DISCUSSION PAPERS
2010
13

Joint Transport Research Centre

*ROUND TABLE*
*18-19 February 2010, Paris*

International Transport Forum

# STIMULATING LOW-CARBON VEHICLE TECHNOLOGIES

## *SUMMARY AND CONCLUSIONS*

OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

International Transport Forum

JOINT TRANSPORT RESEARCH CENTRE

**Discussion Paper No. 2010-13**

# Round Table, 18-19 February 2010

# Stimulating Low-carbon Vehicle Technologies

## SUMMARY OF DISCUSSIONS

May 2010

## International Transport Forum

The International Transport Forum is an inter-governmental body within the OECD family. The Forum is a global platform for transport policy makers and stakeholders. Its objective is to serve political leaders and a larger public in developing a better understanding of the role of transport in economic growth and the role of transport policy in addressing the social and environmental dimensions of sustainable development. The Forum organises a Conference for Ministers and leading figures from civil society each May in Leipzig, Germany.

The members of the Forum are: Albania, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, FYROM, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Italy, Japan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Moldova, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States. The Forum's Secretariat is located in Paris.

## Joint Transport Research Centre

The OECD and the International Transport Forum established a Joint Transport Research Centre (JTRC) in 2004. The Centre conducts co-operative research programmes addressing all modes of transport to support policy making in Member countries and contribute to the Ministerial sessions of the International Transport Forum.

## JTRC Discussion Papers

The JTRC Discussion Paper Series makes economic research commissioned or carried out at the Joint Transport Research Centre available to researchers and practitioners. The aim is to contribute to the understanding of the transport sector and to provide inputs to transport policy design. The Discussion Papers are not edited by the JTRC and they reflect the author's opinions alone. They can be downloaded from:
http://www.internationaltransportforum.org/jtrc/DiscussionPapers/jtrcpapers.html

The International Transport Forum's website is at:
http://www.internationaltransportforum.org/

For further information on the Discussion Papers and other JTRC activities, please email:
itf.contact@oecd.org

## TABLE OF CONTENTS

## 1. INTRODUCTION

If the transport sector is to make deep cuts to its carbon emissions, it is necessary to reduce the carbon-intensity of travel. Reducing travel itself, at some times and places, is sometimes justified but it is extremely unlikely that under expected global economic development patterns overall demand will decline. This holds true even if there is saturation in some markets and demand management policies are widely adopted. Technological change is therefore crucial. The emerging view is that the focus for decarbonising transport should be first to improve the fuel efficiency of conventional engines and then gradually introduce alternative technologies.

Designing good (effective and least costly) policies to ensure the deployment of lower carbon technologies in accordance with policy aspirations requires an understanding of how markets for fuel economy work. The round table investigated this issue, with a focus on passenger car markets, aiming to answer the following questions as well as possible:

- What do consumers take into account when deciding what vehicle to buy?
- What drives manufacturer decisions on what range of vehicles to offer?
- Does the interaction of supply and demand lead to unsatisfactory fuel economy in relation to climate change objectives? Is the outcome unsatisfactory even if climate change is ignored, in the sense that there is "underinvestment" in fuel efficiency? In the latter case, what precisely is meant by an unsatisfactory outcome?

Answers to these questions help guide policy, for example on what instruments to use (fuel taxes and/or standards and/or purchase taxes, subsidies to producers, measures to mitigate information and coordination problems, etc.) to attain greenhouse gas emission abatement targets.

The questions raised are not new, and first principles of economic reasoning immediately suggest answers: consumers make optimal decisions from their own point of view, and all that is needed to align their point of view with the social perspective is a fuel tax that reflects the external cost of carbon implied by that social perspective. Does this basic recommendation need modification when the specificities of the market for fuel economy are taken into account?[1] The answer to this question is twofold.

First, a more in-depth look at this market should not lead anyone to conclude that appropriate carbon prices are a bad idea. Indeed, there is very wide agreement that carbon prices, implemented through fuel taxes or cap-and-trade systems, are a cornerstone of well-designed low-carbon policy in transport. They are critical to creating the demand for low-carbon technology in the market. However, it is unlikely that adequate price increases are

[1] The principle of marginal social cost pricing is also modified in an economy with multiple inefficiencies. This paper largely abstracts from this complication; see ITF 2008, for some discussion.

politically feasible in all countries. Where appropriate carbon prices are not feasible, through the use of fuel taxes or tradable permits, other instruments or combinations of instruments, including consumer information programs, standards and emission-dependent ownership or purchase charges, can mimic them with varying degrees of accuracy. It is also widely acknowledged that land use and transport planning policies, although not discussed as such in the round table, have an impact on transport volumes and emissions and could play a role in broad greenhouse gas management policy packages.

Second, even where the scope for pricing carbon is not tightly constrained politically, it is not clear whether pricing carbon provides sufficient incentives to reduce carbon dioxide emissions in line with aspirations. Additional policy measures may be required that address uncertainty in fuel prices rather than the absolute level of fuel and carbon prices. In particular, fuel economy standards provide a degree of certainty for automobile manufacturers that carbon prices cannot. Such certainty is important for decisions to make capital intensive investments, for example in new internal combustion engine plant, and is required to trigger the investments that are needed for a transformation of the energy-base of transport from petroleum to new, less carbon-dependent propulsion systems. In this view, prices and standards are complementary measures.

Proponents of strong intervention in the transport sector emphasize the need for changing the primary energy sources for transport, assuming carbon free energy sources can provide sufficient energy at acceptable cost (linking vehicle standards to the way alternative energy for transport is produced is not easy). Sceptics of the value of standards in promoting decarbonisation of transport point out that they are potentially very costly as they impose a degree of uniformity in responses across a very diverse set of agents. Sceptics also tend to be more optimistic regarding the potential of reduced driving to cut emissions.

The rest of the paper develops these arguments in detail. Section 2 discusses how consumers' willingness to pay for fuel economy is best modelled. An accurate view on how decisions are made obviously helps design effective and least-cost policy. Section 3 considers the interaction between demand and supply in the market for fuel economy. With this background, section 4 focuses on policy design. This paper does not discuss carbon reduction targets as such. It is assumed that the goal is to reduce carbon emissions from transport very strongly in the long run, so that reliance on fossil fuels is phased out. Whether such a target is appropriate is not obvious, but that is not the subject of this paper (see ITF, 2008 for views on that issue).

## 2. (WHY) IS THE WILLINGNESS-TO-PAY FOR PASSENGER CAR FUEL ECONOMY LOW?

Investing in vehicle fuel economy means incurring higher costs at the time of purchasing a car (or partly sacrificing attributes such as size or performance) in return for lower future costs of use. Basic economics suggests that current and future costs should be traded off at roughly the market rate of interest, i.e. the discount rate applied to car purchase should be

similar to the market interest rate.[2] There is, however, considerable evidence that consumers use implicit discount rates considerably higher than market interest rates. Car manufacturers at the round table reported they see average "payback periods" in consumer decisions on fuel economy of about 3 years. This means that consumers strive to recover any extra expenditure on fuel economy through lower fuel expenditures within 3 years, much shorter than the expected lifetime (or usage time plus resale value[3]) of the car. Translating short payback periods into high discount rates produces values well above market rates (e.g. around 20%).[4] Car manufacturers' views are supported by survey evidence on payback periods as well as by some econometric evidence (see the review in Greene, 2010), although the latter produces a wide range of results (from 4 to 40%). The econometric research evidence on implicit discount rates hence is inconclusive, and the reasons for the variation in results are not clear.

If one accepts the possibility of high implicit discount rates, as many but not all experts do, the question is why they could occur. The term "myopic" is often used to describe the use of high discount rates. This label is not entirely neutral, reflecting an implicitly held view that consumers somehow make a mistake and would be better off if they used lower discount rates. The case for policy intervention then depends on a judgment as to whether consumer sovereignty should prevail or whether consumers should be helped to make better decisions. A different, emerging view is that consumers do not make mistakes but act in their own interest under reference-dependent preferences, so that high implicit discount rates reflect the complexity of decisions in an uncertain environment rather than a shortcoming of decision-making.

The theory of reference-dependent preferences is an alternative to the standard neoclassical theory of behaviour in making choices. The latter posits that choices are driven by outcomes as such. Recent empirical and theoretical advances suggest that assuming reference-dependent preferences allows a better description of behaviour in many circumstances. In this framework, outcomes are evaluated by comparing them to a reference point. An important feature of behaviour that is regularly observed empirically is that choices reveal loss aversion, i.e. losses relative to a reference point reduce utility more than equally-sized gains would increase it. Loss-averse consumers appear to magnify the possible size and the probability of losses, and this is the key to understanding high implicit discount rates, e.g. in markets for fuel economy, where choices are made under uncertainty.

[2] The reason is that, if a higher discount rate were used, the financial return on the saved investment costs would be lower than the increase in fuel expenditures. And if a lower discount rate were used, fuel expenditure savings will be below the market return from the extra money now spent on fuel economy. Of course, there are differences between financial and fuel economy markets that lead to some disparity between discount rates in both, but not enough to explain observed difference.

[3] The role of used-car markets in explaining low willingness-to-pay for fuel economy is not very well understood. It is possible, but not certain, that information imperfections in those markets lead to a low propensity to pay for fuel economy, and this would have knock-on effects in new car markets.

[4] There are several explanations for why the discount rate used for car purchases could be above market rates. However, standard theory has difficulties explaining by how much discount rates exceed market rates.

Uncertainty is pervasive in economic decision-making. In the case of deciding what car to buy, uncertainty over future fuel prices is compounded by uncertainty over how intensively the car will be used, and what level of fuel economy the vehicle will achieve in real world use. Poor information on fuel economy in use is particularly problematic, not necessarily because estimates of averages are bad (the EPA information in the US is accurate on average) but because averages are a poor indicator for individual experiences. Greene (2010) shows how this uncertainty can easily lead to high implicit discount rates and more generally to low willingness to pay for fuel economy.

The standard neoclassical theory on preferences has difficulties capturing this low willingness to pay, as extreme assumptions would need to be made on risk aversion and/or declining marginal utility of income. Reference-dependence and loss aversion provide a plausible description of consumer choices of fuel economy and are consistent with evidence pointing to high discount rates. Of course, this theory is not inconsistent with low discount rates either, as discount rates can differ according to circumstances including consumer type, consumer experience, information constraints, etc. In general, it is plausible that consumers differ in what discount rates they use, according to their preferences and to the circumstances under which they make decisions.

Does this perspective on consumer choices modify policy prescriptions compared to more standard theory? One view is that it does not. If consumers don't want to pay a lot for fuel economy, then aligning socially optimal and private choices of fuel economy just requires higher fuel taxes. (Second-best arguments on what to do when optimal fuel taxes are not politically feasible apply *mutatis mutandis*). In addition, instruments that alleviate uncertainty, e.g. by providing better information, gain appeal in a loss aversion framework.[5] A different view is that fuel taxes are not sufficient to attain ambitious carbon-cutting targets because of choice behaviour, and that this issue weighs heavier when implicit discount rates are high. In other words, emphasizing loss aversion and the need for deep cuts in carbon emissions from transport leads to a different view on policy design. This argument is developed in detail in section 4.

## 3. THE MARKET FOR PASSENGER VEHICLE FUEL ECONOMY

Fuel economy is one attribute of a passenger vehicle. The levels of fuel economy purchased in the market, and the average fuel economy of new vehicles, are the result of the interaction between demand and supply in new vehicle markets. The previous section discussed one feature of demand in the market: for at least some consumers, the willingness-to-pay for better fuel economy is low given the many uncertainties under which fuel economy is chosen and prospective buyers' aversion to loss. Other features of the

[5] Energy efficieincy standards and labels have been developed for many markets but they can be seen mainly as attempts to reduce the negative consequences of inadequate consumer information. Whilst loss aversion is prevalent in many markets the justification for intervening in only a subset of these markets lies in the relative size of the negative social consequences of uncorrected market outcomes.

market include the substantial degree of heterogeneity in preferences and budgets for new vehicles, the importance of strategic interaction among firms in the industry, and the strong dependence of business opportunities on policy choices. We discuss these issues briefly in the following paragraphs.

### *Willingness-to-pay for fuel economy is context dependent*

When there is a perception[6] that many or even most consumers are willing to spend only limited amounts to get better fuel economy it is no surprise that manufacturers focus mostly on other attributes for which the willingness to pay is higher (power, performance, design, etc.). The previous section discussed how such low willingness to pay can result from the combination of loss aversion and uncertainty. In addition, consumers appear to evaluate the fuel economy of their future new vehicle by comparing it to the fuel economy of the vehicle they currently own, not by trading off fuel economy against other attributes in the set of available new vehicles. Taking older technology as a reference point can also lead to lower willingness to pay for fuel economy.[7]

Despite the intuitive appeal of the reference-dependence framework, many experts doubt whether current evidence on low willingness to pay for fuel economy, and generally low price elasticities of the demand for fuel should be taken as evidence that this willingness to pay is low in all circumstances. Consumer choices are the result of the interaction between their preferences, their budgets and prevailing prices and regulations. Estimates of elasticities based on these choices hence are conditional on these same factors, and if one of them changes then elasticities may change as well. For example, there is evidence that price elasticities of the demand for fuel do indeed increase as the price of fuel increases, i.e. consumers become proportionally more responsive to price changes as the initial price level increases.[8] Van Biesebroek (2010) shows preliminary results suggesting very strong heterogeneity of responses to fuel price changes, with quite elastic responses for some consumers, and with higher elasticities as fuel prices are higher. The latter result, that fuel price elasticities of fuel demand are higher as fuel prices are higher is consistent with aggregate evidence, which also points out that the same elasticity declines as incomes rise (Hymel *et al*., 2010). In addition, casual observation of higher and increasing sensitivity of European consumers to fuel-economy supports the view that the level of the fuel price matters. Evidence on the context-dependence of elasticities of fuel demand suggests that energy- and mobility-intensive lifestyles may be less engrained than is commonly believed, so that strong price changes could trigger strong demand responses. That such strong responses have not been observed, e.g. in the US, is simply because fuel price levels have generally been low, even if price changes sometimes were large. Casual observation on short-term responses to price spikes support this view. While this is an argument in favour of fuel price oriented policies over more intrusive regulation, in the sense that pricing policies may be more effective than evidence on past elasticities suggests, there is no guarantee that

6 To repeat, this perception does exist among auto-makers according to the discussion at the round table, while the empirical evidence is partially supportive but inconclusive overall.

7 This point is compatible with reference-dependence, but it is not included in the model as discussed in Section 2.

8 Note also that loss aversion has a relatively smaller impact on choices as fuel prices rise because the expected gains from investing in fuel economy rise while the investment costs do not change.

such policies are sufficient to attain drastic abatement targets. High price levels in the EU have lead to different behaviour than in the US, but have not triggered major shifts in the energy base of private passenger transport. Such a shift is needed if decarbonisation of transport is the objective (which, to repeat, is assumed here, although the assumption clearly is open to debate).

If evidence based on observed choices is not a reliable guide to behaviour under different circumstances, and if survey evidence on hypothetical choices under these alternative circumstances lacks credibility because of its hypothetical nature, evidence-based policy design is a tall order. It is therefore important that research strive to identify fundamentals that are as little context-dependent as possible. In the meantime, policy needs to be made on the basis of inconclusive evidence, i.e. decisions need to be made under uncertainty. Remarkably, consensus on what to do is broader than might be expected (although it is by no means complete) given the available evidence and differing interpretations of it. This will become clear in Section 4.

### *Consumers differ and this matters for policy design*

Consumers differ strongly in what vehicles, i.e. collections of attributes, they like. Manufacturers respond to such heterogeneity in different ways. Some offer a full range of vehicles, attempting to cover the main market segments, but with differences in emphasis among them. For example, several French and German producers offer a wide range of cars, but the first focus more on small cars and the latter more on bigger and more luxurious models.[9] Other manufactures focus on particular segments. For example, BMW offers higher end vehicles only. The observation that there is substantial heterogeneity is straightforward, but its consequences for policy design are sometimes ignored. If all consumers and all manufacturers were strongly similar, then they would all respond similarly to policies. In that case, prescriptive policy is reasonably cost-effective as long as the prescription is in line with the common response. But with strong heterogeneity, it becomes expensive to require all agents to respond in the same manner.[10] For example, it is costly to require someone that drives only 3 000 miles per year to invest in a highly fuel efficient car (Fullerton, 2010). Requiring manufacturers to attain a sales-weighted average fuel economy is particularly onerous for a manufacturer that focuses on relatively fuel-intensive market segments. This can be seen from the fact that luxury brands such as BMW have historically responded to the US CAFE standard by paying the fine for non-compliance instead of complying.

### *Supply characteristics depend on industry structure, demand, and policy*

What vehicles are supplied depends on demand but also on how manufacturers interact among themselves. Heterogeneity in demand matters here, in that it leads producers to offer diversified products in an attempt to match preferences and to weaken competition. For example, the emergence of a taste for SUV's in the US helped US manufacturers maintain

[9] Buyers of lower-end small cars tend to particularly sensitive to the purchase price, more than to expected future fuel expenditures.

[10] In principle this problem could be avoided by adapting regulatory requirements to individual circumstances. But even if regulated parties would have incentives to reveal their characteristics truthfully, collecting the required information would still be very expensive.

profitability (and indeed was engineered by them for that purpose to some extent). This is not to say that competition in the industry is weak, just that there are strategies to try to dampen it. If product differentiation were emphasized, the car industry could be modelled as a monopolistically competitive industry. While plausible, it is more common to model it as an oligopoly. The reason is that oligopoly models emphasize strategic interactions among manufacturers: in deciding what to offer or what prices to set, manufacturers take account of demand conditions and of how they think their competitors will respond to their actions.

If a manufacturer expects aggressive responses by its competitors, it will keep prices fairly close to costs; its rivals will act similarly. The resulting prices benefit consumers directly but reduce manufacturers' ability to cover fixed costs, such as R&D expenses. This is the classical argument that market power may benefit innovation, as it helps generate the funds for it. However, market power also reduces the profitability of innovation, an effect going in the opposite direction. Recent work tends to view the second effect as dominant, so that more competition induces more innovation. To the extent competition in the car industry is strong, this then would mean considerable innovative effort. However, absent credible and strong policies to push innovation in the direction of carbon abatement, such innovation will focus on features for which consumers are willing to pay. Strong competitive responses can induce producers to be "conservative" in supply decisions: experimenting with innovative design choices becomes risky as any mistake (i.e. a more tepid consumer response than expected) translates into reduced market share and lower profits. Manufacturers innovate but at the same time do not wish to deviate from their rivals' choices too much. Such conservatism will be particularly pronounced with respect to features like fuel economy, for which consumer willingness to pay is low at present. The upshot is that strategic interaction in the car industry does not favour strong fuel-economy-oriented supply choices. Policy to steer innovation in the direction of better fuel economy then may be needed, and instruments that affect supply decisions rather directly, such as fuel economy standards, can be more effective than raising the cost of fuel for consumers and should be used in combination with pricing policies. This is the case in particular when transformative innovation (needed for decarbonisation) is the ultimate goal (see Barla and Proost, 2010, and ITF 2010 and references therein).

Supply choices depend on demand and on company strategies, but also on policies (either directly or through demand). As pointed out by Bastard (2010), policies affecting fuel economy choices are widespread (i.e. they have been developed in many countries), they are diverse (with strong differences among countries), and they are prone to frequent change. Relevant policies include fuel economy standards, emission or engine power based ownership taxes, fuel taxes, etc. The diversity of policies among countries is a source of costs for manufacturers. Ownership-based taxes tend to define vehicle classes. Furthermore, the definition of the threshold is critical for manufacturers, as tax liabilities for nearly identical cars may differ strongly if their small differences attribute them to different classes. A continuously graduated system of differentiation avoids this problem. Fragmentation of policies and the arbitrary nature of thresholds cause problems but are not the main headache for manufacturers.[11] The bigger problem is that policies change often. Tax rates in particular are subject to annual revision with little or no notice of the size of the change. Adaptations to policy changes increase costs directly for manufactures, and more so when changes are made at short notice. At least as importantly, there is an indirect cost increase through the

[11] Tax differentiation causes costs for manufacturers, but also complicate their pricing strategies, an issue for producers that is of little wider social concern.

uncertainty that is created. With a history of frequent revision of relevant policies it becomes difficult for government to make a credible commitment to fuel economy policies that are in line with long term greenhouse gas abatement targets. Such a lack of credible commitment is a disincentive to investment by carmakers.[12]

## 4. WHAT POLICY FOR LOW-CARBON VEHICLES?

The previous sections picture the markets for new vehicles and for fuel economy as consisting of heterogeneous consumers, many of whom are perceived to be reticent towards choosing strong improvements in fuel economy given inconclusive empirical evidence on the matter and given doubts whether simple estimates based on past behaviour can capture responses in different circumstances (e.g. higher prices). If ambitious goals for fuel economy improvement are set, then policy intervention will be required to attain them. There is considerable agreement that, if possible, carbon prices should be introduced that are consistent with policy targets. There is less agreement on what to do when such prices are not possible and on what to do *in addition* when such prices are feasible. One source of disagreement lies in what aspects of policy are emphasized: those proposing reliance on taxes alone emphasize the extra costs associated with using other instruments; those proposing a wider array of instruments point to the potential lack of effectiveness of taxes, especially where the goal is to change the primary energy used for transport. Ultimately, the disagreement is not so much about what policies might work and what they might cost, but about how important it is to reach decarbonisation targets with a reasonable degree of certainty. Views on the latter depend on how one weighs the risks of not reducing global carbon emissions overall and on how big one thinks the contribution of the transport sector ought to be in overall abatement targets. Those who agree that the transport sector needs to abate strongly tend to agree on the broad policy principles to be pursued. Section 4.1 explores the basic arguments and Section 4.2 discusses resulting attitudes towards policy instruments.

### 4.1. Reducing fossil fuel use does not equal changing transport's energy base

Fuel taxes are a good approximation to carbon taxes and could thus in principle be used to get the price of carbon right. If equilibrium levels of fuel economy are "low", i.e. the gap between that level and the one aspired to by policy is large, high fuel taxes are needed to close it. However, introducing the appropriate fuel taxes may not be politically feasible. In that case, the best that can be done is to use combinations of other (feasible) policy instruments to mimic the fuel tax (Fullerton, 2010). What combinations of instruments to use is a matter of empirical research, and it is clear that the economic costs of reaching the policy target through second-best policy will be at least as high as under the fuel tax. As

[12] It follows that improving the credibility of long run policy targets is desirable from manufacturers' point of view, as it reduces uncertainty. However, this will not stop them from complaining about the costs of reaching targets, as they prefer less stringent over more stringent policy constraints.

emphasized in the previous section, heterogeneity among consumers and producers drives up the costs of command-and-control policies compared to the first-best fuel tax.

Viewing the use of policy instruments other than the fuel tax as a second-best approach may make sense for countries with relatively low fuel taxes, e.g. the US. Applying the same principle to European countries, however, should lead to the conclusion that other – widely used – policies are superfluous at best and create high extra costs at worst. Some experts subscribe to this view, others do not. One argument sometimes used in favour of additional instruments is that "they work", i.e. they have clearly visible effects. Ownership taxes dependent on emission levels or engine power are an example, as they have clear impacts on vehicle choice. Of course, "effective" does not equal "cost-effective". Ownership charges might be a costly means of attaining abatement targets, e.g. by discouraging the purchase of fuel-inefficient but otherwise appealing vehicles to people that do not drive much. Much less is known about the economic costs of ownership charges than about their direct effects. While ownership charges can be useful, e.g. when owners use discount rates that are thought too high from a social point of view, it is far from obvious that existing charges (which vary very strongly across countries) are anywhere near optimal.

A different argument for additional instruments is that fuel taxes do not discourage fuel use enough. According to the standard framework the best response then is to increase fuel taxes further if that is politically feasible. The argument about the insufficiency of the effects of fuel taxes is sometimes made with reference to Europe, where fuel taxes are high already. It is worth pointing out that it is the whole set of applicable policies, which together imply an unknown but certainly high price of carbon, that generates the insufficient response. Current European policies certainly lead to better fuel economy compared to the situation with less stringent policies or compared to the United States, but they are not capable of triggering a shift in the energy base of transport away from petroleum. Emphasizing the need for such a shift induces some experts to favour additional policy instruments (e.g. Greene, 2010), essentially on the grounds that this is uncharted policy terrain for which the traditional economic prescriptions ("internalize external costs") fall short. The first and foremost challenge is in this case not to price carbon correctly but to move to different primary energy sources. Pricing carbon is instrumental in attaining that objective but it is not sufficient. More generally, current demand-oriented policies cannot deliver in terms of switching energy sources. In the long run, reliance on a combination of improved conventional technology and reduced demand is taken to be insufficient or at least too risky a strategy. Instead, policy should get actively involved in pushing innovation in a particular direction. Arms-length policies (providing good framework conditions for markets to work and correcting price signals where required) may not be sufficient for such steering (see ITF, 2010, for more discussion), and more intrusive policies like standards may be needed.

As explained, one reason for potentially shifting the emphasis to supply of energy is that estimated elasticities of demand for transport are low, indicating high welfare costs and limited effectiveness of demand-oriented policies. However, as discussed in the previous Section, current evidence on transport elasticities may be a poor guide to what demand responses might look like when fuel prices are much higher – more specifically, responses might well be larger when prices are higher. The bottom line here is that the relevant demand elasticities are highly uncertain. This implies that policies working through prices have uncertain effects, and if decarbonisation is the priority such uncertainty needs to be avoided through the use of complementary policies.

A different reason for emphasising technology switching is that this route may be preferred over demand-oriented strategy by policy-makers. Policy-makers might judge that focusing on technology provides more certainty that the desired result will be reached. Alternatively, this preference may be based on perceived voter or pressure group interests. Whatever the reason, it is clear that when policy-makers have preferences on how to reach a policy goal, i.e. they do not just care about getting there as cheaply as possible, then instrument choice may differ from what standard economics would prescribe. The arguments of the previous section then carry more limited weight in policy design than might be expected. The message of the previous section is that care should be taken to avoid the risk that putting a very strong emphasis on attaining a policy goal ends up being a mandate to attain a goal at any cost, no matter how high.

## 4.2. Opinions on instruments

### *Carbon prices, land use and transport planning*

There is, to repeat, wide agreement on the need for appropriate carbon prices. Fuel taxes or cap-and-trade mechanisms can fulfil that role. To take their full effect, carbon prices need to be embedded in a framework guided by land use and transport planning. It was also argued at the Roundtable that carbon prices in transport could usefully be relatively high compared to other sectors, to the extent that mobility is a less elastic and therefore less distortionary tax base than is found in other carbon-intensive sectors of the economy.

### *Fuel economy standards*

Experts at the round table expressed quite broad support for fuel economy standards. Some stakeholders oppose standards on principle, arguing that manufacturers should not be made responsible for energy use in transport. At its most extreme this means no coercive policies (possibly including taxes) should be used. Alternatively it means that policies should work through demand rather than directly on supply. While few would take this line to argue against standards as such, the argument does have some bearing on what kind of standard to use. Defining standards in terms of sales-weighted averages requires manufactures to steer sales in a particular direction, rather than just attaining some performance level conditional on the type of vehicle. Standards can be made less intrusive and more technology-neutral by differentiating sales-weighted average targets by the average weight or size (footprint) of vehicles by manufacturer (fuel taxes, of course, are even more neutral with respect to choices, and therefore to be preferred on these grounds). It was also noted that, if the goal is to push innovation, it may be better not to structure standards to allow shifts in the sales-mix as a compliance mechanism.[13]

An intermediate view is that fuel economy standards are useful when appropriate carbon prices cannot be implemented, but not otherwise. The predominant view during the meeting was that, as it is imperative to abate strongly and quickly, standards should be used to make

[13] However, innovation is commonly seen as an intermediate goal, and if attaining abatement targets is more cheaply done (in a social sense) through modifying the sales mix, that is better. Nevertheless, the industry sees a bigger potential for abatement with bigger cars, because of lower price elasticities and an increased scope for deploying technological solutions.

sure targets are reached. In this view, standards and taxes should be combined and made to be mutually reinforcing. Taxes are mostly a demand-pull measure (Fullerton, 2010) and standards mostly a supply-push measure (Anderson *et al*., 2010). Given the structure of the market for fuel economy and perceived inertia in the demand for driving, both elements are needed (although some argue that driving *should not* be discouraged rather than that it is difficult to discourage it). Consistency between demand and supply-side incentives is required to keep emission concerns squarely among manufacturers' strategic priorities.

The auto industry needs a regulatory environment that provides as much certainty as possible if it is to make the large capital investments necessary to maximise the fuel economy of new cars, and even more so for shifting to new primary energy sources. Standards can provide this certainty, and the longer the planning horizon the better. Binding standards for the short term can be complemented by indicative targets for the longer term. For example the European Union's standard of 130 g CO2 / km by 2012 for the new car fleet average is accompanied by a 95 g CO2 / km target for 2020. Standards may outperform taxes in stimulating innovation because they are more closely tied to supply, where innovative effort is concentrated.[14]

It may also be noted that harmonisation of tax structures is frequently more difficult than harmonisation of standards. This is particularly noticeable in the European Union, where fiscal policy is strictly subject to national sovereignty whereas a single fuel economy standard for the whole region was developed by the European Commission. Moreover, vehicle registration and circulation taxes have an element of local government control in many countries. In relation to the remark that taxes and standards should be mutually reinforcing, Bastard (2010) highlights the lack of coordination between the structure of taxes and vehicle efficiency labels in Europe and the Union's CO2 standards for cars. Poor coordination raises compliance costs for manufacturers and weakens the incentive to design cars to maximise fuel efficiency because of the extreme fragmentation of the European market that results from the different break points employed in differentiation of taxes and labels.

### *Subsidising low carbon vehicles*

Temporary subsidies for low carbon vehicles are sometimes defended on the grounds that such technologies are at a cost disadvantage as long as the scale of production is small compared to that of conventional vehicles and because experience and competition keeps the cost of innovation for internal combustion drive trains relatively low. The subsidy then is designed to ramp up production. This is a separate function to subsidies to R&D intended to stimulate innovation and justified on the basis of knowledge spillovers.

When used, subsidies should be targeted to affect supply rather than increase profits, which is a risk in imperfectly competitive industries. For efficiency, subsidies should be designed to be as neutral as possible with respect to particular technologies. Research prizes combined with performance standards may be fairly neutral but complete neutrality is not possible. Even a subsidy based on graduated performance standards will need to check compliance at some point in time and will rely on imperfect information on (future) costs and

[14] Standards then should become more stringent over time, to mimic the lasting incentive to innovate provided by taxes (as taxes are paid on all units, not just the ones exceeding some regulated level).

performance. If innovation is to be steered in a particular direction, there is a price to pay in terms of abandoning pure neutrality. And while it makes sense to see the subsidies as temporary, deciding when the phase out begins is less than straightforward. Removing subsidies that industries have become dependent on is always difficult, even when the original reason for the subsidy no longer applies. This is a strong argument in political economy for avoiding subsidies in the first place. On the other hand, manufacturers risk seeing subsidies for the purchase of electric or fuel cell vehicles cut back before they can recoup the costs of developing the vehicles. The risks of relying on political commitments are exacerbated by the time it takes to develop new cars of this sort. Governments may be able to guarantee the availability of subsides for 3 or 4 years but just getting new products to market may take much of this time. Electric vehicle subsidies in France, Germany and especially the UK have been structured to provide some security in this respect.

In sum, the risks associated with subsidies induce rather negative attitudes towards them among economists and sometimes manufacturers. Reluctant support is based on the premise that breakthrough technologies are needed if the energy base of transport is to be transformed. Innovation in the car industry is not of the "lone creative entrepreneur" type, as scale and structure prevent this "intuitive" approach to innovation from thriving. The transformative efforts required for very low carbon transport should not necessarily be expected to emerge from industry by itself. Policy intervention then is needed, even given tangible risks that measures will turn out more costly than hoped for, as long as the risks of not attaining policy targets are deemed larger than the risks of intervention.

### *Providing information*

Section 2 emphasized that decisions on what level of fuel economy to invest in take place under considerable uncertainty. One important source of uncertainty is the effective fuel economy that a prospective purchase would deliver. Better information in that respect would lead to better decisions, and loss aversion would become less prominent in affecting outcomes. Better information can come in several forms. Simple labels, analogous to those used to indicate household appliances' energy efficiency in the EU, provide easy guidance for comparison among models.[15] But customized fuel economy information can be helpful as well. Giving prospective buyers access to tools (e.g. online) to investigate how a vehicle's average (labelled) fuel economy would change according to particular driving patterns reduces uncertainty and also invites buyers to think carefully about their usage patterns.

[15] Tax policies and labels should be consistent , i.e. labels and tax incentives should be structured similarly. Given the fragmentation of political competencies, such consistency is not easily attained (as in the case of taxes and standards).

## 5. CONCLUSIONS

Current fuel consumption patterns in passenger car transport markets around the world need to change drastically if transport is to reduce its carbon emissions substantially. This paper has summarized views on how major cuts in carbon emissions from passenger cars are to be accomplished. Although there is debate over whether this should be done, it is taken as an objective here.

The diagnosis that a substantial portion of consumers in major markets are fairly unresponsive when fuel prices rise is widely accepted, despite a lack of conclusive evidence on the matter. However, the relevance of this observation to policy design is disputed, with some experts believing that elasticities will stay low if more stringent emission charging policies are introduced and others seeing potential for increased responsiveness. If consumers do become more responsive as fuel prices rise, then pricing approaches to carbon abatement become more attractive, especially given the large diversity in potential responses, which renders command-and-control policies more expensive.

Regulations, e.g. fuel economy standards, are more costly than charges for CO2 emissions when they reduce flexibility in responses. However, standards are seen as a necessary component of policies that don't just aim to reduce fuel consumption in transport, but rather aim to change its principal source of energy. A preference for standards could be seen as a preference for attaining greenhouse gas abatement through technology rather than through reducing demand. Standards are a complement to prices; higher carbon prices reduce the demand for carbon-intensive energy and stricter standards reduce the supply of carbon-intensive vehicles. Together they send a strong signal. Standards provide certainty to producers on what fuel economy to reach. This helps create a favourable investment climate, especially when long term goals are announced with sufficient credibility.

## REFERENCES


Anderson S., I. Parry, J. Sallee, and C. Fischer, 2010, Automobile fuel economy standards, Review of Environmental Economics and Policy, forthcoming.

Barla Ph. and S. Proost, 2010, Automobile fuel efficiency policies with international cost spillovers, Working Paper, Center for Economic Studies, KULeuven, Belgium.

Bastard L., 2010, The Impact of Economic Instruments on the Auto Industry and the Consequences of Fragmenting Markets - Focus on the EU Case, JTRC Discussion Paper 2010-8.

Fullerton D. and D.H. Karney, 2010, Combinations of Instruments to Achieve Low-Carbon Vehicle-Miles, JTRC Discussion Paper 2010-7.

Greene D., 2010, Why the New Market for New Passenger Cars Generally Undervalues Fuel Economy, JTRC Discussion Paper 2010-6.

Hymel K., K. Small and K. Van Dender, 2010, Induced Demand and Rebound Effects in Road Transport, Transportation Research B, forthcoming.

ITF, 2008, The cost and effectiveness of policies to reduce vehicle emissions – summary and conclusions, JTRC Discussion Paper 2008-9.

ITF, 2010, Transport and innovation – towards a view on the role of public policy, ITF 2010 Forum Paper.

Van Biesebroeck J., 2010, The Demand for and the Supply of Fuel Efficiency in Models of Industrial Organisation, JTRC Discussion Paper 2010-9.