City logistics: the need for a behavioural model

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Abstract

The importance of urban goods transport and its impact and contribution to the quality of life for city communities, is recognized by political institution at all levels.
This literature review on the subject discusses the state of the art on models of urban goods transport.
However none of them take into account how agents respond to policy intervention and most of all how their interaction affects the effectiveness of the policy and its support. In this sense there is the necessity to develop a behavioural model. This article suggests a new stream of modelling based on the recent advances in discrete choice models and on what is called the IACE methodology.
A subsequent paper will show the most common policies of intervention, comparing them and enlightening their advantages and disadvantages.

Keywords: urban freight transport, behavioural model.

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2 Introduction

Urban freight transport is of vital importance for the welfare of cities although it represents a very critical issue too, due to its congestion and environmental impacts.
The importance of transport is reflected by the fact that cities are, at once, consumption sites, they attract goods, and production sites; they generate goods [11].
It is only through the mobility of people and most of all of goods that cities can develop the well known economies of urbanization [9] and so generate and pull their possibilities of economic development [11].
Transport demand is always defined as a derived demand. That is because it is not the transport services that are needed but rather the goods transported and most of all the

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utility that one can derive from consuming the goods[2] in a specific time and place. Goods, in fact, have much more value in the place in which they are consumed than the place on which they are produced [11]. In particular, freight transport increases value in four utility dimensions [44]:

- Space;
- Time;
- Form;
- Possession.

Essentially urban freight transport has to be seen as an economic activity: that is part of the overall economic process of production and consumption and that fulfils the requirements of city population primary needs[3]. This relationship between transport demand and goods demand is reflected in the relationship between their elasticities [12].

It is not however only demand conditions that are changing but also goods supply too. Of particular importance are changes in supply chain management that have a huge impact on the network distribution organization and on the transport activities [60], [9]. The most important changes in freight transport supply are as follows:

- Supply chains are becoming global and so urban freight transport has became much more closely linked with long-haul transport;
- Retailers are trying to lower stockholding costs and the number of depots (reduction in the lead time, JIT strategies);
- Supply chain flows are becoming time sensitive (e-commerce);
- Road transport is augmenting its market share which is already high;
- Competitiveness between freight transport and passenger transport is increasing;
- The high share in urban goods distribution of own transport companies rather than companies contracting 3PL providers [9];
- A need to pursue sustainability, and not only efficiency, in the distribution of goods is increasing [42].

Other than positive effect, linked to freight transport there are negative effects[4] as well. These in particular are [42]:

- High congestion and the connected in-accessibility to almost all infrastructures for commercial vehicles;
- Environnemental impacts (air pollution, noise, vibration, visual intrusion);
- Social (accidents) and security (loading/unloading isssues) impacts of transport distribution operations;
- Energy and infrastructure consumption;
- Disequilibrium among the different supply chain agent’s interest.

We would like to underline this last aspect, because according to us urban freight transport is characterized by a great amount of complexity due, most of all, by the interrelation among different agents (local authorities, local communities, shippers,

[2] A recent approach suggests that what it is required and what generate utility is not the goods itself but its implicit characteristics (properly attributes). See reference [36].

[3]This primary needs (living, eating, dressing) have a direct and in direct impact on freight transport because they affect the urban structure (the goods destinations), the activity distribution (the good generation), and last, they determine the variety of product distributed. See reference [44].

[4] These same critical aspects have inspired the methodological research looking for possible solution to the problems. See reference [44].

carriers, retailers, big or small transport operators, house of commerce, etc) with different interests to pursue (see table 1) and, at least, different perception of the problem.

This complexity has its solution only in finding a long-term equilibrium among these different interests[5].

Table 1: Different interest of urban freight transport actors

Actor	**Main interest in regard of urban goods transport**
Shipper	Delivery and pick-up of goods at the lowest cost while meeting the needs of their customers
Transport company	Low cost but a high quality transport operation, satisfaction of the interests of the shipper and receiver (shop)
Receiver / shop owner	Products on time delivered at a short lead-time
Inhabitant	Minimum hindrance caused by goods transport
Visitor / shopping public	Minimum hindrance caused by goods transport and a high variety of the latest products in the shops
Local government	Attractive city for inhabitants and visitors: minimum hindrance but having an effective and efficient transport operation
National government	Minimum external effects by transport, maximum overall economic situation

(Source: Bestufs, (2004), op. cit)

3 A city logistics definition

In the literature, according to us, there is no common definition of UFT[6] or city logistics[7], even though some concepts are quite common among different definitions. The definition used, in fact, is correlated to the specific methodological approach followed or to the project implemented. In this sense we can identify some dimensions through which we might classify the different definitions of UFT.

A list of the principal dimensions, except the most trivial one that consider UFT as every kind of transport different from the passenger one [44], is presented below:

[5] This is somewhat similar to the "governance approach" suggested by some researchers. See reference [9].
[6] From this point to the end will use the abbreviation UFT for Urban freight Transport.
[7] As some other researchers even for us the different labels used to underline the problem such as urban freight transport, urban goods transport (or distribution) and city logistics are quite similar given the fact that with them we always mean not only the policies used to deal with problem but also the analysis to understand it. See reference [9].

- Freight flows considered (from and to the city, through and within it):
- Unit of analysis;
- Inclusion (or not) of service transport;
- Inclusion (or not) of home-based transport;
- Mode considered;
- Geographical and spatial area covered;
- Kind of transport operation analyzed;
- Actors taken in consideration.

The first dimension is, maybe, the only one common to all approaches that is almost all the studies consider the whole range of freight transport operations that have the urban boundaries as context. For what concern the unit of analysis some studies take as reference the good transported (commodity-based models), others the unit or the vehicle of transport utilized (truck trip-based models)[44], [45], [2], [54], others more, the place on which the activity of loading and un-loading goods is performed (it might be the production site, the wholesaler depot, the retailer premises or even the consumer residence) [3], [6]. Other dimension to take into account is the variety of product [2], [50], [6], and the different typologies of vehicle analyzed [59]. Then some studies include services (defined as trip done to perform an activity of support in the destination site or not directly correlated to freight distribution [2]). Although the importance of home-based transport is increasing as well as the knowledge of it [2], [3], actually, few studies consider it of importance [50], [47]. A big share of studies focuses their analysis on road transport only, but there are some that consider alternative freight mode transport too [6], [57]. In the literature is also different the geographical or spatial context considered (and in some sense the geographical aspect influences the kind of approach followed)[8]. In fact the transport analysis can be focused on small-medium cities only [50], on the core of the cities [15] or in specific areas of it [37]. With the last two dimensions we mean that not all the typologies of UFT operations are considered (multi drop delivery, pick-up and delivery [54], long-haul operations [13], [6], [37], etc.) nor even all the supply chain actors involved, although some studies has a SC approach [6], [29], [27].

4 Models of urban freight transport

4.1Conceptual framework

In the literature, there are different methodologies, models and approach to study UFT. They differ according to the city context, to the geographical area (or country) [4], [50] and also to the researcher point of view that can be focused on the engineering aspects or in the economical ones.

However all studies agree about the specific task or aim to pursue in UFT that is "the optimization of the transport and logistics activities within the city boundaries by private and public agents minimizing the external effects (environment, congestion, energy consumption) in a framework of market economy"[54].

[8] For geographical dimension we mean that the transport problem is different according the specific geographical context analyzed. See reference [4].

Likewise for the definition of UFT, we can identify different dimensions according to which classify the methodologies followed and the models realized in the UFT study. A first classification among models is based on the dimension of which kind of intervention (unit or vehicle of transport, infrastructure, technological innovation, regulation and taxation scheme, subsidies, coordination of the distribution) they try to perform or are focused to. A second classification is to divide the models according to their primary aim, whether it is a planning aim or an operational one [59]. In fact according to the general aim there are different specific tasks (economic development, efficiency, safety, environment, infrastructure and urban structure) or temporal span followed (long term, medium term, short term). Another classification [58] differentiates the research in UFT subject on: qualitative research, focused on identifying the well suited policy interventions, empirical research, specific for each city situation and, at least, modelling research, oriented to construct and implement UFT models. Parallel with this, there is the last classification [44] that, considering UFT as an interaction between supply and demand (and between themselves), ranks the models according to the specific interaction aspect taken in consideration (table 1 present the possible interactions).

The literature presented here is focused only on the analysis of the different models implemented and adopted in UFT study.

Table 1: Interactions between demand and supply

VARIABLE		DEMAND		SUPPLY			
		Commodity	Land use	Road network	Non-Road network	Vehicle	Vehicle movement
DEMAND	Commodity	Commodity	Freight generation	Commodity flow by road	Commodity flow by non road	Vehicle design	Vehicle loading
	Land use		Land use	Location	Location	Building site design	Trip generation
SUPPLY	Road network			Road network	Modal transfer	Traffic design	Road traffic flow
	Non-Road network				Non-Road network	Right-of-way design	Non road traffic flow
	Vehicle					Vehicle	Industry structure
	Vehicle movement						Vehicle movement

(Source: Ogden, K.W. (1992), op. cit)

4.2Models classification

While the conceptual framework presented above and, most of all, the aim of optimizing the operations of freight distribution and minimizing its cost is the common aspect of the whole literature then there are different types of models, each one with its own specific characteristics, advantage and disadvantage (see table 2).

In the subsequent paragraphs we will present an analysis as much accurate as possible of each of them (at least the most important ones).

Table 2: Models classification

Macrocategories	**Econometrics and statistical models**		**Spatial-Network models**				**Demand models**				**Emprical models**
Categories	Trend and time series analysis models	Elasticities models	Flow network models	Price equilibrium models	Entropy models	Equilibrium models	Aggregate demand models		Disaggregate demand models		No specific categories
Sub-categories			*Operationl equilibrium*	*Partial economic equilibrium*	*Statistical equilibrium*	*General economic equilibrium*	Four-step models	Input-output models	Modal split models	Routing and scheduling models	
Characteristics	Longitudinal analysis of freight transport data (time or trend) series	Analysis of variables influencing transport demand	Mathematical optimization of freight flow finding the minimum cost link on the network	Finding the spatial equilibrium price between demand and supply	Finding the flows that maximize the overall entropy on the city	Combination of the first two approach	Application of passenger transport modelling tools to freight transport: generation-attraction-(O-D matrices)-modal split-network assignment	Use of input-output coefficients to determinate the transport demand generation activities	Modal split choice analysis	Routing and scheduling optimization of vehicle fleet under different constraints (e.g. time windows)	Empirical estimation (sometimes through the use of computer software) of freight flow specifically for the city of reference
Advantages	Easy to implement, non data intensive, based on the past to predict the future trends	Multi-mode approach, quick results and policy intervention support	Analysis of supply, demand and freight flows interactions in a specific network				Deep knowledge of modelling tools (experience from passenger transport)	Easy to implement after the determination of input-output coefficients	Use of the recent developments of discrete choice models	Use of the recent IT technologies	Ability to consider the characteristics of the city of reference
Disadvantages	Aggregate analysis and misunderstanding of transport demand generation relevant variables	Inability to consider the combined effect of several variables	Very complex to implement and data intensive				High complexity of freight transport demand rather than passenger demand (non consideration in the modelling phase)	Same disadvantage of time series analysis	Modal choice limited in the urban context	Sometimes the algorithms used for finding the optimal solution give counter intuitive results	Context dependency

(Source: personal elaboration)

4.3Statistical and econometrics models

These models study freight transport demand through the analysis of time series and past trend, for what concern the first sub-category, or through the implementation of econometrical models by which estimate the elasticity of demand[9] and how it respond to the changes in the control variables, for what concern the second sub-category.

An example of the first type of models is represented by the study of Ogunsaya [46] in the city of Lagos, Nigeria. The model adopted is a simple one, and it is characterized by a log-linear regression analysis with a stepwise approach through which progressively identify the most important variable (variables) generating or attracting freight transport demand.

For the second type of models Zlapoter e Austrian [61] give us a review of different econometrical models adopted since the mid-1970. In particular these kinds of models are aggregate in nature and they try to explain the relationship between modal shares (most of all road and rail) and different variables. They differ according to the specific functional relationship utilized or assumed to exist between mode share and independent variables. Several critics must be addressed to these models:

- The aggregate nature of the models;
- The assumption to model the modal choice as it is separated from other logistic choices[10];
- The assumption that supply condition are stable, and that freight quantity transported is an exogenous variable in the model;
- The difficulty to obtain data for specifying variables.

4.4Spatial-Network models

Spatial-Network models try to model the interaction between supply and freight transport demand (let say between shippers and carriers, retailers and customers) with the aim of finding the spatial price of equilibrium between them or minimizing the cost of freight flows on the network links [48]. This lead to two different kind of spatial network models: flow network models and spatial price equilibrium models.

4.4.1Flows network models

Flows network models are also called combined models given their attempt to model the "consistency among the levels of service in the system and flow values (link flows and origin–destination trips), for each stage considered in a particular transportation problem" [19]. Essentially they are mathematical optimization (static or dynamic) models [17], [53]. That is because they describe the interactions between shipper and carrier and the freight flows generated in this interaction, by mathematical formulations. Their structure it is always the same: it consists of a series of nodes (cities) that represent activity location and a series of links (transport routes) that on the contrary represent the freight flow moving from one node to the other. They analyze freight flows in different traffic condition situation paying attention in particular to the travel time and average speed relationship with different level of freight service. The way by which these

[9] One has to say that there are different elasticity indicators to estimate: punctual elasticity, arc elasticity, shrinkage ratio. See reference [56].

[10] This critics it is more relevant for the disaggregate mode choice models (see later paragraphs)

three variables relate each other can have huge impacts (congestion and environmental pollution) on the network condition. The optimization process is realized to find the routes on the network with the minimum overall cost (atmospheric pollution, noise, energy consumption) [17]. However there are different kind of flow network models (network supply models, network demand models, network impact models) [54] characterized by the fact that each model:

- take into account specific aspects of the freight flow problem (such as treatment of multiple modes or multiple commodities, simultaneous or sequential loading of commodities, treatment of congestion phenomena, etc.[22]);
- construct a different objective function to maximize;
- apply different solution algorithms [19].

The principal disadvantage of the network models, paradoxically, is the high complexity of real situations (in particular logistics operations) that cannot be restricted in mathematical formulations. New approach are trying to deal with this complexity using models (heuristic models, systems of intelligence, genetic algorithms, event-based models), that allow much more flexibility [17].

4.4.2Spatial equilibrium price models

Spatial price equilibrium models may be considered an enlargement of neo-classical theory (in particular of firm theory [12]), because as the neoclassical theory, they try to find the equilibrium price in the network between supply and demand. It is said that for a commodity flow to exist between two point (origin and destination), the delivered price for the commodity (equal to the price of the commodity at the origin point plus the transport cost to the destination point) must be equal to the price of the commodity at the destination point [47].

Models that start from this assumptions are called partial price equilibrium models because they take in consideration only the market condition of the commodity being traded (or transported) without considering the condition on other markets (at least on the markets that generate the commodity demand). Usually these models take into account the interactions between three specific agents of a supply chain: producer, consumer, and shipper. The transportation costs are stated as fixed values or as functions of the flows on the network. Producer and consumer behaviours are incorporated by defining a supply and demand function for each region [25].

Evolution to this base model has been taking into account what happen in other markets (as residential and labour markets) and which are the activities that generate commodity demands. The last evolution for these models was been to consider the goods demand as a part of an activities system, where each activity demand interacts with the others within the limit of one single transport network. In this sense we can define this model as a general spatial equilibrium one. Oppenheim [47] gives an example of such a model, where he considers freight demand as a function of different activities (such as shopping). What it is interesting in Oppenheim model is the aim to combine together freight and passenger transport, analyzing their interactions within a framework of a competitive market economy. However since the difficult task to attain, the model is forced to not consider all the actors of a supply chain (it considers just two actors: retailer and wholesalers).

4.5Demand models

There are different types of demand models (four-step models, input-output models, modal split models, routing and scheduling models) but essentially almost all of them[11] try to model the demand (the generation or attraction) aspect of freight services.

4.5.1Four-step models

Adopted from passenger demand analysis, four step models are actually the most commonly applied models in UFT. Four step models can be classified according two approach[12]:

- commodity-based approach;
- vehicle-based approach[13].

However both approaches follow the same structure or step to model UFT, where each step is formalized in a specific equation. These steps are:

1) Freight generation;
2) Freight distribution;
3) Modal split;
4) Network assignment.

According to the specific approach followed these steps might be reduced to only three, erasing the modal split step[14] (according to the vehicle-based approach) or might be augmented to five, with the inclusion of the vehicle loading step (according to the commodity-based [44] approach*)*.

The specific models implemented at each step are very different according to the researcher point of view and his thoughts about the variables that influence the generation and attraction of freight, the modal split and the network assignment.

An enlargement of the commodity-based approach is the study by Holguìn-Veras e Thorson [32] about the need to consider and to model empty vehicle trips.

One of the critique that can be addressed to these models relate to their assumption about the possibility to consider each market not affecting each other (in modeling term it means to apply a sequential approach), when, on the contrary, it is possible that changes in the demand equilibrium of one of them have impact on demand equilibrium of the others. Button suggests [12] an interesting solution to the problem other than apply a simultaneous approach. This solution consists to switch to an *attribute-based* approach [36] (in particular for what concern the mode choice step) rather than assume that utility derive directly by commodities and services *per se* as in the standard neoclassical theory.

4.5.2Input-output models

Input-output models are focused on the estimate of specific coefficients (input-output coefficients) to determine the overall economic activity that generate freight transport

[11] The routing and scheduling models are a bit different because for certain aspects they may be consider supply models given the fact they models the best allocation of vehicles in the city network.

[12] In reality this classification can describe all the models analyzed in this paper because each one of them can study the freight demand adopting a commodity-based approach or a vehicle-based one.

[13] There is even a third approach (trip o tour-based approach) that consider specifically all the pick-up and delivery operations done in the supply chain. See references [13], and [50].

[14] Some authors suggest that even in a urban context where the modal choice is very narrowed, it is important to consider the modal split step (in particular one can view the choice between different type of vehicle as a real mode choice). See reference [12].

demand. The inputs considered are, as usual, capital, labour and raw materials. These are inserted in a matrix through which one can derive the goods and services demanded by all the industrial sectors of the economy (even by the transport sector itself). Then the values obtained are transformed in demand for transport services [48]. An example of such a model is provided by Harris and Liu [26]. Even if this model is not focused on the urban freight transport demand it shows how this sector, and all the economy of a region, is strongly linked to the export sector.

The limits that might be addressed to these models are first of all the indirect estimation of transport demand and linked to this the complexity to estimate, and the reliability associated, of the input-output coefficients.

4.5.3Modal split models

Modal split models can be divided in two types: aggregate models and disaggregate ones [61]. This distinction is based, first of all, on the data utilized to test the model (aggregate versus disaggregate[15]) and second to the corresponded aim, that for the aggregate version is the estimate of market share for a specific mode while for the disaggregate version is to analyze the decision of which mode a particular actor choose for its own distribution strategy.

Taking in consideration just the disaggregate models[16], we can say that mode choice is affected by transport demand, infrastructure demand and by the characteristics of the services supplied [16]. However these variables can be different according to the specific point of view of mode choice analyzed (demand or supply point of view) [34], [18], [39].

Since these models are based on discrete choice theory what they model is the probability that a particular mode alternative is chosen. The diversity among them is reflected by the different assumptions on the error term distribution that form the agent utility function attached to each alternative. So the specifics models could be, for example: multinomial logit [40], nested logit [34], binomial probit [1], multinomial probit.

Some models try to analyze not only the mode choice decision but also the correlated decision about the lot size to transport [1]. Other insert the mode choice decision into a framework in which all the logistics decision (long, medium and short term) are considered and modelled [8], [51].

The limits of these models are, according to us, of different types:

- The first set of limits is linked directly to the estimation procedure applied that is to the limits that discrete choice theory has on its own. These for example might be: identification problems of the models, application of possible elicitation procedures, necessity to use complex models to take into account of possible correlation between alternatives but difficult to estimate;
- The second set of limit instead refers to the complexity of freight transport and so to understand who are the specific actors that ask for (generate) transport services or affect the characteristics of the service (timetable of the delivery, flexibility required, etc.);

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[15] This distinction is not only qualitative in nature but has also a theoretical base. In fact aggregate variables (such as market share) are continuous variables while disaggregate ones (mode choice) are discrete. In this sense this difference has to be reflected in the models applied.

[16] For the aggregate version see the paragraph on statistics and econometrics models.

- Finally the last limit refers to the fact that mode choice in a city context is quite narrowed[17].

To conclude one has to consider that there are other mode choice models that are not based on discrete choice theory. These are [41]:

- classical economic models based on the fact that for each distance and weight there is an appropriate mode of transport even if some studies have demonstrated the shippers strategies affect the mode choice much more than distance and weight and because of this there is a broad band of competition between modes. However with this approach it is important to understand and consider the whole range of cost differential (financial cost, service quality, etc) between modes;
- inventory theoretical models that consider of importance on transport mode choice the inventory strategy of a firms. Because of this the mode choice is dictated by the aim to reach the lowest total logistic cost, after having trade off purchase, order and transport costs. Some limits of these models are the non-consideration of customer service impact and of behavioural differences among shippers on the mode choice;
- trade-off models that consider the mode choice as affected and consequent on the trade off between transport (TC) and non transport cost (NTC);
- constrained optimization models that are similar to the previous ones with the difference that the transportation choice process can be represented by a constrained optimization process with TC optimized subject to several NTC constraints.

4.5.4Routing and scheduling models

Routing vehicles and scheduling (RVS) models are based on the recent developments of information technologies that allow real time communication between vehicle and control centre, information exchange on traffic condition and the "storage" of all pick-up and delivery operations in database [55].

The routing and scheduling task is the determination of the delivery time for the vehicle fleet that starts from a single depot and arrive to different locations (customers) in the network[18] [53].

These models (very similar to the more general flow networks models) are structured in two steps. In the first one it is modelled the assignment of vehicle, their departure time, and the freight order of consignment (or pick-up) to the different customers [53], [54], within a double constraints: temporal (*time window problem*) [53], [35], [38], [42], and unique customer assignment (that is vehicle is allowed to make multiple traverses per day but each customer must be assigned to exactly one route of a vehicle and all the goods from each customer must be loaded on the vehicle at the same time). In the second step the results of the first model become inputs of a second one, called "*box model*", that simulate the freight and passenger traffic on the network with the aim of estimate the average traffic time and to find the minimum cost link. After been estimated this results are reinserted in the first model and so on until equilibrium condition is found.

[17] Even if, as already said in a previous note, one could think of different vehicles choice as different urban transport choices.

[18] However it can be also the contrary that is the deliver may start from different customers and arrive to a single depot.

Likewise the characteristics, even the limits of these models are similar to those of the network models. One could add that sometimes the algorithms used reach, even for simple models[19], counterintuitive solutions.

5 Empirical models

The models shown in this section differ from the other essentially because they are not theoretical models but rather empirical ones. These models, in fact, are developed on the assumption that one has to start directly from the data acquired on real situations to understand how the freight task is implemented in the reference context. Only after that it is possible to build a model that instead of being based on theoretical assumptions try as much as possible to replicate the real situations. According to us, the possible limits of these models are paradoxically based on their own characteristics that is a specific approach may be biased for a specific (city) context.

5.1Freturb

Freturb is a french model based on specific surveys [3] taken among the operators involved in the freight activities. In particular the relevant unit of analysis are directly the whole range of premises in the city. Freturb was implemented specifically to improve and overcome the usual origin-destination matrix approach. The reasons why it would like to differentiate from that approach is, first of all, for the specific distribution operations that characterize freight transport operators, and second, for the limits of models based on O-D matrix to take into account any impacts caused by regulation policies.

Main aim of the model is to give to the local authorities a real tool to reveal urban goods movement changes and to show what urban planning policies are the most appropriate for sustainable distribution.

Four main sequential approaches can be identified in Freturb model:

- a generation of the pick-up and deliveries in each urban area (with a specific consideration for household purchasing trip);
- a module of road occupancy by running vehicle based on the distance travelled between two stops);
- a module of road occupancy by stationary vehicle;
- a module of road occupancy at any instant.

5.2GoodTrip

Goodtrip model (developed by Dutch researchers [7]) try to overcome the limits of other urban goods models such as:

- four step approach models, unable to capture directly freight movements;
- trip-based models, often based on empirical data and unable to evaluate new transport systems;

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[19] In a simple exercise that I have performed during my "Physical and Distribution Logistics" course in Leeds, the algorithm used (it was the really simple one that is based on finding the least-cost routes after having computed the savings matrix) suggested a solution that even if it was the least-cost one it didn't recognized (and so it didn't insert into the solution) that it was possible to link two nodes through a third one (and so performing one delivery more) with the same total distance run.

- good flows based simulation models that need a lot of empirical (not always available) data.

Gootrip is based on a conceptual framework that considers the interactions among four different markets of urban freight transport: spatial organization of activities, goods flows, traffic flows and infrastructure.

Essentially this model is a demand based supply chain model and it can be used to predict the future developments that can affect the logistical efficiency and the external effects on urban goods transport. In particular it takes in consideration the following developments:

- Changes in distribution patterns and mode choice;
- Developments in supply chain organization;
- Changes in demand pattern;
- Environmental improvements.

5.3DISTRA

DISTRA [33] model it is (or it is supposed to be) a specific part of the national Swedish Freight Model (SAMGODS). At least it has two different purposes:

- To supplement the national model covering intra-municipal goods transports as well as short distance inter-municipal transports, and adding LTL traffic services
- To analyze the local/regional problems such as effects on new links, bypasses, dedicates lanes on congestion, CBA assessment, assessment of pricing policies, and assessment of sustainability policies.

The specific characteristics of the DISTRA model are:

- to add data on a low spatial level (even if only road transport data);
- to include service transport;
- to follow an add-ons approach that means give a base structure for the model useful for all region and then provide specific tools (extra modules) to allow regions-specific[20] DISTRA models.

5.4 VISEM/WIVER

The VISEM/WIVER model [21] is based on several in-depth surveys carried out at premises in Munich, Berlin, Hamburg, Dresden, and specific surveys of drivers on their traffic behaviour. The model calculates the demand of passenger transport and commercial road transport (considered as the trips which are generated by drivers during their jobs) by vehicle type using structured data from a city/region databases and surveyed behaviour data from groups of persons and the transport activities of a company's employees. On the assumption that each sender generates one or several vehicle tours per day which start and end at the sender's home zone, the determination of commercial traffic O/D is modelled considering three stages: the starting trip, the connecting trip, and the ending trip.

6 Future research prospective

[20] For region it is meant state regional authorities.

Even if different models have been implemented none of them describe the interrelationship between demand and supply and most of all consider all the actors of a supply chain. If the importance of following a supply chain approach has been recognized [54], [6], still there is a lack for a model that tries to formalize the interactions between the actors of the SC.

We follow an approach suggested by some researchers[21] of the Institute for Transport and Logistics Studies in Sydney, based on an econometric model with stated preferences data [10], [27], [28], [29], [30], [31], that has the aim of modelling the behavioural aspects characterizing the agents of a supply chain and how their interaction affect the support given to the specific UFT policies.

6.1The need for a behavioural model

According to us, the UFT challenge, for what concern the policies of intervention, is linked to the analysis of the impacts and subsequent reactions that those policies have on the actors involved in the urban freight operations. It is not enough to structure the best policies, from the point of view of cost minimized and benefits realized, to resolve the UFT problem. Assuring that a policy has success means that one has to consider the level of acceptability gained by the same policy among the actors to whom it applies. From an analytical point of view, it means that one has to model the behavioural aspects of UFT. The behavioural dimensions that characterize freight transport are spread over all the markets through which it is structured. These markets are: infrastructure market, traffic market, transport market and goods market [6]. The comprehension of the specific (behavioural) aspects of this two last markets can improve the comprehension of the first two.

6.2 A "supply chain" approach

One of the important aspect of UFT is the high level of congestion in the transport network. It is widespread recognized that freight distribution operations usually take place at the same time (pick hours) on which most of the private activities (reaching owns job, taking children to school, going shopping, etc.) are performed. In this sense freight transport overlaps passenger one, causing the high level of congestion mentioned before.

We believe that the principal cause of congestion that has to be addressed to freight transport is a lack of coordination in distribution operations among the different supply chains and, within them, among the agents.

Congestion can be seen as an inefficient use of "time resource" [29] that increase the distribution costs, so every one in the supply chain want this inefficiency to be minimized. This task, however, cannot be followed just by one actor of the chain (usually the last one) with the consequence to shift the burden of the supply chain inefficiency directly on the final consumers. Decisions affecting the time of distribution operations, in fact, are influenced not only by the attributes[22] of the same operations or by the variables generating and attracting freight demand, but also by the willingness of all actors to collaborate for finding the best distribution strategies.

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[21] In particular we refer to Prof. David Hensher and some of his colleagues.

[22] These attributes are, for example: journey time, shipment time, time variability load factor, pricing schemes.

It is for this reason that every congestion scheme (but in general every policy intervention) has to take in consideration the impact and the reaction that it will have on supply chain actors and their willingness to change distribution strategies. In this sense, there is a need to implement a model that identify the preferences of each actor to different pricing schemes and that reveal which are the incentives to give them for changing their strategies [27]. Such a model has the advantage to reveal the willingness to pay [27] of each agent for a congestion scheme, spreading in an efficient way its financial burden.

6.2.1A supply chain definition in the context of UFT

A definition of supply chain in the UFT context might be the following:

"a supply chain (SC)[23] *is a set of links that involve agents (shippers, transport operators, TPLP, etc.), elements (goods or vehicles), relations (for example, between the good transported and the technology of the vehicle use to transport the good) mechanisms (time and route of shipments)"* [31]

According to us it is very important to understand how it is structured the relation among the agent of a supply chain [24]. In particular one need to identify which are the distribution strategies followed and most of all, the role and the influence each member of the chain has on the others. This influence affects the distribution strategies much more than the simple ownership of the supply chain assets[24]. So there is a need to understand which are the attributes (whether characterizing the same operations or the actors themselves) that are the most important in choosing a distribution strategy and first of all a distribution network [27].

Among all the actors, probably, the most important are the retailers and the transport providers that give priority to different set of attributes. Finding a coordinated solution means to find the intersection between this two set of attributes.

6.3IACE methodology: assumptions and characteristics

The methodology suggested is based on the analysis of interactions between supply chain agents with the aim to find a cooperative equilibrium and, in particular, the specific probability that this equilibrium might happen and which incentives one has to give for the equilibrium to last. This methodology merge together consumption theory (*random utility theory*), and game theory (*sequential game*). Two are its most important assumptions:

1) Since there is interaction between people, especially in a network context, (neoclassical theory of) agents independent utility maximization is not anymore possible;

[23] From now on, we will use SC label for Supply Chain if not stated differently.
[24] This interaction effect is also called "neighbourhood effect". We will give a better definition of this effect in a subsequent paragraph.

2) Each agent has an attribute specific influence that is each agent in a relationship network can affect the choice of the others through the impact that he has on a specific attribute.

6.3.1Characteristics

This methodology is structured in a sequence of steps that start from the modelling of the relationships (links) within the supply chain and conclude with the search for the probability to reach coordinated solution such as alternative distribution strategies.

The first characteristic of this methodology is the aim to analyze the decision (choice) that each actor takes about the specific distribution network to which be linked. This choice is structured in three levels (each of them be a requirement for the other):

1) Choice of the relationship type (arm length, coordinated, integrated [24]) to establish with the others, choice that is influenced by the management systems applied[25] in the SC and by the role each agent has within it;
2) Choice of the relationship magnitude (low, medium, high);
3) Choice of distribution network [14] to which be linked.

This model can be thought as a three level (generalised) nested logit where the choice for the distribution network is the marginal choice and those for relationship magnitude and relationship type are the conditional ones (see figure 1).

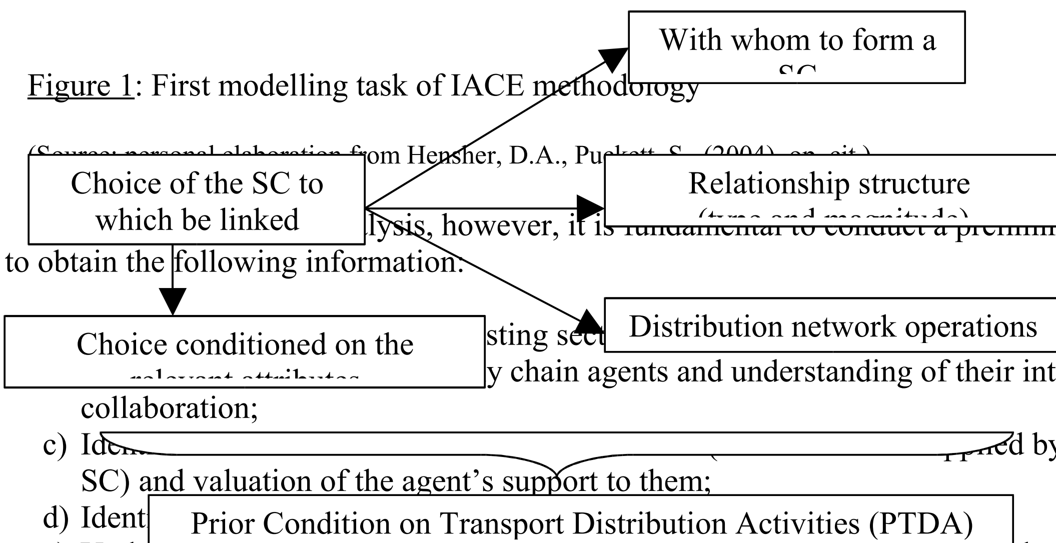

Figure 1: First modelling task of IACE methodology

(Source: personal elaboration from Hensher, D.A., Pu... op. cit.)

...lysis, however, it is ... ary one to obtain the following information:

... sting sect...

...y chain agents and understanding of their interest to collaboration;

c) Ide... ...d by the SC) and valuation of the agent's support to them;

d) Ident...

e) Understanding how to combine the alternative distributive network with the attributes identified.

The primary task of such a model is to understand which potential advantages the sector analyzed might have in changing its distribution strategies.

However given the complexity of modelling the formation of a supply chain and on the assumption (confirmed by in-depth interview [49]) that supply chain tend to stay intact

[25] Some examples are: autocratic, directional, collaborative, leaderless. See reference [31] for the whole classification.

[26] The variables to consider for identifying the most interesting sector are for example: sector market share within the city, typology of vehicle used by the sector in the distribution operations, types of distribution operations implemented (pick-up and delivery, one-stop delivery, etc). See reference [31].

once formed [24], the choice among alternative PCTDAs (Prior Condition on Transport Distribution Activities), can be treated as an exogenous factor that conditions the choices among strategies to respond to the implementation of a congestion charging scheme for agents within these (exogenously-determined) experimental distribution chains [27].

The second characteristics of this methodology is the realization of choice experiments that are focused on a first instance to reveal the support of each agent to different congestion schemes but with the final aim to determine the probability to reach a decisional equilibrium among them.

These exercises are performed in a (simulated) interaction context and linked each other with *forward-backward* mechanism.

In particular the difference between this kind of exercise and the traditional ones is the formal consideration of the presence of interaction among actors so the unit of analysis is not more a single individual but a couple of agents. The individuals that form a couple are linked each other by a specific relationship (analyzed in the first model) and it is assumed that the decisions (or choices) taken by one of them have influences (according to the specific relationship) on the decision of the other.

That is why this methodology is called [10] IACE (***I**nteractive **A**gents **C**hoice **E**xperiments*), because it takes into account the interaction process that happen during the choice exercises. The IACE methodology, however, not only takes in consideration the endogenous interactions (the ones coming from the other agents choices) but the external ones as well. In particular, as figure 2 shows, there are two kind of agent’s interaction:

a) influences of other agents in the SP;
b) influences of broader-based social reference agents[27].

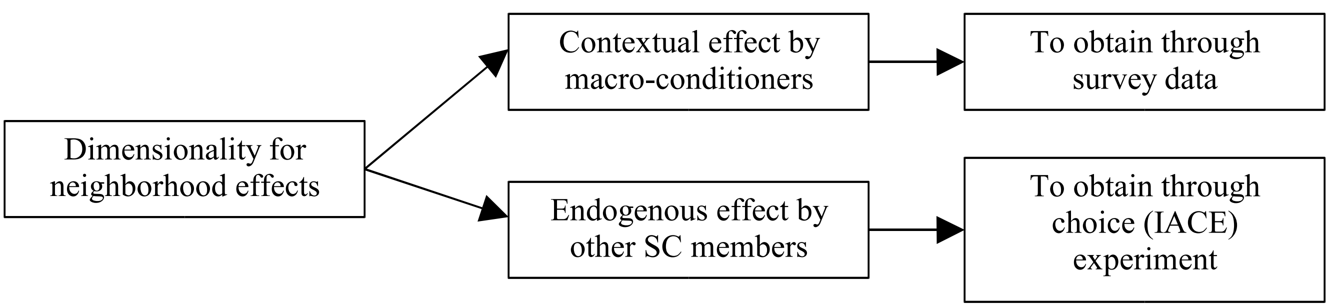

Figure 2: Dimensions of neighbourhood effect

(Source: personal elaboration from Hensher, D.A., Puckett, S., (2005/b), op. cit.)

Together these two influences constitute what is defined as the “neighbourhood effect” in the decision (or negotiation) chain that at least is the source of interactions between agents [28].

The concrete procedure of the IACE methodology is as follow:

- to each couple of agent are submitted a given number of choice exercises;

[27] These are agents that do not belong to the supply chain considered but since they might be in the same position in other supply chain, in the same market or industrial sector of the agent involved in the IACE experiment, they are considered by this agent as reference point.

- except for the first choice experiment involving the first agent (that however it is randomly selected), each agent answer to the exercises on the light[28] of the choice made by the other agent (or agents);
- by the fact that each agent know the choice of the other he may (or may not) adjust his choice to meet the choice of the other;
- this process is performed a several (fixed) number of time until an equilibrium (or a disequilibrium) is reached.

Analytically each agent behaviour q (with q = 1,…Q), or the choice that he makes C_i (with C= C_1…to C_Q), can be described by a joint distribution, conditional on the set of exogenous influences E_Q (a set of K attribute and J characteristics of agents), and on the set of cross-agent externality Z_Q . These last variables are the results of a complex formulation with additional parameters to recognise the elements of cross-agent influence that it is itself conditioned on the amount of information I_q , actual and accumulated during time, that agent q has about the other agents in the chain as well as more global externalities [27].

The two probabilities that this model try to find are the following:

$$\mathrm{Prob}(C_1,\dots,C_Q \mid E_1,\dots,E_Q, Z_1,\dots,Z_Q) = \prod_{q=1}^{Q} \Pr ob(C_q \mid E_q; Z_q) \tag{1}$$

$$Z_q = \mathrm{Prob}\,(C_{-q} \mid I_q) \tag{2}$$

While the first is easy to understand, the second need some explanation. Formally the second equation is called "information elaboration strategy" [27], because each choice C_{-q} of the agent –q is estimated on the base of the amount of information, I_q , that agent q has on him.

On the base of the two precedent equations it is possible to give a first specification of the utility form of an agent in the IACE context:

$$U_{iq} = \alpha_{iq} + \sum_k \beta_{ik} X_{ikq} + \sum_d \theta_d D_{dq} + \sum_g \gamma_g Z_{gq} + \sum_p \tau_p P_p + \omega_{-q} C_{-q} + \varepsilon_i \tag{3}$$

Where:
i..j…I = alternatives
q…Q = agents
X_{ikq} = ultimate attributes (alternative attributes) as evaluated by agent q
D_{dq} = deliberation attributes (agent characteristics) = role agent q play in the SC
Z_{gq} = set of effects representing the information agent q has on agent –q
P_p = set of contextual macro-conditioners effects
C_{-q} = choice made by the other agents
α_{iq} = ASC that is specified as a random parameter

[28] This process can be structured differently if one wants to divide the number of observations into two group giving information of the other agent choice only to the member of one of the group and not to the other. See references [10], and [30].

As this functional form shows, the IACE methodology considers as relevant attributes in the utility function of an agent not only the usual ones (alternative attributes and individual characteristics attributes) but most of all the interaction attributes that are here represented by: the choices of the other agent[29] (C_{-q}); the effects of external agents (P_p); and finally by the information agent q has on agent –q and/or acquire during the interaction process. After that one has to consider that the error term, ε_i , is correlated between agent utilities[30] so the variance-covariance matrix has the form shown in table 3.

Table 3: Variance-covariance matrix in the IACE methodology

	U_{A1}	U_{A2}	U_{A3}	U_{B1}	U_{B2}	U_{B3}
U_{A1}	Σ_{A1}					
U_{A2}	0	Σ_{A2}				
U_{A3}	0	0	Σ_{A3}			
U_{B1}	Σ_{A1B1}	Σ_{A2B1}	Σ_{A3B1}	Σ_{B1}		
U_{B2}	Σ_{A1B2}	Σ_{A2B2}	Σ_{A3B2}	0	Σ_{B2}	
U_{B3}	Σ_{A1B3}	Σ_{A2B3}	Σ_{A3B3}	0	0	Σ_{B3}

Notes: U_{Ai} is the utility of agent A in alternative i

(Sources: personal elaboration from Hensher, D.A., (2002), op. cit)

Other than the presence in the utility function of the other agent choice, what it is interesting in the IACE methodology is the presence of the information processing strategy. Simply stated this information strategy is nothing more than the attitude that every one follow when takes its own decision that is the consideration of the all available information that can help us to better understand the problem at hand. So the presence of this extra variable in the IACE methodology is justified by the fact that [28]:

a) it reflects the process associated with the negotiation process in real market;
b) it accommodates the information load introduced by the SP experiment[31].

An IPS[32] is then influenced by the kind of information sources one agent possesses. Essentially these can be reduced to only two (see figure 3):

- knowledge, that refer to the information an agent has on external factors (macro-conditioners effects);
- processing instructions, that refer to the information an agent acquire during the negotiation process and in practical, during the IACE experiment.

While the first kind of information sources are represented in the utility function form shown above, through the attribute P_p and they do not require further specification, the

[29] In the IACE methodology it is possible to reveal to one agent the choice of the others thanks to the recursive approach followed. In this methodology in fact, the SP exercise are structured in passes (steps) and rounds where each round represent the interview of each agent and each pass is the link between the rounds. For an in depth understanding see references [10] and [30]

[30] It is even possible that the error term is correlated between alternatives for the same agents as way to represent the condition that agent evaluate each alternative on the base of the same preferences and information.

[31] See note 21.

[32] From now on we'll refer to the information processing strategy with the label IPS.

last ones, represented above with the attribute Z_{gq}, need to be modelled through other specific attributes. This can be done following two different approaches:

1) The first approach is to assume that the IPS alternatives might be defined by the dimensionality of each choice task in the IACE experiments;
2) The second one is to specify directly the IPS alternatives through what might be defined the *processing rules attributes*. With this second approach the consequence is to perform a two stage estimation model (a nested logit model). In other words one has to condition the "interaction" choice (the IACE experiment) on the IPS choice (marginal choice).

Following the second approach one has to decide which are the relevant attributes (defined as the processing rules attributes) that form the IPS alternatives. Basically these might be:

a) The agent specific characteristics;
b) The number of attribute levels;
c) The distance of the attributes considered in the SP experiment to some reference attributes (considered important to the decision maker);
d) The number of attributes that can be packed together;
e) The total number of attributes.

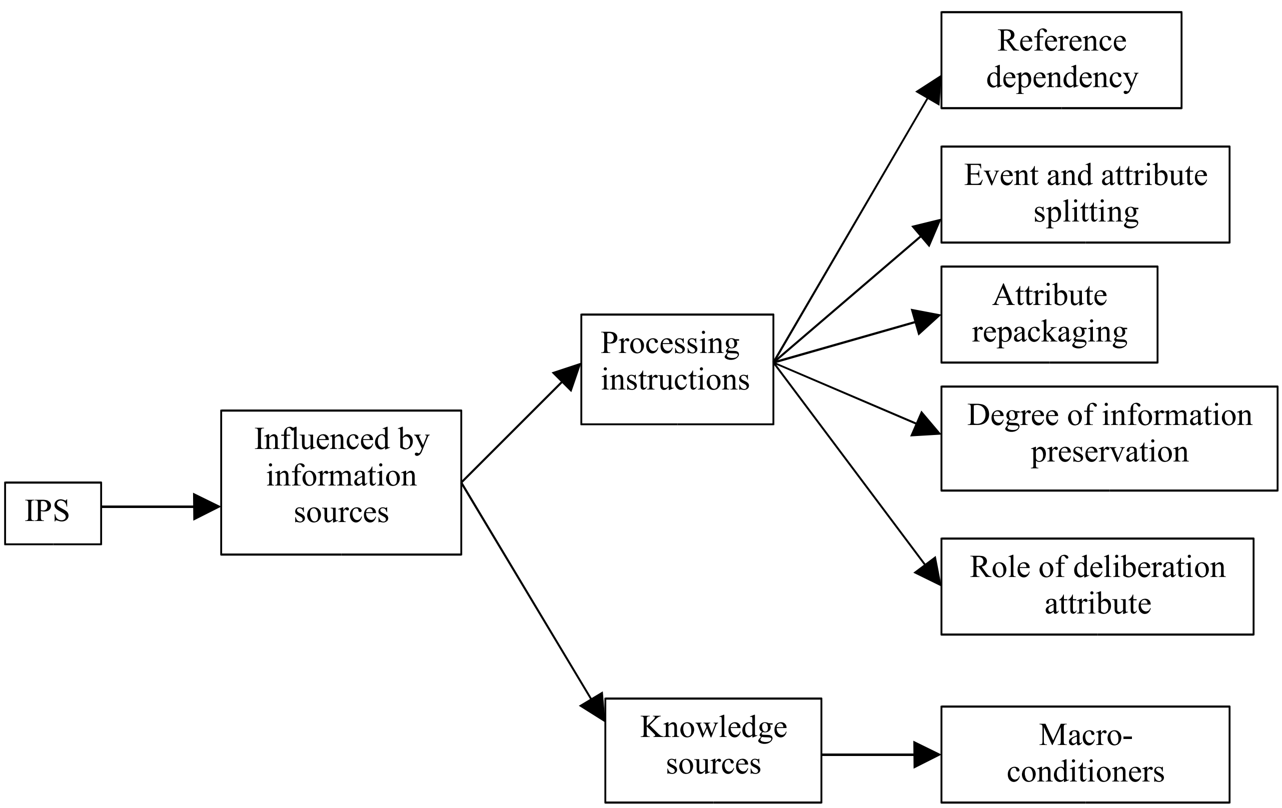

Figure 3: Sources and factors influencing agent processing strategy

(Source: personal elaboration from Hensher, D.A., Puckett, S., (2005/b), op. cit)

As said before the two-step estimation model concludes with the "interaction" choice (the IACE experiment) conditioned on the choice of IPS (marginal choice). Formally equation (3) became:

$$\left\langle U_{iq} \middle| B_{iq}; F_q \right\rangle = \alpha_i + \sum_{ALL\ K} \beta_{iq} X_{ikq} + \varepsilon_i \tag{4}$$

that is essentially a normal utility function (a function of alternative attributes), but it is conditioned:

- on beliefs (B_{iq}) that represent deliberation attributes (personal characteristics) and past information;
- and most of all on the information processing strategy (F_q) that represents how agent progress the information he obtains during the IACE experiment.

In conclusion the most important advantage that IACE methodology has is to reveal which are the barriers to reach a decisional equilibrium and to give a context (we can say a market) through which it can be performed.

7 Conclusion

Urban freight transport is of vital importance for the welfare of cities although it represents a very critical issue too due to its congestion and environmental impacts.

This paper has presented a literature review on the city logistics freight models. Even if there are different approaches and methodologies on the problem, each models has the same common objective, that is "the optimization of the transport and logistics activities within the city boundaries by private and public agents minimizing the external effects (environment, congestion, energy consumption) in a framework of market economy"[54].

However none of them take in consideration the behavioural dimension of the freight logistics task. In particular there is a need to study the interactions between all the agents along the supply chain. This need is justified by the fact that whatever the policy the public authorities want to implement, this policy has to gain the support of the agents directly involved in the urban freight logistics operations that are, at least, the most affected parties by the policy itself. According to us, the policy can be successful and reach its objective only if the policy it is accepted by the supply chain agents (the so-called "acceptability problem").

From an empirical point of view, such a need is reflected on the importance of modelling the behavioural dimension of urban freight logistics.

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