INFACT: INtegrated Freight Analysis within CiTies

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It is the purpose of INFACT to better understand the organization of freight traffic in urban areas and the impacts of strategies and policies that could be set up in that field. INFACT is an acronym for “INtegrated Freight Analysis within CiTies”.

The study examines both sides of inner-city freight traffic: on one hand the logistics activities performed by companies and on the other hand the freight traffic generated by household purchase activities. This study also examines the potential mutual links and interactions between both traffic flows.

Downstream urban freight transport (i.e., the purchase behaviour of households) has been described through an innovative method for mobility surveys: the “Intercept and Follow” method. Upstream freight transport has been simulated with a model, mainly based on generalized costs: transport, store, consolidation and external costs are included in the model. The developed model makes it possible to simulate impacts of possible adaptations, improvements and regulations for different urban logistic concepts.

The store acts as an interface between both transport streams. By consequence a policy measure related to urban freight transport could have a positive (negative) effect for one part of the transport chain, but also a negative (positive) one for the other part. The general effect is not always clear. Knowledge about both transport streams and their potential relationship helps authorities to choose the most adequate policy measures to limit urban freight problems.

The research is a first step to understand better freight traffic organisation in urban areas. The applied pilot methodology can be used for a real full-scale study. Such a study is an invaluable tool for estimating the effect of urban freight transport policies for a sustainable city organization.

Section 1 of the paper describes the downstream part of the study, Section 2 its upstream part, and Section 3 their interface and potential interactions. A brief conclusion is presented in Section 4.

1. Downstream urban goods transport

In general little is known about the downstream goods transport that is the transportation of goods by the customers from the store where they are bought to the place where they are installed, used or consumed. It was therefore judged necessary to plan a survey to describe the purchase behaviour of households. Due to budget (and time) limitations, it was decided to prepare only a pilot survey and to focus this pilot on a new innovative method (for the transport domain): namely the "Intercept and Follow" (IF) method (Mc Fadden, 1996; Zidda, 2000). The goals of the pilot were therefore neither to compare different survey techniques nor to collect representative data for general shopping behaviour. By contrast special attention has been paid to the advantages and drawbacks of the IF technique for mobility surveys.

In the context of interest, the IF method consisted of selecting clients at the exit from stores in Jette (a district of Brussels, which is rather a central urban zone and is connected with a variety of existent transport modes) and following their purchase behaviour during one week (by asking them to fill in a suitable logbook). The selected clients could choose to answer the questionnaire immediately ("face to face questionnaire" with open questions) or later ("auto-administrated questionnaire" with the same questions but in closed form).

For each respondent, the questionnaire investigates socio-economic household characteristics, the purchase behaviour and the related transport behaviour (such as transport mode, trip organization, etc). A logbook had to be filled in for the face to face case as well as for the auto-administered case. An incentive (lottery ticket) was used in order to stimulate the willingness to participate and to answer. Importantly, the storekeepers were also informed (by a letter and a visit by the research team) of the study's objectives and the reasons wherefore their clients were being interviewed.

From the pilot exercise it can be concluded that besides some improvements in the survey organization:

- the weather conditions play an important role in the survey's success, at least when street shopping has to be considered;
- the day of the week has a definite impact on the purchase behaviour of households and the related trips;
- the period of the year also affects the purchase behaviour of households;
- the survey hours have significant effects on the customers' characteristics;
- some questions were wrongly interpreted (e.g. difference between visit to a shop and purchase in a shop) and needed some rephrasing;
- researchers should be aware of possible bias (e.g. by use of the incentive);
- the representability of each class of the population (relative to age, sex or status) is difficult to obtain within the IF context. For a real size survey, preliminary sampling and a posteriori weighting procedures may have to be applied.

The stated difficulties (practical issues and problems related to the understanding of the questionnaire itself) lead to methodological suggestions for improving a real size inquiry which is necessary for drawing firm conclusions about the shopping behaviour of customers.

In spite of the caution necessary to interpret results of the pilot, an interesting behavioural observation nevertheless emerged: a very significant correlation was observed between the age of the clients and the time they purchased their goods. While this fact may have been known by shopkeepers and marketing units, its potential impact in terms of supply chain management and supply chain policy, which the INFACT project reveals, appears to have been unnoticed so far.

2. Upstream urban goods transport

2.1. Modeling urban goods transport based on the "total logistic cost" concept

Three typologies of urban goods transport, namely direct transport, indirect transport with an urban distribution centre and indirect transport via cross-docking towards an urban destination, have been simulated. A comprehensive logistic cost model has been built to represent them. The generalized costs, the so-called out of pocket costs and factors like the value of time are the main ones taken into account. Roughly stated, logistic costs consist of transport, store and consolidation costs (cost of loading and unloading the goods from the goods vehicle). The transport costs were considered with special care, given the nature of the project. Because of the induced "conflicts of interest", store and consolidation costs could not be omitted. Due to a clear lack of data, a cost simulation model was used to calculate the operational costs with respect to different goods vehicles. There are not enough data available to estimate freight behaviour with e.g. an econometric model. Nevertheless, an attempt has been made to include as much as reliable data and to demonstrate among other the practical utility of the model.

It goes without saying that a transport firm should have good knowledge of his logistic costs. The road sector is surely subject to ferocious competition, where each firm has an incentive to minimize costs. An important fact is the relatively low capital need, as compared to e.g. the railway sector, which results in a number of many small firms operating on the minimum level of the average cost curve.

2.2. Conclusion of the modeled typologies

The modeling of the typologies revealed the notable complexity of urban transport. Each transport firm opts for the least costly logistic organization, which does not always stroke with the social optimum because of the generation of external costs. The authorities are at this moment the only party saddled with these costs, explaining the idea to internalize external costs into the price of transport. On the hand, we can wonder to which extent the transport firms and consumers can bear this cost. The analysis demonstrated that external costs are mainly ascribed to congestion in the city, which triggered the incentive to ban heavy weight transport in the city. Through time windows, one can fortify or weaken this prohibition. The results did not show a clear answer to this. An important factor are the consequences of a shift from heavy to light weight transport, which can be retrieved by examining the load factor of these vehicles. A possible (best) outcome may be to the city to only allow full truckloads for the largest goods vehicles. For transport firms, this may imply a reorganization of their transport services.

It appears that a lot of results are relative to the hypotheses we made. A striking variable concerns the value of time or store costs during transport. Besides time, also the value of the goods matters. This proves that congestion or imposed waiting and high-valued goods transport can influence the logistic costs for the transporter significantly.

3. Integration of down- and upstream urban goods transport

Can a link between the supply and the demand side (always) be found? The distribution sector has been investigated to answer this question and to understand the potential relationship between shop deliveries and the purchase behaviour of households. The obvious reason is that the store itself acts as an interface between both transport streams. This relationship can be quite significant, with the result that any measure related to one or to the other side of the transport chain could also affect the other side. Hence, any policy aiming at improving the mobility of the deliveries or the purchase travel behaviour should keep this mutual relationship in mind.

3.1. Urban policy measures to influence freight transport within cities

Authorities (national, federal and local authorities) have several instruments available to limit negative impacts on urban freight transport like e.g.:

- the application of taxes (congestion tax, tax on vehicles depending on load factor, etc.).
- size and weight restrictions for freight vehicles
- time windows for deliveries
- restrictions related to the load factor of freight vehicles.
- the obligation to have a minimal stock area.
- the use of a minimum or maximum number of parking spaces.
- urban prescripts (local legislation).

Policy makers should be aware of both transport flows and consider by consequence the influence of a policy measure on both transport flows (supply and demand side). Following graph indicates that policy measures can have positive and negative effects on both flows. The global effect is not known without a better insight of the on-field situation.

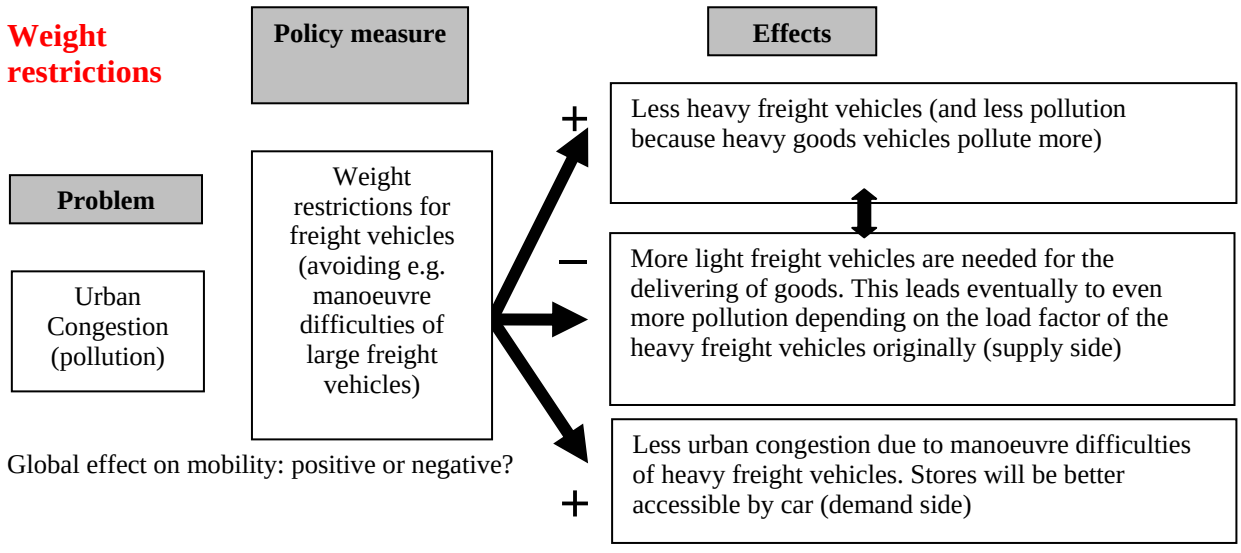


Fig. 1 Possible impact of policy measures on mobility effects, BRRC

In zones with urban congestion (e.g. infrastructure that is not adequate to let heavy goods vehicles pass), one may opt to reduce the number of goods vehicles by enforcing a congestion tax on transport. When the involved goods vehicles are fully loaded, these taxes would not change the situation (urban congestion remains) and would be bad for the global welfare.

Restrictions for heavy goods vehicles to enter the city can in this case be more costly (modelling showed that replacing a heavy goods vehicle through different small goods vehicles can be more costly, both from the viewpoint of external costs as logistic costs). The instalment of time windows can e.g. be a more successful alternative to limit certain goods vehicles during peak hours in certain zones. On the other hand, when there are a lot of goods vehicles with a small load factor, the restriction of not fully loaded heavy goods vehicles and an application of taxes would be good to reduce the number of heavy goods vehicles in these zones.

This example demonstrates that information about the load factor may help policy makers to choose the best, most adequate policy measure to improve local mobility. A cost benefit analysis would help to estimate the overall effect of different alternative measures. Eventually, there is a lot at stake concerning the organization of urban transport. One should think of structural decisions which avoid jeopardizing the economic future of cities.

3.2. Surface as crucial parameter for integration

The available surface and the manner in which it is actually organized by the local storekeeper can be considered as crucial parameters for the interaction between both transport streams. As long as there is no capacity constraint regarding the available space (i.e., shop surface is essentially unlimited), no structural link can be distinguished between the delivery of goods to the store and the purchase behaviour of households. In that case, the general mobility and the storekeeper's management are decoupled: the storekeeper's organizational freedom is only constrained by the local community’s regulations and land-use prescriptions. The potential waste of surface is the biggest disadvantage of this situation (generating opportunity costs for other activities). A policy impacting on one side of this transport chain will therefore not impact significantly on the other side of the transport chain. However, the presence of a capacity constraint creates a clear link between both transport streams, as we now outline.

3.3. Surface as capacity constraint

This capacity constraint (on the shop's surface) can vary from weak to strong. When the constraint is strong (small surface), the various internal activities of the store are possibly strongly affected. What are these activities, or, more accurately, to what functions are different areas of the store devoted?

Several different activity areas can be distinguished in a store, each serving a specific purpose: the stock area, the sales area proper, the car parking area for clients (if any), the area for loading and unloading goods, and the administrative area (kitchen, corridors, offices, etc.). The relative sizes of those areas are important to judge about the potential link between the supply and the demand side. The ratio of stock area to total area and the ratio of patrons' parking area to total area are significant parameters for respectively the supply and the demand side. This is illustrated in figure 2 (next page).

In that figure, the point 1 corresponds to a situation where parking and access are easy but storage and unloading are comparatively difficult. In such a situation, one may expect stringent constraints on delivery times, with the potential traffic disturbances caused by heavy trucks in the shop's neighbourhood. The situation corresponding to the point labelled 3 is opposite to the point labelled 1. Storage/delivery is easy but access for customers is difficult. This is likely to reduce the clients' liberty to shop, and therefore to modify shopping habits or locations (with the side-effect of impacting in turn the shop

profitability). The situation corresponding to the point labelled 2 is intermediate. The oblique line delimiting the shaded area in the picture represents the total area constraint (for constant sales area).

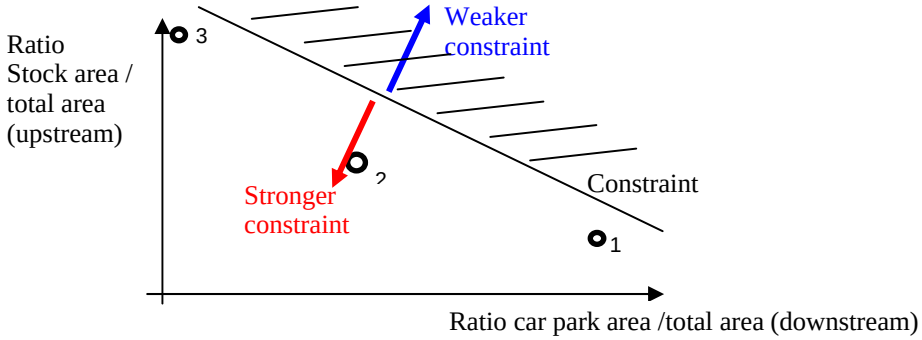


Fig. 2 Constraints for various shops ratios (FUNDP)

We observe that this simple interaction models the effects of two different types of regulatory control actions. The first is that exercised by the shopkeeper him/herself in his/her decision to affect the balance of available shop surface between downstream or upstream functions. The choice between points 1, 2 or 3 in the above figure indicates the potential compromises between upstream and downstream accessibility. The second control action is exercised by the local authorities via the definition and enforcement of land-use regulations. In such regulations, not only the total shop surface may be limited, but the proportion of parking space (or even loading/unloading berths) compared to the total lot surface can also be constrained. This can shift the constraint line in figure 2. Additional control actions are also possible for the local authorities by imposing constraints or facilitating shop accessibility.

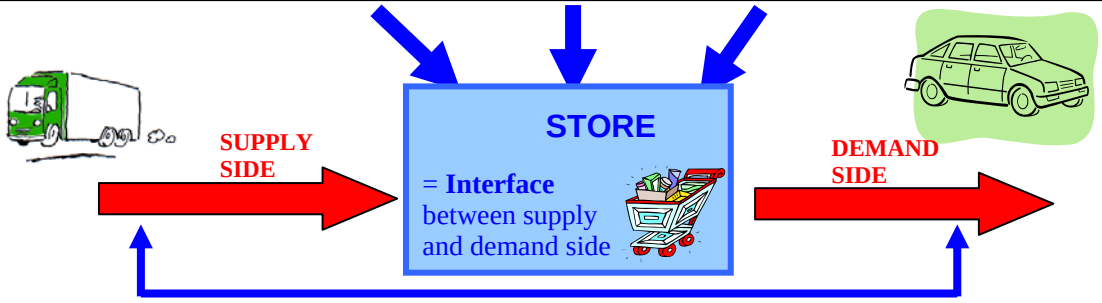
The main conclusion of this analysis is that regulations of this kind may have (and typically have) a definite impact both upstream and downstream. The upstream impact is to alter delivery frequency and times and the downstream impact is to modify shopping habits of local residents. At the same time, the policy makers should be aware of the sensibility of storekeepers with respect to certain policy measures. Storekeepers with a flexible stock constraint (point 1) are less sensible for policy measures (with effect on supply side) than storekeepers with a strong constraint (point 3). Thus, the stronger the surface constraint, the more important the effects of any accessibility policy...

Interviews with storekeepers and design engineers teach us that it is a global trend to offer a maximum number of parking places and that the local storekeeper (in case of supermarkets) has a lot of influence on the design of his/her store (e.g. Delhaize). It should however be noted that is not easy to obtain information about the different activity areas in a shop because these data are considered as strategic commercial information.

3.4. Knowledge about different typologies as base for policy measures

Detailed data to support all these models is beyond the scope of INFACT. In a first simple approach, one might therefore think *at* typologies. As there is a big diversity of stores (size, clients, delivery mechanisms, shop location*s* and layout*s*), initial surveys could aim at detecting "*synthetic* stores" (stores that are repr*esentative for a certain region* or *for* a certain set of conditions). Coupling this with suitable typologies for the supply and demand sides, as well as for surroundings provides some insight to policy makers in their efforts to understand the effects of policy measures on urban freight transport (see following graph).

Typology of surroundings: Location of store (urban/not-urban), accessibility to public services (distance to stops of public services e.g.), transport (and parking) demand in neighbourhood), parking facilities in neighbourhood (total number of on-street and off-street parking places, local policy (urban prescripts, policy measures, etc.)



Typology supply side, logistical organization: - number and size of used freight vehicles (length, width, tonnage), value of delivered goods, frequency and delivery times of freight vehicles, range of products (product variety), sales turnover, the organization itself: single drop or multi drop system, volumes of stock, volumes of sold products and volume of garbage (loss products), policy of storekeeper, dimensions of parking place, occupation rate parking places (barriers: eliminating parking abuse of non-clients), load factor of freight vehicles.

Typology purchase behaviour of households: number of clients (total and hourly, number of cars (total and hourly), parcel size (volume of products, space needed in car's trunk in relation with it's maximal capacity), value of goods, frequency of purchase visits, opening hours store

+ Special attention for special goods (fresh goods like bread)

Fig. 3 Typologies helping to understand effects of urban freight policy measures, BRRC

4. Conclusions

The INFACT project has developed a methodological approach to understand the interactions between the downstream and upstream aspects of freight transport in the urban context. It has developed and tested a survey technique that is able to produce information on the behavioural aspects of shopping and associated goods transport. It has also constructed a comprehensive cost model for the upstream logistic chain, illustrating how various policies can affect the distribution costs for goods (from production to shops). It has finally sketched a model capturing the potential interaction between the downstream and upstream managements through both local authorities' and shopkeepers' actions.

The authors are well aware that the project's results are only preliminary and need further investigation. A more extent data collection is needed when detailed models are to be built, in particular to represent the upstream/downstream link. But we also anticipate that a more detailed analysis may not be easy. In a first attempt, we have indeed contacted supermarket buildings designers to obtain their views on this issue, but they have politely declined our invitation, arguing the proprietary and commercially sensitive nature of the requested information. While this might make data collection harder, it certainly confirms our intuition that the described interaction mechanism is indeed important. This indicates that further work in the directions outlined by INFACT may be of interest in understanding the mechanisms of urban freight transport and in assessing specific policies in this domain.

5. References

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