Logist. Res. (2013) 6:57–62
DOI 10.1007/s12159-013-0101-9

ORIGINAL PAPER

Global urbanization: a major challenge for logistics

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Received: 3 September 2012 / Accepted: 4 February 2013 / Published online: 19 February 2013

Abstract By 2050, 70 % of the world's population, that is, about 6.3 billion people, will live in the world's major urban areas. At the forefront of the urbanization trend, we see the development of so-called "megacities" which, by definition, have a population exceeding 10 million inhabitants. Traffic congestion is frequently reported to be a megacity's most pressing infrastructural problem, even outranking issues related to power and water supply as well as health and safety. Freight traffic is one of the drivers of the infrastructure overload, and at the same time, it is one of its victims. The costs incurred as a result of traffic jams are higher in the congestion of major cities than anywhere else. On the other hand, cities in their most basic state do not have comprehensive logistics systems. The question addressed in this article is whether the concept of "city logistics," which has experienced its first major boom in Germany and some of its neighboring countries, during the mid 1990s, can help to ease this problem—especially if—in contrast to the pilot projects of the 1990s—external effects (reduced pollution, improved mobility, etc.) and opportunity costs (the equivalent of time lost by a large number of people and vehicles trapped in congested roads every day) were included in the list of arguments.

Keywords Global urbanization · Intra-urban freight traffic · City logistics · External effects · Urban retail · Cooperation

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1 The point of departure

By 2050, 70 % of the world's population, that is, about 6.3 billion people, will live in the world's major urban areas. "The fate of our climate will be shaped by the world's cities," the CEO of Siemens AG said in November 2009. While our cities cover no more than one percent of the earth's total surface, they consume 75 % of the total amount of energy used and are responsible for approximately 80 % of all greenhouse gases. For their inhabitants, the main issue is not the rather abstract danger of global warming. In fact, their health is immediately threatened by the polluted air, which intrudes daily into their lungs. Harford [1] reports that "Around seven thousand people a year die prematurely because of traffic pollution in Britain," and he asserts that the figures in the USA look similar.

At the forefront of the urbanization trend, we see the development of so-called "megacities" which, by definition, have a population exceeding 10 million inhabitants [2, 3]. Between the years 2000 and 2012, Shanghai has grown from 12.6 to 21.4 million inhabitants. Lagos has doubled within only a decade, and according to estimates of the region's governor, about two thirds of the overall area are thought to be slums or shanty towns [4]. While there were only five such megacities in 1975, their number is projected to rise to an estimated total of 26 by 2015, 22 of which will be located in developing countries. Moreover, there are numerous other major cities and cities with a population of more than one million that are rapidly approaching the "eight-digit" threshold. In addition, there are areas known as mega-urban regions, that is, agglomerations made up of closely interlinked medium- and large-sized cities that tend to grow more intertwined, such as the Rhine-Ruhr Metropolitan Region, which is home to 11.9 billion people.

Traffic congestion is frequently reported to be a megacity's most pressing infrastructural problem, even outranking issues related to power and water supply as well as health and safety. This is mainly due to a sharp increase in private car ownership which can be observed in these types of cities. While in Jakarta, the capital of Indonesia, there were three million cars on the road 10 years ago, the total number of cars there now has been increased to ten million. In a desperate attempt to uphold mobility, the city of Beijing introduced a new car registration lottery in January 2011, requiring those who plan to purchase a new car to participate in a raffle for a strictly restricted number of new licenses. Similar developments cannot be excluded in the field of freight traffic.

Freight traffic is one of the drivers of the infrastructure overload, and at the same time, it is one of its victims. The costs incurred as a result of traffic jams are higher in the congestion of major cities than anywhere else. On the other hand, cities in their most basic state do not have comprehensive logistics systems. Especially freight traffic is more the result of uncoordinated, individual, case-by-case decisions made by fleet operators. It is obvious that the goal of supplying the city center with a minimum number of vehicles cannot be met under these conditions. The question addressed in the following chapters is whether the concept of "city logistics," which has experienced its first major boom in Germany and some of its neighboring countries during the mid 1990s, can help to ease this problem. According to observations by Allen and Browne [5]: "Surprisingly little attention has been paid to urban freight by researchers and policy makers until relatively recently." From the author's point of view, this issue will inevitably come back as an item on the international agenda.

2 The history and the logic of city logistics

The term "city logistics" refers to the cross-network and cross-company bundling and restructuring of freight traffic in major cities (for a more detailed description of this concept as it was discussed in the 1990s see [6]). More specifically, this means initiating a more compact, cooperation-based scheme to supply the recipients of goods (in particular retailers) in the inner cities. The shipment of goods which were purchased from sources based in different locations is organized in such a way that the "last mile" of transport is effected in the form of a shared service departing from a shared gateway (the city terminal) located on the outskirts of the city (historically speaking, cooperation was the first—though of course not the only—possible approach for creating an institutionalized scheme that allows for a non-redundant supply structure). Independent of the chosen organizational structure, a distinction must be made between two different (although not mutually exclusive) consolidation effects:

1. The term "consolidation of routes" is used to describe an increase in the number of stops along one delivery route while at the same time reducing the distance/time between individual stops (tour density).
2. The term "consolidation of shipments" refers to an increase in the number of shipments delivered per recipient.

In addition to a reduction in the number of stops, a consolidation of shipments helps to reduce the unloading time required per shipment. As a result, the vehicle's cycle time can be enhanced and additional capacities are freed up. Nevertheless, the first effect is more important as it can be generated systematically and is not so much driven by accident.

The focus of city logistics lies on the delivery of shipments brought into the city from other regions by freight carriers and parcel services for the purpose of distribution (the integration of the dedicated supply tours of large retail chains replenishing the shelves of their outlets is difficult). It is important to distinguish this type of transport activity from other types of traffic such as originating traffic, thru traffic, and intra-urban traffic, because the latter offer hardly any starting for an efficient consolidation of shipments.

The main problem of city logistics (and the main reason for it's failure in the 1990s) is the necessity to gather the shipments from the terminals of the different network providers in order to plan deconcentrated and efficiently structured tours that do not overlap and that ideally can even be limited to single neighborhoods or single streets. As Fig. 1 shows, the price to be paid for the consolidation of deliveries implicates an additional transport and goods handling operation, a loss of time on a "critical path," an additional scheduling level and—depending on the arrangement in place—an increase in transaction costs. (The simple model outlined in Fig. 1 assumes that shipments destined for the city area are consolidated when two carriers pass on such shipments to a third carrier for local distribution to be effected via a further (inner city) leg of transport. The figure is taken from [7]). These additional costs were underestimated during the first implementation period and lead to a negative overall balance.

Another problem that would have to be solved shows up when looking at the dual usage of the deployed trucks. Providers of open transportation networks often use the trucks for picking up goods in a milk run tour after they have finished their distribution work in the early afternoon. Although such cases tend to be comparatively rare in the centers of major cities, some of the transport orders placed

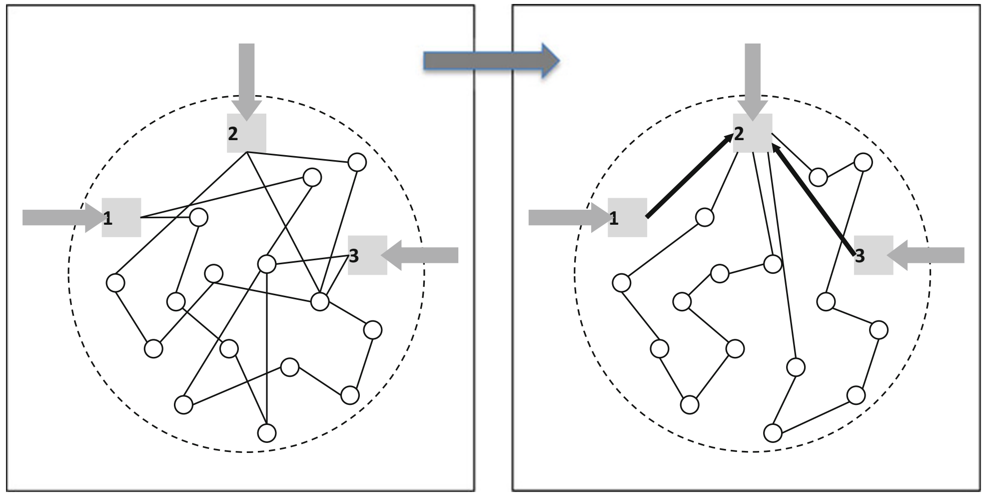

Fig. 1 Basis effects of a city-logistic model

may involve pick ups of several smaller package freight shipments consisting of only a few parcels or pallets each. While it is technically possible to realize cross-carrier pickup tours in the form of consolidated milk runs, the collected shipments would then need to be distributed to the shipment terminals of the forwarders that are in charge of processing the corresponding orders. This not only requires a second, distribution-related milk run, but also leads to laborious reloading and rearrangement operations, because the shipments picked up were not loaded according to the "Last-In-First-Out" principle required for distribution. The question, whether this could be a scenario in which a city logistics service provider might generate similar benefits, can only be answered with reference to concrete data. In any case, collection time is more critical than distribution time because within the usual cycle times outgoing line hauls cannot wait (for a further explanation see [8]). But once the capacities have been shifted to them, there will be no economical alternative.

3 Chances for a reactivation of a formerly stranded concept

One of the reasons why the effects of a consolidation of routes and shipments mentioned above turned out to be not strong enough to outweigh the additional consolidation costs was a lack of critical mass. Behind this was a vicious circle. To many of the partners who should have participated anticipated the negative bottom line, and their disengagement caused the effects they worried about. Moreover, in many cases, the selected cities simply turned out to be too small in order to create well-balanced effects. The best way to explain this is a practical example.

Klein-Vielhauer [9] reports that a cooperation among six forwarders in 1999 successfully reduced the vehicle kilometers traveled in the city center of Regensburg, Germany, by 68 % (presumably, though said figure does not include the pre-carriage runs required). When examining the absolute values, however, this reduction seems considerably less impressive: In fact, no more than 15 vehicle kilometers per day could thus be saved. It is not surprising that a calculation offsetting the 2.5 vehicle kilometers saved per partner against the additional pre-carriage and handling costs did not lead to enthusiasm among the partners. Conversely, this result leads to the insight that city logistics is a concept which is only applicable to sufficiently large cities.

Larger cities can deliver one more reason that can make the concept under discussion profitable. If the line hauls of the network providers' end in a terminal within the respective city, redirecting this transport to a city terminal would not cause additional costs (in comparison with just unloading a smaller part load). In principle, then there would be no need to consolidate shipments by connecting different terminals (nodes of private networks). The shipments would arrive where they are needed. Especially in megacities with an overburdened traffic infrastructure, this elimination of advance work could become the all-important quantum leap required when even pre-carriage vehicles get stuck in traffic, using up time that is then no longer available for the actual delivery.

In practice, however, depending on the size of the city in question, a new optimization problem can arise.

1. In order to avoid cost- and time-consuming pre-carriage operations and handling services, the number of city terminals should be kept as low as possible.

2. On the other hand, depending on the place of origin too strict a limitation of venues can lead to very long line haul tours through or around the city, so that a balancing problem concerning the optimal number and geographic allocation of city terminals will likely occur.

Two conceivable order criteria to solve this problem shall be briefly mentioned here. The first solution is based on the *position of the source regions* and consequently on a preferably quick and simple access of inbound long-distance vehicles to "their" city terminal. Travelers are familiar with it from accordingly scattered terminus stations in big cities such as Paris (Gare du Nord, Gare de l'Est….). Without further operations, the result would be overlapping tours again. Conversely, in order to avoid this, pre-carriage operations are needed by which the receiving terminals supply each other with the consignments destined for their respective distribution zones.

The second solution is *destination area-oriented* and divides the city into zones and/or quarters which are each assigned their own city terminal. In accordance with the "nature" of the idea, delivery tours are being fully straightened out and consolidated during the last mile without any preliminary operation. But the possibility of a direct connection of each individual terminal to inbound regular service from the source regions may be problematic here due to the partitioning of volume disposable to fill the line hauls.

From the viewpoint of the city, this can be regarded as a problem which can be left to the affected network providers. When looking at the consequential costs of congested roads in cities, the idea of an optimum that fits to the needs of all affected parties is unfeasible. Instead, one should try everything to mitigate the bottleneck that hurts the most. This way of thinking will be additionally supported once "external effects" like green house gas emissions or health risks of residents are taken into consideration. Although they might depend on their willingness to cooperate, when push comes to shove the mayors of large cities will not foster network configurations which serve the needs of private network providers at the expense of the needs of the city. This argument can be generalized. Considering the particularly high opportunity cost of an unbundled city supply, stricter political intervention is more conceivable and consequently more probable. Expressed in terms of the transaction cost theory, it could be said that city logistics is going to be a matter of reshaping the relationship between market and hierarchy. (A detailed description of transaction cost theory can be found in [10]).

In any case, it will be up to the city's administration to find an institutional arrangement which is acceptable to the involved parties. Outsourcing the distribution of goods in the city leads to an adaptation of transfer pricing schemes and creates additional control costs. Moreover, the nature of the concept might help the city logistics operator, who acts as a contractor, to gain a monopoly-like position, even if he outrivaled his competitors in a public tender. While local monopolies would create the best possible consolidation effects, we know that they are vulnerable to inefficiency, red tape as well as the opportunistic pursuit of self-interests, and in some regions of the world, they are probably also prone to corruption. However, such problems can be mitigated by developing an appropriate institutional structure. An example may be a joint venture comprising the affected network providers and giving them the opportunity to supervise the service they have given off.

An additional chance for the reactivation of city logistics may be the offering of value-added services. As a basis for the development of such services, the city terminal should be positioned as a decoupling point in the supply chain separating inbound good flows and local distribution by buffers. Urban retail could be supplied in a quicker, more flexible fashion using these stocks via supply requests at short notice. Small retailers could use the buffer stocks stored in city terminals in order to bring their wares into the city in ideally sized batches, thereby saving transportation costs and getting access to higher rebates. On that basis, retailers could even turn storage rooms into sales rooms, allowing them to then offer a broader range of goods.

In these cases, from a systematic point of view, a shift takes place in the city terminal from a push principle toward a pull principle. To the extent that the proximity of the stocks allows the receiving traders to postpone the date of delivery by 1 day, should the need arise, and/or to accept a slightly longer lead time in their supply call-offs, the leeway thus created could be used in tour planning for even better, more balanced vehicle utilization, that is, distribution could be carried out using even fewer vehicles. Further added value might be generated by the support of self-collectors. General acceptance of such leeway could be promoted with the help of price incentive systems.

This entire concept would be made easier by purchasing goods on grounds of a "free city terminal" condition, as that would separate the shippers from the local delivery process and the last mile would no longer be part of their delivery service. (Of course, shippers would have to be so fair as to eliminate the costs saved in local delivery from their former "free home delivery" condition, so that the recipients of the goods can actually pay for the city logistics, now controlled by them). It would also relieve network operators of the problem of having to board the same boat as their competitors during that critical last mile. However, they could no longer use city logistics in advertisement as their own contribution to sustainability. Such a condition can only be enforced by local retailers, which would be able to have a say in delivery timing with such freight terms. If that works out, and local receivers of goods become clients of city logistics, other value-added services can be considered, for example, in the areas of returns and disposal logistics.

For the sake of completeness, it has to be mentioned that this service will not be attractive for large retail chains who have already integrated it, and that there may be wholesalers in place with similar offerings based on a control of the ownership of the goods in demand.

4 Potential for cooperation in the parcel segment

Despite its market share in intra-urban traffic, the parcel segment was excluded entirely from the pilot projects carried out in the 1990s (cf. [11]. The main reason for this exclusion was the heterogeneity of shipments (in comparison with the groupage sector) which has lead to the application of entirely different transportation and handling technologies. Despite such sophisticated, individual systems, one must not jump to the conclusion that there is no potential for city logistics *within the parcel segment*. However, technology may even turn out to be a barrier within this sector.

Due to the homogenous loading units and the high volume of shipments, network operators in the parcel segment usually possess highly automated sorting machines. If such a parcel center supplies several big cities in the vicinity, it will probably become apparent that such sorting machines cannot be duplicated and divided into small sections in city terminals; not even if the daily amount of parcels destined for a particular city is being consolidated across several network providers. The solution would then have to be a two-tier sorting process. It is possible that the resulting quantity might not cause any serious problems for an additional “manual” sorting process during the delivery tours. It may become necessary to explore the possibility of pre-sorting parcels coming into the parcel services’ high-tech terminals and destined for the city terminals according to pre-specified criteria, and supplying the parcels in such a way as that they are suitable for the tours (e.g., in roll containers), so that only a minor handling operation would remain to be completed at the city terminals.

The argument claiming that delivery during the “last mile” is a particularly sensitive process for parcel services (it often makes up around 50 % of the overall transport costs) and cannot tolerate any extra charges, can work both ways. Basically, it disapproves of any and all additional transport and handling operations. On the other hand, one may ask which means of transport should be used in the city jungle if barely anything will work in such surroundings. It is certainly easier for trucks with tours limited to one neighborhood or even to one single street to tolerate traffic jam-related time loss simply because of the consolidated nature of these tours, than it is for vehicles which have to cover extensive parts of the city area on their tours. Again, the cost differential can be sufficient to offset the additional pre-carriage and handling operations.

Political measures can contribute to finding a solution in more ways than one: not only by internalizing external costs (congestion charge), but also by limiting city’s access roads to certain hours or particular districts, in borderline cases even by licensing said access routes, as well as by limiting access to certain low emission vehicles and those that do not produce high levels of noise pollution. There is no better place for such vehicles to help protect the environment than in densely populated areas. Such a limitation of access, which may also include creating more restricted speed zones (which have a similar effect), has an immediate impact on vehicle productivity, thereby facilitating a readiness for horizontal cooperation between competitors, who are typically rather skeptical toward such arrangements.

5 Conclusions

Urban freight traffic is subject to distinct external effects. External savings (“urbanization economies,” “density economics,” “the city as a space of short distances”), which had originally fostered the creation of agglomerations, turn into external costs, and vehicle operators end up being a strain for each other in an unregulated and uncontrolled scenario in which they are to be seen as both victims and offenders at the same time. Nevertheless, city logistics, a concept designed to solve this problem, definitely failed during the first implementation.

It is, however, still possible to imagine a different, more convincing cost-benefit ratio under clearly changed framework conditions, especially if—in contrast to the pilot projects of the 1990s—*external effects* (reduced pollution, improved mobility, etc.) and *opportunity costs* (the equivalent of time lost by a large number of people and vehicles trapped in congested roads every day) were included in the list of arguments (cf. [12, 13]). Even insufficient willingness to cooperate will no longer be an issue. By now, suppliers (including transport network operators as suppliers of services) are increasingly chosen based on whether, and to what extent, they have done their homework on sustainability. Consequently, no network provider would dare these days to acquire a reputation as the environmental bad guy by refusing to participate in city logistics projects. Carbon footprints will show the difference and give the requirement of sustainability more weight in the decision process (cf. [14]).

Moreover, in cities with an overburdened infrastructure, politicians will think about reducing their freedom of choice. Road pricing (cf. [15]) will not suffice to solve the problem, because the impact of congestion charges on the behavior of the providers of transportation networks is uncertain, and nobody can calculate the external costs of their activities which should be the basis of such a pricing (from a theoretical point of view, network providers should be charged according to their marginal impact on congestions and related green house gas emissions). Moreover, in comparison with individual motor traffic the price elasticity of freight traffic is rather low.

But perhaps some potential partners of a city logistics model will not even need political pressure in order to cooperate. As the impenetrability of urban areas grows, operators of open transport networks can become more and more attracted to the idea of buying their way out of their own, capacity-intensive activities in intra-urban traffic, putting the capacities thus released to a more profitable use elsewhere.

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