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Location of freight consolidation centres serving the city and its surroundings

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Abstract

This paper investigates small road hauliers' spatial location and road network accessibility in relation to proposed freight consolidation centres (FCCs). For many decades, the overall load factor in freight vehicles has decreased; smaller volumes of goods have been transported over longer distances. To counteract this, a well-planned localisation of FCCs has been suggested as a measure to improve transport efficiency. Based on 3,024 road hauliers, road haulier associations, freight forwarders, and delivery firms/couriers located in the Western part of Sweden, the analysis show a high concentration of small road hauliers towards the largest city, its immediate surroundings, and towards existing facilities of large freight forwarders and road haulier associations. Furthermore, the accessibility analysis shows that a very large majority of the small road hauliers as well as large forwarders and haulier associations are reached within a short time distance from the proposed FCCs, indicating the potential to establish FCCs serving small road hauliers. While it is not possible to conclude that the 'proposed' FCCs are optimally located, the paper provides a basis to further investigate the most appropriate locations of FCCs serving the city and its surroundings, and whether and under what conditions FCC establishments are viable.

Keywords: Freight consolidation centres (FCCs); small road hauliers; spatial location; network accessibility; optimal location

1. Introduction

This study takes as its point of departure the fact that roads and cities are increasingly saturated by freight vehicles carrying low average loads. For many decades, smaller and smaller volumes of goods have been transported across longer and longer distances in an even larger number of vehicles, whose overall load factor is decreasing (Friedman, 1975; Browne *et al.*, 2007a and b; de Magalhães, 2010). This development influences firms and society at large, since capacity that could have been used more productively is lost. To counteract this trend, freight consolidation centres (FCCs), wherein small loads are consolidated before being delivered to their final destinations in large-size vehicles with high load factors, have once again received attention as a measure to curb freight transport-related externalities

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through a more efficient usage of transport resources. A more thoroughly and well-planned localisation of urban consolidation nodes (and intermodal logistics centres) has been highlighted as a central aspect and measure to improve the efficiency in city distribution (Ljungberg and Gebresenbet, 2004; Browne *et al.*, 2007a; BESTUFS, 2007; Chwesiuk *et al.*, 2010; Kayikci, 2010). Notwithstanding the attention given to the issue, our spatial knowledge of the location of freight transport intensive activities, which is considered to be one of the most complex decision-making problems facing transport analysts (Kayikci, 2010), is often rudimentary, making it difficult to ascertain the most appropriate location for the FCCs.

Research on FCCs has, on the one hand, neglected to study their location in relation to road hauliers, road haulier associations, freight forwarders, distribution zones, and warehouses, and, on the other hand, focused on sub-optimisations with micro terminals serving a limited geographical area, number of shippers and transport operators (Benjelloun and Crainic, 2009; van Duin *et al.*, 2010; Patier and Browne, 2010). Furthermore, analysts often overlook the situation of small road hauliers, as well as the volumes that these operators do not transport through forwarders and road haulier associations, despite the fact that they make up a large majority of all road hauliers, especially in urban freight (Löffler, 1997; Deblanc and Rodrigue 2010). The consolidation project in Nijmegen, Netherlands as explored by van Rooijen and Quak (2010), is a good exception but the gap in the literature remains an opportunity for research that applies a spatial perspective to all road hauliers. The small road hauliers lack the scale and supporting tools for well organised operations, as found in Bologna by Dezi *et al.* (2010).

The focus in this study is accordingly on small hauliers having inferior preconditions for efficient transport services compared to large road hauliers, forwarders and the logistics arms of retail chains. Finally, while long distance transports have been heavily studied, the ‘last mile problem’ and transport in the urban periphery has received less attention, often due to a lack of data, despite the fact that the largest percentage of freight transport by road occurs in these areas (Hesse, 1995; Löffler, 1999; Behrends *et al.*, 2008, van de Riet *et al.* 2008; Chwesiuk *et al.*, 2010; Patier and Browne, 2010). This motivates a wider spatial perspective.

Through an initial analysis of small road hauliers (0–9 employees) spatial location and network accessibility analysis, measuring transport time from two potential FCC locations, this study provides a basis from which to further investigate appropriate locations for FCCs that serve the city and its surroundings, and whether and under which conditions FCC establishments are viable in terms of sufficient volumes and participating hauliers, freight type, accompanying measures, operation, users, etc. In the analysis, the facilities of the road hauliers, road haulier associations, and forwarders make up the nodes, while roads make up the links. The study is located in the county of Västra Götaland (henceforth VG) in Sweden, focusing on the City of Gothenburg (including Mölndal municipality) (henceforth the CoG) (Fig. 1). By including a larger geographical area, this paper avoids focusing on a specific zone. Furthermore, instead of focusing on final delivery destinations, the study begins at the operators’ geographical location, starting with the place of departure for distribution vehicles. The second section provides a theoretical discussion, while the third section outlines the methods and materials used, and a short description of the Swedish transport situation, including truck fleet composition, vehicle kilometres, transport work, load factors, and geographical distribution. The following section presents the findings, and the final chapter concludes the paper.

2. Structure of urban freight transport activities

It is often argued (see Andersson *et al.*, 2005; Ekman *et al.*, 2009; MEEC, 2010) that available information about urban freight structure and scope is limited. More specifically, since transport research has yet to provide a comprehensive idea of how freight transport-intensive activities should be located, this topic demands analysis. To appraise and plan appropriate localisation of such activities, knowledge

about the freight transport industry structure, function and mutual firm connections is needed. The present geographical locations of terminals have often been based on a historical legacy, while access to land has often determined new establishments and relocations, not how localisation can minimise negative externalities (Hesse, 2004; MEEC, 2010). They make up central nodes and flows within the network; they are the fixed points within the distribution system at which goods need to be handled and/or stored.

2.1. Urban structures that discourage consolidation: concurrent dispersal and concentration

Since the penetration of road traffic into society, a continuing trend towards the dispersion of activities has occurred; urban land use is increasingly intensive and density is decreasing. An important factor driving this development is related to the concept of time and cost space convergence. In line with improved transport technology, the time and cost associated with overcoming space has continuously decreased. In effect, this has influenced the total logistic cost concept, wherein the transport factor's relative importance is diminishing. As transport costs marginally influence firms' profit margin; according to Hicks (1977), cheaper transport only results in marginal reductions in the final prices of a moved good; this has enabled outsourced production, centralised distribution, frequent deliveries, unbalanced delivery chains, competition, and, not the least, just-in-time (JIT) production methods.

In comparison to cost, punctuality, flexibility, low inventories, and time factors are central issues within JIT with increased frequencies, and thereby the increased transportation costs which follow from JIT are counterbalanced many times over through reduced inventories and higher quality production. Thus, the demand for frequent deliveries and shorter delivery times has increased, which in itself generates lower load factors and additional vehicle kilometres across a larger number of vehicles (McKinnon, 2003; Hesse and Rodrigue, 2004). This trend is expected to continue. In accordance with the dispersion and concentration to larger units, terminals and other transport related activities are relocated to edge-cities, where neighbourhood acceptance is higher, accessibility to motorways is higher, and access to land is cheaper. The concentration of activities (e.g., terminals) into larger units at fewer locations is expected to continue (Zunder and Ibanez, 2004; Kohn, 2005). Therefore, while the forwarder level is increasingly concentrated into larger entities, enabling consolidation and utilisation of scale economies, the freight transport sector is still made up from a vast number of small road hauliers, a sector where less is known about the opportunity to cooperate through consolidation.

2.2. Simultaneous major and marginal outcomes: area served and current volumes

Contemporary freight distribution systems often lead to sub-optimisations (Ljungberg and Gebresenbet, 2004; MEEC, 2010). Studies concerning the geographical area that an FCC (e.g., a micro terminal) serves are often limited to a certain part of the central city, shopping centres, construction sites etc., often resulting in sub-optimisations. Several studies (Ogden, 1992; Nemoto, 1997; Köhler, 2001; Browne *et al.*, 2005; 2007a) have demonstrated that an FCC can generate large local reductions in vehicle kilometres, but only a marginal reduction at the city level. Based on results from earlier studies, Ogden (1992) concluded that because the number of trucks in central city delivery is only a small percentage of total road traffic in an urban area, the effect of consolidation on the total urban environment is insignificant. More recently, Nemoto (1997) calculated the economic costs and benefits using an FCC. This study showed substantial local reduction of traffic in one city district, but total traffic along the main road into the city centre was reduced by less than one percent. Likewise, Köhler's (2001) study in Kassel, Germany, showed that the reduction in vehicle kilometres in the central business district, generated by the FCC, was marginal.

The results referred only to changes associated with the period in which the FCC was used, excluding transports generated by the FCC. This indicates that micro terminals often generate large local effects, but only minor ones on the city level. If the target is to gain large reductions, an FCC must cover a wider geographical area. Two good examples of this, i.e., studies that incorporate a larger geographical area, are Akiyama's and Yano's (2010) study including the volume of truck deliveries generated by large retail facilities in the Tokyo area, and van Duin *et al.* (2010) referring to the urban consolidation centre project in Leiden, the Netherlands. Initially only the city centre of Leiden was included in the latter study, but due to a lack of participating actors the service area was extended to the whole city. Despite this extension, however, the project failed, partly due to the centre's location outside of Leiden and far from the highway.

2.3. The geographical area as served by an FCC

Freight transport in the urban periphery and its surroundings has received little attention, despite evidence that these areas are, by far, the places where the biggest percentage of freight transport by road occurs (Löffler, 1999). This justifies a wider geographical perspective, but also influences the decision regarding where to locate one or several FCCs. As pointed out by Benjelloun and Crainic (2009), this choice is partially dependent on city characteristics, both its density (activities and population) and spatial scope. One factor that plays against the location of a single FCC in the suburbs outside a large city (see also van Duin *et al.*, 2010) is the rather long distance that vehicles must travel from the FCC into the city where the delivery tour begins. In a comparative study of urban freight studies in the UK from 1970 to the 2000s, Browne *et al.* (2010) show that the distance over which the majority of vehicles are travelling to make deliveries to urban establishments has increased substantially, further justifying a wider geographical perspective when studying the appropriate location of FCCs.

Browne *et al.* (2005) emphasise that the location of an FCC in relation to its market generate important consequences for the traffic and the environment. A location far away from the final customers has the advantage that large long-distance vehicles would not have to enter into the urban area. In addition, the distance over which specially designed environmentally-friendly vehicles were operated could be maximised. However, if small vehicles were used when leaving the FCC, the number of vehicle trips and kilometres could increase. If the FCC instead were located very close to the delivery area, this choice would reduce the distance over which environmentally-friendly vehicles could operate. Further, in BESTUFS (2007), the location of FCCs is treated only superficially. It is noted that the choice of site will have consequences on traffic. The conclusion was that FCCs should, if possible, be located close to intermodal nodes and distribution terminals where the incoming transport assignments are generated, thereby minimising vehicle kilometres driven. However, Leu and Ottosson (2002) recommended that an already existing terminal should be used, due to the costs associated with the construction of a new terminal.

There is a need to balance such issues when deciding upon location. When investigating location decisions concerning intermodal freight logistics centres, Kayikci (2010) points out that all factors influencing the location placement should be considered and well-planned. One critique of the limitations of conventional location selection methods points out that these methods simply add all the indicators to location selection models that consider only one or a few basic elements (e.g., objective functions, potential locations, a distance or time array, or rules deciding allocation).

In sum, a major problem concerning FCCs is the lack of analysis regarding their location in relation to incoming freight, delivery destinations, and road hauliers' mutual localisation (as well as location in relation to freight forwarders), and the geographical area an FCC should cover. The benefits of the

surveyed projects have identified considerable local (sub-system) effects, while the effects on a larger scale (system) are often marginal.

2.4. The Swedish road transport industry structure

The characteristics of the road freight transport situation in Sweden can be summed up as follows; the total vehicle kilometres driven increased by 125% from 1970 to 2006, while total volumes in tons transported decreased more than 25% during the same period and the transport work in tonne-km increased by 94%. The vehicle fleet increased from 218,000 to 510,000 (134%) from 1985 to 2008 (SIKA, 2008, p. 8–10). Light trucks (<3,5 tons maximum load weight) made up 84% of the vehicles in 2008 (including vans operated on private accounts) (*ibid.*, p. 5-6,13). The road hauliers made up 12% (13,000 light trucks and 45,600 heavy trucks). Of the total vehicle kilometres in 2007, those with empty loads made up 23% (measured in max. load weight) (*ibid.*, p. 11). Among light trucks, the latest survey in 2000 (SIKA/Statistics Sweden, 2001) showed that non-loaded runs reached 56% of travel among road hauliers (max weight <3,5 ton). This suggests that there is a large theoretical opportunity to increase the load factor.

Freight is transported across relatively short distances in Sweden, mirroring the general situation in EU27 (EC, 2009), where, in 2007, only 9% of vehicle kilometres took place in transports longer than 300 kilometres (SIKA: 2008:15-16). However, in line with the spatial dispersion of activities, the average transport distances have increased, as Browne *et al.* also found in the UK. The geographical distribution of the vehicle kilometres can partly be identified through statistics on a county level. A Swedish study in 2000 (SIKA/Statistics Sweden, 2001:5) showed that on average, 80% of the vehicle kilometres, including transit traffic, were carried out within a county.

The supply side of the Swedish market for consolidated cargo, characterised by consignments in the range of 30 to 1000 kg sorted and consolidated in terminals, is dominated by the forwarders DB Schenker and DHL. With approximately 80% of the long-distance market they form an oligopoly and they also maintain strong positions in the segments of part loads and full loads. DB Schenker, which is the larger of the two, routed 1.2 million tons distributed over 5.2 million consignments through their terminals in 2003 (Sommar and Woxenius, 2007). The majority of DB Schenker's volume was however transported directly from consignor to consignee as full and part loads. Only 11% of the tons but 73% of the consignments related to consolidated cargo. DB Schenker and DHL are increasingly challenged by the logistics arm of Posten, other forwarders such as DSV, Bring and On Road. Road haulier associations organising a large number of small road hauliers are traditionally strong in segments of full loads, trucks chartered for distribution for retail chains and above all services for the construction industry. The road haulier associations maintain a strong local focus but are increasingly merged into larger entities with a clear ambition to compete also for long-distance transport. As regards the structural changes taking place, in Sweden there were 106 road haulier associations in 2007, down from 307 in 1970, while the number of road hauliers decreased from 17,000 in 1994 to 11,000 in 2007 (Sveriges Åkeriföretag, 2008). The road haulier associations act as intermediaries but allow the organised haulier to also have direct shipper contacts.

3. Method and data

Addressing urban logistics requires an understanding of urban geography as well as supply chain management, which tends to be an uncommon set of skills (Deblanc and Rodrigue, 2010). As land use patterns determine many features of the movement of goods, the spatial distribution of logistics facilities has a direct impact on the number of vehicle kilometres necessary to reach distribution areas. The case

study area, VG, is located in the western part of Sweden (see Fig. 1). Of VG's almost 1,6 million inhabitants, 573,000 are concentrated in the City of Gothenburg (512,000 inhabitants), a geographical unit made up of 20 districts, and in the Mölndal municipality (61,000 inhabitants), hereafter referred to as CoG (Fig. 1) (Västra Götalandsregionen, 2009a:9). Outside of CoG, the areas around the cities of Borås, Trollhättan and Skövde (Fig. 1) also have relatively high population concentrations. A major reason for choosing this area is its position as Sweden's major freight transport-oriented area.

Based on data from the Statistics Sweden database, 3,024 road hauliers, road haulier associations, freight forwarders, and delivery firms/couriers in VG (whereof CoG made up 852, equivalent to 28%) were identified and mapped in the GIS-program Arc-View according to the postal addresses they visited. In order to identify patterns, the operators' spatial locations were tentatively analysed from a VG and a CoG perspective, and in relation to each other. In the next step, the road network accessibility of small road hauliers, including delivery firms/couriers, road haulier associations (>100 employees) and freight forwarders (above 50 employees), as measured in transport time, was analysed in a scenario with two 'potential' FCCs. The location of the 'potential' FCCs was based on high freight transport intensity and good provision of road infrastructure in and around these locations. The transport time from respective FCC was divided into five-minute intervals (0–5, 5–10, 10–15, 15–20, and >20 minutes). It should be noted that the road network used in this analysis represented an optimal network with highest allowed speed, and thus the study considered neither one-way roads nor capacity constraints (e.g., congestions).

The focus is on the small hauliers, since they often operate less efficiently than forwarders (e.g., DB Schenker, DHL, Posten and Bring) and large retailers (e.g., ICA and Lidl). The latter categories operate at a scale needed for supporting the operations with own consolidation terminals and sophisticated information systems (Dezi *et al.*, 2010). The focus on long-distance transport implies location of FCCs at the rim of cities, while the small hauliers with a strong local focus are likely to need FCCs located more centrally in cities. Since private (transport carried out by manufacturers with their own employees and fleet) and independent operators (with their own vehicles, supplying the store) do not have authorised traffic permits and are not allowed to operate for hire or reward, these road haulage operations are excluded.

3.1. Freight traffic situation within the case study area

Before turning to the findings, in order to explain the choice of study area, this section describes the freight traffic situation within this specific area. The distinct orientation of VG's economy towards trade and industry has distinguished it as the country's major transport region; 66% of the container and 19% of the RoRo flows (in tons in 2010) enter and leave via the Port of Gothenburg (Sveriges Hamnar, 2011), and the Landvetter airport is the major airport in terms of inter-continental air freight in dedicated freighters (Västra Götalandsregionen, 2009b:75). Excluding transit transports (e.g., transit goods not ascribed to the port), VG is also overrepresented in terms of domestic and foreign transport volumes. Slightly more than 50% of the goods imported to Sweden, as measured in weight, have VG as its destination (Västra Götalandsregionen, 2009b). Furthermore, long-distance freight transport measured in tonne-km has increased considerably faster within VG, compared to short distance traffic. At the same time, the traffic work in vehicle kilometres performed has grown faster compared to transport work in tonne-km, especially in the short distance transport segment. Turning to the truck fleet, in 2008 the light trucks within VG numbered 65,400, while the heavy trucks numbered 12,800, equivalent to 15% and 16% of the light and heavy trucks in Sweden respectively (SIKA, 2008b.84).

3.2. Freight traffic concentration within CoG

Until the end of the 1990s, trucks made up 6 to 11% of the total average annual daily traffic on the CoG main road network. The largest shares were concentrated along the E6 to the north and roads connecting to Road 155 (Fig. 2) (Hagson and Mossfeldt, 2002). Ottosson and Franzén (2005) also identified major transport-generating clusters, namely the areas of Bäckebol (E6 North), Arendal (155), Marieholm (E45), Gullbergsvass (the junction where E6, E45, E40, and E20 converges), and Söderleden (located between Road 158 and E6 south) (Fig. 2). More recently, a study (WSP, 2009) showed that heavy trucks (measured in number of vehicles) made up 7 to 15% of the total traffic (including buses) on the main routes around Gothenburg. The density of heavy trucks was highest on E6 North, followed by E6 South, Road 155, Road 40, Road E20, and Road E45 (Fig. 2). This study also showed that a large share of the traffic is performed on the roads linked to areas where large forwarders and road haulier associations are located (e.g., the port and three large forwarders made up, on average, 41% of truck traffic on the six major roads). The E6 North and the port are also identified as potential homes to such activities in the municipalities' future comprehensive planning.

4. Findings

From a survey of trucks within the CoG (see WSP, 2009 above), it is suggested that while the port and three large freight forwarders generated approximately 40% of the truck traffic on the major routes, the majority of the trucks did not have these facilities as their destination. It indicates that a large majority of the trucks have other origins and destinations, and accordingly a thorough analysis should include other freight forwarders and large road haulier associations. Further, since a large majority of all small road hauliers transport goods through freight forwarders and road haulier associations, it is important to identify the small road hauliers' location in relation to these organizations. Finally, and of central importance, given the fact that small road hauliers do not transport all their freight through freight forwarders and road haulier associations, it is necessary to identify their locational pattern in relation to each other, since it gives a first indication of whether there is an opportunity for small road hauliers to coordinate their transports through an FCC.

4.1. Location patterns of transport related activities in VG and the CoG

Of the total 3,024 transport operators located within the VG, the road hauliers' population is dominant, composing 83% of operators, followed by forwarders (15%) and delivery firms/couriers (2%) (Table1). In terms of freight forwarders and delivery firms/couriers, there is a strong dominance of these surrounding the CoG, making up 61% and 65% espectively, while only 20% of the road hauliers are located within the CoG (Table 1, Fig. 1). Furthermore, besides the concentration near the CoG, Fig. 1 also shows a concentration in i) the municipalities neighbouring the CoG, ii) the regions around the City of Borås in particular, but also the regions around the cities of Trollhättan and Skövde, and along the major roads radiating out from the CoG (up until 40 to 60 kilometres away).

Table . Transport operators in VG and CoG, distributed by number of employees in VG/CoG.

Activity	0	1–4	5–9	10–19	20–40	50–99	>100
Delivery firms/couriers	43/29	15/11	0/0	2/0	2/0	1/1	0/0
Road hauliers/Associations	1062/233	990/183	230/54	140/40	70/18	12/6	6/4
Freight forwarders	139/78	116/71	78/49	48/31	40/29	20/10	10/8

Source: Statistics Sweden database.

When turning to the transport operators' number of employees (Table 1), among road hauliers, a huge majority has very few employees: 91% and 87% have between 0 and 9 employees in VG and the CoG respectively, while road hauliers with 0 to 4 employees made up 82% of operators in VG and 55% in the CoG. This confirms the pattern found elsewhere, in which the sector is primarily made up of a large number of very small road hauliers. The high concentration of firms with few employees was also identified among forwarders (74% and 72% in VG and the CoG respectively), but even more pronounced among delivery firms/couriers, both in VG and the CoG.

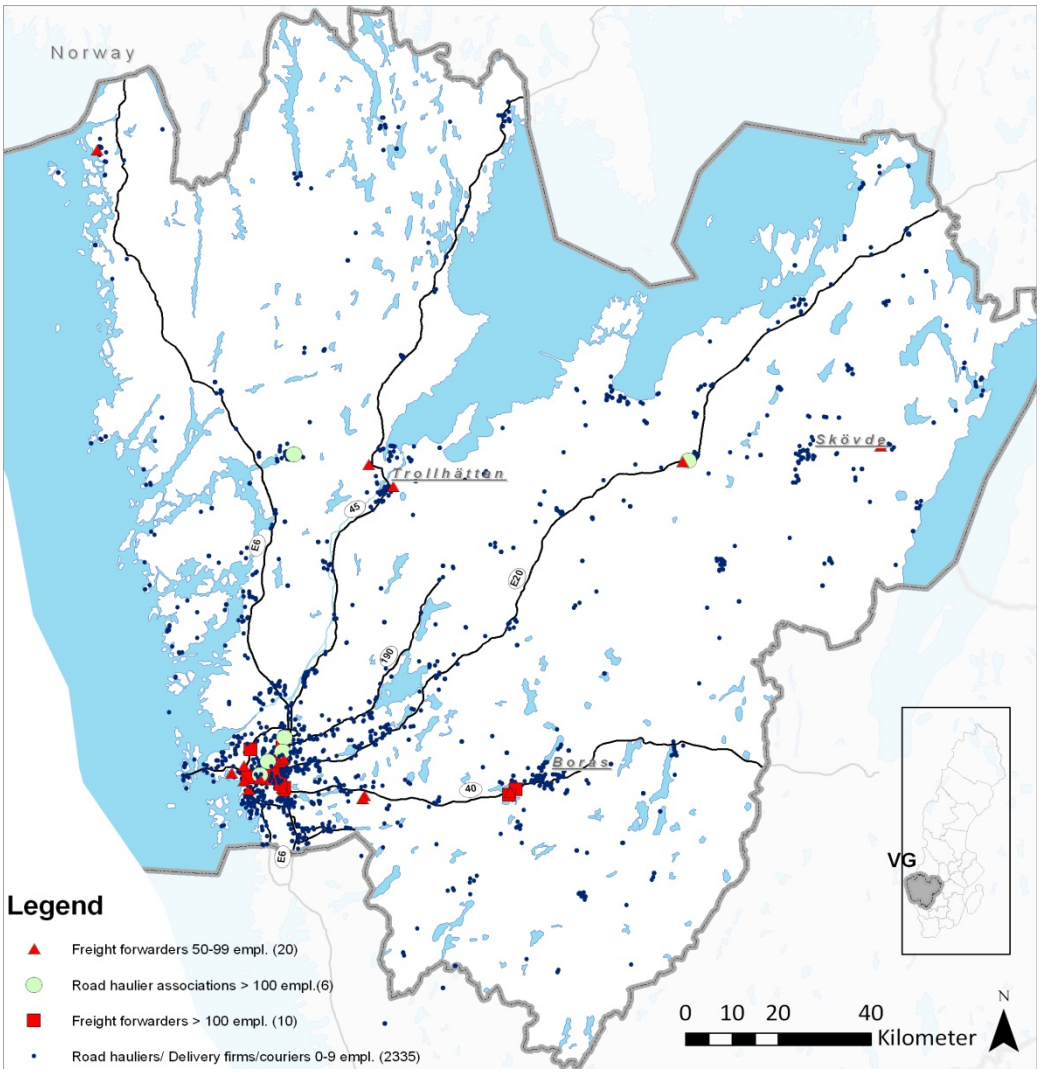

Fig. 1. Location of road hauliers/delivery firms/couriers, road haulier associations, and freight forwarders within the VG, distributed by number of employees. Note that the address locator superposes many road hauliers outside of the CoG, giving the impression of a larger concentration near the CoG than in reality.

4.2. Concentration and dispersion of transport operators in VG and the CoG

Fig. 2 shows that a majority of all small road hauliers are located within or in the close vicinity of four major roads, namely E6 (north and south), E45 to the north, Road 158 to the south, and Hisingsleden to the west. This area runs approximately 17–18 km north to south, and 8 km west to east. Furthermore, a great share of the large freight forwarders and road haulier associations are located within this area and along the roads that delimit this area (in particular, to the freight transport intensive area around Bäckebol along E6 north). Except for one forwarder, all 12 large freight forwarders and road haulier associations (>100 employees) are located within this area. Also, when including road haulier associations with 50 to 99 employees, a survey shows that a large majority are located within or close to this area.

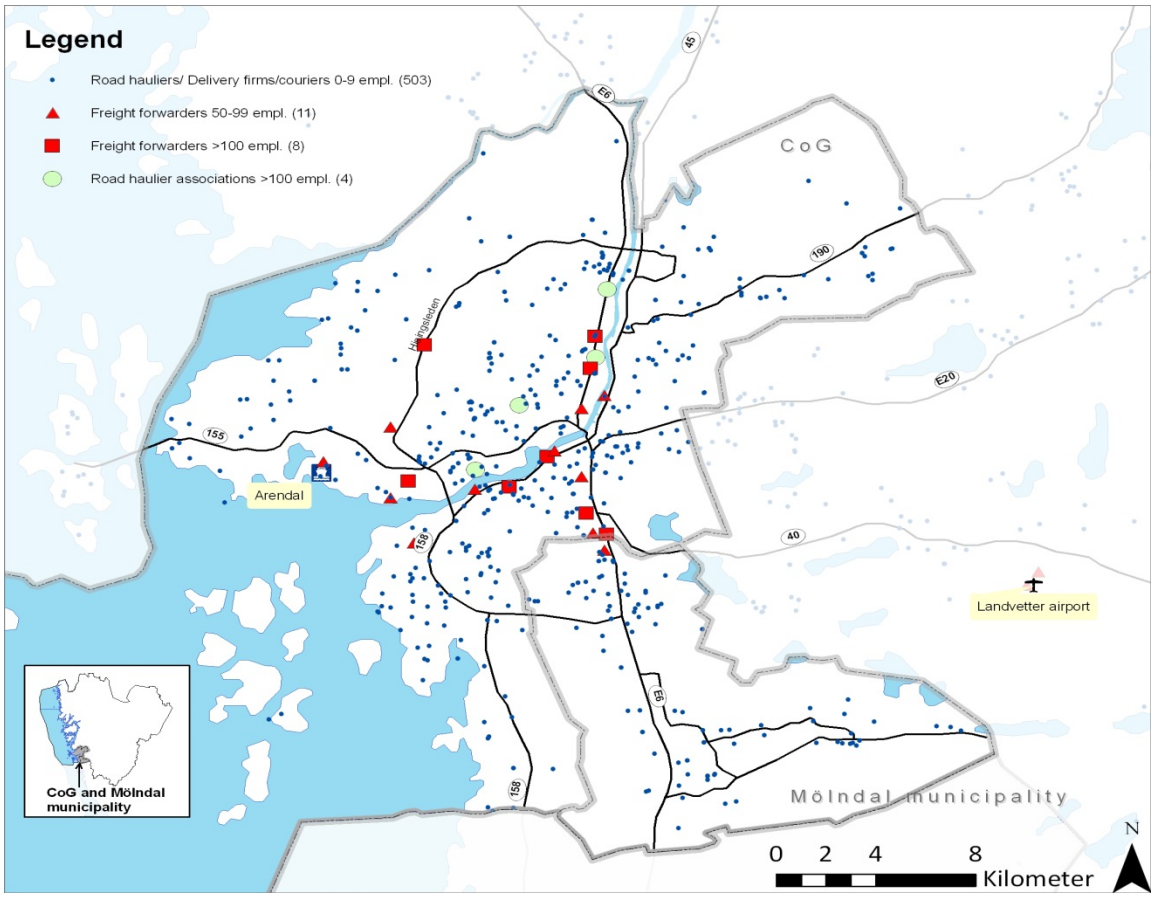

Fig. 2. Location of road hauliers/delivery firms/couriers, road haulier associations, and freight forwarders within the CoG, distributed by number of employees.

Turning to small road hauliers in the CoG and their location in relation to large forwarders and road haulier associations: with the exception of some areas (first and foremost, the southern/south-eastern parts of the Mölndal municipality, the northeastern part of the CoG, and to a lesser extent the southwestern and westernmost parts of the CoG), a large majority of the small road hauliers are located within a relatively short distance (approximately 4 to 5 kilometres) from the large freight forwarders and road haulier

associations (Fig. 2). Fig. 2 also shows a large concentration of small road hauliers immediately to the west (close to the location of large freight forwards and road haulier associations) and east of the river dividing the city, and along E6 heading south. In particular, a large concentration lies in the area where E6 and Road 158 are connected by Söderleden.

4.3. Potential FCC location and its influence on road accessibility

In a potential FCC location scenario, one FCC is located in Bäckebol along E6 North, (Fig. 3) in close proximity to the major logistics area, and one FCC is located where E6 South and Söderleden (located between Road 158 and E6 south) converge (Fig. 3).

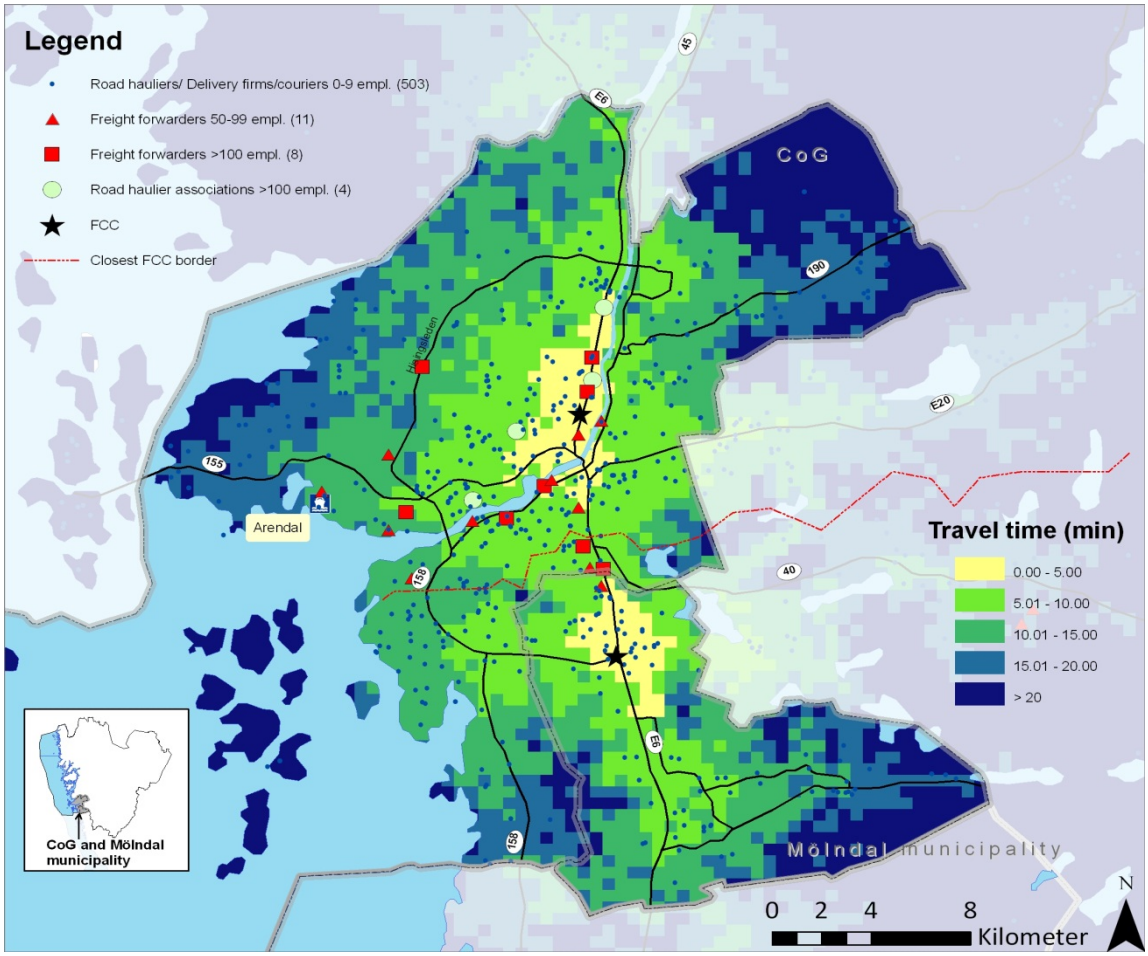

Fig. 3. Travel time from FCCs to road hauliers/delivery firms/couriers, large road haulier association, and large freight forwarders (in minutes/one way). Note that the address locator superposes many small road hauliers, giving the impression of fewer than there are in reality.

The network accessibility analysis, measuring travel time from the nearest of the two potential FCC locations to small road hauliers, large road haulier associations and large freight forwarders, give further

insight into the potential to establish an FCC within the study area (Table 2). In the case of the FCC to the north (Fig. 3), 40%, 26.5%, and 33.5% of the large freight forwarders can be reached from the FCC within 0–5, 5–10, and 10–15 minutes respectively, while 50% of the large road haulier associations are reached within 0–5 minutes and the remaining 50% are reached within 5–10 minutes. As for small road hauliers, a large majority are reached within 10 minutes (close to 64%), while an additional 22.2% are reached within 10–15 minutes, 11.5% within 15–20 minutes, and only 2.5% are located at a distance that takes longer than 20 minutes to travel. For the FCC in the south (Fig. 3), all large freight hauliers are reached within 10 minutes, 33.5% within 0–5 minutes and 66.5% within 5–10 minutes, indicating an even higher accessibility level to these actors in the south. As for the small road hauliers, in the south a majority (53.6%) of the small road hauliers are reached within 10 minutes, although this percent is not as high as for the FCC in the north. Another 38% are located within 10–15 minutes travel time, 7.8% within 15–20 minutes, and less than one percent is located more than 20 minutes away from the FCC.

Table 2. Travel time in minutes from FCCs to small road hauliers, large freight forwarders, and large road haulier associations located within the CoG (percent).

Activity	0-5	5–10	10–15	15–20	>20
FCC North/South					
Small road hauliers (n=337/168)	16.0/17.8	47.8/35.8	22.2/38.0	11.5/7.8	2.5/0.6
Large freight forwarders (n=15/4)	40.0/33.5	26.5/66.5	33.5/0.0		
Large road haulier assoc. (n=4/0)	50.0	50.0			

From Fig. 3, it is thus possible to conclude that a large majority of the small road hauliers, large freight forwarders, and large road haulier associations are located within a short distance, as measured in time, from the two ‘potential’ FCC locations. It also shows that in terms of small road hauliers, the ‘potential’ FCC in the north is more accessible within up to 10 minutes of travel time. Furthermore, Fig. 3 also shows that by locating FCCs that serve small road hauliers close to existing large freight forwarders and road haulier associations (for whom they perform a large share of their deliveries), the small road hauliers may have an opportunity to improve their competitive strength and transport efficiency in certain freight segments and a certain geographical area (i.e., up to a certain distance from the CoG) vis á vis other actors.

This opportunity is even greater when considering the large number of small road hauliers located outside of CoG that deliver goods to CoG. Furthermore, in an optimal scenario, if small road hauliers had a larger space to manoeuvre regarding the deliveries they perform through large freight forwarders and road haulier associations (i.e., be allowed to transport this freight via the FCC), they would have an even greater opportunity to improve their efficiency. However, other actors will most likely challenge this solution, as it represents a head-to-head competition with their own business. A major reason for allowing hauliers to offer transport services independently from the forwarder or road haulier association is that these services are not considered to be outside their own scope of services offered to the market. Rather, allowing the hauliers to offer these services increases the utilisation rate and lower the road haulage price for the subcontracting forwarder or road haulier association, as they otherwise would have had to cover the hauliers’ idleness costs.

Finally, it should be noted that the analysis related to the network accessibility has been based on a ‘potential’ location scenario of two FCC. An in-depth analysis of the most appropriate locations must take other factors into consideration, such as: respective participating road haulier’s freight volume, freight volume not transported through freight forwarders and haulier associations, delivery destinations, type of

goods delivered, number of routes and delivery addresses etc. Weighing these factors will most likely alter the optimal FCC location.

5. Conclusion

This paper has investigated small road hauliers' spatial location and accessibility in relation to proposed FCC locations. For many decades, the overall load factor in freight vehicles has decreased, influencing firms and society productivity negatively. To counteract this, a more thoroughly and well-planned localisation of FCCs have been suggested as a measure to improve transport efficiency. The analysis has shown a high concentration of small road hauliers towards CoG and its immediate surroundings. Furthermore, a large share of the small road hauliers are located in close proximity to existing large freight forwarders and road haulier associations. Finally, the accessibility analysis, measuring travel times to two 'proposed' FCCs, has shown that a very large majority of the small road hauliers, as well as large freight forwarders and haulier associations, are reached within a very short time distance, indicating the potential to establish FCCs serving small road hauliers. While it is not possible to conclude that the 'proposed' FCC are optimally located (further investigation is required, see 'Future research' below), it has provided a basis to further investigate the most appropriate locations of FCCs serving the city and its surroundings (avoiding sub-optimisations), as well as a larger number of participants, and whether and under what conditions FCC establishments are viable.

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