Urban freight transport initiatives – knowing when it is worth the cost

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Abstract

The process of urbanisation is on-going and a large proportion of the economic growth in the world takes place in urban areas. This results in an ever increasing demand for having goods delivered into the city centres, which causes congestion and harmful emissions. Several different kinds of city logistics initiatives have been suggested as part of the solution to this problem. This paper argues that cost-benefit analysis should be used in order to determine when the benefits of introducing different city logistics schemes outweigh the costs and to determine which solution is appropriate in a specific case. The paper also discusses the type of costs and benefits that are likely to arise under different schemes and highlight some areas in which special care must be taken in the analysis.

Keywords: city logistics, urban freight, cost-benefit analysis.

1 Introduction

For the last few decades, the transport sector is the only sector that has shown an appreciable increase in total CO_2 emissions in developed countries, as well as in the rest of the world. Besides contributing to global warming, increased transport volumes have also led to numerous other environmental problems including congestion. During last century total fossil carbon emissions increased fifteen times. In, for example, the USA the transport sector is responsible for around 25% of the CO_2 emissions. Globally, transport sector emissions are generally in the range of 25–30% of total emissions [1, 2].

The record high rate of economic growth during the last century in the now rich countries has been accompanied by other long-term developments of great

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importance, including far-reaching structural change of the economy, which in turn is interdependent with urbanization. The change in spatial structure is a key factor for the long-term development of fossil fuel demand and climate policy.

According to UN population statistics, half the population of the world now lives in urban areas. This concentration is of importance for energy use in all sectors of the economy. In terms of research effort, passenger transport has been much more in focus when it comes to the discussion of solutions to the environmental problems of urban areas than freight transport. The question of urban freight has however been increasingly in focus. (e.g. Taniguchi *et al*. [3], Taniguchi and Thompson [4], Allen and Browne [5], OECD [6]). The establishment of consolidation centres and the coordination of freight transport in urban areas have gained a lot of attention in the last fifteen years and such measures has often come to define the term city logistics. Although it is apparent that such initiatives has the potential to reduce negative externalities such as emissions, noise and congestion and contribute to an improved physical environment they are not without costs. In many cases they require investments in new infrastructure and the financial costs of the individual transportation companies and/or the firms receiving the shipments might increase. It is therefore of the outmost importance to be able to evaluate under which circumstances the gains outweigh the costs.

In appraisal of infrastructure investments, evaluation of public transport policies and in environmental economics the most common way of doing that is to use Cost-Benefit Analysis (CBA) [18]. Despite its popularity in the analysis of other transport policy initiatives the use has been limited when it comes to city logistics initiatives. Pearce *et al*. [18] lists several reasons for using CBA in evaluating the appropriateness of different projects and policy changes. (1) CBA provides a framework for rational decision-making. Decision-makers using CBA will have to consider who benefits and who lose if a policy is implemented and have to consider different aspects of a problem, i.e. avoiding lexicographic decision-making in which a single goal dominates another. (2) CBA points out that any suggested policy or project is just one of many possible options. (3) It is possible to use CBA to arrive to a decision on the optimal scale of the initiatives taken in order to solve a problem and it is possible to arrive in the conclusion that doing nothing is actually the best approach. (4) Properly executed, a CBA will show how different (social) groups in society are affected by a policy or project. (5) The fact that different effects occur at different points in time is taken into account. (6) CBA is democratic in the sense that it is the preferences of the individuals in the society that determines if a project is to be seen as good or not as opposed to politicians, pressure groups or experts.

This paper will therefore discuss the application of cost-benefit analysis (CBA) to the evaluation of city logistics initiatives. The purpose of this is twofold: (1) to identify and describe the potential costs and benefits of the most commonly discussed and implemented city logistics initiatives and (2) provide a discussion on the problems of evaluating different effects that are specific to the appraisal of city logistics schemes.

2 Characteristics of city logistics

Transport demand is usually referred to as a derived demand, i.e. the consumption of transport services does not in itself generate any utility but is necessary in order to make some other kind of consumption possible. This is especially true when it comes to freight transportation; no one derives utility from goods being transported in itself but is necessary in order to make consumption possible. Therefore freight transport can be seen as part of the production process, and as an important input whose demand is determined by the demand for the final products (e.g. Button and Pearman [7]).

The term logistics is usually referring to something broader than just the transportation of gods, in its widest definition it includes the management of the entire supply chain, linking and coordinating the activities within a company and between companies engaged in the production of some good or service. A commonly used definition of City Logistics is provided by Taniguchi *et al*. [3], stating that it is:

"the process for totally optimising the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy" (Taniguchi *et al*. [3]).

The discussion on definitions serves to illustrate two points; (1) logistics is a broader concept than transportation and (2) that, by including environmental issues, city logistics goes beyond the internal considerations of the firm.

In order to be able to properly evaluate measures taken in order to improve urban freight transport it is necessary to identify who the relevant affected parties are. One way of categorizing the relevant parties is to divide them into the groups traditionally used in economic theory, i.e. consumers, producers, government and rest of society. In this context, consumers are those who consume City Logistics services, i.e. spend resources in order to have goods delivered in an urban area. Producers are those who deliver the goods, including those who performs the transport but also the producer of the goods as they are involved in making the decisions on how the goods are to be delivered and/or are affected by such decisions. It should be noted that this division is made for analytical purposes but the consumer and the producer might be part of the same organisation (firm) but the different functions still exist within the organisation and can therefore be analysed as separate entities. Government, or in this context, local government is usually responsible for city planning and local traffic regulations which obviously affect the context in which the logistics activities are to take place. In addition to this, local government is also responsible for providing a pleasant (or at least tolerable) city environment for the inhabitants and those visiting from outside. In this capacity local government often play an important role in coordinating, regulating and/or subsidizing different kinds of initiatives in order to reduce the environmental impact of urban freight transport. The rest of society should be included in the analysis since the

decisions made by the aforementioned actors affect their welfare due to the effects on the city environment.

2.1 Efficiency in city logistics

What constitutes an efficient logistics system if we assume that the demand for freight transport (in terms of volume) is determined by external (to the transport system) factors, i.e. demand is derived from overall consumption? An efficient transport system is one in which total costs, at a given volume, are minimized [8]. Total costs (TC) can be written as:

TC = Consumer Costs (CC) + Producer costs (PC) + External Costs (EC)

In the present context the consumer is the one having goods delivered to a location within a city. Consumer costs consist mainly of costs for keeping inventory (including capital costs) and personnel costs for receiving and handling goods. For the producer, the costs consists of personnel costs (drivers, and costs for handling goods), fuel costs and capital costs (including the cost for using trucks and warehouses) It is important to note that the monetary price paid for the transport is not to be considered a real cost, it is merely a transfer of funds from the consumer to the producer.

External costs are costs affecting others than those involved in the transaction [9, 10]. The external costs arising from urban freight are environmental costs of different kinds. Trucks making deliveries in urban areas contribute to congestion when they drive as well as when unloading, especially in areas in which streets are narrow. The trucks also occupy space that otherwise could be used as parking space, increasing the cost of parking as well as increasing the time it takes to find a parking space. The emissions from the trucks are an important source of pollution in urban areas, and additionally, trucks making deliveries and operating on the streets in a city are perceived as a major threat to the wellbeing of its citizens. People like to walk the streets and enjoy outdoor seating at restaurants without being disturbed by noise or having to worry about themselves or their family members being hit by a truck.

3 City logistics initiatives – their benefits and costs

Many initiatives have been taken in order to reduce the negative impacts of urban freight transport and to increase its efficiency. (For overviews see e.g. Benjelloun *et al*. [11], Allen and Browne [5] and Russo and Comi [12]).

One important category of initiatives is coordination/consolidation centres. They are terminals, in or outside an urban area, in which transhipment of goods from different shippers take place. The shipments from the centre are then coordinated in order to reduce (or minimize) environmental impact. The centres can be operated by an independent actor (e.g. the local government) or by one or several of the shippers in cooperation. There are several examples in Europe of such centres being initiated for operation during trial periods, most of which

have then been shut down after the trial period. These centres have most commonly been initiated by local governments, by themselves or in cooperation with researchers [5].

The main source of benefits of such schemes is the reduction in negative externalities. By coordinating deliveries and thereby reducing the ton-km, emissions, congestion, accidents and disturbances are all reduced. Coordination usually also results in higher efficiency in terms of load factors which in combination with reduced number of kilometres also give reductions to producer costs.

On the other hand, these schemes also have downsides. They are associated with costs from running the centre itself and, depending on the availability of suitable facilities, might require investments in buildings and equipment. Such increases in producer costs are also accompanied by increases in transhipment costs. There might also be increased costs for keeping larger inventories for the producer as well as the consumer. The reason for the (potential) need of keeping higher inventory is that deliveries might occur less frequently, this could also cause increased costs for taking care of the goods upon delivery for the consumer if deliveries have to be made at odd hours. It, however important to point out that it is unlikely that all of these costs occur in every case which makes it important to investigate the effects of each proposed scheme separately.

Another type of initiative that has been taken is to introduce different kinds of environmental zones. This could be regulation of the type of vehicles that are allowed to make deliveries in the urban area (type I). Several possibilities exist as to the type of regulation; it could be regulation of maximum size of the vehicles (length, with, weight), maximum emission levels or regulation of the fuel types on which the vehicles are allowed to run.

The benefits in these cases consist of reduced emissions and possibly of reduced perceived disturbances if smaller vehicles are used. Reducing the choices available to producers is bound to increase their costs. Capital costs increase if they have to choose other vehicles than they would have without the regulation and if required to use smaller vehicles the costs for drivers will increase. It might also be the case that a larger number of smaller vehicles (or the same number operating for longer time periods) will increase the number of accidents in comparison to fewer runs mad by larger trucks.

Environmental zones could also be constructed so that deliveries are allowed only during specific time windows (type II). If the windows are placed during off peak periods, such regulation will clearly result in reduced congestion. This is the primary benefit of such scheme.

This again reduces the flexibility of the system; producers might need to use more trucks in order to be able to deliver the same amount of goods in shorter time (load factors are reduced). This increases producer costs both in terms of capital costs and in terms of wages for more drivers. At the same time, consumers (the recipients of goods) might experience increased cost for personnel if they have to receive goods at odd hours. This is especially important if personnel are needed in connection to night deliveries. Delivering goods at night or in the evenings is generally a good idea in terms of congestion but in

addition to increasing labour costs it might cause increased disturbances due to noise.

Another way of reducing the negative impacts of urban freight transport is by introducing congestion charges and fees for driving and making deliveries in urban areas. Optimally, such fees should be equal to the marginal external cost caused by the delivery. Such fee should probably consist of at least two parts;(1) a fee per km driven in the urban area (should most likely vary by type of vehicle) covering the environmental cost of the emissions and noise and the costs of the additional congestion caused by the vehicle and (2) a fee per minute unloading reflecting the cost of taking up space, causing discomfort for pedestrians and residents, and making noise. There is a large literature on pricing external costs in other contexts (e.g. traffic in general) but it is very seldom mentioned in connection to city logistics. If the correct structure and level of the fee can be found it is an efficient solution since it can be shown to actually achieve the goal of minimizing the total costs of the transport system.

The downside is that the optimal fee might be hard to find but significant improvements could probably be achieved by implementing some kind of (non-optimal) fee. As seen in the general cases of congestion charges it is also common to see heavy political opposition to introducing charges on externalities.

Tables 1 and 2 provide an overview of the potential benefits and costs of different urban freight initiatives.

4 Applying CBA in the evaluation of city logistics initiatives

CBA has been around for a long time, primarily being used for appraisal of infrastructure investments where its origins can be traced back to 19th century France [13, 14]. The theoretical foundations of modern CBA is often said to be found in Pigou [15] which can be seen as an important part of the origins of economic theory of welfare.

The purpose of CBA is to provide a systematic tool that can be used in order to determine if a policy change (project) is good. It is a method that tries to evaluate projects (could be any kind of change) in terms of changes in human wellbeing. A project is considered to be a good project (in terms of the analysis) if the change in social benefits due to the project exceeds the costs associated with the project. Benefits are defined in terms of willingness to pay or willingness to accept compensation. The former is the sum of what the individuals making up the relevant society are willing to pay in order to have the change in question (or pay to avoid a change if the benefits are negative) while the latter is what individuals would require in order to forego a change (or demand in compensation if the benefits are negative) [16–18].

The change in welfare (W) from a project (policy change) can be expressed as the sum of changes in consumer surplus (CS), producer surplus (PS), government budget (B), and external effects (EE) so that:

$$\Delta W = \Delta CS + \Delta PS + \Delta B + \Delta EE$$

Table 1: Overview of possible benefits and costs to consumers and producers as result of different urban freight transport schemes.

Scheme	Consumer Benefits and Costs	Producer Benefits and costs
Coordination Centres	- Increased Inventory costs	+ Increased load factors + Reduced fuel consumption - Transshipment costs increase - Increased capital costs - Increased Inventory costs
Environmental Zones type I Regulation of Vehicle type		- Increased capital costs - Increased labour costs
Environmental Zones type II Regulation of time windows for deliveries	- Increased labour costs	- Increased capital costs - Increased labour costs
Fees/Taxation Congestion charges unloading fees		

Consumer surplus is basically the difference between the value a consumer of a good or service puts on consuming it and the price she actually pays for it. In terms of table 1, from the perspective of the consumer, introducing coordination centres or time windows lower the value of the delivery (or increases the price if the labour cost for accepting goods is seen as part of the price).

Producer surplus is the difference between what the producer gets paid for a good or service and the cost of producing it. In table 2, several factors increasing the costs for the producers, i.e. those delivering the goods, are listed as well as some potential cost reducers. One of the most challenging things to determine in the case of urban freight initiatives is their effects on the supply chain at large. Introducing a coordination centre in a city where several firms previously delivered on their own is bound to have an effect on their entire supply chain. It could be that they already are reloading the goods in a city terminal of their own

Table 2: Overview of possible external effects resulting from different urban freight transport schemes.

Scheme	External effects
Coordination Centres	+ Reduced emissions + Reduced noise + Reduction in accidents
Environmental Zones type I Regulation of Vehicle type	+ Reduced emissions + Reduced noise ? Accidents
Environmental Zones type II Regulation of time windows for deliveries	+ Reduced congestion - Increased disturbances
Fees/Taxation Congestion charges unloading fees	+ Reduced emissions + Reduced noise + Reduction in accidents

in which case a coordination effort might reduce costs. If, however, they have terminals on other places, perhaps at the regional or national level and are delivering directly into the city, introducing a new level at which reloading occur is bound to increase producer costs.

Changes in government net revenue is included since reductions in their revenues means that they has to spend less on something else or increase taxes, both of which reduces welfare (the opposite applies if revenues increase). The major revenue increases that might occur are if taxes or fees are introduced. In the case of urban consolidation centres, they have often been subsidized by government and in many cases the local government has provided the terminal at which the coordination takes place, and in some cases been in charge of its operations. In such cases government spending clearly increase.

External effects are mainly the value of the reductions in emissions and in noise but it could also be such things as a sense of security and a feeling that the city environment is pleasant. Such subtle matters are obviously hard to put a value on (and quantify) but should in principle be included in the evaluation.

4.1 The steps included in a CBA

The steps involved in making a CBA can be described as [16, 18]:

1) Define the objective of the project and define the relevant alternatives.in order to be able to evaluate a project or a policy it is of the outmost importance to

clearly define the objectives. From those objectives one should then identify alternative ways of obtaining the objective. It is also necessary to acknowledge that no project or policy change takes place in a vacuum, i.e. there are always alternative courses of action, one of them being to do nothing which is also a choice. A project should therefore be evaluated in comparison to some alternative cause of action. Although not necessary, it has become common practice to use the alternative of doing nothing (change nothing) as a basis of comparison. However, doing nothing does not imply that nothing changes, the society is a dynamic entity under constant change and therefor effort should be taken in order to identify what would happened if no policy change was introduced.

In the case of urban freight transport initiatives, the objective is often to reduce the environmental impact of deliveries in urban areas and the alternatives could comprise those listed in table 1 (or combinations of them).

2) In the second stage, benefits and costs occurring if different projects (or policies) are chosen has to be identified. For applications to city logistics, this basically coincides with what is done in section 3 of this paper.

3) Once the benefits and cost have been identified, they have to be quantified (measured). In the present case, this translates into making forecasts of requirements on inventory size, warehouse space, number and type of vehicles and different kinds of labour in the alternative causes of action (including if no new policy is introduced). It is also necessary to calculate emissions and noise (if possible) under different alternatives.

4) The quantities identified in the previous step have to be expressed in a common unit of account if they are to be compared. In CBA the unit of account used is money i.e. you have assign a monetary value to the physical quantities. When markets exist for a resource, the market price can be used as a measure of its value. (Unless there are external effects not included in the price associated with its use). If the labour market is functioning the market wage can for instance be used in evaluating the social cost of using labour. (It reflects the value of the best alternative way to use the resource) [16, 17].

For resources without functioning markets other solutions has to be found. There are several ways to evaluate non-market traded goods, in some cases property prices might be used in order to compare the values of properties that are alike in all other aspects than the noise level. There are several other methods available such as Contingent Valuation Method (CVM) but it goes beyond the scope of this paper to elaborate further on this topic. (See Layard and Glaister, [19] or Zerbe and Dively [16] for more information and further references) For practical applications there are many countries and regions, including USA, UK, Sweden and the European Union and has developed guidelines providing standardized values that can be used in many cases.

5) The different costs and benefits identified and calculated to occur at different points in time during the lifespan of the project has to be converted into measures comparable at a single point in time, usually today. Future costs and

benefits are therefore discounted using a proper discount factor reflecting individuals' preferences for consumption today to consumption in the future.

After having gone through these steps the project is considered good if the net present value (NPV), i.e. the present value of the benefits minus the present value of the costs, exceed 0. If several projects (besides the doing noting alternative) are considered one should choose the one with the highest NPV and if several non-exclusive projects are considered one should choose the combination of projects that maximizes NPV. (If several projects are implemented it is important to remember to also evaluate if the effects differ when projects are combined)

5 Concluding discussion

In this paper it is argued that when evaluating city logistics initiatives, proposed or already in use Cost Benefit Analysis (CBA) should play an important role. Even though it is clear that environmental gains can be achieved by the schemes discussed in the literature it is not clear that they should always be implemented. There could be instances where the costs of implementing such schemes (e.g. consolidation/coordination centres) could outweigh the benefits. An especially important issue that has to be taken into consideration is the effects a policy/measure has on the entire supply chain. If a coordination centre means that another level of terminals must be added the environmental gains must be substantial in order to make up for it. It is reasonable to assume that in small towns with little congestion it is less likely that this is the case.

The use of time windows for deliveries are the measure that appears to have the least chance of being sociable profitable. Such measure can reduce congestion but deliveries must still be made so the reduction in emissions might not be that high, it is even possible that it increases if a tight window forces the deliveries to be made by using more trucks.

There is need for more research on the use of fees and taxes in order to give the firms incentives for improving city logistics without other regulations being imposed. There is a large body of evidence of the appropriateness of congestion charges and it is therefore likely that such schemes are an efficient way of reducing the negative impacts of urban freight transportation.

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