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A socio-economic analysis of harmonizing the dimensions of lorries and loading docks in Norwegian cities – costs, benefits and logistic efficiency

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Abstract

In several Norwegian cities there exists the potential for increasing the efficiency of cargo deliveries by reducing the time spent on loading and unloading for each delivery. As Norway lacks regulations harmonizing the dimensions of lorries to the dimensions of loading docks, drivers are often forced to load and unload their cargo on-street instead of onto loading docks. On-street unloading leads to increased walking distances for drivers, which increases time spent unloading the delivery and thus the delivery cost. In addition, on-street unloading may affect other road users such as pedestrians, cyclists, cars and public transportation. Harmonization of the dimensions of lorries and loading docks could therefore potentially reduce both delivery costs and external effects.

This paper looks into a methodological framework for social cost benefit-analyses of harmonizing the dimensions of lorries and loading docks in urban areas. The framework is universal in the sense that it is valid and can be used for evaluations of measures in different cities, however it is based on local data. The innovative part is that the adapted cost benefit-analyses methodology is used on measures connected to urban freight distribution. Another innovative aspect of using the social cost-benefit methodology is the effects of measures quantified in monetary terms. This makes it possible to rank measures tested and evaluated. The framework is tested on scenarios of current interest to be implemented by using data from the central parts of Oslo, limited by the orbital road, Ring 2. Estimations are made using four scenarios; two for estimating the effects of lorry size restrictions, and two focusing on dimensioning of loading docks. The study revealed a lack of relevant data, especially as regards loading docks. The framework can be used for similar analyses in other city areas, based on local data. An important recommendation for improving the quality of future analyses is to ensure data collection from concrete actions directed at cargo distribution in city areas.

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1. Introduction

Urban areas represent particular challenges for national and international freight transport, both in terms of logistical performance and environmental impacts (emissions, noise, accidents, congestion and land use). Urban freight is indispensable for the city's economy. At the same time freight deliveries significantly affect the attractiveness and quality of urban life. Typically, urban freight transport represents between 20 to 25% of road space contributing to between 10 to 20 % of urban road traffic (TURBLOG, 2010).

The generally low load factor in distribution activities increases the total amount of freight-related traffic, and the commercial speed is usually low due to severe congestion in many urban areas. Currently around 74% of Europe's population live in urban areas (United Nations, 2010). The urban share is expected to increase to 84% by 2050, adding further challenges to urban freight transport and last mile delivery solutions.

In several Norwegian cities there is a potential for increasing the efficiency of cargo deliveries by reducing the time spent loading and unloading each delivery. As Norway lacks regulation harmonizing the dimensions of lorries to the dimensions of loading docks, drivers are often forced to load and unload their cargo on-street instead of onto loading docks. On-street unloading leads to increased walking distances for drivers, which increases time spent unloading the delivery and thus the delivery cost. In addition, on-street unloading may affect other road users such as pedestrians, cyclists, private cars and public transportation. Harmonizing the dimensions of lorries and loading docks could potentially reduce both delivery costs and external effects.

In this paper we present a methodology for socio-economic analysis of effects from measures aimed at harmonizing lorry dimensions to the dimensions of unloading docks. This can either be done by establishing specific requirements for the dimensions of unloading docks or by introducing maximum length and/or height of lorries. The lack of harmonization of dimensions of lorries and unloading docks is a general problem, but the conflicts with other traffic is most prominent in inner parts of cities. The analysis subsequently focuses on these areas.

The analysis contributes to the literature by giving a comprehensive discussion of, and a methodological framework for, analysing the expected effects of implementing regulation requiring harmonized dimensions of lorries and loading docks, as well as computational results based on data from Oslo, Norway.

The main purpose of this study has been to develop a methodological framework for performing social cost-benefit analyses on harmonization of lorries and loading docks in urban areas. The resulting framework is universal and valid for analyses of similar projects in other cities, provided that local data are collected.

In this study we have prepared and tested an analytical instrument that renders possibilities to:

- assess the socio-economic optimal sizes of distribution lorries used in Norwegian city centres, and
- measure the socio-economic effect of adapting the dimensions on drive-ins and parking spaces at loading docks, considering the vehicles used for cargo distribution in cities

In case of improved data access, the method can also be utilized for analysing the socio-economic effects of introducing restrictions on lorry size in city centres, with regards to serious accidents (killed or severely injured), safety and well-being of pedestrians and cyclists.

The method and framework is tested using data collected from projects inside the orbital road Ring 2 in Oslo.

2. Method, data and accomplishment

The study is carried out within the framework of social cost-benefit analysis, which is an estimate of the benefits and costs of public actions, measured in monetary values. The purpose of a social cost-benefit analysis is to determine whether the project is socio-economic beneficial or not, i.e. whether the total benefits of the public action exceeds the costs of the project.

In the analysis, we have considered the short term effects, and also disregarded demand effects of the projects. Moreover, some less quantifiable benefit and cost elements are set to 0 or based on assumptions. The study revealed lack of data that necessitated additional simplifications of estimates on important elements in the analysis.

In some of the data and estimates the level of uncertainty is high. This is the case for some of the cost elements, especially on the needs and costs of rebuilding loading docks. For external costs, data problems especially affecting the measurement of project enforcement and the inconvenience inflicted on pedestrians and cyclists.

The analytic work is based on a literature survey, processing of available public statistics, estimates of external costs, and interviews and surveys of transport providers distributing in Oslo. Additionally, we have gained valuable information on the problems and experiences with cargo distribution in cities from a seminar on the future size of freight vehicles arranged by the Norwegian Forum for local goods transport.

3. Current situation

3.1. Delivery conditions

Freight deliveries in cities is influenced by several conditions. There is a trend towards more and smaller shipments, requirements for “just-in-time” deliveries, increased delivery frequencies and requests from the transport operators to use bigger lorries for delivery services. An increasing number of European cities are introducing regulations and restrictions on the use of big lorries in city centres (Efficient Consumer Response, 2000). Another characteristic connected to urban freight distribution is the lack of principal common standards at the EU or national level regulating the dimensions for loading and unloading docks and lorry dimensions in cities. This is due to the fact that different cities have different infrastructure and needs.

Urban freight deliveries are different from other freight transport because the transport is on the street network where bikers, pedestrians and delivery lorries use the same network. The delivery situation itself is characterized by deliveries from the street level. As an example, deliveries from street level or ground level in Oslo was 80.9 % in 2010 (Eidhammer et al., 2011). The final part of the deliveries is from street level and is accomplished by using a sack trolley and hand pallet lorries. The driver must cross the sidewalks or other areas shared with other traffic as bikers and pedestrians. The rest of the deliveries are to receipts in their private area.

The receipt area is not always adapted to distribution solutions requesting bigger delivery lorries to increase the distribution through transport of more shipments and larger volumes on the same delivery trip. Another process that influences the scope and structure of urban freight deliveries is that industrial activities are phased out or have moved away from the cities, and service industries are established in the same areas. Such changes lay the foundation for new types of freight transport and service transport, where deliveries of an increased number of packages, with freight vans, freight taxies, express freight and courier vehicles could be the result (Larsen I and Andersen J, 2004).

In Oslo, Norway a strong increase in number of inhabitants is expected, and predictions estimate this to grow to 600 000 inhabitants by 2060 (Hovi et al., 2011). Urban freight distribution in the Oslo area is forecasted to increase by 50% by 2060.

3.2. Regulations, framework and requirements on lorry height and length

In Norway there is no defined fixed maximum height limit for heavy lorries, but in practice, vehicles must be lower than 4.5 meters to pass bridges and tunnels in the road network. Streets and roads with lower heights are regulated (Norwegian Public Road Administration, 2011a). There are also other local obstacles that introduce different height restrictions in parts of the road network.

One can still consider the introduction of height restrictions in some areas. This is, primarily motivated by the fact that unloading docks should welcome the delivery lorries. One possibility could be to introduce a maximum height of 4.20 meters, which allows vehicles to be loaded two pallets high. Unloading docks and their vehicular access must then have a clear height of approximately 4.5 meters to accommodate these lorries.

Since 4.5 meters is a significant elevation in areas with high property prices, one may also consider whether it would be appropriate to introduce a lower maximum height limits, such as a maximum height of 3.2 meters which is equivalent to the height of many lorries with a box body which are used in and around towns. Unloading docks must in this case be restricted to 3.5 meters high.

In Norway 's length restrictions on vehicles length depends on vehicle type and type of road (Norwegian Public Road Administration, 2011). The general rule is that the road network is divided by the length limitations of 19.5 meters, 15 meters and 12.40 meters roads.

A lorry can have a length of up to 12.0 meters regardless of whether the vehicle is located on a 12.40 meter, 15.0 meter or 19.5 meter road. A great deal of lorries with a length of 12.0 meters are also used in and around towns. This implies that the longest vehicles have problems with access to goods receival areas, and they have problems finding suitable unloading spaces at the street level. In addition, lorries with length 12.0 meter require more space to maneuver in unloading areas than shorter lorries. A relevant measure may be to limit the permitted vehicle length to 10.0 meters in the inner city areas, as has been done in Gothenburg, Sweden.

3.3. Regulations and requirements on lorry height and maneuvering area at unloading docks

In Norway, regulations on the technical requirements for construction of un¬loading docks (Guidelines for structural engineering, 2010) states that docks should have adequate vehicular access adapted to the buildings function.

The building code contains no specific requirements for height of unloading docks, and often consideration for delivery of goods has less priority because high ceilings can provide fewer floors in other areas. Areas for unloading docks are usually considered "unproductive".

If requirements for increased height in goods receival areas is introduced, it will thus be implemented in new buildings, within major modifications or change of use. In dense urban areas there are relatively few new building being constructed. A challenge for changes in existing buildings is that there may be protective or antiquarian conditions that complicate the increased height of unloading docks.

It may also be appropriate to require that unloading docks and unloading spaces will be designed for specific lorry lengths, such as 10.0 meters or 12.0 meters long lorries. For unloading docks, this means that the access drive must have sufficient width. In addition there must be sufficient maneuvering space so delivery lorries can drive to and from load/unload ramps safely. There may be conflicts between land use for deliveries, as well as land use for other purposes. Alternative use of land may be parking or shopping areas.

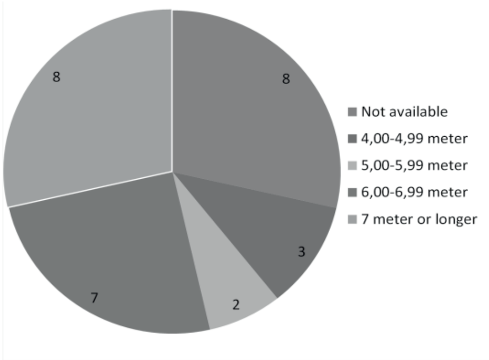
3.4. Lorry fleet

Currently there are variety of lorry sizes and designs used in urban distribution. In our calculations we could not take into account all types of lorries and vans used in city distribution. We had to select those lorry sizes and designs that would be affected by the actual measure.

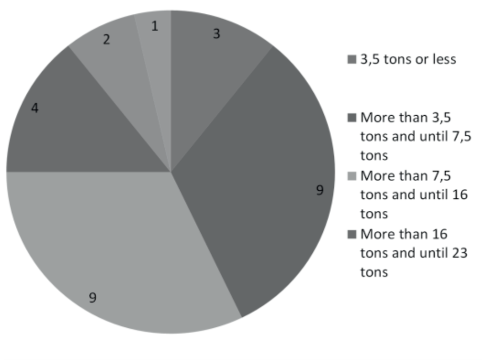
Our assumption indicates that lorries traded in the market would be replaced by lorries with the same characteristics. To get an overview we registered and analysed urban freight lorries for sale in the Oslo region in a given period. The distribution of lorries for different body lengths and total weight, is shown in Figure 1.

We defined three types of lorries as:

- Large lorry; Longer than 10 meters and loading capacity of 21 pallets,
- Medium sized lorry; Length of lorry 9-10 meters and loading capacity of 16 pallets
- Small lorry; Height 3.0 meters, capacity of 10 pallets and length 7-8 meters.



a) Body length on registered lorries



b) Total weight on registered lorries

Figure 1. Distribution of body length and total weight on categories of registered lorries. Number of lorries.

To assess the effect of a situation where larger lorries are replaced with smaller ones, we compared the capacity of the various type of lorries defined by capacity in number of pallets, respectively large, medium and small lorries, see Table 3. In the last two rows specified percentage reduction in capacity at the transition from a big lorry or to medium sized and small lorry, as well as the transition from medium to small lorries. We assume that utilization is unchanged before and after measures, thus expressing that the values in Table 1 also include expected increase in work when transferring goods to smaller lorries.

Table 1. The matrix of the goals' impacts. Source: own work.

	Large lorry	Medium sized lorry	Small lorry
Capacity number of pallets	21	16	10
Reduction in capacity when changing from big lorry	n.a.	24 %	52 %
Reduction in capacity when changing from medium sized lorry	n.a	n.a.	38 %

3.5. Use of urban delivery lorries inside orbital Ring 2 in Oslo

In Oslo there was a survey among transporters, logistic service providers, wholesalers and producers on what lorries was used when delivering goods inside the orbital Ring 2 Oslo (Eidhammer and Andersen, 2011).

The results of the study are based on data from 16 operators who own 1,254 delivery lorries in all. The operators own between 9 and 450 delivery lorries each adapted to goods distribution in Oslo and Oslo surrounding areas. A total of 39% of the delivery lorries are from companies with own their transport or carriers with dedicated transport enterprises and 61% are from carriers and freight forwarders who distribute to others. The distribution delivery lorries on different heights is shown in Table 2.

Table 2. Height of delivery lorries normally used in distribution inside the orbital Ring 2 in Oslo. Number of lorries in different height categories and relative distribution.

Category of height	Number of lorries	%
Number of delivery lorries with height lower than 3.20 meters	132	35.8
Number of delivery lorries with height between 3.21 – 3.80 meters	140	37.9
Number of delivery lorries with height between 3.81 – 4.20 meters	92	24.9
Number of delivery lorries with height higher than 4.21 meters	5	1.4
Total	369	100.0

The results indicate that there is almost the same proportions of delivery lorries in each of the height categories used in the survey. In addition we found that the proportion of goods vehicles with a height of 3.81m to 4.20m is approximately the same regardless of whether the lorries are transporting their own goods or distributing to others. Transporters on own account, however, have a significantly higher proportion of delivery lorries in the height category between 3.21m and 3.80m than what was found for hire and rewardcarriers (62.8% compared to 21.9%). Transporters with distribution to others have a correspondingly higher proportion of the lowest freight lorries.

In the survey we also collected information on the length of delivery lorries delivering goods inside the orbital Ring 2 in Oslo.

Table 3. Length of delivery lorries normally used in distribution inside the orbital Ring 2 in Oslo. Number of lorries in different height categories and relative distribution.

Category of length	Number of lorries	%
Number of delivery lorries with length longer than 10.0 meters	115	31.5
Number of delivery lorries with length between 8.0 – 9.99 meters	95	26.0
Number of delivery lorries with length shorter than 7.99 meters	155	42.5
Total	365	100.0

The results indicate that 68.5% of the delivery lorries have lengths shorter than 9.99m. Other results from the survey indicate that vendors with their own transport have generally longer delivery lorries than what is used by hired carriers. Only 6.2% of those who distribute their own goods use lorries inside Ring 2 with shorter lengths than 7.99m and 52.7% of the delivery lorries are longer than 10.0m. Among the hired delivery lorries we found that two thirds of freight vehicles used for distribution within Ring 2 in Oslo were less than or equal to 7.99m. Only 17.4 % of the lorries were longer than 10.0m.

4. Elements in the cost-benefit analysis

The elements we found reasonable to include in the cost-benefit analysis of actions were directed towards lorry and loading dock dimensions are summarized in Table 4. The different cost and benefit elements are grouped by theme, and for each element the assessment method is stated and divided into three categories:

- Quantitative (Q): These elements are regarded as fully taken into consideration in the assessments, presupposing that the input data is reliable.
- Simple calculation (SC): Elements we have attempted to quantify, however by use of far from satisfactory combinations of procedures and data.
- Judgment (J): For these elements we lack the foundation for estimating values, and have instead provided verbal considerations about the expected impacts.

In the last two columns in Table 4, it is marked whether the cost-benefit element is assumed to be affected by actions directed towards lorry sizes (“Lorry actions”) and/or loading docks (“Loading dock actions”).

The framework for socio-economic assessments contains the following components:

- Cost components related to lorries and logistics, such as operative lorry costs, reloading costs and possible costs of forced renewal of lorry fleet,
- External costs of lorry transports (local emissions, noise, accidents, road wear, global emissions, and congestion costs), plus enforcement costs and reduced safety experienced by other road users,
- Costs related to loading docks are the costs of rebuilding, and also the alternative costs, which include lost income from other profitable use of the expanded loading areas,
- Effects on the delivery situation involve the time spent loading and unloading, and the impacts on other traffic flow, and
- Other effects, such as other societal costs of implementing the actions, and the drivers’ working environment and accessibility conditions.

Table 4. Cost-benefit elements with assessment method.

Component	Cost/benefit elements	Method	Lorry actions	Loading dock actions
A. Vehicles and logistics	Operative lorry costs	Q	X	
	Costs of additional reloading	SC	X	
	Forced renewal of lorry fleet	SC	X	
B. External costs	Local emissions, noise, accidents, road wear, global emissions, and congestion costs	Q	X	
	Costs of enforcement	J	X	
	Reduced safety for other road users	J	X	X
C. Costs related to loading docks	Costs of rebuilding loading docks	SC		X
	Alternative costs for expansion of loading area	SC		X
D. Delivery situation	Time used in delivery situation	Q	X	X
	Impacts on other traffic flow	J	X	X
	Area occupied on street level	J	X	
E. Other effects	Other societal costs of actions	J	X	X
	Drivers' working environment and accessibility conditions	J	X	X

5. Assessed scenarios

In this section we summarize the information used as basis for calculating the baseline scenario representing the current situation. Results from this scenario are then used for calculations of the four measures scenarios to identify changes from the current situation. Table 5 summarizes information related to the shipments and logistics, while Table 6 summarizes the cost components used in the calculations.

Table 5. Basic information on shipments and logistics for deliveries to destination inside orbital Ring 2 in Oslo, 2010.

Segment	From Oslo/Akershus county		From other counties outside Oslo/ Akershus	
	Large lorry	Medium sized lorry	Large lorry	Medium sized lorry
Shipments per year (1 000 shipments)	112	448	28	112
Shipments per delivery trip	6.5	6.5	6.5	6.5
Number of trips per year (1 000 trips)	17.2	68.9	4.3	17.2
Average trip length (t/r) (km)	51	51	195	195
Yearly traffic work (1 000 km)	877	3 514	839	3 354
Number of hours per trip (hours)	4	4	8	8

Table 6. Basic information on lorry operational costs, NOK, 2010.

Operational costs	Large lorry	Medium sized lorry	Small lorry
Operational costs (NOK/km)	4.44	4.01	3.17
Operational costs (NOK/hour)	457	456	420
External costs (NOK/km)	10.31	8.69	8.60

To evaluate the method developed for analyzing the reduction of height of delivery lorries and height of unloading docks, we have in addition to the current situation chosen to study four scenarios. Two of the scenarios analyze the benefits and costs of introducing measures to change the allowable height and length of the delivery lorries, but the current unloading docks are unchanged (scenario 1 and scenario 2). The other two scenarios analyze the benefits and costs in a situation where a portion of our unloading docks rectified to a given standard. In these scenarios (scenario 3 and scenario 4), we analyze an adaptation of unloading docks for two alternative types of delivery lorries.

The analysis area modelled and tested are deliveries within Ring 2 in Oslo. The number of consignments to be delivered was assumed to be the same in all scenarios. All the data and information on operational and external costs per kilometer and per hour was the same in the action scenarios as in the base scenario.

The actions were tested for the following four scenarios, where the example calculations are compared to a base scenario representing the current situation:

Scenario 1. 10 metre restriction. Maximum allowed lorry length of 10 meters and lorry height 4.20 meter. We do not take into account that it is allowed to deliver goods with longer lorries in the morning hours in Gothenburg. Assumptions for the calculations:

- Retains unloading docks as they are currently,
- All distribution with large lorries which are 11-12m long (21 pallets) are transferred to medium sized lorries which are 9-10m long with 16 pallets. This gives a 24% increase in kilometers driven,
- 5 minutes reduced time per delivery where large lorries are replaced with medium sized lorries, and
- Additional transshipment costs, costs associated with accelerated renewal of the lorry fleet and enforcement costs are set to 0.

All other information is identical to the baseline scenario.

Scenario 2. Low lorry solution. Maximum lorry length 10m and maximum lorry height 3.20m. Assumptions for the calculations are:

- Retains unloading docks as they are currently,
- All distribution is transferred to 8-10m long lorries with 16 pallets loading capacity, This gives an 52% increase in kilometers driven for freight compared with large lorries in base scenario and 38% for deliveries accomplished with medium sized lorries, and
- 10 minutes reduced time per delivery where a large lorry is replaced by a small lorry and 5 minutes reduced time when transferred from medium sized lorry.

All other information is identical to the baseline scenario

Scenario 3. Loading dock height. Requiring loading docks to accept 4.20m height lorries (loading dock height 4.50m), and 10.0m long lorries. Assumptions for the calculations are:

- Retains size of delivery lorries as they are today,
- 5 minutes reduced delivery per delivery in the loading docks covered,
- 38 unloading docks are rebuilt, reconstruction area per loading dock is 60 m2, and
- Costs of conversion of the unloading dock is 25,000 NOK/m2, while lost annual rental income is 3,500 NOK/m2.

All other information is identical to the baseline scenario.

Scenario 4. Loading dock height and length. Requiring the height and length of loading docks to accept 4.20m height lorries (loading dock 4.50m), and lorries of 12m in length.

Actions directed towards loading docks are only considered as relevant for new buildings, or change of use for existing buildings. Assumptions for the calculations are:

- Retains the size of delivery lorries as they are currently,
- 10 minutes reduced delivery per delivery in the loading docks covered,
- 76 unloading docks are rebuilt, the reconstruction area per loading dock is 100m2, and
- Costs of conversion of the unloading dock is 25,000 NOK/m2, while lost annual rental income is 3500 NOK/m2.

All other information is identical to the baseline scenario.

6. Results

In order to implement the examples calculated, several choices were made based on judgments, and the quality of the data is also variable. Too much emphasize must therefore not be placed on the results of the calculations.

Table 7 and Figure 2 summarizes the changes in the cost and benefit components for the four project scenarios compared to the basis scenario. Benefits are recognized by positive numbers while the costs have negative signs.

Table 7. Benefit and cost components in the project scenarios. Changes compared to basis scenario. Mill NOK yearly.

	Component	Scenario 1: 10 metres	Scenario 2: Low lorry	Scenario 3: Loading dock height	Scenario 4: Loading dock height and length
A. Vehicles and logistics	Operative lorry costs	-12	-73	0	0
B. External costs	External costs of lorry transport	-1	-26	0	0
C. Costs related to loading docks	Rebuilding costs and alternative costs for loading area	0	0	-13	-42
D. Delivery situation	Time used in delivery situation	28	42	0	1
Total quantified result		15	-58	-12	-41

We see from Table 7 that the estimated benefits in the supply situation is clearly greatest in scenarios relating to restrictions on lorry dimensions. This is because these measures are aimed at goods receipt only relieve the situation in the last few departments that are being rebuilt, while measures aimed at lorry dimensions are believed to have an effect in all reception conditions. However, we see that there are significant costs associated with restrictions on lorry dimensions, especially the low lorry solution that provides large increases in the operational lorry costs and external costs.

The most "extreme" scenarios ("Low lorry" and "Loading dock height and width") emerges as the least attractive. We also see that the 10m restriction scenario and the scenario with height requirements in loading docks appears to have costs at the same level, but the 10 metres scenario seems to provide a much greater advantage in the delivery situation. However, it is difficult to draw firm conclusions when we know that the data is limited and there are many assumptions and assessments done in the calculations. One factor in this respect is that the gain in the supply situation and the costs related to lorry and logistics both can be linked to the carriers. Since the benefits exceed the costs it is expected that there will be no restrictions to use smaller lorries. This factor suggests that either we have underestimated the costs of lorries and logistics or have overestimated the gain in the delivery situation.

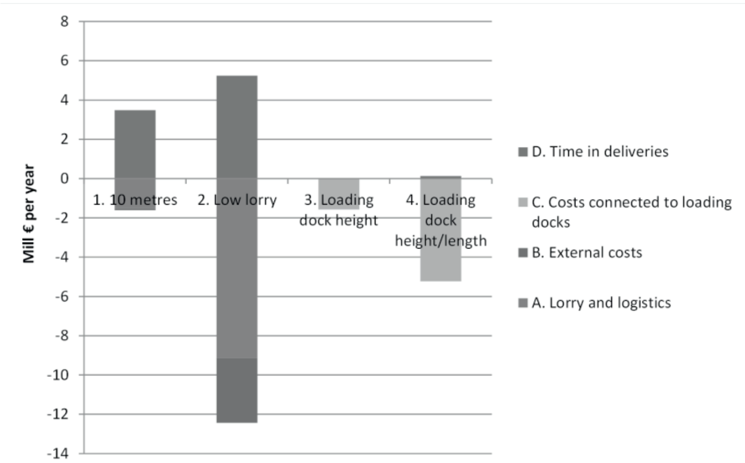


Figure 2. Benefits and costs in different scenarios. Changes compared to basis scenario. Mill € per year.

The results from the estimates show that only Scenario 1 The 10m restriction renders a positive benefit, while the other project scenarios give, using our assumptions and data, negative outcomes. The estimated benefit in the delivery situation is clearly highest in the scenarios involving restrictions on lorry size. The reason is that effects of loading dock actions only surface in the few cases where loading docks are rebuilt , while the actions directed towards lorries are assumed to work under all delivery conditions. We see, however, that there are significant costs resulting from restrictions on lorry sizes, especially with the low lorry solution, where the operation costs and external costs of lorry transport increases considerably.

Another conclusion from the scenario calculations is that the influence on lorry transports with Scenario 1 The 10m restriction, focusing on lorry length, will be far more limited than with Scenario 2 The Low Lorry Solution, which restricts both the height and length of freight vehicles. This is due to the fact that a low lorry solution will exclude many of the currently used lorries. The benefit in the delivery situation is however also high with the 10m restriction, thus this action appears as the most attractive alternative.

Scenario 3 Loading dock height and Scenario 4 Loading dock height and length, i.e. the actions directed towards the loading docks, result in far smaller effects on the delivery situation than does the two lorry related scenarios. The reason is that the loading dock actions only affect the delivery situation at a limited number of loading docks. In these cases, however, the actions could also be of benefit for other road users than those directly involved, but we did not have relevant data for assessing and including this in the analyses.

In the study, several effects have proved difficult to quantify, and are thus not included in the calculations in Table 8 of the scenarios inside Ring 2 in Oslo.

We have nevertheless made some judgments of the less quantifiable benefit and cost elements. The judgments are presented in Table 3, and are graded in the following way:

”--” = Significant cost
”-” = Moderate cost
”0” = No or very little effect
”+” = Moderate positive benefit
”++” = Significant positive benefit

Table 8. Benefit and cost elements not quantified in the action scenarios.

	Component	10 metres	Low Lorry	Loading dock Height	Loading dock Height and Length
B. External costs	Enforcement costs	-	-	0	0
	Reduced safety for other road users	+	+	+	+
D. Delivery situation	Effects on other traffic flow	+	+	+	+
	Area occupied on street level	+	+	++	++
E. Other effects	Other societal costs of actions	0	0	0	0
	Drivers’ working environment and accessibility	+	+	+	+

From the signs in Table 10, we see that the non-quantified effects are generally positive. The only negative component is the assumed enforcement cost of introducing restrictions on lorry sizes. In most cases where decisions are based on the framework for socio-economic assessments presented in this paper, thorough examinations of the above mentioned effects must be carried out.

Our experience is that the amount of available data related to effects of cargo delivery in city areas is at present limited. One important recommendation is therefore to give a higher priority to collection of such data in order to improve the quality of future analyses of cargo distribution in central urban areas.

In order to illustrate how the assumptions affect the scenario estimates, we carried out sensitivity analysis by making adjustments on two of the assumptions, i.e. the number of deliveries per trip, and the time savings in the delivery situation. These examples show that changing the number of deliveries per trip (4 and 10 deliveries, respectively) does not alter our conclusions substantially. For the calculations with the assumption that time savings only occur in 20% of the deliveries with reduced lorry sizes, we found that even Scenario 1, the 10m restriction, does not render a positive benefit.

7. Conclusions

Urban areas represent particular challenges for freight transport, both in terms of logistical performance and environmental impacts (emissions, noise, accidents, congestion and land use). Urban freight is indispensable for the city's economy but at the same time freight deliveries significantly affect the attractiveness and quality of urban life. This paper has presented a framework for social cost benefit-analyses of harmonizing the dimensions of lorries and loading docks in urban areas. The framework is universal in the sense that it can be used for evaluations of measures in different cities, when based on local data. The innovative part is that the adapted cost benefit-analyses methodology is used on measures connected to urban freight distribution. Another innovative aspect is that by using the social cost-benefit methodology the effects of measures is quantified in monetary terms and this make it possible to rank the measures tested and evaluated.

The framework was tested on scenarios of current interest to be implemented using data from the central parts of Oslo, limited by the orbital road, Ring 2. Estimates were made using four scenarios; two for estimating the effects of lorry size restrictions, and two focusing on the dimensions of loading docks.

The estimated benefits in the delivery situation were clearly the highest in the scenarios involving restrictions on lorry size. The reason is that effects of loading dock actions only surface in the few cases where rebuilding loading docks is relevant, while actions directed towards lorries are assumed to work under all delivery conditions. We see, however, that there are significant costs resulting from restrictions on lorry sizes, especially with the low lorry solution, where the operating costs and external costs of lorry transports increase considerably.

The analysis has revealed challenges with access to reliable data, and it has been difficult to make clear conclusions because of scarcity of data. Better and more extensive data on urban freight movements, but also on access conditions and loading bays, should be given increased emphasis in the future, as this may improve the possibility of making informed decisions. The increased emphasis on utilisation of "big data" may reveal data sources that also can be used for this purpose.

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