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Comprehensive evaluation on urban freight logistics in selected tertiary industries of Oslo

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CONTENT

ABSTRACT

City logistics, an important function integrated in city daily operations, aims to support the city's economic and social growth while eliminates environmental impacts to the minimum level. Nowadays, urbanization is still furthering its step fast and cities are becoming bigger in size and population. The limited city logistics capacities and already congested transportation systems are restraining cities from sustainable development. A number of problems in the current city logistics are needed to be identified and addressed.

The aim of this paper is to apply a data-driven methodology with the help of STATA and ArcGIS to analyse urban freight logistics system of Oslo, in alignment with "Det Grønne Skiftet" – The Green Shift Strategy, and offer a basic understanding of city logistics to the policy makers of Oslo. The policy makers can thus refer to our research result and improve the city logistics in line with the overall urban paling strategies.

Due to data's and time's constraints, we narrow down our research into the factors that are mostly relevant to commercial urban freight logistics, such as the population and the grocery stores. Further data can be input into analysis when different evaluations are expected to achieve.

1 Introduction

1.1 Overview of the research area

The concept of logistics often refers to logistics activities applied in business context to improve the efficiency of the operations from the perspective of private companies. From the point of view of a policy maker in urban planning, logistics is thought of as city logistics infrastructures which support activities from business and residents. This paper stands with the latter view and thus focuses on city logistics infrastructures, particularly on those that support the urban freight movements. This is due to the fact that goods movements in urban areas account for a substantial share in urban traffic system and therefore increasingly draw attention for current studies. The policy makers nowadays are aware of the challenges arising from goods transportation activities but in lack of data-driven methodology to support their decisions on investing in urban freight system (Dablanc 2007). Therefore, the expected high efficiency is not yet achieved. The inefficiency may lead to exhaustive use of gasoline which contributes to severe environmental problems. Intergovernmental Panel on Climate Change (IPCC) came up with a new report (2014) underscoring how serious the climate change was and would be. It emphasized that "stabilizing temperature increase to below 2℃ relative to pre-industrial levels will require an urgent and fundamental departure from business as usual". In 2012, urban population accounted for 79% of the emerging world's inhabitants, and it has been projected to reach approximately 85% by 2030 (Blanco and Franco 2013). Consequently, urban freight is often considered a nuisance from the public perspective (Blanco 2014).

Despite the technology development such as the use of electronic or hydrogen cars, better freight logistics helps to improve efficiency. And subsequently, a better freight logistics will help reduce the emission while maintaining its function of serving the society's needs and enabling mobility. More importantly, the Oslo Municipality is planning to set up more lanes for cycling and pedestrian use. How to make use of land smartly and improve the infrastructures, as well as develop an effective and efficient system to control city logistics, are thus highly relevant and important. By conducting the comprehensive evaluation with data-driven methodology on Oslo, we shall be able to assess Oslo urban freight system. The policy makers of Oslo can refer to our research results and thereafter make better policies for the city logistics in order to achieve their goals.

1.2 "Det Grønne Skiftet" – The Green Shift Strategy

"Det Grønne Skiftet", the Green Shift Strategy, is a strategy of Oslo Municipality that deals with climate and energy issues with two ultimate goals which are to reduce half of greenhouse gas emissions by 2030 compared to 1991 and to use 100% fossil-free fuels by 2050. Oslo authorities see a serious problem with global warming. Therefore, they argue that a green shift in energy consumption and production is a must in order to build a renewable and sustainable society. Furthermore, they take into account the forecast that 70% of world population will live in cities by 2050 and thus environmentally friendly urban development is essential. One of their main proposal is to invest in infrastructures of the city that lay the foundation for transportation and construction, aiming to eliminate fossil fuels burning that generates harmful emissions.

There are 9 chapters in the Green Shift Strategy report illustrating specific targets, current status, challenges, opportunities, framework, and a roadmap to achieve all of the objectives. In Chapter 6, Oslo has expressed its ambitious goal of a fossil-free city as follows,

- Good availability of fossil-free fuels and stations.
- Bicycle would increase to at least 16% share of every day travel by 2025.
- All new taxis will use fossil-free fuels from 2020.
- Fossil-free of public transportation by 2020.
- All goods-transportation should use fossil-free vehicles or rechargeable hybrids from 2025.
- 10000 hydrogen vehicles within Oslo and Akershus by 2025.
- Emissions from distribution centers should be reduced 50% by 2020.
- Oslo should facilitate at least 30% of "heavy goods traffic" through Oslo with renewable fuels.
- A sustainable mobility plan for Oslo by 2018.

These targets relate to almost every aspects of transportation regarding public transportation, goods transportation, etc. Hence, a comprehensive evaluation on current city logistics system is a must for the policy makers in Oslo before making any urban planning.

2 Literature review

2.1 City Logistics and urban freight system

The concept of "City Logistics" used in this paper follows the definition presented by Taniguchi and Thompson (2001) as the process that globally optimizes urban freight systems by considering the costs and benefits of schemes to the public as well as the private sectors. Urban freight systems refer to issues between carriers and shippers operating within a transportation infrastructure. As pointed out by Taniguchi and Thompson, urban freight systems are confronting with many problems due to high levels of service and lower costs being demanded by shippers, with carriers having to operate in increasingly congested road conditions. These facts have resulted in rational efforts to increase pickup-delivery truck traffic in urban areas that is currently contributing significantly to traffic congestion, which results in negative environmental impacts such as air pollution, noise, and CO_2 emissions. In short, these issues are expected to be solved by actions originating from the concept of city logistics. Several logistics initiatives based on the concept of city logistics have been proposed in several cities such as advanced information systems, cooperative freight transportation systems, public logistics terminals, load factors control, and underground freight transport systems.

Regarding the urban freight transportation system, four key stakeholders are involved, namely shippers (wholesalers), freight carriers (transport companies), residents, and administrators. All of these stakeholders have their own specific objectives and tend to behave to their best interests. Therefore, city logistics models need to recognize these factors and issues such as transporting, loading and unloading goods at depots or customers, traffic flow on urban roads for freight vehicles as well as passenger cars, and the cost of those activities. Dablanc (2007) grouped city logistics challenges into six categories, which are highly congestion, limited dedicated infrastructure available, limited space to warehouse in stores/establishments, high retail diversity, increasing access restrictions, and deliveries fragmentations. Therefore, urban policies usually have following characteristics: focusing on people's mobility, minimal interaction with private sectors, mostly restrictive policies, no incentives, and no data-driven expertise to design urban freight policies (Blanco, E., and Fransoo, J. 2013).

2.2 Urban Indicators

With the aim of evaluating urban freight logistics, the researchers need to identify the urban indicators first. In Arabic the word for indicator means pointer, which describes how an indicator is intended to point towards some desirable state or course of action. Each indicator is actually a kind of small model in its own right, implying elements of cause and effect, of social norms that constitute progress, and of policy actions and outcomes.

The main difference between indicators and other kinds of data is that the connection with policy is, or should be, explicit. Indicators are about the interface between policy and data. A serious problem for urban policy making has been the lack of appropriate data at the city level. The urban indicators are thus created and introduced to help policy makers to understand and manage cities.

In urban planning, 13 groups of indicators are frequently used (Westfall, Matthew S., and Victoria A. De Villa 2001; Holden, Meg 2006; Turskis, Zenonas, Edmundas K. Zavadskas, and Jurgis Zagorskas 2006). In each of the group, there are several significant indicators. The 13 groups of indicators are as follows:

2.2.1 Population

The first group contains a series of indicators that describe basic demographic and socio-demographic characteristics of the city population, such as:

- *Urbanization*
- *City Population*
- *Population Net Density*
- *Age*
- *Average Household Size*

2.2.2 Equity

A second group of indicators include measures of economic deprivation, such as:

- *Income Distribution*
- *Women-Headed Households in Poverty*
- *Unemployment*
- *Informal Employment*

- *Expenditure on Poverty Reduction*

2.2.3 Health and Education

A third group of indicators specifically measures the society's achievements in health and education, such as:

- *Persons per Hospital Bed*

- *Child Mortality*

- *Infectious Diseases Mortality*

- *Adult Literacy Rate*

- *School Enrollment Rates*

- *School Children per Classroom*

- *Life Expectancy at Birth*

- *Tertiary Graduate*

2.2.4 Urban Productivity

A fourth group of indicators directly addresses measures of economic development.

- *City Product per Capita*

- *Employment by Industry*

- *Household Expenditure*

- *Investment by Sector*

- *Tourism*.

- *Cost of Stay*.

2.2.5 Technology and Connectivity

The fifth group of measurements also deals with economic development, especially in information and communications technology.

- *Corporate Headquarters*

- *Telephone Traffic*

- *Commercial Flights*

- *Internet Hosts*

2.2.6 Urban Land

The land use data are given very difficult to compare because they are expressed in absolute areas, not percentages; some cities show large amounts of land awaiting development, presumably reflecting lack of demand, and some of these also have large areas of vacant government land. The indicators include:

- *Urban Land*

- *Prime Commercial Land Price*

- *Prime Rental and Occupancy Cost*

- *Land Development Multiplier*

- P*ublic Open Space*

2.2.7 Housing

Housing represents one of the most basic of human needs, but this group of measurements is concerned less with measures of housing size or quality; it is concerned more with land use and land costs, including:

- *Dwelling Type*

- *Tenure Type*

- *House Rent to Income Ratio*

- *Floor Area per Person*

- *Housing in Compliance*

- *Homeless People*

- *Housing Production*

2.2.8 Municipal Services

Here are several sub-series of indicators for water, electricity, sewerage/wastewater, telephone, and solid waste collection that measure the delivery of basic service, whether by the public or private sectors, including:

- *Household Connections*

- *Investment per Capita in each service*

- *Operations and Maintenance Expenditure in each service*

- *Consumption of Water per Capita*

2.2.9 Urban Environment

This group of indicators relates closely to the last, since it includes measurements of solid waste generated, solid waste disposal, household sewage disposal, and wastewater treated. It also includes measurements of air pollution, energy use, noise complaints, and damage from natural disasters.

- *Household Sewage Disposal*

- *Methods of Solid Waste Disposal*

- *Wastewater Treated*

- *Solid Waste Generated*

2.2.10 Urban Transport

This group of indicators basically measures traffic, both of people and goods; it includes data on mode of travel to work, median travel time, car ownership, port and air activity, and goods carried by different modes. It also includes some indicators that effectively measure the impact of public policies.

- *Mode of Travel*

- *Median Travel Time*

- *Expenditure on Road Infrastructure*

- *Automobile Ownership*

- *Port/Air Activity*

- *Transport Fatalities*

2.2.11 Culture

This is the most unusual group of measures. As distinct from seeking to provide comparable statistical indexes, it simply lists attendances at each city's leading attractions during the year. Some of these are ongoing, others are time-limited. Because of its nature, this group is difficult to compare.

- *Attendance at Public Events*

- *Attendance at Galleries and Museums*

- *Participation in Sport*

2.2.12 Local Government

This group of indicators measures a variety of input and output measures, such as:

- *Employees*

- *Wages in Budget*

- *Business Permits*

2.2.13 Urban Governance

The final group of measures is again large and highly heterogeneous. It includes:

- *Reported Crimes*

- *Contact with the Public*

- *Delivery of Annual Plan*

- *Voter Participation by Sex*

- *Independence from Higher Government*

- *Representation of Minorities*

3 Comprehensive evaluation framework

In order to offer the policy makers with a data-driven methodology to understand urban freight logistics and thereafter implement urban planning, we apply such an instructive method as "comprehensive evaluation". Comprehensive evaluation is not an exclusive method in analysing urban freight logistics. It has been frequently used in many fields, including economy, politics, environment, etc. (ZHANG, Yan-fei and Hui XU 2010; Nie, Hong-zhan, et al 2010; Wu, Wen-yi and Li LIU 2009) where involve numbers of variables. The basic idea of comprehensive evaluation is to apply PCA (principal components analysis) and then utilize components from the PCA to from a linear combination, in which the variance proportion was used respectively as the weight of each component. The linear combination is therefore called "Comprehensive Evaluation Function" and its result is the final comprehensive score. As a statistical transformation method, PCA helps to simplify and visualize the research questions through reducing multiple variables into several main components that represent the most information of the data set. More importantly, PCA helps to eliminate potential linear correlation among the original variables, which might result in deviation.

The basic steps of comprehensive evaluation using PCA are explained as follows:

1, Form the sample matrix.

$$X=\begin{pmatrix} x_{11} & x_{1p} \\ & \\ x_{n1} & x_{np} \end{pmatrix}$$

where n is the number of the samples and p is the number of the variables.

2, Standardize the data.

$$x_{ik}^{*} = \frac{x_{ij} - \overline{x_j}}{S_j}$$

where $i = 1, 2, ..., n$ and $j = 1, 2, \ldots, p$ .Specifically, $\bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}$ and

$S_j^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_{ij} - \overline{x_j})^2$.

3, Form the correlation coefficient matrix.

$R = (r_{ij})_{p\times p}$

where $R = X^T X$ and $r_{ij} = \frac{1}{n-1}\sum_{k=1}^{n} x_{ki}^{*} x_{kj}^{*}$. Note that r_{ij} is the correlation coefficient between X_i and X_j.

4, Solve the characteristic equation.

$|R - \lambda I| = 0$

where λ is the eigenvalue of R and the variance of its corresponding principal component. Eigenvectors are as well obtained.

5, Identity the principal components and calculate their variance contribution.

$$e_j = \lambda_j / \sum_{j=1}^{p} \lambda_j^2 \times 100\%$$

where e_j is the variance contribution which represents the amount of information that its corresponding principal component carries. The principal components are thereafter ranked in a descending order according to e_j.

6, Chose the principal components.

$$\sum_{j=1}^{m} e_j \geq 85\%$$

where m is the number of principal components that are chosen when their eigenvalues are larger than 1 and accumulative proportion of the first m principal components is larger or equal to 85%. Note that some researchers chose 95% as a benchmark, depending on their own consideration in those study.

7, Express the principal components.

$$Y_j = \sum_{i=1}^{p} a_{ij} X_i$$

where Y_j is the principal component and a_{ij} is the eigenvector from step 4.

8, Calculate the comprehensive score.

$$F = \sum_{j=1}^{m} e_j Y_j$$

where F is the final comprehensive score for each of the samples.

4 Data analysis process, results and interpretation

The data in grids are exported from Statistics Norway[1]. Due to the availability and nature of the data, we have done 3 times of data selection.

4.1. Data selection

Selection 1, city-wide grids selection.

There are 533,918 grids in 1 km^2 totally in Norway. We focus on Oslo and there are 552 grids selected to cover the whole city according to the administrative boundary defined by Statistics Norway (See Figure 1).

[1] https://www.ssb.no/natur-og-miljo/geodata

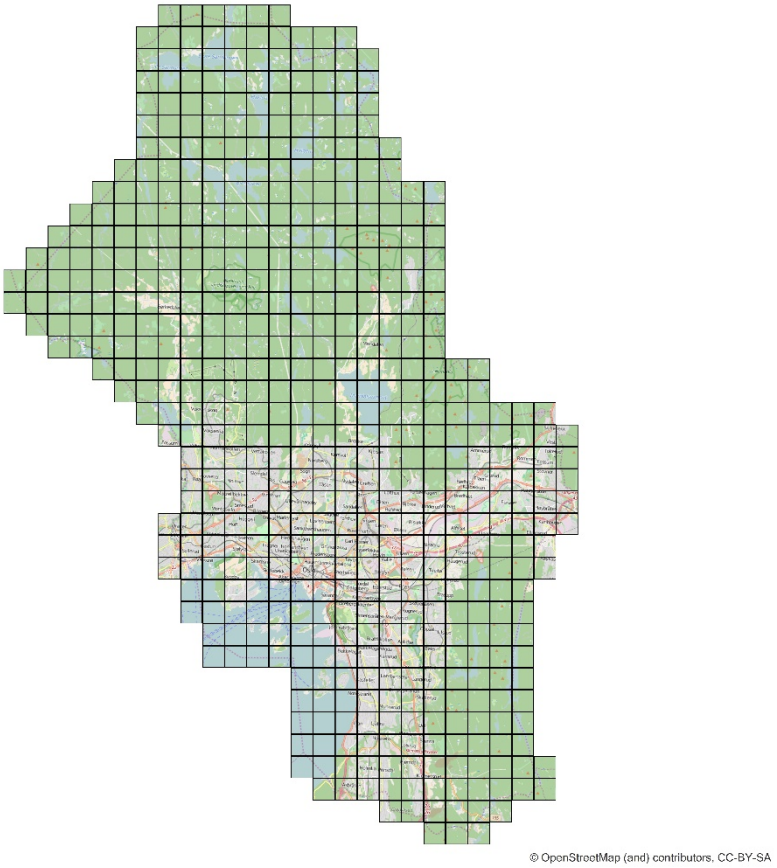

***Figure 1**, City-wide grids selection*

Selection 2, downtown-wide grids selection.

There are plenty of grids covering less populated areas, such as forests and lakes. We focus on downtown areas and there are 92 grids selected according to the definition of Statistics Norway. The downtown areas have been colored with red (see Figure 2).

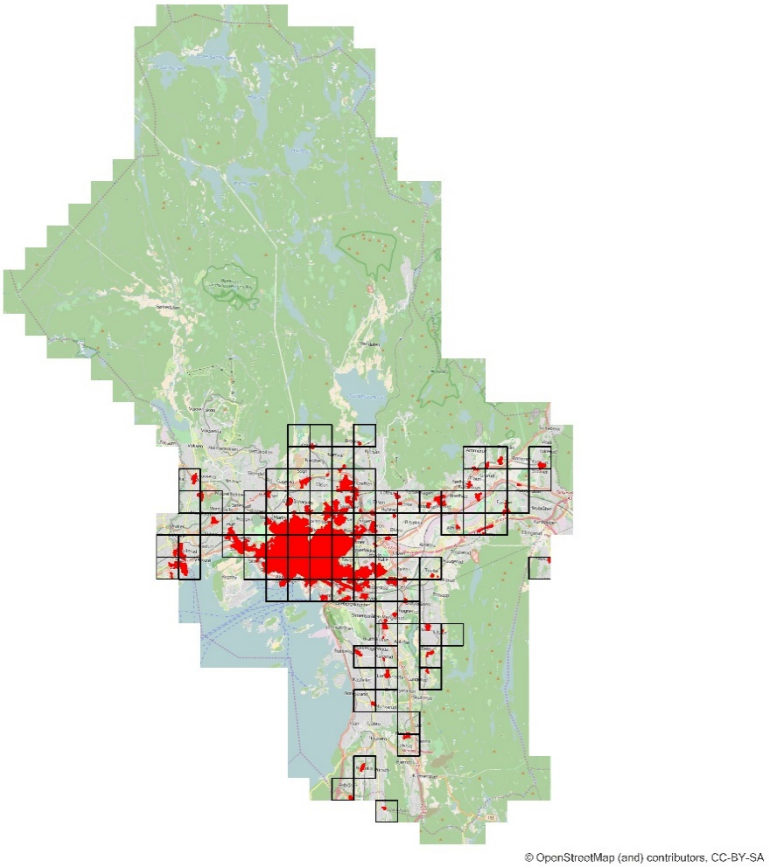

***Figure 2**, Downtown-wide grids selection*

Selection 3, variables selection.

We select 16 variables from the data base and group them into 4 categories as follows,

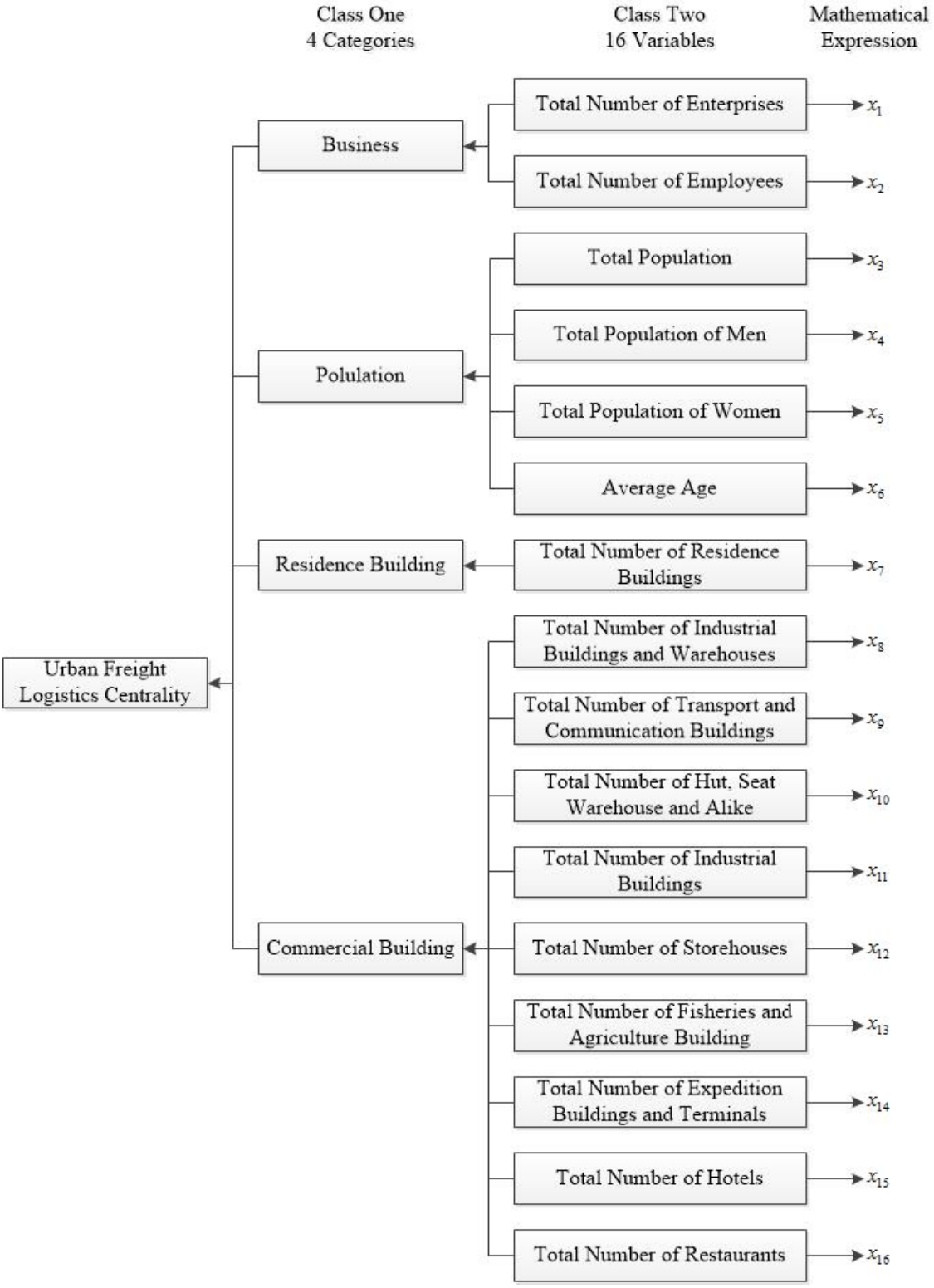

Figure 3, *Variables selection*

There are totally 91 observations, each with 16 variables (see Appendix 1).

4.2. Data analysis

As discussed in previous chapter, we run PCA first and the following tables are the results.

Principal components/correlation — Number of obs = 91; Number of comp. = 15; Trace = 16; Rotation: (unrotated = principal) — Rho = 1.0000

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	6.92078	3.65817	0.4325	0.4325
Comp2	3.26261	1.47583	0.2039	0.6365
Comp3	1.78678	.700875	0.1117	0.7481
Comp4	1.08591	.0804847	0.0679	0.8160
Comp5	1.00542	.242851	0.0628	0.8788
Comp6	.762571	.315629	0.0477	0.9265
Comp7	.446943	.178833	0.0279	0.9544
Comp8	.268109	.0650733	0.0168	0.9712
Comp9	.203036	.0875548	0.0127	0.9839
Comp10	.115481	.0528019	0.0072	0.9911
Comp11	.0626794	.0288364	0.0039	0.9950
Comp12	.033843	.00862376	0.0021	0.9971
Comp13	.0252192	.00973639	0.0016	0.9987
Comp14	.0154828	.0103428	0.0010	0.9997
Comp15	.00514004	.00514004	0.0003	1.0000
Comp16	0	.	0.0000	1.0000

***Table 1**, STATA results*

We choose the first 5 components with cumulative proportion larger than 85%. Ideally, their eigenvalues are also larger than 1 (see Appendix 2), which is always regarded as a benchmark for statistical significance. The eigenvectors matrix for the first 5 components are as well obtained as follows:

Variable	Comp1	Comp2	Comp3	Comp4	Comp5
x_1	0.3265	0.1685	0.1871	0.0215	-0.0061
x_2	0.255	0.3677	0.0548	-0.0041	0.071
x_3	0.2786	-0.3479	0.1812	0.0251	0.0166
x_4	0.284	-0.3388	0.1736	0.0205	0.012
x_5	0.2718	-0.356	0.1885	0.0298	0.0215
x_6	-0.1578	0.1111	0.0659	0.3353	0.3393
x_7	0.2939	-0.3047	0.1995	0.0547	-0.0276
x_8	0.2438	-0.0692	-0.5219	-0.0237	0.1688
x_9	0.3372	0.1331	0.0475	0.0619	0.1162
x_{10}	-0.0329	0.0608	0.0906	0.7892	0.335
x_{11}	0.1849	-0.1043	-0.5698	0.1207	0.0152
x_{12}	0.2793	0.0543	-0.409	0.0389	-0.0017
x_{13}	-0.0521	-0.0437	0.0641	-0.4734	0.8345
x_{14}	0.3146	0.174	0.0064	0.0007	0.1197
x_{15}	0.2151	0.3935	0.1695	-0.0677	-0.0973
x_{16}	0.2249	0.3763	0.108	-0.1007	-0.059

***Table 2,** Eigenvectors matrix*

Therefore, the five chosen components are expressed as follows,

$$Comp1=0.3265x_1+0.255x_2+0.2786x_3+0.284x_4+0.2718x_5-0.1578x_6+0.2939x_7+0.2438x_8+0.3372x_9-0.0329x_{10}+0.1849x_{11}+0.2793x_{12}-0.0521x_{13}+0.3146x_{14}+0.2151x_{15}+0.2249x_{16}$$

$$Comp2=0.1685x_1+0.3677x_2-0.3479x_3-0.3388x_4-0.356x_5+0.1111x_6-0.3047x_7-0.0692x_8+0.1331x_9+0.0608x_{10}-0.1043x_{11}+0.0543x_{12}-0.0437x_{13}+0.174x_{14}+0.3935x_{15}+0.3763x_{16}$$

$$Comp3=0.1871x_1+0.0548x_2+0.1812x_3+0.1736x_4+0.1885x_5+0.0659x_6+0.1995x_7-0.5219x_8+0.0475x_9+0.0906x_{10}-0.5698x_{11}-0.409x_{12}+0.0641x_{13}+0.0064x_{14}+0.1695x_{15}+0.108x_{16}$$

$$Comp4=0.0215x_1-0.0041x_2+0.0251x_3+0.0205x_4+0.0298x_5+0.3353x_6+0.0547x_7-0.0237x_8+0.0619x_9+0.7892x_{10}+0.1207x_{11}+0.0389x_{12}-0.4734x_{13}+0.0007x_{14}-0.0677x_{15}-0.1007x_{16}$$

$$Comp5=-0.0061x_1+0.071x_2+0.0166x_3+0.012x_4+0.0215x_5+0.3393x_6-0.0276x_7+0.1688x_8+0.1162x_9+0.335x_{10}+0.0152x_{11}-0.0017x_{12}-0.8345x_{13}+0.1197x_{14}-0.0973x_{15}-0.059x_{16}$$

We calculate each of the five components for the 91 observations and we have the components matrix (see Appendix 3). On the basis of components matrix, we use the proportion as their weights (see Appendix 4) and calculate the final comprehensive score for the 91 observations (see Appendix 5).

4.3. Results and interpretation

We use Jenks natural breaks classification method[2] (Jenks, George F 1967) to group the final comprehensive scores into 5 clusters and define them respectively.

Cluster	Interval	Number of Cells	Interpretition
	327.062361-976.466279	32	Lowest-central urban freight logistics areas.
	976.466280-2008.612989	31	Low-central urban freight logistics areas.
	2008.612990-3738.030674	16	Midiem-central urban freight logistics areas.
	3738.030675-6663.237351	10	High-central urban freight logistics areas with high population density and strong business activities that generate lots of tracfic and create strong needs for logistics.
	6663.237352-11024.880041	2	Highest-central urban freight logistics areas with high population density and intense business activitis that generate the most trafic and create the most needs for logistics.

Table 3, *Clusters and interpretation*

The highest-central urban freight logistics areas are darkest and lowest-central areas are lightest. From the perspective of city logistics, the policy makers need to inspect and verify whether the logistics development in the certain areas, in terms of both infrastructures and services, is sufficient to support the logistics activities. Further planning therefore can be made accordingly after the gap is identified.

The final results are as well demonstrated in the following figures with the help of ArcGIS.

[2] **Jenks natural breaks classification method**, is a data clustering method designed to determine the best arrangement of values into different classes. The method seeks to reduce the variance within classes and maximize the variance between classes.

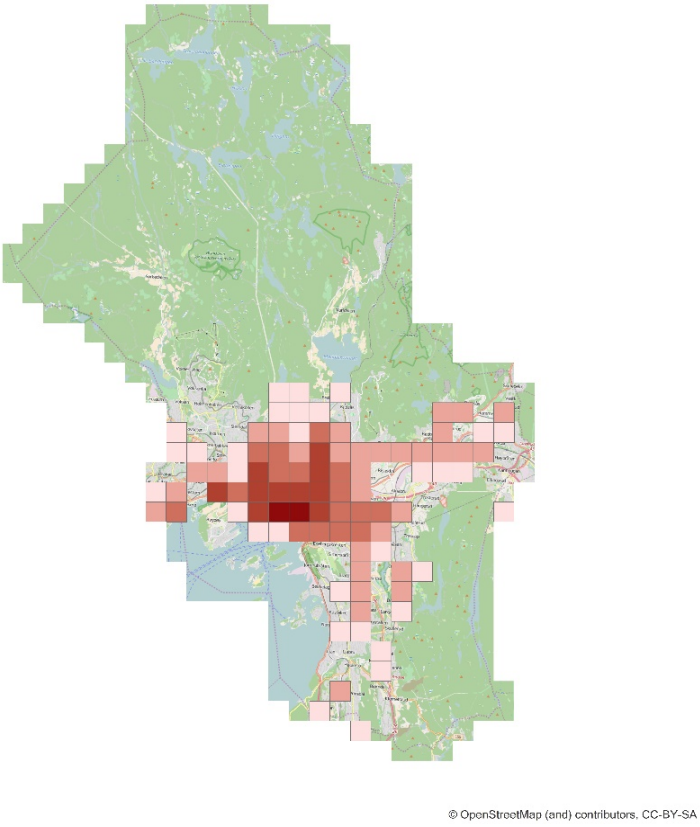

Figure 4, *Cluster in downtown Oslo*

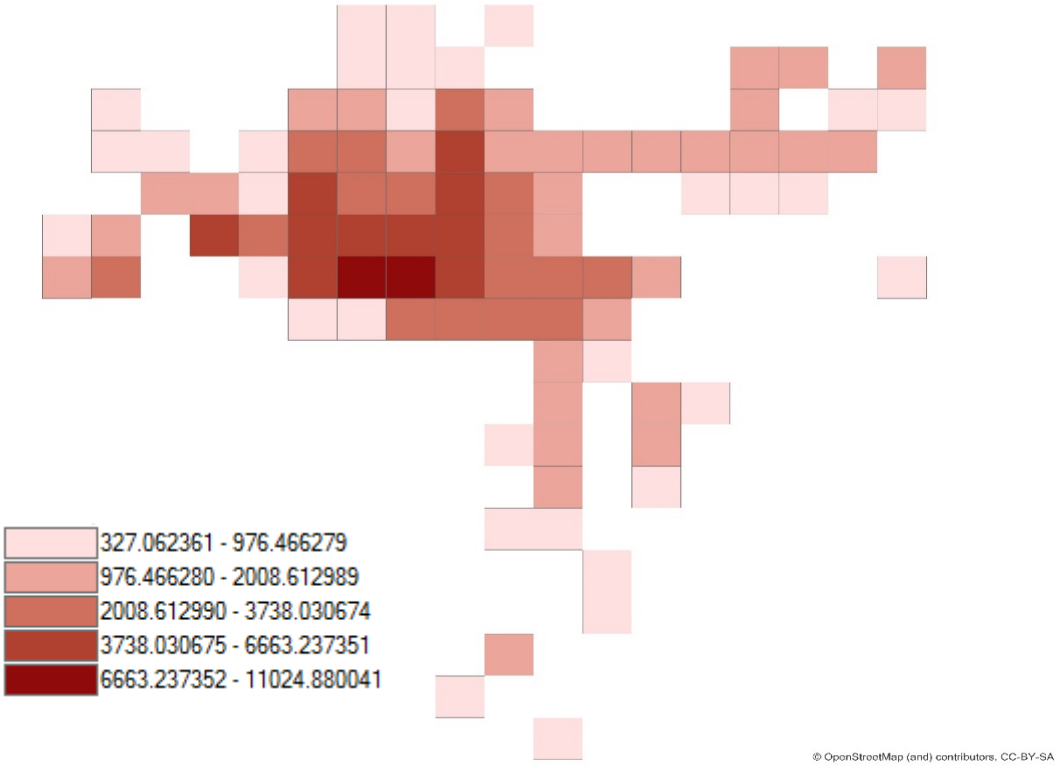

Figure 5, *Results with cluster specifications*

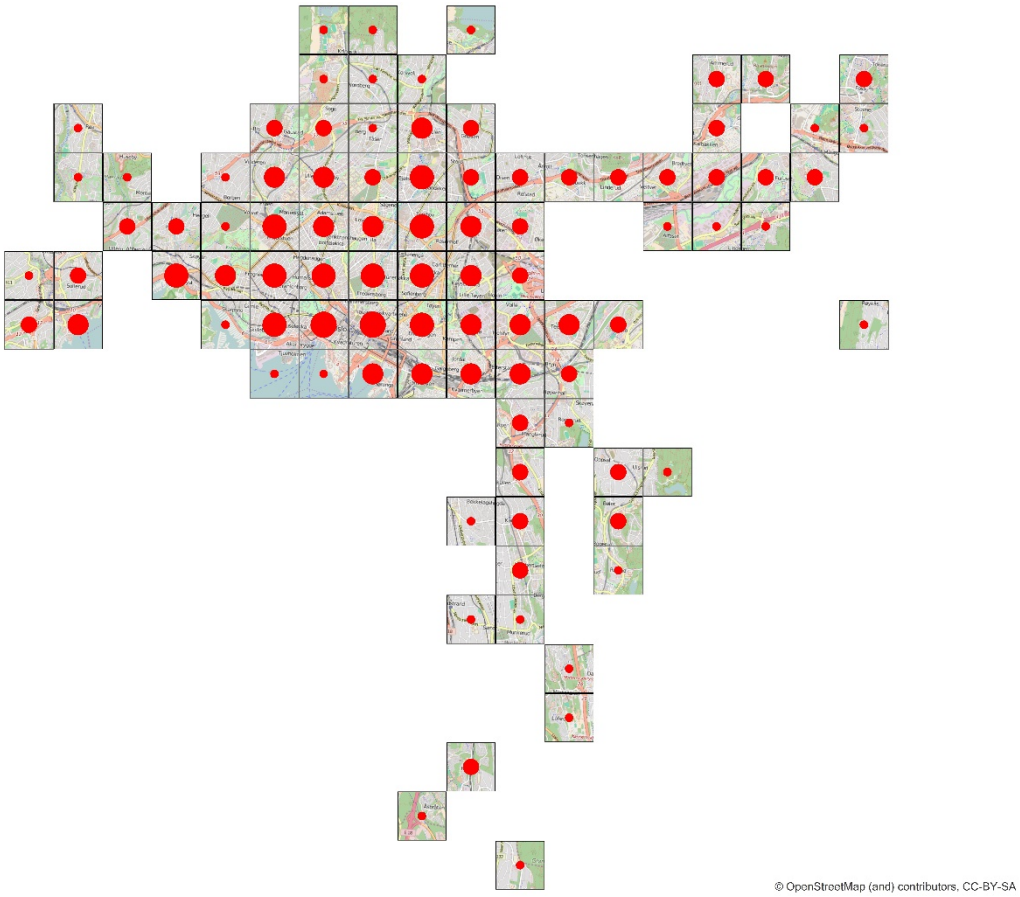

Figure 6, *Interpretation of clusters with pinpoint*

5 Conclusion

Comprehensive evaluation on urban freight logistics is complex. One core challenge is from the attributes choosing. In this article, we use 16 attributes to evaluate urban freight logistics system. However, urban freight logistics is a broad subject, which definitely requires more attributes to fully describe it. Therefore, further study on attributes choosing when analysing city logistics is recommended based on the distinct nature of the city. One suggestion for the policy makers is to take into account public participation when identifying the attributes because the citizens are the end customers of city logistics. Their opinions will truly reflect the needs of city logistics. Another challenge is the data collection. When using grids to classify the city into 1 km^2 cells, data has to be arranged accordingly. How to group and collect the data will depend not only on the researchers' choices but also on the accessibility and availability of the data.

In this article, we also use ArcGIS to visualize the final comprehensive scores. The policy makers can refer to these figures and find out on the map how the city looks like in terms of urban freight logistics. Results can also be demonstrated differently if the policy makers chose to review single attribute, such as the number of employees or warehouses.

The main point of this study is to explore a mathematical method to evaluate city logistics and help the policy makers better understand the city and implement urban planning based on scientific analysis. The method applied in this article can be used as a basis and developed for further study on city logistics.

ACKNOWLEDGEMENT

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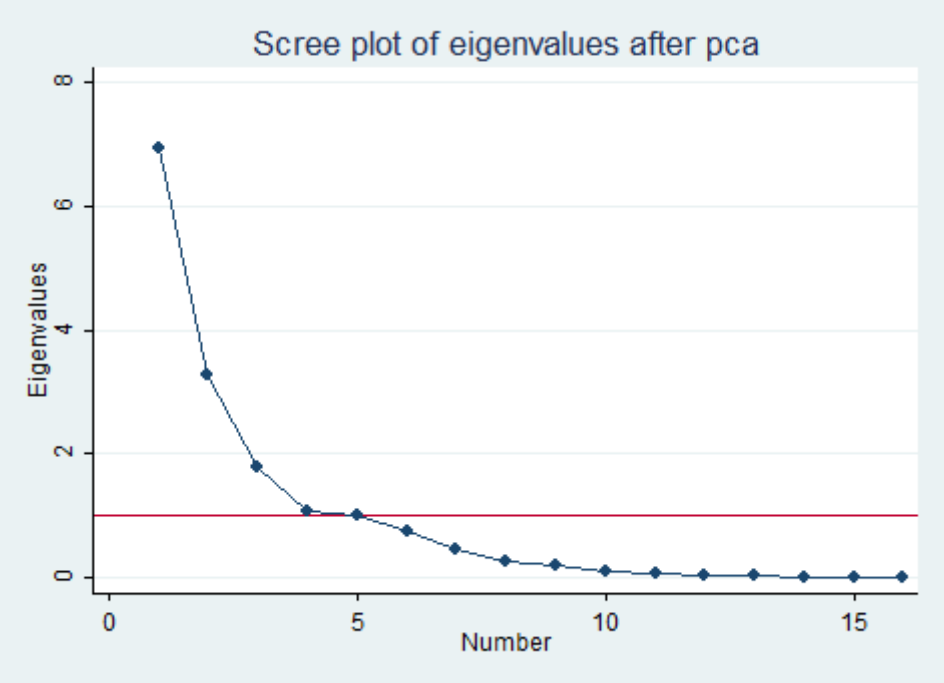
APPENDIX

Appendix 1, Original data of 91 observations

ssb_ID	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}
22550006649000	444	4949	1796	917	879	35.7	765	27	3	0	2	0	8	0	0	0
22550006650000	291	1775	2062	1025	1037	35.7	705	21	3	0	2	0	1	3	0	0
22560006649000	799	11371	864	433	431	46.6	499	15	7	2	5	0	0	2	0	1
22560006650000	658	2320	4149	2037	2112	38.2	1751	30	5	0	2	6	4	3	0	6
22560006652000	280	259	4326	2118	2208	39.5	1896	33	0	0	0	3	2	0	0	0
22560006653000	420	750	3648	1775	1873	39.1	1589	27	3	0	0	2	1	0	0	2
22570006651000	265	2173	3517	1645	1872	42.8	1578	29	2	0	1	2	0	2	0	0
22570006652000	315	1521	2433	1200	1233	43.8	1137	21	1	0	1	10	1	0	0	0
22580006650000	1379	17931	2353	1173	1180	39.3	1453	38	9	0	11	16	2	4	1	4
22580006651000	692	3390	5382	2541	2841	40.2	2668	32	3	0	5	7	0	1	0	0
22590006649000	307	649	948	468	480	45.1	644	4	2	0	1	1	0	0	0	3
22590006650000	1440	3056	7320	3553	3767	41.0	4268	21	7	0	1	2	2	4	0	0
22590006651000	196	532	1796	870	926	36.2	714	12	0	0	1	2	1	0	0	1
22590006652000	431	424	3586	1742	1844	37.6	1297	15	0	0	0	1	2	0	0	0
22600006648000	601	1979	943	523	420	41.5	995	9	4	0	1	8	0	0	1	0
22600006649000	3400	13192	10896	5490	5406	38.2	7162	41	11	0	6	21	1	3	7	0
22600006650000	2272	3201	13883	6707	7176	39.2	9063	20	8	0	3	3	0	3	2	1
22600006651000	1903	12827	9500	4688	4812	39.5	6086	36	9	0	8	11	4	6	0	2
22600006652000	638	10605	2212	1039	1173	40.1	1028	29	3	0	1	7	5	1	0	0
22600006653000	229	6389	1405	687	718	38.8	581	18	1	0	2	4	4	0	2	1
22610006648000	234	3598	48	26	22	45.0	2	22	6	0	2	16	1	6	2	6
22610006649000	6099	38734	1096	601	495	37.5	690	44	25	0	2	26	2	21	21	19
22610006650000	3275	11143	16422	8414	8008	34.7	12011	34	17	0	6	9	1	8	6	5
22610006651000	1708	2439	13309	6370	6939	36.1	8540	34	9	0	4	13	0	4	0	0
22610006652000	390	9335	4122	2142	1980	34.1	2138	34	6	0	1	10	7	5	0	2
22610006653000	417	2799	2493	1222	1271	34.0	2478	17	5	0	2	5	1	2	1	1
22610006654000	148	177	2203	1075	1128	35.8	1139	23	1	0	2	5	1	0	0	0
22610006655000	89	603	1668	856	812	25.6	2323	7	0	0	0	2	0	0	0	3
22620006648000	870	14490	985	553	432	37.2	809	15	4	0	3	5	0	2	6	1
22620006649000	4582	44971	6015	3450	2565	31.8	4746	80	37	0	17	44	0	31	15	26
22620006650000	2528	6084	15657	8107	7550	33.8	10203	64	8	0	34	17	0	6	2	4
22620006651000	1361	6546	10762	5129	5633	35.8	6970	41	18	0	7	17	7	13	0	0
22620006652000	402	748	4830	2276	2554	33.6	2490	25	10	1	1	12	1	10	1	1
22620006653000	299	1058	3566	1767	1799	37.8	1546	13	9	0	0	1	5	9	0	0
22620006654000	258	389	3207	1619	1588	40.8	1322	24	0	0	0	1	3	0	0	0
22620006655000	105	173	1424	695	729	38.8	733	13	0	0	0	1	2	0	0	0
22630006639000	210	2508	2487	1191	1296	34.2	921	19	3	0	3	6	0	0	1	0
22630006648000	984	4214	7215	3804	3411	31.9	4238	50	11	0	16	20	0	8	0	2
22630006649000	2287	12617	19343	10436	8907	32.4	10355	76	17	0	9	42	4	12	0	2
22630006650000	2244	4428	19412	10027	9385	33.6	12084	104	20	0	50	37	2	12	0	1
22630006651000	1613	3586	14505	7357	7148	33.6	9132	45	23	0	16	14	1	16	1	1
22630006652000	1223	3328	14876	7277	7599	35.4	10439	33	16	0	14	9	0	14	0	3
22630006653000	918	12838	3853	1901	1952	36.3	2197	37	14	0	5	18	3	8	0	2
22630006654000	263	729	3369	1675	1694	36.6	1462	23	1	0	6	1	4	0	0	1
22640006640000	302	1019	5039	2453	2586	35.1	1843	34	5	0	4	5	0	3	0	1
22640006643000	380	1173	3177	1548	1629	41.4	1434	40	7	0	5	4	3	3	0	1
22640006645000	398	651	3788	1905	1883	38.9	1424	40	1	0	1	7	6	0	0	0
22640006648000	979	3502	9103	4656	4447	34.7	4951	69	9	0	34	18	0	7	0	1
22640006649000	1121	4713	8107	4052	4055	35.5	4247	79	7	0	35	24	2	5	0	1
22640006650000	775	3081	7602	3747	3855	33.7	4216	42	13	0	3	16	3	9	0	1
22640006651000	1014	3493	11188	6036	5152	33.6	6753	24	2	0	8	7	1	2	0	1
22640006652000	512	3390	5818	2857	2961	34.7	3342	35	8	0	4	14	1	5	0	1
22640006653000	572	798	5354	2681	2673	37.2	2838	33	5	0	6	3	7	4	0	0
22640006655000	257	763	1457	745	712	39.1	621	17	3	0	9	1	1	2	0	0
22650006638000	145	397	2227	1078	1149	41.8	991	14	1	0	3	2	0	0	0	0
22650006643000	308	448	3830	1875	1955	37.3	1644	34	0	0	3	4	5	0	0	0
22650006644000	378	1445	5208	2441	2767	38.3	2592	26	2	0	3	2	4	1	0	2
22650006645000	326	1368	4149	1935	2214	37.9	1836	29	5	0	6	0	3	2	0	2
22650006646000	458	3659	4168	2074	2094	36.3	1714	47	3	0	13	5	0	1	0	0
22650006647000	460	3549	4532	2045	2487	41.5	2282	44	10	0	13	9	4	8	0	1
22650006648000	551	5054	5244	2625	2619	37.3	2396	49	8	0	22	9	5	6	0	1
22650006649000	738	10251	2954	1448	1506	35.4	1651	34	11	0	19	8	0	10	2	1
22650006650000	484	5585	888	411	477	35.4	516	71	3	0	26	26	0	1	0	0
22650006651000	438	1817	4180	2126	2054	36.7	1860	51	2	0	17	20	1	0	0	1
22650006652000	362	688	5175	2572	2603	35.8	2177	31	3	1	2	8	5	0	0	0
22660006641000	245	573	3992	1992	2000	31.3	1222	18	0	0	2	5	0	0	0	1
22660006642000	169	316	2724	1379	1345	36.1	866	12	0	0	2	1	0	0	0	0
22660006647000	178	312	3512	1670	1842	38.6	1632	29	0	0	4	2	5	0	0	0
22660006648000	426	3833	2059	1038	1021	37.6	797	54	6	0	21	15	3	6	0	2
22660006649000	563	6356	3910	1966	1944	37.8	1996	69	8	0	27	22	0	7	0	0
22660006652000	298	588	5360	2603	2757	38.2	2664	33	2	0	1	14	2	0	0	2
22670006644000	147	584	2821	1345	1476	42.7	1381	18	4	0	2	2	1	0	0	1
22670006645000	295	664	6018	2823	3195	37.9	2783	27	2	0	3	7	1	1	0	1
22670006646000	310	802	4775	2323	2452	40.1	1886	35	2	0	3	2	10	0	0	0
22670006649000	476	2079	4229	1948	2281	44.1	2380	59	6	0	16	28	0	5	0	0
22670006652000	324	1016	5097	2483	2614	35.3	2105	26	7	0	2	9	0	3	1	2
22680006646000	61	194	1516	726	790	41.9	664	8	0	0	0	0	1	0	0	1
22680006651000	103	2363	9	7	2	41.6	12	35	9	0	11	16	4	8	0	0
22680006652000	244	1524	4305	2134	2171	33.5	1629	32	3	0	7	16	1	0	0	1
22690006651000	359	3089	1420	674	746	34.2	548	75	6	0	33	32	0	6	0	0
22690006652000	442	4287	1388	624	764	38.8	753	96	3	0	52	25	3	1	0	0
22690006653000	312	952	5360	2556	2804	37.9	2461	34	2	0	4	3	8	2	0	2
22690006654000	267	1322	5835	2923	2912	37.8	2428	31	1	0	1	1	7	1	0	2
22700006651000	189	1609	2494	1280	1214	38.1	934	35	8	0	6	4	4	7	0	0
22700006652000	317	1427	4740	2375	2365	35.9	1628	69	3	0	11	24	1	0	0	2
22700006654000	282	524	5702	2867	2835	38.0	2473	29	2	0	2	5	1	1	0	1
22710006652000	249	349	5630	2814	2816	35.3	2065	32	0	0	0	1	5	0	0	0
22710006653000	216	1560	2989	1524	1465	35.1	1224	59	2	0	13	24	3	0	0	0
22720006649000	104	122	1867	985	882	38.1	683	3	1	0	0	0	2	0	0	0
22720006653000	189	437	4419	2218	2201	36.5	1503	21	1	0	1	3	3	0	0	1
22720006654000	435	1763	8772	4449	4323	37.1	3393	42	3	0	1	8	1	0	0	3

Appendix 2, Scree plot of eigenvalues after PCA



Appendix 3, Components matrix

ssb_ID	Comp1	Comp2	Comp3	Comp4	Comp5
22550006649000	2633.414	414.9728	1144.99	129.1431	410.9983
22550006650000	1904.025	-943.742	1029.891	152.6421	190.847
22560006649000	3788.34	3568.376	1178.171	59.04478	837.5828
22560006650000	3636.619	-2449.48	2087.534	319.6368	273.0736
22560006652000	3124.115	-3441.76	1996.879	338.1015	129.6877
22560006653000	2827.282	-2671.23	1746.996	288.7	147.8438
22570006651000	3062.601	-2081.11	1745.603	274.8768	247.3847
22570006652000	2180.101	-1422.1	1238.097	199.4286	175.3406
22580006650000	6773.956	4751.923	2354.058	167.2507	1325.841
22580006651000	4873.43	-3191.84	2779.761	432.542	363.3206
22590006649000	978.1626	-559.029	565.31	101.8677	74.15123
22590006650000	6578.988	-5020.92	3932.464	633.6525	355.9628
22590006651000	1406.761	-1234.63	854.1935	143.0759	92.12816
22590006652000	2622.915	-2657.78	1656.784	270.4887	128.7123
22600006648000	1518.339	-123.768	754.7887	120.4544	156.31
22600006649000	12660.16	-4327.31	6705.235	971.0212	1102.932
22600006650000	11949.09	-10853	7431.24	1244.681	446.251
22600006651000	10979.14	-3419.2	5691.122	811.4306	1073.115
22600006652000	4448.82	2157.653	1692.449	149.2148	818.2423
22600006653000	2656.949	1237.823	1009.203	92.16694	502.6179
22610006648000	1029.955	1337.445	243.8836	7.3755	276.2438
22610006649000	12718.02	14323.43	3772.433	74.70735	2753.975
22610006650000	16599.15	-10416.1	9545.35	1516.624	1005.895
22610006651000	11103.76	-10672.3	6959.87	1178.13	393.1553
22610006652000	5440.567	-13.8978	2483.87	301.4346	762.4231
22610006653000	2968.484	-1384.99	1619.997	269.6396	227.0931
22610006654000	1655.865	-1786.7	1050.335	187.1898	70.95154
22610006655000	1792.964	-1626.88	1114.58	218.3152	43.26138
22620006648000	4768.892	4550.907	1466.336	64.89826	1048.682
22620006649000	17772.44	11711.8	6380.838	483.0849	3259.892
22620006650000	14119.21	-11326.2	8453.178	1386.229	678.4322
22620006651000	10168.24	-6968.93	5877.575	937.1637	654.033
22620006652000	3751.206	-3770.21	2349.358	397.8139	163.3203
22620006653000	2809.156	-2505.47	1710.473	276.5987	171.0164
22620006654000	2356.388	-2443.07	1484.779	249.0032	116.7606
22620006655000	1083.297	-1129.06	686.9481	125.151	56.09014
22630006639000	2364.855	-1049.88	1250.653	181.8014	249.9056
22630006648000	6681.315	-4586.13	3830.721	609.1289	436.567
22630006649000	17817.64	-11562	10122.26	1539.484	1264.404
22630006650000	16270.26	-15169	10006.06	1680.028	646.5451
22630006651000	12223.99	-11269.4	7538.441	1260.87	499.9544
22630006652000	12610.54	-12090.7	7859.634	1346.505	459.4925
22630006653000	6379.774	1532.166	2683.706	292.9763	997.5783
22630006654000	2577.753	-2473.49	1588.38	262.5752	142.0354
22640006640000	3711.239	-3637.78	2287.001	368.8068	206.9044
22640006643000	2620.778	-2148.04	1550.952	254.4284	172.2095
22640006645000	2828.4	-2759.36	1744.955	283.7351	155.7934
22640006648000	7762.969	-6384.14	4598.93	749.2288	434.3466
22640006649000	7358.429	-5010.8	4184.022	659.0581	509.8439
22640006650000	6524.858	-5302.81	3882.585	627.7271	375.2764
22640006651000	9443.467	-8371.25	5757.174	946.4415	441.1643
22640006652000	5263.065	-3727.64	3033.241	484.5119	359.8742
22640006653000	4210.588	-4195.06	2637.654	442.7966	178.5377
22640006655000	1273.516	-875.141	729.7256	122.9729	101.5937
22650006638000	1676.992	-1676.99	1046.817	182.1199	91.26294
22650006643000	2832.695	-2946.51	1779.857	297.3931	135.2717
22650006644000	4152.583	-3815.42	2543.041	417.898	224.9836
22650006645000	3306.904	-2885.47	1991.899	323.0481	205.212
22650006646000	3916.553	-1997.58	2106.714	311.1434	369.6942
22650006647000	4260.228	-2464.13	2350.394	363.3745	366.5206
22650006648000	5108.37	-2423.75	2719.163	398.052	491.2097
22650006649000	4999.699	1340.571	2071.251	226.9759	796.7902
22650006650000	2252.742	1358.232	761.7042	75.18452	434.0846
22650006651000	3495.824	-2730.1	2024.462	326.8959	236.3536
22650006652000	3818.383	-3945.5	2396.941	394.6615	181.5407
22660006641000	2808.193	-2893.4	1756.782	280.8003	152.2539
22660006642000	1904.267	-2009.88	1202.787	198.5312	102.4904
22660006647000	2572.717	-2794.17	1634.121	279.5449	116.1873
22660006648000	2516.188	-191.618	1151.427	153.625	342.1016
22660006649000	4594.167	-894.562	2210.604	307.2551	549.6593
22660006652000	4019.22	-4269.88	2541.692	431.4404	166.1978
22670006644000	2171.979	-2139.59	1349.724	232.5546	115.9481
22670006645000	4434.583	-4738.45	2813.69	472.2373	189.5794
22670006646000	3519.993	-3547.04	2191.497	355.5303	190.9899
22670006649000	3758.248	-2821.48	2164.097	362.7355	248.0499
22670006652000	3826.828	-3753.28	2368.282	386.655	200.0072
22680006646000	1103.311	-1170.9	702.9182	126.5989	62.28067
22680006651000	658.5747	880.6959	126.7789	7.34978	192.5942
22680006652000	3352.019	-2886.07	1989.204	316.1553	223.4742
22690006651000	1887.595	40.14392	792.2468	112.0123	275.83
22690006652000	2265.422	449.131	884.6364	120.2629	360.9421
22690006653000	4054.466	-4073.56	2527.105	416.5529	203.3834
22690006654000	4387.913	-4262.95	2706.486	434.9361	243.7967
22700006651000	2144.259	-1391.11	1192.699	185.0047	194.1943
22700006652000	3605.029	-3213.09	2129.98	340.3291	237.5016
22700006654000	4129.868	-4474.61	2624.61	437.6048	176.1768
22710006652000	3912.53	-4371.93	2502.7	408.5445	175.5858
22710006653000	2510.266	-1840.79	1407	226.7007	199.8242
22720006649000	1300.366	-1438.89	839.0767	144.2526	66.17093
22720006653000	3074.941	-3334.78	1949.811	316.9808	154.1843
22720006654000	6479.621	-6407.35	4008.837	639.2147	341.5057

Appendix 4, Proportion matrix

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	6.92078	3.65817	0.4325	0.4325
Comp2	3.26261	1.47583	0.2039	0.6365
Comp3	1.78678	0.700875	0.1117	0.7481
Comp4	1.08591	0.0804847	0.0679	0.816
Comp5	1.00542	0.242851	0.0628	0.8788

Appendix 5, Final comprehensive scores

ssb_ID	F	ssb_ID	F
22550006649000	1386.03942	**22640006645000**	884.60956
22550006650000	768.45034	**22640006648000**	2647.60869
22560006649000	2554.25983	**22640006649000**	2704.94103
22560006650000	1345.41847	**22640006650000**	2240.63326
22560006652000	903.55821	**22640006651000**	3112.44568
22560006653000	902.16271	**22640006652000**	1910.52151
22570006651000	1129.42081	**22640006653000**	1301.61125
22570006652000	815.77514	**22640006655000**	468.59477
22580006650000	4256.22071	**22650006638000**	518.38814
22580006651000	1819.62867	**22650006643000**	851.84559
22590006649000	383.78803	**22650006644000**	1344.59012
22590006650000	2326.28268	**22650006645000**	1099.20579
22590006651000	467.59771	**22650006646000**	1566.26594
22590006652000	804.00075	**22650006647000**	1650.34286
22600006648000	733.75012	**22650006648000**	2076.77362
22600006649000	5477.35047	**22650006649000**	2732.52114
22600006650000	3897.66767	**22650006650000**	1368.70233
22600006651000	4809.49091	**22650006651000**	1218.44763
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22620006654000	711.08565	**22690006652000**	1201.01976
22620006655000	327.06236	**22690006653000**	1246.29077
22630006639000	976.46628	**22690006654000**	1375.71504
22630006648000	2451.22545	**22700006651000**	801.72526
22630006649000	6663.23735	**22700006652000**	1179.96888
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BI NORWEGIAN BUSINESS SCHOOL

PRELIMINARY RESEARCH PROPOSAL

Program

Master of Science in Business major in Logistics, Operations and Supply Chain Management

Title

Identifying City Clusters and Critical Areas of the city of Oslo by using Principal Component Analysis and Cluster Analysis

Hand-in date

15.01.2016

Supervisor

Nordli Atle

Students

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Contents

ABSTRACT

The aim of this paper is to apply a data-driven methodology developed at megacity logistics lab at MIT on analysing logistics infrastructure of the city of Oslo in order to identify urban clusters and critical areas and therefore come up with solution proposals to Oslo's policy makers in alignment with "Det Grønne Skiftet" – The Green Shift Strategy. In the introduction part we justify our research area and present the research questions, following by purposes and values of the research. A brief summary of the Green Shift Strategy of the Oslokommune is also given.

In the literature review presented in the second part of the paper, several issues related to urban freight system are discussed to come up with the concept of City Logistics. These arguments follow papers produced by Taniguchi. Issues related to the chosen of urban indicators used in the paper are also presented.

Our research methodology is explained in third part in which we use case study with data analysis using Principal component analysis and k-means cluster analysis supported by statistical software such as STATA with coding of data by Python and visualizing by GIS.

Further justifications on reliability and validity of the research as well as limitations, generalization ability, ethics considerations, and project plan are also presented in the latter parts of the paper.

1 Introduction

1.1 Overview of the research area

Intergovernmental Panel on Climate Change (IPCC) came up with a new report underscoring how serious the climate change was and would be. It emphasized that "stabilizing temperature increase to below 2℃ relative to pre-industrial levels will require an urgent and fundamental departure from business as usual" (IPCC 2014). In 2012, urban population accounted for 79% of the emerging world's inhabitants, and it has been projected to reach approximately 85% by 2030 (Blanco & Franco, 2013). Consequently, urban freight is often considered a nuisance from the public perspective (Blanco, 2014).

Regarding the information from the "Climate & Energy" Strategy, despite the technology development such as the use of electronic or hydrogen cars, better freight logistics helps to improve efficiency and environmental impacts. And subsequently, a better freight logistics will help reduce the emission while maintaining its function of serving the society's needs and enabling mobility. More importantly, the Oslo Municipality is planning to set up more lanes for cycling and pedestrian use. How to make use of land smartly and improve the infrastructure, as well as an effective and efficient system to control city logistics, are thus highly relevant. By implementing the MIT project, we shall be able to assess Oslo by identifying the critical areas with data-driven methodology and come up with solution proposals that match with urban logistics characteristics and rationalize city planning by clusters. The policy makers of Oslo can refer to our proposals and make better policies for the city logistics in order to their goals. A more detail description of this Strategy is given in part 1.5.

1.2 Purpose of the research

The main purpose of this research is to apply a data-driven methodology developed at MIT on analysing logistics infrastructure of the city of Oslo in order to identify urban clusters and critical areas and therefore come up with solution proposals to Oslo's policy makers in alignment with "Det Grønne Skiftet" – The Green Shift Strategy

Based on the results of city segmentations of clusters and critical areas, some suggestions are recommended on criteria of urban freight system.

1.3 Research question

Given the research objectives described above, we arrived at the two following preliminary research questions:

Question 1:

"How to identify city clusters and critical areas of the city of Oslo?"

Question 2:

"How should Oslokommune implement "Det Grønne Skiftet" based on data-driven results from city clusters and critical areas?"

1.4 Value of the research

The practical contribution of this research to the city of Oslo is promising in terms of supporting Oslo to achieve environmental goals in 2030 and 2050 based on an efficient urban freight system. Therefore, this study is highly relevant for practical use as well as reference for further study of segmentation of city logistics infrastructure.

1.5 "Det Grønne Skiftet" – The Green Shift Strategy

This paper delivers a strategy of Oslo in dealing with climate and energy issues with two ultimate goals which are to reduce half of greenhouse gas emissions by 2030 compared to 1991 and to use 100% fossil-free fuels by 2050. Oslo authorities see a serious problem with global warming if it exceeds 2 degrees in growth within this century (according to IPCC), therefore they argue that a green shift in energy consumption and production is a must in order to build a renewable and sustainable society. Furthermore, they take in account the forecast of 70% of world population will live in cities by 2050 and thus environmentally friendly urban development Is essential. One of their main proposal is to invest in infrastructure of the city that lay the foundation for transportation and construction to be independent on fossil fuels and thus harmful emissions (for example, electric charge stations system, hydrogen fuel stations).

A clear ambition of Oslo authorities is also stated that Oslo's responsibility as a leader in providing an innovation solution that can be applied to others towns and cities everywhere in the world is continued to be maintained.

This paper presents "Climate & Energy strategy" by 9 chapters in order to point out specific targets, current status, challenges, opportunities, framework, and a roadmap to achieve all of the objectives. A table of content is as follows:

Chapter 1: Oslo guidelines on the strategy (provides general overview)

Chapter 2: Main objectives, visions of the strategy (briefly summarizes “Climate & Energy” strategy)

Chapter 3: The green shift in Oslo (addresses climate challenges on urban & population development and how proposed actions can lead to fossil-free in 2050)

Chapter 4: Framework (provides assumptions and detailed frameworks of the strategy)

Chapter 5: Changes of energy system in Oslo (addresses the need for changes of energy system of Oslo to phase out fossil fuels)

Chapter 6: A fossil-free Oslo (addresses specific targets, status, challenges, and opportunities within 4 main sectors: transportation, construction, resource utilization, and energy)

Chapter 7: Roadmap of the green shift (provides lists of actions per sectors in chap 6)

Chapter 8: Calculating greenhouse gas emissions

Chapter 9: Explain key concepts

Follows are discussion in chapter 6 regarding transportation that we find many relevant needs.

Previous targets adopted within urban ecology program (2011) and Action plan for environment & climate (2013) that would be applied in the “Climate & Energy” strategy:

- Further growth in passenger transportation should be within public transport, cycling, and walking.
- All vehicles using by “Oslo commune” will generally use zero-emission technology by 2015 (is it achieved or not?)
- Good availability of fossil-free fuels and stations.
- Bicycle would increase to at least 16% share of every day travel by 2025.

Brand new targets:

- All new taxis will go on fossil-free fuels from 2020.
- Fossil-free of public transportation by 2020.
- All goods-transportation should use fossil-free vehicles (electric, hydrogen or biofuels) or rechargeable hybrids from 2025.
- 10000 hydrogen vehicles within Oslo and Akershus by 2025.

- Emissions from distribution centers should be reduced 50% by 2020.
- Oslo should facilitate at least 30% of “heavy goods traffic” through Oslo with renewable fuels.
- A sustainable mobility plan for Oslo by 2018.

These targets relate to almost every aspects of transportation regarding public transportation, goods transportation, energy for transport, areas analysis and transport planning which are discussed in details within chapter 6.

2 Literature review

2.1 City Logistics and Urban freight system

The concept of City Logistics used in this paper follows the definition presented by Taniguchi and Thompson as the process that globally optimizes urban freight systems by considering the costs and benefits of schemes to the public as well as the private sector. Urban freight systems refer to issues between carriers and shippers operating within a transportation infrastructure. As pointed out by Taniguchi, urban freight systems are confronting with many problems due to high levels of service and lower costs being demanded by shippers, with carriers having to operate in increasingly congested road conditions. These facts have resulted in rational efforts to increase pickup-delivery truck traffic in urban areas that currently contributing significantly to traffic congestion, many associated negative environmental impacts such as air pollution and noise, and CO2 emissions. In short, these issues are expected to be solved by actions originating from the concept of City Logistics. A more detail definition by Taniguchi is as follow: “the process for totally optimizing the logistics and transport activities by private companies with the support of advanced information systems in urban areas considering the traffic environment, its congestion, safety and energy savings within the framework of a market economy”. Several logistics initiatives based on the concept of city logistics have been proposed in several cities as follows: Advanced information systems, Cooperative freight transportation systems, public logistics terminals, load factors control, and underground freight transport systems.

Regarding the urban freight transportation system, four key stakeholders involves shippers, freight carriers, residents, and administrators. All of these stakeholders have their own specific objectives and tend to behave in a different

manner. Therefore, city logistics models need to recognize these factors and related issues such as transporting and loading and unloading goods at depots or customers, traffic flow on urban roads for freight vehicles as well as passenger cars, and the cost of those activities. Dablanc (2007) grouped into six categories of city logistics challenges which are highly congestion, limited dedicated infrastructure available, limited space to warehouse in stores/establishments, high retail diversity, increasing access restrictions, and deliveries fragmentations. He also argues that local governments are aware that they need to control goods transport activities, but most do not know how. Therefore, urban policies usually have following characteristics: focusing on people's mobility, minimal interaction with private sector, mostly restrictive policies, no incentives, and no (data-driven) expertise to design urban freight policies (Blanco, E., & Fransoo, J., 2013).

In short, the city logistics toolkit as applied by MIT is claimed to be a data-driven methodology to guide city logistics decisions.

2.2 Urban Indicators

In Arabic the word for indicator means pointer, which describes how an indicator is intended to point towards some desirable state or course of action. Each indicator is actually a kind of small model in its own right, implying elements of cause and effect, of social norms that constitute progress, and of policy actions and outcomes.

The main difference between indicators and other kinds of data is that the connection with policy is, or should be, explicit. Indicators are about the interface between policy and data. A serious problem for urban policy making has been the lack of appropriate data at the city level. The urban indicators are thus created and introduced to help policy makers to understand and manage cities.

In urban planning, 13 groups of indicators are frequently used. In each of the group, there are several significant indicators that form the group. The 13 groups of indicators are as follows:

2.2.1 Population

The first group contains a series of indicators that describe basic demographic and socio-demographic characteristics of the city population, such as:

- *Urbanization*. This covers the percentage of national population in urban areas. Urban areas are defined as settlements over 1,000 people.

- *City Population*. This includes (a) the resident population of the municipal area; (b) the population during daytime working hours, if substantially different; and (c) the annual rate population increase

- *Population Net Density, Persons per Hectare*. City Population divided by Net Residential Land in hectares. Net Residential Land includes all built-up land zoned as residential, including open space and roads. A proportion of mixed-use land has been added, according to an estimate of the relative floor space usage by business and residential. In estimating population net density, the land for the informal settlements can be added to the residential land, and a proportion of the mixed-use land based on floor space for residential and other uses.

- *Age Pyramid*. This covers the number (thousands) of males and females in age categories: (a) Persons 0-14, (b) Persons 15-59, and (c) Persons over 60. The total matches with city population. The age distribution is known as a pyramid because if, say, numbers are expressed as a two-way bar chart for 5-year age groups, with the youngest at the bottom, it usually shows a pyramid structure when the population is growing.

- *Average Household Size*. The city population is divided by the total number of households. If a full census of households is not available, the number of households and number of occupied dwellings can be taken as the same (presuming there are not too many multi-household dwellings). Alternatively, a survey is used to estimate average household size between censuses.

- *Household Formation Rate*. This is the annual rate of increase in number of households.

- *Women-Headed Households*. This is the percent of households headed by women.

- *Household Types*. Types of household include (a) single person; (b) adults only; (c) single parent family, and; (d) adults and children.

- *Informal Settlements*. For informal settlements (a) population, (b) households, and (c) land occupied have been used to calculate persons per household and population density.

2.2.2 Equity

A second group of indicators include measures of economic deprivation, such as:

- *Income Distribution*. This shows annual household income by quintile: income range (maximum and minimum) and average income in the quintile, in US$ or local currency. (a) Q5. Top 20%; (b) Q4. Next 20%; (c) Q3. Middle 20%; (d) Q2.

Next bottom 20%, and; (e) Q1. Bottom 20%. Quintiles are obtained by dividing households into 5 equal groups ordered by income. It is particularly important to know the average income of the top 20%.

- *Women-Headed Households in Poverty*. This refers to the proportion of households below the poverty line. Households with income of US$ 1 a day.
- *Child Labor*. This refers to the number of employed or economically active persons under 15 years of age. Children should be considered as employed if they are working largely in producing goods or services for sale, even where they are nominally in a "school" or similar.
- *Unemployment*. This is defined as those above 15 "without work, currently available for work and seeking work," as a percentage of the full time workforce (employed + unemployed).
- *Informal Employment*. This shows percentage of the total workforce whose major income earning activity is part of the informal sector. The informal sector "consists of persons engaged in the production of goods or services with the primary objective of generating employment and incomes to the persons concerned. These units typically operate at a low level of organization, with little or no division between labor and capital as factors of production and on a small scale. The informal sector includes (a) all unregistered commercial enterprises, and (b) all non-commercial enterprises that have no formal structure in terms of organization and operation." Essentially, it consists of unregistered enterprises, and enterprises with no formal structure.
- *Expenditure on Poverty Reduction*. This covers capital and recurrent expenditure on poverty reduction, all sources including government and NGOs, per poor person. Capital expenditure includes building of housing, shelters, slum relocation, service upgrading, etc. Recurrent expenditure includes food, income, rent and medical assistance, operating expenses of shelters, etc. Only direct subsidies are included. More general expenditures such as basic education, primary health care, safe drinking water, adequate sanitation, family planning, etc. applying to the whole community should be included only if they are delivered primarily to the poor.

2.2.3 Health and Education

A third group of indicators specifically measures the society's achievements in health and education, such as:

- *Persons per Hospital Bed*. This is the city population divided by total number of hospital beds in the city. Includes both public and private hospitals.
- *Child Mortality*. This refers to the probability that a child will die before its fifth birthday, as a percentage.
- *Infectious Diseases Mortality per Thousand Population*. This can be computed as (Deaths from infectious diseases x 1,000) divided by City Population. Infectious diseases include all those that can be passed down from person to person.
- *Family Planning*. This is the percentage of married couples with females in the fertile age group that practices family planning in some form.
- *Adult Literacy Rate*. This refers to the percentage of adult population who are literate. Literacy is defined as being "able to read and understand a simple paragraph in their first written language."
- *School Enrollment Rates*. This covers percentage of children of eligible age, by sex who are enrolled in: (a) primary school, and (b) secondary school. The ages at which enrollment for primary and secondary education is expected to differ between countries, but are generally 6-12 years and 12-17 years of age, respectively.
- *School Children per Classroom*. This covers the total number of school children divided by total classrooms: (a) primary, and (b) secondary for all kinds of school.
- *Life Expectancy at Birth*. This refers to the expected age that a newborn child expects to reach.
- *Tertiary Graduates*. This refers to the proportion of tertiary graduates in the adult population, male and female. Defined as the proportion of male graduates to all adult males, and female graduates to all adult females. Tertiary graduates include graduates and diplomats from universities and all other accredited tertiary level institutions. It does not normally include graduates from vocational private colleges unless they are fully accredited.

2.2.4 Urban Productivity

A fourth group of indicators directly addresses measures of economic development, such as:

- *City Product per Capita*. It is defined as total city product per year divided by population. This figure is not usually directly available, despite its importance. It can be approximated from national figures by several fairly straightforward

procedures. The city income person is usually substantially above national GDP per person figures. If it is not, then an estimation error has probably been made.

- *Employment by Industry*. This includes total employment, for each category: (a) Secondary and infrastructure – Manufacturing, Construction, Utilities; (b) Consumer services – Wholesale and retail, transport, personal services; (c) Producer services – Finance and business services; (d) Social services – Education, health government, and (e) Others – Agriculture, mining and defense. This is a version of Singleman's classification, which is generally regarded as the best way of organizing the services sector.

- *Household Expenditure.* This refers to the proportion of average household income spent on (a) food, (b) shelter, (c) travel, and (d) others. The breakdown must be obtained from a recent household expenditure survey, usually for some higher jurisdiction.

- *Investment by Sector*. These are funds invested per person by economic sector, US$ per annum, on (a) physical infrastructure, (b) housing; (c) manufacturing, (d) services, and (e) others.

- *Tourism*. This includes (a) persons (thousands) and (b) expenditure (US$ millions) of tourists visiting the city, both international and national.

- *Cost of Stay*. This includes the expected cost per stay per day of executives visiting the city, including normal hotel and living expenses.

2.2.5 Technology and Connectivity

The fifth group of measurements also deals with economic development, especially in information and communications technology, such as:

- *Corporate Headquarters*. This covers the number of major national and regional corporate headquarters of businesses with an annual turnover of US$100 million or over.

- *Telephone Traffic*. This refers to the number of telephone calls per annum per person: (a) local, (b) international, and (c) mobile or cellular phone. Includes both private and business calls.

- *Commercial Flights*. This refers to the number of flights leaving per month, for national and international destinations.

- *Internet Hosts per 1,000*. This refers to the number of internet hosts per 1,000 populations.

2.2.6 Urban Land

The land use data are given very difficult to compare because they are expressed in absolute areas, not percentages; some cities show large amounts of land awaiting development, presumably reflecting lack of demand, and some of these also have large areas of vacant government land. The indicators include:

- *Urban Land*. This covers land in hectares zoned as (a) residential, (b) business, (c) services, (d) transport, (e) mixed use, (f) others, and (g) total area.
- *Prime Commercial Land Price*. This refers to the cost of a square meter of land in a prime commercial location, in US$. The most expensive was used.
- *Prime Rental and Occupancy Cost*. This refers to the average costs of occupying prime commercial space, per square meter, in constant US$. (a) prime rental per month, (b) operating costs per month, and (c) statutory charges per month.
- *Land Development Multiplier*. This gives the ratio between the median price of land in a developed plot at the urban fringe in a typical subdivision and the median price of raw, undeveloped land in an area currently being developed (i.e., with planning permission). The comparison should be raw and serviced land in typical urban fringe areas where residential development is allowed (i.e., where planning permission is given and zoning regulations for residential development is in effect). Prices refer to typical 50- 200 unit subdivisions on the urban fringe. This indicator does not apply to local government areas that do not contain part of the urban fringe.
- P*ublic Open Space*. This refers to the proportion of public open space in the built-up area (sometimes known as “green space”). Should include public parks, gardens, reserves, recreation areas, beaches (but not private golf clubs and similar).

2.2.7 Housing

Housing represents one of the most basic of human needs, but this group of measurements is concerned less with measures of housing size or quality; it is concerned more with land use and land costs, including:

- *Dwelling Type*. This covers the percentage of (a) single family houses, (b) medium density, (c) apartments, (d) temporary dwellings, and (e) others (institutions, hostels, etc).
- *Tenure Type.* This covers the percentage of households in housing tenures (a) owned or purchased. These are households with a clear title or ownership (formal housing) of the house and land they occupy, possibly through a company structure or as condominiums or strata title or long leasehold of land, and possibly

encumbered by a mortgage (purchasing). It also covers (b) private rental. These are households in formal housing for which rents are paid to a private landlord who is the legal owner. They include backyard shacks, if the main property is owned. (c) Social housing covers all housing in public, parastatal, or NGO owned or operated housing, including government employee housing and housing owned or operated by cooperatives or housing associations. (d) Sub-tenant households are those renting from another household who is renting the premises. (e) rent-free. Households occupying housing formally owned by someone else and who do not pay rent. (f) Squatter – no rent households are in squatter housing, or housing that has no title to the land on which it stands, and who do not pay rent. (g) Squatter – paying rent are households in squatter housing who pay rent. (h) Others includes nomads, persons in institutions, boarding houses or hotels, and other tenures.

- *House Price to Income Ratio*. This refers to the median house price divided by median household income. It is the ratio of the median free-market price of a dwelling unit to the median annual household income.
- *House Rent to Income Ratio*. This is the median annual rent divided by median annual renter household income. Expressed as percentage. Incomes are median gross incomes of private and public renter households. Rents are contract rents, or the amount paid for the property alone and not for utilities such as electricity, heating, etc.
- *Floor Area per Person*. This is the median floor area per person in m2. The floor area should include all living space, along with bathrooms, internal corridors, and closets. Covered semiprivate spaces such as inner courtyards or verandahs should be included if used by the household for cooking, cleaning, etc.
- *Housing in Compliance*. This is the percentage of housing stock in compliance with local codes. Only housing which has both a clear title to the land on which it stands, and which is constructed with all required building, land use, or land subdivision permits, should be regarded as being in compliance.
- *Net Housing Outlays by Government*. This includes the total net housing expenditures by all levels of government on dwelling construction, rent support, etc., per person.
- *Homeless People*. This is the number of homeless or street people, on an average night. It is defined as the number of people who sleep outside dwelling units (e.g., on streets, in parks, railroad stations, and under bridges) or in temporary shelter in

charitable institutions. Includes people without shelter, without any recognized address, living temporarily in hostels or shelters, and "street children".

- *Housing Production*. This concerns the number of dwellings produced annually, both formal and informal, per 1,000 population (a) on new vacant land, and (b) as net conversions or infill from other uses (can be negative). The latter consists of new units completed on land which was not formerly vacant, plus subdivisions of existing units, less any units destroyed or converted.

2.2.8 Municipal Services

Here are several sub-series of indicators for water, electricity, sewerage/ wastewater, telephone, and solid waste collection that measure the delivery of basic service, whether by the public or private sector, including:

- *Household Connections*. This refers to the percentage of households connected to water, electricity, sewerage/wastewater, telephone, and solid waste collection or percentage of households receiving regular garbage collection.

- *Investment per Capita in each service*. This covers the annual capital expenditure on water, electricity, sewerage/wastewater, telephone, and solid waste collection per person in US$.

- *Operations and Maintenance Expenditure on each service*. This covers the annual total operations and maintenance expenditure on water, electricity, sewerage/ wastewater, telephone and solid waste collection, per person in US$.

- *Consumption of Water per Capita*. This pertains to domestic water supplied or used, in liters per person per day.

2.2.9 Urban Environment

This group of indicators relates closely to the last, since it includes measurements of solid waste generated, solid waste disposal, household sewage disposal, and wastewater treated. It also includes measurements of air pollution, energy use, noise complaints, and damage from natural disasters.

- *Household Sewage Disposal*. This is the percentage of households using different disposal methods: (a) sewage pipe, (b) septic tank (treated), (c) underground pit (untreated), (d) underground communal, (e) pan collection, (f) open ground or trench, and (g) others.

- *Methods of Solid Waste Disposal*. These cover the total solid waste generated (and disposed of both formally and informally) including: (a) percent disposed to sanitary landfill; (b) percent incinerated (formally); (c) percent dumped or burned

in the open (and other informal disposal); (d) percent recycled (formal or informal); and (e) others (any other formal means of disposal).

- *Wastewater Treated*. This is the percentage of wastewater undergoing some form of treatment.

- *Solid Waste Generated*. This includes solid waste generated per person in tons per annum. It does not just include the waste that is collected, but all solid wastes produced by households.

2.2.10 Urban Transport

This group of indicators basically measures traffic, both of people and goods; it includes data on mode of travel to work, median travel time, car ownership, port and air activity, and goods carried by different modes. It also includes some indicators that effectively measure the impact of public policies: expenditure on roads, road congestion, cost recovery from fees, and transport fatalities.

- *Mode of Travel*. This covers percentage of trips to work by (a) private automobile; (b) train, tram or light rail; (c) bus or minibus; (d) motorcycle (two- or three- wheel motorized vehicle); (e) bicycle, including pedicab (pedal-powered vehicle); (f) walking; and (g) others (including boat, taxi, animal or rickshaw). Where several modes of transport are used for a given trip, the hierarchy: train, tram bus, car, not motorized is employed to determine the principal mode.

- *Median Travel Time*. This indicates the average time in minutes for a work trip, over all modes. Train and bus times should include average walking and waiting times, and car times should include parking and walking to the workplace.

- *Expenditure on Road Infrastructure*. This covers the per capita expenditure on roads (3-year average). Expenditure should include capital and maintenance expenditure on all roads in the urban area, averaged in constant value terms over three years.

- *Automobile Ownership*. It is defined as the ratio of automobiles to people of driving age. Automobiles in this case are taken to include all vehicles used for personal transport (including sedans used for business). Minimum driving age varies from 16 to 18 in different countries.

- *Port/Air Activity*. Where the city has either a port or airport this shows the (a) number of commercial ships leaving port (freight and passenger); and (b) number of commercial flights leaving per month, for national or international destinations.

- *Transport Fatalities*. This refers to (a) all transport related deaths per 1,000 population, annually; (b) pedestrian deaths per 1,000 population, annually.

2.2.11 Culture

This is the most unusual group of measures. As distinct from seeking to provide comparable statistical indexes, it simply lists attendances at each city's leading attractions during the year. Some of these are ongoing, others are time-limited. Because of its nature, this group is difficult to compare.

- *Attendance at Public Events*. These are major public events during year, attendance at five largest. Events may include: concerts, festivals, sporting events, conventions, celebrity visits, or political rallies and protests.
- *Attendance at Galleries and Museums*. This is the list of major museum and galleries, with annual attendance.
- *Participation in Sport*. This refers to the percentage of population participating in organized sport. Sport can include non-physical activities like organized chess and bridge. Individual recreation activities, including gambling and video arcades, are not included.

2.2.12 Local Government

This group of indicators measures a variety of input and output measures, such as:

- *Employees.* This covers the total local government employees per 1,000 populations.
- *Wages in Budget*. This is the proportion of recurrent expenditure spent on wage costs.
- *Business Permits*. This recognizes the number of business permits issued in the past five years.

2.2.13 Urban Governance

The final group of measures is again large and highly heterogeneous. It includes:

- *Reported Crimes*. Number of crimes per 1,000 population reported: (a) murders, (b) drug related crimes, (c) thefts.
- *Contact with the Public*. Annual number of public local government meetings and total attendance.
- *Delivery of Annual Plan*. Percent of budgeted expenditure on annual plan delivered. In practice most government bodies deliver close to 100% of plan in the audited accounts, whether or not the budget has actually been expended as planned.
- *Voter Participation by Sex*. Proportion of voters who voted in last municipal elections: (a) proportion of adult males; (b) proportion of adult females.

- *Independence from Higher Government*. Definition of in what circumstances local governments can make their own decisions or are subject to higher government in (a) closing down the council or removing councilors from office; (b) setting local tax levels; (c) setting user charges for services; (d) borrowing funds; and (e) choosing contractors for projects. Also, the percentage of grant funds from higher government known in advance of local budget setting.
- *Representation of Minorities*. Definition of mechanisms for representation of any substantial minorities.

3 Research methodology

In this section we will present a detailed research methodology including choice of research approach, strategy, design, and methods. These choices concerning methodology determine how we gather necessary information to answer the research question mentioned in previous part by data analysis.

3.1 Choice of research strategy and research design

3.1.1 Research approach and strategy

Although epistemological and ontological positions are often explicitly mentioned in the academic research papers, they are important in revealing the philosophy behind the research questions, research design, methods used in collecting and analyzing data, etc. Firstly, regarding epistemological stance of our research paper, the interpretivism's point of view which asserts that "a strategy is required that respects the differences between people and the objects of the natural sciences and therefore requires the social scientist to grasp the subject meaning of social action" (Bryman & Bell. 2011) is employed. Hence, the idea that the research results are depended on the researcher's interpretation will be adopted in our paper. Secondly, the chosen position on the questions of social ontology is constructionism, which states that social constructions built up from perceptions and actions of social actors (Bryman & Bell. 2011). This idea will be discussed in detail in our paper, which is formulated with the emphasis on the active engagement of the Oslo Municipality and the citizens in city logistics development.

Connecting above philosophical stances with the methodology of the research, one of the four social paradigms, namely interpretative paradigm is decided taking into account the assumptions about the nature of Oslo city as well as the function and purpose of the research. According to Bryman & Bell (2011), we here define cities as organizations that they exist without the perceptions of the citizens living

within them, thus. The study of these cities should be done based on these people's experiences (Bryman & Bell. 2011). Additionally, a quantitative research strategy and inductive orientation will be applied, aiming at exploring and contributing to the development of data-driven methodology in analyzing city logistics with a particular focal city and the problem addressed.

3.1.2 Research design

In combination with quantitative research strategy, exploratory case study is adopted as an appropriate design. There are two main reasons for this choice. Firstly, the issues in question involve a phenomenon in a specific context, specifically, the interpreting of the critical areas in city logistics. Research questions are about the phenomenon as 'how' and researchers have no direct control or influence on relevant behaviours. Case study is a means to best understand this kind of phenomenon and its context (Yin. 2012). Secondly, this research design allows exploring the chosen case in depth, thus, brings possibilities of new development on the already studied topic – city logistics. Together with the research questions, the choice of exploratory case design with a single case study is believed to be relevant and appropriate methodology framework, enabling a systematic analytical process to answer research questions and achieve the purpose of this research.

3.2 Research method

On a conceptual level, descriptors of urban form include location, distance, direction, orientation, linkage and patterns (Herold et al., 2005). Regarding this paper, we follow the framework proposed by Blanco, 2014 to develop urban logistics tools and metrics and to guide future research that addresses the definition of geographical scale, centrality, and logistics- oriented metrics, as guiding principles to develop an urban logistics atlas.

3.2.1 Research process

City Logistics Toolkit is a tool to assist the decision making processes regarding urban freight and already been carried out in eight metropolitans around the world. The motivation comes from the recognition of the lack of metrics and tools for city planners to identify drivers of urban freight efficiency. The conduct of the toolkit takes four main phases as follows:

Phase 1: Data Preparation

Necessary data are collected from public source and available data:

- Infrastructure data: Road capacity, road density from OSM data of Oslo (Open Street Map, 2015)
- General data: Population density, commercial density, income and other socio-economic indicators such as waste, numbers of cars, numbers of households from Oslo's statistics Department.

Initial analysis would be the manual removal of several unnecessary areas (in kilometers squared).

Phase 2: Quantitative Analysis

The reduced set of data from phase 1 will be grouped into components using principal components analysis. After that, k-means clustering analysis is used to divide these components into k clusters which removes single event influences (e.g. airports, etc.) and random outliers to conclude final clusters.

Phase 3: Logistics Cluster Interpretation

Based on clusters analyzed from phase 2, relevant logistics areas will be interpreted via radar charts in terms of population, income, road density, road capacity retailers, etc. in total of 13 variables. Based on this interpretation, areas will be grouped into four categories which are downtown, intense commercial and services area, highest income living area, and in-town high income living area.

Phase 4: Validation

Interviews with local experts and field job of 4 weeks in a selected kilometer squared of Oslo will be carried out in order to validate logistics critical areas identified from statistical analysis.

3.2.2 Data analysis

- ***Research variables and measurements***

As the chosen variables of urban indicators is crucial in this paper, we would finalise the research variables after the meeting with Oslo authorities concerning what type of data can be accessed. However, main urban indicators that are in consideration are as follows: 1-Population, Migration, and Urbanization, 2-Income Disparity, Unemployment, and Poverty, 3-Health and Education, 4-Urban Productivity and Competitiveness, 5-Technology and Connectivity, 6-Housing, 7-Urban Land, 8-Municipal Services, 9-Urban Environment, 10-Urban Transport, 11-Culture, 12-Local Government Finance, 13-Urban Governance and Management.

- ***Coding of data***

For processing raw data collected from archives of Oslo, we plan to use a free coding software called *Python* in order to make data available for statistical software. The software used for analysing data is *STATA* which is a very powerful tool with advanced programming foundation. Another way as suggested by MIT is to use the JMP software which is a ready-to-use statistical package without any prior coding necessary. Finally, visualization of the results will be done via GIS.

- ***Analysis methods***

The main statistical tools used in this research are *principal component analysis* and *k-means cluster analysis.*

Principal component analysis is a statistical technique that identifies uncorrelated linear combinations of (high dimensional) variables. Through using the empirical correlation matrix, we can transform a high dimensional data-set to a lower dimensional data-set that can be more easily understood. Therefore, in other words, PCA is a techniques used to reduce dimensionality that reduce many variables to a few that contains most information.

K-means cluster analysis is a technique that aims at partition n observations into k clusters in which each observations belongs to the cluster with the nearest mean, serving as the prototype of the cluster.

3.3 Research materials assessment

Two most important criteria for evaluating the quality of quantitative research are *reliability* and *validity* (Bryman & Bell 2011).

3.3.1 Reliability

Reliability is identified as the stability of a study through the time (Bryman & Bell. 2011). When a study's measures and process are done many times again, a consistent result should be generated. This means that the reliability of the research significantly determines the study's repeatability (Nahid, 2003). For qualitative research part, poor documenting data from interviews or writing notes often causes reliability of the study to be suspicious. For quantitative research part, the accuracy of the data collected from the field work which are highly dependent on the collectors will also greatly influence the reliability of the whole research. Therefore, in order to avoid such problems, we will use case study protocol, develop case study database in details and cross-check data so that when other researchers repeat the procedures, they will obtain more or less the same results.

3.3.2 Validity

Validity is ensured when a measure of a concept really measures the concept (Bryman and Bell 2011). Multiple sources of evidence will be collected and justified by triangulation process in order to confirm the similarity of facts. In addition, several steps including the use of interview guide, the taking of notes during interviews, the informants' review of transcripts and the use of structured analytical method in analysis of data, will be taken to limit bias and increase objectivity both during the interview, written documents using and in analyzing the data. Besides, multiple software, such as STATA, GIS and Python, will be applied in analyzing data and virtualizing the results. Therefore, the findings can be viewed as having a high degree of validity.

4 Limitation of research

First of all, we acknowledge of the disadvantage of single case study research. The findings may have limited generalizable value to a wider setting since they come from the case study of a single city - Oslo. However, the goal of the paper is to study Oslo city and provide applicable suggestions, not to apply the findings to wider settings. It may be possible that the findings can be applied to cities with similar characteristics. Furthermore, as discussed above, the study is believed to have certain contributions in term of analytic generalization. Indeed, the study provides the understanding about the city logistics from the perspective of Oslo city and explores new tools to help policy makers in urban planning. The second limitation involves data collection. There may be certain obstacles to collect all desired information from interviews, such as limited confidential information sharing and no approval from the informants to make tape recorded. Further, access to information related to urban indicators, such as population density and number of warehouse are quite limited. These facts cause difficulty to data collection. We might probably ask Oslo Municipality to open these databases for us so as to carry on our research. Additionally, secondary sources sometimes do not provide sufficient evidence. Thus, we may have to make some assumptions as a base to implement the research. Finally, as Master students, our research skills and experience are still relatively limited. However, writing this paper offers a good opportunity to gain new research knowledge and experience on the topic.

5 Societal and ethical considerations

According to Bryman and Bell 2011, there are two main questions concerning ethics in social research that are: how should we treat the people on whom we conduct research and are there activities in which we should or should not engage in our relations with them. Regarding the first question, we justify our research by answering four main areas suggested by Diener and Crandall 1978 which are whether there is harm to participants, whether there is a lack of informed consent, whether there is an invasion of privacy, and whether deception is involved.

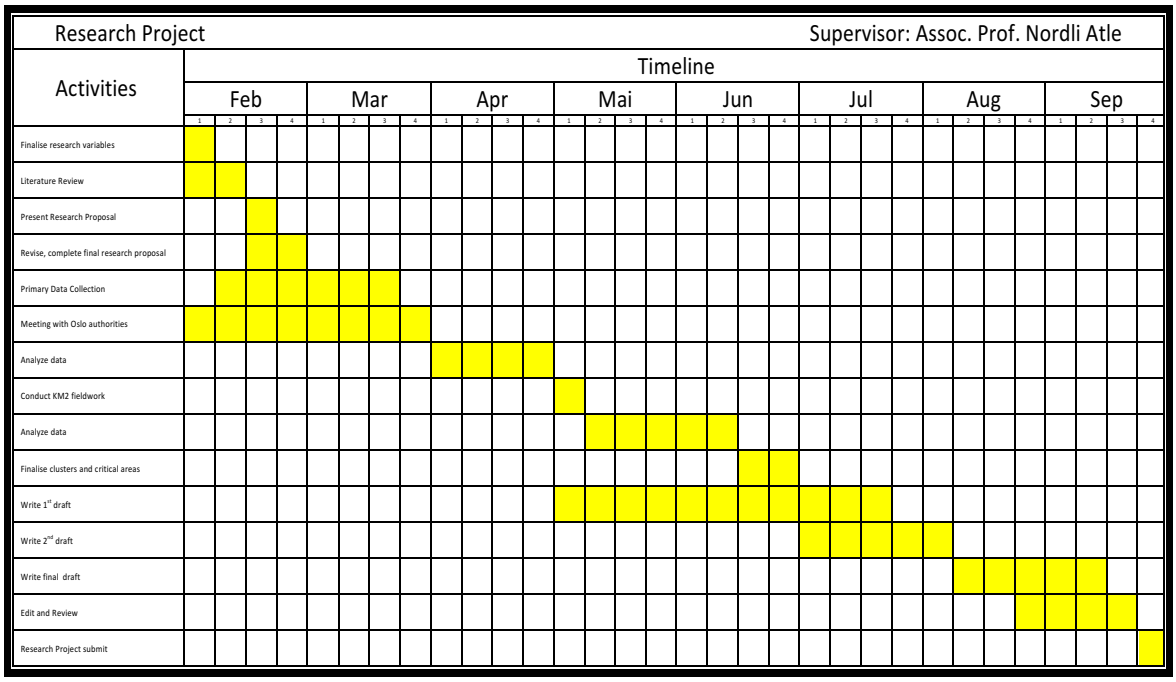
We are sure that this research would do no physical harm, no harm to firms' development, loss of self-esteem, and stress to the firm's representatives who are assigned to fill in the questionnaire form or interview. In ensuring the informed consent, we would obtain the informed consent of the participants by getting them to sign informed consent forms to give respondents the opportunity to be fully informed of the nature of the research and the implications of their participation at the outset. We also guarantee that the anonymity and privacy of those who participate in the research process should be respected and firms' information within the research should be kept confidential. Regarding deception, we guarantee that we would represent our work as something exactly to what it is to the peoples participating in our research.

Concerning the second question mentioned in the first paragraph, we commit to treat all participants in this research equally and no special gifts or incentives or any further engagement in relationship would be given to some specific people.

6 Project Timeline

The detailed project plan is included in Appendix 1.

APPENDIX 1 – Project timeline



APPENDIX 2 – Questions to ask about research quality

Questions to ask about research quality				
Procedures	**Questions**	**Hints**	**Expected Answers**	**Current Answers**
Research Question and Design	Does the research design match the research question?	-What is the research questions? (Descriptive? casual? explicit?) -What is the research design? (Quantitative? qualitative? Case study?)	Yes	
Data Collection	What data were collected, and how were they collected?	Interviews: -What was the basis for selecting the interviewees? -How were the interviewees assigned to groups? -Do interviewees selection and assignment follow the research design? -Are the results influenced by extraneous characteristics of interviewees and contexts? -Are the questions comprehensive and understandable? -Are there any descriptive terms in the questions that might rise ambiguity?	The research report should describe the number of interviewees in the study, as well as their characteristics. This includes not only the characteristics of persons, but also those of entities. In addition, the report should describe how the study's interviewees were chosen and how interviewees were assigned (if they were) to the different comparison groups in the study. More importantly, the sample should be random. As for the questions, they should be easy to understand and free from ambiguity.	

		Written documentations: -Are they up to date? -Are they relevant? -Are they clear and correct?	Yes	
Data Analysis	How were the data analyzed?	-How was the data coded? -What procedures were used to verify the coding?	In qualitative research, the data consist of narrative descriptions and observations. Large amounts of descriptive information are organized into categories and themes through coding. Coding is designed to reduce the information in ways that facilitate interpretations of the findings. A report on qualitative research should give detailed descriptions of the codes.	

Rival Explanations	Are there any rival explanations for the results?	In qualitative research, it is important to rule out rival explanations for the results. This occurs through procedures such as: -Checking back with interviewees to confirm that the researcher's interpretation of their responses, in an interview, for example, is correct. -The use of multiple sources of data. When data from several different sources, such as documents, interviews and observations, converge on the same conclusions, there can be greater confidence in the validity of these conclusions than if only one data source informs conclusions. -A search for disconfirming evidence in which the researcher examines all the data for any evidence that might indicate the conclusions are wrong. -Generation of specific rival explanations for the conclusions and a demonstration of how they do not apply based on the data and the methods used.	No	

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