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The load factor paradox in urban freight transports

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Introduction

Previous research has showed that restrictions on freight transports in city centers to certain hours of the day may have a positive impact on the environment, safety and the sustainable development of cities. At the same time, these limitations can increase the total number of vehicles in cities and also have an adverse effect on the development of the economy. These negative effects could, however, also be due to other restrictions – for example the load factor – and accordingly to factors other than the number of vehicles and the total number of kilometers traveled.

This study deals with scenarios, based on an imagined distribution network – a "milk run". where only the load factor is varied, that is to say to what extent the vehicle's load capacity is used. The term milk run is used in the dairy industry where a vehicle distributes or collects products according to a predetermined route.

An increased the load factor is usually perceived as a way of improving efficiency, but under certain circumstances it may adversely affect both economic and environmental sustainability. The conclusion of this study is that decision-making politicians and officials should not base their assumptions relating to distribution of goods in city centers on simple ratios, since reality is significantly more complex. The study presented here highlights one of the five articles which make up the thesis "Essays on operational freight transport efficiency and sustainability".

Major challenges and measures which are difficult to assess

This study is part of the on-going debate regarding sustainable transport in urban environments. In order to understand the complexity in these issues, the summary begins with a brief overview of the restrictions which are currently used in practice and evolving trends in the transport sector.

In urban areas, transport of goods can represent 20-30 percent of the total number of vehicle-kilometers and 16-50 percent of emissions. The fact that they are an important part of economic development, while they also, at the same time, contribute to congestion, noise and pollution, represents a challenge. In the last decade, the transport industry has become increasingly concerned with the impact of fuel consumption on operating costs, as well as CO2-emissions. This applies in particular to freight transport in urban areas, where most distribution chains begin or end. Further information about the poor resource utilization of the first and the last kilometer follows below.

Efforts by local authorities to try to influence the situation include introduction of various incentives and restrictions, for example by way of local transport alternatives, access restrictions, reloading terminals or access to bus lanes. The haulage contractors, in turn, make efforts to be efficient and environmentally responsible by

driving in a fuel efficient and environmentally friendly manner and by optimizing the load factor.

The last kilometer – expensive and tightly regulated

In freight transport, the last kilometer represents the end of the distribution chain between the supplier and the customer, and yet it represents as much as 28 percent of the transport cost. This problem is addressed in various ways, among others through local regulations. However, the results of such regulations may be unforeseeable and the environmental effects vary considerably. The milk run may be a good alternative to increase the load factor where many, smaller deliveries are needed with a high degree of regularity and if the suppliers – or the customers – are located within a limited geographical area. On the other hand, it requires a more complex coordination for all the parties involved, and an increase of the load factor is not possible without detours and extra stops – entailing a longer distance and more time consumed.

The variable costs for an empty vehicle are always lower than for a fully loaded vehicle under equivalent circumstances. Research has showed that the load factor has dropped, in particular in urban areas, a fact which local authorities try to rectify in various ways. A common way of doing so is by introducing traffic access restrictions – time zones – when transports may be carried out. However, the effects on costs and emissions are difficult to foresee.

Most studies show that as the "time window" narrows, the cost of transport generally increases. Many freight transports are carried out in the morning rush hour, with the associated congestion and traffic jams. The idea is to deliver products to shops and other community functions without having to compete with residents for space. The introduction of time zones entails both economic and environmental costs because of a greater number of vehicles and longer distance traveled. At the same time, a time restriction on freight transport results in obvious advantages to residents with respect to accessibility, safety, noise etc.

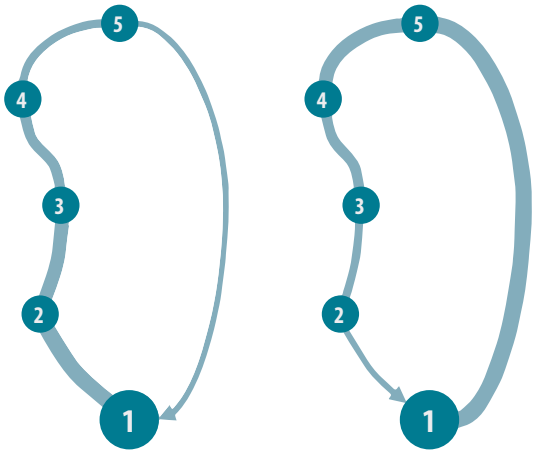
Other types of regulation include restrictions relating to emissions, vehicle age and introduction of environmental zones. However, it is difficult to assess such regulatory measures. Another aspect is that since the 1970s most haulage contractors have moved from urban areas to outer areas. The resulting longer transport distances have increased CO2-emissions.

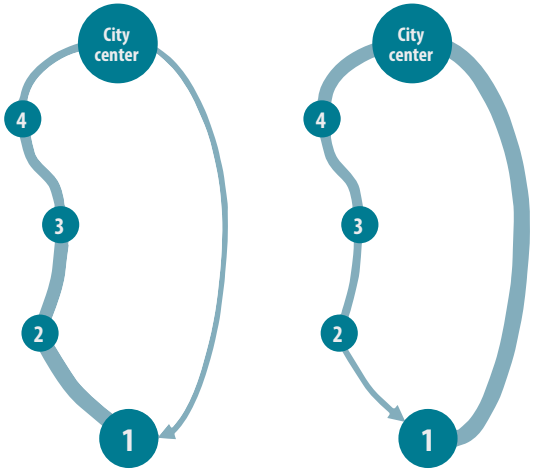
Impact on economy and environment

Previous research has identified a number of paradoxes for transports under various conditions and in various environments, effects which have been proven in theory, in laboratory environments and in practice. What we intuitively perceive as an improvement can, in some cases, in fact have negative effects. For example, a road connection added to a road network to improve the traffic situation could in reality increase the total travel time; an increased capacity may mean that more people chose this alternative with a poorer flow as a consequence.

There are also many paradoxes in "green logistics": Environmental costs are perceived as external (they are borne by society and not by the distributor), the modes of transport are the least environmentally friendly (trucks and flights) and stocks moved to the roads take up space and contribute to traffic congestion – lower distribution costs do not necessarily lead to less environmental impact.

As showed by previous research, models with a fixed route only have regard to the distance travelled, and not to fuel consumption depending on load, vehicle type or driver costs. Even if an increased load factor is generally desirable, there are exceptions, as showed by the example below. The increased load factor in this example results both in a more severe environmental impact and increased distribution cost.





The paradox visualized

The first figure opposite shows a scheduled milk run starting and ending at point 1. The CO2-emission in the example (diesel operated vehicle) is 26 percent higher if the milk run is driven in a counterclockwise direction than if it is driven in a clockwise direction. Assuming that the vehicle returns to the starting point after the completed milk run, the choice of route – clockwise or counterclockwise – could be less than optimal if only the distance traveled were taken into account, since it is the same distance regardless of the direction in which the vehicle is driven. Even though the load factor is higher if the round is driven counterclockwise, it is a more expensive solution resulting in higher emission levels.

In practice, the load factor is only used as a measure of how the vehicle is loaded on leaving the depot. Frequently, the vehicle collects and drops off goods at several locations, and accordingly the load factor varies over the course of the journey.

The second figure shows the effect, in practice, of the paradox. Let us assume that the city center is at point 5, City center, and the depot is in the city outskirts (point 1). If there were access restrictions with respect to load factor or by way of a time window, which route would the distributor then select? Would the fully loaded vehicle select the longer route to the city center (counterclockwise), make its first delivery there and then continue to deliver to the remaining customers on the way back? This would result in a higher average load factor, but also higher levels of CO2-emissions, mainly because the vehicle is driving a longer distance fully loaded.

Summary

Research indicates that time restrictions may have a negative impact in relation to the number of vehicles and total driving distance. The paradox described above neither supports, nor invalidates this theory, since the two alternatives comprise the same distance and only one vehicle. It does, however, contribute to the discussion, since the regulation of time windows and load factor may have a negative effect with respect to fuel consumption depending on aspects other than the number of vehicles and distance traveled. Such factors may include the fact that the distribution depot is located in the outskirts of the city and that some customers along the milk run are located outside the city center, nearer the depot, so that haulage contractors may drive longer distances than necessary with a fully loaded vehicle.

Regardless of the above, it is important to underline that time restrictions on freight traffic in urban centers have clearly positive effects for residents. More studies are required to determine whether this applies to load factor requirements as well. Local authorities and decision-makers should be advised to take note of the location of distribution depots in cities – and specifically if they are located in the outskirts of the city – before making any decisions about restrictions. It is equally important to find out whether haulage contractors have customers on the way in to the city – if so, load factor requirements are probably not an optimal model.

Interesting issues for future research include an examination of the business model and cooperation between haulage contractors and transport purchasers. Who is responsible for optimizing the load factor? Would a fuel supplement prevent price fluctuations or influence the ambition of working with efficiency improvements? How common is this paradox?

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One conclusion of the study is that decision-making politicians and officials should not base their assumptions concerning distribution of goods in city centers on simple ratios – reality is significantly more complex.

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