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Spatial patterns of logistics facilities in Gothenburg, Sweden

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Spatial patterns of logistics facilities in Gothenburg, Sweden

Abstract

In recent years, the location of logistics facilities, in particular with regard to “logistics sprawl,” has emerged as a topic in the literature—that is, a process of spatial decentralisation of logistics facilities in large metropolitan areas. The aim of this paper is to look at logistics sprawl patterns in the Gothenburg metropolitan area, in the south-west of Sweden. Looking at a medium-size monocentric urban region that is also a major port gateway for the country, this study provides novel elements in the study of locational patterns of freight facilities in metropolitan areas. It also provides an opportunity to identify the role of freight in planning, land use and zoning policies. A literature review is carried out on the issues of freight and logistics facilities locational patterns. A quantitative analysis is proposed, using data from Swedish statistics about the number of establishments with a NACE code related to logistics, as well as an original method providing a “cleaned” and more comprehensive dataset. We look at data at two different scales, one metropolitan and one regional, for years 2000 and 2014, as to enable a comparative and diachronical analysis. Logistics sprawl is measured by the average distance of warehouses to their common centre of gravity. Finally, interviews with transport and logistics providers as well as real estate investors and public agencies in the region, add qualitative information on the relative importance of different location factors related to logistics facilities and the issues raised. Logistics sprawl in Gothenburg occurs in specific ways, and differently at the two geographical levels of analysis.

Keywords: Gothenburg, logistics sprawl, urban structure, freight planning, logistics facilities, warehouses

1 Introduction and research statement

Logistics sprawl is defined here as a process of spatial decentralisation of logistics facilities¹ in large metropolitan areas (a more detailed definition is provided below). The aim of this paper is to analyse these locational patterns in the Gothenburg Metropolitan Area (GMA) and the county wherein it is located, namely Västra Götaland County (VGC), in the south-west of Sweden.

In recent years the location of logistics facilities has emerged as a topic in the literature (Cidell, 2011; Dablanc, Rakotonarivo, 2010; Raimbault et al., 2012; Sakai, 2015; Woudsma et al., 2016; Alijohani, Thompson, 2016). A set of 25 case studies around the world has been identified and a preliminary comparative analysis has been proposed in Dablanc et al. (2017). Many of these case studies describe a movement of decreasing presence of logistics facilities in urban centres, and their relocation towards more peripheral areas, also designated as logistics sprawl. This borrows from the concept of “urban sprawl” which, through an extensive literature, has discussed the morphological and functional changes of the location of people and activities that have transformed cities. Logistics facilities also participate in the metropolitan expansion (Heitz, Dablanc, 2015).

Changes in the economy and production and consumption patterns have involved important transformations in supply chains, translating into changes in types and volumes of commodities, location of departure and destination points, traffic flows, frequency of deliveries, and time of freight movements (Ogden, 1992). Large metropolitan areas have played an increasing role in these new supply chains (Hall, Hesse, 2013), concentrating flows and shipments’ processing. Technological developments have facilitated these changes, including digitization of communications and the standardization of logistics factors of production (Veltz, 2017). The growth and internationalization of specialized industries such as third-party logistics provision and logistics real estate and facilities management, have also contributed. Consequently, freight movements and the location of logistics facilities in metropolitan areas have dramatically changed over the past two to three decades, described as the “persistent urbanisation of freight” (Hall, Hesse, 2013, p.247).

The proximity to consumption markets, as well as accessibility and availability of transport infrastructure are commonly reported as explanation factors for the location of a logistics facility in a major metropolitan area. Availability of a local labour market and the role of attractive public policies (in favour of developing logistics

¹ In this paper, we use indistinctly the terms 'logistics facility', 'freight facility', and 'warehouse,' the latter being used commonly - although not always correctly - in the literature. Our purpose is to investigate all types of logistics facilities, defined as buildings where freight shipments are processed one way or the other during a specific supply chain operation.

policies) are also important location factors (Merenne-Schoumaker, 2008). The availability of land is another key factor, and one that can explain that while polarizing in large metropolitan areas, logistics facilities increasingly find themselves in the periphery of metropolitan areas. Logistics operators, or their real estate investors (and often subsequent landlords), look for space, following the new standards for warehouses (which require large spaces), and for cheap land/rent. These can be found at the edges of urban areas, often in former agricultural lands. Endogenous factors also explain logistics decentralization. Urban renewal, changes in regulated land use in dense parts of the metropolitan areas, create a less welcoming frame for logistics facilities. Urban pressure increases, warehouses become more vulnerable and subject to a relocation to peripheral areas, in “pro-logistics” municipalities that see them as job and revenue pourvoyors (Raimbault, 2014). Like most port activities, but with more spatial flexibility (as ports retain a certain amount of spatial inertia), logistics facilities have generally been relocated to peripheral areas under the effect of urban transformations. At the same time, many ports in metropolitan areas have retained a key influence for the location of logistics facilities and port-related activities (Hall, 2013).

The consequences of logistics sprawl can be land consumption, increasing distance of final deliveries, and changes in the logistics system, presenting a new challenge for planning the metropolitan area at local and regional scales.

In continuity with these works, we propose an analysis of logistics locational patterns in the GMA, Sweden, between 2000 and 2014, based on an original method of collecting a comprehensive dataset of warehouses. The case of Gothenburg is interesting in several ways. It is medium-size (in population) city, contrasting with other examples in the literature. It is also the home of Scandinavia’s largest port. GMA’s influence on logistics activities (and locations) goes far beyond the metropolitan area itself. Thus, an analysis of logistics locational patterns at the county level is also carried out. To include both metropolitan and county levels adds to the diversity of case studies currently conducted on spatial location patterns of warehouses in several metropolitan and urban regions in the world (Dablanc et al., 2017). This analysis allows us to put into perspective the development of the location of logistics facilities that occurred. Indeed, in the case of a maritime metropolitan area, logistics locational patterns can also be influenced by the evolution of the seaport and its hinterland.

This study also provides an opportunity to look at several surrounding issues such as the factors influencing industry decisions related to the siting of logistics facilities, the impact of the nature of logistics facilities on logistics sprawl, as well as the role of planning, land use and zoning policies in the location of freight facilities.

After a presentation of the Gothenburg case (Section 2), we describe the data and method used (Section 3). We then identify changes in the location of logistics facilities in the GMA (Section 4) and the VGC (Section 5) between 2000 and in 2014, specifying logistics sprawl indicators for both areas as well as providing industry perspective to provide more qualitative specifications of the quantitative trends observed. Finally, we present conclusions and perspectives in Section 6.

2 The Gothenburg case

The GMA is made up of 13 municipalities (including the City of Gothenburg) in the VGC, located on the west coast of Sweden. GMA and VGC are our two cases of investigation. The GMA represents 3700 km² and 973,000 people, translating into a density of 264/km², while the VGC, with 48 municipalities, has a population of 1.6 million and an area of 22,752 km², hence a density of 67/km².

Gothenburg is the second largest metropolitan area in Sweden. Its business clusters include automotive (e.g., Volvo Cars and Volvo Trucks), manufacturing industry (e.g., SKF), process industry (e.g., Preem and St1 oil refineries), biomedicine (e.g., AstraZeneca), environment technology, infrastructure and logistics (e.g., DB Schenker North), design and market communication. Port of Gothenburg acts as gateway to Scandinavia and some 25% of all Swedish foreign trade and 65% of all container traffic pass through the port (Port of Gothenburg, 2016). In 2017, however, the container port operated by APM Terminals was severely struck by a labour union conflict resulting in a 19% decrease of container throughput (Port of Gothenburg, 2018). The port handled 41 million tons of cargo in 2017, segmented into 24 million tonnes of oil, 644,000 TEU of containers, 593,000 RoRo units and 295,000 cars (Port of Gothenburg, 2018). Only a tiny share of the goods is transhipped directly to other ships and the port has a remarkably good balance between imports and exports.

Establishment of logistics facilities in Gothenburg often aims to serve the entire Scandinavian region. Accordingly, both Port of Gothenburg and Landvetter airport play an important role as logistics centres. Landvetter airport, located approximately 25 km to the east of central Gothenburg is Western Sweden’s international airport, second largest in Sweden, and particularly strong on cargo due to its geographical location in relation to freight-generating business in Scandinavia. The latest Gothenburg Master Plan identifies the area

around the North Trail and E6 north as a logistics area, states that these large industrial and logistics areas are to be preserved for this purpose and should not be freed for regeneration activities, and notes that good access to this area should be secured (Gothenburg City Planning Office, 2009).

3 Method and data

The method we used is based on the collection and analysis of spatial data about warehouses in Gothenburg (including an original method to “clean” warehouses’ databases), as well as on-site semi-structured interviews with transport, logistics and real estate stakeholders and representatives from both local and regional public authorities.²

In order to measure changes in the location of logistics facilities, we investigated logistics facilities location at different time periods. Similar to many European countries, there is no dedicated database on warehouses and logistics facilities in Sweden. We used the NACE (European industry classification system) to identify establishments with warehouses in Statistics Sweden’s database. NACE code 52.10 (“warehouses”) is however not fully satisfactory. Several establishments with warehouses but whose main activity is not warehousing are not identified with this code. For instance, in 2014 only 51 warehouses were identified under the NACE code 52.10 in Statistics Sweden’s database for GMA, which obviously underestimates the actual number of logistics facilities. As an alternative, we developed a methodology to build a new database based on national establishments databases, fieldwork and satellite image reconnaissance. We describe this methodology below, which resulted in 207 warehouses identified in the GMA in 2014.

To identify the location of logistics facilities in the areas of study, we used a database containing all economic establishments with a minimum of five employees in Sweden provided by Statistics Sweden. Data is available for all years, but we prioritised two years (i.e. 2000, and 2014) to make a diachronic analysis possible. In this study, only data for 2000 and 2014 is used, in order to measure the overall trend. This database contains key establishment information, including: name of company owner; type of activity in the form of a NACE code that classifies activities into 732 subclasses; number of employees; address; and type of ownership. The address allows us to geocode the establishments precisely using a GIS software.

The first step was to extract all potential logistics establishments from the database, using NACE codes shown on Table 1. The use of NACE codes entails the following difficulties. This classification is based on the activity declared by the economic establishment upon creation; thus, it is very likely that an establishment is assigned a code that does not reflect exactly the economic activity (there are 732 classes and some of them overlap). In some cases, there could be changes in the NACE classification between years; however, these changes are inconsequential between 2000 and 2014 for logistics and transportation.

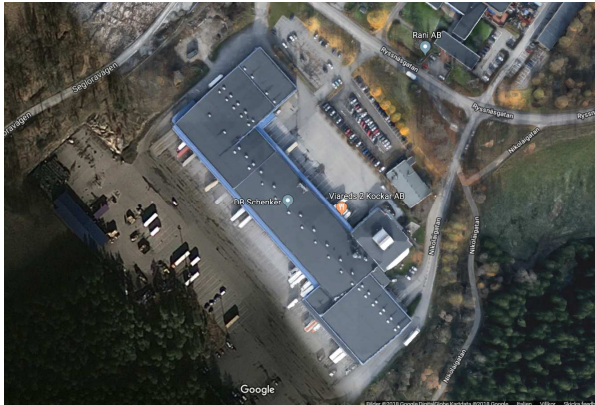
Table 1: NACE codes used for the primary extraction of logistics establishments (Source: Statistics Sweden, www.scb.se/eng)

NACE code	Description
49.41	Freight transport by road
52.10	Warehousing and storage
52.21	Service activities incidental to land transportation
52.22	Service activities incidental to water transportation
52.23	Service activities incidental to air transportation
52.241	Harbour cargo handling
52.242	Other cargo handling
52.29	Other transportation support activities
53.20	Other postal and courier activities

This first extraction led to 612 establishments in VGC in 2014. A major difficulty when using these codes to identify logistics facilities is that as some companies favour own-account logistics and organise their transport activities themselves, they may fill in the NACE code of their main activity for all their establishments, including their logistics establishments. This is not the case for all companies, several companies are very thorough when filling out their documents, and it is possible to find several well-known brands (in the retailing industry

² Interviews were carried out over the period March 2016-June 2017 with PostNord TPL, Bockasjö, Catena, DB Schenker Logistics, Prologis, Business Region Göteborg, Västra Götaland Region, the City of Falköping, the Port of Gothenburg.

especially) when browsing the names of the logistics establishments. Another difficulty with NACE codes is that some of them correspond to passenger transportation as well as freight transportation, especially auxiliary services for land, air and waterway transportation (52.21, 52.22, and 52.23), so it is necessary to make a distinction. Furthermore, several establishments, especially those located downtown, are head offices of large transport and logistics companies and not actual logistics establishments. Finally, within logistics establishments, the NACE code does not inform as to the exact activity of the establishment (which would allow us to distinguish between the parcel industry and other logistics activities for example). After we extracted logistics establishments in GMA and VGC, several filters were put in place to estimate their number more precisely. A detailed overview of the names of the establishments allowed us to discard some records, such as for passenger transport (about taxis, air travel, or public transport). The most important work was to gather information through the observation of satellite images of the addresses and observation of street photographs (Figure 1) using Google Maps and Google Street View. Street photographs were usually dated from 2015. We checked for the morphology of the building, the presence of truck parking, docks, doors, and names. This methodology is the simplest way of determining which establishments contain logistics facilities.



Address: RYSSNÄSGATAN 15, BORÅS
 Warehouse: KALLEBÄCKS TRANSPORT
 (DB SCHENKER)

Figure- 1: Example of satellite image used for logistics establishment reconnaissance. *Source:* Google Maps.

Using the satellite images, names and address, we could remove 36% of the 612 identified establishments. This resulted in 390 warehouses estimated for 2014 in the VGC. Within this total, we reached a total of 207 warehouses for the GMA itself.

For 2000, it was not possible to fully use the same method as we were missing satellite images of that time. First, we compared the 2014 location of logistics establishments with the location of the same establishments in 2000. When the addresses and names of the companies matched, we considered that the 2014 warehouse already existed in 2000. When we were not able to find a warehouse at the same address, we considered either that it was not existent at that time (the 2014 warehouse was built after 2000), or it was relocated somewhere else. We therefore looked for the name in the rest of the region. We also looked at the same address, in case of a change in owner or user. Finally, for warehouses from year 2000 not recurring in the 2014 database, we looked at their address and checked with Google Map and Street view if there was an actual warehouse that may have been missed in the 2014 database, or classified in a different NACE class.

To measure the potential sprawl of the logistics facilities we identified, a centrographic analysis was used. Centrography provides a way of computing the degree of dispersion of a scatter of points (here, each warehouse). It is a method providing a basic but robust and objective quantitative measure of sprawl patterns. It also provides a graphic summary: the Standard Deviational Ellipse (SDE). Those two tools are more efficient when they are used together (Khan 1986). We used ArcGIS to calculate the sprawl indicators (Michell, 2005). We compared the mean distance of warehousing establishments (places of business) from their common centre of gravity for 2000 and 2014. Let us note that we weighted each warehouse by its class of number of employees, contrary to the method used in other logistics sprawl studies (listed in Dablanc et al., 2017, for example). It provides a more accurate picture of the trends (a big warehouse “counts” for more than a small one). It also tends to “mitigate” the sprawl indicator compared with other case studies, as many new large warehouses in Gothenburg are close to the urban area (50% of warehouses of more than 200 employees, which except for one have been built after 2000, are located in the municipality of Gothenburg).

To consolidate our results and observations, as specified earlier, a series of interviews with transport, logistics and real estate providers as well as public agencies in the Gothenburg area were carried out. The conclusions we can draw from these interviews mostly converge with (and provide some explanation to) the main features of the

locational trends we observed through the quantitative analysis.

4 Logistics sprawl in the Gothenburg metropolitan area

4.1. Location of the warehouses in the GMA

Figure 2 shows the location of warehouses in the metropolitan area in 2000 and in 2014. It shows a high concentration of logistics facilities in the centre of the GMA, which parallels the monocentric urban structure of the area.

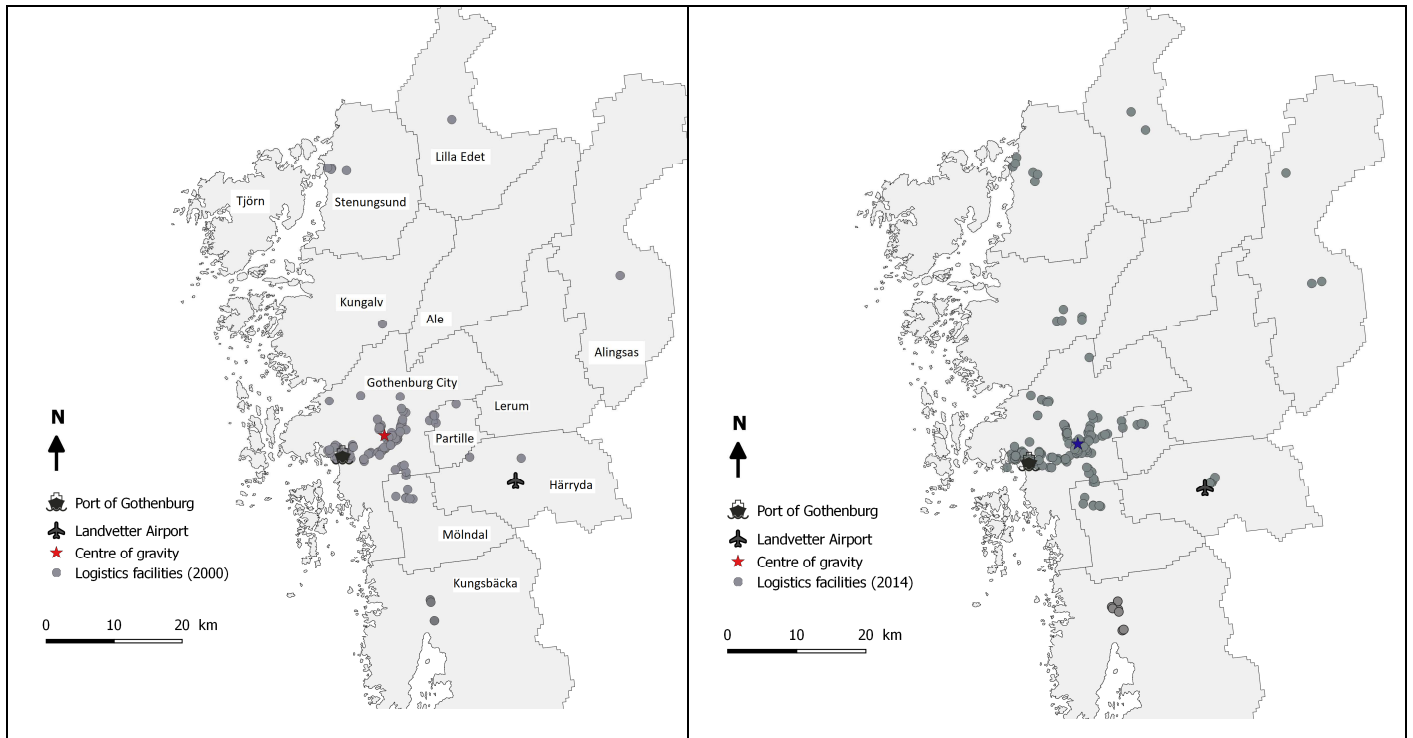


Figure 2: Location of warehouses in GMA in 2000 (left) and 2014 (right)

Warehouses increased both in number and in size (as expressed by the relative growth rate of warehouses with more than 200 permanent employees) in the dense part of the metropolitan area in 2014 compared with 2000 (Table 2). The city of Gothenburg remains the main choice of location for warehouses in the GMA. This concentration is mainly related to its proximity to the Port of Gothenburg, but also (and to a decreasing extent over time) to the intermodal terminal located in the city centre close to the central railway station and Post terminal until it was replaced by an extension of the intermodal terminal in the port area (Monios et al., 2018), which was inaugurated in February 2018. The old terminal was well located adjacent to the main roads E45, E6 and E20 and it acted as a key element of the logistics landscape (Jernhusen, 2010). The presence of warehouses in the city centre is also related to the inherited (historic) location of large industries (e.g., shipbuilding) and transport infrastructures (Olsson, Larsson, 2015). The high concentration of warehouses in the central areas, despite a high population density, can represent a challenge for public policies. On the one hand, it could increase freight traffic in the metropolitan area, bringing with it road congestion and air pollution. On the other hand, this concentration is also a way to maintain consolidated shipments close to the centre before final deliveries. Nevertheless, the intermodal terminal, consolidation terminals and warehouses in the city centre are now replaced by new residential and office buildings as part of urban densification in Gothenburg.

Table 2: Logistics indicators for the Gothenburg Metropolitan Area in 2000 and 2014 and change over time (percent).

Logistics indicators	Gothenburg metropolitan area		
	2000	2014	Change (%)
Population	810,000	973,000	+20.2
Area (km ²)	3695	3695	+00.0
Density (inhabitants/km ²)	219	263	+20.1
Number of warehouses	132	207	+56.8
Number of warehouses with more than 200 permanent employees	1	7	+600.0
Number of warehouses per million people	163	213	+30.6
Number of warehouses per 1000 km ²	37.4	55.5	+48.4
Mean distance from centre of gravity (km)	9.1	13.3	+46.2

Despite the growing number of logistics facilities in the city of Gothenburg, we observed a strong deconcentration dynamics (logistics sprawl) in the GMA between 2000 and 2014. The mean distance to the centre of gravity has increased by 4.2 km from 2000 to 2014, which means a relatively important decentralisation of the warehouses within the GMA (Table 2) and an increasing number of warehouses in the close suburbs. In Figure 3, the difference in the surface area between the dispersion ellipses of warehouses in years 2000 (in red) and 2014 (in blue) shows that sprawl has occurred.

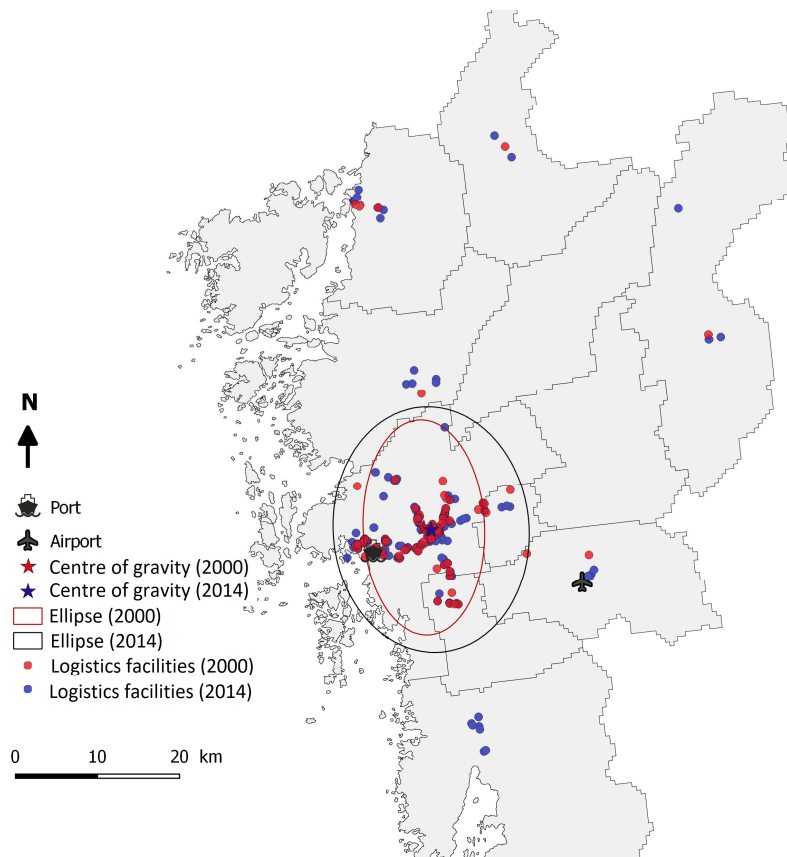


Figure 3: Logistics sprawl in the GMA

Gothenburg is smaller and less dense than other urban areas studied with regards to logistics sprawl (Dablanc et al., 2017), yet logistics sprawl happens. Here too, the decentralisation of warehouses may reflect a scarcity of available urban land and a land market that drives the demand for extensive freight handling facilities toward suburban areas.

Changes in the general dispersion of logistics facilities can be noted. Changes in location also seem to show the importance of transport infrastructure as a factor for location choice. We also observe clusters of warehouses in

the outskirts, in Landvetter (municipality of Härryda) where the main airport is located. This evolution of the location of logistics facilities in the GMA confirms the empirical results of Olsson (2012).

4.2. Factors of sprawl at the metropolitan scale

As mentioned in Section 1, metropolitan areas attract logistics facilities because they provide a proximity to consumption markets, as well as accessibility and availability of transport infrastructure. At a micro scale, logistics operators require large space and cheap land/rent. The land supply usually available around major cargo facilities such as a port, or an airport, is also important a factor for a location decision.

For the case of Gothenburg, it is difficult to differentiate between these various locational drivers. An empirical study (Olsson, 2012) shows that the relationship between transport-related accessibility and land prices affects firms' relocation decision, when some other locational factors appear to be less important in the case of Gothenburg. In Gothenburg, over time, the Port has relocated downstream gradually, though port facilities remained in the metro area relatively close to the centre, which is one main reason for the high concentration of warehouses in the GMA as well as their relative decentralization.

Interviews with the industry (see list of companies in the method section) provided a clarification on location choices for warehouses. At a macro-level, the Gothenburg metropolitan region seems to be increasingly attractive from the industry perspective, both for logistics developers and users of logistics facilities. The metro area offers large consumer markets, large employment markets, and high economic and population growth. For many companies, they also constitute hub areas from which it is convenient to ship/receive goods to and from the Nordic region.³

At the micro-level, land prices become a very important driver for location, favouring areas outside of the dense centres. Moreover, the recent production sites, warehouses and terminals are being consolidated into fewer and larger units, mostly at the fringes of the denser area (Olsson, Woxenius, 2014) where land parcels are available, as well as real estate from specialized investors.

What can be noted from our interviews is that other micro locational factors such as employees' accessibility are of "secondary importance," as most of the projected areas for logistics real estate development are now well connected by roads and public transport. The potential increase in last mile transport costs in the Gothenburg area which could result from a location further away than the current one is not sufficient either to offset the expected benefit of significantly lower rental prices. The only obstacle to full locational flexibility (apart from the land price factor) would be traffic congestion on some road corridors in the GMA, especially in north-south direction. This makes a location at the Landvetter airport more attractive.

To summarize, several factors were identified explaining the specific location of a logistics facility within a given metropolitan area: in decreasing order of mention during our interviews, the cost of land or rental price of a warehouse; the specific delivery/pick-up routes of transport contractors to and from a warehouse for first and last kilometres; easy access to a highway access point. The type of transported goods is also a variable, such as being or not maritime-related. Maritime-related activities such as the automotive industry tend to favour a location close to the Port of Gothenburg although transport cost savings are not always superior to additional rent if locating close to the port. A factor that has not been mentioned, and this goes against trends from other European markets, is the need to locate in a logistics cluster or park, with the services attached to these types of facilities (security, catering, etc.).

4.3. The Port of Gothenburg, a game changer

Under the Port's initiative, several projects are about to concentrate new logistics facilities' development within and just outside the port area. The whole area is marketed "Port of Gothenburg Logistics Park," with a motto: "From dock to warehouse in ten minutes." This future logistics area represents one million m² for logistics facilities, on two main sites, one being port property, the other one mostly municipal or Volvo property. The official objective, for areas closest to the port, is to favour activities that will have some connection with maritime transport, although activities of all sorts may be interested, including e-commerce retailers potentially interested in a reduction in lead time between orders and deliveries. The programme developed includes nearly one million m² for logistics warehouses on two sites which will bring the total logistics sites for the Port to 4 to 5 million m². In addition to the port of Gothenburg, the other owners of the Logistics Park are Bockasjö, Ekländia,

³ If a distributor's market area is related to Norway and the Swedish west coast, Gothenburg will be a favourite chosen hub, providing logistics real estate, workforce and know-how. If the market area is connected to Finland and the Swedish east coast, Stockholm will be the convenient location. In both cases, the largest metro areas are favoured, despite land prices.

NCC, and Prologis, the main logistics property investors in Sweden, with the collective capacity to build 500,000 m². These are ‘speculative’ developments (future users are not yet known), which is rather uncommon for the Swedish market. Together with the private investors, the Port promotes the new developments at real estate exhibitions in Europe. Initially, the Port’s initiative to open up land for logistics development in Gothenburg was not welcomed by other investors. Even though they now cooperate and co-invest, they believe there is a risk, in long term, of supplying too much logistics land, decreasing rental prices and damaging their business model.

The PostNord case is a good illustration of the trends. PostNord TPL (Third Party Logistics) is a subsidiary in the PostNord group, the main mail and parcel company in the Nordic countries jointly owned by the Swedish and Danish states. While the location of PostNord TPL’s current 14 warehouses in Sweden can be explained largely by history as well as land prices, PostNord strategy today is to concentrate regional operations in a single building while also increasing its presence in the densely populated regions (Stockholm and Gothenburg), “despite higher labour costs.” For this, the company is hopeful that the new situation generated by the developments around the Port of Gothenburg will provide logistics property at lower prices in the near future. Gothenburg so far had high rental prices for logistics space (estimated in 2016 at 70-80 €/m² per year for Gothenburg and over 80 € for Stockholm). More remote locations such as Norrköping and Helsingborg provided prices at around 40-50 €. According to PostNord, the situation could change with more supply and subsequent lower rental prices to be expected from the upcoming addition of real estate supply of logistics facilities.

Another change mentioned in our discussions with the industry that may reinforce the port’s attractiveness for logistics activities is the intermodal terminal just outside the gates of the RoRo and container ports that was inaugurated in February 2018.

5. Changing scale and new perspectives: the location of warehouses in the Västra Götaland County

5.1. Location of logistics facilities in VGC

In Table 3, we can find general indicators for warehouses in the VGC.

Table 3: Logistics indicators for the Västra Götaland in 2000 and 2014 and change over time (percent)

Logistics indicators	Västra Götaland County		
	2000	2014	Change (%)
Population	1,495,000	1,615,000	+8.1
Area (km ²)	22,752	22,752	+0.0
Density (inhabitants/km ²)	66	69	+4.5
Number of warehouses	261	390	+49.4
Number of warehouses with more than 200 permanent employees	3	10	+333.3
Number of warehouses per million people	175	242	+38.2
Number of warehouses per 1000 km ²	11.5	16.7	+45.2
Mean distance from centre of gravity (km)	79.3	82.0	+3.4

In Figure 4 we can appreciate the spatial changes and growth in the number of warehouses, while distinguishing several municipalities that seem to be specifically attractive for warehouses, at distances 60-150 km from Gothenburg. Municipalities of Skövde, Linköping and Falköping, located on the margins of the VGC, experienced an increase in the number of logistics facilities. On the other hand, they represent a small part of the number of logistics facilities. We also observe an important growth in the number of warehouses located in the municipalities on the edge of the GMA such as Borås (+25%) or Trollhättan (+37.5%) (which, together, accounted in 2014 for nearly 12% of the logistics facilities of VGC). But, even at the regional scale, the GMA remains the most important place for logistics. In 2000, 50.6% of the warehouses in the VGC were located in the GMA, and in 2014 this number slightly increased to 53.1%. The GMA has increased its share for the concentration of warehouses at the regional scale.

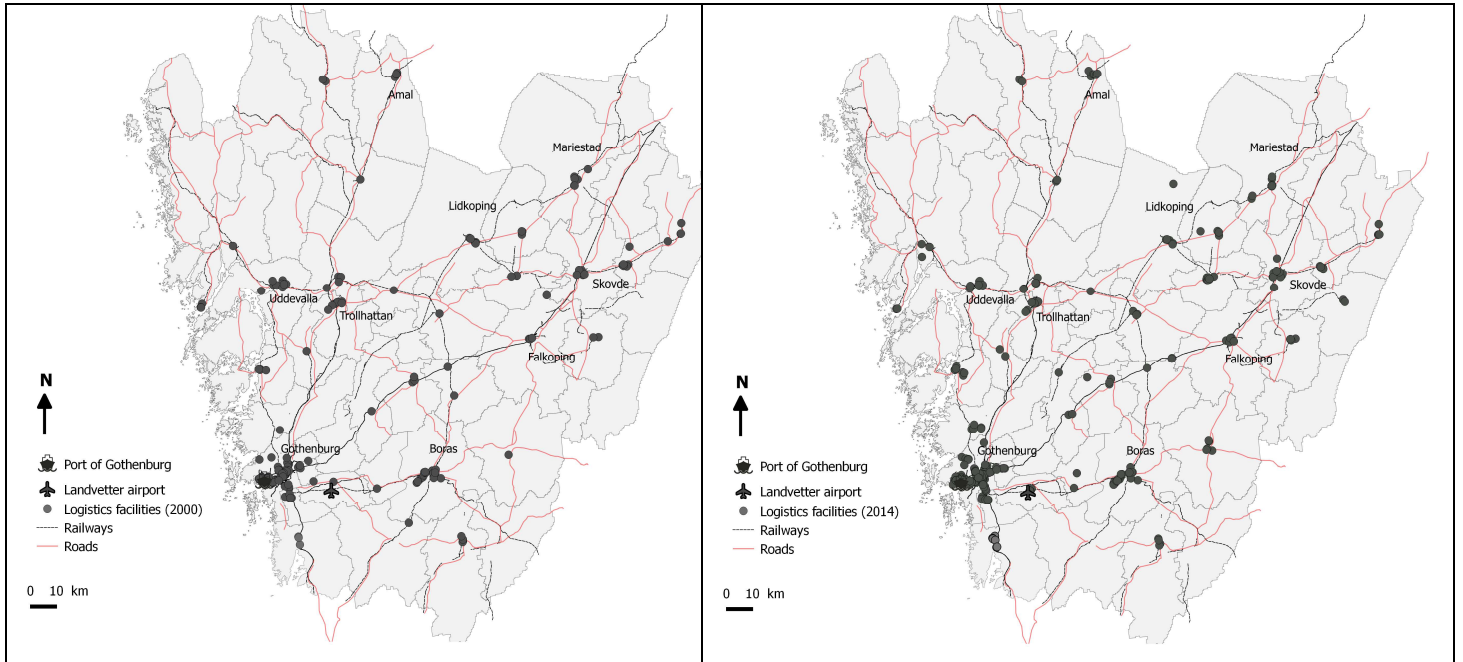


Figure 4: Location of warehouses in Västra Götaland County in 2000 (left) and 2014 (right)

5.2. Deconcentration and reconcentration of warehouses in VGC municipalities

The mean distance to the centre of gravity has increased by 2.7 km from 2000 to 2014 in the VGC. This indicates logistics sprawl at the regional scale, but in a lesser proportion than in the GMA. We observe however a persistent concentration of logistics facilities within the GMA. While the number of warehouses is increasing, they are also spreading around the metropolitan area, but not as such a rapid rate in the rest of the VGC. The number of warehouses in the most populated municipalities of VGC (other than the GMA) increased by 37%; while it increased by 57% within the GMA. The increasing weight of the GMA can be appreciated in table 4, where it is compared with that of other municipalities in the VGC. We grouped all the most populated municipalities of the VGC (Borås, Trollhättan, Uddevalla, Skövde, Lidköping, Vanersborg, Mark, Falköping). The growth in the number of logistics facilities in these agglomerations is on average slower than in the metropolitan area of Gothenburg. As seen earlier, over half of the warehouses in the region are now located in the GMA (50.6% of them in 2000 and 53.1% of them in 2014).

Table 4: Number of warehouses in the Västra Götaland County in 2000 and 2014, and change over time

	Number of warehouses 2000	Share in VGC 2000 (%)	Number of warehouses 2014	Share in VGC 2014 (%)	Changes in number of warehouses (%)
GMA	132	50.6	207	53.1	56.8
Most populated municipalities of VGC (other than GMA)	73	28.0	100	25.6	36.9
<i>Borås</i>	28	10.7	35	9.0	25.0
<i>Trollhättan</i>	8	3.1	11	2.8	37.5
<i>Uddevalla</i>	14	5.4	18	4.6	28.6
<i>Skövde</i>	9	3.4	14	3.6	55.6
<i>Lindköping</i>	7	2.7	8	2.1	14.3
<i>Vanersborg</i>	4	1.5	8	2.1	100.0
<i>Mark</i>	0	0.0	0	0.0	0.0
<i>Falköping</i>	3	1.1	6	1.5	100.0
Neither GMA nor eight most populated municipalities	56	21.4	83	21.3	48.2
VGC	261	100	390	100	49.0

As can be seen from Figure 5 below, both in 2000 and 2014 the dispersion ellipse is elongated from west to east, which means that logistics facilities are dispersed along infrastructures such as roads (E6/22, E20, E45, Rv40) or railways (the Western Trunk Line) that connect Gothenburg to the east, to Stockholm and Jönköping. Rail freight transport in Sweden has increased for the past 20 years, and access of industries to rail lines has been a main target (Gothenburg City Planning Office, 2009). The Bohus Line is an important line for freight trains, as well as the Western Trunk Line, as seen from the cluster of Skövde-Falköping (appr. 150 km northeast of Gothenburg, see Figure 4). Thus, the proximity to that type of transport infrastructure seems to remain an important location factor for warehouses, although this may not be as crucial in the future.

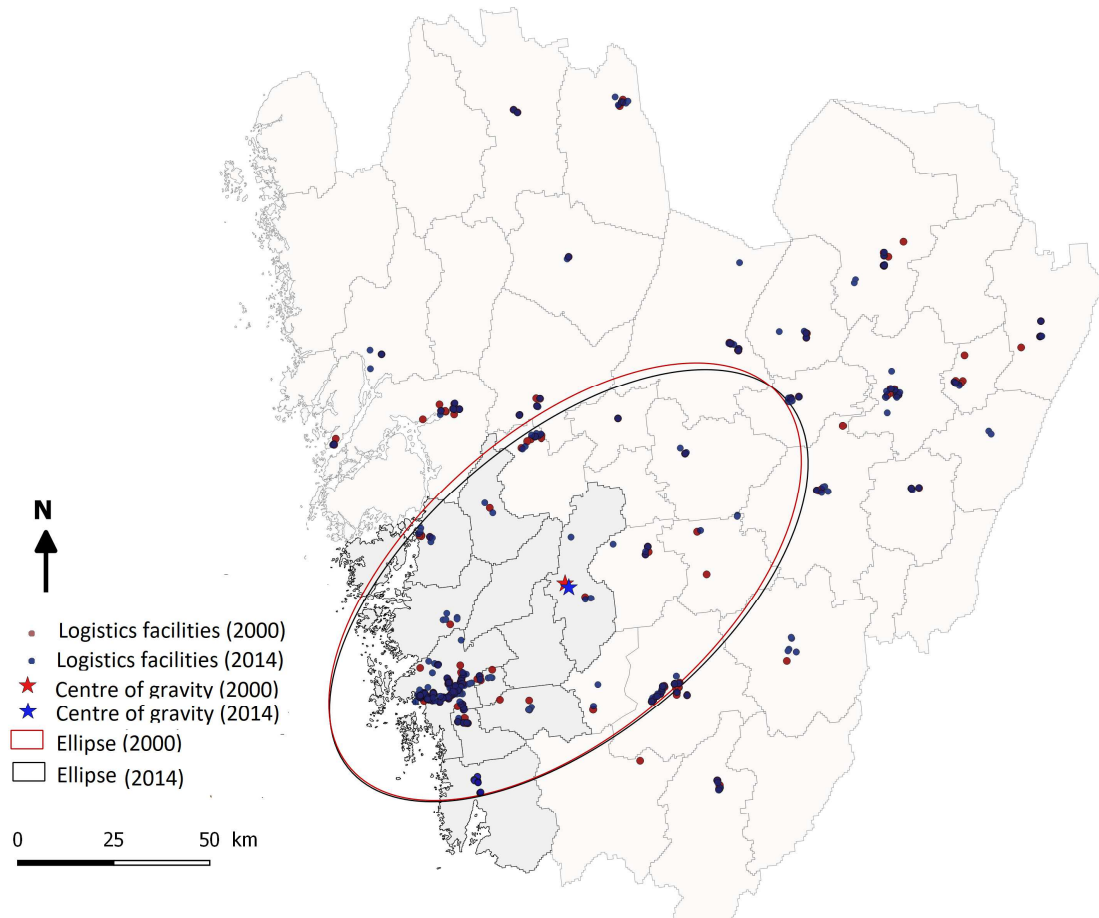


Figure 5: Logistics sprawl in the Västra Götaland County

The example of the municipality of Åmål, on the shores of Lake Vänern 180 km from Gothenburg, illustrates how municipalities in VGC have designed strategies to attract logistics facilities, expecting new jobs (Monios, Bergqvist, 2016). Åmål implemented an intermodal transshipment terminal, one of the few terminals in Sweden with access to inland waterways. The terminal started operating in 2005. Before the introduction of the new terminal, Åmål had an old rail-road terminal which carried about 2000 containers per year but was located next to the passenger terminal and, for safety and low capacity reasons, was to be moved to another place.

The case of the municipality of Falköping is another example. In 2000, the municipality of Falköping submitted a proposal for an intermodal terminal in the area. The location of the terminal took a long time and required the production of many studies. However, at the end of 2006, when the largest Swedish forest products company, StoraEnso, showed interest in the region and in a 40,000 m² facility (Monios, Bergqvist, 2016), the works for the construction of the terminal began. Today, the municipality wants to go further and develop a logistics park, ideally to promote railway operations but which can be disconnected from a direct use of rail.

In addition, more centrally located cities like Örebro and Jönköping offer good locations for central warehouses serving the Nordic countries. Although Swedish manufacturing and trading firms, like in other countries increasingly leave it to third party logistics providers or investors to decide on warehouse location, many retain a close look. We were given the example of a home electronics company that analysed cost of transportation, access to labour force, and access to good housing and day care. A “committed staff” can also make a company choose to locate in a smaller city, such as Jönköping, 150 km east of Gothenburg, which accommodates 1.5 million m² of warehouses today. However, Jönköping represents a “mature market” and is not considered a hot spot anymore by several companies we interviewed.

5.3. Two different visions for logistics development

The seemingly increasing attractiveness of Gothenburg metropolitan area for logistics development (Section 4) may not be in par with strategic planning decision-making at the municipal and regional levels. The Västra Götaland county authorities, as we heard from interviews, aim at “fair regional development,” and are reluctant to port-centred logistics if it were to become dominant. However, municipalities outside of GMA are not as attractive as they used to be for logistics activities. As we saw above, cities such as Falköping, which has based its logistics attractiveness on the provision of good intermodal services, finds itself in difficulty today, with an apparent relative disinterest of investors for this location, as the benefit in terms of lower rental prices does not compensate for the additional distance to Gothenburg. Insufficient volumes (as well as, as rail is concerned, competition with other intermodal terminals in the region) have made new projects relatively more difficult to develop.

6. Conclusion and perspectives

In this article, we have examined the case of Gothenburg, Sweden in relation to the issue of the location of logistics facilities in metropolitan areas. This topic has generated recent interest from research works in geography, regional science and planning in several cities around the world. The case of Gothenburg, a medium-size low-density city on the west coast of Sweden, also an important logistics hub for Scandinavia, is an interesting addition to previous case studies. We have collected and processed data on the number and location of logistics facilities in the metropolitan (Gothenburg metropolitan area) as well as the regional (Västra Götaland County) areas of Gothenburg between 2000 and 2014, and we have engaged a series of interviews with local stakeholders. Our main findings include the following.

- 1) Methodological finding. A careful examination of the Swedish databases for business establishments led us to provide a more realistic set of data for logistics facilities in years 2000 and 2014: about 40% of so-called warehousing establishments were removed from the original list, as they were not freight-related or were misrepresented as warehouses. We did that by selecting the most appropriate NACE codes, then checking consistency by identifying names and addresses, and a visual examination of satellite images.
- 2) Increase in the number of warehouses. The number of warehouses in Gothenburg has increased between 2000 and 2014: +57 % in the GMA and +45 % in the VGC. This actually translates into an increase in the number of warehouses per capita as well as per square metre in both the metro area and the county. This finding is in par with other case studies in Europe and the USA, demonstrating that current supply chains require an increasing number of metropolitan buildings where freight shipments are processed.
- 3) Change in the location of logistics facilities over time. There is a general trend towards spatial decentralisation, especially at the metropolitan level: the mean distance of logistics buildings to their centre of gravity has increased by 4.2 km and 2.7 km respectively in the metropolitan area and the county between 2000 and 2014. Compared with other international case studies (in annual values), this is a medium to high level of sprawl indicator. This also means that small to medium size urban areas such as Gothenburg can experience logistics sprawl. Another finding is that, despite sprawl, freight facilities in majority remain concentrated within the denser part of the county: in the GMA, for more than 53 % of the facilities (a slight increase from 2000). Within the area, many freight buildings remained within the city of Gothenburg since 2000, despite an increasing pressure from the municipality to reorient the use of traditional industrial areas. The presence and economic importance of the Port of Gothenburg in the city certainly plays a role in that 'logistics permanence' in dense areas.
- 4) Industry perspective. For this article, we interviewed several stakeholders involved in logistics development and users of logistics facilities. These interviews confirmed, with some nuances, three main trends observed in the quantitative analysis. The two main consumer markets in Sweden are increasingly attractive to the location of warehouses and distribution centres, despite higher land prices; at a micro-level, logistics facilities tend to locate where rental prices are the most favourable; and the current strategy of the Port of Gothenburg, with new areas opening to warehousing within the port or in its vicinity, is changing logistics real estate development in Sweden, and providing specific characteristics to locational patterns of logistics facilities in Gothenburg. This new perspective is not always well received from stakeholders: some fear it will impact the market for warehouses and may decrease rental prices, threatening traditional real estate business models, while others see a risk in the concentration of logistics development close to Gothenburg at the expense of a more balanced vision of the region's development, and with some potential impacts on metropolitan traffic. We can also consider that Gothenburg, using the opportunity of available land in the port area, is actually achieving what some other cities in the world are only intending to do: increase the supply of logistics facilities closer to urban areas, to serve new demands as well as contribute to a decrease in logistics sprawl and associated impacts.

This work brings further research questions. First, the relationship between different city sizes, regions and warehouse location is still insufficiently understood, that is, the majority of studies have almost exclusively focused on large metropolitan areas (Alijohani and Thompson 2016). The one-sided focus on large metropolitan regions also obscures how differently-sized cities and regions are functionally integrated into the wider national and international space economy leaving room for potential alternative and more context-aware explanations of warehouse location processes. Gothenburg as a case study could be the first of a series of works looking at medium-sized metro areas integrated in their regional and international contexts.

Another question relates to the potential differences in spatial patterns between various segments of logistics real estate. Warehousing means different things for parcel and express transport versus e-commerce fulfilment and deliveries, large retail distribution, or the supply of manufacturing parts. Logistics characteristics differ significantly with, for example, the area, commodity or traffic modes the facility is connected to, or the time products stay in the facility, and if value added services are provided. Our interviews in the Gothenburg region revealed sectorial strategies, that we could not research further in the limits of this article, but which could deserve specific attention in the future. The logistics sprawl literature is often unclear and makes little distinction as to what type of logistics facility is studied. More segmented studies could provide considerable nuances in terms of locational patterns, and planning policies eventually associated to them.

A third direction for research directly relates to the case study we have been looking at. In the case of Gothenburg, a gateway for 25% of all Swedish foreign trade, and one where the port owns attractive and available land for development, specific issues arise. An increasingly important one is labour. Like many ports around the globe, the Port of Gothenburg has a long history of labour union conflicts. The labour dispute in the APM Terminal's container port mentioned above intensified after the empirical work of this article. This has lowered the sentiment of investing in warehouses in the vicinity of the port. Particularly, it relates to warehouses closely connected to the port operations, for which the premium rents only make sense with reliable port operations. There is certainly room for more research on how the robustness of freight operations affect warehouse location decisions characterised by large sunk costs with long depreciation times.

On a wider scale, the Port of Gothenburg is also exposed to potential competition from major transport infrastructure projects elsewhere, such as the Fehmarn Bält rail- and road-tunnel project connecting Denmark and Germany. This project may restructure freight flows, disadvantaging the Port of Gothenburg, since freight destined for continental Europe and/or the large ports in Germany, Netherlands, and Belgium can be transported directly without additional on-/off-loading interruptions in the Port of Gothenburg.

Finally, the Gothenburg case also opens the question of the types of policy and decision-makers that can actually influence warehousing spatial patterns. In Gothenburg, the port authority, as a land owner and a significant economic player, has a specific weight in policy-making. In other cases, different local alliances will be at play between the various public and private stakeholders. Very few studies so far have been looking at the political science of warehouse zoning, planning, and development.

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