# ENVIRONMENTALLY SENSITIVE CHARGING FOR FREIGHT VEHICLES IN LOW EMISSION ZONES

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## ABSTRACT

Cities in Europe are introducing green zones, or low emission zones, with the purpose of improving the local environment for residents and travellers. The research project Green Activity Zones (GAZ) presents a technical concept on how charging for driving within a low emission zone can be based on the vehicle's real activity inside the zone. The amount to be charged is computed as a function of continuous measurements of emissions from the vehicle. The purpose of this paper is to investigate stakeholder influences on decisions in the urban distributions chain, and their potential responses to the GAZ regime. These issues are investigated by surveys conducted among retailers, wholesalers and carriers. The surveys show great variations between stakeholder groups regarding the influence over transport and logistics decisions, and that their individual influence largely determines potential stakeholder responses to the GAZ regime.

*Keywords: Road freight, Low emission zones, Charging, Behaviour, Attitudes*

# INTRODUCTION

## Background

European cities are introducing low emission zones (LEZ), with the purpose of improving the local environment for residents and travellers. These zones are organised as access restriction schemes (ARS) in order to reduce the traffic volume into city centres. A major reason for the increased implementation of LEZ is EU Directive 1999/30/EC, which requires cities with populations over 250,000, or with high population densities to establish an alert threshold for when concentrations of emissions pose a risk to human health. Member states should establish action plans aimed at reducing concentrations to safe levels. The directive encourages member states to establish zones or agglomerates where emissions are monitored and controlled.

National legislation and local regulations on urban access limitations differ widely across Europe. Some regulations completely exclude access to certain vehicles, whilst in other cases access is allowed upon payment of entrance fees, sometimes differentiated according to locally defined classification schemes, typically based on weight and/or Euro standard[1]. On the background of this heterogeneity, and the risk of a fragmented patchwork of urban access regulations being created across Europe, the EC-DG MOVE funded a study to investigate the state-of-the-art and identify possible actions (TREN 2010). The study finds that there is limited and little available data on the impact of implementing ARS. Existing findings point, however, to benefits in terms of traffic reduction and improvements of air quality and the overall performance of transport systems. Most stakeholder groups regard ARS as a powerful policy instrument, and ARS are considered more effective if they differentiate between vehicles according to Euro standards.

However, the heavy reliance upon Euro standards in ARS renders current low emission zones static in nature and implies assumptions regarding the relationship between certain vehicle characteristics and actual emission levels: vehicles with a higher Euro standard are assumed to have lower emission levels. However, recent research shows that real $NO_x$ emission factors for driving in city streets are actually similar across all heavy duty vehicle (HDV) Euro standards I through V (Velders et al. 2011). Thus, Euro standards are not necessarily an effective tool for reducing the most hazardous local pollution in European cities.

## Green Activity Zones (GAZ)

In order to meet the need for a more effective tool for reducing emissions from HDVs, the GAZ research project explores the potential for developing a green zone in which charges

[1] European emission regulations for new heavy-duty diesel engines are commonly referred to as Euro I-VI. Euro I dates from 1992, and the latest Euro VI takes effect from 2013. The maximum permitted limit measured in g/kWh of emission of CO, HC, $NO_x$ and PM have been decreased by each new Euro class.

are based on vehicles' real activities inside the zone. This principle is already known from road pricing concepts based on distance-based charging. GAZ suggests that the amount to be charged is computed as a function of continuous measurements of emissions from the vehicle. The technology and algorithms for these types of calculations are more or less available and the project will develop these further to a new application called GAZ.

The GAZ concept can be considered the next generation for regulation of low emission zones in cities. The fee is calculated using a differentiated pricing of local pollutants ($NO_x$, PM, HC and CO), and emissions costs can be calculated for every link and for every hour and for each direction. Links can be weighted differently, e.g. to reflect specific environmental sensitive areas in the city. An important effect of GAZ is the ability to respond to variations in the seriousness of local pollution, caused for instance by unfavourable weather conditions like inversion problems during winter periods. The GAZ application will also make it possible to design a charging system that is more just, and at the same time provides incentives for reducing the external costs of freight transport. Additionally, users of the GAZ application will be able to document their environmental profile in competition with other transport service providers (Foss 2011).

The main objective of GAZ is thus to introduce a more dynamic and accurate pricing regime than current low emission zones based on static criteria. By creating incentives for behavioural change in urban freight transport, this is assumed to be more effective in terms of emission reduction.

Adaptations in terms of more environmentally friendly behaviour are preconditioned by stakeholders recognising their own influence and latitude, and the ultimate success of GAZ depends on ways in which stakeholders accept and respond to incentives inherent in the GAZ regime. Bjerkan et al. (2012) have previously shown that the *acceptability* of GAZ is higher among stakeholders who perceive GAZ to be fair and effective, and who have a high awareness of the environmental problems caused by emissions. The present paper explores the potential *behavioural responses* of GAZ, and how acceptability and other motivational factors might influences the willingness to adapt.

## Research questions

The successful design and introduction of GAZ depend on its ability to target stakeholders with real potential for influencing choices in the urban distribution chain. The design of an effective and feasible GAZ regime therefore requires knowledge regarding relations and the distribution of power between the main actors within urban freight distribution, as well as their individual motivations and constraints for behavioural adaptation.

Firstly, this paper seeks to identify the individual stakeholders' potential for setting the course towards greener urban distribution, by investigating their influence on decisions within the urban distribution chain. More specifically, the paper asks *(1) which stakeholder groups have the power to induce more environmentally friendly urban freight transport*, and *will GAZ create incentives to do so for this/ these group(s)*?

Secondly, this paper further aims to investigate if and in what ways stakeholders will adapt to the GAZ regime. A central question is thus, *(2) what behavioural responses are available to stakeholders*? And *what are the stakeholders' own evaluation of likely adaptations*?

Finally, the paper seeks to explore the influence of motivational factors on future behavioural responses of carriers. Building upon Bjerkan et al. (2012) this paper asks *(3) what effect does acceptability, perceived fairness, perceived effectiveness and problem perception have on carriers' anticipated behavioural adaptations to GAZ*?

The paper is organized as follows. First, previous research on the issue of stakeholders' behavioural adaptations to freight pricing regimes is presented. The next section accounts for the methodology used in the study, after which the empirical results from three stakeholder surveys are outlined. Finally, the results from the study and the implications thereof are discussed.

# EXISTING KNOWLEDGE AND RESEARCH

## Stakeholder target groups

City logistics is a business characterized by complex interactions between numerous stakeholders. A stakeholder is an actor or group of actors which affects or is affected by the phenomenon under study (see also Freeman 1984). Among stakeholders traditionally identified in logistics are receivers, carriers and forwarders (Ogden 1992). Recent research also emphasizes the involvement of policy makers, decision makers and local authorities (Lindholm 2012, Russo and Comi 2010, Stathopoulos et al. 2011). The scope of this study is limited to a *simplified logistics chain* from shipper via carrier to receiver. In the context of this paper the shipper is represented by wholesalers, the provider of transport services is represented by carriers, and the receiver is represented by retailers.

## Stakeholder responses

Research on the behavioural responses to road pricing for freight transport is very limited. Among those who exist, two main types of studies can be distinguished, depending on whether they are based on stakeholders' assessments of likely adaptations in the event of a planned or hypothetical pricing scheme, or studies of real adaptations *after* the implementation of a pricing scheme. Research in the latter category is especially lacking. The behavioural responses of other stakeholder groups than carriers to freight pricing schemes are also by and large neglected in existing research. This is understandable, as the carriers are the first to be targeted by pricing mechanisms. Nevertheless it is important to include the viewpoints of other parts of the logistics chain to anticipate the full impact of pricing schemes.

One of the main objectives with charging regimes is to induce a more balanced utilization of the infrastructure (Quak and van Duin 2010). More specifically, they are generally aimed at encouraging changes in travel times, route choices, mode choices, types of vehicle utilized, or at reducing the amount of transport (Steg and Schuitema 2007).

Loukopoulos et al. (2004) maintain that different behavioural adaptation strategies to pricing policies aimed at passenger transport are ordered according to a cost-minimisation principle for the individual. Accordingly, people will first make behavioural adaptions which involve the least inconvenience (trip chaining, route changes etc.). When such adaptations are not sufficient or feasible, they may adapt in more costly and burdensome ways (e.g. changing travel mode, reducing transport). An ordering of adaptation options can be assumed to be present also in freight transport, as private carriers seek to minimize transportation costs and maximise sales (Taniguchi and Tamagawa 2005). This is confirmed by Rössger et al. (2009) who studied behavioural effects of price differentiation measures for road freight based on interview surveys in several European countries. Their study showed that the stated likelihood of different behavioural responses in the event of pricing schemes was significantly smaller for short-term changes than for long-term changes.

Quak and van Duin (2010) studied Dutch hauliers' anticipated behavioural adaptations to a road pricing regime by use of surveys. The majority answered that there would be no change in their behaviour, as they would pass on the extra costs to their clients or absorb the costs in their own profit margins. The authors argue that this option is not a long term strategy, and that other choices will have to emerge in the long term.

Findings from European cities show that targeted environmental regulations for freight transportation in general are among the most efficient ways to reduce emissions (Dablanc 2008). According to Russo and Comi (2011), the primary benefit of low emission zones is that they provide incentives to utilize more environmentally friendly vehicles. In the coming of the low emission zone implemented in London in 2008, Browne et al. (2004) found that adapting the vehicle fleet to the demanded Euro standard was by far the most likely anticipated effect in the view of freight companies. Other options such as changing routes, entering the zone without paying and switching to smaller vehicles were considered much less likely. A later effect study of the London low emission zone also shows that the fleet turnover did increase substantially in the immediate aftermath of implementation before returning to national average in the subsequent years (Ellison et al. 2010).

Holguín-Veras et al. (2012, 2006) maintain that in many cases policies designed to encourage off-hour deliveries only induce behavioural change if they target the receivers. This is due to two mechanisms: 1) a balance of power in most goods segments where the customers of transport services determine delivery times, and 2) the high competitiveness in the transportation market which deprives the carriers of the ability to send a price signal to those who can implement behavioural change. Thus, the carriers have in many cases no choice but to implement strategies that help them cope with the impacts of pricing without affecting their customers.

The studies presented above focus mainly on managerial level effects in the freight companies, such as fleet renewal, change of delivery times, change of routes and load optimization. In recent years, another form of adaptation has emerged on the driver level – eco-driving. Driving style constitute the most influential factor on fuel efficiency, and eco-driving can reduce fuel consumption by 10 %, and thereby reduce emissions by an equivalent percentage (Barkenbus 2010, McKinnon 2008). Increased driver training is therefore an important indicator that should be included in studies of behavioural adaptations to freight pricing schemes.

### Motivational factors in stakeholder responses

Emission zones are controversial solutions because of the additional costs met by private companies (Campbell 1994). The successful implementation of any measure depends on the acceptability of involved stakeholders. In contrast to the typical European low emission zones, GAZ represents a dynamic model for road user charging. A common perception is that dynamic and variable charging schemes have a rather low acceptability (Vrtic et al. 2007), which could pose a significant obstacle to the realization of the GAZ regime. Bjerkan et al. (2012) have previously shown that the acceptability of GAZ is low among carriers, but high among wholesalers. Furthermore, their study shows that acceptability of GAZ is correlated with the perceived fairness and the perceived effectiveness of GAZ, as well as problem perception. This is in line with other studies on acceptance of pricing measures (Fujii et al. 2004, Gaunt et al. 2007, Rienstra et al. 1999).

According to Rössger et al. (2009), motivational factors such as acceptability, perceived fairness and perceived effectiveness are important determinants of future behavioural adaptations. This is because restrictive schemes may incur an adverse psychological effect termed "Psychological Reactance" in the target group, if these schemes are perceived to be unfair or unreasonable. This can result in resistance in the form of not changing behaviour to the extent possible, or even refusing to make any change. In the study by Rössger et al., survey results among freight operators show that the acceptability and the perceived effectiveness of differentiated pricing schemes are strongly correlated with the likelihood of future behavioural changes.

## METHOD

### Pilot interviews and literature review

The possible range of behavioural adaptations and attitudes to environmental pricing was initially investigated by pilot interviews with key stakeholders and a limited literature review of similar studies. They uncovered a complex decision-making structure, involving many actors, that renders different stakeholders both possible beneficiaries and disadvantaged by potential adaptations.

Because of the difficulty with identifying simple cause-and-effect relationships, survey techniques like stated choice/stated preferences could not be employed. Instead, potential behavioural consequences of GAZ were investigated through detailed web-surveys among retailers, wholesalers and carriers.

## Surveys and samples

### *Retailers*

Delivery needs and practices were investigated by a web-survey conducted among 119 retailers in five Norwegian cities: Oslo, Bergen, Trondheim, Stavanger and Tromsø. They represented a wide variety of retail segments. Clothing and textile, restaurants and grocery stores were the largest segments, covering one half of the sample. The retailers were most commonly located in the city centre (69 %), at a shopping centre (58 %) or they were part of a retail chain (69 %). The number of employees varied between 2 and 300, but nearly 8 of 10 retailers had 20 employees or less. The retailers were served by an average number of 17 suppliers of goods (wholesalers, manufacturers etc.).

Available retailer responses to the GAZ regime are estimated by use of two measures. The first measure relates to *criteria for choice of transport provider*. All retailers who themselves are in position to choose transport providers were asked to rate the importance of four criteria when acquiring transport services. The criteria *price*, *punctuality*, *undamaged goods* and *environmental friendliness* were rated on a 3-point scale where *1=not important* and *3=very important*.

The second measure of potential retailer responses is related to their *willingness to choose transport providers with an environmentally friendly profile*, if such information was available. This was measured by the question *'If possible, would you choose a transport provider which could prove the transport was environmentally friendly?'*

### *Wholesalers*

The net sample from the survey among transport managers in supplier companies consisted of 15 companies. These companies deliver goods to customers in one or more of the four largest cities in Norway (Oslo, Bergen, Trondheim and Stavanger) and hire some or all transport services from carrier companies. Although a sample of 15 is relatively small, it includes transport managers in some of the largest and most important wholesaler companies in Norway. As such, the sample represents suppliers responsible for a large share of supplies to Norwegian cities. The respondents represent a variety of goods segments, and are as such expected to cover a wide range of perspectives among Norwegian suppliers.

Available wholesaler responses to the GAZ regime are based on three measures. As for retailers the first measure relates to *criteria for choice of transport provider.* Wholesalers

were asked to rate the importance of ten criteria on a 4-point scale where *1=unimportant* and *4= very important*[2]. Included criteria were *a) time from order to pick up*, *b) time from pick-up to delivery*, *c) punctuality*, *d) undamaged goods*, *e) frequency*, *f) regularity*, *g) flexibility*, *h) environmental friendliness*, *i) competence*, and *j) price*.

Secondly, wholesaler responses also relate to their *willingness to choose transport providers with an environmentally friendly profile.* This is measured by the same question as applied in the retailer survey.

Potential behavioural responses of wholesalers finally relate to their *handling of increased transport expenses* if the GAZ charge is passed on from carriers. In the wholesaler survey, this is measured by the question *'How would your company handle increased transport expenses as a result of GAZ charges to carriers?',* and respondents could choose one of four responses: *a) encourage carriers to pollute less without changing carrier*, *b) change to a less polluting carrier*, *c) accept increased transport expenses*, and *d) other*.

### *Carriers*

The web survey among carriers involved a net sample of 196 companies located in or around the four largest cities in Norway (Oslo, Bergen, Trondheim and Stavanger) with at least weekly transport commissions in one of the cities. Carriers of mixed and bulk cargo constituted the majority of the sample, and over half of the carriers were small firms with 1-5 employees.

Available carrier responses are presented by use of three measures. As for the other stakeholders, the first measure relates to *criteria for choice of transport provider.* The same question is applied for carriers and wholesalers alike, but for carriers this refers to their perception of criteria as valued by commissioners of transport services.

Carrier responses also relate to *behavioural adaptations to GAZ*, more specifically actions to reduce emissions and hence the GAZ charge. Carriers were asked to estimate the likelihood of ten alternative actions on a 4-point scale, where *1=very unlikely* and *4=very likely*. Included actions were *1) change/optimize driving routes, 2) more environmentally friendly vehicles, 3) use larger vehicles, 4) increase vehicle load factor, 5) more eco-driving, 6) avoid peak periods, 7) increase night and evening deliveries, 8) pass on extra costs, 9) absorb costs in lower profit margins, and 10) cooperate with others*. The list of behavioural actions is a subset used by Quak and van Duin (2010), but *more eco-driving* is added for the purpose of this study.

Finally, behavioural adaptations indicated by carriers are investigated in the light of *motivational factors*. More specifically, these factors refer to five indicators: acceptability, fairness, effectiveness, scheme perception and problem perception.

[2] Initial analysis of the retailer survey indicated a need for a more detailed response scale. Therefore this question was measured on a 4-point scale in the wholesaler and carrier surveys.

*Acceptability* is measured by the question '*What attitude do you hold towards low emission zones in Norwegian cities, as described in this survey?'* on a 5-point scale where *1=very negative* and *5=very positive.*

*Fairness* is measured by the question '*How fair or unfair do you think that a pricing scheme based on the actual amount of emission is?'* on a 5-point scale where *1=very unfair* and *5=very fair.*

*Effectiveness* is measured by the question '*How effective do you think that a pricing scheme based on the actual amount of emission would be?'* on a 5-point scale where *1=very ineffective* and *5=very effective.*

*Scheme perception* is measured by agreement to the statement '*The description of the GAZ concept was well understood'* on a five-point scale where *1=disagree completely* and *5=agree completely*.

*Problem perception* is measured by the use of responses to five statements regarding climate and pollution challenges. An additive index was computed which ranged from *1=very low to 4=very high*.

# RESULTS

## Potential target groups

One purpose of this paper is to investigate individual stakeholders' potential influence on decisions within the urban distribution chain. Although goods deliveries are ultimately transported to retailers, they are not necessarily responsible for acquiring transport services. The retailer survey shows that the majority of retailers are in fact *not* responsible for acquiring the freight of goods to their own stores. Figure 1 shows that 79 % of retailers never acquire transport for own deliveries, whereas a mere 6 % of retailers acquire transport services for all deliveries themselves. Furthermore, 15 % acquire transport for some deliveries.

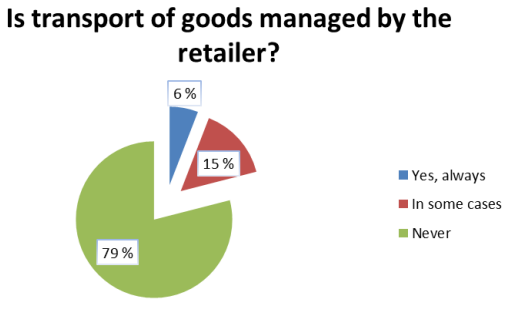


Figure 1 – Management of transport to retailers. N=119

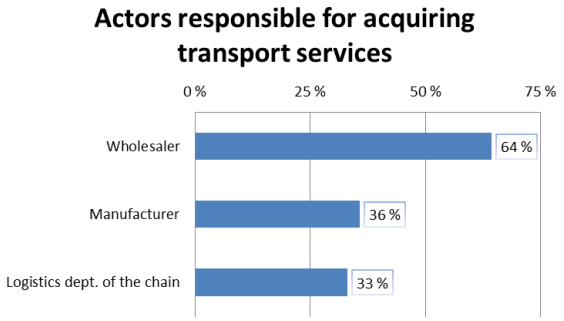


Figure 2 – Actors responsible for acquiring transport services to retailers. Multiple responses. N=112

The retailer survey shows that wholesalers appear to be the most prominent stakeholder in acquiring transport services. Figure 2 shows that 64 % of retailers name wholesalers as responsible for acquiring transport services, whereas 36 % refer to manufacturers. Additionally, one third of retailers rely on the logistics department of the retail chain to which

they belong for acquiring transport. These are to a large degree franchise retailers with a centralized system for goods deliveries.

The remote role of the retailers in acquiring transport is confirmed by the carriers. According to the carrier survey, 4 % of carrier transport commissions are ordered by retailers. The most typical contractor for the carrier is forwarding agents (42 %), followed by wholesalers (26 %) and manufacturers (22 %). Wholesalers thus control a large part of transport services in urban distribution. Four out of five wholesalers have an own logistics department for acquiring transport services. Further, 40 % of wholesalers commissioned all transport services to other transport providers, and 60 % commissioned some.

## Retailer responses

Retailer responses are first estimated by *criteria for choice of transport provider*. A small subset of retailers acquires transport services themselves, and Figure 3 shows their rating of different criteria when choosing transport providers. The figure shows that *undamaged goods* was rated highest, followed by *punctuality*, *price* and *environmental friendliness.*

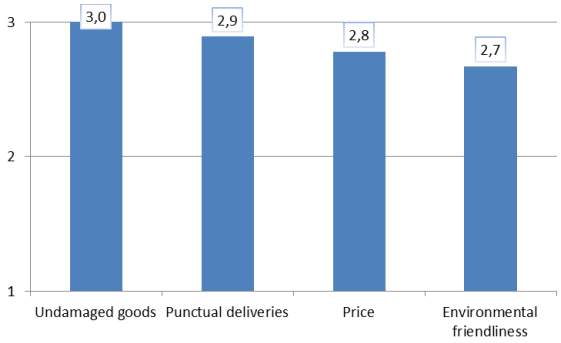


Figure 3 – Retailer criteria in choice of transport provider. N=9

The retailer survey also shows the retailers' *willingness to choose transport providers with an environmentally friendly profile*. In general, the environmental profile of transport providers did not appear to be a major concern for retailers. This might result from retailers being unable to distinguish between transport providers with high and low emissions. Only 6 % of retailers are to a large degree able to make such a distinction. Still, 36 % of retailers would choose an environmentally friendly transport provider if such a distinction was possible, and another 45 % would choose an environmentally friendly transport provider if it reduced costs. This indicates that retailers, to the degree they are responsible for acquiring transport services, will reward transport providers who succeed in keeping low emissions, and hence low costs, within a GAZ regime.

## Wholesaler responses

As for retailers, environmental friendliness appears to be the least important wholesaler criteria in choice of transport provider (Figure 4). Undamaged goods, punctuality and price are most important, which is also identical to retailer findings.

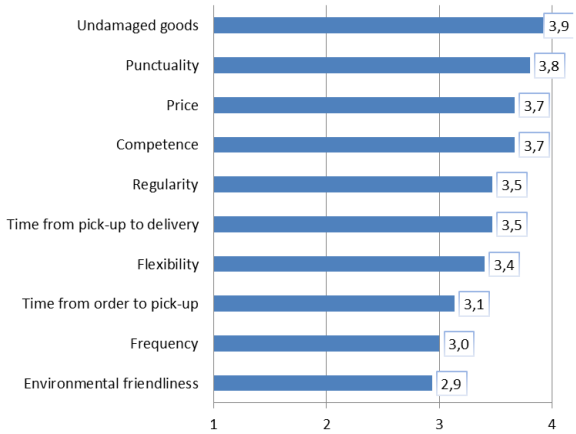


Figure 4 – Wholesaler criteria in choice of transport provider. N=15

As retailers, wholesalers struggle with differentiating between carriers with high and low emission levels. Nonetheless, a large majority are *willing to choose a transport provider with an environmentally friendly profile*. A total of 80 % would do so if it was possible to distinguish between transport providers on the basis of environmental contribution. To many, however, such a choice is preconditioned by costs: choosing environmentally friendly transport providers proves less attractive if associated with cost increases. However, the survey showed that 60 % of the wholesalers have already made efforts to encourage their carrier(s) to behave more environmentally friendly.

Finally, wholesalers report their *handling of increased transport expenses* if the GAZ charge is passed on from carriers. 47 % of wholesalers will replace the carrier, and 40 % will encourage the carrier to find cost saving, less polluting solutions without changing carriers. Estimates of what level of price increase would trigger a move towards changing transport provider varied between 0.5 % and 20 %, the 95 % confidence interval being 5.5 % - 13.3 %.

## Carrier responses

### *Criteria for choice of transport provider*

As for the other stakeholders, the carrier survey showed estimates of criteria for selecting transport provider. In the carrier survey, this refers to *carriers' perception of criteria as valued by commissioners of transport services*. Figure 5 shows that carrier responses are coherent with the ranking of wholesaler criteria, and that environmental friendliness is valued even lower among carriers. This suggests that carriers estimate the value of environmentally friendly transport among commissioners as lower than what is actually the case.

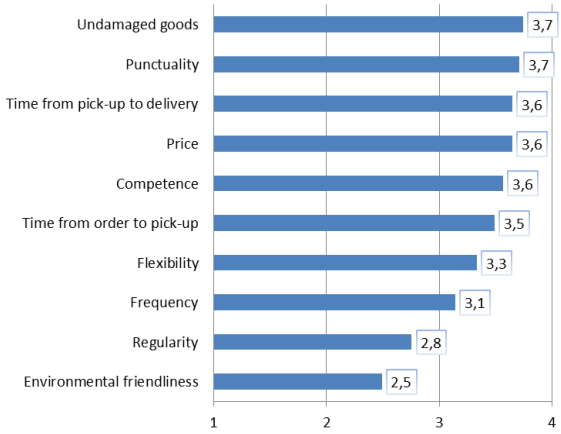


Figure 5 – Carrier perceptions of criteria in choice of transport provider. N=196

## *Behavioural adaptations*

The carriers' expected behavioural adaptions to GAZ show that the most likely response is to pass on the extra costs (Figure 6). This is the only alternative that on average scores 'likely'. Overall, carriers claim not to be in a position to increase prices to recoup losses from a GAZ charge. The carrier survey shows that nearly half of all carriers will be unable to compensate GAZ charges by increasing costs. As such, it is surprising that passing on extra costs is the most common response. However, it might represent the more feasible solution since many carriers already take many of the listed actions in an effort to keep fuel expenses down. For example, the survey shows that even today 63 % of the carriers use Euro class V vehicles, 62 % are already maximising load capacity, 52 % practice eco-driving, 33 % optimize driving routes and as many are using large vehicles in order to drive fewer trips.

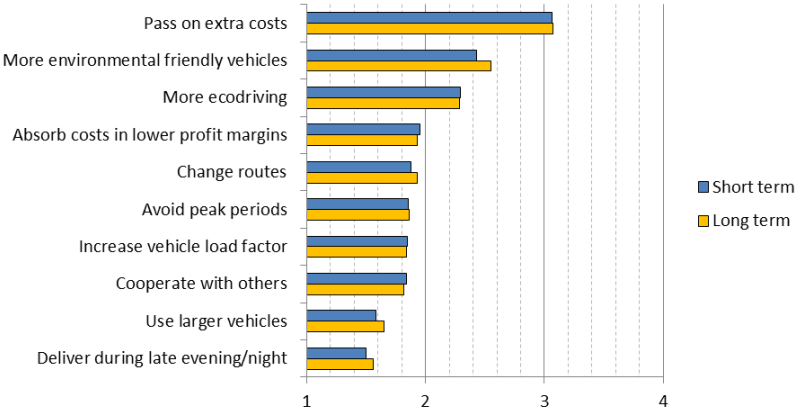


Figure 6– Carriers' assessment of likelihood of behavioural responses to GAZ. N=196

The second most likely behavioural response to GAZ is use of more environmental friendly vehicles. Using new vehicles with lower emissions, such as Euro class V HDVs, are already a widespread measure for reducing fuel expenses. Such responses to GAZ are thus familiar to carriers and might appear feasible.

Eco-driving is also expected to be a frequent response to GAZ. The majority of carriers (55 %) have not provided drivers with formal training in eco-driving, and explain this by referring to costs of formal training or claim that drivers already know how to practice eco-driving. Thus, there seems to be a potential for more widespread use of formal training in eco-driving if a GAZ regime were to be introduced. Further, major vehicle manufacturers are increasingly incorporating eco-driving assistance systems in their HDVs.

### *Statistical influences of motivational factors*

Finally, carrier behavioural responses are investigated in light of motivational influences. Correlations between motivational indicators and the likely behavioural responses to GAZ listed in Figure 6 were studied, and combined indicators for behavioural responses were created. Disregarding economic consequences like passing on extra costs and absorbing higher costs in lower profit margins, the four behavioural responses with the highest degree of statistical correlation with the attitude indicators were selected for the additive indicator. Here, results for *the likelihood of short term responses* (LSTR) are presented as the dependent variable, since motivational factors provide marginally greater explanatory power for short term responses than for long term responses. The dependent variable LSTR is the sum of the following four behavioural response indicators: *more environmental friendly vehicles, increase vehicle load factor, more eco-driving* and *change routes*.

Figure 7 shows the bivariate correlations (Pearson) between acceptability and LSTR on the left hand side, and motivational indicators on the right hand side, which came out as significant. The indicator for scheme perception did not have significant correlations with neither acceptability nor LSTR, and the indicator for problem perception did not correlate significantly with LSTR.

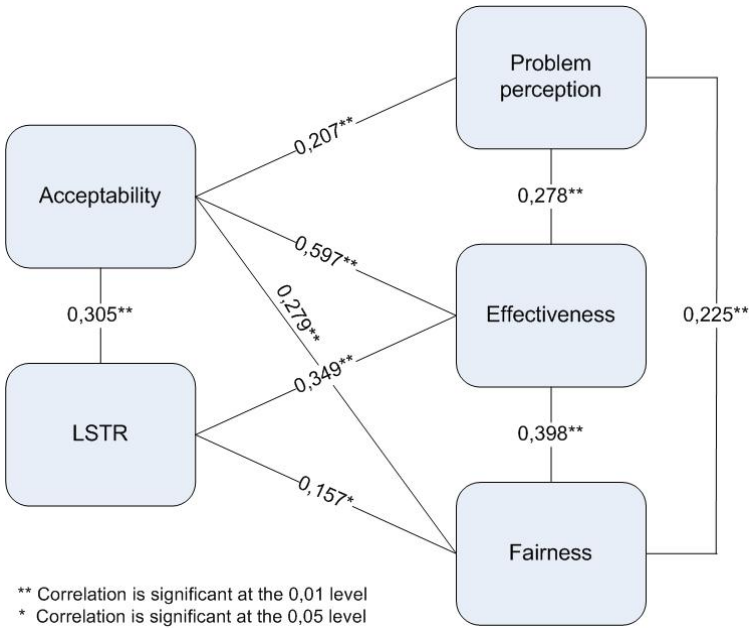


Figure 7– Correlation coefficients. N=196

Effectiveness is the strongest single predictor of acceptability, followed by fairness and problem perception. It is also evident that interrelationships between these predictors are fairly high. To investigate how these independent and correlated variables covariate in predicting acceptability, they were entered in an OLS regression model, and subsequent results using backward elimination were obtained. Table I shows that problem perception and fairness were eliminated because of insignificant contributions in explaining the variance of acceptability. Based on this model, it can be concluded that carriers' perceptions of climate and pollution problems or their views on fairness did not contribute significantly in explaining the acceptability of GAZ. Only their expectations about the effectiveness of GAZ remain a significant predictor.

Table I – Regression coefficients. Prediction of acceptability

| Dependent Variable: ACCEPTABILITY | | | | | |
|---|---|---|---|---|---|
| Model | | Standardized coefficients | t | Significance | Adjusted $R^2$ |
| 1 | (Constant) | | 1,70 | 0,090 | 0,349 |
| | Fairness | 0,044 | 0,69 | 0,490 | |
| | Effectiveness | 0,568 | 8,73 | 0,000 | |
| | Problem perception | 0,038 | 0,63 | 0,532 | |
| 2 | (Constant) | | 2,90 | 0,004 | 0,351 |
| | Fairness | 0,050 | 0,78 | 0,436 | |
| | Effectiveness | 0,577 | 9,08 | 0,000 | |
| 3 | (Constant) | | 3,71 | 0,000 | 0,353 |
| | Effectiveness | 0,597 | 10,25 | 0,000 | |

The model described in Table II shows regression results with LSTR as the dependent variable, and the three motivational factors *acceptability*, *effectiveness* and *fairness*. Here, only fairness is eliminated, and both effectiveness and acceptability (significant only at the 7.5 % level) remain.

Table II – Regression coefficients. Prediction of LSTR

| Dependent Variable: LSTR | | | | | |
|---|---|---|---|---|---|
| Model | | Standardized coefficients | t | Significance | Adjusted $R^2$ |
| 1 | (Constant) | | 6,35 | 0,000 | 0,123 |
| | Acceptability | 0,150 | 1,77 | 0,078 | |
| | Effectiveness | 0,253 | 2,86 | 0,005 | |
| | Fairness | 0,014 | 0,19 | 0,848 | |
| 2 | (Constant) | | 11,62 | 0,000 | 0,127 |
| | Acceptability | 0,151 | 1,79 | 0,075 | |
| | Effectiveness | 0,259 | 3,07 | 0,002 | |

This model supports the explanatory power of effectiveness, and suggests that belief in the effectiveness of a price differentiation measure like GAZ is important for behavioural change to occur. Secondly, high acceptability increases the likelihood of future behavioural changes. These findings are in line with the results presented by Rössger et al. (2009), although they found acceptability to be a more important motivational factor than perceived effectiveness.

# DISCUSSION AND CONCLUSIONS

One purpose of this paper has been to investigate the stakeholders' relative influence on decisions within the urban distribution chain. The results show that retailers are less influential than expected. Retailers in this study place orders and are the ultimate receivers of goods deliveries, but they do to a very limited degree manage the flow of goods to their stores. Only 6 % acquire transport services for all goods themselves and a further 15 % arrange transport for some of their deliveries. According to the retailers, wholesalers are the most important stakeholder group when it comes to managing transport of goods, followed by manufacturers and logistics departments of the retail chain for franchise retailers. The remote role of retailers is confirmed by carriers, who report that only 4 % of their transport commissions are ordered by retailers. Forwarding agents or wholesalers cover 68 % of their commissions, and manufacturers 22 %.

Another purpose of this paper has been to investigate the likelihood of different behavioural responses to a GAZ regime among stakeholders. Interestingly, wholesalers ranked price as one of the most important criterion for selecting a transport provider. This is important since the success of GAZ depends on the freight market's willingness and ability to respond to price signals. Furthermore, almost one half of the wholesalers would have taken action to replace the transport provider if they had to pay for high pollution levels caused by the carrier. Another 40 % would encourage the carrier to find less polluting solutions.

However, the results indicate that the likelihood of the price signal being sent to the wholesalers is limited. Only a small minority of the carriers found themselves in a position where they could increase their transport charges as a consequence of GAZ. Nearly half were not able to do so even in the long run. This is due to a highly competitive market where the price, as the most important criterion, has to be kept at a minimum.

Although carriers find it hard to pass on extra costs, this was ranked the most likely behavioural response to GAZ. This is in line with findings by Quak and van Duin (2010) who found that carriers in the short term try to limit logistics changes by passing on extra costs or absorbing the extra costs in their profit margins. According to Quak and van Duin, logistics changes are therefore more likely in the long term. The present study, however, shows few differences between short term and long term carrier responses. This should be seen in light of carriers' current efforts (such as optimizing routes and load capacity, avoiding peak hours, training for eco-driving) to keep fuel expenses and hence emissions to a minimum level. As shown in Bjerkan et al. (2012), the carriers are not convinced that GAZ would be effective, because they consider the potential to reduce emissions to be marginal.

This is in line with Holguín-Veras et al. (2006), who argue that financial incentives in the freight sector are not necessarily effective tools, as the competition for transport commissions hinder the price signal to reach the customers of transport services. In less competitive segments of the freight market pricing schemes could, however, be expected to be more effective.

This paper further shows that using cleaner vehicles is the second most likely behavioural response to GAZ among carriers. But as Euro V HDVs have equally high levels of $NO_x$ and $NO_2$ in real urban traffic as other HDVs, effective emission reduction will not occur until the current fleet is replaced by Euro VI vehicles.

The majority of wholesalers and retailers are not able to distinguish between carriers with high and low emissions. This might be a reason why environmental friendliness is ranked as the least important criteria when wholesalers choose their transport provider. The results indicate that the wholesalers would like to see documented emission levels for transport services. In this sense, the GAZ application could be a useful instrument by providing relevant information about emission levels to stakeholders, whether a GAZ pricing scheme is implemented or not. This would be particularly valuable for businesses promoting a green image.

The final purpose of this paper has been to explore the influence of motivational factors on behavioural responses among carriers. Both effectiveness and acceptability proved to be significant explanatory variables for predicting the likelihood of short term responses, in terms of use of modern vehicles, exploitation of vehicle load capacity, eco-driving and route optimization. This implies that the perceived effectiveness of a price differentiation measure like GAZ is important for behavioural changes to happen, and that high acceptability increases the likelihood of future changes in response to the measure.

As noted in the introduction, previous research has found that environmental regulations for freight transport in general are effective. Given the present structure of the freight market and emission levels from the cleanest HDVs available, the findings of this study suggest that GAZ may not be as effective as one could hope. The potential for more environmentally friendly behaviour seems small in the goods segments under study, and the low acceptability of GAZ among carriers indicates that the feasibility of such a regime in the present political climate is limited. However, the environmental concern and acceptability of a GAZ regime are higher among the other stakeholder groups, indicating that feasibility might increase. Further, the GAZ application in itself represents a valuable evaluation tool, as it holds potential for measuring real emission levels and as such demonstrating the effect of policies aimed at reducing pollution from freight transport. As shown in this study, the perceived effectiveness of GAZ is an important determinant of behavioural changes among carriers. Thus, if a given measure is proven effective by use of the GAZ application, the likelihood of intended behavioural adaptations occurring after implementation of such policies can be assumed to increase. Finally, more accurate information about emission levels might facilitate more precise, efficient and feasible implementation of environmental measures in urban areas.

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