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The milk run revisited: A load factor paradox with economic and environmental implications for urban freight transport

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ABSTRACT

Research has shown that time access restrictions in city centers might increase social sustainability aspects such as livability or safety, but might also increase the number of vehicles and the total distance travelled; which have negative environmental impact and can decrease economic sustainability. In this paper we see that this negative effect could also be the result of other access restrictions, like load factor restrictions, and may be related to factors other than the number of vehicles and total distance travelled. Such as if the distribution center is in the outskirts of the city and customers are situated outside the city center. In this study a common urban distribution network scenario is presented – the milk run – where only the load factor is changed. Increasing the load factor is usually regarded as a way of improving efficiency, but we observe that under certain conditions improving the load factor affects economic and environmental sustainability, by increasing total costs and emissions. Following insights from this study, policy makers and companies should be careful when using single key performance indicators in urban freight distribution.

1. Introduction

In urban areas, the movement of goods may account for 20–30% of the total vehicle kilometers travelled, and for 16–50% of emissions from transportation (Dablanc, 2007). This presents particular challenges. On the one hand, transportation of goods is an important economic activity, but it also increases congestion, noise and emissions. In the past decade, the transportation industry has been increasingly concerned over the effect of fuel usage on operational costs and on CO_2 emissions. This is particularly the case in urban freight transportation, where most logistics chains start or end, and which therefore also deals with "first or last mile" related inefficiencies. The local authorities try to improve the situation by implementing incentives and by imposing restrictions including, for example, local freight networks, access restrictions, consolidation of deliveries, and access to bus lanes. Operators themselves try to improve their efficiency and take environmental consideration by advocating eco-driving and by improving the load.

The concept of "milk run logistics" originates from the dairy industry and describes a situation in which one vehicle distributes or collects goods from a number of customers or suppliers and circulates according to a pre-defined route.

This paper connects to the on-going conversation on the trade-offs in sustainable urban freight distribution, see e.g., Stathopoulos et al. (2012) and Arvidsson et al. (2013), by presenting a counterintuitive theory for milk run distribution in urban areas. It starts by supplying the reader with information on restrictions used in practice and trends in urban freight transport. Then examples of paradoxes and contradictions in sustainable transportation are presented. Drawn on the two

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previous sections a load factor paradox is introduced. Some implications and remarks for local authorities and operators in conjunction with this paradox conclude the paper.

2. Inefficiencies in the last mile and some counter-measures

In freight transportation, the last mile is the final phase of a distribution network in which goods move from a supplier to a customer. The Council of Supply Chain Management Professionals (CSCMPs) estimates that as much as 28% of all transportation costs occur in the last mile (Goodman, 2005). This estimate depends on the number of customers, the variety of shipments, and reliability issues related to congestion (Rodrigue et al., 2009). These inefficiencies are tackled in numerous ways. For example, local authorities in European cities have implemented a number of different regulatory- and incentive-based policy measures. The trend is toward more consolidation, co-ordination and regulations paired with incentives. Studies on the effects of these measures on supply chains show the complexity of these issues (Danielis et al., 2010), since the environmental outcomes vary.

Milk runs may be a good way to increase the load factor (vehicle utilization) if very frequent small deliveries are needed on a regular basis and the suppliers – or customers – are located within a small geographic area. The general downside is the increased coordination complexity for all parties involved (Chopra and Meindl, 2007). Hall (1987) states that improving the load factor is not possible without driving vehicles out of their way to visit extra stops, which means longer vehicle routes and travel times (see Woxenius (2012) for a review of freight-related detours). Variable costs of an empty vehicle are always lower than a vehicle operating with a full load if travelling with the same speed, over the same route and using the same type of vehicle (Xiao et al., 2012). In a study by Sahin et al. (2009) it is shown that for a truck travelling 1000 km from Turkey, carrying 20 tons and with a load factor of 70%, the fuel costs constitutes 60% of the total costs where the other parameters are investment costs, operational costs, maintenance, and external costs; see also Table 1. The variance in fuel usage depends on e.g., speed, aerodynamics, tire pressure, and driving behavior.

Research has shown that load factors have been falling, especially in an urban context (OECD, 2003; Browne et al., 2007; De Magalhães, 2010). Thompson and Hassall (2012) and Gonzalez-Feliu and Salanova (2012) suggest a collaborative urban network to achieve higher load factor and lower travel distances, and Cherrett et al. (2012) suggest collaborative procurement of freight services in last mile delivery as a way to consolidate deliveries. Local authorities have long tried to identify opportunities to achieve higher load factor (Cherrett et al., 2012), to the extent that it has even been used in the public debate on infrastructure, where politicians have claimed that new investments can be avoided if the operators fill up the vehicles better (Woxenius, 2012). Research has also been carried out to examine the need for collaboration between logistics and marketing professionals (Ellinger et al., 2006; Boyer et al., 2009), where the challenge is to balance short delivery windows with the desire of the logistic companies for longer delivery windows which yield more efficient routes (Boyer et al., 2009). Others have surveyed hauliers to calculate the load factor as well as a range of other operational efficiencies (Léonardi and Baumgartner, 2004) pointing out the benefits of consolidation (Ülkü, in press) and ways to improve it (McKinnon, 2000). Public–private and/or private-private collaboration has been suggested as one step to tackle the trade-offs in urban distribution (Allen et al., 2010; Muñuzuri et al., 2005; Crainic et al., 2004). From an urban transport planning perspective a similar notion is used by Bayliss (1977) calling it a "participatory process".

One of the most common policies used by local authorities is access time windows (Muñuzuri et al., 2005; Danielis et al., 2010). This system dates back to the Roman period, where chariots were banned from the city of Rome at particular times of day (Banister et al., 1993; Nagurney, 2005). Today deliveries restricted to certain times of day are common strategies, implemented by local authorities as a means to increase load factor and separate the interaction between residents and heavy goods vehicles, although the effects on total costs and emissions are often difficult to predict (Danielis et al., 2010; Browne et al. 2005). In most studies, more narrow time windows are shown to negatively correlate with delivery costs (Boyer et al., 2009; Quak and de Koster, 2007, 2009). However, much of the urban delivery activity unfortunately takes place during the morning congestion period (Allen et al., 2008; Cherrett et al., 2012). And as Muñuzuri et al. (2005, in press), Quak and de Koster (2007, 2009), and Danielis et al. (2010) point out that time window restrictions come at a cost of financial and environmental sustainability, owing to an increase in number of vehicles and total distance travelled. Nonetheless, time window restrictions contribute to social sustainability by improving livability, safety, access to the city center for customers, noise reduction, as well as minimizing visual intrusion and hindrances for citizens.

Efficient vehicle loading, reducing vehicle kilometers travelled and fleet renewal is considered to be important from a policy perspective (Thambiran and Diab, 2011). A number of European cities have introduced environmental zones (OECD, 2003) and low emission zones that help to accelerate the introduction of cleaner vehicles and reduce the number of older,

Table 1
Typical fuel consumption in liters per 100 km for Volvo lorries (Mårtensson, 2003).

Type of truck	Maximum load weight	Gross weight	Liters/100 km empty	Liters/100 km full
Typical fuel consumption in liters per 100 km for Volvo lorries				
Distribution truck	8.5	14	20–25	25–30
Regional truck distribution	14	24	25–30	30–40
Truck with semi-trailer long haul	26	40	22–27	30–37
Road trains long haul	40	60	28–33	45–55