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Transportation Research Procedia 12 (2016) 181 – 192

Transportation Research Procedia

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The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June 2015

French surveys of the delivery approach: From cross-section to diachronic analyses

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Abstract

This paper presents a diachronic analysis of two surveys carried out in the city of Bordeaux (France). The first one was performed in 1994, the second in 2013. The interest is that the second survey followed a very similar methodology as the first one performed twenty years previously. It allows us to identify invariant parameters of the complex urban goods movements system, and also to distinguish, for the parameters that have undergone significant changes, those resulting from changes in the city and those resulting from changes in logistics.

Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics

Keywords: Urban Goods Movements survey, data collection method, cross-section analysis, diachronic analysis, Bordeaux UGM survey.

1. Introduction

This communication presents the first results of a survey performed during 2013 on goods transport in the city of Bordeaux. The interest of this survey is that it followed a very similar survey performed twenty years previously. Such successive surveys on urban passenger transport with questionnaires and standardized sampling rules have

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Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics
doi:10.1016/j.trpro.2016.02.057

been available for more than thirty years. Regarding goods transport, this is the first time that we can perform intertemporal comparisons.

It should be borne in mind that, in the 1990s, the French government wanted to implement a vast national research program called "Goods in the City". Many attempts had been made previously (Ambrosini and Routhier, 2004, Allen et al. 2012). However, it was observed that they failed to elucidate the mechanisms of urban logistics in a suitable manner, which was attributable to the fact that they most often used a classical unit of observation: the transport of a certain weight between a point of departure and a destination.

This was undoubtedly pertinent for interregional transport but provided little help for understanding goods transport in urban areas, especially in terms of road occupancy, as every attempt in this direction had failed: they all came up against the obvious fact that a model simulating tons or tons-kilometres had little meaning when a ton of goods can sometimes be transported in a single batch. For example a pallet of mineral water, but it can also be transported in several thousand batches, for instance in the case of daily supplies of drugs to pharmacies. Hence the methodological choice which consisted in studying parking and trips in terms of road use for each movement (shipment or delivery) and for transport between two successive places of movement.

This research program planned the funding of three major surveys whose design was entrusted to the LET (Laboratoire d'Economie des Transports). These surveys were performed in France in 1995-1997 in the three cities of Marseille, Bordeaux and Dijon. The latter were chosen due to the variety of their sizes†, and also because their local authorities volunteered to participate in this research. A large number of publications (Patier & Routhier, 2009) were able to draw from this initial wave of surveys whose merit was above all to reveal the invariants between the results of the three cities involved, and to clearly identify the rare factors that appear to depend on the size of conurbations.

The recent survey on the urban area of Bordeaux followed a methodology very similar to the first one performed twenty years ago (the same survey method and establishment weighting procedure), allowing the diachronic analyses as we will explain in the section 2. Another survey was carried out recently: the "Paris region UGM survey" (Toilier et al, 2015) but it is not concerned by this paper.

One of the main dimensions of the comparison is relative to the evolution of the urban area of Bordeaux. This evolution will be described in the section 3 and, in order to compare the results of the two surveys, it will be explained the necessity to recalculate the weighting of the establishments of 1994, since the typology had evolved between the two survey campaigns.

Owing to this correctly weighted data basis, we will emphasize the invariance of the generation of movements in the section 4, and in a section 5 the change to be taken into account.

2. Survey methodology and diachronic comparison

The unit of observation is the movement, defined as the service provided to a given economic firm by a given vehicle, to deliver or pick up goods (or both at the same time).

The survey is based on three levels of data collections.

On the one hand, these surveys addressed establishments that shipped and received goods. They are used to characterize the establishments by variables that allow explaining the formation of goods flows (type of activities, type of premises, number of jobs, availability of a fleet of vehicles, etc.). All types of activities, all size of the firms are taken into account. The establishments are selected on the basis of an exhaustive file produced by the INSEE (French National Statistics institute), the SIRENE file. This file contains information that permits to build a representative sample regarding the activity, the number of jobs, and the geographic location.

The selection of establishments was done on the basis of stratification according to the activity performed by the establishment and its size (number of employees). The stratification had changed between the first survey in Bordeaux and that in 2013. The first had been built on the basis of a literature review and expert opinions, and comprised 66 groups (ST66); the second stemmed from the results of the first surveys that permitted refining

† Marseille (1,050,000 inhabitants), Bordeaux (750,000) and Dijon (240,000).

typology ST66 to obtain 45 classes of activity (ST45) to be distinguished in 115 groups (ST115) according to their size category.

These surveys provided a precise description of the establishment's activity as well as all the deliveries and pickups of goods performed in this establishment over a full week. Much information based on the unit of observation, in this case the "movement" (delivery or pickup), was collected, making it possible to know the precise conditions under which this movement occupied the road.

On the other hand, the surveys addressed the drivers carrying out the transport. Each of the drivers who visited the establishment were given a questionnaire in which they could describe their vehicle, its route, its stops and the goods delivered to each delivery point or picked up along the route. This provided a great wealth of information on the statistical system in which the delivery surveyed was performed. For both the establishment and the driver, the information was collected at the place of contact between these two actors: the place of the movement. It was therefore possible to simultaneously capture information on three components fundamental for understanding urban goods transport:

- The logistics organization of companies that receive or ship the batches transported,
- The environment of the loading and unloading points (on the road, in a dedicated space, etc.),
- The organization of the transport itself (round, distances, number of stops, etc.).

At last, the haulier survey addressed the main transport companies active in the city in order to obtain information on the urban and interurban logistics organisations of the largest transport operators in the city. It permits to understand the link between the intra-urban flows and those that enter and leave the city.

As shown in Toilier et al. (2015), only 1,500 surveys are necessary to take into account the diversity of the activities carried out in the urban territory. In 1994, 1,505 establishments were surveyed in the 46 municipalities which compose the urban area of Bordeaux. 1,570 were surveyed in 2013, but between the 2 surveys, the conurbation of Bordeaux had grown to 50 municipalities. Moreover, the city of Bordeaux which funded the survey asked to survey an additional municipality that it considered as important in terms of goods movements, thus increasing the perimeter to 51 municipalities. The following map shows the differences between successive perimeters.

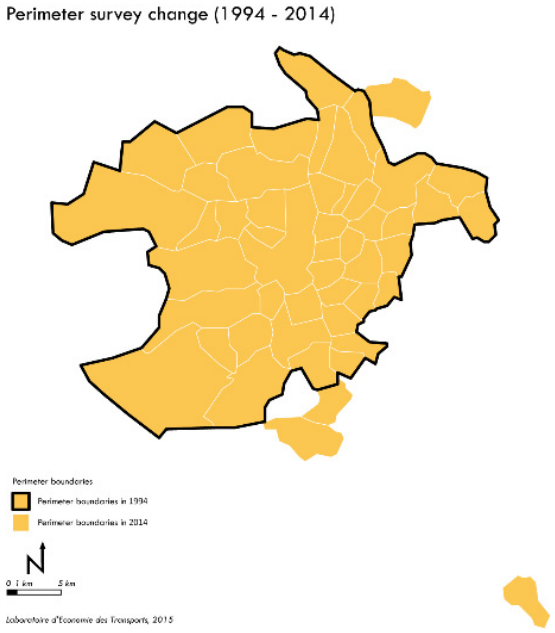

Fig. 1. Perimeters of surveys

To compare the results of 2013 with those of 1994, we conserved only the establishments belonging to the perimeter of the first survey. Thus, after eliminating the unusable questionnaires, 1 236 establishments were kept for the analysis.

3. Evolution of the city of Bordeaux as exogenous factors

Given the variables identified during the previous survey campaign as discriminating the generation of movements and road occupancy by delivery vehicles, we examined how the Bordeaux region had evolved with respect to these variables. The main evolutions are given in Table 1 and shown on the map further on.

Table 1. Evolutions of the productive system between 1994 and 2013

Activity	1994				2013			
	No of establishments	No of jobs	Average No of jobs / estab.	% of jobs	No of establishments	No of jobs	Average No of jobs / estab.	% of jobs
Agriculture	613	1,989	3.2	1%	1,323	3,201	2.4	1%
Crafts- services	12,561	44,010	3.5	13%	19,381	61,708	3.2	14%
Industry	3,142	56,206	17.9	16%	3,794	48,973	12.9	11%
Wholesale	2,228	17,769	8.0	5%	2,680	17,477	6.5	4%
Hypermarkets	183	12,481	68.2	4%	186	11,062	59.5	3%
Small retail	8,821	35,124	4.0	10%	10,794	43,466	4.0	10%
Offices	12,481	170,341	13.6	50%	22,491	234,827	10.4	55%
Warehouses-Transport	400	5,819	14.5	2%	426	5,344	12.5	1%
Total	40,429	343,738	8.5	100%	61,075	426,057	7.0	100%

This table firstly confirms that the urban area of Bordeaux underwent indisputable growth. The number of establishments grew faster than the number of jobs (+51% and 24%).

This growth in the number of jobs is notable in every sector, apart from:

- The industrial sector where the loss of jobs corresponded to that occurring at national level for the same period (-13%).
- The wholesale trade and Hypermarkets: the average size of establishments is smaller in urban zones than 20 years ago

However, it is noteworthy that the variations in the number of establishments and those in the number of jobs are far from being homothetic. We must neglect the warehouse-transport sector since it underwent changes in definition which makes comparisons very difficult, making a detailed study necessary.

Two sectors had highly significant growth:

- Offices, with an increase of 80% of the number of establishments and 38% of the number of jobs
- Craft services, with an increase of 54% of the number of establishments and 40 % the number of jobs.

This obviously resulted in the development of medium sized businesses (the average size of 8,5 jobs in 1994 and 7 jobs in 2013), that necessarily had effects on urban freight transport.

The number of jobs increased less quickly than the number of establishments, which may correspond to gains in labour productivity and also to the setting up of establishments of smaller size and with smaller workforces than before. This appears to be the case for the wholesale and hypermarket sectors.

The following maps show the evolution of the urban structure:

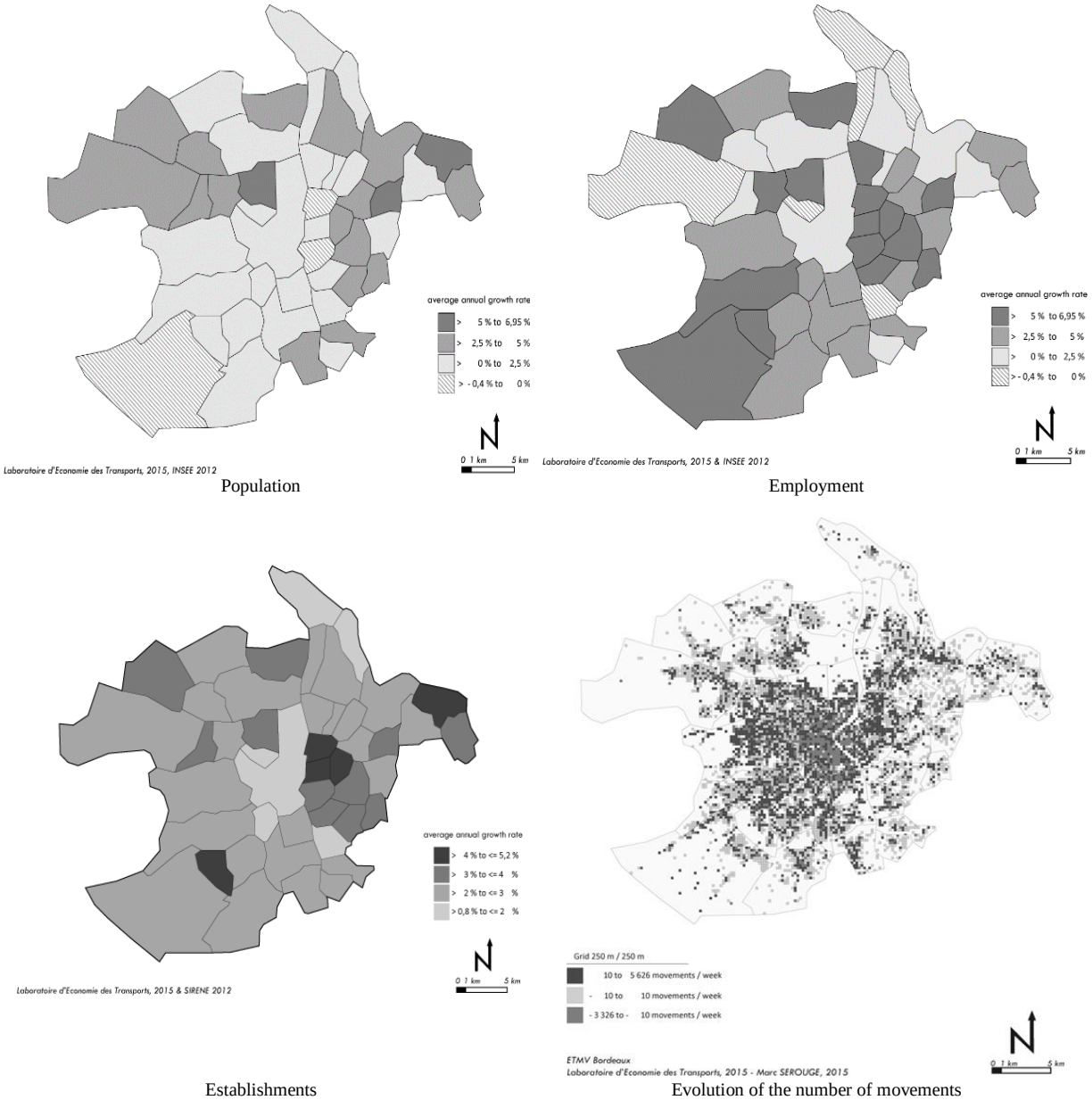

Fig. 2. Evolution of the urban structure and of the goods movements of Bordeaux from 1994 till 2014

These maps confirm that the city of Bordeaux itself did not evolve significantly. The population, the number of establishments and the number of employments remains stable. On the other hand we observe significant modifications in the rest of the urban area. The municipalities which gained most jobs are the ones which lost a part of their population, a sign of an urban restructuring.

The most striking fact is the growth of tertiary jobs on all the perimeter (except in the city of Bordeaux) and the decline of jobs linked to the industry, to the wholesale trade and to logistics (warehouses and transport) on the whole perimeter. The development of the offices sector in dense urban area and the departure of the most generative

activities of goods flows in the periphery modifies the generation of movements (deliveries and pick up) in the perimeter as shown in the following maps.

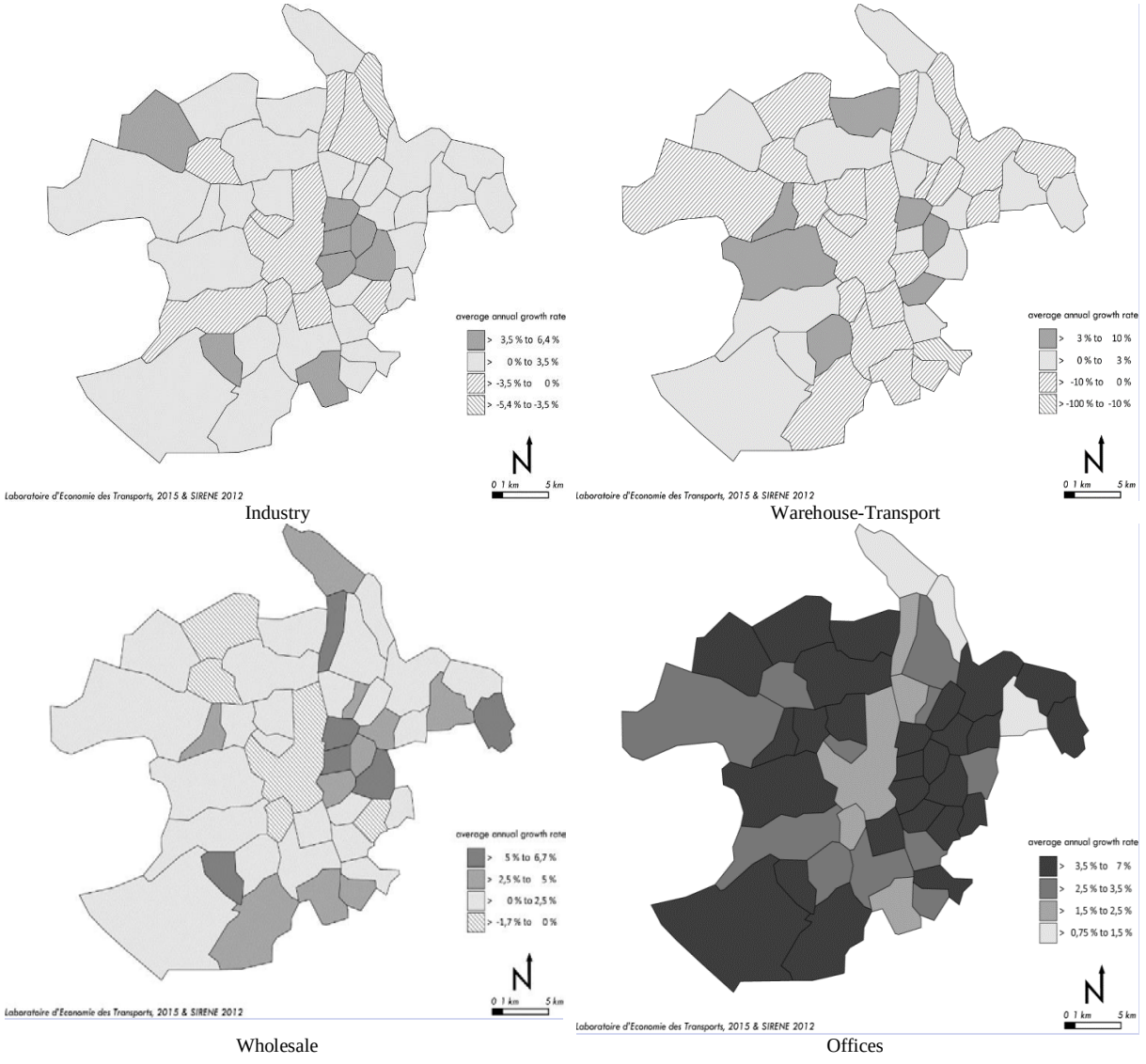

Fig. 3. Evolution of the number of establishment according to the activity

These modifications are typically exogenous for the logistic activities and thus for the FRETURB model.

The establishments surveyed were weighted as a function of their inclusion in the typology (ST115) on the basis of two criteria: their weight in number of establishments, and their weight in employment in the study area. All the results concerning movements were calculated on the basis of the weighting assigned to employment, as the surveys showed that there was a strong link between the size of the establishment and the number of deliveries and pickups. On the contrary, the variables characterising the environment in which the establishment was installed and its accessibility were not linked to employment and therefore calculated with a weighting assigned to the number of establishments.

To compare the results of the two surveys, it was therefore necessary to recalculate the weighting of the establishments of 1994, since the typology had evolved between the two survey campaigns. Each establishment surveyed in 1994, as well as each establishment identified in the SIRENE file, was assigned to a new category of the typology in order to calculate these two weights. The reassignment of the establishments of 1994 to the ST115 categories highlighted the fact that certain categories of activity had not been fully taken into account in the previous survey. In particular, large administrative establishments had not been fully taken into account, quarries had not been surveyed, and regarding warehouses, only private platform type warehouses had been surveyed.

Determining the number of employees was complex as it had to be performed for each ST115 category of the stratification. However, the SIRENE file did not supply numbers of employees but only workforces by size category, meaning on the one hand that no non-salaried employees were included in the file (it should be noted that 47% of establishments had no employee in 1994), and, on the other, that the number of salaried employees was known only approximately in the categories with high numbers in particular (by group of 100 employees). Using these partial data, our work consisted in estimating the number of employees by relying on the results of the previous surveys and on comparisons with the employment figures supplied by the INSEE aggregated on the scale of the area of study.

For 1994, we calculated employment on the basis of the SIRENE file with the FRETURB software which used the results of the first campaign of surveys to assign a number of employees according to their ST115 and their size category. The results of this estimation were compared positively with the employment estimations supplied to us by the INSEE on the scale of the survey perimeter.

For 2013, we also used the estimations provided by FRETURB but the processing of the survey carried out in Ile-de-France showed that the employees by ST115 and size category produced during the first campaign of surveys led to overestimating the total employment. Likewise, the number of employees estimated by FRETURB for the city of Bordeaux showed an overestimation in comparison to the statistics available for this territory. While waiting for the end of the second survey campaign, which will permit consolidating the calculation of employment, we revised the employment calculation procedure of FRETURB to obtain a number of employees consistent with the global statistics (for Bordeaux and Ile-de-France).

This revision of the weighting of the results for the 1994 survey explains why the figures presented here are quite different from those taken from previous publications.

The first campaign of surveys highlighted invariants in the generation of flows (Gerardin et al. 2000), making it possible to develop the FRETURB model now used by fifty cities in France and the rest of Europe.

This validated using the successive steps of FRETURB (Routhier and Aubert, 1999, Bonnafous et al, 2013) to perform this initial presentation of diachronic comparisons. On this basis, we systematically raised the question of whether the statistical observation performed 20 years later confirmed the hypotheses of invariance underlying the model or whether it was desirable to modify certain elements.

It should be borne in mind that the first hypothesis on the average number of weekly movements m of an establishment e takes the form:

$$m_e=\varphi(a,w,p)+\varepsilon_e \quad (1)$$

where

a is the category of activity of the establishment i.e. 45 activities distinguished (Gerardin et al., 2000);

w denotes a class of number of employees;

p is an index that distinguishes the functions of the premises served (shops, warehouses, offices, head offices).

ε_e is a residual term that expresses that relation [1] is not an exact equation.

Note that for variable a, if 45 categories of activity are distinguished in the model, in this communication we group these 45 categories into 8 main sectors of activity that appear in the following tables and which correspond to the first level of breakdown in the French statistical system.

4. Invariances in the generation of movements

Equation (1) allows us to distinguish the two families of evolutions that have to be identified. First, there are evolutions we can qualify as exogenous, that is to say which affect the numerical values of variables a,w and p of equation (1). These are normal transformations of the localization system and, of course, of the productive system of the companies. These evolutions do not raise major problems for the implementation of the FRETURB model since they are inputs that are contained in the statistical files of the establishments. Given the most significant changes in the structure of activities described in Table 1 and the decisive role of the size of establishments in terms of jobs when determining the number of movements, it is useful to examine how these changes are expressed. Table 2 below provides several clarifications.

Table 2. Evolutions in the number of movements between 1994 and 2013

Activity	1994			2013		
	No of movements	Movements / job	% movements	No of movements	Movements / job	% movements
Agriculture	1,107	0.6	0%	1,553	0.5	0%
Crafts- services	48,047	1.1	15%	75,883	1.2	21%
Industry	40,718	0.7	**13%**	45,013	0.9	**13%**
Wholesale	66,295	3.7	21%	49,274	2.8	14%
Hypermarkets	9,633	0.8	3%	8,041	0.7	2%
Small retail	83,234	2.4	**26%**	93,924	2.2	**26%**
Offices	32,649	0.2	10%	65,646	0.3	18%
Warehouses-Transport	36,799	6.3	12%	203,36	3.8	6%
Total	318,482	0.9	100%	359,669	0.8	100%

This table was certainly one of the items of information the authors of this communication desired the most. In particular, it allows knowing whether the invariants that emerged from crossing the statistics (between the three cities concerned) in the first wave of surveys had remained invariant through time. Indeed, the relation between the number of weekly movements and the number of jobs in the establishments of the same sector appeared to be very stable (Ambrosini and Routhier, 2004, Ambrosini et al., 2010).

The average ratio of the weekly number of movements per jobs decreases from 0.9 to 0.8.

The main explanation of the fall in the number of movements per job was linked to the reduction of the movements generated by two major generators of deliveries/pickups, i.e. wholesalers and warehouses. Given the reserves expressed previously on the way the warehouses had been selected in 1994, this reduction of movements may be artificial and confirms the difficulty of including this category of establishment adequately in diachronic surveys. For wholesalers, the reduction likely stems from an improvement of logistics organisation. The result was a decrease from 21 to 14% of the relative weight of the total mobility generated.

On this last point, a specific in depth data analysis will be necessary in order to confirm the range of this evolution.

The commercial sector remains the most generative sector of flow with 42 % of the movements in 2013. The first important result is the stability of the movements/jobs ratio in the case of the retail sector, hypermarkets, services-crafts, and offices (in grey in Table 2). This suggest that for these five sectors generating a large proportion of movements (nearly 67% of the total), the evolutions were of a mainly exogenous nature and depended only on the values of w in the equation (1).

On the contrary, other sectors suggest that endogenous evolutions occurred, which had significant impacts on the parameters of this equation. Firstly, the share of employment of the offices sector had risen considerably, and this growth in employment went hand in hand with growth in the number of movements per job. However, this sector generates few goods deliveries/pickups.

Two sectors in particular are concerned and explain the weak decrease of the ratio when adding all the activities.

5. The changes to be taken into account

The three variables that determine the number of movements for the establishments are obviously not independent: if the establishment is a tobacconist's, there is little chance that it will have several dozen employees; if it is a hypermarket, there is little chance that it will have less than ten employees. Thus, by combining the three criteria by assuming that we can distinguish 45 activities, 10 classes of numbers of employees and 4 premises functions then, theoretically, there are 1800 possible combinations. In reality, the surveys of the first wave showed that only 115 of these 1800 combinations corresponded to the situations observed.

This therefore led us to partition all the establishments:

$$\mathbf{E = \{E_1, E_2, \ldots E_c, \ldots E_C\}} \quad \text{such that:}$$

$$e \in E_c \Rightarrow me = mc = \varphi(a_c, w_c, p_c) \qquad (2)$$

Where ac, wc and pc are particular values of three variables for category c of the establishment.

The work now in progress therefore consists in identifying which of these 115 categories c whose movements/jobs ratio has changed substantially and for which it is necessary to modify the parameters of the function $\varphi(a_c, w_c, p_c)$, or its specification.

It should be borne in mind that it is easy to formulate a matrix of movements in the base of equation (2), using a file of establishments that specifies their localization and the numerical values of the three parameters ac,wc and pc. This matrix of movements by zone z and by category of establishment c is written as:

$$\mathbf{M = m_{z,c}}$$

The next step is to formalize the occupancy of the road caused by these movements, whether they are stops or the circulation of vehicles between two movements. To do this, FRETURB takes into account:

- The type of vehicle used (utility vehicles under 3.5 tons, rigid trucks or semi-trailers);
- The management mode (own or third party account);
- The organization in "direct route" to perform a single movement or in a round grouping several movements.

The combination of these factors therefore leads to 12 logistical categories of operator which are identified by the index l. Naturally, there is a relation between the category of establishment c and the logistics category l: a pharmacy rarely receives deliveries by rigid truck whereas such a vehicle can perform almost all the deliveries of certain establishments. The model determines that each establishment category c is served by a logistic operator category l according to frequency $f_{c,l}$ independent of the zone to which the establishment belongs. Whence the matrix of logistic frequencies:

$$\mathbf{L = f_{c,l}}$$

The generation of movements by zone and by logistics category is therefore written as:

$$\mathbf{G = M.L = g_{z,l}} \qquad (3)$$

The first results of the 2013 survey suggest that the most significant changes probably affected the numerical values of L. This can be illustrated by first considering the vehicles used, as shown in the Fig. 4.

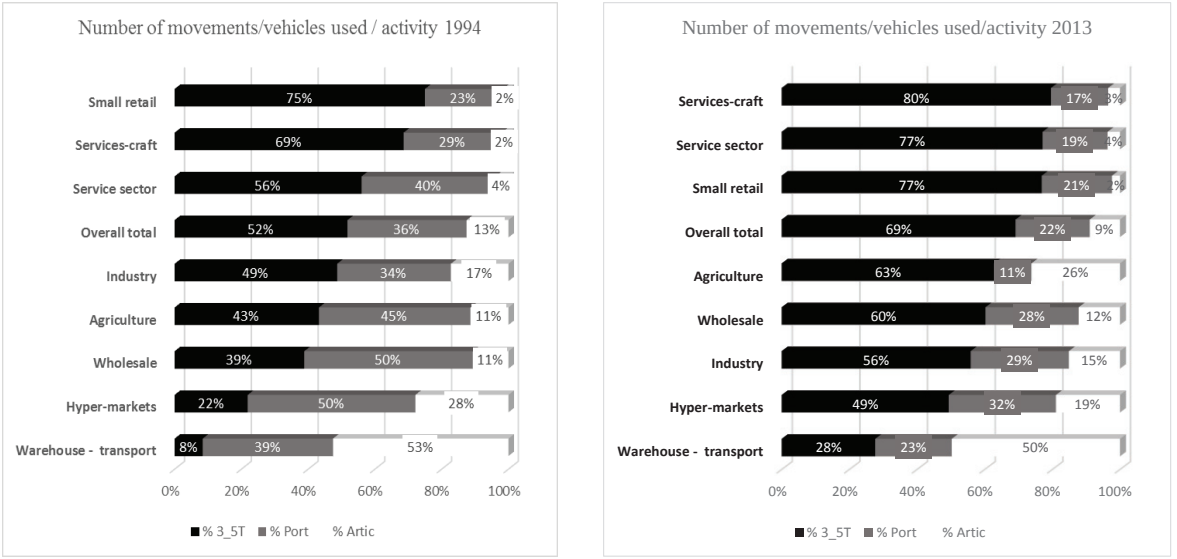

Fig. 4. Evolutions of logistics options between 1994 and 2013-type of vehicles used

The trend of using increasingly light vehicles stands out clearly. Taken as a whole, with the emergence of the bicycle (and delivery tricycle), which amounted to 2% for all the sectors, the market share of "under 3.5 tons" vehicles, which include small cars, increased considerably.

The trucks which achieved in 1994 half of the movements generated by the agriculture, the wholesale trades and the hypermarkets, represents now less than one-third.

The articulated trucks continue to carry half of the movements generated by the warehouses-transport sector.

The largest logistics evolution appears in the Fig. 5 which reveal a highly significant increase (+39%) in the use of third party transport.

In the commercial sector and the Warehouses, the significantly own account decreasing explains the decrease of the number of movements/job (see Table 2).

We know that this involves a much larger proportion of movements performed in rounds, as opposed to direct route, and that the occupation of roads by vehicles in circulation is much less dense, as expressed in the road part of the FRETURB model that determines both the occupation linked to vehicle stops and occupation linked to movements (Routhier & Toilier, 2007, Bonnafous et alii, 2013).

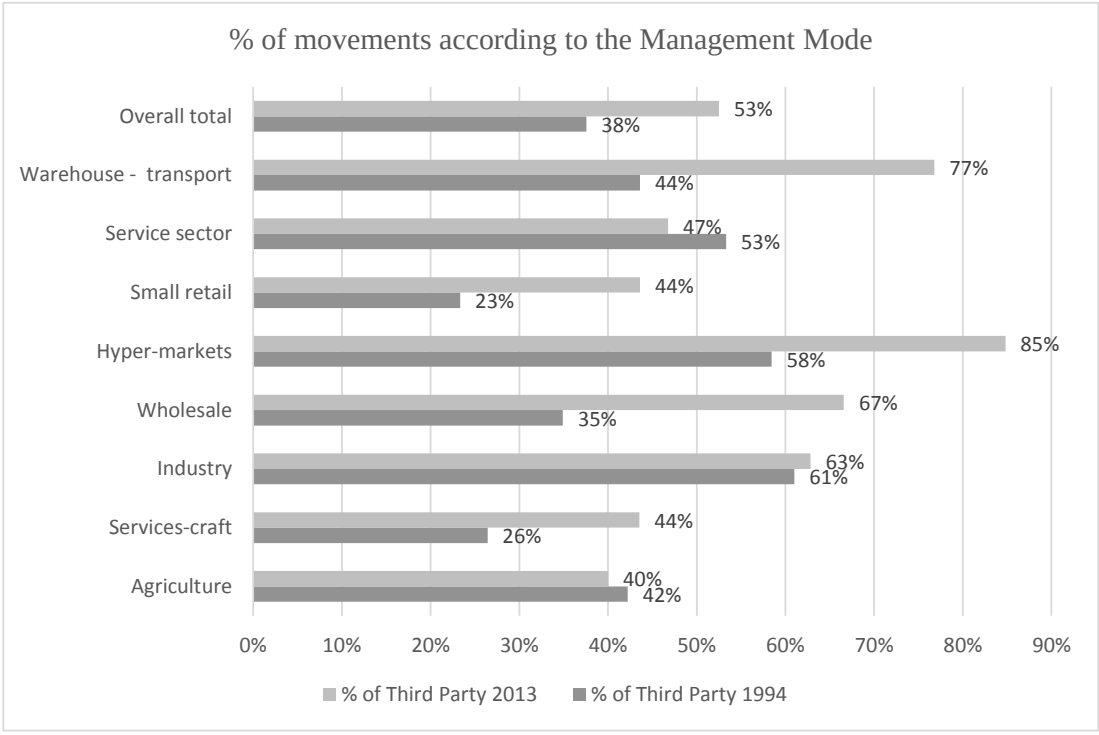

Fig. 5. Evolutions of logistics options between 1994 and 2013 - the Management Mode

Next table shows that the overall part of the deliveries (including the reverse) and of the pick-ups remains steady over time.

Table 3. Evolutions of logistics options between 1994 and 2013 per type of movements

nb.Movements	1994		2013	
Activity	%deliveries	%pick-ups	%deliveries	%pick-ups
Agriculture	54%	46%	61%	39%
Services-craft	83%	17%	74%	26%
Industry	53%	47%	61%	39%
Wholesales	34%	66%	45%	55%
Hyper-markets	92%	8%	82%	18%
Small retail	90%	10%	79%	21%
Offices	79%	21%	69%	31%
Warehouses-transport	57%	43%	47%	53%
Overall Total	68%	32%	67%	33%

A new organisation takes shape in the type of observed movements. In 1994, their repartition was 68% of deliveries and 32 % of pick-ups, numerous vehicles realised an empty return. While the average rate is unchanged, several sectors developed considerably.

We observe that the part of deliveries increase in the upstream logistics (agriculture, industry, wholesale) and the part of pick-ups increase in the last mile activities.

Two hypotheses can explain a part of this result:

- The development of the reverse logistics, in order to optimize the filling of trucks, thus to be more virtuous reducing GHG emissions,
- The important increase of home deliveries in order to meet consumer expectations, which are not always virtuous as regards the environment and the optimisation of the rounds.

6. Conclusion

Those results draw two tracks for analyzing the changes in time: exogenous changes (essentially on localization and weight of the activity: matrix M in equation [3]) and the evolution of logistics options in each of them (matrix L). The main result highlights that the movement per job ratio is reported on the changes in the structure of the activity and its logistics. A more thorough analysis has to be held to explain those changes. We will not mention the "road" or the car model in the current stage of processing the Bordeaux survey, as we do not yet have the analyses allowing us to identify the invariants and what has to be changed in the model.

Nevertheless we can observe that we obtained the main results to validate and fuel the FRETURB model, currently used to simulate road occupancy in fifty cities in France and neighbouring countries (Bonnafous et al., 2013). Indeed, the work of methodological reflection prior to the surveys carried out in the 1990s was based on a simple observation, i.e. the relative efficiency of personal mobility surveys used to fuel urban mobility models depended on the fact that these surveys were designed progressively as a function of the models' specifications. Thus there was a strong correlation between the increasingly less questionable pertinence of successive models and the pertinence of statistical data.

Reflections on the design of this novel survey therefore consisted in searching for a comparable relation, and fuelling a model of urban goods transport. Little by little, this sketch was to become FRETURB, an operational model that can be transposed easily from city to city, the results displayed in this paper confirming that the model is working.

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