Tax Revenue Implications of Decarbonising Road Transport

SCENARIOS FOR SLOVENIA

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Foreword

This report investigates how tax revenue from transport fuels could evolve over time as vehicles rely less on fossil fuels, providing a conceptual framework and data-driven analysis. Reducing the reliance on fossil fuels in the transport sector is a welcome development that will reduce dependence on fossil fuels and improve climate and health outcomes. However, under current settings, reduced fuel use will also lead to a loss of tax revenues, which may put stress on government budgets. Based on simulations for the Republic of Slovenia, the report assesses the taxation of road transport and investigates how tax policy could adapt to declining fossil fuel use in the long term, while maintaining revenues at current levels.

Developing analytical frameworks and data-driven analysis is crucial to understand the various interactions between tax policy and decarbonisation, which is necessary to support OECD member and non-member countries ensure that they understand the importance of undertaking future tax reforms in order to secure sustainable revenue sources over the long term.

This report was discussed by the OECD's Joint Meetings of Tax and Environment Experts. It was approved by the Committee on Fiscal Affairs and the Environment Policy Committee on 19 April 2019, and prepared for publication by the OECD Secretariat and the International Transport Forum (ITF).

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Executive Summary

Excise duties on fuel used in road transport represent a significant share of tax revenue in several countries. Under current policy settings, this tax revenue base will shrink as the fuel-efficiency of internal combustion engines improves and the electrification of the transport sector progresses, driven by policy commitments or the declining costs of electric vehicles. Eroding tax bases lead to declining revenues, which puts stress on government budgets in the long run. Policymakers need to anticipate the potential decline of fuel tax revenues and decide whether and how to respond.

Tax Revenue Implications of Decarbonising Road Transport: Scenarios for Slovenia analyses the revenue implications of potential reductions of fuel consumption in road transport, and investigates potential policy responses assuming that the objective is to maintain total tax revenue associated with road transport. The potential to raise tax revenue fairly and efficiently depends on tax design features beyond revenue stability, such as external cost management, administrative costs as well as fairness and equity concerns. These considerations are discussed in the report.

In the Republic of Slovenia, 14.6% of total tax revenue collected at the central government level in 2016 came from excise duties and carbon taxes levied on diesel and gasoline used in road transport. The report provides an in-depth assessment of the Slovenian transport tax system, focusing on the three main tax bases in the sector: vehicles, fuel use and road use. It explores revenue impacts under current policy settings and for different scenarios on the take-up of new vehicle technologies. Against this background, it then analyses different tax policy reforms with a 2050 horizon. The tax reforms include changes to fuel and carbon taxes, vehicle taxes and distance-based charges, and consider the potential behavioural responses to tax reform. Together, the scenarios describe potential revenue erosion in road transport and orders of magnitude of alternative tax policy response to compensate for it.

The analysis is based on a model developed for the purpose of this study and which links tax revenues to potential developments of tax bases in the long run. The model combines detailed micro- and administrative data with scenarios of technology take-up. While the evolution of technologies and vehicle fleets is uncertain, the report applies scenario analysis to provide a plausible narrative about potential tax base developments, with no predictive intent. The model is flexible and applicable to a broad set of countries with varying tax policy questions. It is also capable of handling data sources of different granularity.

Key findings:

Under current policies, tax revenues from diesel and gasoline use in private cars is likely to decline substantially in the coming decades in Slovenia.

- Under the assumption that fuel-efficiency improves in line with European standards until 2030 and that alternative fuel technologies account for roughly 60% of new car purchases in 2050, total tax revenues from fuel used in passenger cars in Slovenia would drop by 56% between 2017 and 2050 if demand for cars and car use develops as expected.

- The picture for trucks is different, with a less pronounced drop in fossil fuel use over the 2050 horizon, due to a slower expected take-up of alternative technologies. Furthermore, Slovenia's current toll system for trucks provides an effective means to raise revenue independently of fuel use.

Gradually reforming the tax system, starting now, allows for a smooth adaptation to technological changes in the vehicle fleet and the timely implementation of accompanying measures.

- Technological changes, e.g. a transition towards more fuel-efficient and alternative fuel technologies, take time to percolate through the car fleet. Therefore, fuel tax revenues from private cars erode only gradually over time, which leaves leeway to adapt tax policy.
- For example, a relatively modest charge on all kilometres driven on Slovenian motorways that gradually increases over time may cover the revenue loss from fuel taxes on passenger cars. For the main technology scenario and assuming motorway use develops as expected, this charge would start at a level of EUR 0.007 per kilometre in 2020 and increase to EUR 0.046 per kilometre in 2050.
- However, reform implementation also takes time and requires preparation and discussion with stakeholders. Early preparation and a gradual approach will reduce the risk of disruption. It will also create room for carefully designing policies, tailoring communication and developing the necessary accompanying measures.
- Accompanying measures could encourage the development of alternative travel modes, such as public transport, or take the form of support to those households that are affected disproportionally by the reform in the short run, but cannot easily adapt to the reform due to budget constraints.

Shifting from taxes on fuels to taxes on distances driven can contribute to more sustainable tax policy over the long term, improving environmental and mobility outcomes.

- In the long run, revenues can be sustained by gradually increasing fuel or carbon taxes, to cover the external costs closely related with fossil fuel use, and by phasing-in distance-based charges for cars, to reflect external costs closely related with distances driven. Such a tax system would gradually shift revenues to an alternative and likely more stable tax base, distance driven, while further reducing distortions.
- An efficient distance-based system for passenger cars would provide a direct link to the amount of kilometres driven, instead of charging an all-you-can-drive access to the road network. This requires phasing out the current vignette system for cars and adopting a distance-based system, as currently applies to trucks.
- The existing distance-based charging systems for trucks could raise revenue and manage external costs more efficiently, in particular congestion as well as air and noise pollution, by differentiating rates by time and place to account for congested nodes in the network and population exposure to pollution.

- Maintaining total transport tax revenue may not be the foremost objective of a sustainable tax policy strategy. Efficiency considerations imply aligning tax rates with external costs closely related to vehicle, fuel use and road use. Options for tax reform outside the road sector are available too and may further improve the efficiency and effectiveness of the overall tax system.

Chapter 1. Introduction and key policy recommendations

This chapter provides the context and motivation for the analysis of how tax revenue from transport fuels could evolve over time as vehicles rely less on fossil fuels. Based on simulations for the Republic of Slovenia, the report provides an in-depth assessment of the taxation of road transport and suggests how tax policy could adapt to declining fossil fuel use in the long term. The chapter also provides the main results from the analysis and specific policy recommendations. The analysis shows that tax revenues from fossil fuels used in private cars may decline substantially in the coming decades. Gradual tax reforms, with an evolving mix of taxes, shifting from taxes on fuel to taxes on distances driven, could contribute to more sustainable tax policy over the long term.

This report analyses how tax revenue from road transport in the Republic of Slovenia might evolve as the use of fossil fuels in road transport declines. Reducing the consumption of fossil fuels is a welcome trend, for example from the climate or health perspective and in terms of reduced energy dependence, but may put stress on government budgets. In 2016, revenues collected from excise and carbon taxes on fossil fuels used in road transport represent roughly 14.6% of total tax revenue collected at the central government level in Slovenia.[1] A decline of these revenues raises challenges for the central government's budget.

The aim of this report is to provide an in-depth assessment of the taxation of road transport in Slovenia and to inform about the speed and depth of changes to tax revenue when the vehicle stock shifts towards technologies that rely increasingly less on fossil fuels. It studies different options for tax policy reform that may stabilise tax revenues in the long run.

Several transnational trends have the potential to erode fossil fuel tax bases in the transport sector. These are not restricted to the Slovenian economy. In particular, ongoing improvements in the fuel-efficiency of traditional car technologies allow driving a given distance using less fuel. In addition, alternative fuel vehicles, such as battery electric vehicles, plug-in hybrids or fuel cell electric vehicles, increasingly penetrate the car fleet, also reducing the need for fossil fuels. The appeal of alternative fuel vehicles is rising because of falling production costs, increasing driving ranges and lower charging times, as better-performing batteries are developed. In addition, consumer interest in the specific, and often superior, noise and acceleration characteristics of electric vehicles appears to be rising. Finally, political commitments to fight climate change and air pollution are a further impetus to reduce fossil fuel consumption in the transport sector.

Fossil fuels are not the only tax base in road transport. Governments typically collect tax revenues from three tax bases: energy use, vehicle stock and road use. For example, in Slovenia, purchasing fuel involves paying an excise duty and a carbon tax for each litre of gasoline or diesel. The users of motor vehicles in Slovenia are also subject to a one-off registration tax and an annual motor vehicle tax. When driving on Slovenian motorways, a car needs to carry a vignette, while truck drivers pay tolls per kilometre driven.

The three tax bases in road transport interact and the technological trend towards fuel-efficient and alternative fuel vehicles will affect each of the bases differently. The present analysis informs about the potential changes in the composition of the three tax bases over time under different technology scenarios and estimates the resulting tax revenue implications. It further analyses how tax reform may counteract potential revenue losses from reduced fossil fuel use.

The analysis relies on a simulation tool based on a vehicle turnover model that tracks the evolution of transport tax bases over time. In a first step, it evaluates a range of potential scenarios relating to the development of tax bases, i.e., energy use, vehicle stock and road use, in Slovenia between 2017 and 2050. In a second step, the analysis estimates tax revenues given the current tax system in Slovenia (baseline) and evaluates the development of revenues over time based on the scenarios and outcomes from step one. Finally, it simulates different proposals for tax reform and explores their revenue potential. Tax reform simulations focus on fuel taxes, vehicle taxes and the taxation of road use and account for estimated behavioural responses to changes in tax rates.[2]

The evolution of tax bases in road transport depends strongly on technology developments that, at present, remain uncertain. For example, the speed at which fuel-efficiency increases and alternative technologies will penetrate the vehicle fleet in the future remain unclear. Therefore, the analysis estimates future tax bases and revenues under specific technology scenarios. The scenarios are chosen based on a review of the literature estimating the penetration of alternative fuel vehicles. The main scenario used in the present analysis applies the International Energy Agency's 2°C Scenario for Europe (IEA 2DS) to the Slovenian case. A definition of the IEA 2DS is provided in IEA (2017[1]).[3] In line with IEA 2DS, it assumes that alternative fuel technologies account for 25% of passenger car purchases in 2030 and 62% in 2050 – compared to a 2% share in 2017.

Consequently, the analysis does not yield tax base or revenue *predictions*, but derives results from *scenario analysis*. Scenario analysis intends to provide a plausible narrative about potential future developments and appropriate policy responses, which is useful in the context of technology uncertainty. However, results from the scenario analysis have no predictive intent (see Box 5.1).

The assessment leads to the following conclusions and policy recommendations:

- The tax revenue loss from reduced fossil fuel used in private cars may be substantial in the coming decades. Under the assumption that alternative fuel technologies account for roughly 60% of new passenger car purchases in 2050 (following the IEA 2DS) and fuel-efficiency improves in line with European standards, total tax revenues from fuel used in passenger cars in Slovenia may drop by 56% compared to 2017.
- The picture for trucks is different. The drop in fossil fuel use is likely less important over the horizon considered and for the scenarios covered in the analysis, because of slower take-up of alternative technologies. Furthermore, Slovenia's current toll system for trucks provides an effective means to raise revenue independently of fuel use.

A gradual reform of the tax system starting now may allow a smooth adaptation to the technological change in the vehicle fleet. Technological changes take time to percolate through the entire car fleet. Therefore, fuel tax revenues erode only gradually over time, which leaves some leeway to adapt tax policy. However, tax reform implementation also takes time and requires preparation and discussion with stakeholders. Early preparation and a gradual approach will reduce the risk of disruption and create room for developing and implementing the necessary accompanying measures.

Comprehensive transport tax reform to stabilise revenues includes finding the right mix of taxing distances driven, vehicles and fuel. Tax reform simulations show that the revenue potential in the sector is constrained by behavioural responses to tax increases, tax competition and existing regulations. Some of the main findings are as follows:

- Tax reform that increases fuel or carbon taxes and regularly adjusts nominal rates to inflation will effectively raise revenue in the short to medium run in Slovenia. In the longer run, once the low-carbon transformation is on its way, the revenue potential from fuel taxes is limited in the passenger car segment of the market. Setting unilaterally high fuel taxes may trigger fuel tourism and erode tax bases from international drivers, in particular as regards trucks. Higher European Union (EU) minimum rates on fuel excise could help reduce the pressure from fuel tourism.

- Revenues can be sustained in the long run by gradually increasing fuel or carbon taxes that cover the external costs closely related with fossil fuel use in vehicles and by phasing-in distance-based charges for cars to reflect external costs closely related with distances driven. In addition, the existing distance-based charges for trucks could be differentiated further to align better with external costs. Such a tax system would gradually shift revenues to an alternative and likely more stable tax base, road use, while further reducing distortions.

- A more efficient distance-based system for passenger cars would set as a base the amount of kilometres driven. This requires phasing out the current vignette system for cars and adopting a driving based system, as currently applies to trucks. Using the modern electronic toll infrastructure, which is in place on all motorways in Slovenia, will help contain costs of implementing distance-based charges for cars.

- The current distance-based charging systems for trucks could raise revenue and manage external costs more efficiently, in particular congestion as well as air and noise pollution, by differentiating rates along time and place to account for congested nodes in the network and population exposure to pollution.

- Currently, the revenue potential from distance-based charges is limited by regulation. For example, within the EU, current legislation allows rates to vary in line with some environmental objectives (air pollution and noise) and traffic management (congestion), setting maximum values for these external costs. A co-ordinated approach across countries to support a revision of the maximum values to reflect the full driving-related external costs could make the system more efficient.

- Finally, vehicle taxes may also be part of the tax reform package. An advantage of vehicle taxes is their lower administrative burden compared to distance-based charges. However, if they were to cover the shortfall in revenues from fuel excise over time, they would need to increase substantially over time and gradually cover alternative fuel vehicles too. Their limited ability in managing external costs from driving reduces their appeal from a transport and broader mobility perspective.

Designing efficient tax policy requires considerations beyond pure revenue raising concerns. The potential to raise revenue fairly and efficiently depends on design features that relate to revenue stability, external cost management, administrative costs as well as fairness and equity concerns. Table 1.1 shows that fuel, vehicle and distance-related taxes contribute differently to the aspects to long-run revenue stability, which deserves consideration in the discussion of transport tax reform.

Table 1.1. Summary of impact evaluation by tax type

	Fuel or carbon tax	Vehicle tax	Distance-based charges
Long-run revenue stability	☹	☺	☺
External cost management			
- CO_2 emissions	☺	☹	☺
- Air pollution	☹	☹	☺
- Driving-related external costs (e.g., accidents, congestion, noise and air pollution exposure, road damage, use of public space)	☹	☹	☺
Administrative and implementation costs	☺	☺	☹

Note: Actual impacts depend on the exact design of the tax as further discussed in Section 2.2. Additional impact categories are discussed in the report, e.g. equity considerations, but are not reported here for reasons of clarity.
Source: OECD/ITF illustration. Van Dender (2019[2]) provides an in-depth discussion of the contribution of different tax types to external cost management.

Fiscal objectives can provide an impetus for tax policy reform when fuel efficiency improves and alternative fuel vehicles increasingly penetrate the fleet. In the longer run, decarbonisation of transport is necessary to contain the risks of climate change. Policy instruments, including tax policy and carbon pricing, play an important role in this process.

Finally, careful design and tailored communication is essential for the success of comprehensive tax reform in the road sector, given the involvement of numerous stakeholders. In particular, it will be necessary to communicate the benefits of the reform (e.g. in terms of the provision of public services through tax revenue, improved environmental outcomes) and to underline that the reform implies a shift in the composition of the tax burden, but not necessarily in the size of the burden.

However, to gain support for tax reform, it is necessary to develop a good understanding of the potential negative consequences (e.g. how changes in tax liability from reform are distributed along income and spatial dimensions) and to design appropriate policy responses. For example, accompanying policy measures may encourage the development of alternative travel modes (e.g., public transport) in the long run or support those households that are affected disproportionally by the reform in the short run, but cannot easily adapt to the reform due to budget constraints.

The report starts by describing the conceptual framework for the analysis (Chapter 2). Chapter 3 provides information on the current tax system in road transport in Slovenia and Chapter 4 on the data sources that were available for the analysis. Chapter 5 introduces the modelling tool and presents the estimated development of tax revenues over time in the baseline scenario. Chapter 6 simulates and analyses potential tax reforms that may stabilise revenues in the long run.

Notes

[1] The total tax revenue used to calculate the percentage was collected from the OECD Global Revenue Statistics Database. It excludes revenues collected by local governments and social security funds, as these categories are less relevant for transport taxation in Slovenia. Data on fuel tax revenue come from the Ministry of Finance of the Republic of Slovenia.

[2] Keeping revenue stable by raising additional revenue in the transport sector might not be the foremost objective from a sound revenue-raising perspective. Other tax reform options, outside the road sector, may be more efficient. However, for illustrative purpose, the simulations focus on tax reform that can stabilise transport tax revenues in the long run.

[3] The "2°C Scenario (2DS) lays out an energy system pathway and a CO_2 emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100."

References

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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:

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

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

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.

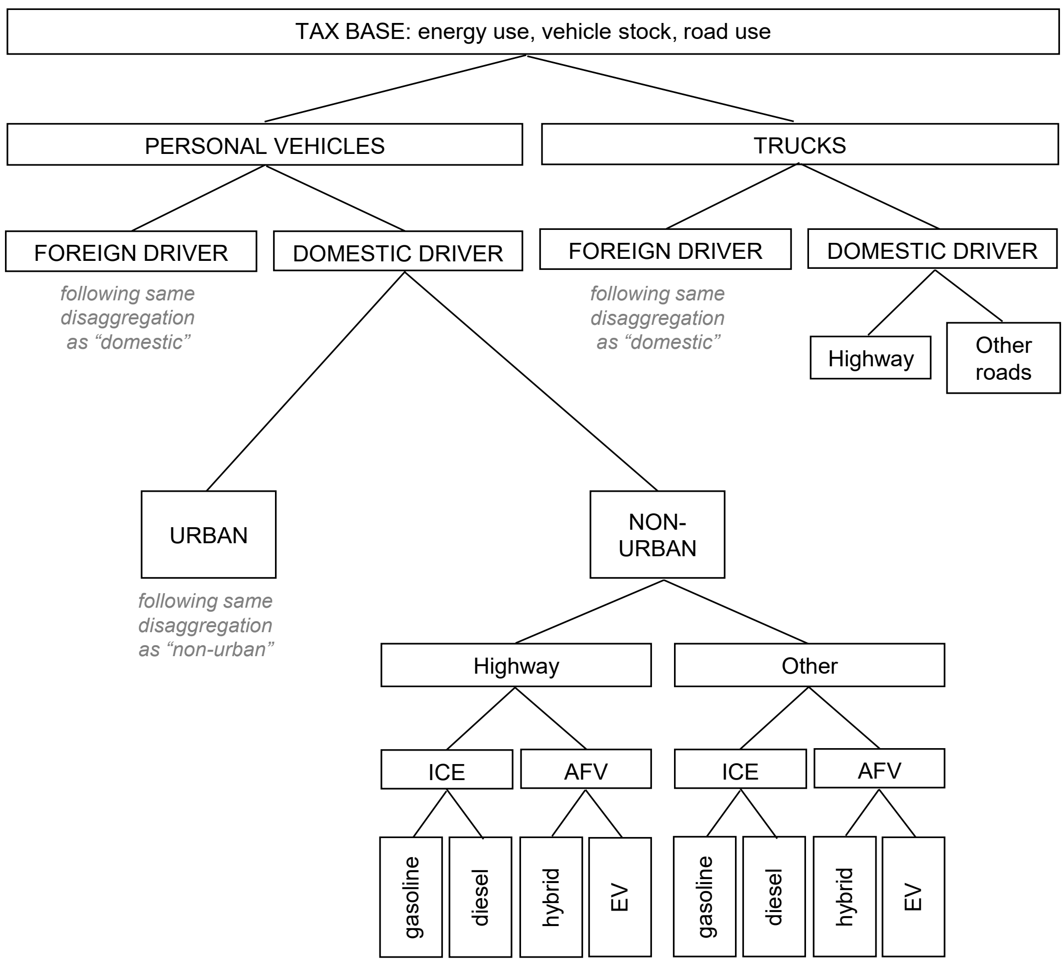
In view of the higher revenue stability and the better management of external costs from driving, distance-based charges becomes an appealing option to fuel and vehicle taxation, even if the administrative costs of managing the former are more important. Van Dender (2019[26]) reviews literature on the 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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Chapter 3. The Slovenian road transport tax system today

This chapter gives a brief overview of the Slovenian tax system for road transport. It describes the different taxes that are levied on the three relevant tax bases (energy use, vehicle stock and road use), their rates and scope in 2017 as well as the associated revenues that were collected throughout 2017.

The Slovenian tax system for road transport covers the three tax bases, energy use, vehicle stock and road use, to a varying extent. This chapter gives a brief overview on the different taxes, their rates and the bases to which they apply in 2017 as well as the associated revenues that were collected throughout 2017.

Fuel purchased in Slovenia is subject to a fuel specific excise duty, a carbon tax and additional taxes. In addition, a 22% VAT rate applies. Slovenia levies energy taxes within the framework of the EU Energy Tax Directive (2003/96/EC), which sets minimum rates for the taxation of energy products in member states of the EU.

For gasoline, Slovenia applies an excise duty of EUR 0.5078 per litre[1] and a carbon tax of EUR 0.0398 per litre. Additional taxes amount to EUR 0.1222 per litre supporting the strategic stockpile, to EUR 0.00736 per litre for promoting energy end-use efficiency, and to EUR 0.00911 per litre for promoting electricity generation from renewable energy sources and high-efficiency cogeneration (European Commission, 2018[1]).

For diesel, the excise duty amounts to EUR 0.4261 per litre[2] and the carbon tax to EUR 0.0467 per litre. The higher carbon tax on diesel compared to gasoline reflects the different carbon content of the two fuels. The additional taxes amount to EUR 0.01166 per litre (strategic stockpile), EUR 0.008 per litre (promotion of energy end-use efficiency) and EUR 0.0099 per litre (promotion of electricity generation from renewable energy sources and high-efficiency cogeneration). Refunds can be claimed for diesel that is used for commercial purposes in trucks above 7.5 tonnes, to the extent that the excise duty rate is reduced to EUR 0.330 per litre (European Commission, 2018[1]).

Electricity use is subject to an excise duty of EUR 0.00305 per kWh and an additional tax of EUR 0.0008 per kWh used to promote energy end-use efficiency (European Commission, 2018[1]). Fuel inputs to the production of electricity are also subject to fuel excise duties, a carbon tax, and the relevant additional taxes. These input taxes are not part of the present analysis, although they form part of government revenue. In addition, electricity production in Europe is covered by the European Emissions Trading System, which adds an additional price on the kWh used in Slovenia. Revenues from the auction of tradable permits are not taken into account in the present analysis.

Two types of vehicle taxes exist in Slovenia.[3] Passenger cars are subject to a one-time motor vehicle tax when they are registered or put into circulation in Slovenia for the first time. The registration tax applies ad valorem, as a percentage of the vehicle’s sales price (excluding VAT) and is restricted to passenger cars only. Tax rates depend on the type of fuel used and the CO_2 emission profile of the vehicle. The registration tax rate is adjusted, for example, according to the vehicle’s environmental criteria based on the European emission standards (EURO), i.e., vehicles associated to a class below EURO 5 are subject to a higher tax. Battery electric vehicles (BEV) pay the lowest rate (0.5%). Exemptions from the registration tax apply to vehicles for large families, disabled people, ambulances, as well as for historic, sport and diplomatic vehicles (Ministry of Finance of Slovenia, 2018[2]).

When registering a vehicle in Slovenia (for personal and commercial use) the vehicle user is also subject to an annual motor vehicle tax. The tax is based on the vehicle category (passenger car, different truck types, buses, motorbikes) and adjusted according to the vehicle’s capacity or weight. For example, passenger cars pay a fixed rate according to their engine capacity (ranging from EUR 62 for engines below 1 350 cm^3 to EUR 565 for engines above 4 000 cm^3). Trucks without trailers are taxed based on the maximum allowed weight (ranging from a fixed rate of EUR 101.94 for trucks below 4 tonnes and a varying rate of EUR 22.86 per tonne for trucks that weigh more than 4 tonnes). The tax increases by class when the vehicle has a rating below EURO 5 and decreases when the vehicle's class is above EURO 4. Several exemptions from the annual motor vehicle tax apply, in particular, vehicles that exclusively run on electricity (BEVs) are exempt from the tax, while hybrids and plug-in hybrids are not exempt (Ministry of Finance of Slovenia, 2018[2]). As opposed to an ownership tax levied independently of registration, the Slovenian annual vehicle tax only applies to users of registered vehicles.

Road use in Slovenia, more precisely motorway use, is subject to either an obligation to carry a vignette or a kilometre-based toll depending on the specific vehicle category. Vehicles that weigh more than 3.5 tonnes pay a kilometre price when driving on motorways, collected through a modern microwave technology system that communicates with installed gantries. The toll rate depends on the number of axles as well as the EURO class of the vehicle and ranges from EUR 0.1464 per km (for EURO 6 vehicles with two to three axles) to EUR 0.5074 per km (for vehicles with more than three axles and an emission class below EURO 3). Vehicles below 3.5 tonnes, on the other hand, are required to have a valid vignette when circulating on Slovenian motorways. The price of vignettes depends on the vehicle category (motorcycles, two-track motor vehicles and caravans), its height and the length of the validity of the vignette. In particular, vignettes are available with a yearly, monthly or weekly validity period.

In 2017, an amount of EUR 7 892 million was collected in total taxes at the central government level in Slovenia (OECD, 2018[3]).[4] Revenues from excise duties and carbon taxes levied on fuels in road transport amount to EUR 1 152 million, representing 14.6% of total tax revenue at the central level. Revenues from vehicle taxes amount to EUR 187.5 million, or 2.3% of total revenues (Ministry of Finance of Slovenia, 2018[4]). Revenues from tolls and vignettes amounted to EUR 431 million in 2017. These funds are collected by the Slovenian motorway company and are not part of the government budget. They represent 5.5% when compared to total tax revenue collected at the central government level.

Although other tax provisions may affect revenues and tax bases beyond those discussed above, they are not included in the present analysis; for example, the tax treatment of commuting expenses and company cars used for private purposes (Harding, 2014[5]). OECD (2018[6]) finds that "the reimbursement of expenses incurred in relation to work-related travel, including transportation costs to and from work, is not taxed under the [personal income tax]" in Slovenia. Generous tax treatment of transport to work allowances reduces tax revenues, although the policy rationale for such benefits (i.e., limited transport infrastructure at the time of introduction) may be less relevant today. Likewise, the analysis does not look at the revenue effects from tax incentives for zero- and low-emission vehicles (such as purchase subsidies for BEVs and PHEVs) or for public transport (German et al., 2018[7]).

Notes

[1] The analysis uses excise duty rates as applicable throughout 2017. The excise duty for gasoline is set at EUR 0.47829 per litre as of 22 May 2018.

[2] The analysis uses excise duty rates as applicable throughout 2017. The excise duty for diesel is set at EUR 0.39272 per litre as of 22 May 2018.

[3] A new tax applies to vehicles that are deregistered as of 1st April 2019.

[4] The figure is based on the OECD Global Revenue Statistics Database and includes revenue collected at the federal or central level. It excludes the supranational level, local governments and social security funds, as neither of these government levels collects taxes on energy use, vehicles or road use in Slovenia.

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Chapter 4. Data

This chapter provides an overview of the different datasets used in the analysis.

This chapter lists and briefly summarises the datasets that were available for the analysis. The model is flexible to incorporate data sources at different levels of granularity.

The full Slovenian vehicle registration dataset is available from the Ministry of Public Administration of the Republic of Slovenia on the OPSI web portal (Ministry of Public Administration of Slovenia, 2017[1]). The present analysis uses the 2017 version of the data, which gives an overview of the entire Slovenian vehicle stock for that year. The data provides detailed information on different vehicle characteristics, such as vehicle category and age, technology, size, fuel-efficiency and EURO class. All 1.2 million passenger cars registered in Slovenia in 2017 are represented.

The vehicle registry shows that in 2017, 52% of passenger cars run on gasoline, while 48% run on diesel. Alternative fuel vehicles were only marginally present (0.2%). In terms of age, 22% of all registered passenger cars were younger than five years and 22% older than 15 years. In 2017, 33 585 trucks heavier than 3.5 tonnes were registered in Slovenia. More than 99% of these trucks were diesel fuelled.

The Statistical Office of the Republic of Slovenia (SURS), provided statistics on driving patterns in Slovenia, comprising the number of vehicle-kilometres driven per vehicle and fuel type, by location and by the country of registration (Statistical Office of Slovenia, 2018[2]).

The Jozef Stefan Institute provided estimates from Slovenia's national energy model in the transport sector up to the year 2035.

Anonymised data on tax revenues collected at vehicle registration in 2017 were obtained from the Financial Administration Office of the Republic of Slovenia (Financial Administration Office of Slovenia, 2017[3]). The dataset indicates – per vehicle registered in 2017 – the size of the tax base (i.e., sales price), the tax rate as well as the amount of the tax payable. Available vehicle characteristics included vehicle and fuel type, CO_2 emissions and EURO class as well as engine power.

Finally, the Ministry of Finance of the Republic of Slovenia provided information on energy purchases in Slovenia and the associated excise and carbon tax revenues based on information from the Financial Administration of the Republic of Slovenia (Ministry of Finance of Slovenia, 2018[4]). In 2016, an amount of 0.6 billion litres of gasoline and 1.6 billion litres of diesel used in road transport were taxed. In 2016, truck drivers claimed tax refunds for commercial diesel on 32% of all diesel purchases. The main part of these refunds reached Slovenian nationals (74%), with Romania, Hungary and Slovakia being the largest foreign beneficiary countries.

References

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Chapter 5. Assessment framework and results for the baseline scenario

This chapter introduces the assessment framework used in the analysis. It describes the simulation tool developed to evaluate the development of transport tax bases over time and to infer implications for tax revenues in the Slovenian road transport sector. The chapter highlights the model structure and scope and presents results for a baseline scenario. It also discusses the main technology scenario adopted for modelling the uptake of alternative fuel vehicles and provides sensitivity analysis to this key input parameter. Tax revenues from fuel excise levied on passenger cars may significantly decline under current policies when fuel-efficiency improves and the uptake of alternative fuel vehicles increases.

To evaluate the development of tax bases in the Slovenian road transport sector over time (energy use, vehicle stock and road use) and to evaluate the associated tax revenue implications, a simulation tool based on a vehicle stock model was developed. This chapter provides information on the model design and underlying assumptions, and presents results for a baseline scenario.

Section 5.1 provides an overview of the overall model and its scope. Section 5.2 introduces the model components, their input data and related assumptions in more detail. This section also discusses the main technology scenario adopted for modelling the uptake of alternative fuel vehicles. Section 5.3 provides information on how main model outputs, i.e., tax revenues, are derived for each tax base under current tax policies (baseline scenario). Section 5.4 presents results for the baseline scenario, against which tax counterfactuals are built in Chapter 6. Finally, Section 5.5 provides results of sensitivity analysis to some key input parameters.

5.1. Overview of the model and scope

5.1.1. Design requirements

The model captures the most important margins that are necessary to build relevant and robust scenarios to assess transport taxes in Slovenia and potential tax reform. It provides both appropriate detail and sufficient flexibility to answer strategic questions concerning transport tax policy in the presence of eroding fossil fuel tax bases. Several requirements need to be met that are summarised below and detailed further in the respective subsections:

- **Tracing vehicles over their lifetime** – this is to reflect that vehicle usage profiles and vehicle efficiency levels differ over the vehicles' lifetime (e.g. older vehicles typically travel less and are less energy-efficient than newer vehicles);
- **Reflecting the development of different and new vehicle technologies** and their penetration into the vehicle sales market over time;
- **Accounting for imported second-hand vehicles**, which make up a relevant share of Slovenia's vehicle sales market;
- **Using data and forecasts available from national sources**; where this is not possible, use recognised alternative sources.

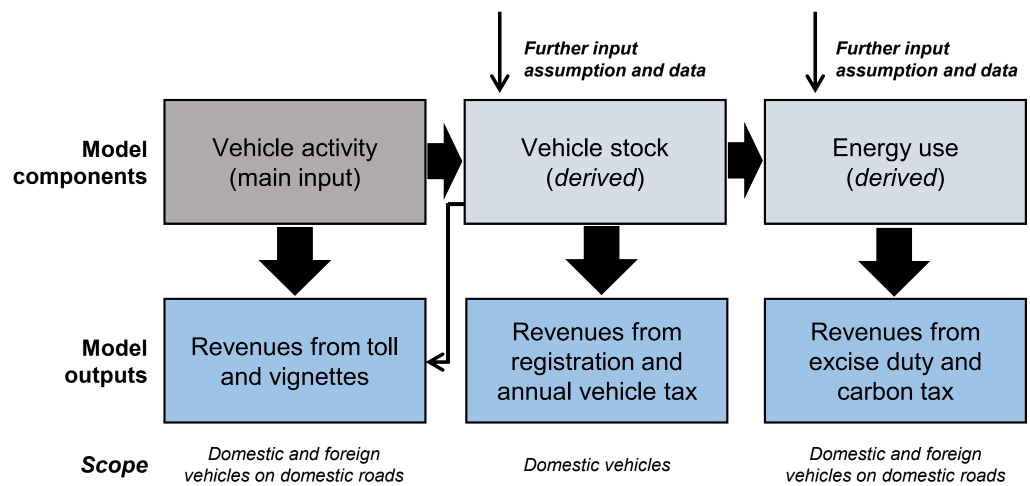
5.1.2. Model structure

To calculate Slovenia's vehicle stock for the time period 2017-2050 and derive the associated energy consumption, a vehicle stock model was built that allows retracing vehicles and their use over time. Figure 5.1 provides an overview of the functioning of the model.

In a nutshell, a vehicle stock model simulates the development of the vehicle fleet that is required to meet future vehicle activity (or transport demand). The evolution of vehicle activity over time is a main input to the model and captures how exogenous factors like GDP and population growth may affect travel demand. The model simulates how new or second-hand vehicles enter the existing vehicle stock, while older vehicles "die" (i.e. they are scrapped or exported) in line with a vehicle survival function that provides the probability for a vehicle of a certain age to survive one more year in the fleet. The vehicle activity, the derived vehicle stock and its structure (in terms of the vehicles' age, technology and associated fuel-efficiency) determine the energy use of the vehicle fleet.

Tax revenues can then be derived from vehicle activity (in case of tolls), the vehicle stock (in case of vehicle registration taxes and annual circulation taxes) and energy use (in case of excise duty and carbon tax) – see Section 5.4. For tolls, excise duty and carbon tax, the vehicle activity of domestic and foreign vehicles on Slovenian roads is relevant. Registration taxes and annual circulation taxes for vehicles apply to domestic vehicles only.

Figure 5.1. Overview of model components and outputs



Source: OECD/ITF representation.

5.1.3. Model scope

The scope of the model is defined by its geographic coverage, the time horizon it accounts for, and the types of vehicles it covers:

- The **geographic coverage** of the model is Slovenia. More specifically, the model considers vehicles registered in Slovenia and vehicles driven in Slovenia (whether foreign or domestic).
- The **time horizon** of the model is 2050 to allow for relevant future technology developments in the vehicle sales market. The base year is set to 2017. From 2020 onwards, model outputs are derived in 5-year steps.
- The **vehicle types** that are covered are passenger cars and trucks with a maximum mass exceeding 3.5 tonnes. Note that 2- and 3-wheelers, light duty vehicles (i.e., vans), buses or special purpose vehicles are not considered in the analysis. Their respective fuel consumption and related tax revenues are therefore not included in the calculations.

5.2. Description of model components and related input assumptions

The following sections provide insight into the data inputs to, and functioning of, the three model components outlined in Figure 5.1 that allow the calculation of tax revenues from the three relevant tax bases: the “vehicle activity”, “vehicle stock” and “energy use” components. The main description of each component refers to the approach that was taken for passenger cars. Due to restricted data availability, a simplified approach was followed for trucks as outlined at the end of each subsection.

5.2.1. Vehicle activity component

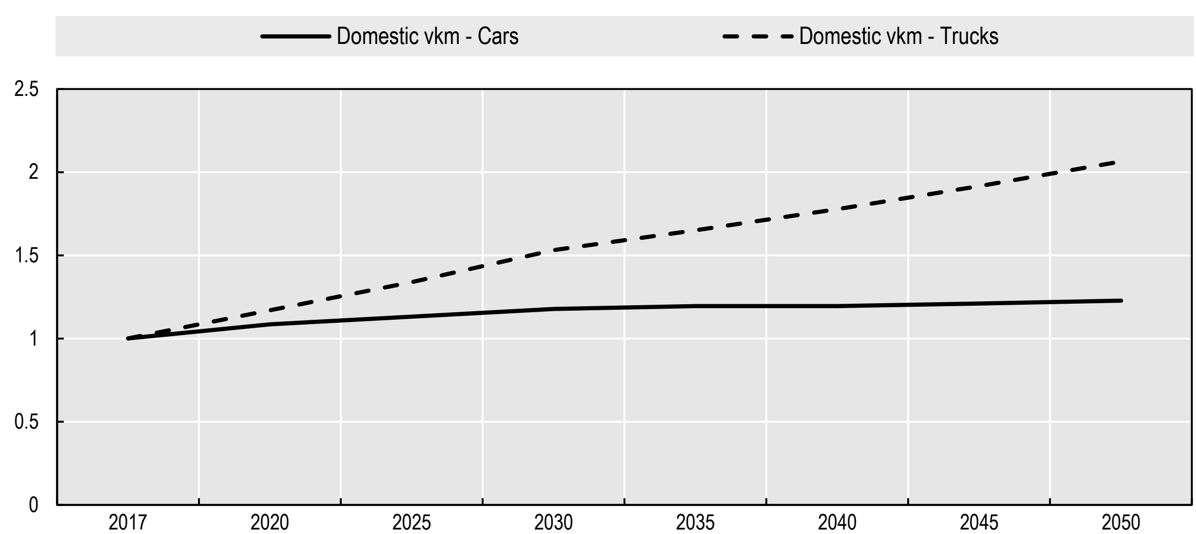
The vehicle activity component provides total road transport demand forecasts in Slovenia in terms of vehicle-kilometres (vkm) to the year 2050. Transport demand from both foreign and domestic vehicles on Slovenia’s roads is considered.

The Statistical Office of the Republic of Slovenia (SURS) provided vehicle activity for the year 2016. For simplicity, vehicle activity in 2017 was assumed to be the same as in 2016. Up to the year 2035, vehicle activity forecasts stem directly from Slovenia’s national energy model. For the period from 2035 to 2050, vehicle activity is extrapolated by applying the growth rate from 2030 to 2035 to all following 5-year intervals.

Figure 5.2 provides an overview of the vehicle activity used in the analysis for the period from 2017 to 2050, for both passenger cars and trucks; values are indexed to the year 2017. The vehicle activity of trucks is projected to almost double by 2050. Passenger car activity increases by around 20% from 2030 to 2050.

Figure 5.2. Vehicle activity on domestic roads for passenger cars and trucks, 2017-2050

Values are indexed to the year 2017



Source: Slovenia national energy model (2017-2035) and extrapolation (2035-2050).

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5.2.2. Vehicle stock component

The vehicle stock component defines the Slovenian vehicle stock over time including its age distribution and technology composition. It assesses the number of vehicles that are needed to satisfy the demand for road transport by domestic vehicles,[1] which requires information on the composition of the vehicle stock in the base year, as well as assumptions concerning the lifetime and annual mileage of vehicles.

Information on the **vehicle stock** in the base year was obtained from Slovenia's vehicle registration dataset (Ministry of Public Administration of Slovenia, 2017[1]). Table 5.1 shows the distribution of Slovenia's passenger car fleet across different vehicle age groups and technologies in 2017. Vehicles were grouped into five age and five technology categories throughout the analysis. The latter distinguishes between petrol and diesel vehicles (including conventional hybrid vehicles), plug-in hybrid electric vehicles (PHEVs)[2], battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs).

Table 5.1. Passenger car stock by age group and technology in Slovenia, 2017

Vehicle age (years)	Petrol	Diesel	PHEV	BEV	FCEV	Total
0-4	9.5%	12.2%	0.1%	0.1%	0.0%	21.8%
5-9	12.7%	14.7%	0.0%	0.0%	0.0%	27.3%
10-14	13.7%	15.2%	0.0%	0.0%	0.0%	28.9%
15-19	12.2%	4.5%	0.0%	0.0%	0.0%	16.6%
20+	4.2%	1.0%	0.0%	0.0%	0.0%	5.3%
Total	52.3%	47.5%	0.1%	0.1%	0.0%	100.0%

Note: PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles. LPG (Liquefied petroleum gas) and CNG (Compressed Natural Gas) vehicles (and variants thereof) were allocated to petrol; biodiesel blends were allocated to diesel. In total, LPG, CNG and biodiesel vehicles account for less than 1% of the total vehicle stock. As PHEVs are not listed separately, their share was derived from estimates from Slovenia's national energy model.
Source: Vehicle registration dataset (Ministry of Public Administration of Slovenia, 2017[1]).

Concerning the **annual mileage** of a vehicle, the present analysis considers that, on average, older vehicles travel less than newer vehicles and vehicle usage profiles differ with vehicle technology given different running and upfront costs (e.g. diesel cars typically travel more than petrol cars). Table 5.2 shows the annual vehicle mileage assumptions by vehicle age category and vehicle technology for passenger cars as derived from Slovenian data.

Table 5.2. Annual mileage on domestic roads per passenger car by age and technology

(in km, rounded to the nearest 100)

Vehicle age (years)	Petrol	Diesel	PHEV	BEV	FCEV
0-4	12 200	23 100	23 100	23 100	23 100
5-9	12 300	19 100	19 100	19 100	19 100
10-14	9 300	14 000	14 000	14 000	14 000
15-19	9 500	12 600	12 600	12 600	12 600
20+	5 700	8 500	8 500	8 500	8 500

Note: PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles.
Source: OECD/ITF calculation based on vehicle registration dataset (Ministry of Public Administration of Slovenia, 2017[1]) and SURS (2018[2]).

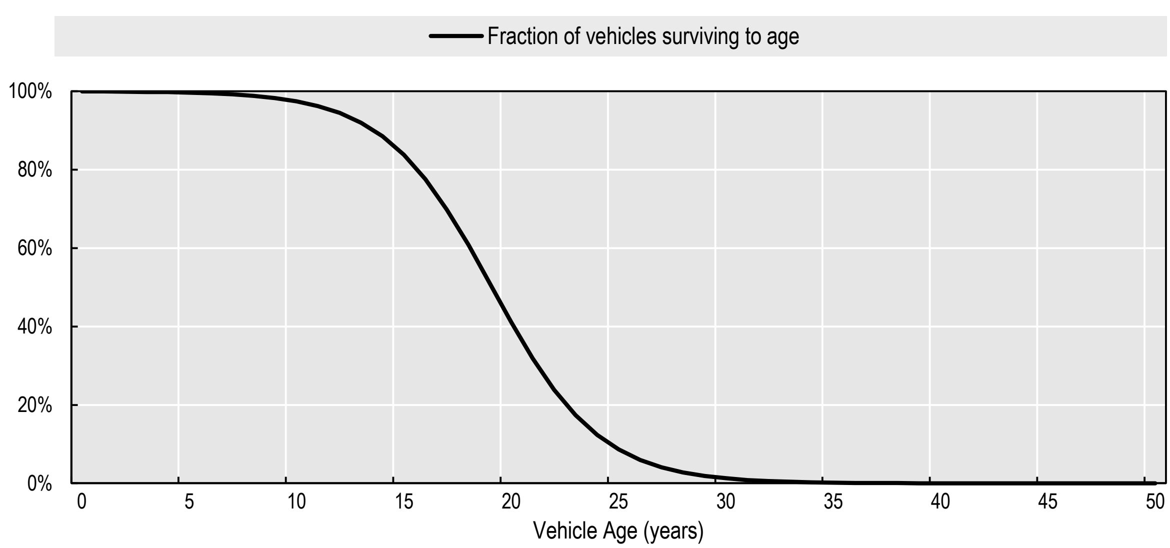
The mileage values for diesel and petrol vehicles were derived from annual vehicle mileage data for Slovenia's total vehicle fleet provided by SURS (in billion vkm in 2016). This data – disaggregated by vehicle technology and age group – was divided by the relevant vehicle stock in each group as reported in Slovenia's vehicle registration dataset for 2017.

Data points for alternative vehicle technologies are rare, resulting from their currently very limited representation in Slovenia's vehicle fleet. Consequently, it is not possible to derive a robust estimate for the average mileage for these vehicle technologies. It was therefore assumed that alternative-fuel vehicles follow the same pattern as diesel vehicles. This choice relates to the similarity of these vehicle technologies with respect to the distribution of costs; i.e., they are subject to high up-front but relatively lower running costs compared to petrol vehicles.

The model adjusts the vehicle stock over time in line with the assumptions on the vehicles' lifetime and the penetration of new and imported cars. The future vehicle stock is matched with the vehicle activity forecast based on the mileage values outlined in Table 5.2, which are assumed to remain constant over the model horizon.

A **vehicles' lifetime** is defined exogenously by a vehicle survival curve (see Figure 5.3 for passenger cars). This curve provides the probability of a vehicle to stay in the vehicle fleet for one more year as a function of the vehicle's age. The specific curve that is used in the present analysis was established for the European Commission (see Ricardo (2016[3])) and reflects the life of the EU's average passenger car. According to the curve, a car that is 10 years old has a 97%-likelihood to stay in the fleet for at least one more year. This drops to an 84%-likelihood for a car that is 15 years old. Said differently, a new car has a likelihood of around 95% to stay in the fleet for 10 years or more. This likelihood drops to around 68% for 15 years or more, or 10% for 20 years or more.

Figure 5.3. Vehicle survival curve for passenger cars



Source: SULTAN Model (see Ricardo (2016[3]) for more information).

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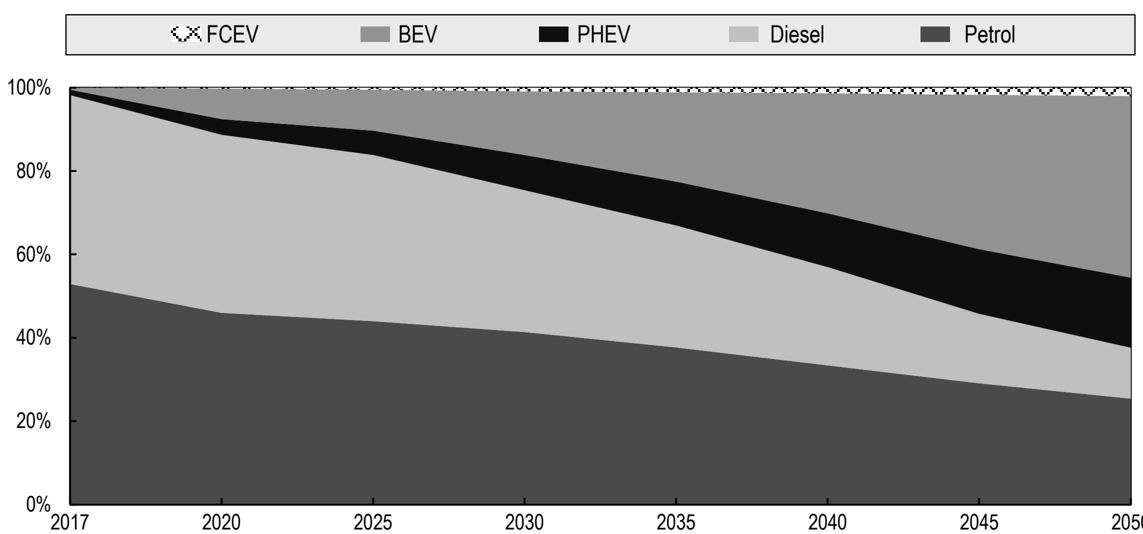
New vehicles enter the vehicle fleet every year, so that the overall travel demand is satisfied; they are either newly purchased or imported. In 2017, a majority of **newly registered** cars (first registrations) in Slovenia was running on fossil fuels: 53% on petrol and 45% on diesel (Ministry of Public Administration of Slovenia, 2017[1]). However, these shares are projected to change in the future when alternative fuel vehicles (BEVs, FCEVs and PHEVs) increasingly penetrate the fleet.

The future penetration of alternative fuel vehicles is modelled exogenously. Following a review of the current literature, which is discussed in Section 5.5, the main scenario is in line with the International Energy Agency's (IEA) two-degree scenario (2DS) for Europe (IEA, 2017[4]). The policy-driven 2DS sets out a decarbonisation pathway in line with international policy goals. It depicts the vehicle technology shares that would be required in the future to meet a world where average global temperature increases are limited to 2°C at a 50% chance, at least.

Applying the IEA 2DS to the Slovenian case, Figure 5.4 shows the vehicle technology penetration in percent of new vehicle sales. By 2050, above 60% of newly purchased vehicles are either PHEVs, BEVs or FCEVs, compared to a 2% share in the base year. Because technology evolution remains largely uncertain, an alternative scenario that is more optimistic about the uptake of alternative fuel vehicles is discussed as further described in Section 5.5.

Figure 5.4. Technology shares for passenger cars (new vehicle sales), 2017-2050



Note: PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles.
Source: Technology shares for 2017 stem from national vehicle sales data for Slovenia. Technology shares beyond 2017 are aligned with IEA 2DS (IEA, 2017[4]).

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Around one third of passenger cars entering Slovenia's vehicle fleet each year are **car imports**. As a result, it is also relevant to assess how these vehicles enter the fleet. Table 5.3 shows the age distribution of car imports, as identified in Slovenia's vehicle registration dataset. In 2017, imported cars were relatively young (69% below 5 years).

To model the vehicle turnover, it is assumed that both the total share of imports in 2017 (33%) and their age distribution remain constant over time.

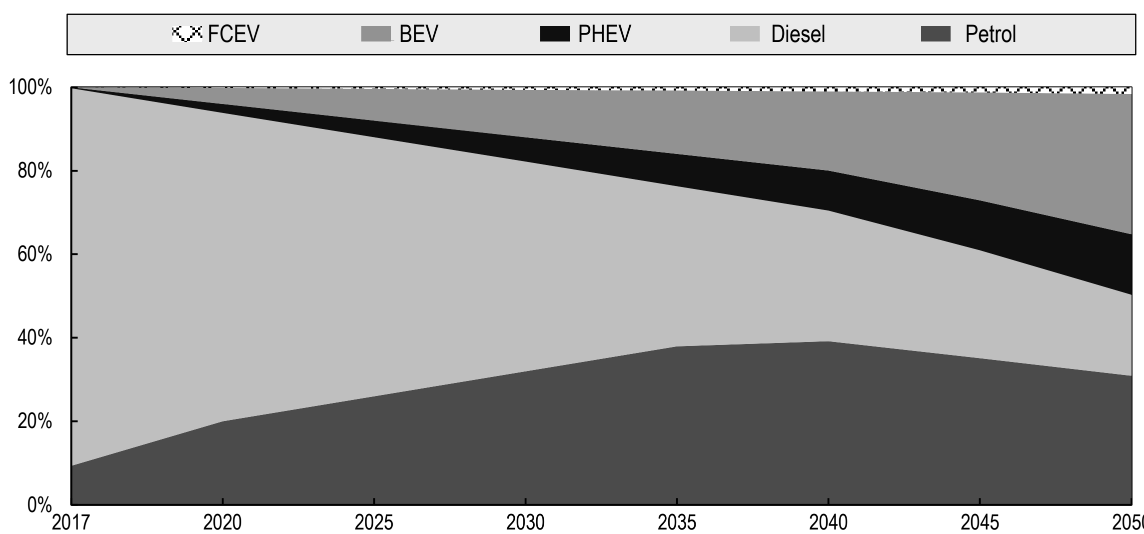
Table 5.3. Age distribution of vehicle imports in Slovenia, 2017

Vehicle age (years)	Share
0-4	69%
5-9	24%
10-14	5%
15-19	1%
20+	1%
Total	100%

Source: Vehicle registration dataset (Ministry of Public Administration of Slovenia, 2017[1]).

The technology distribution of future car imports is of high uncertainty. Based on expert judgment from Slovenia, it is assumed that the current high share of diesel imports (90%) will diminish to the benefit of alternative fuel vehicles over time (see Figure 5.5). Such an evolution is in line with the 2DS and can be justified by the fact that vehicle stocks in car exporting countries adapt to the 2DS.

Figure 5.5. Technology shares for passenger cars (vehicle imports), 2017-2050



Note: PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles.
Source: Technology shares for 2017 stem from vehicle import data for Slovenia. Technology shares beyond 2017 are based on own calculation following IEA 2DS (IEA, 2017[4]).

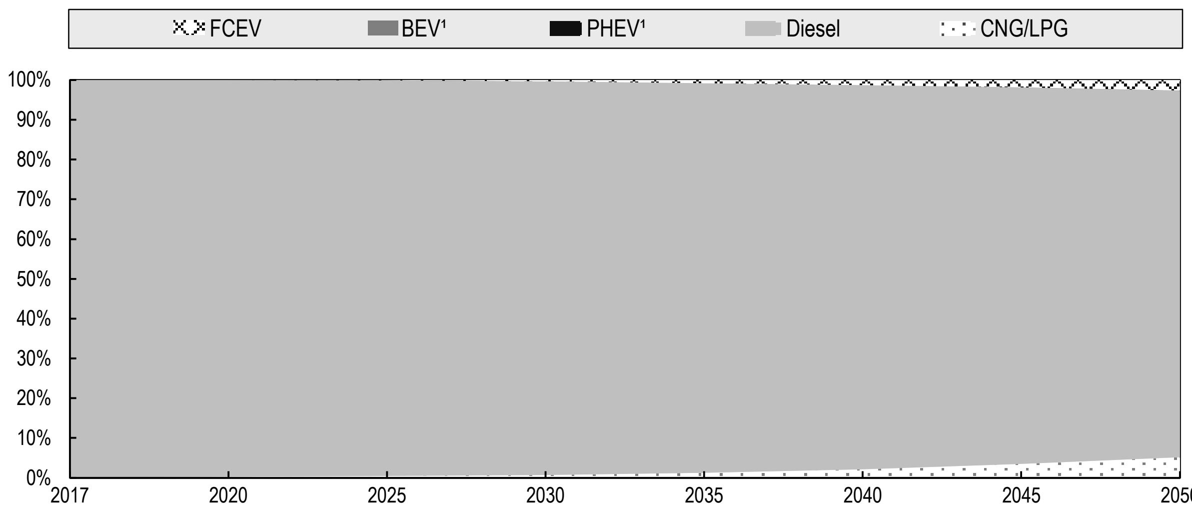
StatLink http://dx.doi.org/10.1787/888933923355

Approach for trucks

Modelling the turnover of the vehicle stock for trucks follows a simplified approach compared to passenger cars. This is because of the relatively limited data availability for trucks. Notably, disaggregate data on the energy consumption of individual trucks in Slovenia is not available. As such, a detailed analysis of the age and technological distribution of trucks that would allow assessing the fleet's energy consumption in more detail is not carried out.

The model assumes an average vehicle lifetime of 11 years for all trucks (European Commission, 2014[5]). After each 5-year interval that is covered in the model, the relevant amount of trucks is replaced with new vehicles. A distinction between new and imported vehicles is not made for this vehicle type. As is the case for passenger cars, the technology penetration of new trucks follows IEA's 2DS – see Figure 5.6, which assumes a constant high share of trucks running on diesel. BEVs start phasing in from 2025; however, at a slow rate, attaining a share of 6% by 2050.

Figure 5.6. Technology shares for trucks (new vehicles entering the fleet), 2017-2050



Note: CNG – Compressed Natural Gas; LPG – Liquefied petroleum gas; PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles.
1. The data for these series are close to zero and, therefore, not visible in the figure.
Source: Technology shares for 2017 stem from vehicle registration dataset (Ministry of Public Administration of Slovenia, 2017[1]). Technology shares beyond 2017 are based on own calculation following IEA 2DS (IEA, 2017[4]).

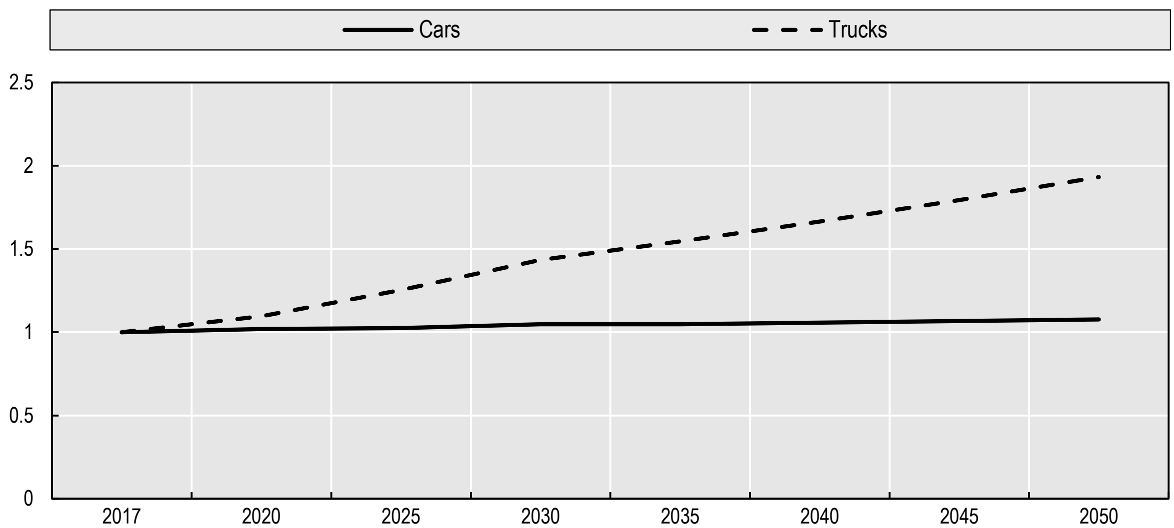
StatLink http://dx.doi.org/10.1787/888933923374

Output of the vehicle stock component

The **output of the vehicle stock component** is the number of vehicles by technology and vehicle age that make up Slovenia's total vehicle fleet in a given year over the model horizon (2017-2050) – information that feeds into the energy use component of the model. Figure 5.7 shows the development of the size of the vehicle fleet (for passenger cars and trucks) over time. It closely follows the trend of the vehicle activity forecasts.

Figure 5.7. Vehicle fleet size for passenger cars and trucks, 2017-2050

Values are indexed to the year 2017.



Source: OECD/ITF calculation.

StatLink http://dx.doi.org/10.1787/888933923393

5.2.3. Energy use component

The energy use component of the model defines the amount of energy (i.e., fuel and electricity) that is necessary to cover vehicle activity in Slovenia – whether carried out by domestic or foreign vehicles – in a given year. The energy consumption of domestic vehicles can be directly derived from the vehicle stock component by multiplying the energy consumption of a vehicle (in *litre fuel/km* or *kwh/km*) with the annual domestic mileage of that vehicle (in *km*), accounting for the vehicle's technology and age, and summing over the whole vehicle stock. Vehicle-kilometres by foreign vehicles are assumed to follow the energy use pattern of domestic vehicles.

Energy consumption of petrol and diesel cars can be derived from vehicles' CO_2 emission values, which directly relate to fuel use. Data on emission values per vehicle are readily available in Slovenia's 2017 vehicle registration dataset. Conversion factors allow deriving a vehicle's fuel use from its specific CO_2 emission values (see Table 5.4).

Table 5.4. CO_2 content of one litre of fuel

Fuel type	gCO_2 per litre of fuel
Petrol	2321.72
Diesel	2480.34

Source: IEA (2017[4]).

However, the CO_2 emission values in the vehicle registration data represent test values, which do not necessarily reflect real-world emissions (and hence energy consumption). Test values are obtained when testing vehicles on pre-defined test-cycles and under specific conditions. It has been shown that test values regularly deviate from real-world emissions. As a result, the present analysis applies correction factors to the CO_2 emission values reported in the vehicle registration dataset. ICCT (2015[6]) has established such values and shown that these correction factors have increased in recent years and are projected to increase further over time if test procedures do not change in the future.

ICCT (2015[6]) distinguishes correction factors for petrol, diesel and plug-in hybrid vehicles and different road types (urban and interurban). For the purposes of this study, an average correction factor by vehicle technology was derived – see Table 5.5. These correction factors adjust the CO_2 emission values that are recorded in Slovenia's vehicle registration dataset for petrol, diesel and PHEV vehicles. The adjustment accounts also for the age of the vehicles and the finding that the deviation between test values and real-world emissions has increased over time.

Table 5.5. Correction factors for test-cycle emission values for passenger cars, 2000-2020

Year	Petrol	Diesel	PHEV
2000	1.10	1.12	1.22
2005	1.16	1.17	1.27
2010	1.23	1.23	1.33
2015	1.34	1.40	1.50
2020	1.46	1.55	1.65

Note: PHEV – plug-in hybrid electric.
Source: ICCT (2015[6]) provides indications for PHEVs for 2015 - factors of other years are derived from diesel and assumed to be 0.1 higher (i.e. similar to 2015); 2020 factors are assumed to apply also to 2025-2050.

Defining the fuel consumption via CO_2 emission values is convenient for developing projections for vehicles' fuel consumption. This is because European Commission targets with respect to the energy efficiency of vehicles are set in terms of vehicles' CO_2 emissions (not their fuel consumption). More specifically, the average CO_2 emission value for the total new passenger car fleet in 2021 is to meet $95gCO_2/km$ (see Regulation No 333/2014 of the European Parliament and of the Council), as tested on the New European Driving Cycle (NEDC). Further targets will be set as relative reduction targets in comparison to the 2021 target to avoid irregularities with the phase-in of new test procedures. It is assumed that an intermediate 15% reduction target for 2025 and a 35% reduction target for 2030 will be agreed.[3]

The model assumes that new vehicle sales in Slovenia meet, on average, the European Commission targets, which yields the average CO_2 emission values (in NEDC terms) by vehicle technology as shown in Table 5.6. Note that these values depend on the assumed technology penetration in new vehicles sales: the more zero-emission vehicles (BEVs, FCEVs) are sold in the future, the higher the average emission values of other vehicle technologies may be, while still meeting the overall vehicle emission target. Also, average emission values across the whole fleet depend on the assumed technology penetration across in new sales. The development of passenger car CO_2 emission values after 2030 is assumed to be in line with IEA's projections for Europe (IEA, 2017[4]). These are very moderate improvements of around 1% for each 5-year interval.

Table 5.6. CO_2 emission values of new cars by vehicle technology, 2020-2050

(in NEDC terms; in gCO_2/km)

	2020	2025	2030	2035	2040	2045	2050
Petrol	106	87	75	73	72	72	72
Diesel	97	87	79	78	77	76	76
PHEV	42	38	31	30	30	30	30
BEV	-	-	-	-	-	-	-
FCEV	-	-	-	-	-	-	-
Average new car fleet	**95**	**76**	**62**	**49**	**41**	**35**	**49**

Note: NEDC – New European Driving Cycle, PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles.
Source: OECD/ITF calculations.

The assumed average electricity consumption of PHEVs, BEVs and FCEVs in Slovenia is provided in Table 5.7 and stem from advertised values for best-selling respective vehicle models in Europe in 2017, corrected by 50% to account for a divergence to real-life driving based on expert judgment. For PHEVs and BEVs it is assumed that values will very moderately improve over time, i.e. less than 1% in each 5-year interval. This is in line with IEA's assumption for BEVs (IEA, 2017[4]). FCEVs are assumed to improve from 0.37 kWh/km in 2017 to 0.20 kWh/km in 2050 in line with IEA (2017[4]) for Europe.

Table 5.7. Electricity consumption of passenger cars by vehicle technology, 2020-2050

(in kWh/km)

	2020	2025	2030	2035	2040	2045	2050
Petrol	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-
PHEV	0.0900	0.0893	0.0886	0.0878	0.0872	0.0868	0.0866
BEV	0.1946	0.1931	0.1915	0.1898	0.1885	0.1877	0.1871
FCEV	0.3680	0.3353	0.2730	0.2465	0.2188	0.2024	0.2032

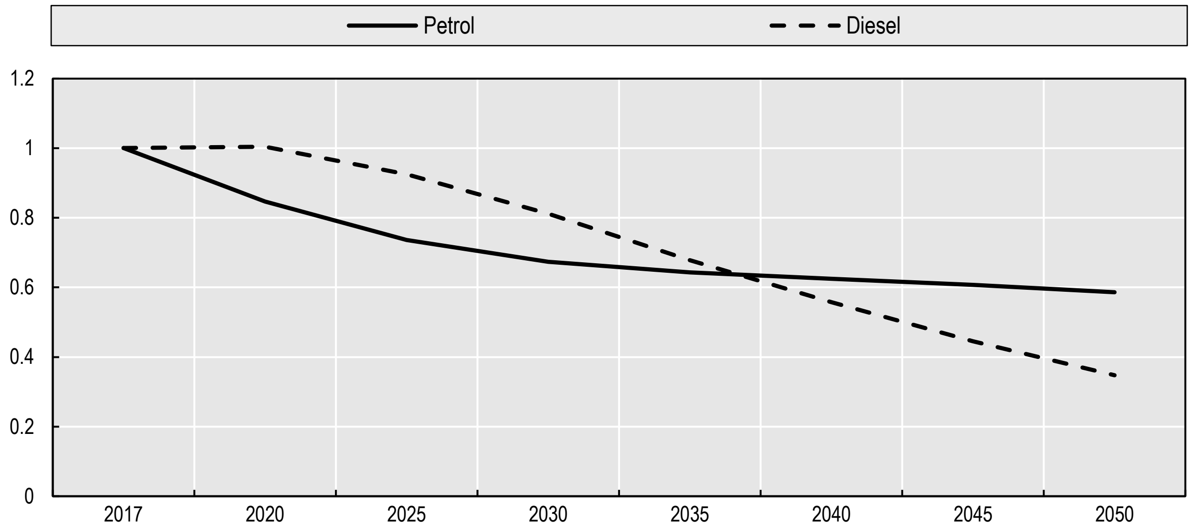
Note: PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles.
Source: Various.

Output of the energy use component (passenger cars)

The output of the energy use component is the energy use by energy type (petrol, diesel, electricity) that meets the demand for transport activity on Slovenian roads in a given year. Figure 5.8 and Figure 5.9 show how petrol, diesel and respectively electricity consumption of passenger cars develop over time (2017-2050) according to the model. Results are based on the input assumptions described above and assume an increase in vehicle activity to 2050 given in Figure 5.2. The skyrocketing electricity consumption is only shown for completeness. It can be explained by the very low starting value in 2017 and reflects the uptake of electric vehicles presented in Figure 5.4.

Figure 5.8. Petrol and diesel consumption for passenger cars, 2017-2050

Values are indexed to the year 2017.

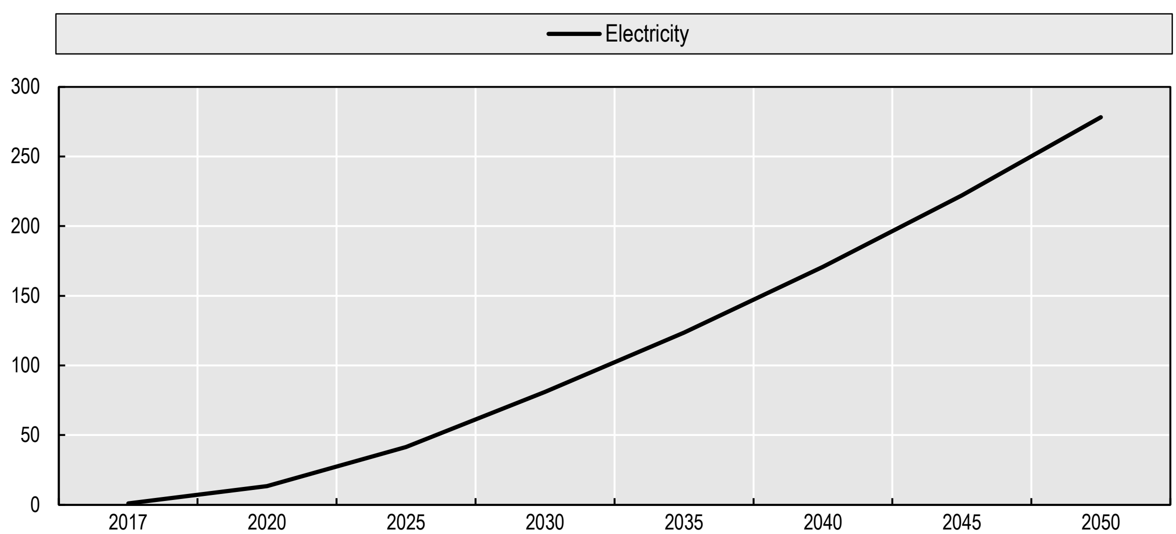


Source: OECD/ITF calculations.

StatLink http://dx.doi.org/10.1787/888933923412

Figure 5.9. Electricity consumption for passenger cars, 2017-2050

Values are indexed to the year 2017.



Source: OECD/ITF calculations.

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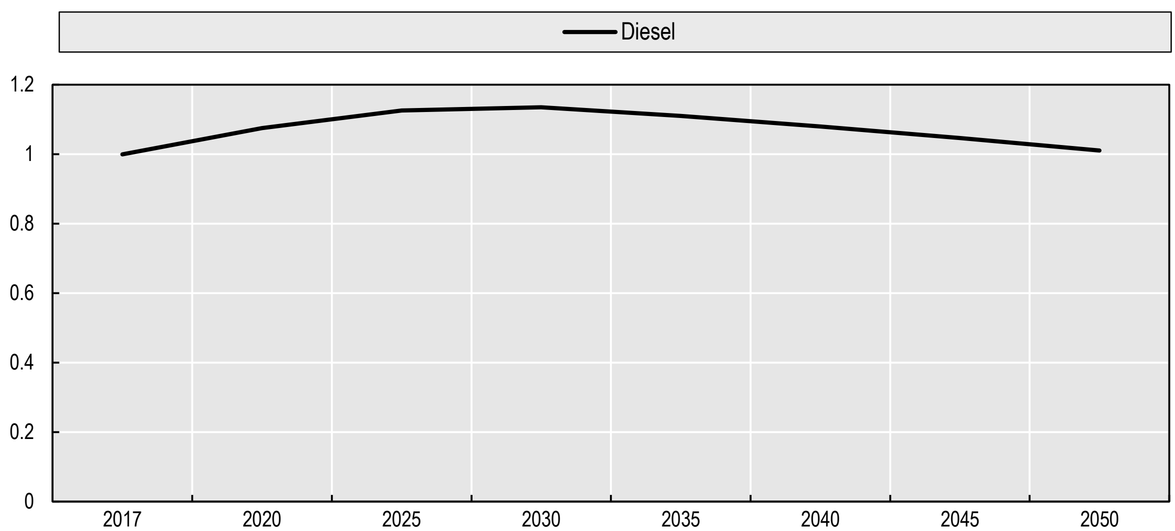
Approach for trucks

The approach for trucks is in principle the same as for passenger cars. However, CO_2 emission values are not available as testing and reporting procedures similar to passenger cars have not been put in place. Based on expert judgment, it was assumed that the average real-life fuel consumption for diesel trucks was 40 litres/100 km in 2017 and that this drops with the renewal of the fleet and the phase-in of fuel-efficiency standards for trucks similar to those of passenger cars to close to 20 litres/km by 2050.

Figure 5.10 shows the resulting modelled reduction in diesel consumption to 2050. The increase in vehicle activity is balanced by increased fuel-efficiency over time. Given the assumed low penetration of electric trucks, the consumption of other energy sources remains negligible.

Figure 5.10. Change in diesel consumption by trucks, 2017-2050

Values are indexed to the year 2017.



Source: OECD/ITF calculations

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5.3. Deriving model outputs for a baseline scenario

Final model outputs – being toll and tax revenues from energy use, vehicles and road use in Slovenia over the model horizon (2017-2050) – are derived by combining the intermediate outputs of the different model components (tax bases) with the current tax structure in Slovenia.

The baseline scenario assumes that the toll and tax system in 2017 as described in Chapter 3 remains in place. The following sections treat fuel and carbon taxes, vehicle taxes and tolls in turn, and provide most relevant information as to how revenues were calculated and calibrated (where possible). Actual quantified outputs for a baseline scenario are provided in Section 5.4.

5.3.1. Fuel and carbon taxes

Excise duties (including additional taxes for strategic stockpile, energy efficiency, renewables and cogeneration) and carbon taxes apply to all petrol and diesel fuel sales as explained in Chapter 3. For electricity, only the output tax is included in the analysis, while any other tax or input taxes on fuels that are used in electricity production are disregarded for simplicity. Respective revenues are obtained by multiplying tax rates (per unit of energy) with the petrol, diesel and electricity purchases that are calculated in the model's energy use component.

It is assumed that all energy purchases resulting from vehicle activity on domestic roads result in tax revenue for Slovenia. In other words, it is assumed that the fuel and electricity for all kilometres driven on Slovenian roads are purchased in Slovenia. This approach has been chosen to disregard potential strategic behaviour linked to fuel tourism into (or out of) Slovenia in the baseline scenario. Section 6.1.1 discusses fuel tourism in more detail.

5.3.2. Vehicle taxes

Two types of vehicle taxes exist in Slovenia, a one-time motor vehicle registration tax and an annual motor vehicle tax. Revenues from vehicle taxes are calculated by multiplying tax rates with the respective new vehicle stock (registration tax) or the total vehicle stock (annual tax) in a year.

The **registration tax** is paid on newly registered vehicles in Slovenia (whether new or imported). It applies to passenger cars, but not to trucks. For passenger cars, the tax rate depends on a vehicle's i) type of fuel (distinguishing electricity, diesel and other), ii) CO_2 emission value (in g/km), iii) EURO standard, iv) engine capacity (in cm^3). The tax rate applies ad valorem as a percentage of the vehicle's sales price (exclusive of VAT). Electric vehicles with zero tailpipe emissions pay the lowest rate (0.5%).

Revenues from the registration tax in the base year are calculated by multiplying tax rates with sales prices. Detailed data on revenues from the registration tax in 2017, provided by the Slovenian Ministry of Finance, allows the distributions of vehicles across all parameters that define a vehicle's registration tax for the base year to be determined. To calculate future revenues, the relevant distributions are shifted for future years to reflect the uptake of new vehicle technologies (in line with the shares provided in Figure 5.4 and Figure 5.5), and of increasingly fuel-efficient conventional vehicles (diesel and petrol). As this study does not aim to assess the future development of EURO standards or engine capacity for petrol or diesel vehicles, respective distributions are assumed constant. This translates into the assumption that potential future changes in such distributions would result in revisions to the registration tax system.

Registration tax calculations are calibrated against the actual tax revenue in 2017. Future changes to tax revenue are the result of changes in the size and composition of the vehicle fleet, vehicle technology shares and fuel-efficiency values (i.e. CO_2 emission values) as defined in the vehicle stock and energy use component respectively.

The **annual motor vehicle tax** applies to registered passenger cars and trucks. In the case of passenger cars, the tax depends on the vehicle's engine capacity. Vehicles with zero tailpipe emissions (BEVs and FCEVs) are exempt from the tax. For trucks, the tax depends on the vehicle weight (or engine power in some instances) and EURO class.

Similar to the method applied for calculating the motor vehicle tax revenue, the dataset on vehicle registrations in 2017 is used to define distributions across all relevant vehicle parameters for the base year. These distributions are then adjusted over time to account for the uptake of alternative fuel vehicles. In the model, future changes to the motor vehicle tax are the result of changes in the size of the vehicle fleet and its composition in terms of new vehicle technologies, as defined in the vehicle stock component.

5.3.3. Distance-based charging

In Slovenia, passenger cars using the motorway are subject to purchasing a vignette, while trucks pay tolls levied on a per-kilometre basis.

Calculating the revenue from vignettes requires assumptions concerning the number of domestic and foreign vehicles that acquire a vignette. Respective assumptions were implemented in the model and calibrated against the total 2017 vignette revenue obtained from ASECAP (2018[7]).

Vignettes are currently not dependent on the energy efficiency of vehicles. In the model, future changes in vignette revenue therefore only stem from changes in Slovenia's vehicle stock (as calculated in the vehicle stock component) and the estimated number of foreign vehicles using Slovenia's motorways. The latter is assumed to develop in line with the vehicle activity of these foreign vehicles on domestic motorways, as defined in the vehicle activity component. This translates into the assumption that the annual mileage per foreign vehicle on Slovenia's roads remains constant. The share of vehicle activity on motorways was obtained from SURS for the base year and is assumed to remain constant over time.

The revenue from tolls for trucks is estimated in the model by multiplying the domestic vehicle activity (from the vehicle activity component) with toll rates. In 2017, toll rates varied with the EURO class and the number of axles of a truck. Slovenia's vehicle registration dataset provides information on these two parameters for all trucks registered in Slovenia in the base year. This allows establishing a distribution of trucks along the relevant parameters and applying the relevant toll rate. Foreign vehicles driving on Slovenia's roads are assumed to follow the same distribution as national vehicles along these parameters.

Toll revenues are calibrated against actual revenue observed in 2017 that was obtained from ASECAP (2018[7]). Future changes in toll revenue are the result of changes in total vehicle activity of domestic and foreign trucks on Slovenia's motorways.

5.4. Results for the baseline scenario

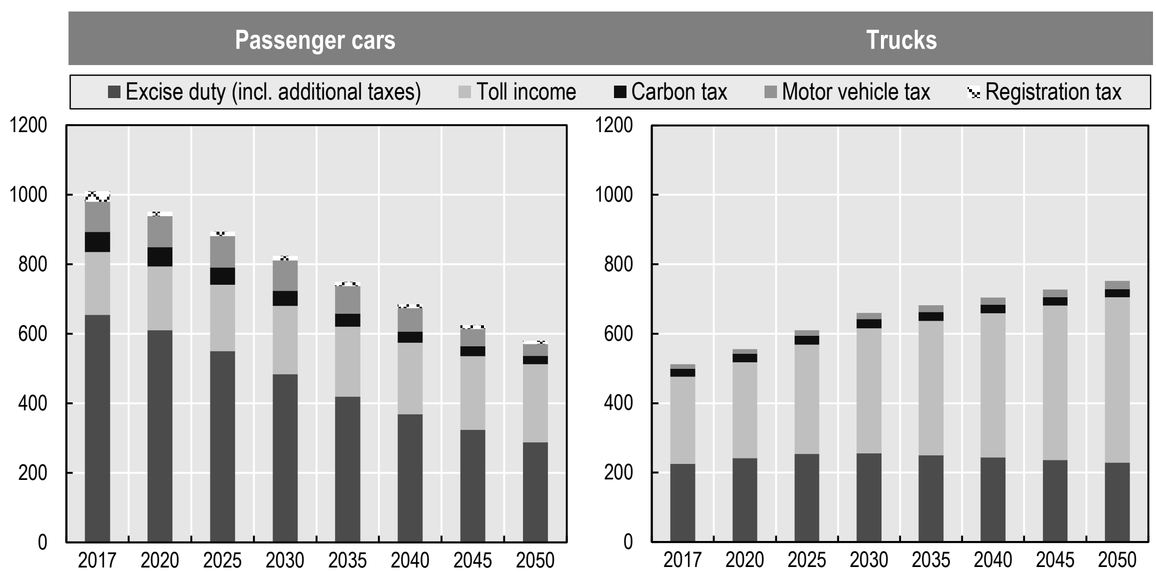
Figure 5.11 shows the overall model outputs, i.e., the revenue for the different tax bases considered in the analysis (energy use, vehicle stock and road use), for passenger cars and trucks for the baseline scenario (i.e. under current policies) for the IEA 2DS. The following main observations can be made:

- For passenger cars, the dominant share of tax revenue in 2017 comes from excise duty (65%), followed by revenue from vignettes (18%) in the base year. Other tax revenues sum to around 17%. By 2050, the share of excise duty revenues declines significantly to less than 50% of revenues in the base year.
- In the case of trucks, main revenues are collected from tolls (49%) and excise duty (43%) in the base year. Other tax revenues sum to less than 7%. By 2050, the share of toll revenues increases to more than 60%.
- Overall revenues from passenger cars decrease by around 44% in the period from 2017 to 2050. This is mainly due to the erosion of the fuel tax base and resulting decreases in excise duty and carbon tax revenues (-56%). The drop in revenues from the excise duty is driven by the fuel-efficiency improvements and uptake of alternative fuel vehicles according to EU emission standards and the IEA 2DS. In

addition, revenues will decline as a result of a reduction in vehicle taxes, arising from a growing share of electric vehicles in the fleet, which are currently exempt or subject to reduced rates. These losses are partly offset by a slight increase in vignette sales, thanks to an increasing size of the total vehicle fleet.

- Overall, revenues from trucks increase by around 47%. This is mainly due to an increase in vehicle activity resulting in an increase in toll revenues. Revenues from excise duty remain relatively stable over the years as the effect of increased activity is here balanced by the assumed fuel-efficiency gains of diesel trucks. Also, other tax items remain relatively stable given the assumed continued dominance of diesel trucks to 2050.

Figure 5.11. Tax revenue from passenger cars and trucks for the baseline scenario, 2017-2050



Source: OECD/ITF calculations.

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5.5. Alternative fuel technology scenario

The evolution of tax bases and revenues depends on assumptions regarding the uptake of new vehicle technologies that, at present, remain largely uncertain. The model derives baseline results following IEA's 2°C scenario for Europe (IEA 2DS) from 2017 (IEA, 2017[4]). Outputs are based on *scenario analysis* and should not be interpreted as *predictions* of tax revenue or bases (see Box 5.1).

Box 5.1. Scenario analysis

Analysing the future technology take-up in the vehicle fleet and potential impacts on tax revenue requires careful consideration of the uncertainty related to future technological developments. The present report builds on *scenario analysis* of technological developments and their relationship with tax bases and revenues, but does not aim to make *predictions* about the future.

- **Predictions** attempt a statement on the most likely outcome or estimated development of future, uncertain events.
- **Scenarios**, on the other hand, describe potential and plausible outlines of future events, based on a set of assumptions regarding key relationships, without an attempt to evaluate the likelihood of these events.
- **Scenario analysis** can be seen as a *what-if* analysis that is useful to inform decision-makers about potential future opportunities and challenges in the presence of uncertainty that may otherwise be neglected. Results from scenario analysis have no predictive intent, but show potential future developments conditional upon the assumptions taken.

The main scenario adopted in the present analysis applies the penetration of alternative fuel technologies as described in the International Energy Agency's 2°C Scenario for Europe (IEA 2DS) to the Slovenian case. "The 2DS describes an energy system consistent with an emissions trajectory that recent climate science research indicates would give an 80% chance of limiting average global temperature increase to 2°C" (IEA, 2018[8]).

The IEA 2DS was chosen based on a review of the literature that estimates the uptake of alternative fuel vehicles measured as a percentage of new car sales. Table 5.8 contrasts the results from 2017 studies of comparable markets. Both the Bloomberg New Energy Finance and Slovenia's own national energy model use values for the uptake of electric vehicles in new passenger car sales go well beyond the IEA 2DS.

Table 5.8. Estimates for technology uptake, 2017

Share of electric vehicles in new passenger car sales.

	2025	2035	2050	Market
IEA 2DS	10%	20%	40%	Europe
IEA 4DS	2%	4%	11%	Europe
Bloomberg New Energy Finance	30% (2030)	70% (2040)		Europe
Slovenia's national energy model	19%	34%	--	Slovenia

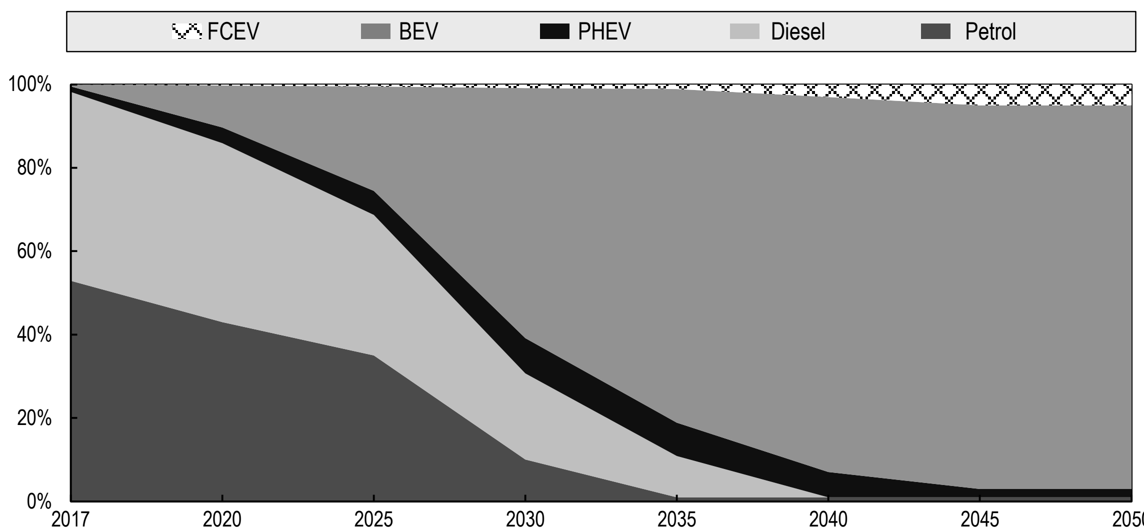
Note: IEA 4DS – scenario to limit temperature increases to maximum 4°C.
Source: IEA (2017[4]), Bloomberg New Energy Finance (2017[9]) and Slovenia's national energy model.

Results for the IEA 2DS, especially with regards to passenger cars, can be interpreted as a lower bound for the penetration of electric vehicles when compared to other studies from 2017. This is also the case when comparing the IEA 2DS with more recent scenarios by the IEA. For example, IEA's "EV30@30" scenario reflects climate ambition in line with a "Beyond 2DS" world (limiting temperature rise to 1.75 degrees, instead of 2.0 degrees) and results in a combined share of PHEV, BEV and FCEV of around 96% in new vehicle sales by 2050 (IEA, 2018[10]; IEA, 2018[11]).

Given the uncertainty around technological developments, an alternative scenario is presented, which accounts for a more ambitious outlook on the uptake of electric vehicles in the passenger car fleet (Figure 5.12). Under this alternative scenario, electric vehicles make up 70% of newly purchased cars in 2030, and more than 90% by 2040. Figure 5.13 provides the tax revenues that result from such a penetration pattern as derived by the model under current policies. In this scenario, tax revenues would fall by another 25% compared to the baseline scenario, to around 30% of 2017 levels.

Figure 5.12. Alternative scenario for the technology penetration of passenger cars, 2017-2050

Shares in new passenger car sales.



Note: PHEV – plug-in hybrid electric; BEV – battery electric vehicles; FCEV – fuel cell electric vehicles; conventional hybrid vehicles are included in petrol or diesel vehicles, depending on the fuel they use.
Source: OECD/ITF calculations.

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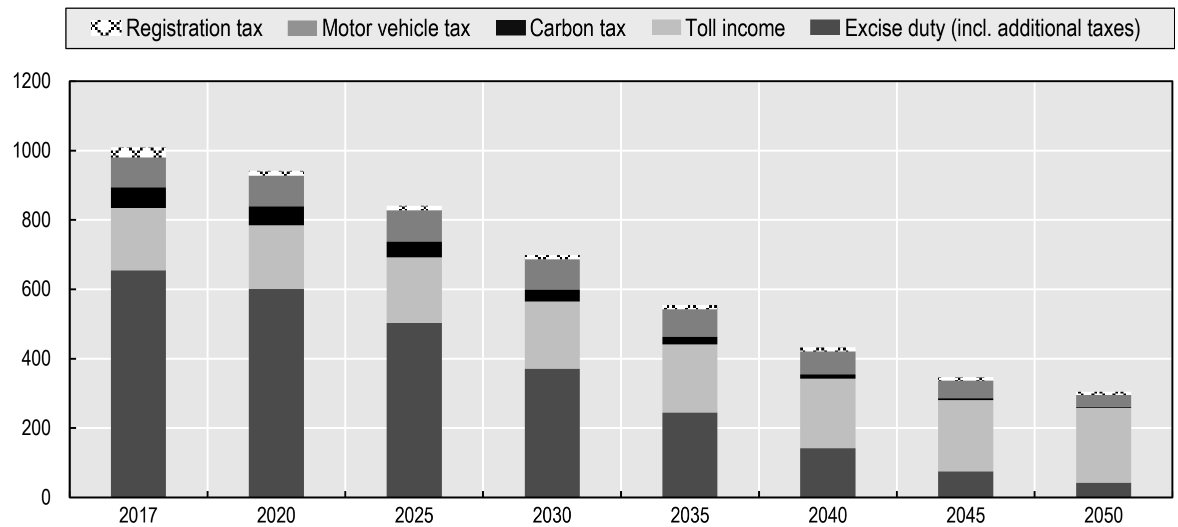
Figure 5.13. Tax revenue from passenger cars for alternative technology scenario, 2017-2050



Source: OECD/ITF calculations.

StatLink http://dx.doi.org/10.1787/888933923507

Notes

[1] Vehicle activity data from SURS allow distinguishing vehicle activity between domestic and foreign vehicles on Slovenian roads. For defining the domestic vehicle stock, only vehicle activity of domestic vehicles is relevant. The share of vehicle activity of domestic vehicles in total vehicle activity is assumed constant to 2050.

[2] Throughout the analysis it is assumed that PHEVs drive on petrol besides electricity.

[3] The European Commission, in November 2017, proposed new reduction targets of 15% (2025) and 30% (2030) for average CO_2 emissions from new passenger cars (COM(2017)676). In October 2018 the European Parliament voted for amendments that would set more ambitious targets at 20% (2025) and 40% (2030) respectively, while the Council position keeps the 2025 target at 15% as in the original proposal and would set a 35% reduction target for 2030. (During the writing of this report, a provisional agreement was reached setting a reduction target of 15% by 2025 and of 37.5% by 2030.)

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Chapter 6. Tax reform simulations to stabilise revenues

This chapter studies options for tax policy reforms designed to stabilise tax revenues in the road transport sector at current levels, in the long run. It simulates the potential impact of tax reform on revenues for the main technology scenario, considering behavioural adjustments. The focus is on the passenger car segment of the market, where the erosion of the fuel base is expected to be at its highest. The following tax reforms are considered: increasing conventional fuel or carbon taxes on gasoline and diesel, adapting the taxation of motor vehicles and charging based on distances-driven.

The scenario analysis of the road transport sector in Slovenia shows that tax revenues from fuel excise levied on passenger cars may significantly decline under current policies (baseline scenario) when fuel-efficiency improves and the uptake of alternative fuel vehicles increases. The present chapter studies options for tax policy reform that aim at stabilising revenues from passenger cars in the longer run. It simulates the potential impact of tax reform on revenues for the IEA 2DS scenario. The focus lies on the passenger car segment of the market, where the fuel base erosion is likely highest.

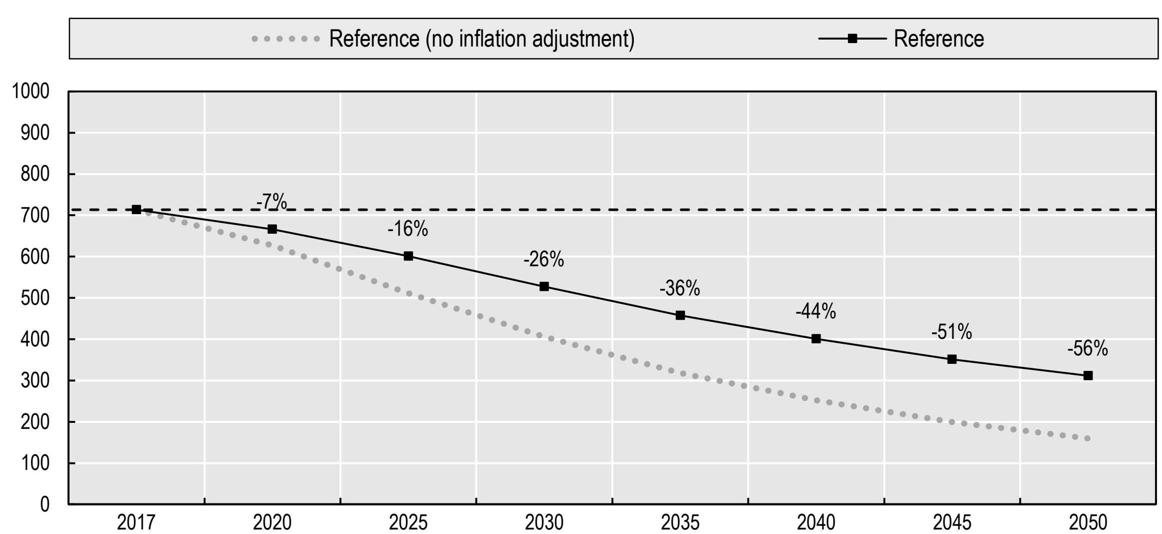
The decarbonisation of tax bases is assumed to be exogenous to this analysis. While policy instruments considered in the analysis will affect the speed at which tax bases decarbonise beyond their effect on tax revenues, this relationship is not accounted for in the calculations. Linking the effect of tax reform to emissions could be an interesting extension for further analysis.

Tax reform in the transport sector can take different angles and affect the three tax bases (energy use, vehicle stock, road use) differently. To counteract a drop in fuel tax revenues several margins exist. For example, revenues may be sustained by increasing conventional fuel taxes on gasoline and diesel, by eliminating vehicle tax exemptions for electric cars or by charging distances. Tax reform outside road transport may be another efficient way to generate additional revenue, but that is beyond the focus of this analysis.

6.1. Fuel and carbon taxes

Figure 6.1. Fuel and carbon tax revenue from passenger cars for baseline scenario, 2017-2050

Baseline scenario (current policy); tax revenue in million EUR.



Note: Model results for fuel and carbon tax revenue for the IEA 2DS and under current policies. Results are presented for situations where tax rates are adjusted for inflation (black line) and where they are not (grey dotted line).
Source: OECD/ITF calculations.

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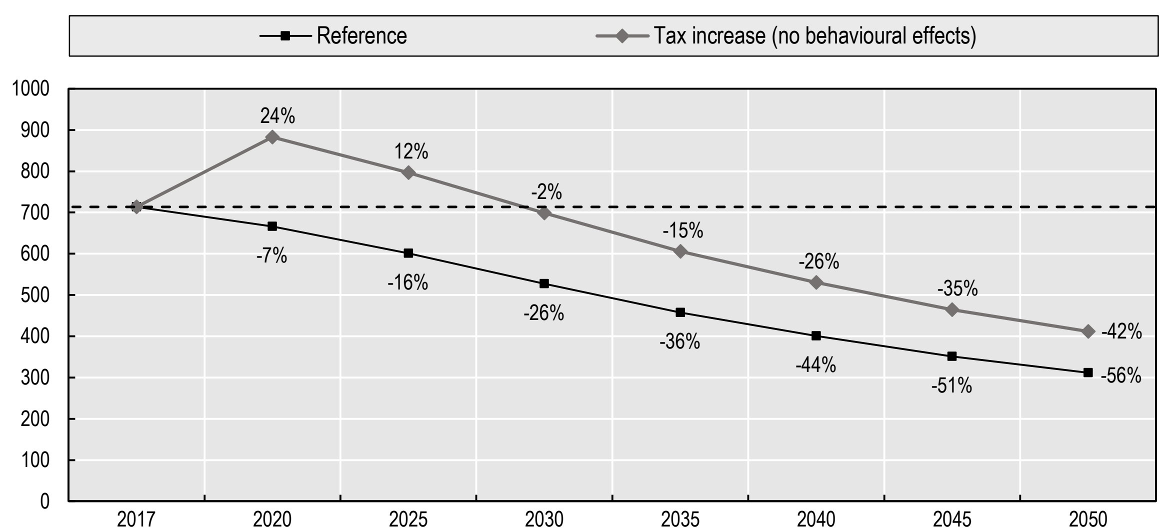
Tax revenue from fuel used in passenger cars drops significantly in the IEA 2DS scenario and much more strongly when tax rates are not adjusted to inflation. The black line in Figure 6.1 shows the evolution of tax revenue from fuel used in passenger cars as derived by the model in the baseline scenario (see Chapter 5): revenues decline steadily reaching –56% in 2050 compared to 2017 levels. This baseline scenario assumes that the real level of current fuel taxes persists over time and that rates are indexed to inflation. That is to say, a total of EUR 0.5763 and EUR 0.5024 are levied per litre of gasoline and diesel respectively (including fuel excise[1], carbon and additional taxes). Conversely, the grey dotted line in Figure 6.1 represents fuel tax revenues, where current tax rates persist but are not adjusted with inflation and when inflation averages at 2% over the years. If nominal tax rates do not rise with inflation, real tax rates decline and gradually erode tax revenue even further than in the baseline scenario.

Increasing conventional fuel taxes on diesel and petrol can delay the revenue loss from tax base erosion, as shown in Figure 6.2. However, a one-time increase does not necessarily cover the revenue loss in the long run. The grey line depicts results from a simulation in which tax rates on diesel and petrol increase to the level of Slovenia's most ambitious neighbour in terms of fuel taxation for private car use, Italy. As of 2020, rates are set to EUR 0.728 and 0.617 per litre respectively and are inflation adjusted in later years. While the simulation shows that a one-time increase in tax rates pushes revenues up in the short to medium term (2020-2030) relative to the baseline, the revenue loss is not fully covered in the longer run (2030-2050).

Figure 6.2. Simulation of fuel and carbon tax revenue from passenger cars after tax increase, 2017-2050

Most ambitious neighbour, no behavioural effects; tax revenue in million EUR.



Note: Simulation of fuel and carbon tax revenue for the IEA 2DS assuming real tax rates increase to EUR 0.728 per litre of petrol and EUR 0.617 per litre of diesel as of 2020. Revenues from the baseline scenario (black line).
Source: OECD/ITF calculations.

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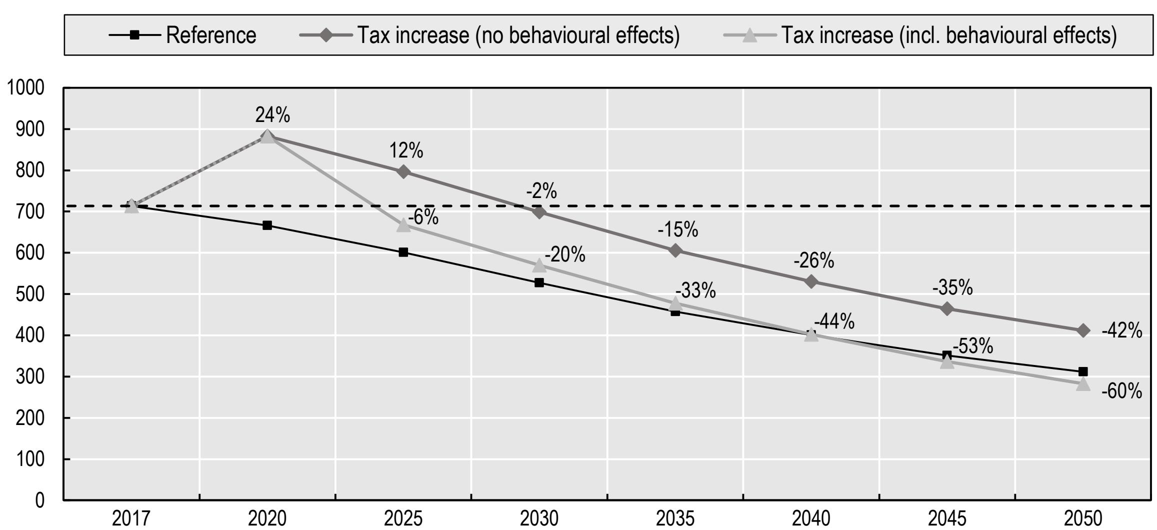
The pattern at which revenues erode follows the speed at which alternative fuel vehicles penetrate the car stock and fuel-efficiency improves. Countries that aim to keep tax revenues stable by focusing uniquely on fuel and carbon tax reform would thus need to increase tax rates on gasoline and diesel continuously – mimicking the speed and extent at which the fossil fuel base erodes. Simulation shows that tax revenues in 2050 may reach similar levels as in 2017 under a tax reform that raises the carbon tax gradually to reach a tax rate of around EUR 80 per tonne of CO_2 in 2030 and EUR 340 per tonne in 2050, keeping everything else equal. (This translates into a tax rate of EUR 0.178 per litre of petrol and EUR 0.198 per litre of diesel in 2030.) An increase in tax rates to this extent would likely speed up the penetration of alternative fuel vehicles.

The revenue potential from fuel and carbon tax reform depends significantly on how strongly fuel demand reacts to price increases. The above-mentioned simulations assume no behavioural adjustments following tax reform, while results presented in Figure 6.3 derive from a simulation that includes precisely such behavioural effects. More specifically, the simulation assumes that tax rates on gasoline and diesel rise to the Italian level in 2020 and that the entire fuel tax base shrinks in 2025 in response to the rate increase. Following the literature (discussed in Section 2.2.1) the simulation applies a long-run elasticity of -0.5 indicating that a 10% increase in fuel prices reduces fuel demand by 5% all else equal.

Figure 6.3. Simulation of fuel and carbon tax revenue from passenger cars including behavioural adjustments, 2017-2050

Most ambitious neighbour, including behavioural effects; tax revenue in million EUR.



Note: Simulations for fuel and carbon tax revenue for the IEA 2DS assuming tax rates increase to EUR 0.728 per litre of petrol and EUR 0.617 per litre of diesel as of 2020. Simulations include a one-time behavioural effect in 2025 following a price elasticity of -0.5 (light grey line) and no behavioural effect (dark grey line). Revenues from the baseline scenario (black line).
Source: OECD/ITF calculations.

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When accounting for behavioural effects, the revenue potential from fuel and carbon tax reform shrinks considerably. A strong increase in fuel or carbon taxes risks eroding fuel tax revenue more rapidly than in the absence of tax reform. As shown in Figure 6.3, the light grey line (representing tax revenues from a simulation that considers a behavioural effect of -5% for a 10% increase in prices) drops below the levels of the dark grey line (representing tax revenues from the same simulation but excluding behavioural adjustments). As of 2040, revenues even drop below the baseline scenario (black line). Note that the -0.5 elasticity derives from backward-looking analysis and may be seen as a lower bound of the behavioural response. Technological progress may increase the sensitivity of the fuel base to tax rates.

In conclusion, the simulations show that fuel or carbon tax increases can delay the potential revenue loss from fuel base erosion in passenger cars in the short or medium run, but that the potential is limited in the long run. Over time, a steady increase in rates would be required to counteract the likely fuel base erosion from changes in car technologies. These increases need to be substantial to keep revenue streams at current levels. Fuel use may further decrease in response to such price changes (both because higher prices may accelerate the uptake of alternative fuel vehicles and because consumers may drive less and more efficiently). A smooth adaptation to the potential revenue erosion may require tax reform that goes beyond fuel taxation.

Increasing fuel tax rates substantially may also raise distributional and political economy concerns. In particular, it raises questions about the level of fuel and carbon taxes that can be implemented and sustained and what measures are designed to support those parts of the economy that encounter challenges in adjusting to higher prices in the short run (e.g. people facing tight budget constraints or those living in areas where public transport is not readily available). This ultimately raises questions on how revenues from fuel and carbon taxes are used. Marten and Van Dender (2019[1]) argue that broad and flexible constraints on revenue use can strengthen support for carbon pricing if the revenues from the tax are put to socially beneficial use.

From an economic efficiency standpoint, fuel or carbon taxes should cover the external costs that one litre of fuel use entails – but not be levied above that level (see Section 2.2.3). Estimates of the external costs from fuel use in rural areas, where congestion as well as population exposure to air pollution is low, differ largely from those in an urban context, where congestion and air pollution costs are much higher (Parry, Walls and Harrington, 2007[2]; Van Dender, 2019[3]). Because these externalities relate more directly to driving than to fuel use, taxes related to driving will manage such costs more efficiently.

6.1.1. Fuel tax competition

The revenue potential from fuel tax reform in Slovenia is limited further by the interaction with tax policies in neighbouring countries. As discussed in Section 2.2.2, studies find that countries in interconnected geographical areas may keep fuel taxes at low levels in an attempt to attract foreign drivers that can cross the frontier easily to take advantage of lower fuel prices in neighbouring countries. The European Energy Tax Directive (2003/96/EC) establishes minimum excise rates to avoid a race-to-the bottom of taxes on fuels in European member states. It sets a minimum rate of EUR 0.359 per litre of petrol and EUR 0.330 per litre of diesel.

Excise taxes are not the only component of the price that end-users pay at the pump and may induce fuel tourism. The retail fuel price depends on other taxes and duties, such as carbon taxes and VAT, but also on the wholesale price of oil, and on mark-ups that service stations charge. The overall fuel market structure, the size of the specific supplier and the exact location of service stations matters for their price setting behaviours. Regulation may matter too. For example, in Slovenia, the government regulates the price of fuel sold at service stations that are located on motorways. Overall, taxes and duties represent 63% and 61% of the average retail price for petrol and diesel in Slovenia in 2017 (Table 6.1 and Table 6.2).

Retail prices for fuel used in passenger cars vary widely in the area comprising Slovenia and neighbouring counties, as reported in Table 6.1 and Table 6.2. For example, the relatively large price differential between Italy and Slovenia (approximately EUR 0.26 and 0.20 per litre of petrol and diesel) may incentivise mobile Italian households that live in the border region to fill up their tank in Slovenia.

Table 6.1. Petrol prices in Slovenia and neighbouring countries, 2017

Prices and excise are expressed in EUR per litre of fuel, yearly averages.

	Price at the pump	Pre-tax price	VAT rate	Excise duty and other indirect taxes	Tax as a share of total price
Austria	1.18	0.488	20%	0.493	59%
Croatia	1.27	0.496	25%	0.517	61%
Hungary	1.15	0.505	27%	0.401	56%
Italy	1.53	0.524	22%	0.728	66%
Slovenia	**1.27**	**0.465**	**22%**	**0.576**	**63%**

Note: Fuel for private use; price quotes for Euro-super 95 from the main retail operators in each country.
Source: Weekly Oil Bulletin, 2017 (European Commission, 2018[4]).

Table 6.2. Diesel prices in Slovenia and neighbouring countries, 2017

Prices and excise are expressed in EUR per litre of fuel, yearly averages.

	Price at the pump	Pre-tax price	VAT rate	Excise duty and other indirect taxes	Tax as a share of total price
Austria	1.11	0.511	20%	0.410	54%
Croatia	1.17	0.529	25%	0.410	55%
Hungary	1.16	0.541	27%	0.378	53%
Italy	1.38	0.516	22%	0.617	63%
Slovenia	**1.18**	**0.462**	**22%**	**0.502**	**61%**

Note: Fuel for private use; price quotes for gasoil from the main retail operators in each country.
Source: Weekly Oil Bulletin, 2017 (European Commission, 2018[4]).

Raising fuel taxes in Slovenia would increase the revenue potential per litre of fuel sold and establish a level playing field with neighbouring countries that charge higher taxes, with the likely effect that some of the Slovenian fuel tax base from foreign driving shifts back to the drivers' country of origin. Calculating the potential tax base loss requires precise information on the number of cars that travel in and out of Slovenia for that purpose, their fuel-efficiency and the associated price elasticities. A simple back-of-the envelope calculation shows the diesel and petrol sold in Slovenia to citizens of the Italian border municipalities may represent 1.3% of current fuel tax revenues.[2] This calculation assumes that Italian households in the border municipalities resemble the Slovenian average in 2017 regarding vehicle ownership, usage and fuel use and uses elasticities derived in Rietveld, Bruinsma and van Vuuren (2001[5]).[3]

While the foreign fuel tax base in terms of private cars is relatively modest, tax competition for fuel tax bases may be more relevant for trucks. Because trucks can carry large amounts of fuel and may cross many countries in Europe on their routes, fiscal planning can reduce production costs significantly. Trucks are eligible for a reduced excise rate in some European countries and are eligible to claim refunds on VAT.

In Slovenia, the revenue potential from international truck traffic is significant. The Statistical Office of the Republic of Slovenia estimates that foreign trucks cover more than 74% of all kilometres driven by trucks on Slovenian motorways (Table 6.3). The large number of kilometres driven on motorways in Slovenia transforms directly into significant toll revenue (Figure 5.11), but also fuel tax revenue. For example, in 2016, at least 32% of all diesel purchased in Slovenia for road transport was used in trucks, as measured by the amount of litres for which a tax refund for commercial diesel was claimed (Ministry of Finance of Slovenia, 2018[6]).[4] Trucks registered outside of Slovenia covered one quarter of these refunds – with the top origins being Romania, Hungary and Slovakia.

Table 6.3. Road traffic by trucks on Slovenian territory, 2016

In vehicle-kilometres

	All roads	Motorways	Other roads
Domestic vehicles	32%	26%	63%
Foreign vehicles	68%	74%	37%

Note: Only trucks heavier than 3.5 tonnes are considered.
Source: Statistical Office of the Republic of Slovenia (2018[7]).

Excise rates for commercial diesel vary across the region and are set at, or close to, the EU minimum rate in Hungary and Slovenia (Table 6.4). This lends support to the empirical finding that diesel excise levels in Europe are set strategically in response to tax rates in neighbouring countries (Evers, De Mooij and Vollebergh, 2004[8]; Paizs, 2013[9]) and to the theoretical finding by Kanbur and Keen (1993[10]) according to which small countries charge lower rates in the presence of tax competition. However, when including the carbon tax and other additional taxes on fuel use, the total tax rate on commercial diesel in Slovenia exceeds the Italian rate.

Table 6.4. Tax rates for commercial diesel in Slovenia and neighbouring countries, 2018

Excise rates are expressed in EUR per litre of fuel.

	Austria	Hungary	Italy	Slovenia	EU minimum rate
Commercial diesel rate	0.425	0.337	0.403	0.330	0.330
Commercial diesel rate incl. additional taxes				0.406	

Source: Excise Duty Tables (European Commission, 2018[11]).

The minimum excise rate established at the European level keeps tax rates on diesel in check in the region and avoids a race-to-the bottom, yet some strategic behaviour seems to continue. A co-ordinated approach at the European level may achieve a more efficient tax system while containing tax competition further. Depending on the exact policy objective, such a co-ordinated approach could, for example, index minimum rates to inflation and progressively increase minimum rates to reflect the level of climate costs associated with fuel use. From an external cost perspective, lower rates for diesel than petrol are not justified. Santos (2017[12]) finds that current petrol and diesel taxes in Slovenia (and most European countries) are too low to cover marginal external costs from driving.

6.2. Vehicle taxes

Vehicle tax reform is another channel through which additional tax revenue in the transport sector could be raised. As detailed in Section 2.2.1, the type of vehicle tax matters for the stability of the revenue stream: while revenues from one-off registration taxes depend on fleet-turnover and the business cycle, annual taxes on circulation generate a more stable revenue stream. Because vehicle taxes apply to users of cars registered in Slovenia only, vehicle tax reform can only cover the domestic tax base.

Setting an annual tax at the level of EUR 40 per car registered in Slovenia in 2020 (that increases gradually to EUR 306 per car in 2050) would cover the revenue loss from fuel taxes on passenger cars as derived for the IEA 2DS. The tax equivalent considered in the calculation does not differentiate along other dimensions, such as the air pollution and carbon emissions profile or the fuel type of a vehicle. It compares to a current annual tax that amounts to EUR 40 for the average gasoline car and to EUR 62-100 for the average diesel car (BEVs are currently exempt).

Table 6.5. Annual vehicle tax equivalent to cover revenue loss from fuel taxes on cars, 2020-2050

One vehicle tax per car; no differentiation along car dimensions; no behavioural effects.

	2020	2025	2030	2035	2040	2045	2050
Fuel tax revenue loss from passenger cars for IEA 2DS (million EUR)	47.6	112.5	186.1	256.1	312.7	362.4	402.1
Annual vehicle tax equivalent (EUR per car)	39.6	93.4	150.0	202.2	243.1	279.6	306.0

Note: The vehicle tax equivalent is derived by dividing the revenue loss from fuel used in passenger cars by the number of cars registered in Slovenian in each year as calculated in the model for the IEA 2DS.
Source: OECD/ITF calculation.

Reforming vehicle taxes implies a tension between the government's objectives to raise additional revenue and to engage in a low-carbon transition, as higher vehicle taxes (which would apply to all vehicles regardless of their environmental impact) may limit the switch towards more efficient or alternative fuel vehicles. For example, high registration taxes may reduce fleet turnover, because they incentivise households to forego buying a new car. In addition, taxes based on the sales price of a vehicle, as the registration tax in Slovenia, may slow down the take-up of new technologies further, because they incentivise households to choose relatively cheaper or second-hand cars instead of cars with new and relatively more expensive technologies.

Differentiated vehicle taxation based on technological or environmental performance may support the rollout of alternative vehicles, but a gradual phase-out of tax exemptions for electric vehicles will be necessary to sustain revenues once the technological transformation is on its way. Currently, Slovenia exempts battery electric vehicles (BEV) from the annual vehicle tax and applies the lowest rate of the vehicle registration tax. With the increased take-up of electric vehicles, revenues from these taxes will shrink significantly (see Figure 5.11).

Differentiated vehicle taxation has an effect on purchasing behaviour, however, often at substantial additional revenue cost. Studies find that consumers react to one-off registration or purchase taxes that differentiate according to CO_2 emissions, by buying more fuel-efficient cars (D'Haultfœuille, Givord and Boutin, 2014[13]; Gerlagh et al., 2018[14]; Yan and Eskeland, 2018[15]). However, this differentiation has often led to revenue forgone (e.g. in the case of France and Israel (D'Haultfœuille, Givord and Boutin, 2014[13]; OECD, 2016[16]). Also in Norway, preferential vehicle tax treatment and other benefits have spurred demand for electric vehicles in recent years, but have led to a significant drop in government revenues from vehicle taxation (Norwegian Ministry of Finance, 2018[17]). The consumer response to periodic vehicle taxes, on the other hand, is less clear and may be smaller (Alberini and Bareit, 2017[18]; Gerlagh et al., 2018[14]).

Several countries have implemented *feebates*, where a tax for high-emission vehicles ensures revenue to provide rebates to purchases of low-emission vehicles (e.g. France, Japan, Norway, Sweden, and Switzerland). The French feebate was designed to be revenue neutral, but ex-post revenue collected on high-emission vehicles did not cover the cost of the rebate (D'Haultfœuille, Givord and Boutin, 2014[13]). Regularly adjusting the pivot point of the feebate (i.e., the emission rate at which the fee turns into a rebate) may help stabilise revenues while the fleet is transforming. Implementing smooth rate schedules, as opposed to step-wise schedules, will avoid excessive bunching and provide a uniform and ongoing incentive to improve the emission profile of each vehicle (Anderson and Sallee, 2016[19]).

Several questions over the benefits of vehicle taxation remain. First, vehicle taxes appear not to be a particularly equitable tool to raise revenues (Chatterton et al., 2018[20]; Eliasson, Pyddoke and Swärdh, 2018[21]). It will be necessary to assess carefully the distributional impact of vehicle taxes in Slovenia and potentially design support measures accordingly. Second, vehicle taxes are not an efficient tool to manage external costs either, because they cannot properly incorporate the external costs related to driving behaviour – in contrast to fuel taxes and distance-based charges. To increase the efficiency of vehicle taxation in Slovenia, one would need to tailor tax rates more closely to the average environmental impact of vehicles, including the damages from air pollution. Raising rates over time to the appropriate level may help create support for such a reform.

6.3. Distance-based charging

Charging distances by the kilometre can constitute a promising long-term strategy to collect stable revenues. The tax base from driving is less affected by technological change in the vehicle fleet, as driving is typically less elastic than fuel use (see Section 2.2.3) and as tax competition with neighbouring countries is limited in countries that are not easily bypassed. For example, the distance-based charge levied on trucks in Slovenia appears to be much more resilient to impacts of a decarbonising vehicle fleet than the vignette system for passenger cars, which does not account for the actual number of kilometres driven (see model outputs presented in Figure 5.11). Well-designed, distance-related pricing schemes also align better with the principles of an efficient system of road taxation than *all you can drive* vignettes (Van Dender, 2019[3]).

Going forward, a relatively low tax on the kilometres driven that gradually increases over time can generate significant amounts of revenue in Slovenia. Table 6.6 shows the rate per kilometre driven on Slovenian roads that would cover the revenue loss from fuel taxes on passenger cars as derived for the IEA 2DS. If all passenger car kilometres driven on any road in Slovenia were covered, such a tax would amount to EUR 0.0025 per kilometre in 2020 and EUR 0.018 in 2050. If the tax was restricted to motorway kilometres but included all vehicles (passenger cars and trucks), its level would increase to EUR 0.007 per kilometre in 2020 and EUR 0.046 in 2050. No behavioural adjustments of driving patterns related to the increase in distance-based charges are considered in this calculation.[5]

Table 6.6. Kilometre tax equivalent to cover revenue loss from fuel taxes on cars, 2020-2050

No differentiation along vehicle dimensions; no behavioural effects.

	2020	2025	2030	2035	2040	2045	2050
Fuel tax revenue loss from cars for IEA 2DS (million EUR)	47.6	112.5	186.1	256.1	312.7	362.4	402.1
Km-equivalent; all car kilometres; any road (EUR per vkm)	0.0025	0.0057	0.0091	0.0123	0.0148	0.0168	0.0182
Km-equivalent; car and truck kilometres; motorway only (EUR per vkm)	0.0071	0.0158	0.0247	0.0330	0.0389	0.0433	0.0458

Note: The kilometre tax equivalent is derived by dividing the revenue loss from fuel used in passenger car by the number of kilometres driven by passenger cars on all Slovenian roads (second row) and by the number of kilometres driven by all vehicles (passenger cars and trucks) on Slovenian motorways (third row).
Source: OECD/ITF calculation.

Differentiating distance-based charges along several dimensions may be desirable to promote the efficiency of the road tax systems, but these are not considered in the calculations above for the sake of simplicity. First, a differentiation according to vehicles' emission profiles (including air pollution) can strengthen incentives to use more fuel-efficient or alternative fuel vehicles. The Slovenian toll system currently accounts for the EURO class of a truck, while the existing vignette does not apply a similar differentiation for passenger cars. Second, tax levels may also reflect an area's population density, thereby accounting for exposure to emission and noise. Third, differentiating taxes along places and time provides an effective tool for traffic and congestion management; for example, via charging higher rates when and where roads are congested. The current toll system for trucks in Slovenia uses microwaves that communicate with gantries built on the motorway, a technology that can rather easily implement toll rates that vary with population density and congestion rates. Although both tolling systems are not directly comparable, a differentiation of vignette rates with EURO classes of cars can help to take vehicles' environmental characteristics into account.

Setting tax rates at the level of the external costs from driving will improve the efficiency of the Slovenian tax system, while ensuring that rates are not set so high as to distort the allocation of resources. Distance-based charges are more appropriate than fuel taxes to capture several external costs from driving; e.g. air pollution in the case of fossil fuel consuming cars, noise pollution, accidents, congestion and the use of public space.

There is a case to extend and improve the taxation of road use in Slovenia. An additional differentiation of truck tolls (e.g. based on vehicle characteristics, the population density of a location and congestion levels) would increase the efficiency of the current system and may be achieved at relatively low additional costs. Transforming the vignette system for passenger cars into an actual distance-based charge will achieve more stable revenues over time and better traffic management. Such a transformation may be facilitated by using the existing toll infrastructure but would need to consider the different technical, organisational and legal aspects of personal vehicles compared to trucks. It could also be complemented more gradually, by starting the assessment (and taxation) of kilometres driven per odometer readings at annual car inspections and transforming to the existing toll infrastructure with differentiated rates afterwards. (NB: This would not capture foreign vehicles.) Revisions of the vignette system need to be seen in the context of potential harmonisation efforts in the field at the EU level, so will take account of a broader set of considerations than those considered in this study. The results of the present analysis are one potential input into the broader.

Political and social resistance to tax reform that focuses on implementing and improving distance-based charges requires well-designed policies supported by a tailored and effective communication campaign. For example, gradually phasing-in distance-based charges in Slovenia while the fleet decarbonises will keep the tax burden stable over time for many drivers; it rather shifts the composition of taxes from fuel use towards driving. Recent advances mean that administrative burden and technological limits are becoming less of a hurdle (Van Dender, 2019[3]).

Even if the phasing-in of distance-based charges in a decarbonising environment will not raise the average tax burden, it will affect specific driving types differently. For example, taxes will shift from vehicles that are heavily reliant on fossil fuels towards vehicles that are driven longer distances. Distance-based charges that account for the efficiency level of a vehicle may contain the effect of such a shift.

Additional simulation of the distributional impacts of tax reform, along income and geographical dimensions, would be required to design an appropriate policy response and successful implementation through effective and tailored supporting communication strategies. For example, further analysis based on the present modelling tool could simulate the tax burden of different driving types in the future and determine those types that are most affected by a tax reform. This will support future efforts for designing appropriate policy responses, including support measures for those parts of the population that will be most adversely impacted because they may not be able to adjust their driving behaviour easily in the short run, due to external constraints such as an absence of travel alternatives (e.g. public transport) or financial constraints.

Notes

[1] The analysis uses excise duty rates as applicable throughout 2017, i.e., EUR 0.5078 per litre of gasoline and EUR 0.4261 per litre of diesel. As of 22 May 2018, the excise duty for gasoline and diesel is set at EUR 0.47829 per litre and EUR 0.39272 per litre respectively.

[2] This calculation assumes that all private households living in the Italian municipalities of Gorizia and Trieste (data from Italian National Institute of Statistics) purchase 25% of their fuel in Slovenia given the current price differential of approximately EUR 0.25. (Following Rietveld, Bruinsma and van Vuuren, it is assumed that for each EUR 0.05 price differential, Italian car owners purchase 5% of their fuel in Slovenia.)

[3] Rietveld, Bruinsma and van Vuuren analyse fuel purchase behaviour of Dutch households in the border region with Germany. Through a stated preference approach, the authors find that households living in the border region (30 km away from border) will purchase 5% of their fuel in Germany, when the price differential is at EUR 0.05.

[4] This number represents a lower bound for fuel used in trucks, assuming that some trucks may not claim a refund and because only trucks above a weight of 7.5 tonnes can claim a refund.

[5] The responsiveness to price increases is typically lower for the driving than for the fuel use base (see Section 2.2.1), which is due to the fact that few substitution possibilities exist in the short to medium run for driving, particularly in areas with poor public transport infrastructure.

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Tax Revenue Implications of Decarbonising Road Transport

SCENARIOS FOR SLOVENIA

This report investigates how tax revenue from transport fuels could evolve over time as vehicles rely less on fossil fuels, with a focus on the case study of the Republic of Slovenia. Reducing the reliance on fossil fuels in the transport sector is a welcome development from the perspective of its climate and health impacts and of reduced energy dependence. However, under current settings, reduced fuel use will also lead to a loss of tax revenues, which may put stress on government budgets. Based on simulations for Slovenia, with a 2050 horizon, the report provides an in-depth assessment of the taxation of road transport and investigates how tax policy could adapt to declining fossil fuel use in the long term if the objective is to maintain revenues at current levels while taking fairness and efficiency considerations into account. It finds that gradual tax reforms, with an evolving mix of taxes, shifting from taxes on fuel to taxes on distances driven, can contribute to more sustainable tax policy over the long term.

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