POLICY INSTRUMENTS FOR REDUCING CO_2-EMISSIONS FROM THE SWEDISH LOGISTICS AND FREIGHT TRANSPORT SECTOR

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ABSTRACT

Swedish politicians have set the target of a fossil independent fleet of vehicles by 2030 and an 80 % reduction of CO_2 by 2050 in order to keep the 2-degree international agreement. In order to achieve this, policies and instruments are regarded to play an important role. In this paper we analyse instruments in practice and in theory for reducing CO_2-emissions from the Swedish logistics and freight transport sector and their potential in short, middle and long run. In this paper, four categories of instruments are analysed: economic, legal, knowledge based and societal in a literature study. Literature is rich on environmental transport instruments in general, however, concerning freight transports and logistics there are only few articles. Although many instruments are general and can be implemented in different sectors, their potential might be uncertain due to the lacking empiri. However, we can conclude that, economic instrument are important in the short run until new techniques are at hand. Legal instruments are in the short run important sharpening limits for emissions or releasing vehicle restrictions. Knowledge based instruments are important for changing behaviour and can influence logistical factors, such as design of production- and inventory policies. Societal instruments such as infrastructure investments are important in the long run adapting to the new techniques. Policy instruments often focus private/public transport but when it comes to freight transport, fewer instruments are considered and implemented although the freight sector accounts for about a third of CO_2-emissions from transports. This study points at the possibility and potential in using instruments in the freight sector, and the need of more empiri. Articles in transport policy seldom focus on logistics and freight transport, hence the logistics and freight transport research community needs to be more involved in transport policy.

Keywords: Freight transport, Policy Instrument, CO_2-reduction

CO_2-EMISSIONS FROM THE FREIGHT TRANSPORT SECTOR

The Swedish government has set a though target in their fossil independent vehicle fleet by the year 2030 and a reduction of carbon emissions by 40 % (compared to the 1990-level) by 2020. In order to achieve this, the transport policy instruments are regarded to play a major role, hence they must be correspondingly though.

The transport sector counts for about a quarter of the Swedish energy consumption. 93 % is used by the road sector. Freight transports counts for about 30 per cent of the road sectors energy consumption (Energimyndigheten, 2011). Regarding CO_2-emissions from inland transports, they measured 20 160 ktonne in year 2009, of which 18 899 ktonne stemmed from road transport. 6 555 ktonne CO_2 came from heavy vehicle, buses and light lorries (Swedish Environmental Protection Agency, 2011). Given this, it is not so surprising that most transport policy instruments concern road transport. A literature search showed that almost all literature in the area focus on cars or public transport. Only a few articles and reports specifically studies instruments for the freight transport sector. Yet freight transports counts for about 32 % of the CO_2-emissions from inland transports.

This paper is a part of the LETS 2050 research program at Lund University. The core mission of the LETS research program is to identify, explore and suggest ways that Sweden can *implement low-carbon energy and transport systems for 2050*, in order to reach the ambitious climate policy objectives suggested by the 2°C target.

In this paper we analyse instruments in practice and in theory for reducing CO_2-emissions from the Swedish logistics and freight transport sector. Literature is rich on environmental transport instruments in general, however, concerning freight transports and logistics there are only a few articles. Although many instruments are general and can be implemented in different sectors, their potential might be uncertain due to the lacking empiri. In the paper we analyse four categories of instruments: economic, legal, knowledge based and societal in a literature study.

RELATIONSHIP BETWEEN CO_2-EMISSIONS AND FREIGHT TRANSPORTS

There are different models on how CO_2-emissions are depending on freight transports, for example McKinnon (2008) defines 7 key parameters:

1. Modal split
2. Average handling factor
3. Average length of haul,
4. Average payload on laden trips

5. Proportion of kms run empty

6. Carbon intensity of the energy source

Figure 1 below, shows how McKinnon maps the relationship between weight of goods produced in an economy and CO_2-emssions from freight transport operations.

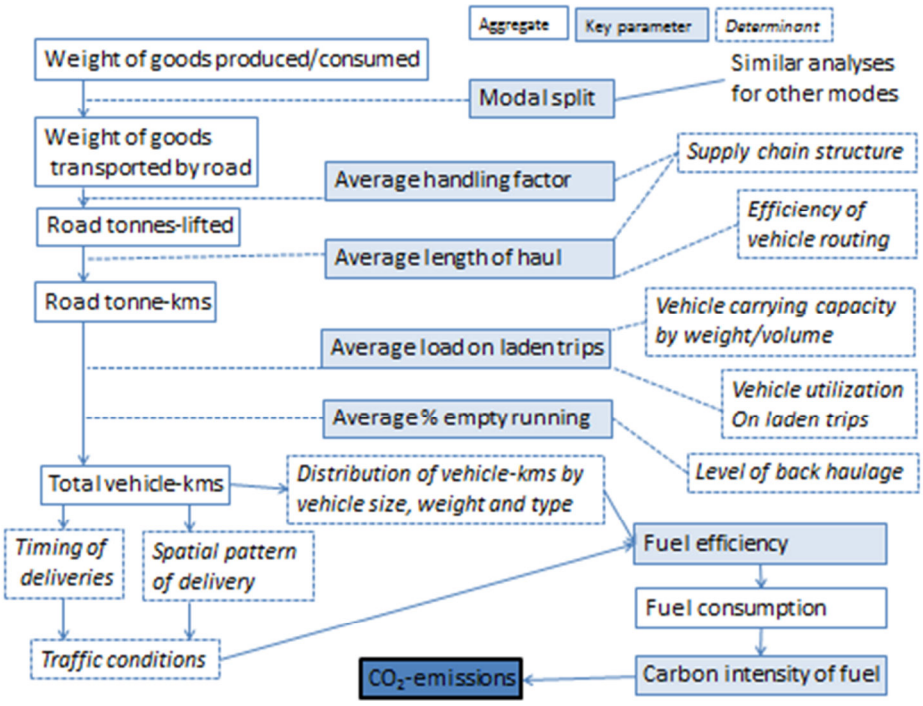

Figure 1 CO2-emissions from a supply chain using road transports (McKinnon, 2008)

Another model is the decomposition model develop with in the LETS 2050 project at Lund university (Eng Larsson et al., 2011).

$$CO_2\text{emissions} = \text{GDP} \times \frac{\text{ton}}{\text{GDP}} \times \frac{\text{tonkm}}{\text{ton}} \times \frac{\text{vehiclekm}}{\text{tonkm}} \times \frac{\text{kWh}}{\text{vehiclekm}} \times \frac{CO_2\text{emissions}}{\text{kWh}}$$

GDP	INVERSE VALUE DENSITY	TRANSPORT INTENSITY	TRAFFIC INTENSITY	ENERGY INTENSITY	EMISSIONS INTENSITY

The factors in this model are:

1. Gross Domestic Product, GDP

2. Inverse value density, tonne/GDP

3. Transport intensity, tonnekm/tonne
4. Traffic intensity, vehiclekm/tonnekm
5. Energy intensity, kWh/vehiclekm
6. Emission intensity, CO_2/kWh

Later in this paper we will use this model for analysing the different transport policy instruments.

TRANSPORT POLICY INSTRUMENT

Transport policy instruments are the society's tools for influencing people, undertakings and other organizations and their behaviour in the transport sector. In respect of environmental policy, instruments are adopted in order to influence lifestyle and behaviour as well as for speeding up the developmental process.

Generally policy instruments are required to be cost efficient (the aim is reached at lowest possible cost), viable (it is easy to administrate and supervise), to have a high acceptability, to raise incentives for technical development and changed consume patterns, and in the case of environmental instruments; to assure the target is reached as quickly as possible (OECD, 1989).

There are different ways of categorizing policy instruments. In this paper we have chosen to use four categories:

- Economic
- Legal
- Knowledge based
- Societal

Below we will discuss different instruments within these four categories and their potential for reducing CO_2-emissions from the freight transport sector.

Economic Instruments

Economic instrument is all about internalizing external costs. By internalizing the "polluter pays principal" is achieved. If every transport mode had full internalization, e.g. by means of taxes etc. the modal split would be completely different and the overall demand of freight transports would probably be lower (McKinnon, 2008). We will not dig into the economic

theory behind the instruments here, but interested can find a description in i.e. Santos (2010a).

Economic instruments within the environmental area are characterised by (OECD, 1989);

- There is an economic stimuli
- There is a possibility of voluntarism
- Authorities are involved
- The aim is to maintain or improve the environment by the instrument.

Sweden has today a number of instruments for reducing CO_2-emissions from freight transports. A short description follows below together with descriptions of instruments yet not being used.

Carbon tax on fuels

Carbon taxes on fuels are common in many countries. It is an effective instrument for generating incomes to the state at a low cost. In Sweden a tax on energy, carbon and sulphur is charged on fuels and electric power, with the only exception of fuel for air. The effectiveness of the fuel taxes is dependent on price and driving distance elasticities. It is in general considered to have a significant effect, especially on cars. The price elasticity of diesel is lower than for petrol, indicating that freight transports are less sensitive for price increases (SIKA, 2004).

The potential for future carbon reductions from freight transports due to carbon taxes are not easily to forecast, then no estimates for the freight transport sector has been found. It is likely that price increases to a large extent can be passed on to transport buyers. If the taxes should correspond to full internalization, the increase would have to be substantial, for the case of UK road freight transport in 2006 it would require a 50 % increase in taxation (McKinnon, 2008). Also more recent estimates from the Swedish Transport Administration (2012) indicate an increase of the driving cost with 50 % in order to reach the target. This increase includes diesel as well as petrol, and comprises passenger and freight transports. The increase in driving cost can be imposed as carbon tax or infrastructure fees (Trafikverket, 2012).

Congestion taxes

Congestion taxes or charges are used to reduce traffic in areas with high density, in order to improve accessibility and reduce carbon emissions. Under 2006 the “Stockholmsförsöket” was launched as a test. In 2007 the taxes was made permanent and will also be introduced

in Göteborg in 2013. The tax is charged to Swedish vehicles on weekdays between 6.30 and 18.30 and is differentiated according to rush hours. An assessment of the "Stockholmsförsöket" showed a decrease in vehicle mileage. For the heavy lorries there was a decrease with 7.8 % within the fee zone and a decrease of 1.58 % within the county (Miljöavgiftskansliet, 2006).

Vehicle tax, Road fee and Infrastructure fee

Vehicle tax and road fees (Sweden belongs to Eurovignette) are instruments that influence the choice of vehicle and have long term impact due to the life span of the vehicles. Today infrastructure fees are only applied on rail transports. For sea and air there are port fees, take-off and landing fees respectively. A differentiated infrastructure fee based on societal marginal cost for each mode would better reflect the true costs and lead to another distribution of modal split.

Tax exemption of biofuels

According to article 8.4 in the directive 92/81/EEG is tax exemption allowed for carbon dioxide neutral fuels. So far has this tax exemption been necessary in order to increase the share of biofuels in the market, however the cost have been very high for the emission reduction accomplished, nor has the contribution of technical development been suffice (Riksrevisionen, 2011).

Transport subsidy

Transport subsidy can be granted to transports of a distance at minimum 401 km for freight transport on rail, road or sea within certain industries for the four northernmost counties in Sweden. This instrument could theoretically impact carbon dioxide emissions, however today these effects are marginal nor is the aim of this instrument assorted to environmental policy, but with small changes it could be. Rather the aim is to promote regional development within northern Sweden (Tillväxtverket, 2011).

Emission Trading System, ETS

Trading with emission allowances is a corner stone in the EU policy combatting climate change. The inclusion of the transport sector has been discussed for long and since 2012 the air transport is included.

A global trading system including all sectors would be a "first-best" solution since the reductions would take place where they are least expensive (Rothengatter, 2008). The costs of reducing carbon dioxide emissions from the transport system are considered to be higher than in those sectors that are included in the ETS today (Blom et al., 2007, Holmgren, 2006).

Kilometre tax

Since 2005, Germany has a kilometre tax for heavy lorries over 12 tonnes. Kilometre taxes are also to be found in Schweiz, Austria, the Czech Republic, Slovakia and Poland. The aim of the tax has been cost recovery of construction, maintenance in connection with heavy traffic. However, a kilometre tax could also aim at reducing carbon dioxide emissions, since a new EU regulation allows cost recovery for external effects, like emissions and noise (Pressemitteilungen online, 2011).

The experience in Germany shows a decrease in empty running by 15 %. Further a swift to Euro 5 vehicles has shown to be profitable if the motorways are used much, at the same time a downgrading of the fleet has been noticed, so that vehicle used for short distances are smaller than 12 tonnes and hence excluded from the kilometre tax. Some shift from motorways to main roads in order not to pay the tax has been noticed, whereas no considerable modal shift to the railway has occurred. These impacts correspond well with the simulated effects before the tax was adapted (Kågeson and Sundberg, 2006, Doll, 2007, Bundesamt für Güterverkehr, 2006).

The acceptance is in general higher for non-economic instruments, such as traffic free zones in the city centre, compared to road fees as solution to traffic problems. However, the German transport industry has accepted the kilometre tax, mainly since it also includes foreign vehicles. The tax is not considered to solve the problems of maintenance and congestion, nor does it contribute to increasing transport efficiency (Link, 2008).

Marginal tax on CO_2

A marginal tax on carbon dioxide (compare income tax) could imply a ground level of energy consumption and all consumption above that level is subject to a marginal tax, hence it would be expensive to increase the energy consumption and the incentives to be economical would increase (Helby et al., 1999). The environmental effect of a marginal tax compared to the normal carbon dioxide tax is considered to be high, however concerning the societal cost effectiveness the relationship is opposite. Tax change reforms would give “double profit”. Regarding distribution policy this instrument is positive. Like a normal CO_2-tax, a marginal tax contributes to an increase in demand for energy efficient technologies. Compared to normal CO_2-tax acceptance is higher.

Trading with freight capacity or interconnection/”public transport” for freight

A trading system for available capacity in load carriers could be used to increase average load on laden trips (compare with infrastructure access on rail, telecommunication or power traded at NordPool). This means that all free capacity (volume/weight) is reported to a stock exchange where it is auctioned out. According to Swedish Road Administration, measures in this area have a potential to decrease carbon dioxide emissions by 27 ktonne by 2020 and 40 ktonne by 2050 (Vägverket, 2004).

Legal instruments

Legal instruments are laws and regulations, i.e. “command and control” (CAC). A restriction is adopted and then it has to be complied (controlled). The advantage with this type of instruments are that they are easy to adopt and the result is predictable, the disadvantage is that they are inflexible and do not encourage improvements above the standards (Baumol and Oates, 1988). Compared to economic instruments their cost efficiency is generally lower, but legal instruments can be preferable if there are not any asymmetries in information, the risk of governmental failure is low and the regulated entities responds coherent, e.g. if the optimal emission level is zero and the substance should be forbidden (Santos et al., 2010a).

Classifications/Regulations

Regulations of sulphur and lead in fuels is common in many countries (Santos et al., 2010a). Concerning CO_2-emissions there is for example “Low Carbon Fuel Standard” in California aiming at a 10% decrease of carbon intensity (Farrell and Sperling, 2007). In Sweden fuel is classified according to sulphur and lead (Transportstyrelsen, 2009). Further there is a regulation about the percentage of ethanol allowed in fuels (EU, 2009). In Sweden all vehicles are classified according to environmental standard, as part of EU the Euro norm is standard.

Another important regulation area is the physical (length, capacity, weight and volume) vehicle regulations. Vehicle with a high loading capacity has the potential of being more environmental friendly, since by putting more goods on one trailer it might be possible to avoid a transport with a second trailer. Improving the utilisation of vehicle loading capacity is subject to five sets of restrictions according to McKinnon (2008); regulatory, market related, inter-functional, infrastructural and equipment-related. The inter-functional restrictions are about the relationship between transport and other functions in the company. Often managers prioritise these other functions before transport effectiveness. Hence, information can be an important complementary instrument.

Environmental Zones, restrictions of vehicle circulation and idle, and property rights

Traffic restriction in cities can be achieved in many ways. Environmental zones can be designed in various ways, main point is that vehicles not fulfilling certain standards are not allowed to be used within the zone, whereas vehicles fulfilling the standards normally have to pay for driving in the zone. These standards can be successively more restrictive. Sweden has environmental zones in Stockholm, Göteborg, Malmö and Lund for heavy vehicles. Idling is regulated in local environmental directives. In Sweden idling normally is restricted to 1 minute. To prohibit traffic in city centres are common in conjunction with certain delivery windows. Delivery times can be regulated to times when it is less congestion to decrease CO_2-emissions. Traffic can also be restricted in terms of property rights, for instance by licensing ownership as in Singapore. In order to own a vehicle a license is required. The licenses are limited and has to be allocated according to any principle (Santos et al., 2010a).

The effects of these kinds of instruments depend on how they are adapted. Foremost it can be used as instruments for impacting the choice of new vehicle and speeding up technology development.

Obligation schemes

An obligation scheme means that a certain percentage of something, for instance fuel sold, has to be bio fuel. It could also be possible to have obligation schemes for eco vehicle techniques etc. an assessment of an obligation scheme for bio fuels would be a cost effective component, together with other instruments in the strive for 10% renewable energy in the transport system by year 2020 (Energimyndigheten, 2009). The other instruments are needed to stimulate a long run technical development.

Other regulations

One important factor impacting fuel consumption is the vehicle status. Poorly maintained vehicle consume more fuel. This relates both to engines as well as tires. Regulating maintenance interval could increase the standard of the vehicles and hence decrease CO_2.

Procurements of transport could be regulated to contain environmental criteria. Today voluntary procurement formats can be used like Q3 (Q3, 2013).

Increased e-commerce implies a shift from passenger/private transport to freight transport, which is more eco efficient. Regulating consumer rights like free returns means fewer obstacles for shopping online, since the risks decreases.

Performance based standards

Standards based on performance, PBS, instead regulatory based standards, RBS, is gaining in popularity. PBS allows for instance all vehicles fulfilling the required performance regardless of technique used, whereas RBS is only allowing a specific technique.

Knowledge based instruments

Knowledge based instruments are information, research and development. Generally it is considered to be a “soft” instrument, since it is unconditioned. Information can influence behaviour, increase knowledge and comprehension, hence prepare and increase acceptance for other “hard” forcing instruments (Naturvårdsverket, 2011). Throughout the supply chain the different actors’, from lorry drivers to managers, behaviour can be influenced by information, often with relative low cost and have a huge impact. An example is “Freight Best Practice”-programme in Great Britain (Lawson et al., 2007). The programme cost was 2 million Pounds resulting in 65 500 ton less CO_2 emitted and 83 million in savings.

Information campaigns and programme about how to increase energy efficiency and what variables are important can involve e.g. vehicle design, maintenance, eco driving (can improve energy efficiency with about 10 % (McKinnon, 2008, Jack N, 2010). Important to consider is long term appliance of the new knowledge and support systems for maintaining the new improved behaviour. Information about increased vehicle utilisation concerns backhaul transportation, packaging logistics, consolidation, transport optimised order cycles and collaboration between companies (McKinnon, 2008).

Research and development is about creating new knowledge and finding new solutions to problems. Concerning decreasing CO_2-emissions, development of new techniques are crucial (Santos et al., 2010b). It concerns improving energy efficiency in the short run and in the long run to make transport independent of fossil fuels. Today we find techniques in various maturity degrees, e.g. different bio fuels, hybrid vehicles and electrical vehicles. Research is carried out both in industry and in the public sector. Businesses can gain advantages and market share over their competitors, as well as monopoly profits through patents. The social utility from research far exceed the private, hence the private expenditure for R&D are less than social optimum. Hence, funding of research and development is an important instrument (Santos et al., 2010b).

Demonstration programmes/projects usually has an economic ingredient, such as a subsidy, but usually also requires co-funding. The EU Marco Polo programme 2003-2006 reach the target of shifting 12 billion tonne kilometres from road to rail and sea at a yearly saving in external costs between 11.4 and 15.7 per subsidised Euro (Millán de la Lastra, 2007). Marco Polo II (2007-2013) has the target of 20.5 billion.

“Best practice” or “success stories” could also be used as instruments. Projects can be initialised within industry or in cooperation with authorities. An assessment from Swedish Environmental Protection Agency (Naturvårdsverket, 2002) showed that “best practice” could be an effective instrument if information was targeted to the target group from a reliable remitter. Communication must take place where the receivers are found. Further, best practise should support other instruments. A central portal for best practise could facilitate application and deployment. Today portals can be found at different places i.e. http://www.godaexempel.nu/, which is run by the Swedish association of environmental managers, or at the Swedish Environmental Management Council as well as other authorities.

Benchmarking or rating could be used as an instrument, if carried out by authorities. Today various ranking list are published by NGOs, like the Greenpeace guide to greener electronics (Greenpeace, 2013) or Newsweek Green Ranking (Newsweek, 2013). Ranking list can be used by companies to improve their image and to gain competitive advantages. Clean Shipping Index is a project with in West Sweden to improve the environmental performance from shipping. Within this project a ranking list is used for benchmarking (Clean Shipping Project, 2011). By using national statistics the ranking/benchmarking could be formalised.

Transport and logistical parameters such as fill rate, empty running, energy efficiency solemnly and in combination with vehicle utilisation are important KPIs (key performance indicators).

Environmental certification or environmental product declarations are voluntary measure from companies in order to communicate their environmental concern. Within EU there already are standards like EMAS and EU Eco label. In Sweden freight transports can be labelled with “Bra miljöval” from SSNC (Naturskyddsföreningen, 2013).

SOCIETAL INSTRUMENTS

This category focus infrastructure, both investments and physical planning. Infrastructure investments can contribute to reductions on carbon dioxide emissions by shortening the distances, increased capacity to diminish congestion, but new infrastructure normally also create new demand and hence can contribute to increased emissions. The Swedish infrastructure investment plans comprise a forecast of increased traffic volume. Less emission from increased energy efficiency could be counteracted by this increased traffic volume. Investments in infrastructure that would benefit a shift from road to other modes less emission intensive, such as rail or new carbon neutral techniques (e.g. electrical roads), would decrease emissions from the transport sector. Today, no significant shift to rail can take place in Sweden due to restrictions in capacity (Energimyndigheten and Naturvårdsverket, 2007). Infrastructure for loading/filling up electrical or hydrogen gas driven vehicles also has to be considered.

Modal shift or intermodal transports also depend on infrastructure in terminals. Another important issue is how passenger and freight transport are prioritised on the rail. Speed and reliability are important factors that are affected by infrastructure investments. Availability for rail can be increased by investments in industry siding. The Swedish Road Administration estimated that increased intermodality could decrease carbon dioxide emissions by 94 ktonne by year 2020 and 140 ktonne by year 2050.

Intelligent transport systems (ITS) concern issues like safety, environment and mobility. In 2010 the Swedish Government founded an ITS-council to improve safety, efficiency and environment. ITS can impact environment through design and planning of the road net. By improved traffic and vehicle surveillance statistics could be gained for future improvements, and traffic can be eco steered in real time. ITS makes it also possible, to introduce dynamical charging, to an instantaneous social marginal cost for infrastructure. Theoretically, this would lead to optimal distribution of capacity and emission level.

Transport lean town and country planning means that the physical planning of housing, work places and leisure is designed to minimize transport. This is an instrument which is seldom used today. Sweden has so far no regulation in this area. According to The Swedish Road Administration a reduction by 0.2 Mtonne by 2020 and 1.6 Mtonne by 2050 could be reached

by lean town and country planning (Energimyndigheten and Naturvårdsverket, 2007). Effects from this instrument will be seen in the long run (Naturvårdsverket, 2007, Wendle, 2006).

RELATIONSHIP BETWEEN DIFFERENT POLICY INSTRUMENT AND CO_2-EMISSIONS FROM FREIGHT TRANSPORTS

Since freight transport is not very well analysed in literature, it is hard to evaluate different instruments potential in the future. The Swedish Road Administration (Vägverket, 2004) estimated different measures in their climate strategy for the whole transport sector. The result showed that if these measures were taken the target was likely to be reached. For the year 2010 CO_2-emission amounting 21.8 Mtonne without measures was predicted, if measures was taken CO_2-emissions was predicted to be 16.8Mtonne. The actual figure for 2010 was 20.46 Mtonne ((Naturvårdsverket, 2013). Hence, we can conclude that we are already behind time schedule, implying reductions must be even larger in future.

Given the estimated figures from the Swedish Road Administration, it is possible to calculate estimates of the different categories of policy instrument and their respective potential for the future. As can be seen in Table I, economic instruments are important in the short to middle run, whereas their importance diminish in the long run, when new techniques have been introduced. The knowledge based instruments are equal important during the whole time frame, whereas legal instruments have most potential in the short and middle long run. The potential of societal instruments lies in the long run.

Table I – Different policy instrument categories potential for CO_2-emission reduction

Year	Economic instruments	Knowledge based instruments	Legal instruments	Societal instruments	Total
2020	61%	17%	11%	11%	100%
2050	34%	16%	8%	42%	100%

In the beginning of this paper the decomposition model was presented. This model has been elaborated within the LETS 2050 project at Lund University, of which this study also is a part. Hence we have tried to picture the relationship between the instruments described in this paper with the different factors in the decompositions model, in order to better describe the relationship between different policy instruments and how they impact reductions of CO_2-emission from the freight transport sector. Table below summarise how different policy instruments impact the different decompositions factors. In the decomposition model GDP is a factor, however impacting GDP is not part of this paper, hence this factor will not be considered.

Regarding inverse value intensity, this is a factor which is hard to influence with transport or logistics. Here the focus rather is on product design and material choice, which can be

influenced through information and counselling, as well as research and development. In direct connection with transport we see a security aspect. By increased security among transports, waste can be diminished, which will lead to less tonnes to be transported in order to guarantee accurate amount at delivery point. Knowledge based instruments can be used for this purpose as well as ITS.

Transport intensity decreases when a transport load unit is transported less, ceteris paribus, e.g. when the distance between production place and consumption place diminish. Knowledge based instruments can be used to impact the behaviour of managers in how to create sustainable/green supply chains.

Traffic intensity decreases if we can decrease the number of vehicle kilometres ceteris paribus. This either requires less kilometres per vehicle or less vehicles performing the kilometres, i.e. more load per vehicle and hence avoidance of x kilometres. Instruments impacting this factor are many of the economic instruments. By increasing the cost per kilometre (i.e. by CO_2-tax or kilometre tax) measures to counteract the raised cost are likely to be taken. Example of such measures are decreased empty running, increased load capacity, increased consolidation, transport conformed production and supply.

Energy intensity decreases by using less energy per vehicle kilometre ceteris paribus. Different transport modes have different energy intensity. By shifting to more energy efficient modes it is possible to decrease the carbon dioxide emissions. Incentives to modal shift can be created by differentiated infrastructure fees. Apart from this, there are factors impacting fuel consumption, such as driving style, traffic flow, speed, vehicle maintenance. Hence knowledge based instruments can impact this factor as well as legal. In the short run education in eco driving could be an important factor, ITS in order to greening traffic control and steering. Economic instruments such as congestion taxes could also be important in the short run.

Emission intensity decreases as emissions decrease per energy unit ceteris paribus. Instruments impacting this factor are economic instruments such as vehicle tax and road fee, tax exemption for biofuels. Letting vehicle tax vary with CO_2-emissions the vehicle fleet can be impacted in the middle long run. Tax exemption for bio fuels give incentives to shift vehicles. Different regulations about fuel and/or vehicle standards that are successively sharpened as well as obligations schemes are important instruments in the short to middle long run. Knowledge based instruments contributes with new techniques that can be introduced in the long run. Probably, new infrastructure will be required for the new technique (i.e. electrified roads), hence infrastructure investments are important instruments.

Regarding the time frame it is most likely that the factors of traffic and energy intensity can be impacted in the short run, at middle long run the traffic, energy and to some extent transport intensity can be impacted. In the long run the focus will be on value and emission intensity.

Table II - Relationship between different policy Instruments and decomposition factor

Decomposition factor	Policy Instrument
Value Intensity ***Tonne/GDP***	Information and counseling Research and Development Demonstration projects and Best practice Benchmarking and rating
Transport intensity ***Tonnekm/ton***	Information and counseling Research and Development Demonstration project and Best Practice Benchmarking and rating Infrastructure Investments Transport lean town and country planning
Traffic intensity ***Vehiclekm/tonnekm***	CO_2 tax on fuels Kilometer tax Marginal tax on CO_2 Trading with emission allowances Trading with load capacity Infrastructure fee Information and counseling Research and Development Demonstration project and Best Practice Benchmarking and rating Vehicle Regulations Infrastructure Investments Transport lean town and country planning
Energy intensity ***kwh/Vehiclekm***	Congestion tax Trading with emission allowances CO2 tax on fuels Kilometer tax Marginal tax on CO_2 Infrastructure fee Information and counseling Research and Development Demonstration project and Best Practice Benchmarking and rating Vehicle Maintenance Regulations Environmental Vehicle Classification ITS Infrastructure Investments Transport lean town and country planning
Emission intensity ***CO_2-emissions/kWh***	Vehicle tax and road fee Tax exemption for biofuels Trading with emission allowances Kilometer tax Information and counseling Research and Development Demonstration project and Best Practice Benchmarking and rating Classification/Regulation of fuels Environmental Vehicle Classification Obligation Schemes Infrastructure Investments

CONCLUSION

There is much literature about policy instruments for improving environmental performance from transport. Mostly, economic instruments are analysed and road transports. Further the majority of studies concerns cars and public transports. Only few articles directly analyses freight transport, with the exception of kilometre tax and trading with emission allowances. This is also reflected in this paper, which unintended focus road freight transport. However, since the largest part of carbon dioxide emission stem from this sector it might be justified.

In this paper four categorises of instruments have been analysed; economic, legal knowledge based and social. We can conclude that economic instruments are most important in the short run before new carbon neutral techniques are at hand. However, the potential is unsecure since transport cost typically is a small part of product value, hence the impact of cost increases probably are smaller than for cars. Economic instrument imply higher cost and if the cost increase cannot be put forward to the customer, improved efficiency is required. In the short run this can be accomplished through increased utilisation of vehicle load capacity by less empty running or increased consolidation. In the middle long run it can imply a change in modal split (some obstacles should be removed by then). In the long run new technologies have been introduced and the importance of economic instruments will diminish. One purpose of economic instruments is to raise incentives for development of new techniques.

Knowledge based instruments have great potential in impacting logistical factors. Through information, behaviour at different functions in the companies can be influenced and changed. In the short run it is possible to better adapt production and supply to become transport lean, choice of suppliers according to the proximity principle. In the middle run changes in design of the transport chain and handling are possible, and in the long run transformation of the whole supply chain to be environmental conform. Important is to influence behaviour as soon as possible before the new techniques are at hand.

Legal instruments are important in the short run by successive tighten regulations of limit values, in order to speed up technological development. In the middle long run it could imply vehicle relaxations in favour for longer, heavier load units.

The societal instruments are most important in the long run, due to long lead times, with the exception of ITS, where techniques already are at hand and will continue to develop in the future. Hence, route optimisation and other driving technical factors could be impacted in the short run. In the middle long run real time traffic control could be applied. New infrastructure and transport lean town and country planning could be applied in the long run, however due to the long lead times, it is important to consider these instruments and start to plan for them in the near future.

	Short term	Mid term 2020-2030	Long term 2050
Economic instruments	Less empty running Increased consolidation Improved efficiency	Change in modal split Environmental supply chain design ”Public transport” of freight	New technologies
Knowledge based instruments	Eco Driving Transport conformed production and inventory management Eco labelling/rating	Less handling, fewer nodes Environmental supply chain design	New technologies
Adminstrative instruments	Limit values Eco zones	Obligation schemes for fuel and or vehcile techniques Vehicle regualtions	
Social Instruments	ITS (routing and driving) Eco traffic governanace	Infrastructure for handling Real time stearing of traffic	New infrastructure Transport lean town and country planning

To conclude there are few real innovative instruments for the future, however estimates shows that it is possible to reach the target with the arsenal of policy instrument described above, given they are adopted. Probably economic and legal instruments will play a bigger role in the short run impacting foremost traffic and energy intensity, whereas knowledge based instruments are equal important throughout the whole period. In the long run societal instruments will gain effect by impacting emission and transport intensity.

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