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The Diesel Differential

**DIFFERENCES IN THE TAX TREATMENT OF
GASOLINE AND DIESEL FOR ROAD USE**

Michelle Harding

OECD CENTRE FOR TAX POLICY AND ADMINISTRATION

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ABSTRACT

The diesel differential: differences in the tax treatment of gasoline and diesel for road use

Diesel and gasoline account for around 95% of energy used for road transport in the OECD and for the largest share of revenue from taxes on energy. In 33 out of 34 OECD countries, diesel fuel is taxed at lower rates than gasoline both in terms of energy and carbon content. To assess whether this difference is warranted from an environmental perspective, this paper examines the rationales for taxing both fuels, considering the externalities (including local air pollution, carbon emissions and other social costs related to road transport) associated with the use of each fuel and the fuel efficiency advantage of diesel vehicles. The revenue, distributional and competitiveness consequences of increasing tax rates on diesel are also briefly considered and the revenue effects of the tax treatment of diesel are shown to be significant. We conclude that the externalities associated with each fuel show that the lower tax rates that currently apply to diesel fuel are not justifiable from an environmental perspective. Reduction of the diesel differential is warranted. A gradual approach to removing the differential would allow the adverse distributional and competitiveness impacts to be mitigated during the transitional phase.

RÉSUMÉ

Avantage fiscal en faveur du gazole : différences de traitement fiscal de l'essence et du gazole à usage routier

Le gazole et l'essence représentent environ 95 % de l'énergie consommée pour le transport routier dans la zone OCDE et génèrent l'essentiel des recettes issues des taxes sur l'énergie. Dans 33 des 34 pays de l'OCDE, le gazole est taxé à des taux inférieurs à ceux applicables à l'essence, tant du point de vue du contenu énergétique que de la teneur en carbone. Afin de déterminer si cette différence est justifiée d'un point de vue environnemental, ce document examine les raisons qui sous-tendent l'imposition de ces deux types de carburants, tenant compte des externalités (pollution atmosphérique locale, émissions de carbone et autres coûts sociaux induits par le transport routier, etc.) associées à l'utilisation de chacun de ces carburants et la moindre consommation des véhicules diesel. Les conséquences sur le plan des recettes, de la distribution et de la compétitivité d'un relèvement des taux d'imposition du gazole font également l'objet d'une analyse succincte et les répercussions de la taxation du gazole sur les recettes fiscale s'avèrent significatives. En conclusion, les externalités associées à chacun de ces carburants ne justifient pas, d'un point de vue environnemental, les taux d'imposition plus faibles actuellement réservés au gazole. Une réduction de l'avantage fiscal en faveur du gazole est justifiée. Une réduction progressive de cet avantage permettrait l'atténuation dans la phase transitoire des effets défavorables sur la distribution et la compétitivité.

FOREWORD

The author would like to thank several current and former members of staff in the OECD's Centre for Tax Policy and Development and the Environment Directorate for their helpful comments on this paper, including Bert Brys, Nils Axel Braathen, James Greene, Pierre LeBlanc, Stephen Matthews and Kurt Van Dender. The author would like to particularly acknowledge the assistance provided by Kurt Van Dender and James Greene in the development and presentation of the analysis. The author is also grateful to Delegates to the Joint Meetings of Tax and Environment Experts for their comments on earlier drafts of this working paper and to Violet Sochay and Michael Sharratt for help with preparing the paper for publication. The author is responsible for any remaining errors.

**THE DIESEL DIFFERENTIAL: DIFFERENCES IN THE TAX TREATMENT OF GASOLINE
AND DIESEL FOR ROAD USE**

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THE DIESEL DIFFERENTIAL: DIFFERENCES IN THE TAX TREATMENT OF GASOLINE AND DIESEL FOR ROAD USE

EXECUTIVE SUMMARY

Road transport energy, the vast majority of which is derived from gasoline and diesel, forms a significant proportion of energy use in most OECD countries. Road transport is critical to modern economies, but the associated fuel use contributes to current environmental challenges, notably climate change and local air pollution, and driving contributes to other social costs. This paper considers the different environmental and social costs of gasoline and diesel, and asks whether the current tax treatment of diesel fuel reflects its relative environmental impacts. It finds that the diesel differential, i.e. the lower tax rate on diesel compared to gasoline observed in most OECD countries, is at odds with the higher environmental cost of diesel use.

Governments have access to a range of policy tools to address the environmental and social costs of fuel use. One possible approach is to tax gasoline and diesel for road use to ensure that the full costs of fuel use are reflected in the price of each fuel type. Among OECD countries, 30 of 34 countries tax diesel at lower rates than gasoline per litre. Taking into account the higher energy and carbon content of a litre of diesel relative to a litre of gasoline, 33 of 34 OECD countries tax diesel at lower rates per unit of energy or carbon dioxide.

The environmental and social costs from the use of these fuels include their contribution to climate change through emissions of greenhouse gases, particularly carbon dioxide, and emissions of local air pollutants, such as nitrogen oxides, particulate matter and sulphur dioxide. Other social costs, such as congestion, noise, accidents and infrastructure wear can to some extent be reflected in fuel taxes. The key conclusion of this paper is that these environmental and other social costs do not support the lower tax rates that currently apply to diesel. Diesel emits higher levels of both carbon dioxide and harmful air pollutants per litre than gasoline. This implies that, from an environmental perspective, the level of tax needed to reflect these environmental costs should be higher for a litre of diesel than a litre of gasoline. The other social costs are more directly linked to distance travelled than to the amount of fuel used. However, since diesel vehicles are often more fuel efficient and thus travel further on a litre of fuel, the social cost per litre of fuel is likely to be higher for diesel than for gasoline. This too implies that the level of taxation reflecting these social costs should be higher for a litre of diesel than for gasoline.

Diesel vehicles are often more fuel efficient than their gasoline counterparts on a model to model basis, although when the car fleet as a whole is considered this difference is considerably reduced due to the higher number of large vehicles in the diesel fleet. However, from an environmental perspective, a fuel efficiency advantage does not warrant lower tax rates on diesel fuel. In setting tax rates per litre of fuel, the appropriate comparison between fuels is the environmental cost per litre of fuel use. The environmental costs are higher per litre of diesel. The higher efficiency of diesel vehicles will itself result in lower fuel costs over time, a benefit which is entirely captured by the owner. Therefore, there is no environmental policy need to use taxes to encourage the purchase of more efficient vehicles.

Environmental considerations call for the removal of the diesel differential, as there is no environmental reason to attach a tax preference to diesel. Other policy concerns, including infrastructure development and maintenance, revenue raising, industry policy, economic growth, competitiveness, price

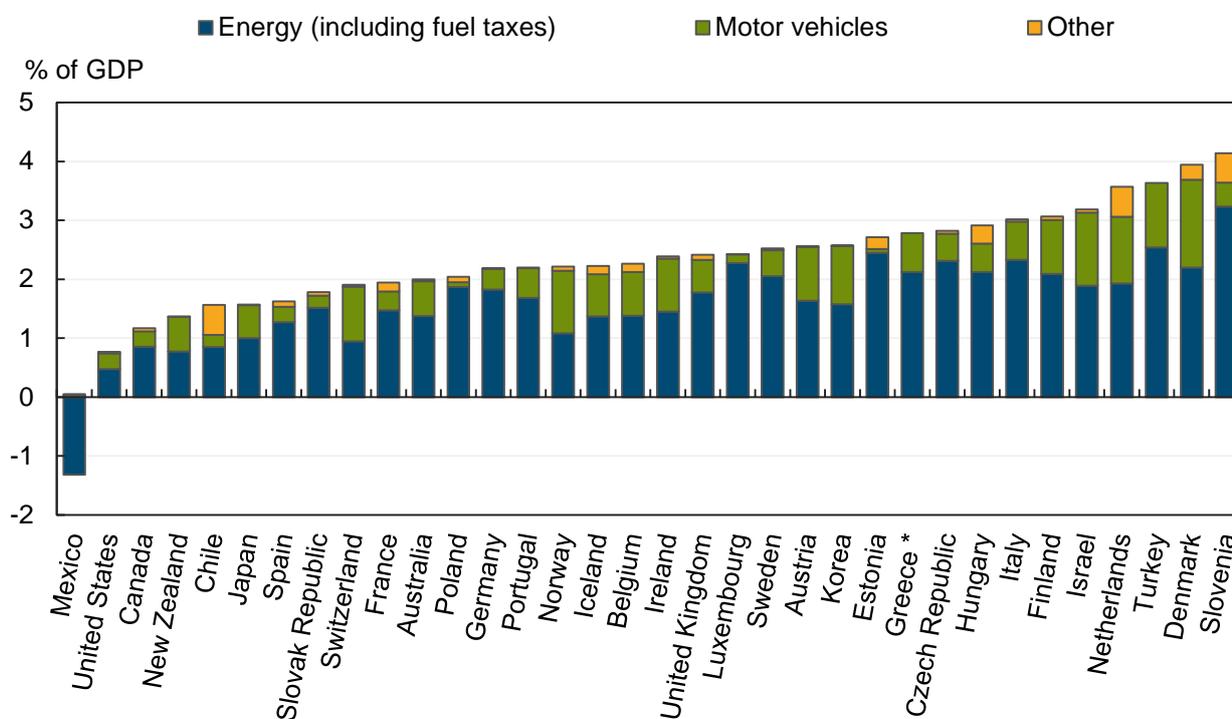
levels, fairness and income distribution indicate that the differential should be removed gradually in order to mitigate the transitional impacts of an increase in diesel tax rates. Policymakers have a range of other tools available that could be considered alongside tax changes to address these concerns. Nevertheless, transitional time and gradual introduction of any changes would allow those more adversely affected to adapt in advance of any increases in the diesel tax rate. More targeted forms of assistance could be provided for those in particular need without providing adverse environmental signals.

1. Introduction and purpose

Energy is a key input to modern economies and a substantial contributor to the standard of living in OECD countries. However, the use of energy has a wide range of environmental and social costs, particularly associated with the use of fossil fuels to generate energy. These costs include the contribution of energy use to climate change, local air pollution, resource depletion and vulnerability to energy supply shocks.

Energy use is often subject to policy interventions in the form of taxation and regulation in order to reduce these environmental and other social costs, or more commonly, to raise revenue. Whether intended to or not, taxation is a powerful tool that can help to ensure that prices better reflect environmental and other social costs such as congestion and infrastructure. Energy use, particularly in the transport sector, is widely taxed in the OECD, and revenues from energy taxes amount to 72% of all revenues from environmentally related taxation in the OECD.

Figure 1. Environmentally-related tax revenues, 2012



Source: OECD calculations, based on OECD Database of instruments used for environmental policy (OECD, 2013c). Energy taxes include taxes on fuels and other energy products. Motor vehicle taxes include taxes in relation to the ownership or annual registration of motor vehicles. Other includes taxes levied on all other taxes bases of environmental relevance, such as taxes on waste, hazardous material, other air pollutants and water. A * indicates that data for that country is for 2011.

Information on the amount and composition of energy use in OECD countries, and the tax rates that apply to that energy use, were published by the OECD in *Taxing Energy Use* (OECD, 2013). *Taxing Energy Use* notes several apparent inconsistencies in the taxation of different fuels, including marked differences in the taxation of different fuels used for similar purposes and of similar fuels used by different users.

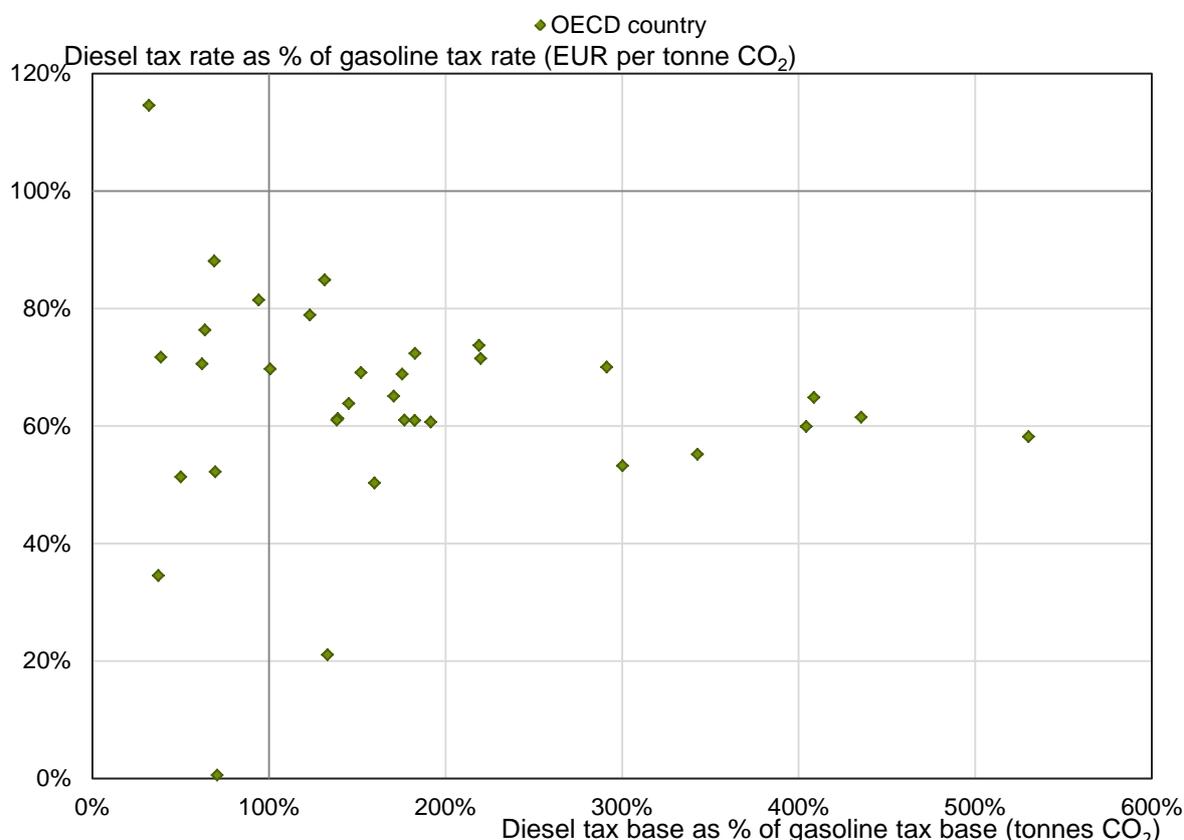
One of the most common patterns highlighted by *Taxing Energy Use* is the difference between the tax rates on diesel and gasoline for road use, whether measured as rates per litre, per gigajoule or per tonne of

CO₂. Thirty OECD countries tax diesel road fuel at lower rates per litre than gasoline used for the same purpose. Converted into tax rates based on, alternately, energy and carbon content, the tax rates on diesel relative to gasoline are lower in 33 out of 34 OECD countries.

To the extent these differences in tax rates do not reflect the different environmental and other social costs of these fuels, the incentives provided to consumers, households and businesses are not aligned with the comparative environmental costs of using gasoline or diesel. The differences in taxes can influence both the amount of energy consumed in transport and its composition. The degree of alignment of the difference in fuel taxes with the difference in environmental impacts is likely to have the greatest potential for behavioural adaptation in terms of fuel-type choice in the passenger car market, where there is a high degree of substitutability between gasoline and diesel cars. The impact is likely to be less significant in the heavy vehicle market, which is almost exclusively comprised of diesel vehicles, due to the scarcity of viable alternatives.

In the market for passenger cars, the lifetime costs of car use are the most significant determinant of car choice (although non-financial variables such as safety, size, appearance and reliability are also important) and the presence of taxes on the purchase of vehicles and on vehicle fuels have been shown to be significant in influencing ownership decisions between gasoline or diesel vehicles (Mayeres, 2001). Although the approximation of lifetime costs may be imperfect – consumers may for instance over or under-value fuel costs or apply high discount rates to fuel costs in the short-term (King, 2007) – fuel taxes that do not reflect the different externalities associated with fuel use can influence consumer choices about the vehicle to choose and the associated environmental outcomes.

Figure 2. Relative tax rates and bases of diesel and gasoline for all road use (carbon emissions)



Source: OECD calculations, based on *Taxing Energy Use* (OECD, 2013). Tax rates are as of 1 April 2012 (except 1 July 2012 for Australia); energy use data is for 2009 from IEA (2011a). Figures for Canada and the United States include only federal taxes.

There is an apparent relationship in OECD countries between the tax advantage of diesel relative to gasoline and the amount of diesel used for road transport relative to gasoline as shown in Figure 2. Although this is based on static observation and is not direct evidence of causation, it seems likely that the lower tax rates on diesel have contributed to the dieselisation of the passenger fleet that has been observed in many OECD countries.

Road use of gasoline and diesel comprises a large proportion of energy use in OECD countries. Given the different environmental impacts of these two fuels, and the lower tax rates on diesel in almost all OECD countries, this paper considers the policy rationales for the taxation of road fuel to determine whether the current tax treatment of diesel fuel reflects its relative environmental impacts. When considering the transition towards environmentally appropriate tax rates on gasoline and diesel, policymakers will of course consider a wide range of other relevant policy considerations – notably fairness, competitiveness impacts and distributional concerns – particularly during the transitional phase. These broader policy concerns are discussed briefly in sections 3 and 4.

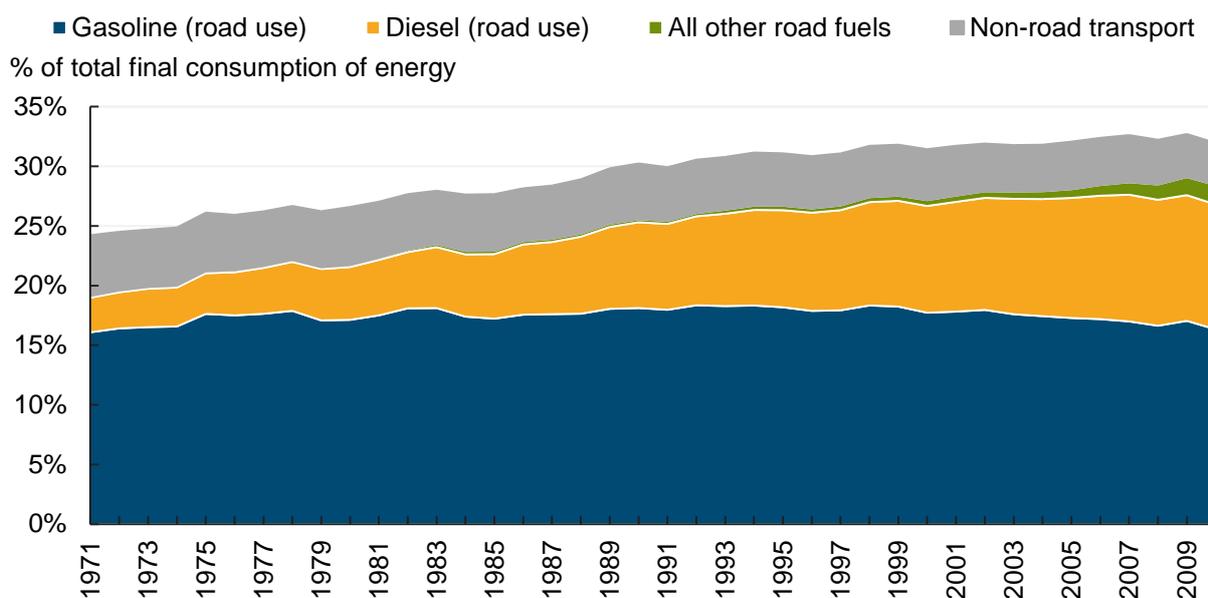
This paper is structured as follows. Section 2 considers the use of diesel and gasoline for road transport across the OECD and the tax rates applied to both fuels. Section 3 examines the policy rationales for the taxation of diesel and gasoline. Section 4 discusses some of the related policy implications of fuel taxation. Section 5 notes the implications for the taxation of diesel and concludes.

2. Use and taxation of diesel and gasoline

Energy used for transport

Energy used for transport amounted to 28% of all energy used in the OECD in 2009, up from 19% in 1971. In 2010, energy for road use amounted to 89% of transport energy, with almost all energy for road use in the OECD being derived from gasoline or diesel (IEA, 2011a). Energy for road use therefore has important environmental implications. It represented, for example, around 23% of all carbon emissions from energy use in the OECD in 2009 (OECD, 2013) and around 16% of emissions of fine particulate matter (PM_{2.5}) in 2010 (EEA, 2012). Figure 3 summarises the use of energy in the OECD from 1971-2011.

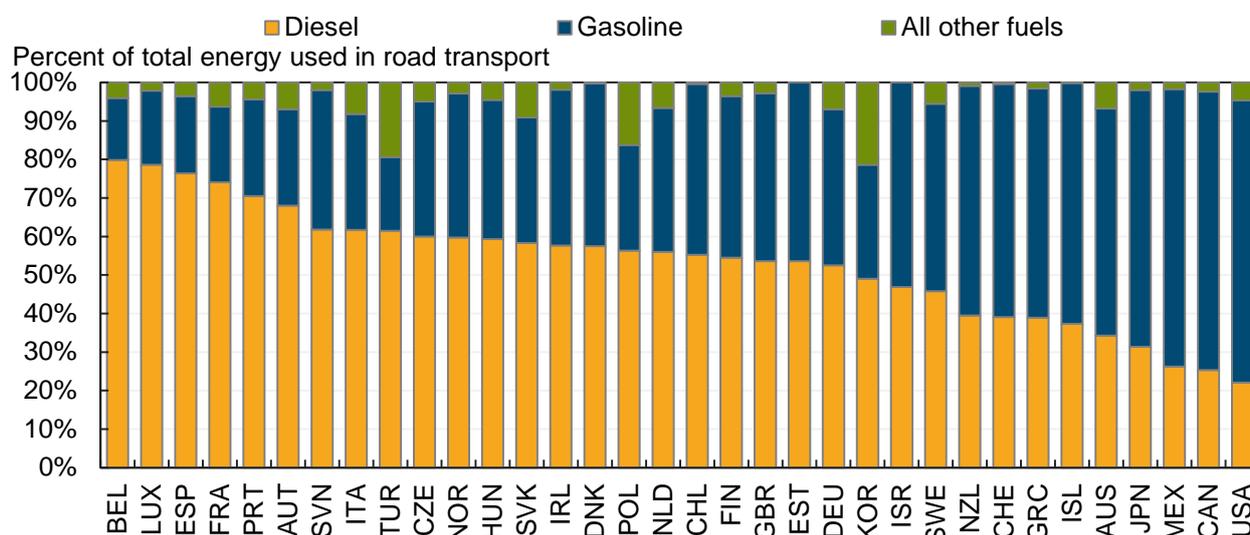
Figure 3. Energy use for transport in the OECD, 1971-2010



Source: OECD calculations, based on data from the *Extended World Energy Balances* (IEA, 2011a).

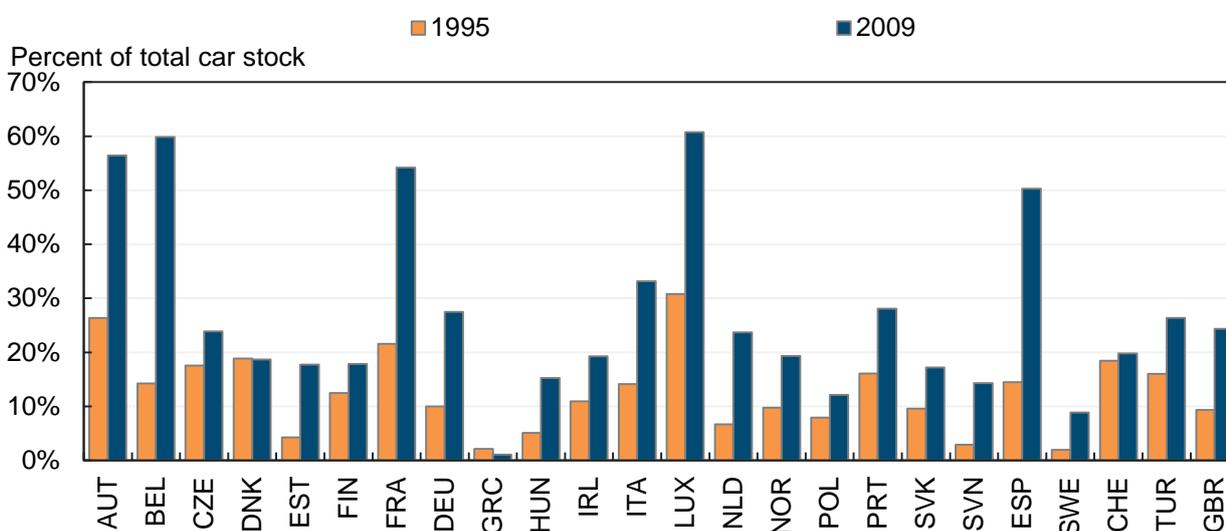
Diesel is the most heavily-used fuel for road transport in 23 of 34 OECD countries, although the vastly greater share of gasoline relative to diesel in the United States means that gasoline is used more than diesel across the OECD as a whole. The use of diesel as a road fuel in the OECD has increased significantly over the last 50 years relative to use of gasoline and other fuels (IEA, 2011a).

Figure 4. Sources of energy used for road transport, 2009



Source: OECD calculations, based on *Taxing Energy Use* (OECD, 2013).

Figure 5. Diesel vehicles as percentage of total car stock (OECD European countries)



Source: OECD calculations, based on European Union, 2013.

Historically, diesel has been the primary fuel used in heavy-vehicle transport and continues to account for over 95% of the fuel used in this market in the OECD. It is used in the heavy-vehicle and light-vehicle market for commercial purposes due to its relative fuel efficiency advantages and the additional torque it provides at low speeds. However, much of the increase in the use of diesel across the OECD has been driven by the increasing use of diesel in private passenger transport. Figure 5 shows the growth in diesel cars as a proportion of the total vehicle stock (which obviously lags trends in new car purchases) in

European OECD countries from 1995 to 2009. In the European Union, diesel cars now form on average 54.9% of new car registrations (EEA, 2013).

Fuel efficiency of gasoline and diesel cars

Diesel vehicles are widely acknowledged to be more fuel efficient than gasoline vehicles, which is a key reason for the use of diesel fuel by heavy vehicles. Diesel fuel contains approximately 10% more energy per litre than gasoline fuel, with around 35.9 megajoules per litre of diesel and 32.6 megajoules per litre of gasoline. Diesel engines are more efficient at converting this energy into motion than their gasoline counterparts, in part because diesel engines are more efficient in matching air to fuel and can operate efficiently on a wider range of air-to-fuel ratios.

In private passenger cars, the relative fuel efficiency of gasoline and diesel vehicles is affected by characteristics such as vehicle size, weight and aerodynamic properties, engine size and power, engine technology (for example, the use of turbocharged direct fuel injection) and driving conditions, such as driver behaviour, speeds travelled, road conditions, vehicle maintenance, and the choice of tyres (Greene, 2008). The increasing power-to-weight ratios observed in newer cars means that driver behaviour – particularly speed (Bonilla, 2009) – is becoming increasingly important as a determinant of fuel efficiency.

Fuel efficiency can be measured either as a function of fuel used per amount of distance travelled (litres per 100 kilometres) or as a function of distance travelled per amount of fuel used (kilometres per litre or miles per gallon). The first measure is more widely used in Europe (with the exception of Denmark, the Netherlands and the United Kingdom) and in New Zealand, Australia, Canada and Japan, whereas the second measure is more commonly used in the United States and United Kingdom. Both functions are mathematically equivalent, with one being the hyperbolic function of the other. In discussing fuel efficiency, for simplicity, this paper will use fuel efficiency measured in kilometres per litre.

The differences between the fuel efficiency of gasoline and diesel passenger vehicles can be measured in many ways, including by direct comparison between two otherwise identical models, comparison of all new vehicles of the two types using weighted sales data, or comparison of the overall fleet. Comparisons made directly between a gasoline and diesel vehicle of the same model, with similar weights and engine capacities, consistently demonstrate that diesel passenger vehicles are more fuel efficient than their gasoline counterparts, although the difference is declining with regard to more modern gasoline vehicles. Table 1 shows recent estimates of the difference in fuel efficiency based on a model-to-model comparison.

Table 1. Fuel efficiency in km/litre of diesel cars with respect to gasoline cars – model-model analysis

Study	Fuel efficiency advantage	Comment
Schipper (2002)	26-33%	Fuel efficiency advantage reduced if gasoline model uses turbocharged direct injection rather than indirect injection models
Sullivan et al., (2004)	25-29%	Based on matched vehicle weights for passenger cars between 1100 and 2100 kilograms
EPA (2011b)	20-30%	Decrease in fuel consumption relative to gasoline cars when analysis is conducted based on the respective weight of the cars. Diesel cars also observed to be more efficient if matched on the basis of footprint.
IFS (2012)	10-20%	Efficiency of gasoline and diesel cars more similar in recent models
EPA (2013)	9-93%	Study measured efficiency advantage in miles per gallon; converted to litres per kilometre by the OECD.
Minjares (2013)	17-40%	Lower advantage in the United States, of around 31%. Study measured efficiency advantage in miles per gallon; converted to litres per kilometre by the OECD.

Source: OECD, based on studies cited.

Comparisons of vehicle-weighted sales, by contrast, show that the efficiency of the average diesel passenger vehicle sold is not significantly greater than that of the average gasoline passenger vehicle. This is due to the different composition of sales of gasoline and diesel vehicles, with diesel car sales being more heavily weighted than gasoline car sales towards cars with larger engines (Ó Gallachóir et al., 2009; Schipper, 2002). Although diesel passenger vehicles may be more fuel efficient on a one-to-one analysis, because diesel passenger vehicles tend to have larger engines than gasoline passenger vehicles, the difference between total carbon dioxide (CO₂) emissions per kilometre for diesel and gasoline passenger vehicles as a whole has been declining (IFS, 2012; EEA, 2013).

Taxation of gasoline and diesel for road use

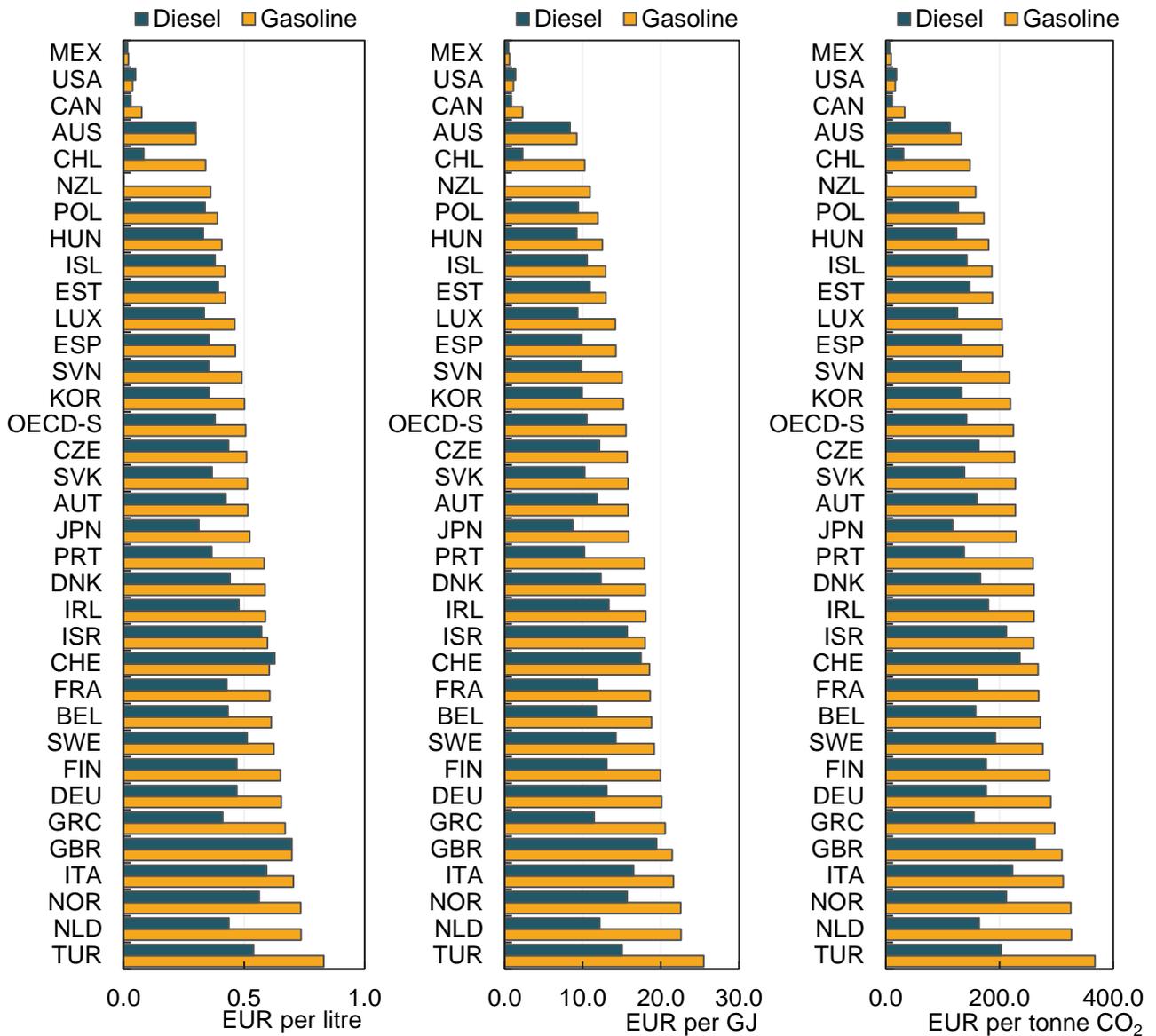
Gasoline and diesel for road use are taxed in almost all OECD countries. They are typically taxed at substantially higher rates than fuels used for other purposes such as heating and process use or electricity generation (OECD, 2013). The tax revenues from diesel and gasoline therefore form the major proportion of revenue from energy excise taxes in OECD countries (see Figure 1 above).

Within each country however, gasoline and diesel are usually taxed at different rates. Diesel is taxed more heavily per litre than gasoline in Switzerland and the United States; at the same rate per litre in Australia and the United Kingdom; and at lower per litre rates in Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Greece, Germany, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and Turkey.

As noted, a litre of diesel contains about 10% more energy than a litre of gasoline. A litre of diesel also produces about 18% more CO₂ emissions than a litre of gasoline. As a result, if the per litre tax rates are converted to rates on the basis of energy content or carbon emissions, diesel is taxed more lightly than gasoline on an energy or carbon basis in all OECD countries other than the United States.

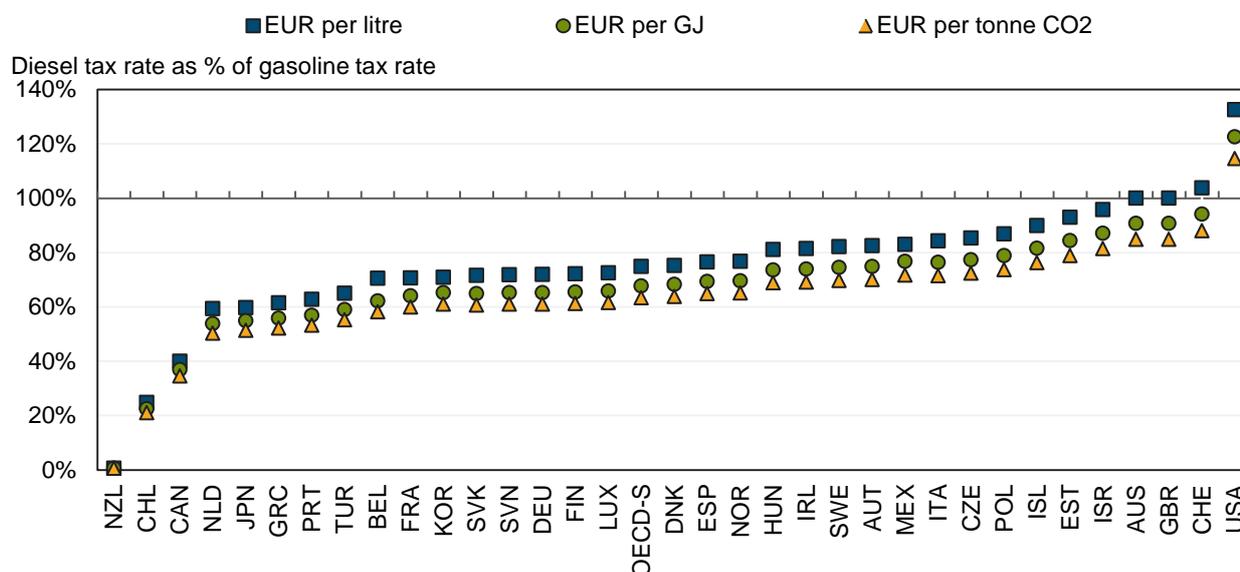
Most countries tax fuel on a per-litre basis. Converting the per-litre rates to effective tax rates on an energy basis (EUR per GJ) more closely links the rates to the economic value to users – the underlying energy content – of each fuel. Similarly, showing the per-litre rates as effective tax rates based on the carbon content of the fuel (EUR per tonne CO₂) shows more their relation to the climate impact of the two fuels. Figure 6 shows the tax rates on gasoline and diesel in all OECD countries on a per litre, per GJ and per tonne of CO₂ basis. Figure 7 shows the difference between the rates as a proportion of the gasoline tax rates. This demonstrates that for countries that provide a tax preference for diesel on a per-litre basis, the discrepancy is greater when the effective tax rate in terms of energy content is considered and still greater when the effective tax rate in terms of CO₂ emissions is considered.

Figure 6. Tax rates on gasoline and diesel for road transport (left panel, taxes in EUR per litre, centre panel, taxes in EUR per GJ, right panel, taxes in EUR per tonne CO₂)



Source: OECD calculations, based on data taken from *Taxing Energy Use* (OECD, 2013). Tax rates are as of 1 April 2012 (except 1 July 2012 for Australia). Figures for Canada and the United States include only federal taxes. OECD-S is the simple OECD average; OECD-W is the weighted OECD average.

Figure 7. Difference between gas and diesel tax rates



Source: OECD calculations, based on data taken from *Taxing Energy Use* (OECD, 2013). Tax rates are as of 1 April 2012 (except 1 July 2012 for Australia). Figures for Canada and the United States include only federal taxes. OECD-S is the simple OECD average; OECD-W is the weighted OECD average.

Context of fuel taxation: related taxes and regulatory settings

Road fuel taxes are applied within a broader regulatory framework. This framework – which includes taxes, regulatory policies and infrastructure decisions – affects both vehicles and road use. Relevant taxes include taxes on vehicles levied either at the time of purchase or registration or on an annual basis, road user charges, the tax treatment of company vehicles and the tax treatment of commuting expenses. Taxes on vehicles at the time of purchase are widely used in the OECD and can be based on the relative fuel efficiency of the vehicle, with one more pronounced variation being seen in the *bonus-malus* scheme used in France, where the purchase of a car may be taxed or subsidised depending on the efficiency of the vehicle. Vehicle taxes may also vary based on a number of other vehicle characteristics, such as emissions, power and fuel type (OECD, 2013c). Taxes on the personal benefit an employee receives from the use of company vehicles may also be differentiated based on fuel efficiency (or a related concept, CO₂ emissions per kilometre) as in Belgium or the United Kingdom. These taxes will influence overall car fleet composition and fuel use, particularly when company cars form a large part of car registrations and the overall car fleet (OECD, 2013b).

Several OECD countries differentiate purchase or registration taxes between diesel and gasoline cars, either directly or indirectly applying higher rates to diesel cars. In some countries, these taxes are deliberately set at a rate that roughly offsets the difference between diesel and gasoline tax rates, on average. Taxes which are levied based on the CO₂ rating of the car, such as the *bonus-malus* scheme in France, will indirectly apply a higher tax rate on diesel cars than on a gasoline car with the same fuel efficiency rating, due to the higher content of carbon in diesel fuel. Taxes may also distinguish explicitly between gasoline and diesel cars, as is the case in Finland, where diesel cars pay an additional tax (currently set at EUR 0.055 per day per 100 kilograms of weight) that is not applicable to gasoline cars (Trafi, 2013). Similarly, New Zealand levies road user charges (set by reference to the type of vehicle) per kilometre driven by diesel vehicles but not by gasoline vehicles.

Applying higher rates of tax or road user charge to diesel vehicles may offset some of the impacts of taxing diesel fuel at lower rates than gasoline fuel. However, they do not directly internalise the environmental and other social costs of diesel consumption. For example, higher transaction charges at the time of purchase or higher annual taxes on diesel vehicles may affect decisions about car characteristics (for example, about fuel-efficiency or the fuel type of the vehicle purchased) but they do not incorporate the cost of using an additional litre of fuel. Road-user charges (on a per kilometre basis) will go further toward incorporating the other social costs associated with diesel use into driving decisions, but will do so only indirectly, in that a highly fuel-efficient vehicle will pay the same tax rate per kilometre as an inefficient vehicle – despite using less fuel to travel that kilometre. To ensure that environmental and other social costs of fuel use are accurately taken into account, the impact of existing purchase or registration taxes on vehicle choice, vehicle characteristics and driving behaviour should be carefully considered alongside the levels of fuel tax in each country, an exercise which is beyond the scope of this paper. Determining the optimal mix of fuel taxes and taxes on vehicles or road use could be an avenue of future work.

The taxation of gasoline and diesel in OECD countries which are members of the European Union is constrained by the Energy Tax Directive (European Commission, 2003). The current directive provides minimum rates for the taxation of both diesel and gasoline: EUR 0.359 per litre of unleaded gasoline and EUR 0.33 per litre of diesel. Under the Directive, member countries are expressly permitted to apply different rates to commercial and non-commercial diesel under certain conditions, provided that the minimum rates are observed for both uses of the fuel. A recent proposal to revise the Directive would require tax rates for these fuels to be set based on two components: a fixed amount per unit of CO₂ emissions – the same for each fuel; and a fixed amount per unit of energy – also the same for each fuel. As diesel has both higher energy content and carbon emissions per litre than gasoline, this would mean that under the proposed revisions to the Directive, the per-litre tax rate on diesel would be higher than that on gasoline. The proposed amendments to the Directive would also increase the minimum rates applicable to these fuels to EUR 0.36 per litre of unleaded gasoline and EUR 0.39 per litre of unleaded diesel. Further, if countries chose to apply rates above the prescribed minimums, these rates would have to be applied consistently to fuels used for the same purpose, such as diesel and gasoline for road transport. The proposal also is to abolish the possibility of charging different rates for commercial and non-commercial use of diesel in transport. A transitional period of approximately 10 years would be allowed before the new directive took full effect (European Commission, 2011). The revised directive would raise tax rates on gasoline from EUR 0.359 per litre to EUR 0.360 per litre and tax rates on diesel from EUR 0.300 per litre to EUR 0.390 per litre (European Commission, undated).

Fuel and vehicle standards also affect the use of road fuels and the market for vehicles. Fuel standards have had a considerable impact in lowering the amount of lead and sulphur in road fuels. Vehicle standards are widely used across the OECD and have considerably influenced both the fuel efficiency and level of pollutants emitted by vehicles (Clerides, 2008). Continual improvement in the regulation of fuel efficiency and emissions of nitrogen oxides and particulate matter has contributed to major changes in the composition of the fleet. Vehicle standards differ between major regions, with tighter standards generally applying in Europe and Japan relative to other OECD regions such as Australia, Canada and the United States (An, 2004), although all standards have been progressively tightened (OECD, 2012).

However, there are often significant differences between the fuel economy measured during a test cycle and that observed under real-world driving conditions, with differences of between 15-25% observed (Schipper and Tax, 1994; Mock et al, 2013). A number of factors contribute to this, including the formula used to represent the driving cycle, differences in conditions on all parts of the cycle, driver behaviour, lack of maintenance, and test vehicles differing from those sold (Bonilla, 2009, citing Schipper and Tax, 1994). This difference between real world fuel efficiency and that measured by test cycles is often higher for diesel vehicles than for gasoline vehicles (Bonilla, 2009; Meyer, 2009) and has been observed to have

increased over time, possibly due to manufacturers taking advantage of leniencies in the testing procedures used (Mock et al, 2013).

There are a range of other policies which are relevant to the consideration of taxation of gasoline and diesel. These include policies which impact road use, such as road pricing, congestion charging, noise controls, and road safety policy. These policies vary considerably both across OECD countries and also in different areas within each country.

3. Rationale for road fuel taxation

Many countries tax road fuels primarily to raise revenue, whether for general purposes or to fund highway infrastructure and services. Given the relative inelasticity of the tax base, the economic cost of raising revenue is perceived to be low. Further, road taxes tend to be a stable revenue source since demand for these fuels tends to be relatively inelastic, although improvements in fuel efficiency can erode revenues.

From an economic perspective, taxes on road fuels may also be used in order to internalise environmental and other social externalities associated with their use. The negative externalities of energy use arise where the consumption of energy imposes a cost on a third party. Pigou (1920) showed that imposing a tax on an activity with negative social costs creates incentives to reduce these costs by internalising the costs into the production and consumption decisions related to that product. As the use of both diesel and gasoline in road transport contributes directly to local pollution and climate change, and is indirectly (though sometimes only weakly) correlated with a variety of other social costs including congestion and infrastructure costs, they are textbook examples of the types of costs for which Pigouvian taxation is warranted.

To fully internalise the negative externalities associated with fuel use, a Pigouvian tax should be set at a rate equal to the externality – that is at the marginal social cost of the pollution damage and the other externalities associated with fuel use. This ensures that fuel users incorporate the full costs of fuel use into their decision making and that the tax system is neutral, in terms of the environmental signals it provides, between the two fuels.

Imposing differential tax rates on final consumption that are higher than the marginal cost of pollution may be justified in some cases, particularly for fiscal purposes. Under Ramsey taxation, higher tax rates should be imposed on goods with relatively inelastic demand, in order to minimise the reductions in welfare which inevitably result when taxes drive a wedge between prices and costs and induce people to buy less of the things that they want (Ramsey, 1927). For fuel products, demand is generally relatively inelastic, making these a good target for Ramsey taxation.

For these reasons, Parry et al (2007) determine that the optimal fuel tax will be comprised of two parts – the first, which corrects for the range of externalities associated with fuel use, and the second, as a Ramsey tax component, which should be used in the presence of fiscal need if the taxed commodity is a relatively weak substitute for labour.

Differential tax rates on gasoline and diesel that do not reflect the respective social costs associated with the two fuels imply non-neutral taxation. By increasing the relative price of diesel by less than that of gasoline, whether or not the level of gasoline taxation is optimal, this tax preference provides incentives at the margin that have detrimental environmental impacts.

Using gasoline and diesel taxation to internalise externalities

Fuel taxation can be used to internalise a wide range of externalities: including those directly connected to fuel use, such as greenhouse gas emissions (especially CO₂) and local air pollution (e.g. nitrogen oxide, particulate matter, and sulphur dioxide), and those less closely connected to fuel use but instead connected to the “extent, location, and timing of travel” (Parry, 2007) such as congestion, accidents, noise and infrastructure costs. Although a function of fuel used, the costs associated with some forms of air pollution also vary based on the location and timing of travel. Broadly, the types of cost include:

- *Contribution to climate change:* The contribution of both fuels to climate change through emissions of CO₂, other greenhouse gases and black carbon;
- *Local air pollution:* The impact of exhaust fumes from both fuels on local air pollution through emissions of a number of pollutants, including nitrogen oxides (NO_x), particulate matter (PM), and sulphur dioxide (SO₂);
- *Other social costs:* The impact of increased car use on congestion, accidents, noise and infrastructure wear and tear.

The nature of these impacts is considered further below.

Contribution to climate change

When combusted to generate energy, gasoline and diesel emit a range of greenhouse gases. The primary greenhouse gas emitted from combustion of both fuels is CO₂, although both fuels also emit small quantities of methane, nitrous oxide and hydrofluorocarbons. CO₂ accounts for between 95 and 99% of total greenhouse gas emissions from fuel use from passenger vehicles when converted into a CO₂ equivalent basis (EPA, 2011; EPA, 2013; IPCC, 2006). It is thus the most significant determinant of each fuel’s contribution to climate change.

The primary determinant of the level of CO₂ emissions is the amount of carbon in the fuel that is combusted. No technologies currently exist for the reduction of carbon emissions relative to the amount of fuel used (Parry, 2007). Regardless of how the fuel is burnt, or the fuel efficiency of the vehicle, the quantity of CO₂ emitted from a given quantity of gasoline or diesel is fixed and depends on the amount of carbon in the fuel (EPA, 2011; EPA, 2005; EPA, 2012; EEA, 2012; IPCC, 2006).

Although there may be some differentiation between the amounts of carbon per litre of gasoline or diesel in different countries, the level of carbon emissions from combustion of these fuels is relatively fixed, assuming full oxidation of both fuels. Measured per litre, diesel has a carbon content around 18% higher than that of gasoline, meaning that the social costs in terms of contribution to climate change from burning one litre of diesel fuel are 18% higher than for a litre of gasoline.

Table 2. CO₂ emitted per litre of road fuel (grams per litre)

	Gasoline	Diesel
Grams of CO ₂ emitted per litre of fuel used	2 259	2 662

Source: OECD calculations based on IEA (2011a; 2011b).

Estimates of methane and nitrous oxide emissions from the combustion of gasoline and diesel (which account for between 1 and 5% of greenhouse emissions from these fuels) are not fixed per unit of fuel used but can vary considerably based on the engine type and abatement technologies used. For any given vehicle, however, increased fuel use will multiply the amount of emissions from either fuel, meaning that

there is a direct link between the quantity of fuel used and the level of these emissions. Generally, emissions of methane and nitrous oxide can be said to be higher for a litre of gasoline than for a litre of diesel. Emissions of hydrofluorocarbons are primarily related to air-conditioning and thus unrelated to the quantity or type of fuel use (EPA, 2011).

Table 3 summarises data from the EEA (2012) on emissions of gasoline and diesel for a typical European car fleet.

Table 3. Range of other greenhouse gases emitted per litre of road fuel used by passenger cars
(CO₂ equivalent grams per litre)

		Mean	Minimum	Maximum
Methane	<i>Gasoline</i>	20.48	6.11	26.74
	<i>Diesel</i>	1.37	0.51	1.73
Nitrous oxide	<i>Gasoline</i>	45.47	29.36	70.64
	<i>Diesel</i>	21.86	11.06	26.89

Source: OECD calculations based on EEA (2012) IEA (2011a). Methane and nitrous oxide are converted to CO₂ equivalents using their Global Warming Potentials (100 year time horizon) found in EPA (2011).

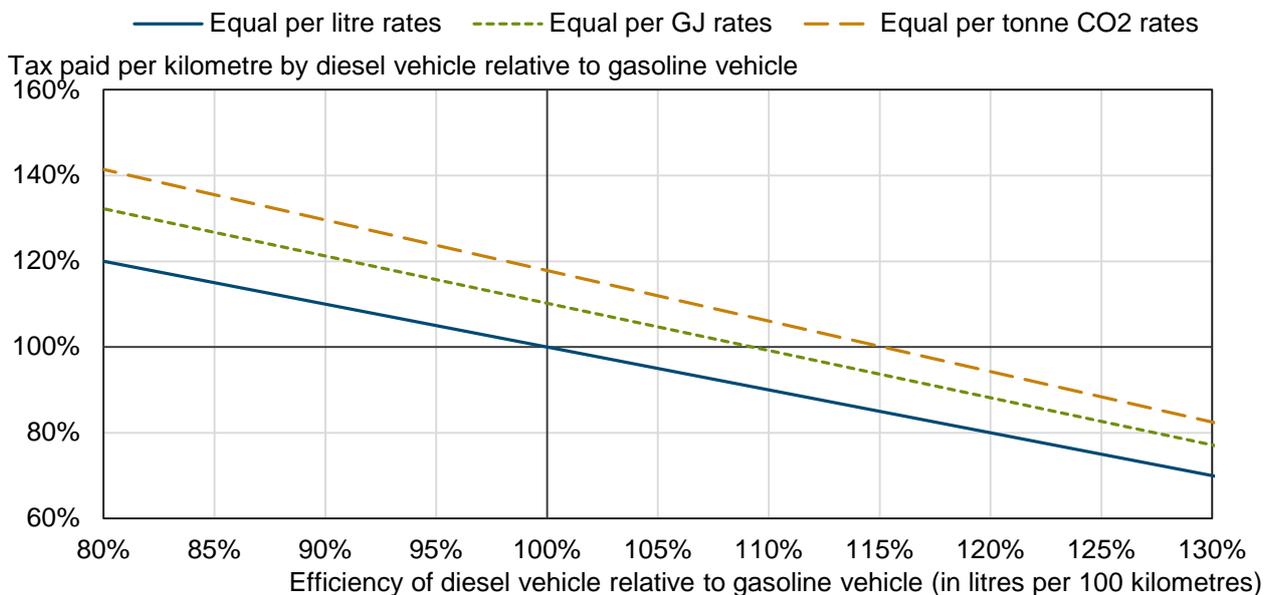
As evidenced in Tables 2 and 3, emissions of methane and nitrous oxide account for a very small proportion of greenhouse gas emissions from fuel use. It is therefore clear that a litre of diesel produces more greenhouse emissions than a litre of gasoline by approximately 15.5%. Since fuel taxes are set on a volume basis (a per-litre rate), the component of fuel taxes that is intended to internalise CO₂ emissions ought to be correspondingly higher on a per litre basis, although equivalent per unit of CO₂. This is likely to be a comparatively small part of the total tax burden, given the relative scale of the other environmental and social externalities associated with fuel use.

The relative fuel efficiency of diesel and gasoline cars (see Table 1 for estimates of their relative fuel efficiencies) does not affect the amount of carbon emitted per litre of fuel used. However, when emissions are considered on a distance basis – that is CO₂ emissions per kilometre – rather than a volume basis, the relative fuel efficiency of the cars does have an impact. The higher fuel efficiency of diesel cars *may* mean lower CO₂ emissions per kilometre travelled, but only if the diesel car is at least 15% more efficient than the gasoline car it displaces – high enough to offset the additional CO₂ emissions generated from the use of diesel. This is not unequivocally the case. The diesel efficiency advantage is less than 15% on some model-model comparisons – and a diesel car may not be a close match to the gasoline car it displaces. More importantly, however, the fuel efficiency advantage of diesel results in lower fuel costs per km travelled. This is a benefit internalised by the driver. By contrast, the cost of CO₂ emissions is not internalised. Even though a litre of diesel *may* take a car further than a litre of gasoline, it will contribute more to climate change than a litre of gasoline. This implies that a higher tax per litre of diesel is warranted, at least in respect of the climate change component.

The greater fuel efficiency of diesel cars is also internalised into the amount of tax paid per kilometre. Figure 8 shows the difference in the amount of tax paid by the owner of a diesel car relative to the owner of a gasoline car at differing levels of fuel efficiency, in three scenarios: where the tax rates for diesel are set at the same level as gasoline in (respectively) volume, energy content, and carbon content terms. The horizontal axis shows the fuel efficiency of the diesel car in litres per 100 kilometres as a percentage of the gasoline vehicle: for example, at 100% the fuel efficiency is the same, and at 110%, the diesel vehicle is 10% more efficient than the gasoline vehicle. The vertical axis shows the amount of tax paid per kilometre by the driver of a diesel vehicle relative to the amount per kilometre paid by the driver of a diesel vehicle. As fuel efficiency increases, a diesel vehicle owner will pay less tax per kilometre. If fuel tax rates are equalised per litre, the owner of a diesel vehicle will pay less tax than the owner of a gasoline vehicle if

the diesel vehicle is of equal or greater fuel efficiency. If the tax rate is equivalised per unit of energy, or per unit of carbon emissions (both of which would imply a higher per litre rate for diesel relative to gasoline), an owner of a diesel vehicle that is at least 10% or 15% more efficient, respectively, will still pay less tax per kilometre travelled than the owner of the gasoline vehicle.

Figure 8. Impact of fuel efficiency on tax paid per kilometre



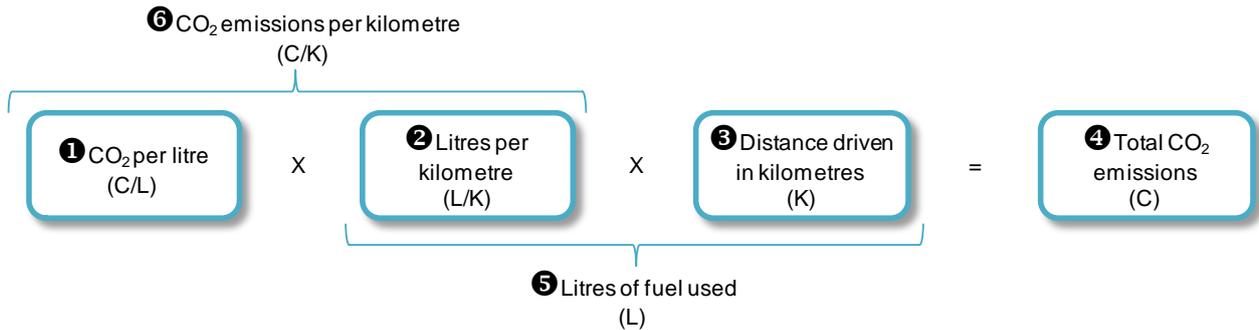
Source: OECD calculations

Furthermore, there is not a sound case to give a tax preference for diesel in order to encourage people to switch from gasoline to diesel cars. It should not be assumed that changing relative prices will leave behaviour unaffected. Basic economic principles imply that using taxation to provide a lower relative price for diesel may well lead to a rebound effect by encouraging car owners to drive more or to purchase a larger vehicle, potentially reducing or eliminating the environmental benefit from higher efficiency. Box 1 considers the emissions of CO₂ from road vehicles and the impact of the rebound effect in more detail.

CO₂ emissions from road vehicles and the rebound effect

The total CO₂ emissions from a given vehicle is the product of the amount of CO₂ emitted per litre of fuel (which depends on the fuel type), the fuel efficiency of the vehicle, and the distance the vehicle is driven. This relationship is summarised in Figure 3-1.

Figure 1-1. Calculation of total CO₂ emissions from fuel use



Source: OECD

① CO₂ per litre is the carbon intensity of the fuel. This is a fixed factor depending on the type of the fuel and is not altered by different technologies or use patterns. For gasoline fuel, emissions when combusted are around 2 259 grams of CO₂ per litre; and for diesel fuel, around 2 662 grams per litre (assuming 100% oxidisation).

② Litres per kilometre driven gives the fuel efficiency of the particular vehicle. This will vary considerably across vehicles based on the weight, performance and engine technology of the vehicle. Other factors such as driver behaviour, road surface, and urban or rural driving will also affect fuel efficiency. Typically, gasoline vehicles have lower levels of fuel efficiency than a diesel counterpart with a similar weight and level of performance.

⑥ Multiplying the carbon intensity of the fuel used (CO₂ per litre) by the fuel efficiency of the vehicle (in litres per kilometre) gives the amount of CO₂ emissions per kilometre driven for any given car. Therefore, a diesel car will produce less carbon emissions per kilometre than its gasoline counterpart if it is at least 15% more fuel efficient (measured in terms of litres per kilometre); if not, it will produce more CO₂ per kilometre travelled.

③ Distance driven in kilometres will vary for every car. Diesel cars, on average, drive further than gasoline cars. Part, but not all of this difference, can be attributed to the presence of heavier vehicles and high-use vehicles such as taxis in the diesel fleet (Schipper, 2012; which found they drive between 40-100% more).

⑤ Multiplying the fuel efficiency of the car (measured in litres per kilometre) and the distance driven (in kilometres) will determine the total amount of fuel used by the vehicle. Diesel vehicles will use less fuel than gasoline vehicles if the fuel efficiency advantage is large enough to offset any increase in driving relative to a gasoline vehicle.

④ Total CO₂ emissions for a given vehicle are the product of multiplying the carbon intensity of the fuel used, the fuel efficiency of the vehicle and the distance travelled in the vehicle.

The total CO₂ emissions of the diesel and gasoline fleets are the sum of these emissions for each car in the fleet. Therefore it is the fuel efficiency of the entire fleet that will influence the average amount of carbon emitted per kilometre, which will be influenced by the decisions made at the margin. Although diesel cars may be more fuel efficient on a one-to-one analysis, on average, the difference between total CO₂ emissions per kilometre for diesel and gasoline cars has been declining, to the point where the average new diesel car is not significantly more fuel efficient per kilometre than the average new gasoline car (EEA, 2013).

The greater fuel efficiency of diesel vehicles, measured against their direct gasoline counterpart may lead to a rebound effect which reduces or eliminates the gains in efficiency made. The rebound effect is further often exacerbated by lower taxes on diesel which further lower operating costs. There are two types of rebound effect (Schipper, 2002):

- Given the reduced fuel costs due to fuel efficiency gains, consumers may choose to buy larger vehicles or to adopt more fuel-intensive driving styles than they otherwise would have. This effectively increases **②** in the equation above.
- The reduction in fuel costs may cause consumers to drive further, increasing **③** in the equation above. The overall impact on fuel used will depend on whether or not the fuel efficiency benefit is offset by the increase in driving. Increased driving as a result of fuel cost changes in the long run has been found to have an elasticity of 10-30% (Sorrell et al., 2009). Schipper (2002) found that in Europe, diesel cars typically use more fuel and drive further than gasoline cars and that while some of this increase in driving can be linked to the use of diesels for heavy transport and for taxis, this cannot fully explain the difference.

Finding evidence of the scale of this rebound effect is difficult, as the counterfactual is difficult to determine. In particular, one must consider to what extent more distance-intensive consumers or those with larger vehicles have switched to diesel precisely because of its fuel efficiency advantage; and to what extent the fuel-efficiency and cost advantages have caused the switch from gasoline to diesel, larger vehicle purchases or increased driving. A study of driving habits in France found that consumers who changed from gasoline to diesel vehicles had driven on average approximately 16 000 kilometres per year in their gasoline car but increased driving to 19 500 kilometres per year in their diesel car, while spending approximately the same amount on fuel (Hivert, cited in Schipper, 2002). This is a 22% increase in distance driven, consistent with the range of elasticities noted above. Similarly, Schipper (2002) found that despite the greater efficiency at a matched-pair level, diesel vehicles emit far more CO₂ than the average gasoline car in the five countries studied due to the increase in distance travelled. In short, the rebound effect of fuel efficiency and lower taxes on diesel is likely to be significant enough to cause any CO₂ savings from diesel vehicles to range from small to significantly negative (Schipper, 2002).

Local air pollution

The combustion of diesel and gasoline emits a range of other pollutants which contribute to local air pollution, health problems and early mortality. Common pollutants associated with transport fuels include nitrogen oxides, particulate matter, sulphur oxide, volatile organic compounds (VOCs) and carbon monoxide.

Nitrogen oxides and volatile organic compounds contribute to the formation of smog. Particulate matter, particularly of a finer nature, is related to increases in eye and respiratory irritation, cardiovascular disease, lung cancer and consequent premature death (OECD, 2012; Parry, 2007). Emissions of carbon monoxide reduce oxygen in the bloodstream and cause breathing and cardiovascular difficulties (Parry, 2007). The World Health Organisation estimated that, globally, outdoor air pollutants caused 3.7 million premature deaths in 2012 (WHO, 2014).

Unlike carbon emissions, emissions of these pollutants, with the exception of sulphur dioxide, are not based on the amount of the pollutant in the fuel. Instead they depend on the combustion technology used, including the temperature of combustion. A range of technologies (for example, through the use of catalysts or particle traps) are effective in reducing the amount of these pollutants for a given quantity of fuel. Therefore, the amount of pollutant emitted for a given quantity of fuel will differ considerably between different vehicle types, dependent on the technology used. Nonetheless, increases in the amount of fuel used by any given vehicle will continue to increase the amount of these emissions for that vehicle. Emissions of sulphur dioxide, however, are directly linked to the amount of sulphur in the fuel used.

Combustion of diesel fuel typically emits higher levels of nitrogen oxides, particulate matter (particularly finer particulate matter) and volatile organic compounds; although the amount of these pollutants is gradually being reduced as diesel technology improves. Combustion of gasoline fuel emits more carbon monoxide than diesel vehicles, although the amount of carbon monoxide emitted is considerably reduced in newer gasoline vehicles due to the use of three-way catalysts (Schmitz, 2000).

Typically, diesel fuel is considered to have worse local air pollution effects than gasoline (OECD, 2012; IFS, 2012), primarily due to the higher emissions of particulate matter and nitrogen oxides per litre. However, advances in technology, due in large part to tighter vehicle standards, have reduced some of these emissions from newer diesel vehicles in some countries; and changes in the technology used by gasoline vehicles to improve fuel efficiency have increased their emissions of some pollutants, e.g.:

- Particle traps are particularly effective in reducing the particulate matter emitted by diesel vehicles, while improvements in the fuel economy of gasoline vehicles, particularly through the use of direct injection engines, has led to increased particulate matter from gasoline vehicles (Courbe, 2013; Mohr et al., 2006; Minjares, 2013). With very efficient filters, diesel cars may emit less particulate matter than gasoline cars with direct injection (Courbe, 2013; Mohr et al., 2006), although emissions of finer particulate matter (PM_{2.5}) continue to be higher from diesel than gasoline vehicles even under Euro 6 standards (Minjares, 2012).
- Fuel standards have had a considerable impact in reducing the sulphur content of both gasoline and diesel. In the EU, for example, sulphur quantities for gasoline have been reduced from 165 parts per million in 1996 for gasoline and 400 parts per million for diesel, to 40 parts per million for gasoline and 8 parts per million for diesel in 2009. (EEA, 2012/13).

Actual emissions, however, are a function of the entire vehicle fleet, including older vehicles which do not meet the most current standards, as well as of other factors such as driver behaviour and the effective maintenance of technologies that improve fuel efficiency or to reduce pollution. Taxes on gasoline and diesel ensure that the social costs of these fuels are taken into account by all drivers.

To illustrate the different levels of pollutants emitted per litre of diesel and gasoline, Table 4 shows, on a per litre basis, the range of the pollutants associated with gasoline and diesel fuels in the European Union. Across the average vehicle fleet, emissions of particulate matter and nitrogen oxides are higher for diesel vehicles than for gasoline vehicles. The levels of these emissions may decrease over time due to more stringent regulation of the company car stock, which in many countries has a significant impact on the characteristics of the overall vehicle fleet (Parry, 2007), although the lag between the introduction of new standards and the turnover of the car fleet can be considerable and on-road performance is often worse than test cycle standards, particularly for diesel vehicles (Weiss et al, 2012; Carslaw et al, 2011). In countries with less stringent pollutant standards, or older vehicle fleets, the emissions of nitrogen oxides and particulate matter by diesel vehicles are likely to be much higher.

Table 4. Range of pollutants emitted per litre of road fuel (grams per litre)

		Mean	Minimum	Maximum
Carbon monoxide	<i>Gasoline</i>	71.417	41.315	227.234
	<i>Diesel</i>	2.467	1.519	6.067
Nitrogen oxide	<i>Gasoline</i>	7.361	3.777	25.202
	<i>Diesel</i>	9.600	8.296	10.281
Particulate matter	<i>Gasoline</i>	0.025	0.017	0.034
	<i>Diesel</i>	0.815	0.593	1.956
Volatile Organic Compounds	<i>Gasoline</i>	8.474	4.680	29.022
	<i>Diesel</i>	0.519	0.304	1.393

Source: OECD calculations based on EEA (2009) and IEA (2011a).

The local air pollution effects may also depend on the location of car use. Increased air pollution in remote regions may have lower health effects than in more populated regions but higher impacts on natural resources and vegetation. Different air pollutants also vary in the distance they can travel and their residence times. Nitrogen oxides are relatively local in effect whereas particulate matter, carbon monoxide and methane can travel over far greater distances and remain in the atmosphere for between several months, or in the case of methane for 8-10 years (OECD, 2012).

Due to the complex interplay between different air pollutants, and their differing effects between and within countries due to the location of their use, weighing the different air pollutants from gasoline and diesel fuel to determine the overall impact of air pollution from both is difficult. In Los Angeles, for example, nitrogen oxide and volatile organic compounds were found to be the most significant contributors to local air pollution costs, whereas emissions of carbon monoxide were found to be too low to have noticeable health effects (Parry, 2007). This finding, together with the higher emissions of particulate matter from diesel fuel implies that diesel fuel has higher local air pollution costs per litre than gasoline.

Other social costs of road transport

Taxes on road fuels are often intended to internalise other externalities associated with vehicle use, such as congestion, accidents, noise, road wear and tear, and oil dependence. The use of taxes on road fuels to internalise these costs may explain the higher rates of tax on transport fuels than on other fuels in OECD countries. The cost of congestion, accidents, noise, infrastructure wear-and-tear and oil dependence are also likely to be of substantially larger magnitude than the costs of climate change or local air pollution from vehicle use (Parry, 2009; IFS, 2012).

These externalities are a function of the amount, location and timing of vehicle traffic. They are only indirectly tied to fuel use in that greater fuel use generally reflects increased vehicle distance which will tend to contribute to these other costs, though to varying degrees in different circumstances. The use of fuel taxes to internalise these externalities is therefore necessarily rather imprecise and can at best incorporate average costs, which provides no targeted incentive to the driver of a vehicle to reduce these externalities. Incorporating these costs into fuel taxes provides an incentive for drivers to reduce fuel consumption. To the extent this happens through reductions in distance travelled, other social costs may decrease; however, fuel taxes also incentivise increased fuel efficiency, which is unlikely to reduce these externalities (Small and Van Dender, 2007). Time- and location-specific road pricing would generally be a more targeted and effective tool to address congestion, accidents and noise. Nonetheless, if more specific tools to internalise these externalities are not able to be used for complexity or political economy reasons, a fuel tax may be a second-best option to partially incorporate these external costs into the decisions of road users.

These social costs of fuel use are more closely related to the distance driven than to the amount of fuel used *per se*. For many of these costs, there is no reason to suppose that the cost per kilometre would differ between gasoline and diesel vehicles. However, the higher presence of heavy-use and larger vehicles in the diesel fleet may increase certain of these costs – particularly noise, infrastructure and congestion costs (Parry, 2009; Mayeres, 2001)

In contrast to the case of carbon emissions or local air pollution, the relative fuel efficiency of gasoline and diesel vehicles is relevant to the consideration of these costs, given that they are tied more directly to distance than to fuel use. The higher efficiency of diesel cars means that the amount of fuel required to drive a given distance will be lower. If fuel taxes are used as a proxy to internalise these costs, the fuel efficiency of diesel cars therefore does not provide a reason to impose a lower tax rate per litre on diesel than on gasoline and in fact implies that a higher tax rate per litre may be appropriate from an environmental perspective. The higher energy content per litre of diesel relative to gasoline or the higher

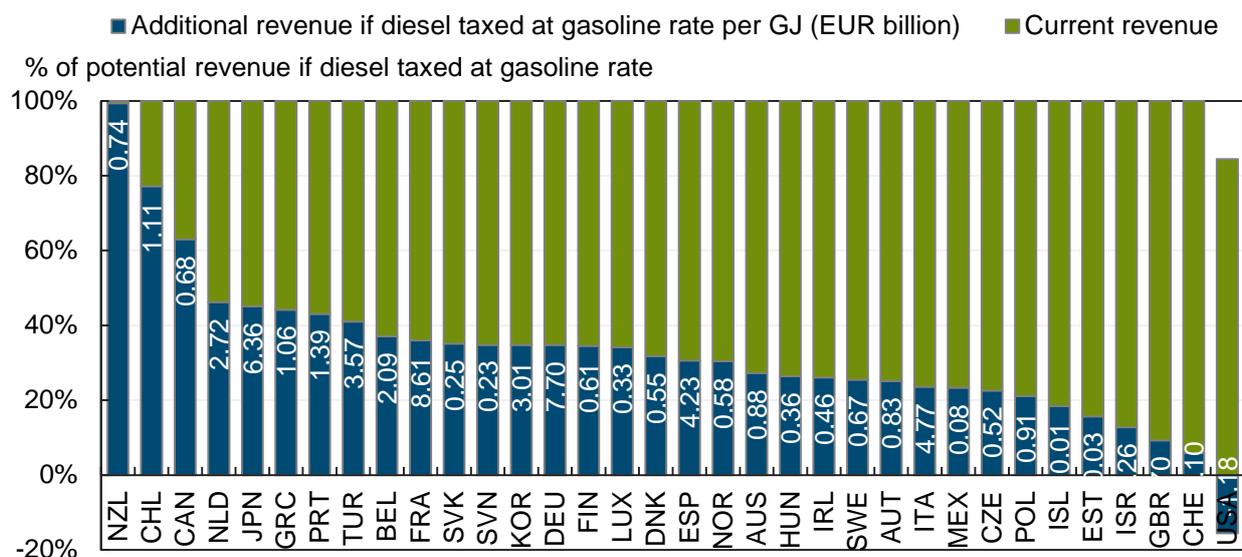
average fuel efficiency of diesel vehicles could be used as a rough proxy for the greater distance (and thus higher contribution to these other externalities) typically associated with a litre of diesel fuel.

Raising revenue

OECD governments also tax road fuels in order to raise revenue, given the relatively inelastic demand of road fuels. When considering the optimal rate of taxation on road fuels, taxation above Pigouvian levels may be justified for fiscal purposes, particularly on goods with relatively inelastic demand such as fuel products (Ramsey, 1927).

To the extent that gasoline and diesel respond differently to price changes, this may provide a reason for differential taxation. However, while there are significant differences in price elasticities for gasoline and diesel between different countries, on average, the price elasticity for gasoline and diesel is similar (0.11 – 0.33 for gasoline and 0.13 – 0.38 for diesel) (Dahl, 2011). Inter-country differences may provide some grounds for taxing diesel or gasoline at lower rates, but it is not apparent which fuel is more responsive between countries which would explain the lower tax rates on diesel found in almost every OECD country. Further, Mirrlees et al. (2011) note that building a strong case for differentiating tax rates based strictly on the elasticity of goods or their relationship to labour is difficult (as quoted in IFS, 2012). For these reasons, differences in the respective elasticity of diesel and gasoline do not provide a clear rationale for the lower taxation of diesel.

Figure 9. Static estimate of revenue if diesel taxed at the same rates per GJ as gasoline



Source: OECD calculations, based on data taken from *Taxing Energy Use* (OECD, 2013). Revenue estimates are static and do not take into account likely behavioural responses if taxes on diesel were to increase. Tax rates are as of 1 April 2012 (except 1 July 2012 for Australia); energy use data is for 2009 from IEA (2011a). Figures for Canada and the United States include only federal taxes. The estimate for New Zealand does not include road-user charges payable per kilometre by diesel vehicles.

The current differential between gasoline and diesel tax rates has large revenue implications. For illustrative purposes, Figure 9 shows a static estimate of revenue that could be raised by increasing current tax rates on diesel to match those on gasoline in energy terms as a proportion of the total revenue that would be raised from diesel taxes at this level. Across the OECD (excluding the United States) the total amount of revenue raised under this approach is EUR 57.4 billion. The VAT payable by end-users of diesel would be additional to this amount. This estimate does not take into account potential changes in behaviour

(e.g. reduced use in fuel) that might be induced by equalisation of the tax rates. Using fuel price information for 2012 (IEA, 2013) and price elasticities of demand from Dahl (2012), the behavioural response appears to be muted, resulting in a decrease in the revenue estimate in the order of 5% due to reduced consumption of diesel (although part of this reduction in revenue would likely be recaptured due to increased use of gasoline). The estimates also do not take into account changes to other policies (for example, road user charges or annual taxes that are set to equal the amount of revenue difference between gasoline and diesel fuel) that would result if tax rates on diesel were increased. They should therefore be seen as an upper bound estimate.

A possible impact of raising tax rates would be to increase tax leakage where there are neighbouring jurisdictions. If increases in diesel taxes raise diesel prices above those in neighbouring countries, sales of diesel fuel – and thus tax revenue – are likely to shift toward the lower-taxed jurisdictions. If the decrease in sales is great enough to offset the increased tax revenue per litre of fuel sold this could in fact reduce revenues. This impact will vary significantly across OECD countries depending on their relative sizes, the ease of cross-border travel and the price of fuels in neighbouring economies. The recent moves toward distance-based charges for heavy vehicles in several OECD countries may have been driven by these tax competition issues.

4. Broader policy impacts of fuel taxation

In considering the appropriate tax rates on diesel and gasoline fuels policymakers will have reference to a multitude of other relevant policy considerations in addition to the environmental and other social costs of fuel use. Tax rates on fuel use feed into a complex policy debate that touches on a broad range of other policy concerns, including infrastructure development and maintenance, revenue raising, industry policy, economic growth, competitiveness, price levels, fairness and distributional concerns.

From an environmental perspective, the difference in tax rates between gasoline and diesel is not supported by their respective external costs. Reducing this difference for environmental reasons while giving due consideration to other policy concerns is possible, for example, through the use of reduced rates, targeted assistance and gradual introduction. The difference in tax rates could conceivably be addressed by lowering tax rates on gasoline, by increasing taxes on diesel, or by a combination of both measures, with a resulting intermediate rate for both fuels (which could conceivably be set a rate to ensure that total revenues from both taxes are broadly unchanged). Nor does the analysis suggest that tax rates on gasoline are necessarily optimal at current levels (see, for example, Parry, 2005 and 2009). Typically, and partially due to the significant revenue shortfall that would result from lowering tax rates on gasoline, much of the debate in OECD countries has focused on reducing the disparity from an environmental perspective by increasing tax rates on diesel. Mitigating the transitional impacts of any increase in diesel tax rates is an important consideration in the policy debate on the appropriate tax rates on diesel.

In many countries, lower tax rates on diesel fuel have their origins in the use of the fuel in commercial transport, which historically was the primary use of the fuel. Although diesel is increasingly used for non-commercial transport, it continues to be almost the only fuel used in heavy transport, with natural gas, gasoline, and renewable fuels typically accounting for less than 5% of the fleet. The availability of vehicles of other fuel types is therefore a key difference between the commercial and non-commercial vehicle markets. The market for commercial diesel vehicles, and to a lesser extent, commercial diesel fuel, is thus likely to be comparatively inelastic, relative to the non-commercial market.

In this context, increased tax rates on diesel may provide a policy concern for policymakers because of their impact on commercial transport. Increased costs for commercial transport could translate into higher production and transport costs across the economy, creating competitiveness concerns both in relation to transport-intensive industries and with regard to neighbouring jurisdictions. A related concern

is the impact of increased production and transport costs on the price levels of consumer goods, which would increase households' cost of living. Finally, commercial vehicles are generally able to exercise greater choice (in contiguous countries) over the jurisdiction in which they purchase fuel than non-commercial vehicles, meaning that the tax base for commercial fuel is effectively more mobile than that for non-commercial fuel. Leakage of tax revenues into neighbouring jurisdictions is another concern policymakers should weigh in considering the tax rates to apply to diesel fuel.

Applying differential tax rates to commercial and non-commercial diesel may be one means of balancing the environmental costs of diesel against these concerns, particularly in the short-term. This possibility is also expressly envisaged by the European Energy Tax Directive under certain conditions, although both uses of diesel are constrained by the minimum rates set by the Directive (European Commission, 2003). In practice, a few OECD countries apply different tax rates to commercial and non-commercial diesel. Belgium applies a lower rate to "commercial diesel" for use in taxis, buses and trucks than to non-commercial diesel (OECD, 2013a). Australia and Slovenia allow rebates or refunds of taxes paid for some use of diesel: in Australia, a fuel tax credit that partially offsets excise taxes is available to vehicles weighing over 4.5 tonnes; and in Slovenia, a partial refund of excise taxes is available on diesel used for commercial transport of goods and passengers, lowering the effective excise tax rate to the minimum level provided for by the Directive.

To mitigate the transitional costs for the commercial sector, where the opportunity for substitution is limited in the short run, temporary lower rates for commercial vehicles or rebates of taxes on diesel used for commercial transport may be appropriate. Proposals for revising the Energy Tax Directive would remove the possibility to tax commercial and non-commercial diesel use differently, as doing so is no longer warranted on energy-efficiency and environmental grounds.

The fairness of increasing taxes on diesel is also an issue of concern to policymakers. Households, businesses and the car industry have made decisions and personal or business decisions made on the status quo. The car industry has, for example, invested heavily in diesel technology, partially as a result of the increased demand in diesel due to lower taxes on diesel fuel (Goerlich, 2012), as well as in response to fuel-efficiency standards and voluntary agreements with government bodies. Households have also made vehicle purchasing decisions influenced by the relative prices of gasoline and diesel under current tax settings and thus would be adversely affected, particularly in the short-run, by increases in diesel prices. These concerns must be weighed against the environmental objectives of reflecting external costs in taxes. Allowing transitional time and increasing diesel tax rates gradually could ease the impact of taxes on these groups by allowing them to realise the return on their current investments and adjust their future plans as necessary to minimise the impact of the increase.

A further important consideration with regard to changes in tax settings is their impact on distributional outcomes. Raising taxes on transport fuels is sometimes thought to be regressive as those on lower incomes could be expected to spend, on average, a greater proportion of their incomes on transport than those on higher incomes. In developed economies, this pattern may not be as severe as first thought - fuel taxes are mildly regressive as a proportion of annual income (Morris and Sterner, 2013; IFS, 2012), but less so when considered against lifetime incomes (Poterba, 1991). Measured as a proportion of annual expenditure - a closer proxy for lifetime incomes - fuel taxes are broadly proportional across income groups (Morris and Sterner, 2013). OECD (2014) indicates that when measured as a proportion of expenditure, fuel taxes in Turkey are in fact progressive.

The impact of changing tax rates on diesel is not uniform across any particular income level, as the impact would primarily be felt by households with diesel vehicles. In the short-term, the ability of these households to respond to the increase in the tax will be constrained to the extent they are able to respond by reducing their travel in the diesel vehicle (either through reductions in the total distance travelled or

substitution towards another form of transport) and is also inelastic in the longer-term (Dahl, 2012). Considering the impact of changing tax rates on diesel alone on distributional concerns, therefore, requires a deeper understanding of patterns of diesel vehicle ownership and use by different household types. A related OECD workstream will investigate this in more detail.

To the extent that those on higher incomes are more able to afford to replace a personal car, and to do so with an often more expensive diesel car, the benefit of the current tax differential of diesel will be disproportionately captured by those on higher incomes. Further, the environmental consequences of diesel use – particularly the health costs of air pollution – are disproportionately likely to be borne by those on lower incomes (Bell and Ebisu, 2012). The distributional consequences of the status quo should also be considered against any changes in tax rates to align the taxes on gasoline and diesel better with their respective environmental impacts.

Policymakers have a range of other tools available that could be considered alongside tax changes to address certain of these concerns. Transitional time and gradual introduction of any changes would allow households who are more adversely affected to adapt in advance of any increases in the rate. More targeted forms of assistance could be provided for those in particular need, for example through returning some of the revenues from increases through direct transfers or tax rebates.

Concerns about industrial competitiveness, fairness, and the impacts of increased energy prices (and flow-through) on low-income households are important elements that should be carefully considered alongside the environmental and other social costs of fuel rates when designing the transition to road fuel taxes that better align with environmental impacts. It is not clear, however, that fuel taxes are the best mechanism available to policymakers to address these concerns. From an environmental perspective, wherever possible, it is generally preferable to use other, more targeted, tools to address these concerns to avoid providing adverse environmental signals.

5. Conclusion

Drawing on the analysis, some broad conclusions about the respective levels of gasoline and diesel taxes across the OECD can be made.

Firstly, the environmental and other social externalities associated with diesel and gasoline use do not support the lower tax rates that currently apply to diesel. The CO₂ emissions per litre of diesel are higher than for gasoline implying that a tax component reflecting these costs should be higher for a litre of diesel than for a litre of gasoline. The level of most harmful air pollutants is also generally higher for diesel cars, although the emergence of new technology and vehicle standards has lowered these impacts and may continue to do so. This too implies a higher tax rate per litre of diesel fuel. Finally, the costs of the other main externalities associated with road use – congestion, accidents, noise and infrastructure costs – are more a function of distance travelled than of fuel volumes. Since diesel vehicles generally travel further on a litre of fuel than gasoline vehicles, this also implies a higher tax rate per litre, perhaps based on the relative higher energy content of diesel fuel or on the typical fuel efficiency advantage of diesel cars.

Secondly, the higher fuel efficiency of a diesel vehicle compared to a similar gasoline model does not warrant, from an environmental perspective, the lower tax rates applied to diesel. This is for many reasons:

- Taxes on diesel and gasoline are based on the amount of fuel used. Therefore, the appropriate consideration in internalising externalities is the size of the externality in relation to the amount of fuel used, rather than the distance travelled. This means that for costs linked to the amount of fuel use, such as greenhouse gas emissions and emissions of local air pollutants, where diesel has a higher rate of emissions per litre, taxes on diesel should

simply reflect the greater amount of damage per litre. The fuel efficiency advantage of diesel engines is not relevant to the question of air pollution or carbon emissions per litre of fuel. For costs that are more closely linked to distance travelled, such as congestion, accidents, noise, and infrastructure wear-and-tear, the greater fuel efficiency of diesel vehicles implies that a higher tax rate per litre is appropriate for diesel.

- The greater fuel efficiency of diesel cars relative to their gasoline counterparts is not a sound rationale for a tax preference to encourage greater use of diesel vehicles. The higher efficiency of diesel vehicles is reflected in lower fuel costs over time and this benefit is entirely captured by the owner. Using taxation to lower the relative price of diesel may lead to a rebound effect by encouraging car owners to drive more or to purchase a larger vehicle, potentially reducing or eliminating the environmental benefit from higher fuel efficiency.
- Moreover, with a tax rate set on a per litre basis, fuel efficiency will lower the tax paid per kilometre, providing its own incentives to increase fuel efficiency regardless of the difference between gasoline and diesel rates.

Thirdly, policy settings that reduce externalities from fuel or road use also need to be considered when setting tax rates. The impact of vehicle standards in reducing local air pollutants will decrease the level of the tax per litre required to internalise the remaining externalities. The use of road pricing, congestion charging, or noise controls would similarly lower the externalities that should be included. Higher fuel efficiency, however, does not provide a reason to lower tax rates on a per litre basis as the level of externality per litre remains unchanged. Conversely, for costs which are a function of distance travelled, higher fuel efficiency instead increases the tax rate per litre of fuel needed to internalise these costs (Parry, 2007).

Fourthly, fuel taxes are not determined on environmental grounds alone. Considerations related to revenue raising, economic growth, industry policy, competitiveness and equity matter as well. Gradual removal of the diesel differential would allow households and firms to adapt to the changing relative costs of road fuels, so that better environmental performance is attained with minimal transition costs.

To ensure that the taxation of both fuels is neutral from an environmental perspective, taxes per litre of diesel should be *at least* equal to the rate applied to a litre of gasoline. For distributional and competitiveness reasons, this may be a useful first step towards true alignment with relative environmental impacts. Ideally, the tax rate would include a component per litre that is equal in carbon terms to reflect the higher contribution to climate change caused by a litre of diesel. Given the greater air pollution associated with the use of a litre of diesel fuel and the need to impose a higher rate of tax on diesel to reflect the higher costs associated with road use due to its greater fuel efficiency (as a diesel vehicle will likely drive further per litre, incurring more road use costs per litre than a gasoline vehicle), this suggests that a second component be added to the carbon component per litre of fuel. For diesel, this second component should at least be equal in energy terms to the similar component on gasoline, as a proxy for the air pollution and other impacts associated with road fuel use.

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