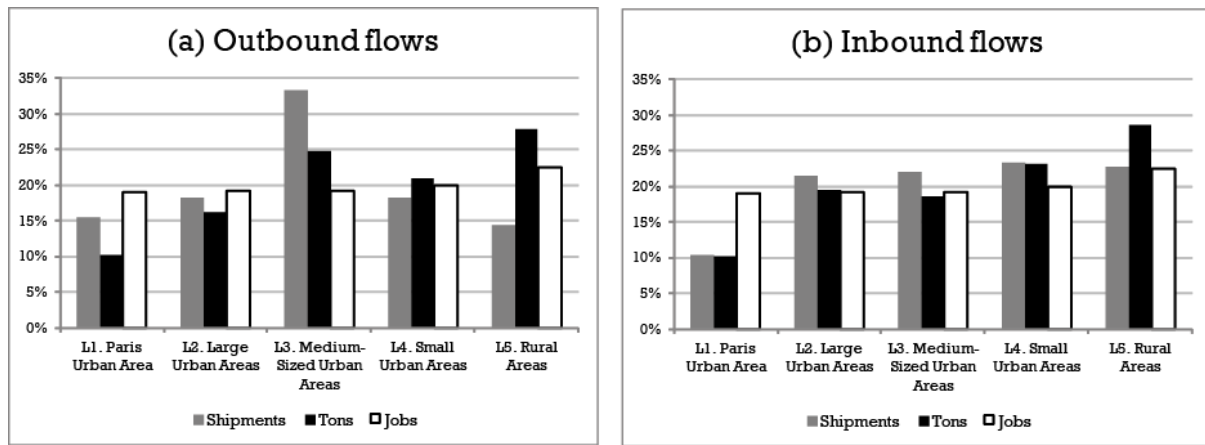
### **Distributions of Jobs and Flows Are Similar**

One can expect that the volume of flows generated by the different levels of the urban hierarchy is proportional to their economic potential. To examine this relationship, shipments, tonnes, and jobs are compared (Figure 1). Inbound and outbound flows are underrepresented in Paris and the large urban areas: their shares of shipments (33%) and tonnes (28%) are less important than their share of jobs (40%). By way of a corollary, this first finding confirms the importance of medium-sized and small urban areas and rural areas in structuring the geography of freight flows. In particular, the findings emphasize the structural role of medium-sized urban areas in terms of shipments and tonnage, and the rural areas, in tonnage but not in shipments.

The relations between flows and jobs vary with the direction of flows: inbound and outbound (Figure 1). Inbound flows seem to be more related to jobs than outbound ones (Figure 1a). The inbound flows of Paris are exceptionally limited (10% of shipments and tonnes) in view of its importance in jobs (19% of jobs). In addition to the underrepresentation of inbound flows in Paris, rural and small urban areas receive more flows than expected because of their jobs. Moreover rural inbound shipments are rather heavy (1.6 t).

Outbound flows are less linked with jobs (Figure 1b) and exhibit a different pattern depending on the unit used: shipments or tonnes. Again, Paris flows are limited, but less limited in shipments than in tonnes, meaning that their average weight is rather light (0.9 t). Rural areas also generate relatively few shipments but their average weight is very heavy (2.5 t). This exceptional average weight is partly

because of the importance of agricultural activities (production, wholesale trade), which tends to generate large shipments.



© U. Paris Est, IFSTTAR, AME-SPLOTT, AME-LVMT (2013) Source: [Jobs] INSEE, SIRENE (2004), [Flows] IFSTTAR, ECHO (2004)  
Figure 1: Share of Each Size Class in Jobs, Shipments and Tons. (A) Outbound (B) Inbound (Source: Authors, 2015)

**Table 3: Flows Generated by the Different Levels of the Urban Hierarchy; All Activities** (Source: Authors, 2015)

	Flows (Shipments)		Flows (Tonnage)		Average weight of shipment (tons)		Average distance of shipment (km)	
	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound
L1. Paris UA	16%	10%	10%	10%	0.9	1.3	309	306
L2. Large UA	18%	21%	16%	20%	1.2	1.2	255	340
L3. Medium-Sized UA	33%	22%	25%	19%	1.0	1.1	210	258
L4. Small UA	18%	23%	21%	23%	1.5	1.3	255	196
L5. Rural	14%	23%	28%	29%	2.5	1.6	231	165
Total	100%	100%	100%	100%	1.3	1.3	245	245

© U. Paris Est, IFSTTAR, AME-SPLOTT, AME-LVMT (2013) Source: IFSTTAR, ECHO (2004)

The intensity of freight flows also varies depending on the level involved, reflecting the different roles of urban centers inside the freight system. Shipments are to be equally distributed between the levels of urban hierarchy (Table 3). Outbound shipments are very concentrated: level 3 (medium-sized urban areas) alone accounts for one-third of shipments and the share of the other levels generates 14% to 18%. Comparatively, inbound shipments are better distributed between the different levels of hierarchy (21% to 23%), with the exception of Paris (10%), where those are considerably underrepresented.

The distribution of tonnages between the levels of urban hierarchy varies less depending on the direction of the flows. Again, flows are noticeably underrepresented in Paris (10% of outbound and inbound tonnages). The main imbalances between inbound and outbound tonnages can be found at



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levels 2 (16% of outbound and 20% of inbound tonnage) and 3 (25% of outbound tonnage and 19% of inbound tonnage).

Shipments involving rural areas (level 5) are the heaviest, regardless to the direction of flows (2.5 t inbound, 1.6 t outbound). The deviation between rural and the other flows is higher for outbound (twice the average weight) than for inbound (1.2 the average weight). The light weight of the shipments shipped from levels 1 (0.9 t) and 3 (1 t) deserves to be highlighted.

The average distance of shipments also varies significantly depending on the level of urban hierarchy, and that is true for both directions. The shortest distance of shipments is 210 km (level 3) and the maximum distance is 309 km (level 1). The average distance of the shipments generated by the other levels of the urban hierarchy is close to the average value (between 231 km and 255 km). For inbound flows the distance varies regularly with the level of hierarchy: it goes from 306 km and 340 km in levels 1 and 2 to 165 for level 5. As showed in Table 1, the differences of scope of flows between levels cannot be attributed to the distances between urban areas, because the latter are rather the same for every level.

In order to provide a standardized view of our results, a normalized ratio between flows and employment has been calculated for each level of the urban hierarchy (Table 4). Values under 100 reflect situations in which the flows generated by the urban level are less important than expected owing to its economic potential (measured by the number of jobs). Conversely, values above 100 characterize situations in which flows are more important than expected. The strikingly low values of Paris (53.7 to 82.1) reflect its weakness as a generator of freight flows. On the contrary, the high values of medium-sized urban areas for shipments (112.7 to 170.4) reflect their strong influence on the French freight system. Rural areas are characterized by the underrepresentation of outbound shipments and overrepresentation of tonnes (both with regard to the inbound and outbound flows). All in all, the distribution of flows between the different levels of the urban hierarchy cannot be solely be attributed to the distribution of employment.

**Table 4: Ratios between Flows and Employments** (Source: Authors, 2015)

	Outbound index		Inbound Index	
	Shipments	Tons	Shipments	Tons
Paris	82.1	53.7	54.7	53.7
Large UA	95.3	84.9	111.4	101.6
Medium-Sized UA	170.4	126	112.7	94.9
Small UA	93.35	108.2	118.2	115.05
Rural Areas	64.4	124	101.3	127.1

\* Inland France, excluding Corsica and Overseas Territories

© U. Paris Est, IFSTTAR, AME-SPLOTT, AME-LVMT (2014) Source: INSEE, SIRENE (2004)

Definition of freight-related activities (IFSTTAR, 2004)

### A System Dominated by Vertical Flows

The hierarchical analysis shows that vertical flows prevail (85% of shipments and 90% of tons). Inside this hierarchy, one in two shipments goes downward (51% of shipments, 42% of tons) and one in three to a higher-ranked entity (35% of shipments, 47% of tons) (Table 5). By contrast, urban and rural

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areas have few exchanges with same-ranked entities (horizontal flows, representing only 15% of shipments and 10% of tons). The matrix also highlights the nested pattern of flows: 39% of shipments and tons go to neighboring levels of urban hierarchy. The average weight of shipments is 1.3 tons and varies considerably depending on its hierarchical pattern. Horizontal shipments are lighter (0.9 t) than the average. Among vertical flows, upward shipments (1.8 t) are significantly heavier than downward ones (1.1 t). Shipments are conveyed, on average, over 245 km. This average distance varies little regardless to the hierarchical pattern. Upward flows are conveyed over longer distances (272 km) than downward ones (226 km). The length of horizontal flows is close to the average (250 km).

Table 5: Freight Flows between the Levels of the Urban Hierarchy; All Activities(Source: Authors, 2015)

	Shipments	Tonnage	Average weight of shipment (tons)	Average distance of shipments (km)
Upward flows	35%	47%	1.8	272
<i>L to L+1</i>	17%	25%	1.9	255
<i>Other upward</i>	18%	23%	1.7	287
Downward flows	51%	42%	1.1	226
<i>L to L-1</i>	22%	14%	0.8	266
<i>Other downward</i>	28%	28%	1.3	193
Horizontal flows	15%	10%	0.9	250
Total	100%	100%	1.3	245

\* Inland France, excluding Corsica and Overseas Territories

© U. Paris Est, IFSTTAR, AME-SPLOTT, AME-LVMT (2012) Source: INSEE, SIRENE (2004)

All in all, these global results (which cover very different activities) show that freight flows are essentially hierarchical and confirm our main hypothesis. Flows take place mainly between urban areas of (very) different population sizes. Comparatively, ahierarchical flows are marginal. Inside the hierarchical flows, the share of shipments going immediately to the next level (directed to the level  $n-1$  or  $n+1$ ) is particularly high. It represents about a half of upward shipments and tonnages and slightly less for downward flows. This means that freight flows between urban areas are often organized in interlocking subsystems.

Regarding the weight, upward shipments (1.8 t) are considerably heavier than downward and horizontal ones (1.1 t and 0.9 t, respectively). Globally, the share of Paris (level 1) on outbound flows is twice as little as expected, except outbound shipments, in which it is slightly higher (16%) but still above the average (20%). Medium-sized urban areas (level 3) seem to play an important role in the generation of outbound shipments (33%), contrasting with the marginal role of rural areas (level 5, 14% of outbound shipments). The average distance of shipments varies with the urban hierarchy, more regularly for inbound than for outbound. Shipments departing from rural areas (2.5 t) are twice as heavy as the average (1.3 t). This overall analysis provides empirical evidence of hierarchical organization of freight flows between urban areas. It doesn't explain the causes, but simply the consequences in the spatial organization of freight flows.

## DISCUSSION AND CONCLUSION

This article provides a new analysis of the organization of freight flows between French urban areas based on a shipper survey. It brings empirical evidence that confirms theoretical assumptions on the

hierarchical pattern of inter-urban freight flows. Conclusions may be grouped in the three following ways.

The supply of urban areas is hierarchically organized: inter-urban flows take place mainly between urban areas of different levels. The characteristics of supplying vary a lot depending on the hierarchical level of urban area. Paris and the large urban areas are essentially supplied from smaller urban areas, and these shipments are lighter than the average. Conversely, small urban and rural areas are supplied from higher levels of urban hierarchy, and these shipments are heavier than the average. This result is consistent with the simultaneous decline of manufacturing and the development of distribution activities observed in large urban areas of developed countries since the 1980s. In this context, the main challenge for decision makers is to manage the rapid expansion of distribution activities, which have become increasingly concentrated in large urban areas (Guerrero & Proulhac, forthcoming).

Inside hierarchical flows, upward and downward flows are very different. On average upward shipments are almost twice as heavy and are carried over longer distances than downward ones.

The catchment areas of urban areas are linked to population size and reveal the central place structure. The average distance of freight flows is here interpreted as a proxy of the scope of the catchment areas of urban areas. These catchment areas vary directly with the population size. This relationship has been verified both for shipments and tonnes. Vertical ties are predominant: more than one in two shipments go to a lower-ranked entity and more than one in three to a higher-ranked entity. Comparatively, horizontal flows are less important than one would expect from recent works on urban networks.

In order to be statistically representative, the urban area of Paris has been considered here as a whole, even if it contains several important urban centers. The existence of a hierarchy of urban centers inside the urban area of Paris should not be excluded. This metropolitan issue will be tackled by a recent urban goods movement survey carried out in Paris.

The outcomes of the research confirm that productive systems are not disconnected from territories. Obviously, not all activities are equally organized. Further research is needed in order to understand how goods are carried between places, perhaps by zooming in a more disaggregated way on economic activities. Research improvements may be obtained by more reflection on the main activities of consignees. In fact, manufacturing flows can reflect both intra-sector links (intermediate products) and inter-sector links (finished products going to markets). Taking into account the activities of consignees will lead to a sharper differentiation of the patterns of manufacturing flows between urban areas (Guerrero & Proulhac, 2014). Finally, these results are representative of the French situation and new research needs to be carried in other countries in order to provide more general conclusions.

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## APPENDIX

Outbound and Inbound Flows (in Millions) by Size of Urban Area (Source: Authors, 2015)

## Supplying cities from abroad

In millions	Outbound		Inbound		Outbound + Inbound	
	Shipments	Tons	Shipments	Tons	Shipments	Tons
Paris Urban Area	76	65	51	66	127	131
Large Urban Areas + 400 000 inhab.	90	105	105	125	195	230
Medium-sized Urban Areas 100 000 - 399 999 inhab.	164	159	108	119	272	278
Small Urban Areas 8 000 - 99 999 inhab.	90	134	114	148	204	282
Rural Areas	71	179	111	183	182	363
<b>Total*</b>	<b>490</b>	<b>643</b>	<b>490</b>	<b>641</b>	<b>980</b>	<b>1,284</b>

\* Inland France, excluding Corsica and Overseas Territories

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**David Guerrero** is a researcher on the freight transportation team (Ame-Splott) of the French Institute of Science and Technology for Transport, Development and Networks (Ifsttar). He received a PhD in economic geography in 2010 at the University Paris 7. His field of interest is the geography of freight transport, especially for topics pertaining to ports, maritime transport, and global supply chains.

**Patrick Nierat** is a researcher on the freight transportation team (Ame-Splott) of the French Institute of Science and Technology for Transport, Development and Networks (Ifsttar). He also teaches at Ecole Nationale des Ponts et Chaussées and several universities. His fields of interest are transport supply, competition between modes, and modal shift.

**Laurent Proulhac** is a study engineer at the Université Paris Est (France) and Ifsttar in the Laboratory City Mobility Transport (LVMT). He also teaches the geography of transport systems and geographic information systems (GIS). He has published several papers on these topics in international peer-reviewed academic journals and books.