Chapter 2. Tax revenue scenarios in road transport: A conceptual framework

This chapter introduces the conceptual framework used to describe the main characteristics of the taxation of road transport, encompassing the three main tax bases in the sector: energy use, vehicle stock and road use. The chapter also discusses how different tax types contribute to specific aspects of a sustainable tax policy strategy over the long term, taking revenue, fairness and efficiency considerations into account. Finally, the chapter discusses the degree of tax base disaggregation that is relevant to answering strategic questions concerning transport tax policy.

This chapter introduces the conceptual framework used to describe the main characteristics of the taxation of road transport. It first introduces a revenue function encompassing the three tax bases in the sector: energy use, vehicle stock and road use. Second, it considers the contribution of different tax types to specific aspects of a sound revenue-raising policy. Third, the chapter concludes by discussing the degree of disaggregation of the main tax bases necessary to capture shifts in tax bases that are relevant to answering strategic questions concerning transport tax policy.

2.1. A revenue function in road transport

Governments collect tax revenue in road transport from three tax bases: energy (*E*), vehicle stock (*V*) and road use (*M*), i.e. kilometres driven, which can be summarised in the following revenue function:

$$Revenue = R_E + R_V + R_M \qquad (1)$$

$$= \sum_i (tax_i * Joule_i) + \sum_j \left(tax_j * nb\ vehicles_j\right) + \sum_k (tax_k * km\ driven_k)$$

Revenue from energy (R_E) relates to energy purchases in a country. It includes all energy types, i, such as gasoline, diesel and electricity, used in road transport. Currently, energy use in road transport derives predominantly from fossil fuels, but may shift towards alternative fuels following technological advances, falling prices for alternative fuel vehicles and stringent climate or air pollution policies. The energy base comprises fuel that is bought (and taxed) within a country, even if combusted abroad. Countries tax energy in road transport generally via excise duties per litre of fuel or specific taxes on the carbon content of the fuel (OECD, 2018[1]). Sometimes emissions from road transport and electricity production are instead, or additionally, covered by an emissions trading system (OECD, 2018[2]).

Additional revenue (R_V) is collected from motor vehicles that are registered in a country. Tax rates can depend on a combination of specific vehicle characteristics, *j*, for example, a vehicle's type (i.e., whether the vehicle is a bus, passenger car, truck, motorcycle), engine power, weight, type of fuel used, whether the vehicle is used for commercial or personal purpose, or according to the environmental performance of the vehicle. Countries tax motor vehicles, for example, via one-off registration or sales taxes and via recurrent taxes on vehicle use or ownership. These taxes usually take the form of specific taxes or ad valorem taxes on the price (OECD, 2018[3]).

Revenue can also be derived from road use (R_M). Countries can tax the number of kilometres driven, where driving types, *k*, distinguish, for example, between specific vehicle characteristics, driving on specific roads (tolled vs non-tolled), driving at a specific time of the day, or can depend on an area's population exposure or congestion level. Typical road-pricing systems take the form of distance charges (e.g. motorway or city tolls) or congestion charges. Alternatively, taxation can take an access charge approach, for example in form of a vignette or some types of congestion charging (e.g. cordon fees). Such systems require fees to be paid to access the public road network for a specific period of time, but have no direct link to the amount of kilometres driven.

The three tax bases in road transport are connected. For example, driving a given distance with a specific vehicle technology determines the amount of energy that a vehicle uses; e.g. driving 100 km with an efficient internal combustion engine requires less energy than driving the same amount of kilometres with an inefficient engine. To represent the relationships between tax bases, the present analysis makes some assumptions (e.g. on the average number of kilometres driven and the average fuel used per vehicle technology and a given vehicle age), which are further discussed in Chapter 5.

The revenue function in equation (1) helps to illustrate how the technological trend towards more fuel-efficient and alternative fuel vehicles may affect tax bases differently. For example, improving the fuel-efficiency of internal combustion engines reduces the amount of fuel used to drive a given distance everything else equal. Shifts towards vehicles using alternative fuels will affect the vehicle and energy tax base. Chapter 5 presents details on the technology scenarios used in the analysis and their impact on the three tax bases.

Finally, the revenue function is useful to illustrate implications of tax reform on revenues. For example, increasing fuel taxes will have the immediate effect of increasing tax revenues via the impact on R_E. However, drivers may reduce fuel consumption as a consequence of higher fuel taxes, either by driving less or by driving more efficiently (e.g. through shifting towards more fuel-efficient vehicles or alternative fuel vehicles) or both. Chapter 6 simulates the tax base and revenue effects under different tax reforms in the transport sector, while considering these types of behavioural responses.

2.2. Sound revenue-raising from taxation in road transport

Fair and efficient revenue-raising in road transport requires consideration of issues related to revenue stability, tax competition, tax system efficiency, administrative costs, as well as fairness and equity implications. This subsection discusses these themes, differentiating, where necessary, between fuel and carbon taxes, vehicle taxes and charges on road use. Table 1.1 in the introduction provides a summary of the findings.

2.2.1. Revenue stability

Stability of transport tax revenues depends on the responsiveness of tax bases to changes in tax rates, and this varies with specific design features of a tax and the broader economic context. For example, consumer responsiveness to taxation varies with the original price level (i.e., are prices high or low before the tax reform), household characteristics (such as income and geographical location), and the availability of substitutes, e.g. public transport and car-pooling (Douenne, 2018[4]; Gillingham and Munk-Nielsen, 2019[5]; Spiller, Stephens and Chen, 2017[6]). If substitutes are expensive or unavailable, behavioural responses may only occur at high price levels. In contrast, where substitutes are readily available at small additional cost, price response can be substantial even at relatively low price levels.

The responsiveness of tax bases to changes in prices, or in tax rates, is generally expressed via *backward-looking* elasticities that are less informative in the present situation, where the likelihood of deep change is significant. Usually, estimates of elasticities relate to past fuel consumption, vehicle use or kilometres driven, i.e., consumer behaviour that is associated with the circumstances prevalent at that time, such as income levels and available substitutes. Such backward-looking elasticities are useful to evaluate future trends only to a limited extent in a situation where technological progress has the potential to develop alternative means of transport and change relative prices deeply, and where a sectoral transformation is sought.

Another aspect of revenue stability is inflation. Often fuel excise applies as a volumetric unit charge, and nominal tax rates do not always automatically increase with inflation. Therefore, real tax rates decline, gradually eroding tax revenue (OECD, 2018[1]). Mahler et al. (2017[7]) determine substantial revenue forgone from energy taxes in Germany because nominal tax rates are not adjusted for inflation. Some countries index statutory tax rates for inflation, including Australia, Chile, Denmark, the Netherlands, Norway and Sweden.

The literature suggests that excise duties and carbon taxes on fossil fuels may be an attractive instrument to raise stable revenue in the short run given the relatively low short-run responsiveness of the tax base to prices. Meta-analyses of backward-looking elasticities by Graham and Glaister (2002[8]) and Labandeira, Labeaga and López-Otero (2017[9]) find that gasoline consumption typically reduces around 2-3% in the short run when fuel prices rise by 10%, while the responsiveness is larger in the long run (see also Braathen (2000[10])). Recent studies have found much larger behavioural responses to changes in tax rates than to changes in pre-tax prices of a similar magnitude (Rivers and Schaufele, 2015[11]). The potential of fuel taxes to foster a switch towards more fuel-efficient and alternative fuel vehicles reduces their potential to generate stable revenue streams in the longer run.

The stability of revenue from vehicle taxation depends on the design of the tax. A periodic tax on vehicle ownership or circulation (i.e. usage) induces a fairly stable revenue flow, whereas the one-off character of a registration or a purchase tax renders revenue dependent on fleet turnover and the business cycle. Vehicle taxes can inadvertently set up a tension between revenue raising and environmental objectives. For example, a registration or purchase tax may reduce fleet turnover and thereby technology take-up, because it can push households to delay buying a new car. Ad valorem taxes, which apply as a percentage on the sales price of a vehicle, that do not vary with environmental criteria tend to incentivise price-sensitive households to choose relatively cheaper or second-hand cars instead of cars with new and expensive technologies.

Distance-based charges can help establish a relatively stable revenue stream when transport decarbonises, because they primarily relate to driving and not to the amount of fuel that is used to drive. Although distance-based charges incentivise driving fewer kilometres, few substitution possibilities for driving exist in the short to medium run in areas where public transport networks are not well developed. This lack of alternatives reduces the elasticity of driving compared to the elasticity of fuel consumption and improves the efficiency of raising revenues via distance-based charges (Parry and Small, 2005[12]). (In the long run, Molloy and Shan (2013[13]) suggest that households may consider changes in transportation costs in their residential location choice, if they have decided to relocate anyways.) Drivers also seem to respond less strongly to fuel prices in adjusting distances driven than they do in adjusting fuel consumption (Small and Van Dender, 2007[14]), which makes driving a more stable tax base and taxes related to driving a superior tool to raise revenues in the transport sector. Distance-based charges are also a promising tool to raise revenue in a future with more automated vehicles and shared services, because, similar to other tax categories, they can be made neutral with respect to the ownership or the usage of the vehicle.

The revenue stability from distance-based charges depends also on the design of the tax. Instruments that reflect driving behaviour, such as distance-based or congestion-based schemes, will perform better in targeting driving behaviour. Conversely, vignette systems are charged per vehicle and driving period, but do not vary with the amount or the timing of driving. This makes them equivalent to a tax on accessing the road network, instead of a charge on driving, which limits their potential to manage driving behaviour fairly and efficiently and to raise revenues. Mandell and Proost (2016[15]) mention that vignettes raised less revenues than comparable distance-based charges in Europe in the past.

2.2.2. Tax competition

International competition for mobile tax bases can affect the potential to raise tax revenues in the transport sector, in particular, revenues related to the fuel tax base (but also related to the driving base, if a jurisdiction can be bypassed easily). Vehicle taxes apply only to domestic vehicles, which reduces the potential for international competition.

Fuel tourism can significantly affect tax revenues collected from fuel taxes and lead to tax competition across jurisdictions. Governments levy excise duties and carbon taxes in the country where fuels were purchased, as opposed to the territory where the vehicle is driven and the fuel ultimately combusted. Jurisdictions may set low rates in the hope of attracting foreign fuel tax bases. Tax competition can push drivers to alter their routes, not for a specific destination, but solely to refuel their tanks and benefit from low excise duties.

The impact of fuel tourism on tax revenues can be particularly strong with respect to diesel used in trucks, as trucks often travel internationally and can store large quantities of fuel (Mandell and Proost, 2016[15]). Fuel tourism at the passenger car level occurs particularly in border regions. Its intensity depends on different factors, including transport costs (e.g. distance to a border, valuation of time and frictions related to language, money, and border procedures), but also on income, infrastructure, and the availability of alternative travel modes (e.g. public transport). Recent studies find evidence for fuel tourism across European countries and US states (Banfi, Filippini and Hunt, 2005[16]; Manuszak and Moul, 2009[17]). Recently, Kennedy et al. (2018[18]) suggested that in the Republic of Ireland approximately 9% of tax revenues from excise duties in road transport may be attributed to fuel tourism.

Tax competition for mobile tax bases is particularly likely in interconnected geographical areas, where competences for setting tax rates are heterogeneous and border crossing is simple. For example, Evers, de Mooij and Vollebergh (2004[19]) and Paizs (2013[20]) find evidence that European governments strategically set diesel excise levels in response to tax rates or tax changes in neighbouring countries. In line with findings from the general tax competition literature, e.g., in Kanbur and Keen (1993[21]), small countries seem to set lower diesel tax rates than large countries (Paizs, 2013[20]; Rietveld and van Woudenberg, 2005[22]). De Borger and Proost (2012[23]) discuss the different mechanisms for governments' strategic behaviour in setting transport tax rates and the related theoretical literature. Analyses of fuel tax competition do generally not look at governments' tax setting behaviour when tax bases erode exogenously (e.g. from technological evolution) as in the present case.

The European Energy Tax Directive (2003/96/EC) sets minimum excise duty rates, which limits the erosion of rates via tax competition across European member states to some extent. Currently, minimum rates are set at EUR 0.359 per litre of petrol and at EUR 0.330 per litre of diesel. The minimum rates prevent countries from taxing fuel below these levels, but they have "not been sufficient to prevent the persistence of significant divergences" across EU member states (European Commission, 2007[24]). The EU minimum rates have not been revised since 2003 and reflect neither the energy content nor the CO_2 component of fuels. This results in taxation that is not neutral across fuels and may bias decisions towards less taxed fuels, which are not necessarily the most socially efficient choice.

In the context of tax competition, distance-based charges provide some advantages over alternative tax instruments. While vehicle taxes cover a country's residents only, distance-related taxes or congestion charges are independent of the nationality of the driver and instead relate to the territory where driving takes place. At the same time, the risk for base erosion through tax competition plays a less prominent role for distance-related taxes than for fuel taxes – at least in those countries that drivers cannot bypass easily. A co-ordinated approach across several countries within a specific transit region may reduce the potential for tax competition further.

Mandell and Proost (2016[15]) suggest that distance-based charges for trucks can be "contagious" across countries and be the preferred tool in a country's tax competition game. They find that the possibility to tax distances on top of fuel use allows countries to attract commercial driving through reduced fuel taxes while keeping revenues stable via the distance tax. However, existing regulation in Europe may mitigate these competition effects, particularly in countries where fuel taxes are set at the minimum level and where caps on the level of distance-based charges are binding.

2.2.3. Tax system efficiency

Optimal taxation theory provides no reason for taxing intermediated goods (e.g. commercial trucks and cars or fuel used for work related travel) in a situation where externalities are priced. By the Diamond and Mirrlees (1971[25]) result, taxing intermediate inputs to production will distort the allocation of resources away from the taxed towards the non-taxed input. In the case of commercial trucks, for example, a high vehicle tax would distort decisions away from using trucks in production processes towards more expensive inputs, even if they yield equivalent outputs and environmental effects.

Intermediate inputs that generate externalities, such as fuel and vehicle use and driving, should ideally be taxed at a rate that reflects external costs. Currently, the full range of external costs from driving are under-priced in many countries. This includes estimates of external costs which relate to using fossil fuel technologies during driving (e.g. carbon emissions, air pollution and noise), but also those costs that are unrelated to fossil fuel use and would remain present even under a fully decarbonised vehicle fleet (in particular, accidents, congestion, road damage, noise, use of public space and reduced mobility for non-drivers). Van Dender (2019[26]) gives an overview of some of the driving-related external costs by kilometre in different contexts, e.g. rural vs urban driving, different degrees of congestion.

Fuel taxes and distance-based charges are more efficient in targeting driving-related external costs compared to vehicle taxes. The latter are suboptimal in this respect, as vehicle taxes can only account for average vehicle characteristics, but not the externalities related to driving behaviour, the amount and the place of driving (Van Dender, 2019[26]).

Fuel taxes are a good instrument to account for external costs from CO_2 emissions, because these emissions are proportional to fuel use. However, they target other driving-related external costs less well, in particular those that depend heavily on vehicle technology, driving behaviour, the specific driving location and pollution exposure that varies across geographic areas.

Vehicle taxes can differentiate according to the emission profile of a vehicle, including both local air pollution and carbon emissions. Focussing vehicle taxes only on fuel-efficiency or CO_2 emissions can stimulate the sale of diesel cars despite their negative impact on health and the environment through air pollution (Teusch and Braathen, 2019[27]). The vehicle purchase tax in Israel, for example, accounts for many different emissions, including carbon dioxide, particulate matter and nitrogen oxides (OECD, 2016[28]). Current vehicle taxes do generally not account for the observed gap between real-life emissions and the advertised emission profiles derived from test cycles. For given tax rates, the increasing gap between test and real-world emission values leads to substantial amounts of tax revenue forgone in 11 European member states (Forum Ökologisch-Soziale Marktwirtschaft / Green Budget Germany and Green Budget Europe, 2018[29]).

Distance-based charges, if carefully designed, have the potential to deliver more efficient road transport because they can reflect additional external costs related to driving (Parry and Small, 2005[12]). For example, distance-based charges can vary depending on the average pollution profile and weight of a vehicle and as such reflect the costs related to air pollution and road damage. They can also mirror spatial and temporal variation in driving; thereby reflecting population exposure to external costs, such as noise and air pollution, and integrating costs from congestion during peak hours and locations. Neither fuel nor vehicle taxes are able to integrate the external costs from driving differentiated by location and time as efficiently as distance-based charges do (Van Dender, 2019[26]).

In the EU, distance-related charges for trucks apply within the framework of the EU Eurovignette directive (1999/62/EC) and subsequent amendments (2006/38/EC and 2011/76/EU). The original Eurovignette directive said that charges should relate to costs for developing, constructing and operating the network. Revisions of the directive complement this "user pays principle" by a light version of the "polluter pays principle", i.e. current truck toll rates may vary to a certain degree in order to account for environmental (air pollution and noise) or traffic management objectives. However, maximum values on external cost charges limit their potential to reflect full external costs from driving. For passenger cars, no specific EU legislation exists. Pricing road use, by cars or trucks, also needs to respect the broader principles set out in the EU Treaties, in particular the principle of non-discrimination on the grounds of nationality.

2.2.4. Fairness and equity implications

The potential distributional consequences stemming from transport tax reform need to be considered. Estimating and presenting the distributional effects along income and spatial dimensions can form a basis for designing accompanying policy measures that may support tax reform. Accompanying measures may advertise and encourage the use and development of alternative travel modes (such as public transport or car-pooling) and support households that are affected disproportionally by the reform in the short run, but cannot easily adjust to the reform due to budget constraints. Bento (2009[30]) shows that different support measures (flat transfers, income-based transfers or distance-based transfers) can have important and different impacts on the distributional impacts of gasoline taxes.

Distributional effects of fuel taxes differ across countries, income levels (Sterner, 2012[31]; Flues and Thomas, 2015[32]) and geographic areas within a country, because differences in work distances play an important role in driving patterns. For example, fuel taxes may place a disproportionally high burden on households living in rural areas (see simulation in Bureau (2011[33]) and Spiller, Stephens and Chen (2017[6])), who cannot reduce driving needs in the short run by substituting towards public transport, moving location or changing jobs. Similarly, in the absence of revenue recycling, distance-based charges may have adverse effects on households with long commutes and that cannot easily adjust driving patterns in the short run. (Levinson (2010[34]) reviews the equity effects of road pricing.)

Vehicle taxation also has equity impacts. Ad-valorem vehicle taxes may be progressive if low-income households purchase less expensive cars more often. In addition, if vehicle taxes are differentiated by emission bands, providing lower rates for more efficient vehicles, and if high-income households predominantly drive fuel-efficient cars, the tax could be regressive. Fully exempting electric vehicles from taxation likely benefits predominantly high-income households that can afford purchasing these vehicle types.

The widely applied tax exemptions and benefits for electric vehicles are not only expensive in terms of revenue foregone, but are likely to be regressive too. Borenstein and Davis (2016[35]) show that an income tax credit in the United States for plug-in electric vehicles disproportionately benefits the top income quintile, receiving 90% of all credits. The authors explain this strong regressive effect by the fact that low-income households may not invest in expensive electric vehicles and by the non-refundability of the credit. A recent study by Muehlegger and Rapson (2018[36]) shows that means-tested subsidies directed towards low- and middle-income buyers in California achieve electric vehicle take-up in this segment of the market, but that the revenue cost is large.

2.2.5. Administrative costs

The costs of collecting fuel taxes are relatively low. Fuel excise and carbon taxes are relatively easy to administer, as the number of fuel producers or importers is low. Compliance costs for taxpayers are usually low too. Where fuel used for commercial purposes benefits from reduced rates, compliance costs increase, as it requires truck companies to either file refund claims in all countries where fuel was purchased or to adjust tax returns and respond to audits.

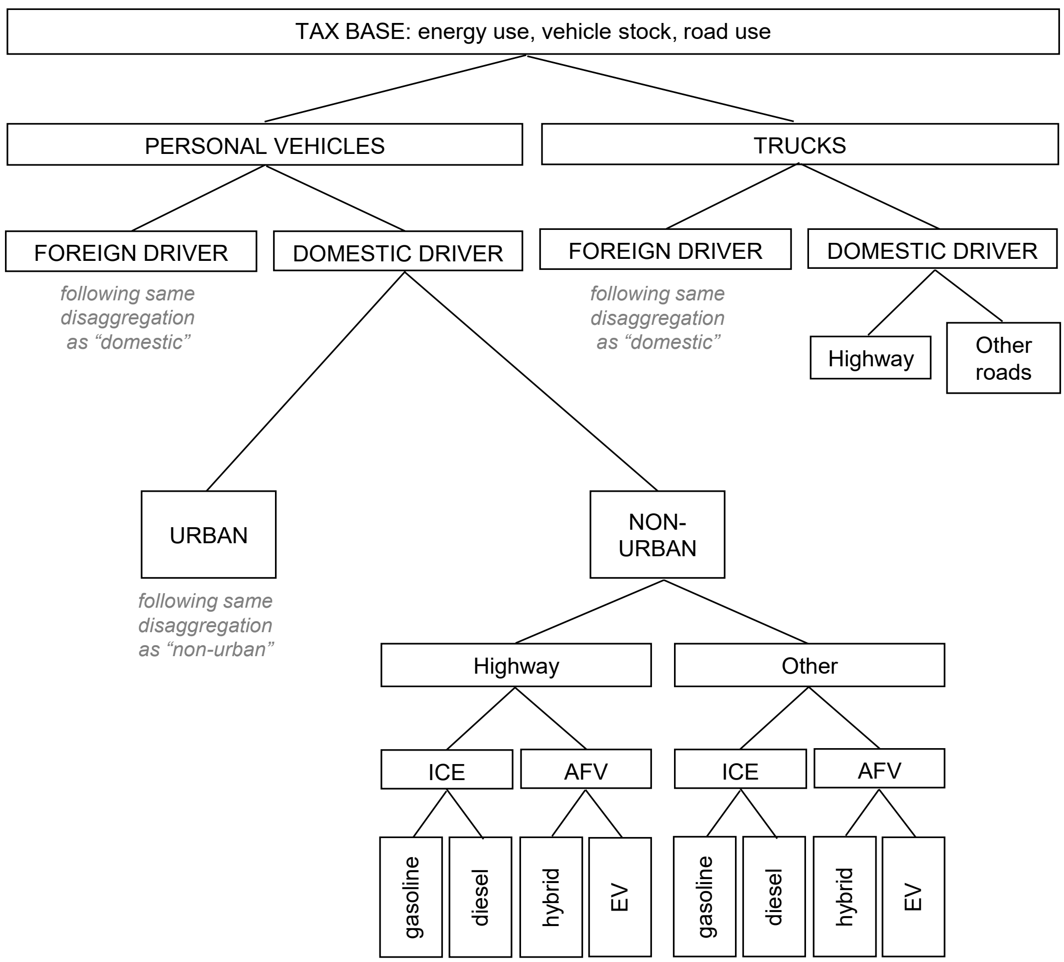
In view of the higher revenue stability and the better management of external costs from driving, distance-based charges becomes an appealing option to fuel and vehicle taxation, even if the administrative costs of managing the former are more important. Van Dender (2019[26]) reviews literature on the costs of electronic tolling systems, concluding that distance-based charging systems have historically been expensive, but that historical data may not be a good indicator to predict costs in the future. Technological progress in charging techniques allows systems to become fine-tuned to particular circumstances and be run efficiently to bring costs down compared to historical estimates. In countries where tolling infrastructure already exists, benefits to extending distance-based charges to a wider tax base may outweigh additional costs.

Privacy concerns about data collection through distance-based charging system should be addressed. For example, simple odometer readings can assess distances travelled by a vehicle without detailed information on the driving, but such systems cannot implement rates that vary with location and congestion levels. GPS-based systems, which track a vehicle's position and driving anytime, can accommodate differentiated rates. Carefully designing GPS-systems may reduce potential privacy concerns. For example, in Oregon's experimental distance-based charging programme and the current German truck tolling system, driving-related data are destroyed as soon as drivers pay their road user charge (Kirk and Levinson, 2016[37]; Langer, Maheshri and Winston, 2017[38]).

2.3. Tax base disaggregation

Simulating the development of tax bases and revenues under different technology scenarios and future tax reform requires disaggregating further the three tax bases (energy use, vehicle stock and road use). The disaggregation needs to capture all margins that are relevant to answering strategic questions concerning transport tax policy. For the present analysis, the relevant shifts in tax bases derive both from technology change and from potential behavioural adjustments to tax reform. A potential disaggregation is sketched in Figure 2.1.

Figure 2.1. Disaggregation of tax bases along relevant behavioural and technology margins



Note: AFV = alternative fuel vehicle; EV = electric vehicle; ICE = internal combustion engine.
Source: OECD/ITF representation.

Breaking down the tax bases into personal as opposed to commercial vehicles, such as trucks, captures the fact that these vehicle categories use different technologies. For example, currently trucks mainly rely on technologies using diesel, while personal vehicles use different types of fuels. In addition, the speed and extent at which these technologies develop in the future likely varies across both categories. (Note that 2- and 3-wheelers, light duty vehicles (i.e. vans), buses or special purpose vehicles are not considered in the analysis.)

Personal and commercial vehicles also differ in their driving patterns and potential behavioural responses to tax reform. Drivers of personal vehicles typically respond to increases in fuel prices by reducing fuel use (see Section 2.2.1), while it is often argued that road freight is relatively price inelastic. However, Graham and Glaister (2004[39]) find that the latter may not be the case as several studies report a decrease in fuel consumption following a fuel price increase in freight, acknowledging that evidence is still sparse.

The simulation would ideally also discriminate between the residence countries of drivers as some tax types, such as vehicle taxes, apply only to domestic drivers. The margins and magnitude of behavioural response to tax reform likely differ in this dimension too. While a foreign truck driver who crosses Europe regularly can decide to refuel in many different countries along the route, a domestic driver, who would not leave the country under general circumstances, will be more restricted in the choice of where to purchase fuel.

It would also be necessary to differentiate some locational aspects of driving, in particular whether a vehicle is driven on a motorway or on other roads, and whether the driving takes place in an urban context or not. When incorporating separate road types, different margins for tax reform can be considered, e.g. the introduction of motorway tolls, congestion charges or other distance-based measures. Since driving behaviour and the availability of substitutes (e.g. public transport) varies substantially across urban and non-urban areas, a breakdown along these lines would be necessary to capture the relevant behavioural responses to tax reform. For example, an increase in fuel taxes may have different implications on driving and energy use-patterns depending on the availability of public transport in specific areas.

Because the tax system in road transport often includes special provisions for alternative fuel vehicles (AFV) as opposed to vehicles with an internal combustion engine (ICE), a further disaggregation in this respect may be useful. For example, beneficial treatment for AFV's is available across a large set of countries, e.g. in the form of vehicle tax incentives or reduced road tolls (German et al., 2018[40]). AFVs and ICEs also use different fuel types and respond differently to changes in fuel taxes as well as technological evolution. A further division of ICEs according to the specific fuel-efficiency of different car models or technology types can capture differences in the energy consumption profiles of these cars.

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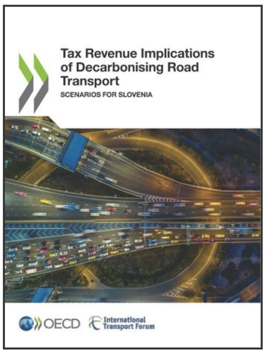

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