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GREEN URBAN DISTRIBUTION: EVALUATION OF ADAPTED MEASURES FOR THE CITY OF OSLO

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ABSTRACT

The paper presents results from a study of urban freight measures in the city of Oslo. More specifically, it presents methods and results from an ex ante study of seven potential city logistics measures. The study is based on a survey among 67 representatives from three stakeholder groups. Furthermore, a generic ex post evaluation framework is presented, and an example of how the framework has been applied to evaluate a demonstration of electric distribution vehicles. The study gives explicit and systematic documentation of multiple stakeholder perceptions related to several measures in urban freight. Only a few studies have done so previously. The measure assessed most positively is environmentally friendly vehicles. The ex post evaluation of demonstrated electric vehicles suggests that electric vans can serve parts of the express shipment market very well with their existing range. Removing uncertainties related to their performance and financial viability is an important task for further take-up of these vehicles. The study provides a basis for designing viable and effective measures in order to achieve more environmentally-friendly and effective freight distribution in the city center of Oslo. Also important is the methodology providing a systematic and informed approach to policy design and implementation. As such, the study is useful to other cities and scientists in search for viable and efficient measures in specific local contexts.

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KEYWORDS: Urban freight; environmentally friendly; stakeholders; survey; effects; evaluation.

INTRODUCTION

The city of Oslo is in rapid growth, with a population expected to increase by over 30 % by the year 2030. As a consequence, the demand for transport services will rise rapidly and markedly over the next years, and freight distribution is also expected to increase by 50 % by 2030 (City of Oslo, 2011).

Freight deliveries are vital to an attractive and living city centre with shops, restaurants and other businesses. Nevertheless, freight distribution causes hazardous gas emissions, congestion, noise and other disturbances. Furthermore, freight vehicles are often in conflict with other road user groups such as pedestrians, cyclists and public transport.

As a consequence of urbanization and requirements to reduce pollution, the City of Oslo is considering how transportation of both goods and passengers can be effectively optimized. Even though some improvements for greener freight transport have already been achieved, the City of Oslo is seeking new innovative measures that may improve the situation for stakeholders and for the environment even further. In line with this, the project Green Urban Distribution (GUD) aims at identifying and demonstrating environmentally friendly and efficient solutions for urban goods distribution in the city centre of Oslo.

Policy design must always be based on knowledge of the particular context to which the policy will apply. Even though reports from initiatives taken in other cities may show positive results, a thorough analysis of the implications of transferring these measures to the context of another city is required (Macário and Marques, 2008). Thus, in order to implement successful urban freight measures, it is of vital importance that potential measures are properly assessed in a local context beforehand.

Some of the measures tested in other European cities have showed good results, while others have caused unwanted consequences. A general observation is that the evaluation results in many cases are absent or not published. The evaluations already realized are often adapted to the measure at-hand. Better evaluation frameworks could lay the ground for more transferable experiences and learning between countries and cities.

On these grounds, proper and thorough *ex ante* assessments as well as *ex post* evaluations are key elements in the formation of suitable urban freight policy measures in Oslo. This is sought accomplished by a methodological process consisting of six steps; from identifying a wide range of potential measures in a comprehensive state-of-the-art study, to selecting, adapting and evaluating measures found to be the most feasible and efficient in the specific context of Oslo. Finally, a business model for one measure for more efficient and environmentally friendly urban freight is developed. The process is illustrated in Figure 1.

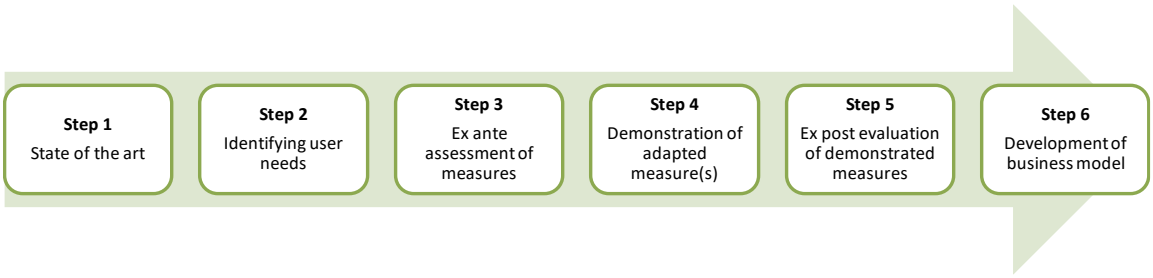

Figure 1: Methodological process

The process in the project thus goes from a broad perspective in terms of number of potential measures to a narrow scope where one or two measures are demonstrated and evaluated. Involvement from different stakeholder groups is seen as an important success criterion, thus dialogue with and between these groups is very much in focus throughout the whole project.

In this paper, focus will be placed on steps 3 and 5 in Figure 1; assessing and evaluating measures. The objective of the paper is thus twofold. Firstly, the paper presents methods and results from an *ex ante* study of potential measures. The study is based on a survey among the stakeholder groups viewed as most affected by an implementation of the measures in question. Secondly, the evaluation framework used in an *ex post* study of demonstrated measures is presented, as well as how the framework has been applied to evaluate a demonstration of electric distribution vehicles. Together, the two parts of the paper shows evaluation of measures before and after implementation in the GUD project.

The study provides a basis for designing viable and effective measures in order to achieve more environmentally-friendly and effective freight distribution in the city centre of Oslo. More important for the wider audience, however, is the methodology providing a systematic and informed approach to policy design and implementation as well as evaluation. As such, the study is useful to other cities and scientists searching for viable and efficient measures in specific local contexts.

EX ANTE ASSESSMENT OF MEASURES

The role of stakeholders

The successful introduction of new measures depends on the acceptability and receptivity of involved stakeholders. In order to successfully implement city logistics policies, it is of vital importance to recognize and adequately understand the concerns of different stakeholder groups (Stathopoulos et al., 2011).

One of the most important predictors of a measure's feasibility is therefore its consequences to involved stakeholders. Stakeholders will adhere to a measure only if it will not inflict any negative consequences upon them (Rogers, 1983), or if positive consequences outweigh negative ones. Further, negative consequences are typically more important to stakeholder evaluations than the measure's

effectiveness (Schuitema and Steg, 2005). Consequently, stakeholders should play an important role in revealing potentially negative and positive outcomes of a measure before it is implemented.

The importance of stakeholder involvement in decision making is recognized in a variety of research fields, although appearing with different labels such as stakeholder collaboration, public participation, citizen participation and stakeholder management to mention some.

Nevertheless, the existing knowledge on stakeholder perspectives on urban freight policy is limited (Bjerkan et al., 2014). In contrast to for instance public transport, authorities have typically not acknowledged their own potential influence in achieving efficient freight transport (Lindholm, 2012). Along with other factors, this has caused a vacuum in urban freight allowing for uncoordinated activities characterized by lack of cooperation between actors. Managed and determined stakeholder involvement is therefore crucial for advancing towards efficient urban freight, and is likely to represent an untapped resource more in urban freight than other transport areas. Additionally, urban freight represents far greater potential in tackling environmental challenges as it is a leading cause of both noise and local pollution in urban areas.

In complex areas such as urban freight transport joint strategies cannot be achieved without collaboration between public and private stakeholders (Gray and Wood, 1991). Not attending to the interests and perspectives of stakeholders often leads to poor performance, failure or disaster (Bryson et al., 2011). Conflicts between stakeholder interests call for open dialogue to which all stakeholders can contribute (Hensher and Brewer, 2001). Public-private understanding, collaboration and partnership is necessary in order to achieve sustainable urban freight transport (Crainic et al., 2004), and, in particular, long-term public-private partnerships can have positive effects on outcomes for both groups (Lindholm and Browne, 2013).

The importance of integrating stakeholder views is very much appreciated in the GUD project. The ex ante approach for assessing potential measures is therefore based on interviews with the most relevant stakeholder groups.

A stakeholder can be defined as an actor or group of actors which affects or are affected by the phenomenon under study (Banville et al., 1998, Freeman, 1984, Munda, 2004). Recent research has identified carriers, end-receivers and local authorities as the most relevant stakeholders in the urban distribution chain (Russo and Comi, 2010, Stathopoulos et al., 2012, Lindholm, 2012). These are also considered vital for the introduction of measures in the city of Oslo, and are the main focus in the GUD project. For a more in-depth discussion on the involvement and roles of diverse stakeholder groups in the urban distribution chain, see Bjerkan et al. (2014).

Measures

An increased international focus on reducing emissions from urban freight has resulted in a significant number of city initiatives and new practices in this domain, as well as studies of these practices. In a state of the art report, Roche-Cerasi (2012) identified and documented European city logistics practices. Based on stakeholder interviews and a focus group seminar (Bjerkan et al., 2014), followed by an initial assessment of the suitability of the identified logistics practices for the local context of Oslo, the following measures were found to be of most relevance:

- Off-hour deliveries
- Booking of loading bays
- Multiple use lanes
- Urban consolidation centre
- Access restrictions
- Environmentally friendly vehicles
- Unmanned freight receipt

Off-hour deliveries

Today, the majority of deliveries in the city centre of Oslo are made between 9 AM and 3 PM, when stores and office buildings are open and staff is present to receive the goods. If more deliveries are made during evenings, nights and early mornings, the time spent in traffic is likely to be significantly reduced, resulting in lower emission levels and more predictable delivery times (Holguín-Veras et al., 2012). Furthermore, the delivery stop times will be reduced, with easier and more direct access to delivery points. Focus group interviews with stakeholders in Oslo have indicated that both carriers, end-receivers and authorities recognize these gains and are positive towards off-hour deliveries (Bjerkan et al., 2014).

Booking of loading bays

One of the main problems for carriers in inner cities is to find a place to unload the vehicle near the delivery point. When no loading/ unloading space is available, the carrier is forced to drive around until he/ she finds a space, or place the vehicle illegally. This entails negative effects on traffic flow, environment, and safety. It also delays deliveries to the receiver and causes unpredictable delivery times for both the carrier and the receiver.

By using a system of booking or otherwise pre-approval of access to loading bays for certain types of vehicles, the plausibility of finding an available space increases. This has been tried and evaluated in Bordeaux as part of the ELTIS project, and positive impacts on emissions were found (Gerardin, 2004).

Multiple use lanes

In the city centre of Oslo, buses and trams constitute a significant portion of the traffic. Certain streets are open only to buses or trams, and the authorities will establish the same regulation in more streets. Giving distribution vehicles access to bus streets outside peak hours may lead to a more efficient utilisation of available street areas. For the carriers this could lead to shorter delivery times and

reduced emission levels, and for the receivers the delivery times can become more predictable.

Urban consolidation centre
Consolidation of goods from different carriers in a centre in or near the outer limits of the city centre can lead to more effective goods distribution, by facilitating fewer and/ or more environmentally friendly distribution vehicles. As Browne et al. (2005) puts it: *The key objective of Urban Consolidation Centers (UCCs) UCCs is the avoidance of the need for vehicles to deliver part loads into urban centers.*

This measure may thus reduce local emissions from goods distribution significantly. A considerable number of UCCs have been planned, implemented and demonstrated, often through projects financially supported by public authorities (Roche-Cerasi, 2012, Campbell et al., 2010).

Access restrictions
There are several types of access restriction schemes that may be implemented in order to reduce traffic and thereby vehicle emissions in certain areas. Such schemes are typically based on criteria such as time windows and/ or vehicle characteristics, and may imply full denial of access or pricing schemes. In Oslo, variations of access restrictions already exist in pedestrian areas and streets reserved for buses and trams.

Environmentally friendly vehicles
Increased use of bicycles or vehicles driven by electricity or gas may lead to a significant reduction in emissions, thus representing a very efficient measure for more environmentally friendly freight distribution. Smaller vehicles may also be easier to park near delivery places.

Unassisted deliveries
Delivery solutions that do not require receiver staff to be present may contribute to a more effective and environmentally friendly distribution of goods, by facilitating deliveries outside regular office/ opening hours. For instance, placing goods in a secure container or storage room will reduce the need for a physical receiver to be present.

Methods

The ex ante assessment of measures is based on a multi criteria approach, based on perspectives from *Multi-actor multi criteria analysis* (MAMCA). MAMCA is a methodological tool to understand and analyse the role and input of stakeholders in strategic processes within the transport domain. This method explicitly includes stakeholder perspectives in evaluating transport measures with reference to stakeholder objectives. MAMCA is a stepwise methodology in which stakeholders and their key objectives are identified and weighted (Macharis et al., 2012). Indicators are then constructed for each criterion in the evaluation, before an

evaluation matrix is used for ranking alternatives according to their strengths and weaknesses.

The approach in the present study rests on notions from MAMCA, as it compares and ranks criteria and alternatives. However, it does not aim at reaching specific strategy formulation. The results presented in this paper rather represent a step to reach successful measure implementation by identifying strengths and weaknesses as seen by the different stakeholders.

A web survey was carried out among 67 local stakeholder representatives. The GUD project partner group included three large carrier companies, four organisations representing the interests of carriers, drivers and the merchants in Oslo, as well as national road authorities and the City itself. The link to the web survey was distributed to representatives from these partners and to other relevant stakeholders within and outside their organisations.

The survey focused on assessing consequences of the measures, represented by criteria set on the basis of interviews with the stakeholder groups. The carriers and end-receivers were asked to consider a set of consequences of the measures for *freight distribution* in the city centre of Oslo, by the following question:

- In light of the present situation, what consequences do you think that [measure] will entail for carriers/receivers in the following aspects:
    - Work hours
    - Security for staff
    - Security for goods [only receivers]
    - Time spent in traffic [only carriers]
    - Predictable deliveries [only receivers]
    - Parking facilities [only carriers]
    - Time spent on delivering/ receiving goods
    - Costs
    - Economic profit
    - Reputation
    - All in all

Representatives from the authorities were asked to assess the consequences for *society*:

- In light of the present situation, what consequences do you think that [measure] will entail for carriers/receivers in the following aspects:
    - Time spent in traffic for freight vehicles
    - Time spent in traffic for people walking or biking
    - Time spent in traffic for public transport
    - Noise
    - Use of street area
    - Costs
    - Law enforcement
    - Attractive city

- All in all

For *freight distribution*, the carriers and end-receivers should assess consequences represented by the following criteria:

- Predictability
- Economy
- HSE
- Delivery time
- Overall consequences

For *society*, representatives from the authorities should assess consequences represented by the following criteria:

- Traffic for distribution vehicles
- Traffic for walking/ cycling
- Traffic for public transport
- Noise (where relevant)
- Land use
- Costs
- Enforcement
- Attractive city
- Overall consequences

For each criteria, the measurement scale ranged from 1=*very positive consequences* to 5=*very negative consequences*, recoded into the scale -2=*very negative consequences* to 2=*very positive consequences* in the analyses presented in this paper. The respondents were also free to comment every measure.

The questions were introduced by a short description of the measure in question. The completion time of the questionnaire was 10-20 minutes.

The survey is not representative for the stakeholders in the city centre of Oslo as a whole, but it does give valuable input from a large and varied selection of stakeholders in the local setting. As the survey was voluntary the composition of the sample was difficult to control. The end-receivers formed the largest group of respondents with 42 % of the sample, representing shops, restaurants and coffee places, hotels and canteens. Representatives from local and central authorities amounted to 36 % of the sample, representing sub-areas like city and road planning, parking regulations, environmental issues, urban freight and public transport. Carriers constitute only 13 % of the sample, and are thus underrepresented in the survey. However, these respondents represent large companies handling the majority of deliveries to receivers in the city centre of Oslo. Thus, their opinions are of great importance. The last 9 % of the sample are representatives for interest groups for carriers and end-receivers, and also include two consultants with expertise in the area of urban traffic planning.

Survey results

The following sections present the survey results from stakeholders' multi-criteria assessments of each of these measures.

Off-hour deliveries

The survey revealed a less optimistic assessment of this measure than reported in focus group interviews, as limitations regarding HSE (working hours and security for drivers and receiver staff) and noise were pointed out (Figures 2 and 3). Some respondents, notably among end-receivers, were also concerned about increased wage costs. They argue that it would be too expensive to have staff in their shop or office reception solely for the purpose of receiving goods. The respondents also comment that some types of goods are not suited for deliveries outside opening hours, such as high-value articles and drugs.

Previous research has identified the end-receivers (Holguín-Veras et al., 2006, Holguín-Veras et al., 2012) or wholesalers (Tretvik et al., 2013) as the most influential parts of the logistics chain when it comes to deciding time of delivery. Thus, policies designed to encourage off-hour deliveries should target the transport service buyers in order to be effective. In line with these findings, the carriers in the survey comment that off-hour deliveries are not feasible as most customers require that the deliveries are made when the receiver is present; that is during opening hours.

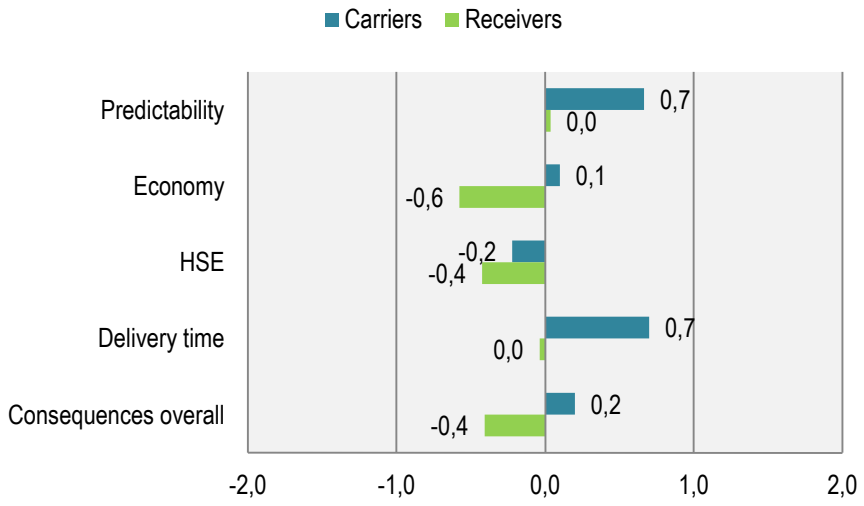

Figure 2: Assessment of off-hour deliveries. Carriers and end-receivers.

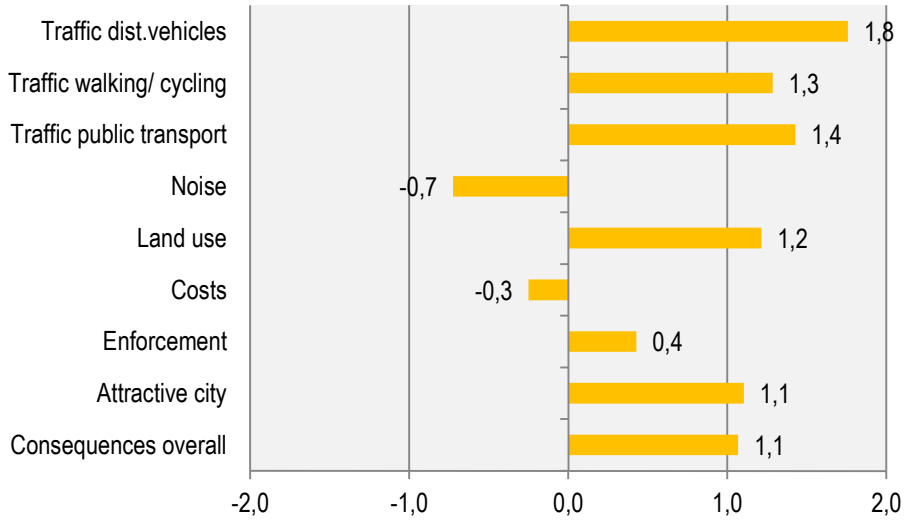

Figure 3: Assessment of off-hour deliveries. Authorities.

Booking of loading bays

The respondents in the Oslo survey are concerned that a booking system of loading bays is not feasible. If a driver has booked a parking space and for some reason (traffic and weather conditions, delays with earlier deliveries) is unable to arrive at the specified time, the space will be left unavailable to other drivers even though it is not physically occupied for that time period. Thus, such a system could lead to more inefficient use of street area, contrary to the intentions.

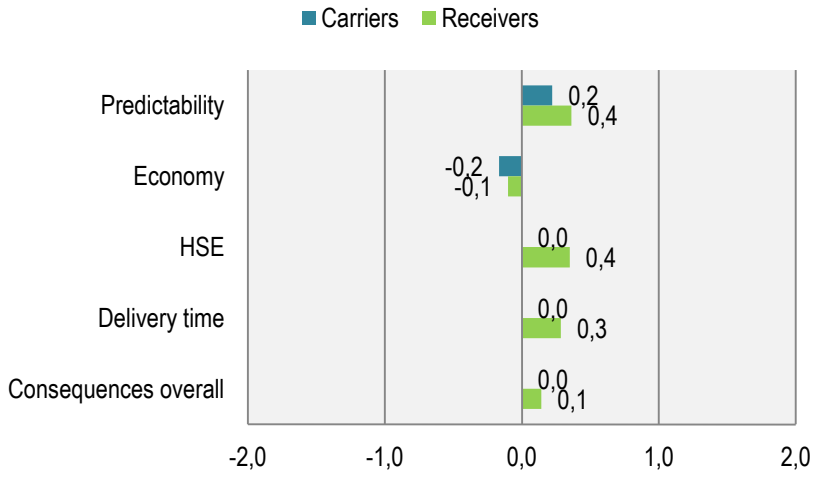

Figure 4: Assessment of booking of loading bays. Carriers and end-receivers.

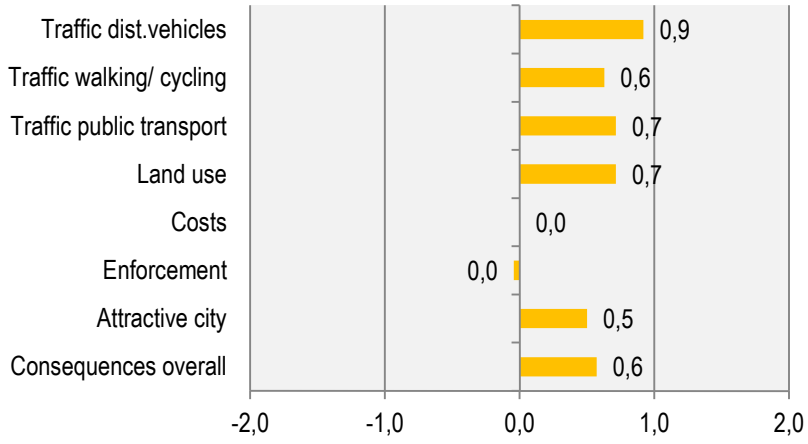

Figure 5: Assessment of booking of loading bays. Authorities.

A more feasible way to increase availability of parking space for carriers could be to restrict availability for other vehicles. In Oslo, most parking spaces are only allowed for shorter stops for loading/ unloading goods or passengers. These spaces are accessible not only for carriers but also for private drivers, wholesalers with direct deliveries of for instance fruit or office supplies, taxis and workmen. Making these spaces accessible only for carriers in the time periods where most deliveries are made could therefore be a more suitable measure than pre-booking for a single vehicle.

Multiple use lanes

The respondents are positive towards giving carriers access to bus streets outside peak hours, although carriers and receivers are more positive than authorities. However, some point out that the need to access these streets is most prominent during peak hours, and that the usefulness of such a measure would be limited in the busiest streets as there is a continuous flow of buses and trams.

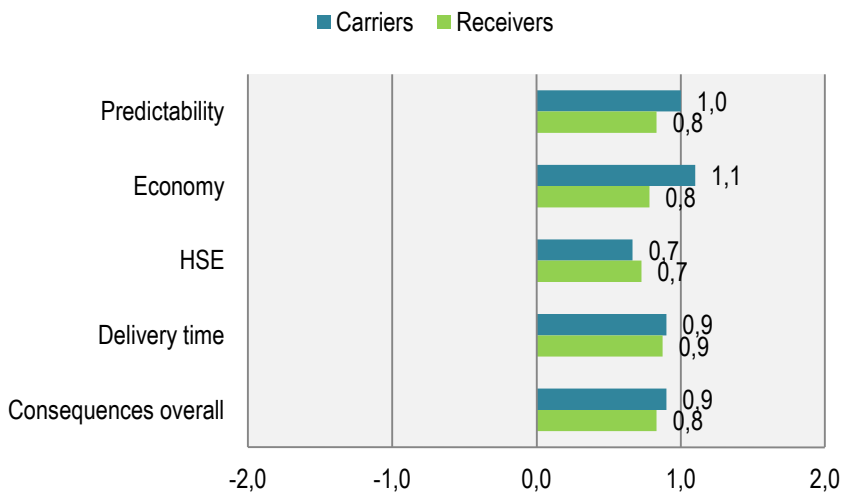

Figure 6: Assessment of multiple use lanes. Carriers and end-receivers.

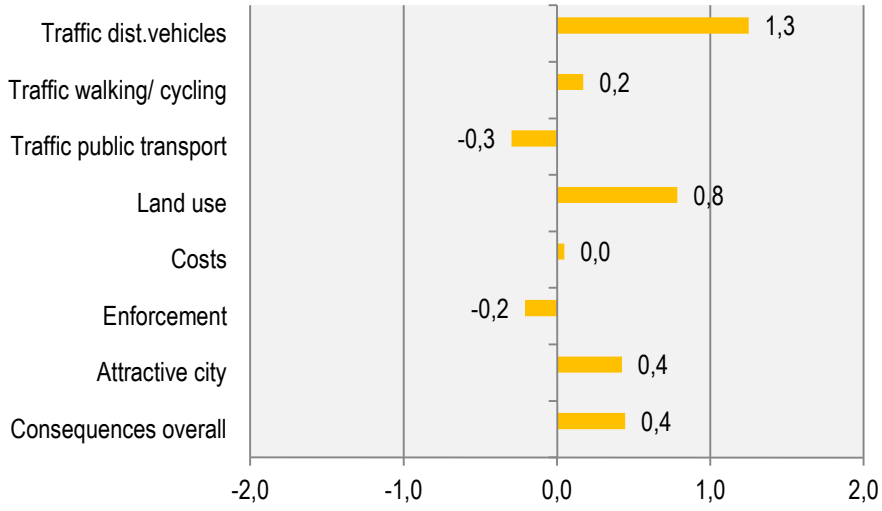

Figure 7: Assessment of multiple use lanes. Authorities.

Such a measure necessitates effective regulation and control of the number of distribution vehicles allowed in the bus streets simultaneously, to avoid delays for buses and trams. Restricting access only to environmentally friendly distribution vehicles would enhance the environmental benefits. It is an important aim both for local and national authorities that public transport should be an attractive alternative to driving private cars. Combined with a solid population growth, the number of buses, trams, cyclists and pedestrians in the city centre of Oslo are expected to increase markedly over the next years. Thus, before implementing such a measure a thorough study of potential and capacity is needed.

Urban consolidation centre

In the survey, respondents from the authorities are mainly positive towards the idea of a consolidation centre (Figure 9), whereas carriers and receivers are more sceptical (Figure 8). They comment that a UCC would represent an additional level of goods management and as such would be too demanding with regard to time and costs. Carriers also point out that goods are already consolidated within the company and optimized so that most vehicles are filled.

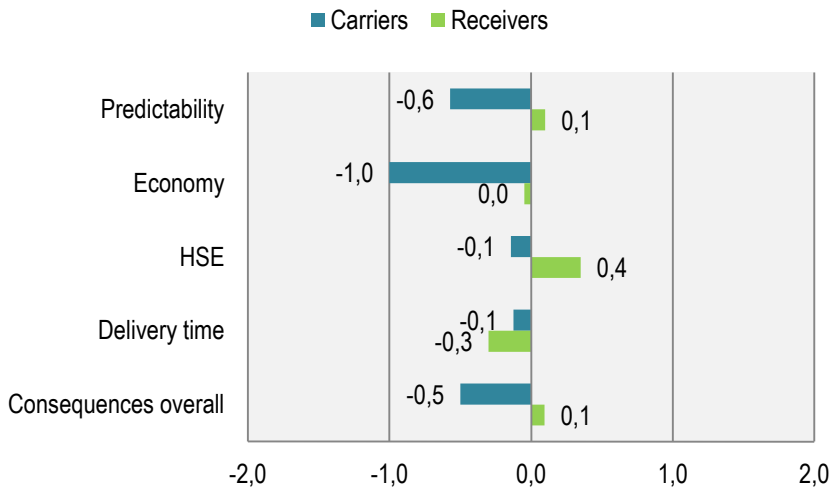

Figure 8: Assessment of urban consolidation centre. Carriers and end-receivers.

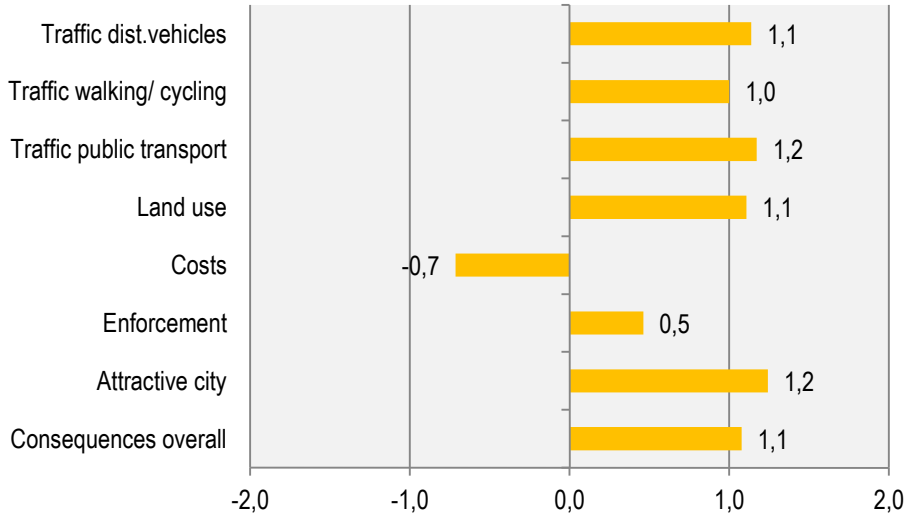

Figure 9: Assessment of urban consolidation centre. Authorities.

Although the willingness to use consolidation centres is limited among commercial actors, local authorities may force on the establishment of such centres by

demanding that freight distribution in the city centre must be accomplished by use of environmentally friendly vehicles. Moreover, counter-terror measures planned for implementation in Oslo after the terror attacks in 2011 may necessitate consolidation and alternative last-mile transport with approved vehicles.

Access restrictions

The stakeholder views on access restrictions depend on the actual measure design and criteria for restriction. In general, the carriers and end-receivers in the survey are very negative towards access restrictions (Figure 10), while the authorities are more positive (Figure 11). Several respondents comment that access restrictions would only work in combination with other types of measures, such as environmentally friendly vehicles, consolidation centre and/ or off-hour deliveries. Some are even concerned that goods deliveries will be so difficult and costly that commercial actors will move out of the inner city.

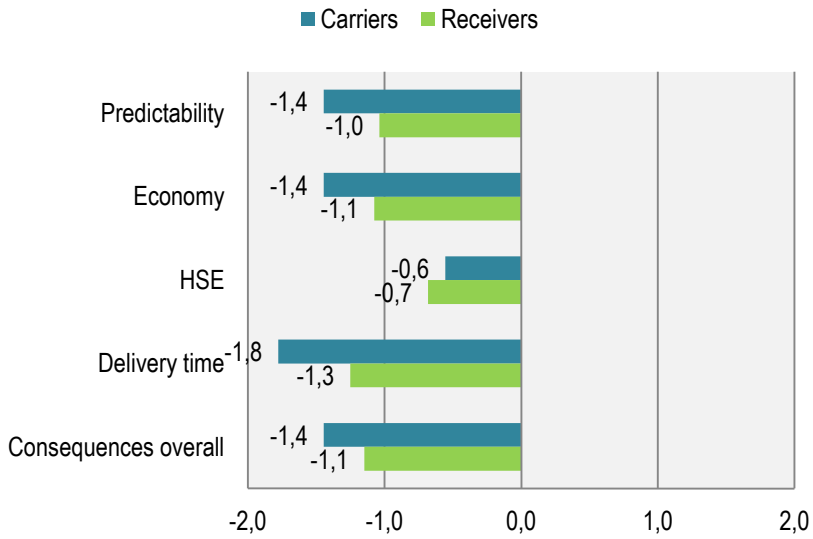

Figure 10: Assessment of access restrictions. Carriers and end-receivers.

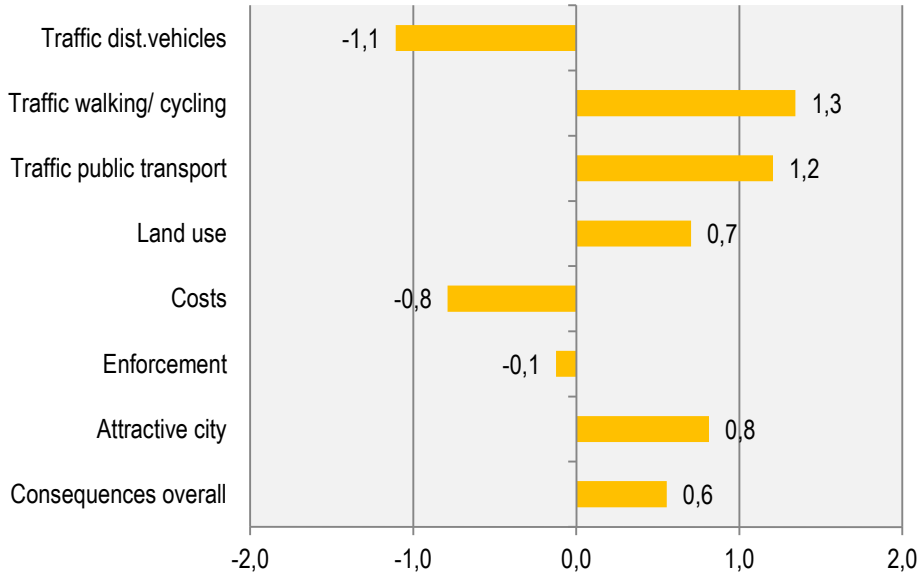

Figure 11: Assessment of access restrictions. Authorities.

Environmentally friendly vehicles

Carriers in Oslo are rather optimistic towards increased use of environmentally friendly vehicles (Figure 12). This is somewhat surprising, as the carriers will have the economic burden of investing in new and more environmentally friendly vehicles, at least in a short-term perspective. It should be noted that the carriers represented in this survey are mainly large companies already using electric and gas driven vehicles, who for various reasons would like other companies to take the same steps. The results may therefore not be representative for the whole stakeholder group.

The end-receivers in the survey are more negative to this measure, mainly because of the economic consequences (Figure 12).

In the GUD project, use of small electric distribution vehicles has been tested in the city centre of Oslo. The evaluation results from this demonstration are documented in the next section of this paper.

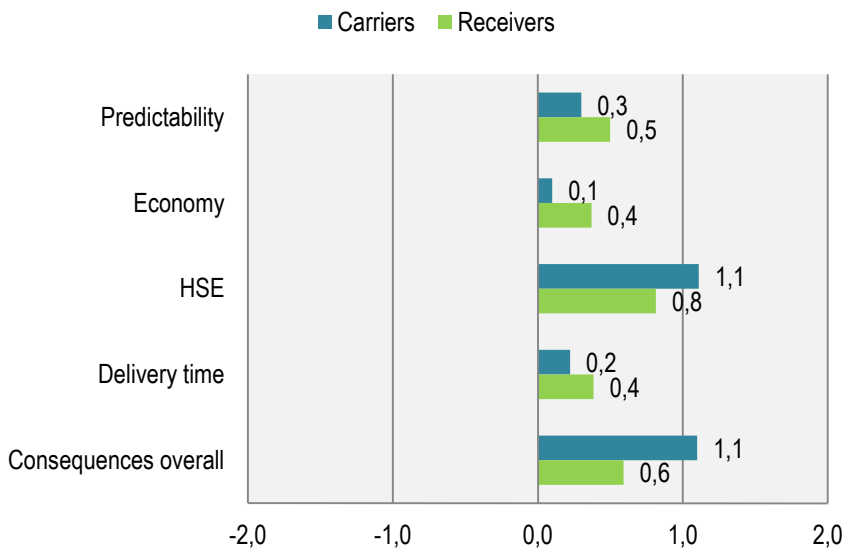

Figure 12: Assessment of environmentally friendly vehicles. Carriers and end-receivers.

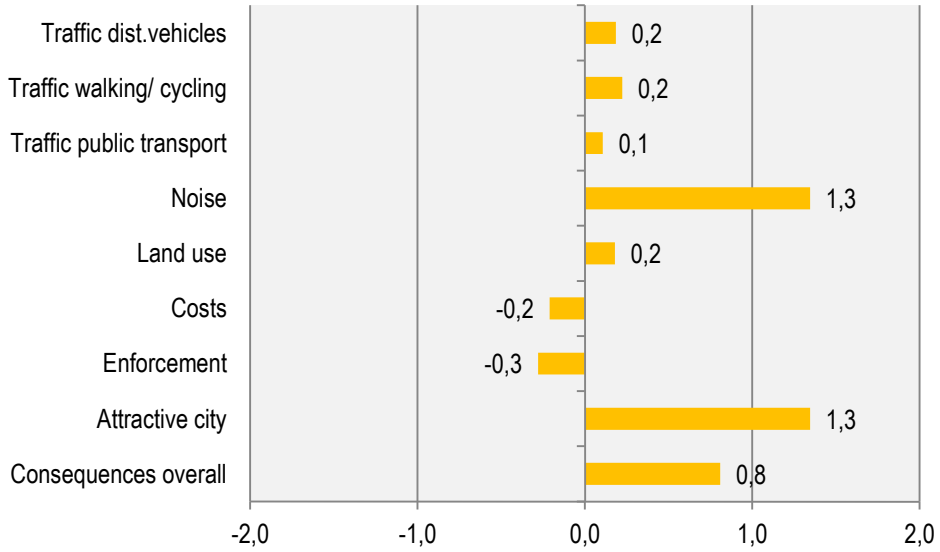

Figure 13: Assessment of environmentally friendly vehicles. Authorities.

Unassisted deliveries

The response to measures with unassisted deliveries is mixed in the GUD survey. The authorities are positive (Figure 15), while the carriers and the receivers are somewhat negative (Figure 14). All stakeholder groups comment that such an arrangement would not be suitable for large deliveries, neither for goods that require uninterrupted cooling or freezing, nor valuable goods, medicines and alcohol (due to security reasons). As such, the effect of such a measure is assumed to be limited. Furthermore, the staff could also be required to pick up the goods themselves, which introduces issues related to HSE (heavy lifting) and ability to leave the shop.

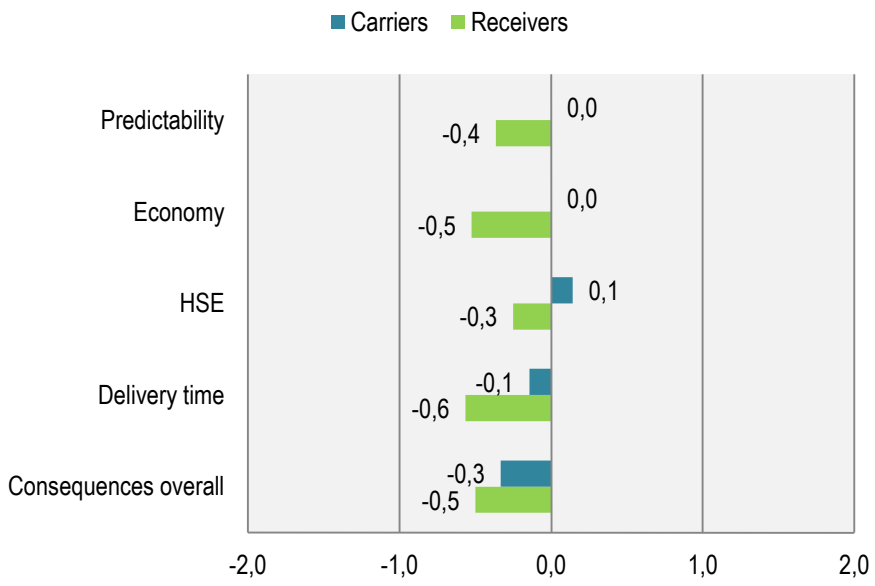

Figure 14: Assessment of unassisted deliveries. Carriers and end-receivers.

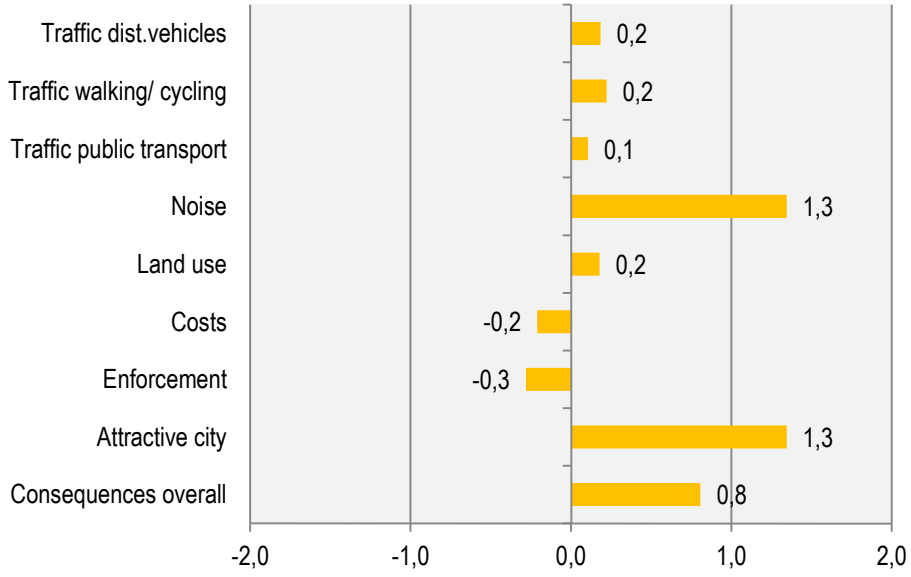

Figure 15: Assessment of unassisted deliveries. Authorities.

Overall assessments and conclusions

Figure 16 shows the mean scores for each measure from carriers (blue columns), end-receivers (green columns), authorities (yellow columns), and from all groups together (brown columns).

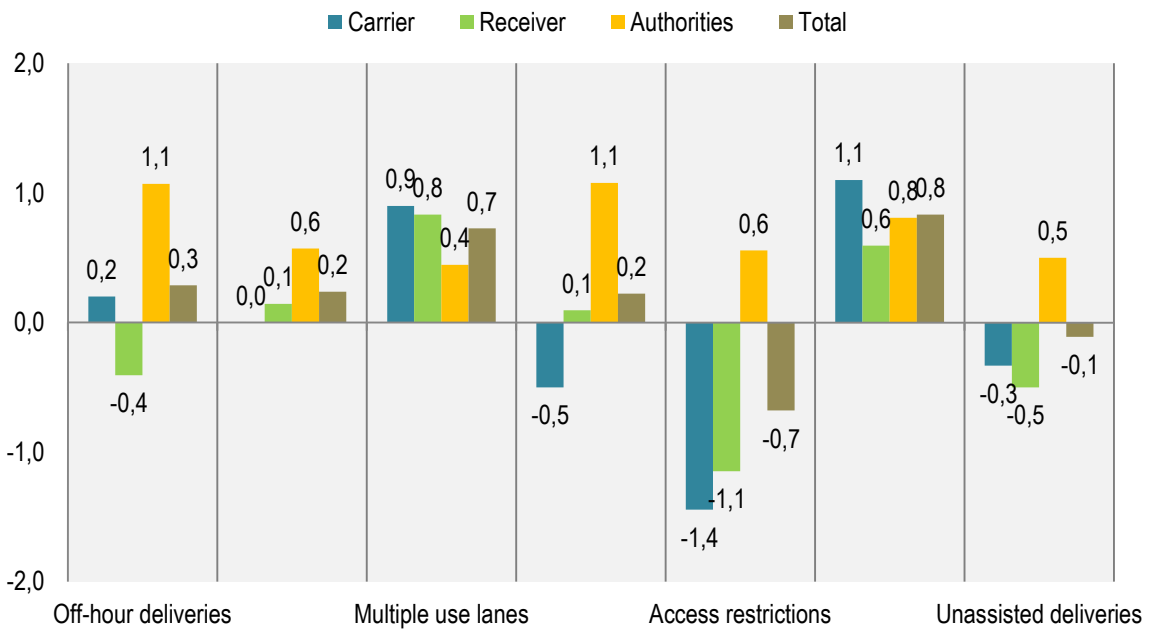

Figure 16: Assessments of consequences of measures for urban freight distribution by stakeholder groups and for stakeholder groups combined (total).

Figure 16 shows that in total, the measure that the stakeholders assess most positively is more use of environmentally friendly vehicles. The measure that is assessed most negatively is access restrictions for distribution vehicles. The figure also shows that the three stakeholder groups are not in harmony in how they assess the measures. Notably, the authorities have differing views from the two commercial stakeholder groups. For example, the authorities are much more positive towards access restrictions and urban consolidation centres than the carriers and the end-receivers, while they are more negative towards multiple use lanes. Thus, the authorities lean towards restrictive measures, while they are reluctant to prioritize freight transport over passenger transport.

It is important for the authorities to keep a positive and productive cooperation environment with the commercial actors. In order to achieve such an environment the authorities are recommended to evaluate how policy measures viewed as necessary can be modified to become acceptable to the most important stakeholder groups. Or vice versa, how measures unwanted by the authorities but welcomed by other stakeholder groups can be adapted to become a viable solution. This is no easy task, and requires extensive knowledge about other stakeholders' needs and prerequisites, only attainable by collaboration.

To give an example of how a policy measure can be adapted based on the survey results: Multiple use lanes is a measure wanted by the carriers, but the authorities see it as conflicting with the important goal of attractive public transport system. This measure can be modified so that only environmentally friendly distribution vehicles earn access to bus lanes, and/ or only outside peak hours. Consequently, the lanes are open for freight transport at hours where the capacity is high. The

measure is thus adapted to become acceptable, although not optimal, for each stakeholder group, and positive for society as a whole. With survey results or other data as a basis, similar adaptations can be done to other measures in order to achieve city logistics practices that are both acceptable and efficient in a local context.

EX POST EVALUATION OF MEASURES

For the purpose of evaluating a set of demonstrated measures in the GUD project, an evaluation framework has been established. In the following, the framework is presented and utilised in an ex post evaluation of electric distribution vehicles.

The ex post evaluation framework is more oriented towards documenting facts and effects than the ex ante assessments. The methodology from the ex ante assessments rests on the notion that stakeholder anticipations are crucial to consider in order to prepare for successful implementation of viable and effective measures, while the ex post framework seeks to document actual effects of demonstrated measures. Documented effects can in turn modify stakeholder perceptions, where these are based on beliefs more than experience.

For these reasons the ex ante and the ex post evaluation are based on different approaches.

Evaluation framework

In order to evaluate a set of heterogeneous measures, the evaluation framework must be designed in a general manner. The evaluation approach is therefore not targeted towards specific measures, it is rather general and intended for use of any measure aimed at improved urban freight.

The framework comprises a set of indicators for comparison of scenarios with and without a measure. Litman (2009) defines an indicator as a variable chosen and defined to measure the development towards an objective. Indicators serve two main purposes (OECD, 2003):

1. They reduce the number of measurements and parameters that otherwise would be needed for an exact representation of an situation or state
2. They simplify the communication of results to users

CIVITAS POINTER (2009) and STRAIGHTSOL (2012) define four main impact areas that should be considered when measures in the transport sector are evaluated. These are *Economics*, *Environment*, *Society* and *Transport*. For the present study, a simplified and slightly adapted version of the STRAIGHTSOL framework (STRAIGHTSOL, 2012) was used. In total 20 indicators are used to represent the four impact areas, these are shown in Figure 17. There will be interrelations between indicators, typically (but not exclusively) from left to right in

Figure 17. All indicators will not be relevant for all measures, but they should together be able to capture the most important aspects of relevant measures.

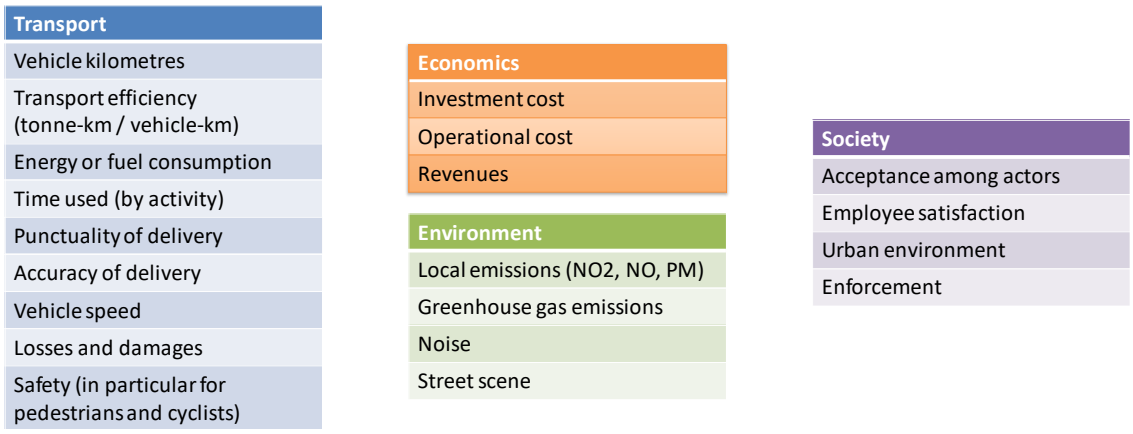

Figure 17: Indicators organized by main impact area

Depending on the measures evaluated, each of the indicators may be analysed for one or more stakeholders. It is thus possible to study distribution effects and to look at how different stakeholders are affected by a measure.

Ex post evaluation of electric vehicles

Methods
The evaluation framework was applied to evaluate the effects of using electric vehicles in urban freight. The evaluation is based on data from a demonstrator carried out in the GUD project.

The demonstrator was accomplished with assistance from the logistics service provider BRING Express (BEX). This company is one of the largest courier and express shipment providers in Norway. They have a strong environmental strategy and one of their goals is to establish a fleet of electric vans for their operations. Express shipments in cities are well suited for electric vehicles, with short distances and small volumes.

During 2012 BEX tested several electric vehicles in their operations for one or more days, ranging from simple Comarths to electric versions of Ford Connect and Renault Kangoo. After these experiences, they decided to test the Renault Kangoos more extensively. BEX does not own the vehicles they use, they rather engage transporters as subcontractors, who often act as drivers as well. The testing was therefore performed by transporters who volunteered.

Two Renault Kangoos were tested in real operations during two weeks in the inner parts of Oslo, one operating fixed routes, while the other one was used in ad-hoc operations. Significant effort was placed on actual measurement of the operations that took place, and the vehicles were equipped with GPS devices monitoring their

movements. In addition, the drivers were equipped with cameras enabling them to take photos of their delivery conditions and the actual parking of the vans.

Results
Below we summarize the main results within the four impact categories transport, economics, environment and society.

Transport
The logistics operations were conducted in a similar way with electric vehicles as if the same operations were conducted with traditional diesel vehicles. Thus, the majority of the transport-related indicators were not affected by the measure. The testing of the electric vehicles suggested that on most days the battery capacity was sufficient for shorter delivery routes within the inner parts of Oslo. On a few days it was necessary to charge the car during lunchtime to have enough capacity for the remaining day.

The most prominent effect was obtained for the indicator related to energy use and fuel consumption. Sund et al. (2013) have calculated the litres of diesel saved by use of electric vehicles to be roughly 4.8 litres per day. Given 220 days in operation per year, this gives an annual saving of 1,056 litres of diesel per vehicle. Sund et al. (2013) maintains that this estimate probably is conservative.

Economics
Norway has the world's highest uptake of electric passenger cars. This is largely attributed to fiscal measures as lower taxes on new cars and additional benefits like access to public transport lanes, exception from toll charges and from parking fees on public parking places. The latter benefits also apply for electric vans, while the tax benefit on new vans is much smaller. Based on a calculator tool developed by the organization *Grønn Bil* ("Green car"), comparisons were made between electric vans and conventional diesel vans. Assuming that cars were leased, electric vans were estimated to cost around 500 Euros more per year than diesel vans. Assuming that cars were bought, electric vans were estimated to be around 500 Euros cheaper than diesel vans. These calculations were based on a Peugeot Partner Electric van. The overall finding from these calculations is that electric and diesel vans seem to be about equal in terms of financial performance. There is however uncertainty involved, and this uncertainty is particularly high for the electric cars.

In the electric passenger car market the technological developments are moving fast and this has made investment in electric cars risky. When Nissan Leaf was introduced, the price of other electric cars was cut drastically. Analogously, the improvement of technology may lead to high depreciation costs for those who invest in electric vans today. The investment in electric vans may thus seem more risky than investment in conventional diesel-fuelled vans. It is also known that the capacities of batteries are reduced over time, and replacement batteries are expensive. The Renault Kangoos that were tested by BEX come with battery

leasing based on a monthly fee, where the battery is guaranteed to have a capacity of at least 75 % of that of a new battery. This may reduce some of the uncertainty.

Environment

Evaluating emission effects in an urban setting is a complex task. However, for the indicators related to local emissions and greenhouse gas emissions it is possible to calculate savings from the saved diesel consumption due to electric powering of the vehicles.

A key finding from the Green freight transport project is that freight transport service providers have production systems that provide a digital mirror image of the freight transport activities (Levin and Norvik, 2013). The GUD project draws on this and includes GPS traces to get more detailed emission estimates by calculation of average speeds between stops on the route. Thus the emission estimates are more accurate and will document effects related to change in time of day, routes and access to parking spaces for electric vehicles. From the data set collected in the demonstration of electric distribution vehicles the activities of two days were studied in detail.

In order to assess the emission effects of using electric vehicles instead of an ordinary diesel vehicle, the route driven by the demo vehicles was applied as a basis to calculate emissions from a diesel car (Euro IV). The calculations show that diesel cars would have used 0.07 litres diesel per km, producing around 0.17 kg of CO_2 per km and 0.49 g NO_x. Further details are given in Table 1.

Table 1: Calculated emission savings for replacing diesel vehicles with electric vehicles in the GUD demonstrator

		Diesel (litres)	CO_2 (kg)	NO_x (g)	*sPM (g)*	HC (g)	CO (g)
Day 1	**Total**	4.77	12.68	35.82	*2.56*	1.38	4.20
	Per km	0.07	0.17	0.49	*0.04*	0.02	0.06
Day 2	**Total**	4.80	12.76	35.95	*2.55*	1.39	4.60
	Per km	0.07	0.18	0.50	*0.04*	0.02	0.06

It should be noted that the emission calculations are conservative as they assume that when the vehicle is parked for pickups and deliveries the engine is always shut down and not idling.

To study the effect of on/off-peak emissions average speeds per hour were accessed. Average speed emission functions from the ARTEMIS project (Boulter and McCrae, 2007) were used to calculate the emission reductions by switching to electric vehicles. For CO_2 calculations it was assumed the direct emission from using electricity in Norway was 0 g/kWh as Norway's energy is produced from renewable resources.

Based on standard emission factors and estimation of values, the environmental savings caused by the reduced emission of one diesel car has been estimated to around 450 Euros per year. That being said, Oslo has experienced air quality problems the latest years related to NO_2, which has not been accounted for in the estimated values. The impact of emission savings may therefore be larger than calculated.

Society
The use of electric vans is not controversial and most stakeholders have a positive attitude to it. The issue of acceptance is therefore mostly related to whether transporters are willing to test these vans. During the demonstration period BEX gave some benefits to the electric vans, they were for instance given priority during assignment of jobs, and their routes were planned with an eye on the range of these vehicles. The employee satisfaction for the drivers was good, but these were biased in the sense that they volunteered to participate in the demonstration.

Future outlook
The testing of electric delivery vehicles by Bring Express (BEX) appeared successful. The vehicles have been tested during real operations, which may remove doubts and uncertainties. Even though some charging has been required during lunchtime, the Renault Kangoos have been able to operate some of the BEX services in a similar way as with diesel-fuelled vans.

After the demonstration, one of the transporters working for BEX invested in an electric van, this was the first electric van of BEX in the Nordic countries. The further long-term experiences of this transporter will probably influence the further up-take of electric vans among the BEX transporters. A more extensive testing will be needed to convince other transporters to change.

CONCLUDING DISCUSSION

This paper has documented the results from an *ex ante* stakeholder survey on potential policy measures for more environmentally friendly and efficient urban distribution in Oslo. The evaluation framework for an *ex post* study of actual effects of selected measures is also presented, and applied to evaluate the impact of environmentally friendly vehicles.

One important scholarly contribution of this study is its explicit and systematic documentation of multiple stakeholder perceptions related to several measures in urban freight transport.

The ex ante assessments show that the measure that overall is considered to entail the most positive consequences for both urban freight transport and the society is environmentally friendly vehicles. The ex post evaluation of electric vehicles tested in the GUD project suggests that electric vans can serve parts of the express shipment market very well with their existing range. With basis in the

ex ante assessments, removing uncertainties related to the performance and financial viability of electric vans seems to be an important task for further take-up of these vehicles.

The study has shown that there is a will and a need from all parts to improve the present urban freight situation in Oslo. However, there are several conditions that must be in place to achieve successful implementation of environmentally friendly and efficient solutions. Stakeholder groups are marked by significant heterogeneity, both inside and between the groups, posing a significant obstacle for optimal outcomes. More efficient and environmentally friendly urban freight performance is thus preconditioned by the involved stakeholders' knowledge about other actors' roles and needs. Furthermore, solutions that are optimal for one stakeholder are likely to be suboptimal for others. In order to implement successful measures it is therefore vital to adapt measures so that they are both efficient in terms of greening urban freight and acceptable to all parties. This requires a collaborative process where both facilitating and hampering factors are brought forward and openly discussed.

The overall objective of such collaborative processes is to reach what we have labelled 'common ground'. Common ground refers to an abstract area where a selection of measures (or rather combinations of measures) assessed as most likely to be both efficient and accepted by all stakeholder groups are found. That is, an area where each stakeholder perceives the advantages of measure implementation to be greater than the disadvantages. This is not to say that stakeholders see common advantages or disadvantages: what represents an advantage to one stakeholder might very well represent a disadvantage to another. The notion of common ground is deconstructed and explained in detail in Bjerkan et al. (2014).

A collaborative process is facilitated by objective and documented knowledge on expected consequences from policy measures. Therefore, both locally based *ex ante* assessments and *ex post* evaluations of measures that are demonstrated locally or implemented elsewhere form a vital basis in the policy design process. This study provides an example of how such knowledge may be gained, through frameworks that are generic and applicable to other local contexts. The evaluation frameworks used in this paper can therefore be a useful template for similar green freight initiatives to come. The paper may also serve as a guide for policymakers in the design and implementation of new policy measures for urban freight. Furthermore, it may form a basis for comparisons of both ex ante and ex post evaluations of measures across cities or countries. As such, this study represents an important contribution to the field of urban freight policy.

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