

Loss of revenues in passenger car taxation due to incorrect CO₂ values in 11 EU states

CREDITS

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EXECUTIVE SUMMARY

The gap between type-approval and real-world CO₂ emission values for passenger cars has been widening quickly for several years now and was reported to be 42% in 2016 by the International Council on Clean Transportation (ICCT/TNO 2017). The extreme divergence observed today impairs many governments' tax revenues. The majority of EU member countries levy motor vehicle taxes based on type-approval CO₂ emission values, which turn out to be a seriously flawed tax base.

This analysis shows that in the eleven countries under consideration, tax revenues from car registration and ownership would have been more than €10 billion higher in 2016, if CO₂ emission values had been more realistic. For comparison, actual total motor vehicle tax revenues in Germany amounted to €8.95 billion in 2016. The countries analysed include Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, the Netherlands, Spain, Sweden and the United Kingdom. Over the period 2010–2016, the deficits accumulate to a total loss in the range of €40–50 billion. The substantial tax deficits imply that intended price signals of the taxes have been much weaker.

Flawed CO₂ emission values undermine climate policy in many ways. Besides its fiscal dimension, the emissions gap is problematic for consumers, society as a whole, car manufacturers and governments (ICCT 2016a). Unreliable or flawed information on fuel consumption and emission values deceives consumers and leads to buying decisions based on false assumptions of future fuel and climate costs. It undermines climate and environmental policy efforts. It distorts competition between manufacturers, penalizing the ones with more realistic emission values.

The most important implication from this analysis is that the regulatory framework needs to be fixed and sharpened. CO₂-based taxation and other CO₂-based instruments, like the European Union's mandatory emission reduction targets, require reliable CO₂ emission values. This is also true for other pollutants like nitrogen oxides. Some steps in the right direction have been taken, but the framework remains inadequate. Most importantly, the introduction of the Worldwide harmonized Light vehicles Test Procedure (WLTP) will reduce the gap between type-approval and real-world emission values, but it will not resolve the fundamental problems. The gap will remain large and is even expected to grow again over time (Stewart et al. 2015). Tax deficits will hence remain substantial.

Our analysis also shows that there is a lot of untapped potential in the way motor vehicle taxes are designed in the eleven EU member countries. The incentive scheme created by the tax system is non-dynamic and incoherent with its goals in many cases. Different taxes should address different goals and externalities, and they have to be designed accordingly. For example, registration taxes target purchase behaviour much more effectively than taxes on car ownership. In contrast, driving behaviour is not addressed by either of them, and it has to be addressed by other instruments. Periodical taxes on ownership usually do not have a strong price signal and are hence less effective in achieving ecological goals. An elaborate system of energy or carbon taxes, registration taxes and road charging is desirable.

Looking at the taxes individually, it is apparent that some design features are more effective while others might have unintended consequences. Comparing the countries' different tax curves, we illustrate how decisions about their shape and position, underlying tax calculations, minimum and maximum rates or other exemptions affect the resulting incentive scheme created by the tax.

Lastly, the current taxation of motor vehicles needs to be adapted to future changes and challenges. The decarbonisation of the transport sector requires, among many other things, alternative fuels and technologies and more ambitious policy instruments. Most car taxes are, of course, build around the conventional technologies and should be adjusted with future developments in mind.

1 Introduction

In recent years, an increasing divergence has been observed between real-world fuel consumption and related CO₂ emission values of passenger cars on the one hand and the values measured at the test stand on the other. According to the International Council on Clean Transportation (ICCT/TNO 2017), the difference between official and real-world CO₂ emission values was around 9% on average in 2001. This gap has quickly widened to 42% in 2016 and continues to grow. Studies by other organizations, manufacturers and public authorities support these observations (see e.g. DUH 2017, Ministère de l'Environnement, de l'Énergie et de la Mer 2016, Schmidt/Georges 2015, Transport & Environment 2016). Leaked measurement results by the German Ministry of Transport and Digital Infrastructure revealed high gaps even under laboratory conditions (Spiegel 2016, Mock 2017), but later disappeared in the official report (BMVi 2017).

Incorrect CO₂ emission values have several negative consequences for consumers, society as a whole, car manufacturers and governments (ICCT 2016a). Consumers are deceived by unreliable data on fuel consumption and make buying decisions based on distorted information, which causes them additional, unexpected costs. Climate and environmental policy efforts are undermined, leading to higher CO₂ emissions. In the case of other emission values, e.g. for nitrogen oxides, air quality and health problems have also emerged – especially in larger cities. The social costs of driving are misrepresented. Furthermore, manufacturers with more realistic emission data have a competitive disadvantage in comparison to manufacturers with low but unreliable values. Last but not least, governments are faced with a substantial loss in revenues of CO₂-based car taxes as taxes were collected on the base of incorrect CO₂ emission values.

The aim of this analysis is to quantify the last, fiscal dimension of incorrect CO₂ emission values on passenger car tax revenues for eleven EU member countries, namely Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, the Netherlands, Spain, Sweden and the United Kingdom. The majority of EU member countries levy motor vehicle taxes based on type-approval CO₂ emission values. Revenues of these taxes are adversely affected by the emissions gap.

Our analysis shows that billions of euros in tax revenues are foregone every year because of the increasing divergence. In the eleven countries analysed, vehicle tax revenues would have been higher by more than €10 billion in 2016, if CO₂ emission values had been more realistic. This also implies that price signals of these taxes have been much weaker than intended. The total cumulated tax deficit over the period 2010–2016 was estimated to be in the region of €40–50 billion. Evidently, countries with more ambitious, CO₂-based car taxation reveal the highest relative deficits. It is striking but not surprising that countries with more ambitious, CO₂-based car taxation have the highest deficits relative to their fleet sizes.

Table 1: Executive Summary – Main statistics and results

	Tax Deficit 2016	Cumulated 2010–2016		Tax Deficit 2016	Cumulated 2010–2016
	in million Euro			in million Euro	
Austria	560	2,527	Luxembourg	27	110
Belgium	212	687	Netherlands	2,554	11,981
Denmark	831	3,227	Spain	>500	2,500–5,000
Finland	273	1,315	Sweden	245	814
France	2,599	10,946	United Kingdom	2,238	7,977
Germany	1,189	4,090			
			Total	>11,228	<46,174

Sources: own calculations based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), KBA (2017a), ICCT/TNO (2017)

The introduction of the Worldwide harmonized Light vehicles Test Procedure (WLTP) for new type approval in September 2017, which will be mandatory for all new cars as of September 2018, will most certainly reduce the gap between type-approval and real-world emission values, and hence the tax deficit, to some extent. The gap will however remain large and is expected to grow again over time (Stewart et al. 2015).

To lay the ground for the calculation of the tax revenues losses chapter 2 and 3 take a brief look on the development of the CO₂ emissions gap, implications of the WLTP introduction and CO₂-based passenger car taxation in EU countries. Chapter 4 describes the data and methodology used in this paper. Using data on registration of new

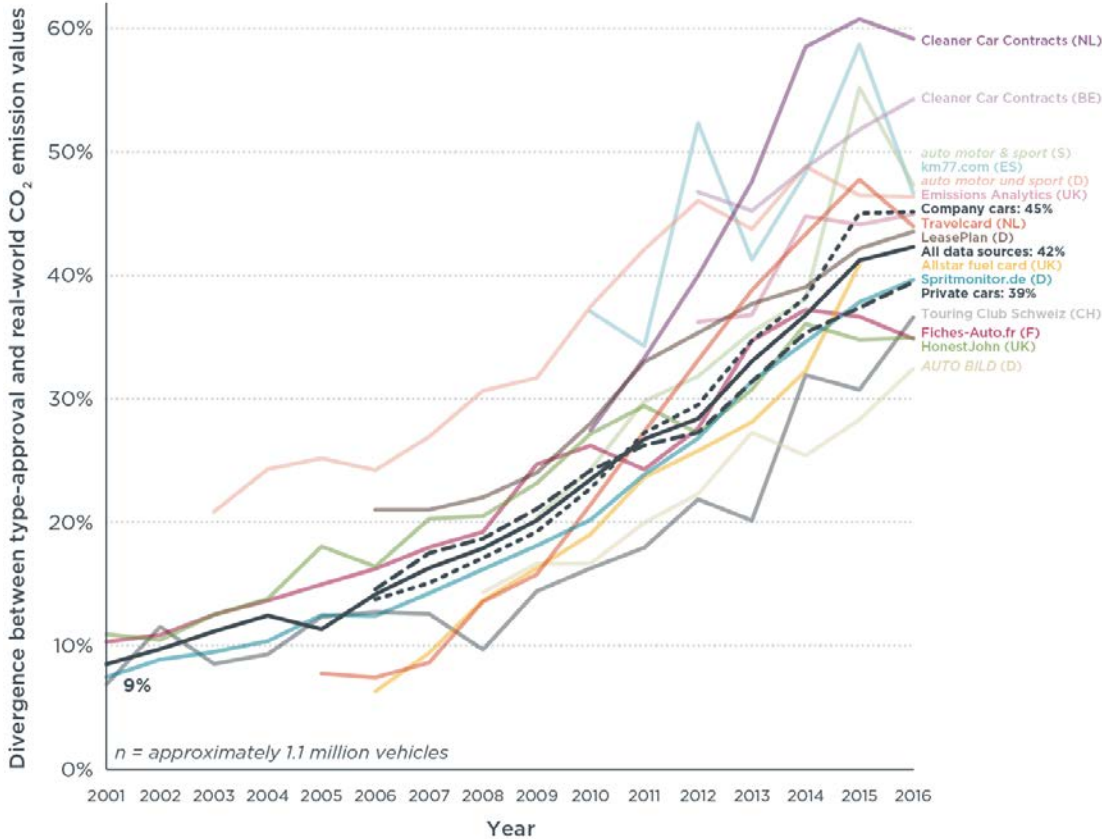
passenger cars by the European Environmental Agency (EEA 2017), we calculate the difference between the theoretical tax revenues based on type-approval CO₂ emission values and adjusted real-world values (based on ICCT/TNO 2017) for 2010 till 2016. The results are presented for each country individually in chapter 5.1 to 5.11, including a brief description of all relevant taxes and country-specific methodology. Chapter 6 summarizes the results and discusses the differences in tax design in the eleven countries. Finally, in chapter 7 some policy implications and recommendations are derived from the analysis.

2 CO₂ emissions: type-approval and real-world

To a certain degree deviations between official and real-world emission values cannot be avoided, as individual driving behaviour and conditions cannot be perfectly replicated in a standardized test environment. Extreme deviations as observed today are however problematic for several reasons. Firstly, incorrect values have a fiscal impact because they affect many CO₂-based motor vehicle tax revenues and may lead to significant tax deficits (the focus of this analysis). Secondly, they impair the effectiveness of the tax instruments, thereby undermining climate and environmental policy goals. Thirdly, consumers are misled by incorrect values and, as a consequence, they underestimate their future fuel expenses as well as their CO₂ emissions. Correct values are necessary for good buying decisions. Lastly, car manufacturers compete in a distorted market. Customers cannot distinguish real technological advances from notional advances on the test stand, which penalizes manufacturers with more realistic type-approval emission values.

The extent of the deviations between real world CO₂ emissions and type approval emission values has been analysed in quite a few studies and reports. The ICCT (ICCT/TNO 2017) evaluated data on more than one million vehicles from 14 different platforms and portals (e.g. fleet management, leasing companies, consumers, benchmark tests) from Belgium, France, Germany, Great Britain, the Netherlands, Spain, Sweden and Switzerland. The results are summarized in Figure 1. The data show that the divergence between type-approval and real-world CO₂ emission values was around 9% in 2001. Over the years, this gap has increased rapidly to intolerable levels: in 2016 the gap amounted to 42% on average.

Figure 1: ICCT/TNO (2017) figure showing the divergence between real-world and manufacturers’ type-approval CO₂ emission values for various data sources



Source: ICCT/TNO (2017)

The Worldwide harmonized Light vehicles Test Procedure (WLTP) was introduced for new vehicle types in September 2017 and will be mandatory for all new cars as of September 2018. It will most certainly reduce the gap between type-approval and real-world emission values to some extent. The gap will however remain large and is expected to grow again over time (Stewart et al. 2015). For the United Kingdom, Stewart et al. estimate that the WLTP could initially bring down the gap to about 23% in 2020. The authors suggest, however, that exploitable shortcomings of the WLTP as well as rising market shares of hybrid and plug-in hybrid cars are likely to lead to another increase to about 31% in 2025.

3 CO₂-based passenger car taxation in EU countries

Taxation of passenger cars and other vehicles is (partly) based on CO₂ emission values, or equivalently fuel consumption, in 19 out of 28 European member countries (see Table 2). Incorrect type-approval CO₂ values hence have been negatively affecting tax revenues and their environmental effectiveness in the majority of the EU28 for many years now.

Table 2 gives an overview of passenger car taxation in the EU28. The table indicates page numbers for all countries analysed in this study. Besides value-added taxes (VAT), most countries impose a one-off tax on purchase or registration of a new (or often also used) car as well as a periodical tax on ownership. In most cases, taxation is based on CO₂ emissions or fuel consumption and/or other vehicle characteristics like cylinder capacity or power. Registration taxes oftentimes also take into account vehicle prices.

Table 2: Summary of passenger car taxation in EU28 (CO₂- and fuel consumption related taxes bold and highlighted in grey)

Country	Page	Registration Tax	Taxes on Ownership (Passenger Cars)
Austria	14	Price, CO₂ emissions , fuel type, CO₂-based malus	Engine power
Belgium	16	CO₂ emissions , Cylinder capacity, age, regions	CO₂ emissions , cylinder capacity
Bulgaria	-	-	Engine power
Croatia	-	CO₂ emissions , fuel type	Engine power, age
Cyprus	-	CO₂ emissions , cylinder capacity	CO₂ emissions
Czech Republic	-	-	Engine size
Denmark	19	Fuel consumption , safety equipment	Fuel consumption , weight
Estonia	-	-	None
Finland	21	CO₂ emissions , price	CO₂ emissions , weight x days
France	24	CO₂ based Bonus-Malus system	CO₂ emissions
Germany	26	-	CO₂ emissions and cylinder capacity
Greece	-	CO₂ emissions , price	CO₂ emissions or cylinder capacity
Hungary	-	Age, cylinder capacity	Age
Ireland	-	CO₂ emissions , price	CO₂ emissions
Italy	-	Kilowatt, weight, seats	Engine power
Latvia	-	Weight, fuel type	Weight, cylinder cap., engine power
Lithuania	-	-	None
Luxembourg	28	-	CO₂ emissions or cylinder capacity
Malta	-	CO₂ emissions , price, vehicle length	CO₂ emissions , vehicle age
Netherlands	30	CO₂ emissions , fuel efficiency	CO₂ emissions , weight, province, fuel
Poland	-	Cylinder capacity	None
Portugal	-	CO₂ emissions , cylinder capacity	CO₂ emissions and cylinder capacity
Romania	-	CO₂ , cylinder capacity + exhaust emissions	Cylinder capacity
Slovakia	-	Engine power, age	Cylinder capacity
Slovenia	-	CO₂ emissions , price	Cylinder capacity
Spain	32	CO₂ emissions , price	Engine rating
Sweden	34	-	CO₂ emissions , weight
United Kingdom	36	- (CO₂-based 'first year rate' of ownership tax)	CO₂ emissions , cylinder capacity

Source: based on ACEA (2016, 2017a)

4 Data and Methodology

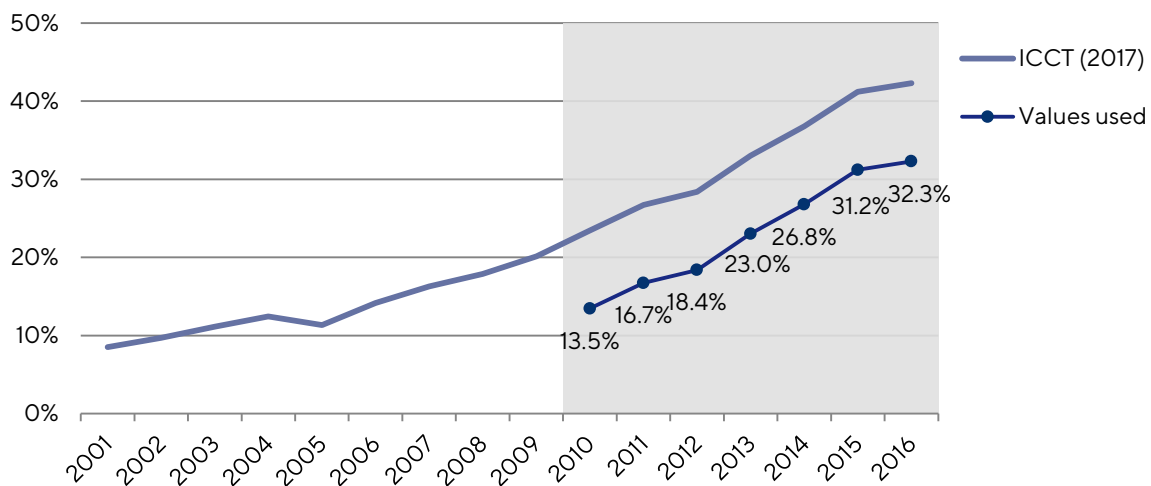
Using data on registration of new cars by the European Environmental Agency (EEA), we estimate the tax deficit for CO₂-based taxes on purchase and ownership of passenger cars due to incorrect CO₂ values in 11 EU member states for the years 2010 till 2016. The tax deficit is calculated as the difference between theoretical tax revenues based on type-approval CO₂ emission values and more realistic values adjusted to the findings of ICCT/TNO (2017). Information on vehicle taxation and tax computations is primarily taken from the European Automobile Manufacturers' Association's annual tax guides (ACEA 2010, 2012, 2014, 2015, 2016, 2017a). The methodology is based on an analysis carried out by Green Budget Germany on the German motor vehicle tax (FÖS 2016).

The EEA dataset includes, among other things, manufacturer name, type-approval number, specific CO₂ emissions (type-approval value), vehicle mass, engine capacity, fuel type etc., which in most cases is sufficient to determine tax rates and estimate theoretical tax revenues with a dependency on CO₂ emission values.

Data on the gap between type-approval and real-world CO₂ emission values by ICCT/TNO (2017) are used to approximate the real emissions value for each car registration in the EEA data. The results of the ICCT are based on a large sample of around 1 million vehicles and can therefore be seen as representative. The results are consistent with the results of other analyses and official investigations as mentioned in chapter 1. In contrast to other studies, the ICCT data provide sufficient width and temporal resolution for our calculations. The study is updated annually.

The average gap amounted to 23.5%, 26.7%, 28.4%, 33.0%, 36.8%, 41.2% and 42.3% for the years 2010 till 2016, respectively (ICCT/TNO 2017). For the calculations, a gap of 10% is considered to be reasonable and was deducted for several reasons. First, driving cycles cannot perfectly replicate real-world driving conditions and driving patterns. Second, the ICCT data show that a divergence of 10% was also prevalent at the beginning of the 2000s. Third, 10% is often regarded as a tolerable limit for deviations in Germany due to a judgement by the German Federal Supreme Court in 1997 (VIII ZR 52/96). In contrast, deviations up to 4% are permitted in the laboratory (Schmidt/Georges 2015). Real emissions gaps of 13.5%, 16.7%, 18.4%, 23.0%, 26.8%, 31.2% and 32.3% are hence used for the calculations (see Figure 2).

Figure 2: Comparison of observed divergence (ICCT/TNO 2017) and values used for calculations



Source: own graph based on ICCT/TNO (2017)

With this information at hand the type-approval CO₂ emission values in the EEA data are adjusted to approximate more realistic values. Theoretical tax revenues can then be calculated again on the basis of the adjusted emission values. The difference in theoretical tax revenues based on type-approval and adjusted real-world values yields the tax deficit.

It should be emphasized that the calculations are static. Only the direct effect of CO₂ emission values on specific tax revenues (i.e. from registration taxes and annual vehicle taxes) is taken into account with all other things held constant. In particular, reactions in behaviour by car owners and car buyers and adjustments in taxation as a result of changes in emission values are not taken into account, although they are more than likely. For instance, the consumer response to registration taxes is often found to be elastic (see e.g. Adamou et al. 2014, Brand et al. 2013,

D'Haultfœuille et al. 2014, Gerlagh et al. 2016, Kok 2015). Correct emission values imply much higher tax rates in many cases, which would certainly lead to responses in consumer decisions and hence lower registration tax revenues. On the other hand, demand reacts rather inelastic to annual vehicle taxation (see e.g. Alberini/Bareit 2017, Gerlagh et al. 2016, Malina 2016). The deficits in registration and annual vehicle taxes, estimated with our static approach, hence should be interpreted as a very theoretical approximation of the fiscal dimension of incorrect CO₂ emission values.

We do not estimate total tax revenues, but only include tax components that are determined or affected by CO₂ emission values. For example, the German motor vehicle tax is based on two components: cylinder capacity and CO₂. The first component is not affected by incorrect CO₂ emission values and can be disregarded for the purposes of this paper. Only CO₂-based tax components are included. We also do not take into account indirect effects e.g. on energy taxation. Incorrect CO₂ emission values may result in higher tax revenues, because fuel consumption turns out to be higher than expected, if expectations were based on type-approval values. Actual consumption values are however easily observable, so that expectations should adapt quickly. The link between emission values and energy tax revenues is hence not as clear-cut.

It is taken into account that some new vehicles can be de- or re-registered in the same year or the years thereafter, in which case no taxes on ownership are payable in certain periods. For such cases data by the German Federal Motor Transport Authority (KBA 2017a) is used for all countries to approximate the percentage of registrations that remained registered in every year (see Table 3). For example, of all the cars registered in 2010 (first row) 85.2% were still registered in 2017 (last column). Estimations of annual or periodical tax revenues are adjusted accordingly.

Table 3: Percentage of cars (by year of registration) still registered on January 1 2010, ..., 2017

	1.1.2011	2012	2013	2014	2015	2016	2017
2010	91.4%	92.3%	93.5%	89.0%	84.2%	87.2%	85.2%
2011	.	91.1%	93.1%	94.7%	89.9%	89.2%	87.6%
2012	.	.	90.7%	93.2%	94.9%	89.7%	88.1%
2013	.	.	.	91.0%	92.9%	94.5%	88.9%
2014	91.0%	93.4%	94.8%
2015	90.8%	92.9%
2016	91.3%

Source: own calculations based on KBA (2017a)

4.1 Data limitations

Some data limitations and corresponding assumptions are relevant for several countries and are summarized in the following paragraphs. Country-specific assumptions and limitations are discussed in the country chapters.

- The EEA does not provide data for **registrations before 2010**. Tax deficits for these years thus cannot be calculated, although many CO₂-based tax systems were introduced before 2010. For example, vehicle excise duties have been based on CO₂ emissions in the United Kingdom since 2001. The French Bonus-Malus system was introduced in 2008. More than 4 million cars were registered in 2008 and 2009, but are not included in our estimates. Similarly, the annual malus was introduced in 2009. In Germany, the CO₂-based component of the motor vehicle tax was introduced in July 2009. Therefore, 1.7 million new car registrations in the second half of 2009 are not considered in the calculations, which reduces the tax deficit estimations by tens of millions euros annually. In the Netherlands, the purchase tax has a CO₂-based component since 2008.
- Vehicles using **alternative fuels and technologies**, including biofuels, natural gas, LPG, hydrogen, electrical or hybrid systems, were not taken into account. There is no sufficient data basis for systematic divergences between their type-approval and real world emissions values. The share of such vehicles in new car registrations is however still relatively low in the EU, 4.2% according to ACEA (2017b). Their impact on the results is limited but growing. Some reports point to high divergences between type-approval and real-world CO₂ emission values for plug-in hybrids (PHEV) (see e.g. Kadijk et al. 2015). The high electric drive share in the New European Driving Cycle (NEDC) is one reason for low type-approval emission values, which can often not be achieved under realistic conditions (Stewart et al. 2015). For this reason PHEV benefit from favourable tax treatments in many countries. This is particularly relevant in countries with progressive CO₂-based tax structures or tax exemptions for low-emission vehicles, e.g. in France and the Netherlands.
- The EEA dataset does not provide information on **vehicle ownership**. Tax exemptions or tax reductions for certain groups of people cannot be incorporated in the calculations. For example, special-purpose vehicles, e.g. ambulance and taxi, may be eligible for a full or partial tax refund in many countries. In Belgium and France, there are malus exemptions and reductions for large families. Many countries, including the United Kingdom, have exemptions for disabled persons.
- Similarly, the data do not distinguish between privately owned cars and **company cars**. In some instances different taxes apply to both groups. In such cases we adjust our estimations with additional data if feasible. Such cases are explicitly mentioned and explained in the relevant country chapters.
In many countries, the private use of a company car is treated as a benefit in kind and taxed as income. In some countries, e.g. Austria, Netherlands and United Kingdom, taxation takes into account vehicles' CO₂ emission values. Due to the lack of data on company cars the effect of diverging emission values on company car related income taxation is not considered in this study.
- The EEA data do not provide the exact **date of registration**, only the year. Tax changes were made within a year in some instances. Such cases are explicitly mentioned and explained in the relevant country chapters.

5 Country Analysis

The following eleven countries are analysed regarding their tax losses due to incorrect type-approval CO₂ emission values:



- [Austria](#)
- [Belgium](#)
- [Denmark](#)
- [Finland](#)
- [France](#)
- [Germany](#)
- [Luxembourg](#)
- [Netherlands](#)
- [Spain](#)
- [Sweden](#)
- [United Kingdom](#)

In total, more than 150 million passenger cars were registered in these 11 countries in 2015, a share of 60% of the total car registrations in all 28 member states of the EU (Eurostat 2017).

The results and implications of the country analyses can be found in chapter 6 and 7.

5.1 Austria

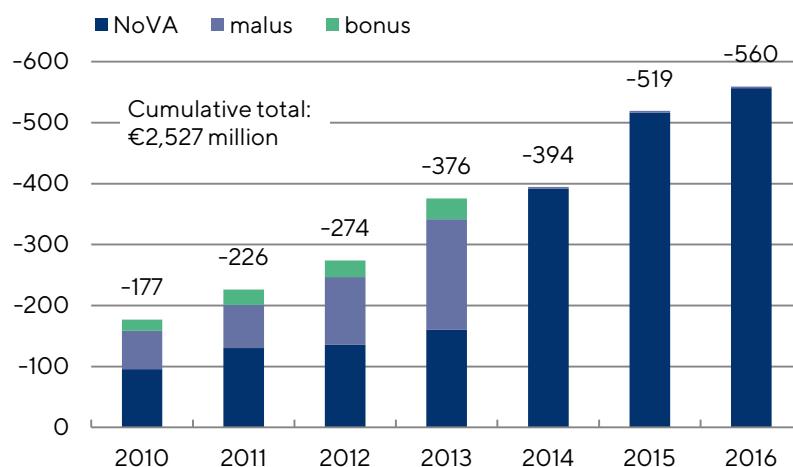
Country Profile	
Relevant taxes on purchase	Pollution tax (NoVA) based on CO ₂ emissions (fuel consumption), price and fuel
Relevant taxes on ownership	-
New car registrations, 2016	329,263
Total passenger vehicle fleet, 1.1.2015	4,748,048
Average CO ₂ emissions of new registrations (type approval), 2016	120.5g/km EU: 118.1g/km
Tax deficit, 2016	€560 million
Cumulated total deficit, 2010-2016	€2,527 million



Key Results

The Austrian pollution tax on the purchase of passenger cars and motorcycles (Normverbrauchsabgabe, NoVA) and parts of its bonus-malus system have been calculated on the basis of type-approval CO₂ emission values or fuel consumption since its introduction in 2008. **The cumulative tax deficit due to the widening gap between type-approval and real-world emission values for new passenger cars only amounts to €2.5 billion for the years 2010 till 2016.** The deficit has been larger since the reform of the NoVA in 2014. The deficit was €560 million in 2016, which is more than the revenues generated by the tax (€450 million in the 2016 budget; BMF 2017).

Figure 3: AT – deficit by tax and year, in million euros



Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), BMF (2017), EEA (2017), ICCT (2016b), ICCT/TNO (2017)

It is to be expected that the tax deficit will continue to grow until all new cars are type-approved under the WLTP (as of September 2018). The new test procedure will most certainly reduce the gap between type-approval and real-world emission values initially. The gap can however be expected to grow again due to unresolved, exploitable shortcomings of the test procedure as well as the increasing share of hybrid and plug-in hybrid cars (Stewart et al. 2015). ...

Description of relevant taxes

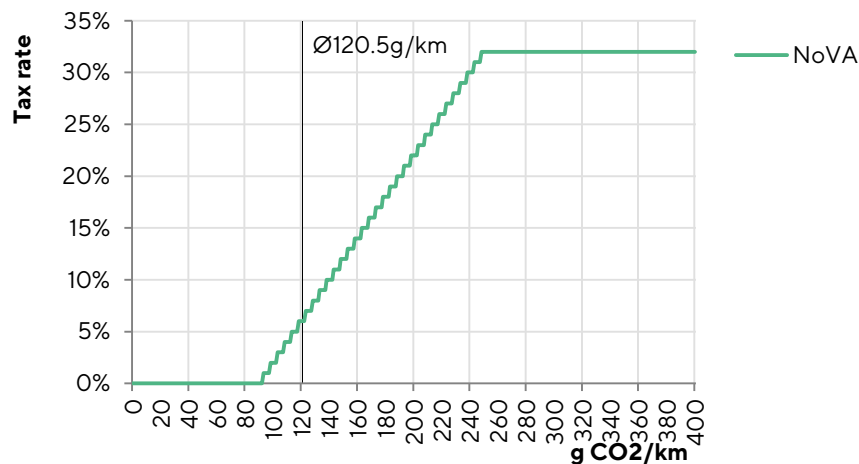
Normverbrauchsabgabe (NoVA) is a pollution tax on the purchase of new and used passenger cars and motorcycles that are registered in Austria for the first time. The tax rate has been based on CO₂ emission values since March 2014 and has been applied to the net purchase price or commercial leasing fee of the vehicle. Before its reform in 2014, NoVA had been based on fuel consumption rather than CO₂. NoVA is supplemented by a **bonus-malus-system** that includes additional charges and deductions for certain vehicle characteristics, including CO₂

emissions.

The new NoVA tax rate, which was introduced in March 2014, is calculated as the difference between the type-approval CO₂ value and 90g/km divided by five, with 0% and 32% being the minimum and maximum values. It is hence linearly increasing from 0% to 32% between 90 and around 250g/km and sensitive to changes in emission values (see tax curve in

Figure 4; the national average emission value of new passenger car registrations in 2016 is indicated as a point of reference). The rate is multiplied by the net purchase price (the tax base), to calculate the amount payable. In addition, there is a malus fee of €20 for every gram of CO₂ exceeding 250g/km. In 2016, only 0.2% of all new passenger car registrations fell into this category. There are also deductions depending on the type of fuel that have been changed regularly over the last years.

Figure 4: AT – NoVA, tax rate on net purchase price; based on tax formula



Source: graph based on ACEA (2016, 2017a), BMF (2017)

Until February 2014, the tax rate had been calculated on the basis of fuel consumption: the difference between official fuel consumption (in litres per 100 km) and 3l/100km (2l/100km for diesel) times 2%. The maximum tax rate had been limited to 16%. However, additional charges due to the bonus-malus system had been higher. A malus of €25 had to be paid for every gram CO₂ above 160g/km from 2010 until February 2011. In 2011, another two thresholds (180 and 220g/km) had been added, for which €25 per gram had to be paid on top. So, every gram above 180g/km (220g/km) had been taxed at two (three) times €25. The three thresholds were lowered to 150, 170 and 210g/km in 2013. A bonus of at most €300 had been given to cars emitting less than 120g/km from 2008 until February 2014. The system also included bonuses and additional charges based on fuel type (alternative fuels) as well as emissions of particulate matter and nitrogen oxides, which are not taken into account here.

In Austria, the private use of company cars is treated as a benefit in kind. The computation of the benefit takes into account the CO₂ emission value of the car. The monthly benefit is either 1.5% or 2% of the vehicle price depending on CO₂. The effect of the real-world gap on income taxation is not considered though.

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a) and Federal Ministry of Finance (BMF 2017).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here. NoVA is applicable to new and used passenger cars and motorcycles not yet registered nationally. Only new passenger cars are however taken into account in this study.

The EEA dataset does not provide values for fuel consumption, which are necessary to determine the old NoVA rate from before February 2014. Fuel consumption was hence derived from the CO₂ emission values using the following conversion rates: 2,330 g CO₂/l gasoline and 2,640 g CO₂/l diesel.

The NoVA rate is applied to the net vehicle price to determine the amount of tax payable (plus/less any applicable bonus-malus fees). Since we do not have price data for the individual car, we use the annual average passenger car price in Austria, as provided by (ICCT 2016b), less 20% VAT and a 10% safety margin. The latest market statistics are available for 2015, which are also used for the year 2016.

5.2 Belgium

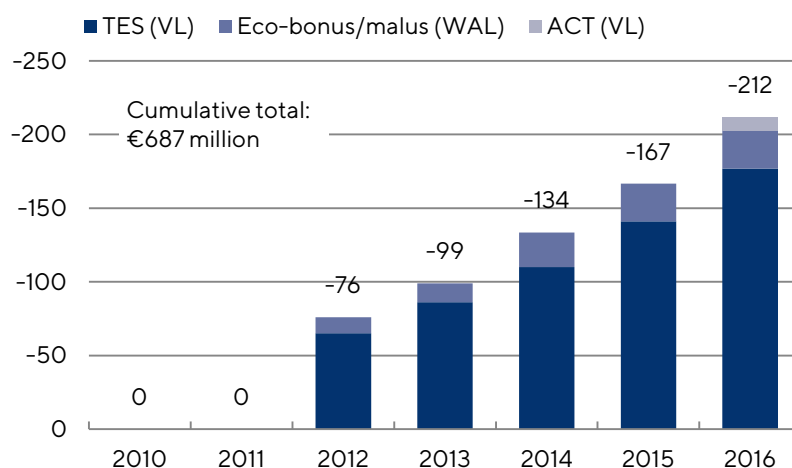
Country Profile	
Relevant taxes on purchase	Tax on entry into service (TES) and eco-bonus/malus system based on CO ₂ emissions
Relevant taxes on ownership	Flemish annual circulation tax (ACT) based on CO ₂ emissions
New car registrations, 2016	540,955
Total passenger vehicle fleet, 1.1.2015	5,623,579
Average CO ₂ emissions of new registrations (type approval), 2016	115.9g/km EU: 118.1g/km
Tax deficit, 2016	€212 million
Cumulated total deficit, 2010-2016	€687 million



Key Results

Different schemes for taxes on registration and ownership might apply in the three Belgium regions: Flanders (VL), Wallonia (WAL) and the Brussels-Capital Region (BCR). CO₂ emissions values are part of the tax base for the Flemish tax on entry into service (TES) and annual circulation tax (ACT) as well as the Wallonian eco-bonus/malus. The growing gap between type-approval and real-world emission values has thus been leading to rising tax deficits, which were estimated to be €212 million in 2016. **The cumulative tax deficit amounts to at least €687 million for the years 2012 till 2016.** This value is likely to be an underestimation because several aspects could not be calculated. Most importantly, TES and eco-bonus/malus also apply to purchases of second-hand cars, which are not taken into account in this study. Also, no estimations could be made for the Wallonian eco-bonus/malus system before 2012.

Figure 5: BE – deficit by tax and year, in million euros



Source: graph and calculation based on ACEA (2017a), EEA (2017), ICCT/TNO (2017), KBA (2017a)

Description of relevant taxes

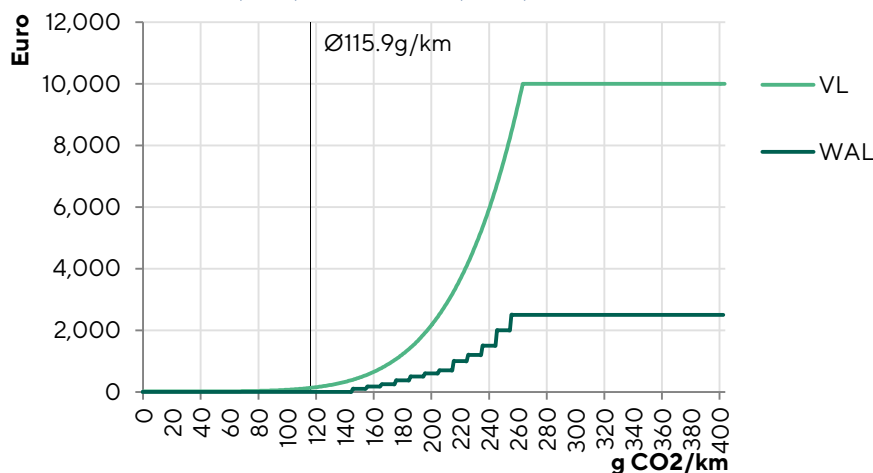
The Belgian **Tax on Entry into Service (TES)** is a registration tax for new and second-hand cars, minibuses and motorcycles based on engine power and age. Only new car registrations are taken into account here. Belgian regions can have additional or adjusted tax schemes. A CO₂-related component is integrated in the tax schemes in the Flemish and Walloon region.

In the **Flemish region**, TSE has been based on fuel, age, Euronorm and CO₂ emissions since 2012. It is calculated with a single formula that incorporates the different components. The tax payable is growing exponentially with CO₂ emissions (see tax curve in

Figure 6). The minimum and maximum amounts were set at €40 and €10,000 in 2012 and have been adjusted to inflation annually. The tax curve is especially steep between 150 and 250g CO₂/km. Tax computations are thus very sensitive to divergences in emission values within this range. The cap at €10,000 benefits high-emission vehicles with more than 250g CO₂/km.

The **Walloon region** has been using a CO₂-based **eco-bonus/malus system** for private car purchases in addition to TES since 2008. A bonus for low-emission vehicles had been paid until and including 2013. In 2014, the system was extended to also include legal persons (except companies with leasing business) and the bonus was terminated. From 0 to 145g/km no malus has to be paid. Thereafter the tariff increases every 10g/km, starting at €100 for 146–155g/km. The maximum amount payable is limited at €2,500 for cars with more than 255g/km. Before 2012, the bonus/malus amount had also been dependent on vehicle price and properties of the owner's previous car. Therefore, calculations cannot be made for these years.

Figure 6: BE – TES in Flemish (VL) and Walloon (WAL) region, tax amount payable; based on exponential tax formula (VLA) and tax table (WAL)



Source: graph based on ACEA (2017a)

Different periodical **taxes on ownership** apply to private and company cars. Company cars are taxed at the federal level. The **solidarity contribution** is computed on the basis of a linear function of CO₂ emissions, and it has to be paid if the company car can be used privately. Since the EEA data do not distinguish between private and company cars, we can only vaguely approximate the size of the total tax deficit. According to May (2017), there were 425,000 company cars available to employees in 2015. The annual tax deficit for a single car with average CO₂ emission value (117.8g/km in 2015), for example, is close to €330, assuming a 32.3% emissions gap. For 2010, we find this value to be €160. The annual deficit is thus likely to be around a hundred million euros, and it is increasing quickly due to the rising gap.

Private ownership of cars is taxed at the regional level. The basis for all regions is the **annual circulation tax (ACT)**, which is based on engine power. CO₂ has been part of the tax base only in the **Flemish region** since 2016. ACT tariffs have been adjusted depending on CO₂, fuel type and Euronorm. With regards to CO₂, the tax amounts are increased or decreased by 0.30% for every gram above or below 122g/km, with upper and lower limits at 500g/km and 24g/km. We find that the revenues from the Flemish ACT in 2016 would have been €9.4 million higher, if emission values had been more realistic.

There was a **CO₂-based tax incentive** in the years 2010 and 2011. Private cars with less than 105g CO₂/km (or between 105 and 115g CO₂/km) were eligible for a tax reduction equivalent to 15% (3%) of the sales price. The data show that approximately 290,000 new registrations in total had emission values below 105g/km in 2010 and 2011. After adjusting the emission values for the real-world emission gap, only 7% of these cars stay below the 105g/km threshold. 93% would not have been eligible with more realistic emission values. Without data on car ownership and vehicle prices, the fiscal effect cannot be calculated.

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a) as well as Federal Public Service Finance (2015, 2016).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1.

The EEA dataset does not disaggregate registrations by regions nor ownership. In order to be able to assess the regional tax schemes, we used the regions' share in new passenger cars as an approximation. Based on Hooftman et al. (2015), we use the following shares for all years: 54% (VL), 29% (WAL) and 16% (BCR). This approach assumes that there are no structural differences in vehicle characteristics between regions. For ownership, we assume, based on Harding (2014), that 41% of all new car registrations are company cars.

The Flemish TES and eco-bonus/malus in the Walloon region are also levied on second-hand cars, which are not taken into account. Leasing companies are exempted from TES (VL) and Ecomalus (WAL).

5.3 Denmark

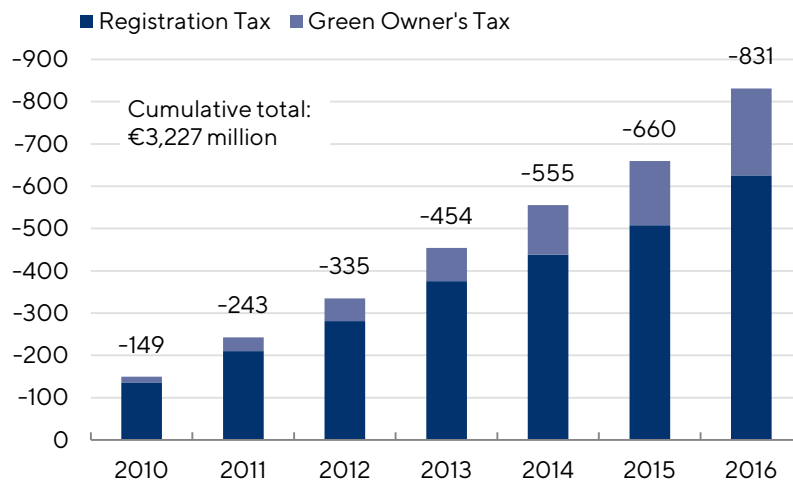
Country Profile	
Relevant taxes on purchase	Registration tax based on i.a. price, fuel consumption, fuel type
Relevant taxes on ownership	Green Owner's Tax based on fuel consumption and fuel type
New car registrations, 2016	221,068
Total passenger vehicle fleet, 1.1.2008	2,580,000
Average CO ₂ emissions of new registrations (type approval), 2016	105.9g/km EU: 118.1g/km
Tax deficit, 2016	€831 million
Cumulated total deficit, 2010-2016	€3,227 million



Key Results

Danish taxation of passenger cars has been based, among other things, on fuel consumption, which is equivalent to taxation based on CO₂ emission values. The type-approval and real-world emissions gap thus has been leading to a bias in tax calculations. **The cumulative tax deficit amounts to more than €3.2 billion for the years 2010 till 2016.** Of this total, around €0.8 billion accrued in 2016. The deficit is huge considering the small fleet size and it is growing with the widening gap and the increasing number of new passenger car registrations every year. In the case of the periodical green owner's tax, the deficit is also growing because every generation of registrations adds to the stock of vehicles liable for taxation.

Figure 7: DK – deficit by tax and year, in million euros



Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), ICCT/TNO (2017), KBA (2017a)

It is to be expected that the tax deficit will continue to grow until all new cars are type-approved under the WLTP (as of September 2018). The new test procedure will most certainly reduce the gap between type-approval and real-world emission values initially. The gap can however be expected to grow again due to unresolved, exploitable shortcomings of the test procedure as well as the increasing share of hybrid and plug-in hybrid cars (Stewart et al. 2015). In the case of the green owner's tax, the WLTP does not change taxation of cars registered before its introduction. The corresponding part of the deficit is likely to only grow more slowly after 2018.

Description of relevant taxes

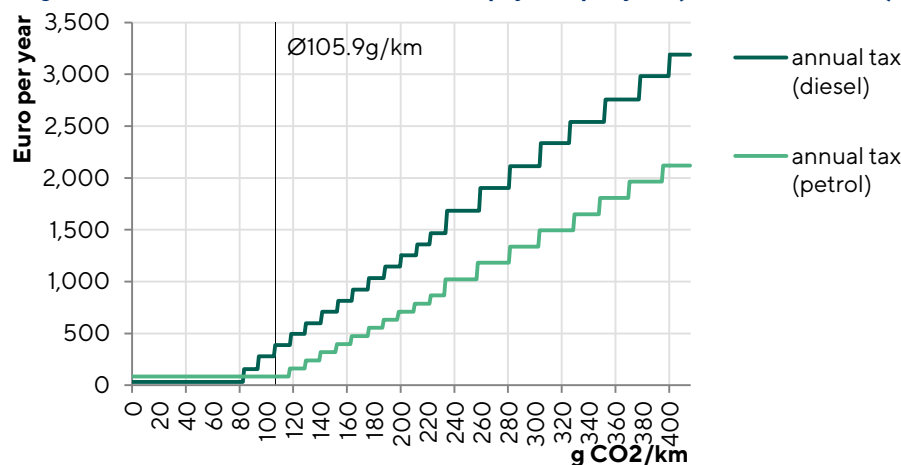
Vehicle registration tax has to be paid for cars, motorcycles, taxis, vans, buses etc. when registered for the first time in Denmark. For passenger cars, the tax has been 105% of the taxable value up to around €10,000 and 150% (180% until October 2015) of the remaining value. The threshold is adjusted to price indices and thus has been

rising over time. The taxable value is based on a vehicle's sales price and is raised or lowered depending on fuel consumption and other vehicle characteristics like safety equipment. For petrol and diesel cars, the taxable value is reduced by DKK 4,000 (approx. €536) for each km/l above 16 and 18, respectively. The taxable value is increased by DKK 1,000 (approx. €134) for each km/l below. The limits in km/l are equivalent to around 150g CO₂/km for petrol and diesel. The minimum registration tax payable is DKK 20,000 (approx. €2,690) for all private passenger cars.

For the calculations of the tax deficit, we compare the reductions/increases of the taxable value based on type-approval fuel consumption values and the adjusted real-world values. We only apply 105%, because the total taxable value is not deductible from the data. The steep increase of the registration tax deficit between 2010 and 2016 is due to an increasing number of new passenger car registrations as well as the rising divergence between type-approval and real-world values.

The **Green Owner's Tax**, which was introduced on 1 January 2010, is a semi-annual road tax based on fuel consumption in km/l (values are converted to g CO₂/km here for coherence). Tax rates are defined in a tax table, which is updated frequently, and they are different for diesel and petrol cars. The resulting tax curve is flat from 0g/km up to around 80g/km for diesel and 120g/km for petrol. After these points the tax increases every 10 to 30g/km by DKK 240 to 870 (€32 to 117). The increases are higher for diesel than petrol. In other words, the tax curve (see Figure 8) for diesel is steeper. For example, the tax was DKK 1,190 (€160) for petrol and DKK 2,640 (€355) for diesel at around 150g/km in 2016. At 220g/km the tax rates were DKK 2,930 (€394) and DKK 4,670 (€627), respectively. As a result, Danish passenger car taxation (registration tax as well as green owner's tax) are sensitive to fuel consumption values, or equivalently CO₂ emission values.

Figure 8: DK – Green owner's tax, amount payable per year (converted to Euro); based on tax table



Source: graph based on ACEA (2017a)

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a) and The Danish Ecological Council (2015).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

The EEA dataset does not provide values for fuel consumption. It was hence derived from the CO₂ emission values using the following conversion rates: 2,330 g CO₂/l gasoline and 2,640 g CO₂/l diesel.

Registration tax also applies to used vehicles and is calculated in the same way as for new ones. The taxable value is however based on market prices. Used vehicles are not considered in this study though.

For the years 2011 and 2013, the tax tables of the previous years (2010 and 2012) were used for the green owner's tax.

Currency conversions were made using average annual rates, as provided by the Canadian Foreign Exchange website.

5.4 Finland

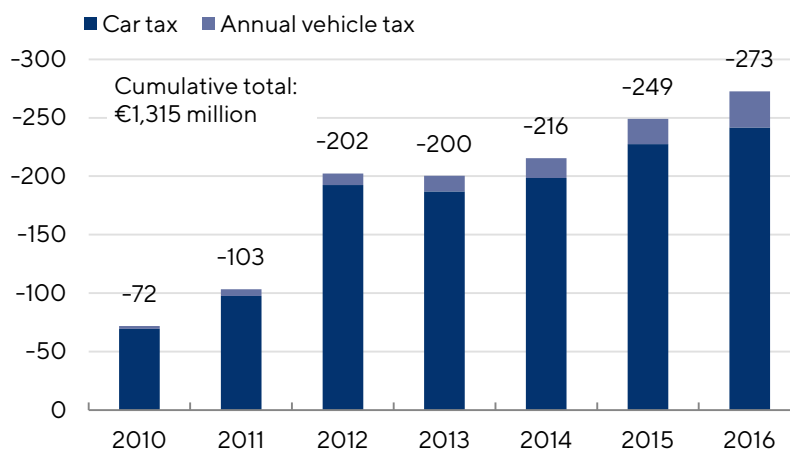
Country Profile	
Relevant taxes on purchase	Car tax based on CO ₂ emissions and price
Relevant taxes on ownership	Annual vehicle tax based on CO ₂ emissions
New car registrations, 2016	115,317
Total passenger vehicle fleet, 1.1.2015	3,234,860
Average CO ₂ emissions of new registrations (type approval), 2016	119.9g/km EU: 118.1g/km
Tax deficit, 2016	€273 million
Cumulated total deficit, 2010-2016	€1,315 million



Key Results

The Finnish one-off car tax and annual vehicle tax have been based on type-approval CO₂ emission values over the whole period under consideration. The increasing divergence between type-approval and real-world emission values thus has been leading to a bias in tax calculations. **The cumulative tax deficit amounts to more than €1.3 billion for the years 2010 till 2016.** Of this total, almost €0.3 billion accrued in 2016 alone. The large majority of the deficit is caused by the car tax, but the annual vehicle tax is growing in importance with every additional generation of new car registrations.

Figure 9: FI – deficit by tax and year, in million euros



Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), Finnish Transport Safety Agency (2015, 2016a, 2016b), ICCT/TNO (2017), KBA (2017a)

The introduction of the WLTP will reduce the emissions gap at first, which will also reduce the deficit of the car tax. The deficit of the annual vehicle tax will initially however only grow more slowly. The amount of vehicles subject to the tax is increasing by around 100,000 registrations every year and the WLTP will only apply to new registration from September 2018 onwards. Earlier registrations are not affected and will hence add to the deficit as long as they remain in the Finnish vehicle fleet. Additionally, tax rates were increased in 2017 and the emissions gap is expected to increase again after the introduction of the WLTP (Stewart et al. 2015).

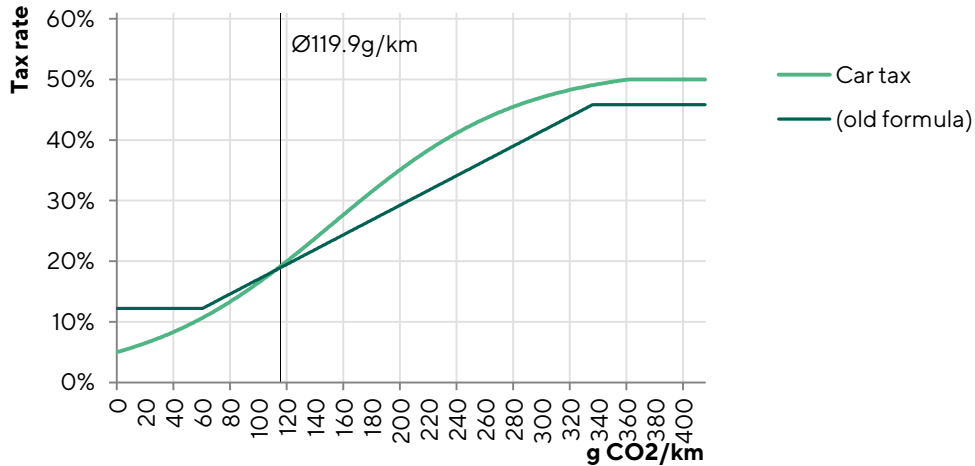
Description of relevant taxes

The Finnish **car tax after first registration** is based on CO₂ emissions (in g/km) and the list price including VAT. The tax rate had been calculated with a linear function of CO₂ ($4.88 + 0.122 \cdot \text{CO}_2$) until March 2012. The minimum and maximum rate had been set to 12.2% and 48.8%, respectively. Since April 2012, it has been calculated with a logistic function of CO₂ ($52.15 - 51.95 / (1 + e^{0.015 \cdot (\text{CO}_2 - 152)})$) with minimum and maximum set to 5% and 50%. The re-

sult is an “S”-shaped tax curve with its steepest point at 152g/km (see Figure 10). The new formula is more sensitive to CO₂ and therefore has led to a visible increase in the tax deficit from 2011 to 2012, despite fewer new passenger car registrations. The deficit was calculated on the basis of annual average passenger car prices (see data and methodology).

Between 2017 and 2019, car tax rates will be reduced by at most 5.4 percentage points for passenger cars with CO₂ emission values of 141g/km or less.

Figure 10: FI – Car tax, tax rate on sales price; based on logistic tax formula

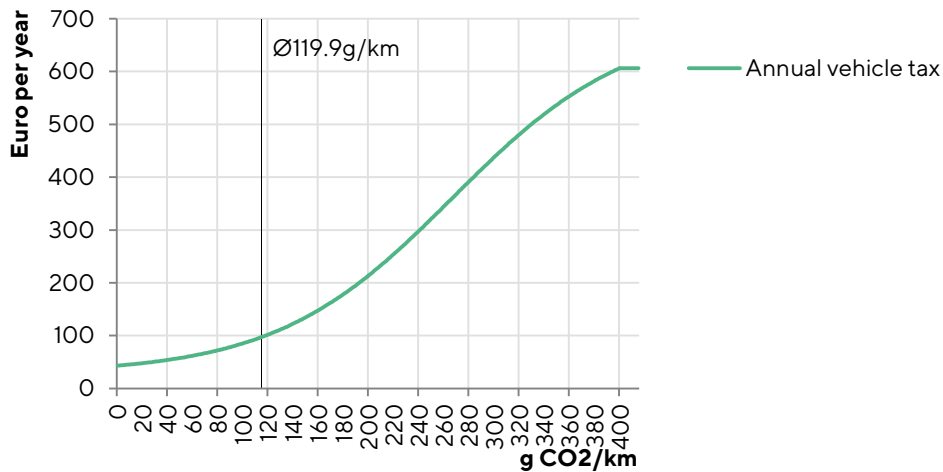


Source: graph based on ACEA (2016)

The **annual vehicle tax** is a tax on vehicle ownership and consists of two components. The basic tax for passenger cars and vans has been calculated on the basis of type-approval CO₂ emission values since 2010. The second component is based on vehicle weight and applies to vehicles that are not powered by petrol. For diesel cars both components apply. Only the basic, CO₂-based component is relevant for this study though. The tax rates for every emission value from 0 to 400g/km are stated in tax tables. In 2016, they ranged from €69.71 for 0g/km to €617.94 for 400g/km and more. Like the car tax, the annual vehicle tax rates appear to be the result of a logistic formula (see Figure 11), which is however not provided.

Its deficit has been growing annually from €2.4 million in 2010 to more than €31 million in 2016. On the one hand, the emissions gap has been constantly growing (ICCT 2016a). On the other hand, the amount of vehicles subject to the annual vehicle tax has been increasing by around 100,000 new registrations every year.

Figure 11: FI – Annual vehicle tax, amount payable per year; based on tax table with underlying logistic formula



Source: graph based on Finnish Transport Safety Agency (2016b)

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a), Finlex (2007, 2011) and Finnish Transport Safety Agency (2015, 2016a, 2016b).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

The car tax rate is applied to a vehicle's list price to determine the amount of tax payable. Since we do not have price data for the individual car, we use the annual average passenger car price in Finland, as provided by (ICCT 2016b), less a 10% safety margin. The latest market statistics are available for 2015, which are also used for the year 2016.

5.5 France

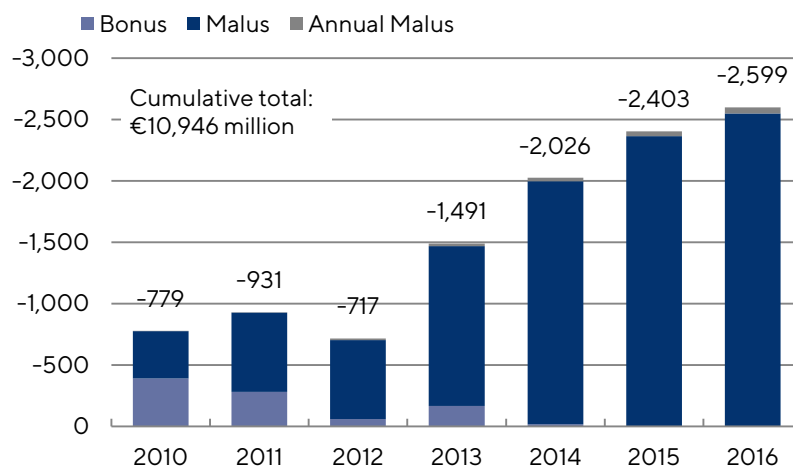
Country Profile	
Relevant taxes on purchase	CO ₂ -based Bonus-Malus system
Relevant taxes on ownership	CO ₂ -based annual malus
New car registrations, 2016	2,167,061
Total passenger vehicle fleet, 1.1.2015	32,326,000
Average CO ₂ emissions of new registrations (type-approval), 2016	109.8g/km EU: 118.1g/km
Tax deficit, 2016	€2,599 million
Cumulated total deficit, 2010-2016	€10,946 million



Key Results

Several motor vehicle taxes in France are based on type-approval CO₂ emission values. The divergence between type-approval and real-world values has thus been leading to enormous losses of tax revenues. **The cumulated deficit for the years 2010 until 2016 amounts to almost €11 billion.** Of this total, around €2.6 billion accrued in 2016 alone. Since 2012, the deficit has been caused mainly by the one-time malus upon registration, and it is increasing due to the growing divergence of emission values as well as a steepening malus curve.

Figure 12: FR – deficit by tax and year, in million euros



Source: graph and calculation based on ACEA (2017a), EEA (2017), ICCT (2016a)

The tax deficit is likely to grow in 2017. Firstly, the gap between type-approval and real-world CO₂ emission values has been constantly growing (ICCT 2016a). Secondly, the calculations of the one-time malus were significantly tightened as of January 2017 (see e.g. ACEA 2017a). The WLTP will most certainly reduce the gap initially, but the divergence is expected to increase again (Stewart et al. 2015).

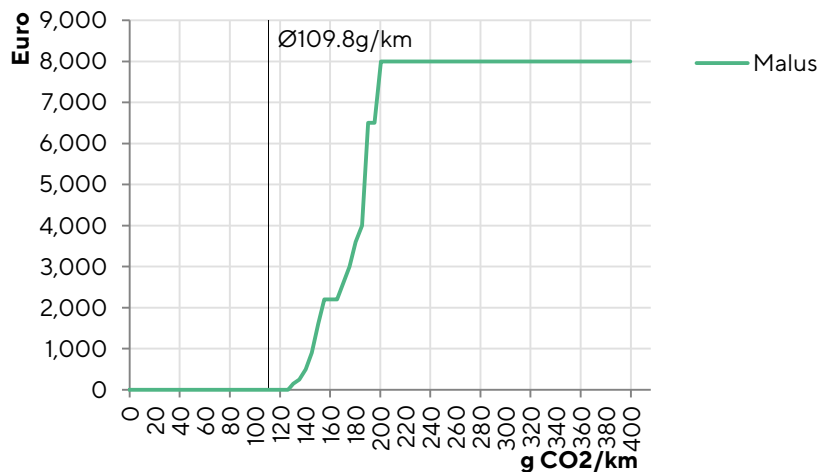
Description of relevant taxes

A **CO₂-based Bonus-Malus system** of registration tax was established in January 2008. For passenger cars that are registered for the first time in France a premium is granted or a penalty has to be paid depending on the vehicle's type-approval emission value.

The **one-time paid malus** depends on the vehicle's CO₂ emissions (g/km) or, if not given, the vehicle's horsepower. The emission thresholds and maximum penalties have been tightened over the years. In 2010, a malus of €200 had to be paid for cars within the 156-160g CO₂/km threshold. The maximum penalty of €2,600 was due for 250g/km or more. In the years 2014 until 2016, the malus ranged from €150 (131-135g/km) up to €8,000 (>250g/km). The tax curve for 2016 is shown in Figure 13. According to the EEA data, less than 250,000 new regis-

trations in 2016 had type-approval emission values of 131g/km or higher and thus had to pay the penalty. After adjusting these values for the real-world gap, we find that more than 1.6 million new registrations are above the 131g/km threshold. The resulting tax deficit for the malus in 2016 is estimated to be €2.5 billion. In 2017, the thresholds were replaced by a single formula to smooth the malus curve and avoid threshold effects (ACEA 2017a). The tax deficit will be significantly higher with this new method, because the malus curve is much steeper than before. The cap of the malus at €10,000 flattens the penalty after 190g CO₂/km, benefitting high-emitting vehicles.

Figure 13: FR – Malus, amount payable; based on tax table



Source: graph and calculation based on ACEA (2017a)

The **Bonus** is a one-time paid incentive to buyers of low-emitting passenger cars. The premium granted is differentiated by CO₂ emission thresholds. The bonus for low-emitting vehicles (<61g/km) ranged from €1,000 to €6,300 in 2016. In 2010, the bonus was also given to passenger cars with up to 125g/km. The highest premiums are restricted to a certain percentage of the vehicle purchase price (usually 20% to 30%). Since the EEA dataset does not provide vehicle prices, our calculations are based on the minimum values that might apply in such cases. The tax deficit for the bonus is therefore underestimated.

Annual taxes on ownership of passenger cars registered in France are based on CO₂ emissions, horsepower or weight. The **annual malus** for privately owned passenger cars as well as the **taxation of company cars (TVS)** have a CO₂-based component. The annual malus was introduced on 1 January 2009 and amounts to €160 per year for cars above a certain level of CO₂ emissions. The level was 245g/km in 2010 and has been reduced to 190g/km. According to the EEA data, around 10,000 new registrations in 2016 had type-approval emission values above 190g/km and hence have to pay the yearly penalty. After adjusting the emission values for the real-world gap, we find that more than 113,000 new registrations are above the threshold. The EEA data do not distinguish between private registrations and company cars, which is necessary for the computations of the annual malus. According to Harding (2014), company cars accounted for 32% of new passenger car registrations in France between 2009 and 2011. This percentage was deducted from the calculations as an approximation.

The deficit for the TVS was not calculated. The tax computations require more detailed information about company cars, which the data do not provide.

For detailed information on all taxes see e.g. ACEA (2017a), ADEME (2013).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

5.6 Germany

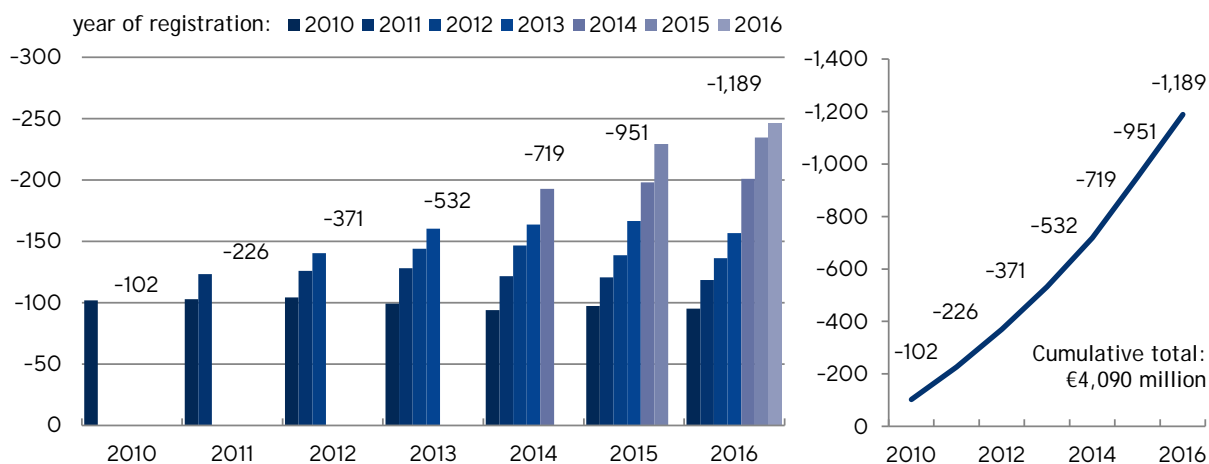
Country Profile	
Relevant taxes on purchase	-
Relevant taxes on ownership	Annual motor vehicle tax based on CO ₂ and cylinder capacity (Kraftfahrzeugsteuer)
New car registrations, 2016	3,317,930
Total passenger vehicle fleet, 1.1.2017	45,803,560
Average CO ₂ emissions of new registrations (type-approval), 2016	127.0g/km EU: 118.1g/km
Tax deficit, 2016	€1,189 million
Cumulated total deficit, 2010-2016	€4,090 million



Key Results

The German motor vehicle tax (Kraftfahrzeugsteuer) for passenger cars has been calculated on the basis of cylinder capacity and type-approval CO₂ emission values since its reform in July 2009. The increasing divergence between type-approval and real-world emission values thus has been leading to a bias in tax calculations. **The cumulative tax deficit amounts to almost €4.1 billion for the years 2010 till 2016.** Of this total, around €1.2 billion accrued in 2016 alone, which corresponds to 13% of the total motor vehicle tax revenues (€8.95 billion in 2016). **The deficit will further grow** with the increasing divergence and with every additional generation of registrations as illustrated in Figure 14.

Figure 14: DE – tax deficit by year and year of registration (left), annual tax deficit (right), in million euros



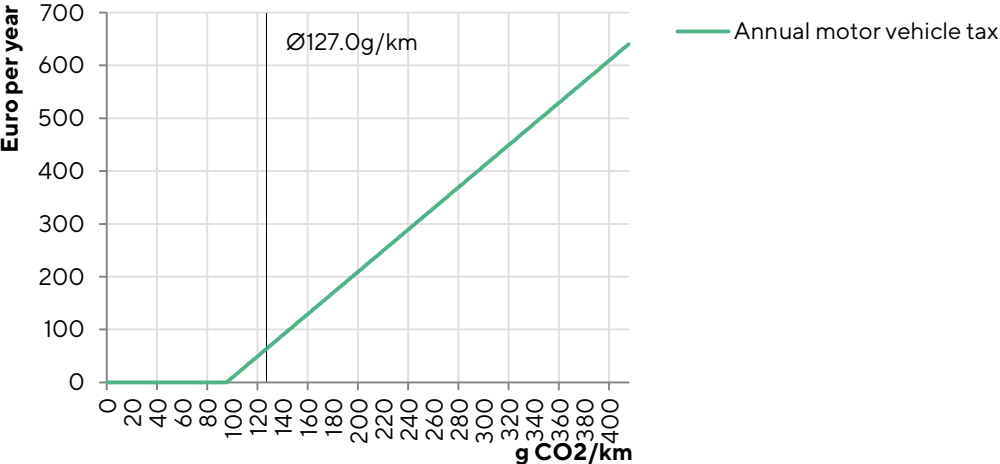
Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), ICCT (2016a), KBA (2017a), ICCT/TNO (2017), Zoll (n.d.)

The tax deficit will continue to grow over the next years. On the one hand, the gap between type-approval and real-world CO₂ emission values has been constantly growing (ICCT 2016a). On the other hand, the amount of vehicles subject to the reformed motor vehicle tax is increasing by around three million new registrations every year. The Worldwide harmonized Light vehicles Test Procedure (WLTP), which will apply to all new car registrations from September 2018, will most certainly reduce the gap to some extent, but it will not change the situation for all the cars that have been registered before its introduction. Additionally, the gap is expected to grow again as manufacturers learn to exploit the new procedures shortcomings and with the rising market share of hybrid and plug-in hybrid vehicles (Stewart et al. 2015). **The annual tax deficit will therefore only grow more slowly after 2018.**

Description of relevant taxes

The annual **motor vehicle tax** for passenger cars in Germany was reformed in 2009. Passenger cars registered before 1 July 2009 have been taxed based on emission classes (European emission standards for i.a. NO_x, CO, PM) and on cylinder capacity. Since July 2009 passenger cars (except for purely electric and fuel-cell vehicles) have been taxed on the basis of their cylinder capacity (cm³) and their CO₂ emissions (g/km) (Zoll n.d.). The tax base of the first component is €2 per 100cm³ for petrol cars and €9.50 for diesel cars. The higher rate for diesel is supposed to offset its lower energy tax rate. The second component taxes every gram of CO₂ above a gradual tightening tax-free base margin for CO₂ emissions as applied in the year of initial car registration. The limit was 120g/km from 2009 until the end of 2011 and 110g/km until the end of 2013. Since 2014, the target margin of 95g/km has been applied. The resulting linear tax curve is shown in Figure 15. The national average emission value of new passenger car registrations in 2016 is indicated as a point of reference.

Figure 15: DE – Annual vehicle tax, amount payable per year; based on linear tax formula



Source: graph and calculation based on ACEA (2016), Zoll (n.d.)

The CO₂ component of the motor vehicle tax is calculated using type-approval CO₂ emission values determined in the New European Driving Cycle (NEDC) until August 2018, which will be followed by the WLTP. As a consequence of the deficiencies of the driving cycle and the growing divergence between type-approval and real-world emission values, the CO₂ component has been too low, leading to accumulating tax deficits.

For more detailed information on the German motor vehicle tax see e.g. ACEA (2017a) and Zoll (n.d.)

Data and Methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

5.7 Luxembourg

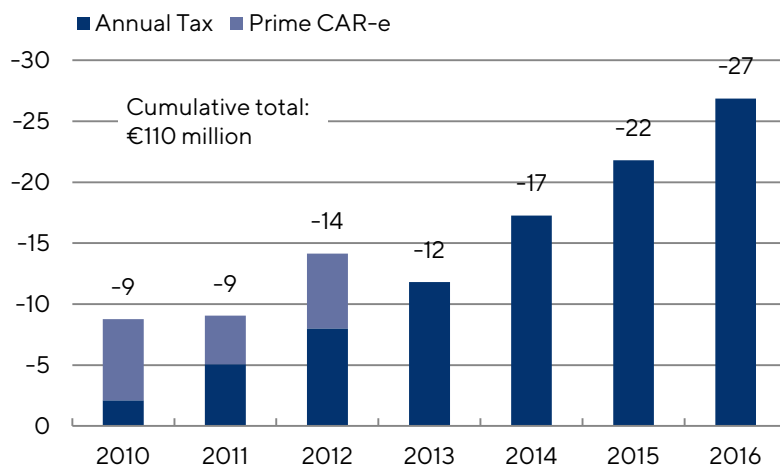
Country Profile	
Relevant taxes on purchase	PRIME CAR-e incentive based on CO ₂ emissions (discontinued)
Relevant taxes on ownership	Annual tax based on CO ₂ emissions
New car registrations, 2016	49,462
Total passenger vehicle fleet, 1.1.2015	381,103
Average CO ₂ emissions of new registrations (type approval), 2016	126.1g/km EU: 118.1g/km
Tax deficit, 2016	€27 million
Cumulated total deficit, 2010-2016	€110 million



Key Results

The Luxemburgish annual tax on car ownership has been calculated on the basis of type-approval CO₂ emission values for new registrations since 2001. The increasing divergence between type-approval and real-world emission values thus has been leading to a bias in tax calculations. **The cumulative tax deficit amounts to €110 million for the years 2010 till 2016.** Of this total, around €27 million accrued in 2016. The deficit is growing with the increasing divergence and with every additional generation of registrations as illustrated in Figure 16. The prime CAR-e incentive for low-emission vehicles added between €4 and 6.7 million per year before its discontinuation.

Figure 16: LU – deficit by tax and year, in million euros



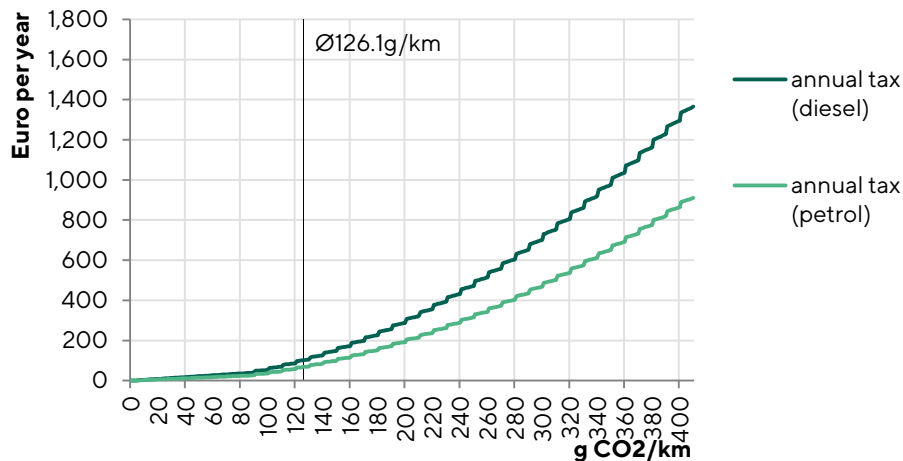
Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), ICCT/TNO (2017), KBA (2017a), Ministère de l'Environnement (2014)

It is to be expected that the tax deficit will continue to grow over the next years. The gap between type-approval and real-world CO₂ emission values has been constantly growing (ICCT 2016a), and the amount of vehicles subject to the annual tax is increasing by almost 50,000 new registrations every year. The WLTP will most certainly reduce the gap at first, but it will not change the situation for all the cars that have been registered before its introduction (September 2018). Additionally, the gap can be expected to grow again after the introduction of the WLTP. The annual tax deficit will therefore only grow more slowly after 2018.

Description of relevant taxes

The **annual tax** on car ownership is based on CO₂ emission values for all new passenger car registrations since 2001. Tax rates are calculated using a simple formula ($a*b*c$): a) type-approval CO₂ emissions (in g/km), b) a factor of 0.9 for diesel cars and 0.6 for all others, c) an exponential factor of 0.5 that is increased by 0.1 for every 10g above 90g CO₂/km. The tax curve is hence exponentially increasing with CO₂ and somewhat steeper for diesel cars (see Figure 17). The tax has to be paid annually, so that every year of new registrations adds to the deficit.

Figure 17: LU – Annual tax, amount payable per year; based on tax table



Source: graph based on ACEA (2016, 2017a), Ministère de l'Environnement (2014)

From 2007/2008 until the end of 2012, there had been a **prime CAR-e incentive** of €750 on the purchase of vehicles emitting less than 100g CO₂/km. The threshold had been 120g/km until July 2010 and 110g/km since August 2010. Cars with less than 90g/km (100g/km in 2010) had been eligible for a premium of €1,500. Under special circumstances (e.g. large families, handicapped, alternative fuels) vehicles with less than 160g/km had also been eligible. Such cases are however not taken into account.

There had also been a **prime CAR-e incentive** for electric vehicles and plug-in hybrids with 60g/km or less until 2014 and a **prime CAR-e plus** scrapping incentive with higher benefits for lower CO₂ emission values. As described in chapter 4.1 alternative fuels and technologies are however not considered and the scrapping scheme cannot be calculated for data reasons. The latter depends on the withdrawal and ownership of an old car as well as certain vehicle characteristics, for which no data is available.

In Luxembourg, the private use of company cars is treated as a benefit in kind. The computation of the benefit takes into account the CO₂ emission value of the car in the case of the lump-sum method. The monthly benefit varies from 0.5% to 1.8% of the vehicle price depending on CO₂ and fuel type. The effect of the real-world gap on income taxation is not considered though.

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a) and Ministère de l'Environnement (2014).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

5.8 Netherlands

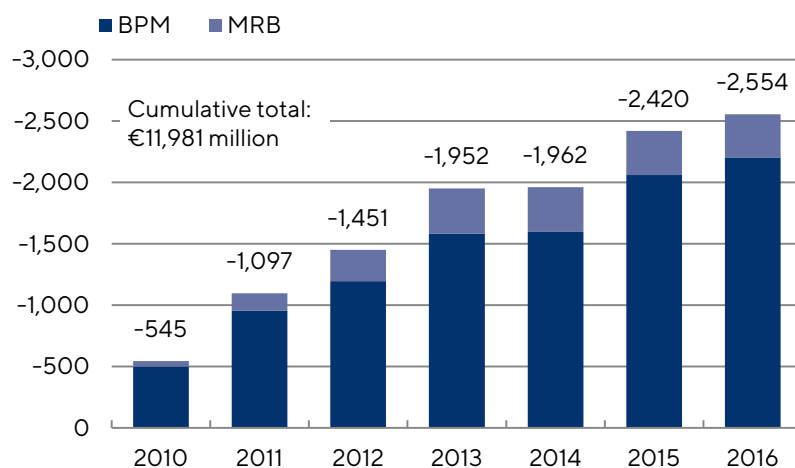
Country Profile	
Relevant taxes on purchase	Purchase tax based on CO ₂ , fuel (Belasting Personenauto's en Motorrijwielen, BPM)
Relevant taxes on ownership	Periodical road tax based on weight, province, fuel, CO ₂ (Motorrijtuigenbelasting, MRB)
New car registrations, 2016	377,862
Total passenger vehicle fleet, 1.1.2013	7,932,000
Average CO ₂ emissions of new registrations (type approval), 2016	105.5g/km EU: 118.1g/km
Tax deficit, 2016	€2,554 million
Cumulated total deficit, 2010-2016	€11,981 million



Key Results

In the Netherlands, taxes on purchase and ownership of passenger cars are based i.a. on type-approval CO₂ emission values. The increasing divergence between type-approval and real-world emission values has therefore been leading to a bias in tax calculations. **The cumulated deficit for the years 2010 until 2016 amounts to approximately €12 billion**, of which more than €2.5 billion accrued in 2016. The belasting van personenauto's en motorrijwielen (BPM), a registration tax, is particularly sensitive to the divergence because of its highly progressive CO₂-based (g/km) tax rate structure for passenger cars. The amount payable can be substantial and small changes in CO₂ have significant effects. For all 377,862 passenger car registrations in 2016, the difference in the calculated BPM based on type-approval and adjusted real-world CO₂ emission values was more than €5,800 per car on average. It is important to emphasize again that the calculations are static and do not incorporate possible reactions in buying behaviour. Also, the BPM's tax structure would most probably have been designed differently, if the emission values had been more realistic.

Figure 18: NL – deficit by tax and year, in million euros



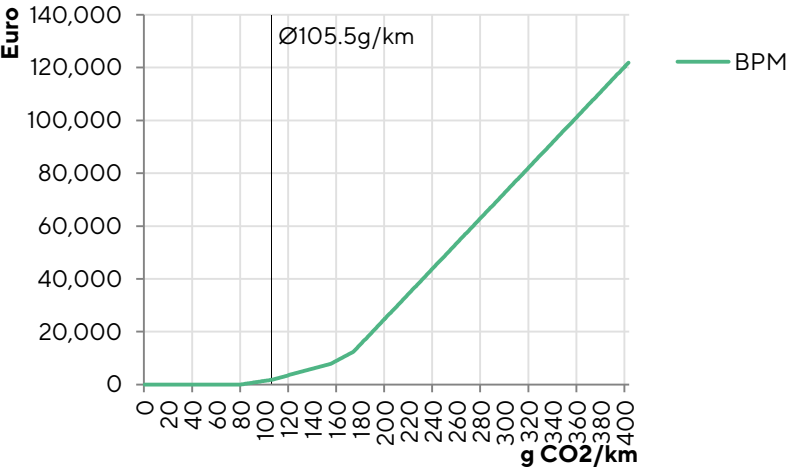
Source: graph and calculation based on ACEA (2017a), Belastingdienst (n.d.), Belastingdienst (2017), EEA (2017), ICCT/TNO (2017)

The tax deficit is likely to continue growing in 2017, but will sharply decline with the introduction of the WLTP. On the one hand, the gap between type-approval and real-world CO₂ emission values has been constantly growing (ICCT 2016a), which affects the BPM substantially. Also, the BPM was tightened again in 2017. On the other hand, the WLTP will reduce the size of the gap for all new car registrations as of September 2018. The gap will however remain sizable and is expected to grow again (Stewart et al. 2015), so the deficit may remain substantial, too.

Description of relevant taxes

All new and used passenger cars in the Netherlands are levied with the **BPM (Belasting van personenauto’s en motorrijwielen)** upon first registration. The registration tax’s emission components are calculated on the basis of a vehicle’s CO₂ emission value (g/km) and fuel type, and have been tightened and modified over the years. For each gram of CO₂ per kilometre a specific amount of tax is added. The rate increases above certain thresholds, so that higher rates apply to less efficient cars. For example, each gram of CO₂ from 1 to 79g/km (80-106g/km, 107-155g/km, 156-174g/km) was taxed at €6 (€69, €124, €239) in 2016. Above 175g/km each gram was taxed at €478. The emission thresholds had been differentiated for diesel and gasoline until 2014. In 2010 and 2011, tax breaks for cars within certain emission thresholds (extra aftrek voor net niet zeer zuinige personenauto’s) applied. On top of that, a surcharge applies to diesel cars since 2012. The diesel surcharge has been raised continuously and was €86.43 per gram above 67g/km in 2016. Additionally, a fixed surcharge of €175 has to be paid for all cars that have been emitting more than 1g CO₂/km since 2015. The amount was raised to €353 in 2017. In total, the BPM can change significantly with slightly different CO₂ emission values due to its highly progressive tax rate structure.

Figure 19: NL – BPM, tax amount payable; based on tax table plus linear formula



Source: graph and calculation based on ACEA (2017a), Belastingdienst (2017)

The **Motorrijtuigenbelasting (MRB)**, a periodical motor vehicle tax on the ownership of passenger cars, is calculated on the basis of vehicle weight, differentiated by fuel and province. Exemptions apply for low-emission vehicles. Until 2013, petrol and diesel cars emitting no more than 110 and 95g/km, respectively, were exempted from MRB. The limit was reduced to 50g/km for the years 2014 and 2015, which effectively excluded petrol and diesel cars, and mainly benefited plug-in hybrid and electric vehicles. Today, only zero-emission vehicles are fully exempted. Vehicles emitting 1 to 50g/km pay 50% of the tax. For detailed information on BPM and MRB see e.g. ACEA (2017a), Belastingdienst (n.d., 2017).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Only country-specific assumptions and limitations are discussed here. If a car is hold and used in the Netherlands, BPM has also to be paid, even if the vehicle was registered in another country. There are exemptions for company cars and people moving to the Netherlands. Only cars registered in the Netherlands are however taken into account here. Euro 6 diesel passenger cars were eligible for a rebate of €1,500, €1,000 and €500 in 2011, 2012 and 2013, respectively. This does not affect the calculations of the CO₂-based tax components but the total amount payable (until 2012, the BPM had an additional component based on the net catalogue price). Euro classifications are however not provided in the EEA data.

In 2012, BPM tax rates and brackets were changed in the middle of the year. Since the EEA does not break down registration data by month, the deficit for that year was calculated on the basis of both systems. The value shown here is the simple average of both methods. MRB is differentiated by province and tax rates have been increased frequently. However, the EEA dataset does not provide information on the place of registration, and ACEA does only have tax rates for 2010, 2012 and 2014 for Utrecht. Therefore, tax rates from Utrecht in 2010 are used for all registrations and years. The tax rates in Utrecht appear to be slightly below the average of the twelve provinces and later tax increases are not taken into account, so that the deficit is likely to be underestimated.

5.9 Spain

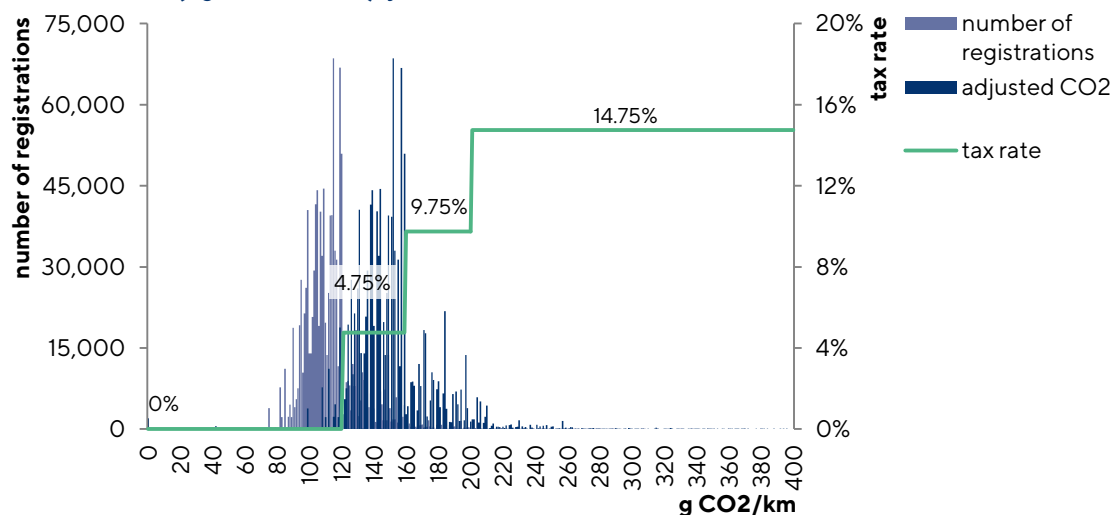
Country Profile	
Relevant taxes on purchase	Special tax on registrations, based on CO ₂ emissions and vehicle price
Relevant taxes on ownership	-
New car registrations, 2016	1,185,296
Total passenger vehicle fleet, 1.1.2015	22,355,549
Average CO ₂ emissions of new registrations (type approval), 2016	114.4g/km EU: 118.1g/km
Tax deficit, 2016	>€500 million
Cumulated total deficit, 2010-2016	€2,500–€5,000 million



Key Results

The Spanish Special tax on registration (Impuesto Especial sobre Determinados Medios de Transporte) for passenger cars has been calculated on the basis of type-approval CO₂ emission values and vehicle price since 2008. The increasing divergence between type-approval and real-world emission values thus has been leading to a bias in tax calculations. A precise estimate cannot be given, because of a lack of information on vehicle prices. A vague approximation however shows that **the cumulative tax deficit for the years 2010 till 2016 is likely to be in the range of €2.5 to 5 billion**. The deficit is growing over the years due to the increasing divergence. As illustrated in Figure 20, a zero tax rate applied to the majority of new registrations in 2016 when looking at type-approval CO₂ values. After adjusting these emission values, most cars are moved to higher tax brackets.

Figure 20: ES – distribution of new registrations by official and adjusted CO₂ values (left-hand scale), tax rates (right-hand scale), year 2016



Source: graph and calculation based on ACEA (2017a), EEA (2017), ICCT/TNO (2017)

It is to be expected that the tax deficit will continue to grow until all new cars are type-approved under the WLTP (as of September 2018). The new test procedure will most certainly reduce the gap between type-approval and real-world emission values initially. The gap can however be expected to grow again due to unresolved, exploitable shortcomings of the test procedure as well as the increasing share of hybrid and plug-in hybrid cars (Stewart et al. 2015).

Description of relevant taxes

Impuesto Especial sobre Determinados Medios de Transporte is a special tax on the first registration of vehicles that was introduced in 2008 (Departamento de Aduanas e II.EE. 2008). For new passenger cars, the tax base is the vehicle's price. Different tax rates apply depending on the type-approval CO₂ emissions values. For vehicles with 0 to 120g CO₂/km, the tax is 0% of the price. For emission values between 120 and 160g/km, the tax rate is 4.75%. 9.75% of the price has to be paid for registration of cars with 160 to less than 200g/km and 14.75% for cars with 200g/km or more. Tax rates and tax brackets have not been adjusted since their introduction in 2008.

The rates mentioned above apply on the Spanish Peninsula and the Balears Islands and thus are the standard for the large majority of new car registrations. Regional governments may however raise tax rates by up to 15%. Lower rates only apply on the Canary Islands and tax rates are zero in Ceuta and Melilla.

Neither vehicle price nor locations of registration are provided by the underlying data. Therefore, only a very vague approximation can be given.

Figure 20 shows that a significant amount of new registrations in 2016 move to higher tax brackets when looking at the adjusted CO₂ emission values in comparison to their official values. Considering type-approval values, 78% of all new passenger car registrations fall into the first tax bracket and are taxed at 0%. After adjusting CO₂ values only 5% remain. The majority of cars (73%) is now in the second tax bracket where the tax rate would be 4.75%. Assuming net sales prices of €10,000 and €20,000¹, the resulting tax deficit is between €550 million and €1,100 in 2016.

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a) and Departamento de Aduanas e II.EE. (2008).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

There are many missing entries for fuel type in the EEA data for Spain in the year 2013. Fuel type is not provided for almost 600,000 out of 732,629 new registrations, so that almost no calculations can be done for 2013. Therefore, this particular year is not taken into consideration. This issue appears to be unique to the country and year.

¹ The average price including taxes was €24,599 according to (ICCT 2016b). VAT in Spain has been 21% since September 2012.

5.10 Sweden

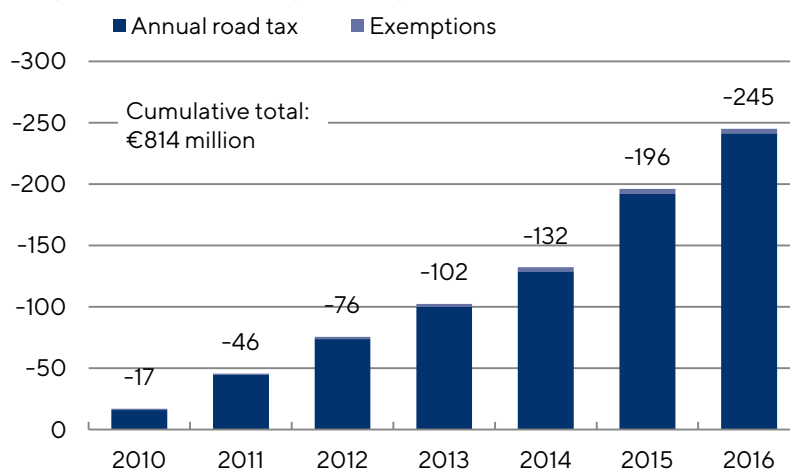
Country Profile	
Relevant taxes on purchase	-
Relevant taxes on ownership	Annual road tax, tax exemptions and premiums based on CO ₂ emissions
New car registrations, 2016	366,833
Total passenger vehicle fleet, 1.1.2015	4,668,262
Average CO ₂ emissions of new registrations (type approval), 2016	122.8g/km EU: 118.1g/km
Tax deficit, 2016	€245 million
Cumulated total deficit, 2010-2016	€814 million



Key Results

The Swedish annual road tax has been calculated on the basis of CO₂ emission values for all passenger cars with Euro 4 or newer. Exemptions from the tax as well as a premium for low-emission vehicles also have been depending on CO₂ values. The increasing divergence between type-approval and real-world emission values thus has been leading to a bias in tax calculations. **The cumulative tax deficit amounts to almost €0.8 billion for the years 2010 till 2016.** Of this total, around €0.2 billion accrued in 2016 alone. The deficit has been growing with every additional generation of new registrations (366,833 in 2016), for which the annual tax has to be paid until deregistration. The increasing divergence and rising tax rates have been accelerating this development.

Figure 21: SE – deficit by tax and year, in million euros



Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), ICCT/TNO (2017), KBA (2017a)

It is to be expected that the tax deficit will continue to grow over the next years. The gap between type-approval and real-world CO₂ emission values has been growing (ICCT 2016a), and every new generation of registrations adds to the persisting deficit. Also, a proposed reform of the road tax in July 2018, which includes a bonus for low-emission vehicle and higher tax rates (malus) for high-emission vehicles, is likely to make the tax more sensitive to CO₂ emission values. On the other hand, the WLTP will reduce the gap between type-approval and real-world values. The gap will however remain sizable and is even likely to grow again (Stewart et al. 2015).

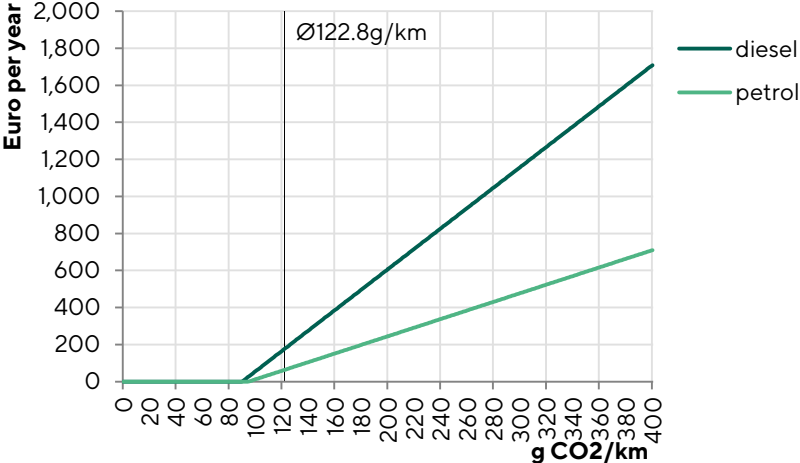
Description of relevant taxes

The **annual road tax** for passenger cars in Sweden is based on type-approval CO₂ values for cars with Euro 4 technology or newer and thus has been applicable to all new registrations under consideration. Euro 4 was introduced for type-approval in 2005. Taxation of older vehicles is based on weight and fuel.

Tax computation is based on a formula that is a linear function of the CO₂ emission value. Every gram CO₂ above a

certain threshold (111g/km since 2015) is taxed at a certain rate (SEK 22 for diesel and petrol since 2015). Threshold and tax rates have been adjusted regularly. Lower tax rates have been applied to cars with alternative fuels (SEK 11 since 2015). In addition to the CO₂ component of the tax, a base rate of SEK 360 has to be paid for all passenger cars. For diesel cars, the sum of both components is multiplied by a certain factor. It has been lowered from 3.15 in 2010 to 2.37 in 2015. The tax curve for diesel is thus still more than twice as steep as for petrol.

Figure 22: SE – Annual road tax, amount payable per year (in Euro); linear tax formula



Source: graph based on ACEA (2016, 2017a)

There have been five year road tax exemptions for ‘green’ vehicles. Since 2013, to classify as ‘green’ a vehicle needs a low CO₂ value relative to its weight. This is determined by a given formula. Until 2012, cars with 120g CO₂/km or less had been considered ‘green’. Diesel cars additionally had to have particulate emission values of less than 5mg/km. Since we do not have data on this, only petrol cars are taken into account for the years 2010–2012.

A reform of the road tax was announced for July 2018. The proposal includes a bonus for low-emission vehicles and higher tax rates (malus) for high-emission vehicles.

Since January 2012, privately and commercially registered cars emitting 50g CO₂/km or less, which almost exclusively comprises electric, hybrid electric and hydrogen, have been eligible for a **premium (Supermiljöbilspremie) for low-emission vehicles**. The premium was SEK 40,000 until 2015 and still is for vehicles with zero emissions. The premium for cars with 1–50g/km was reduced to SEK 20,000 in 2016. For companies the premium is limited depending on the price difference between the low-emission vehicle and a conventional car with comparable characteristics.

For detailed information on the taxes see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

The tax deficits created by cars with alternative fuels are not calculated, as explained in chapter 4. It is worth noting though that many plug-in hybrid electric vehicles have been benefitting from lower road taxes, exemptions and premiums. Taking into account the evidence for their real-world emissions gap, these benefits might not have been justified in many instances.

5.11 United Kingdom

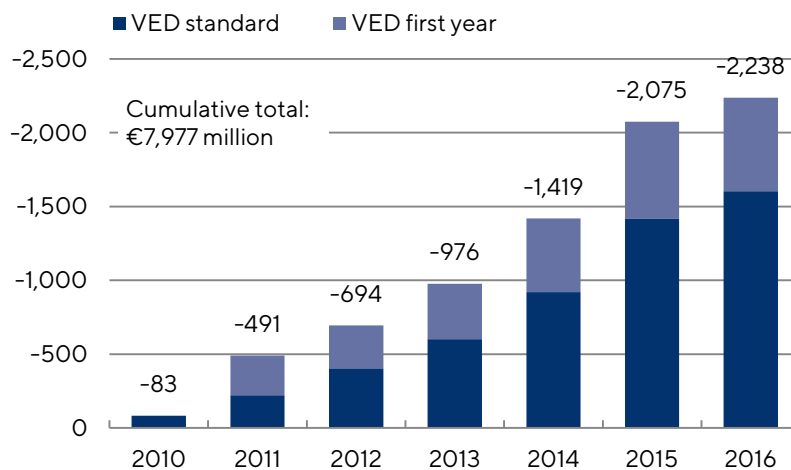
Country Profile	
Relevant taxes on purchase	('first year rate' of ownership tax (VED) based on CO ₂ emissions)
Relevant taxes on ownership	Vehicle excise duty (VED) based on CO ₂ emissions and fuel type since 2001
New car registrations, 2016	2,687,083
Total passenger vehicle fleet, 1.1.2015	30,250,294
Average CO ₂ emissions of new registrations (type approval), 2016	120.1g/km EU: 118.1g/km
Tax deficit, 2016	€2,238 million
Cumulated total deficit, 2010-2016	€7,977 million



Key Results

The British vehicle excise duty (VED), a periodical road tax on car ownership, has been calculated on the basis of type-approval CO₂ emission values and fuel type since 2001. The gap between official and real-world emission values hence has been leading to a bias in tax calculations. **The cumulative tax deficit amounts to almost €8 billion euros for the years 2010 till 2016.** Of this total, around €2.2 billion accrued in 2016. As illustrated in Figure 23, both parts of the tax, the first-year payment after registration as well as the periodical standard payment for the following years, have been affected and the deficit has been growing steadily. For the VED standard, the deficit of course has been growing with every additional generation of new registrations (2.69 million in 2016), for which the periodical tax has to be paid until deregistration. Other underlying reasons are the widening gap between CO₂ values as well as increasing tax rates.

Figure 23: UK – deficit by tax and year, in million euros



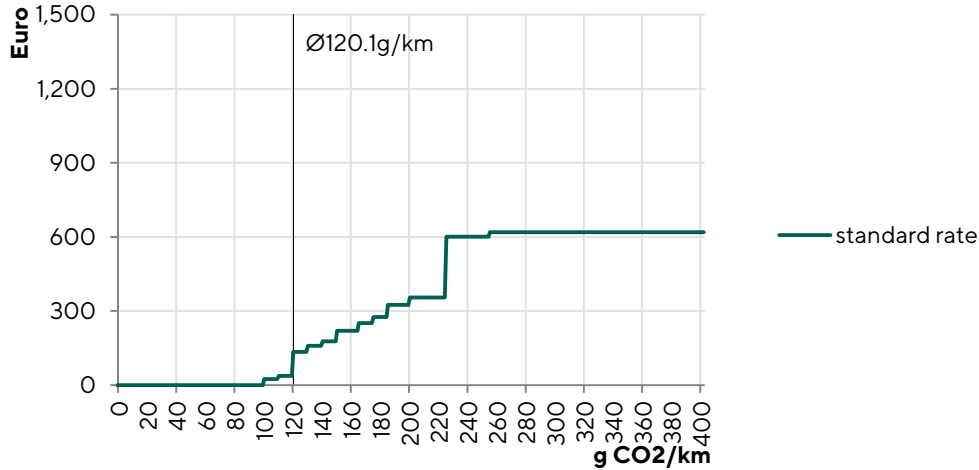
Source: graph and calculation based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), Government Digital Service (n.d.), ICCT/TNO (2017), KBA (2017a), Parkers (2012)

The VED was reformed in 2017 and standard rates are no longer based on CO₂ emission values. The corresponding part of the deficit will thus disappear. First-year rates however have been increased substantially and the new tax curve is much steeper. The second part of the deficit is thus likely to increase until the WLTP applies and will remain sizable afterwards.

Description of relevant taxes

Vehicle excise duty (VED) is a periodical tax levied on the ownership of vehicles. The tax was reformed in 2017 and renewed regulations apply to vehicles registered on or after 1 April 2017. The following describes the tax as applicable to registrations between March 2001 and March 2017, which covers the period for which the tax deficit was calculated. Since March 2001, VED tax rates for cars have been based on CO₂ emissions (in g/km) and differentiated by fuel type. Different rates for diesel and petrol had been applied until 2007. Slightly lower rates have been in place for alternative fuels since 2012. Tax rates have been adjusted annually.

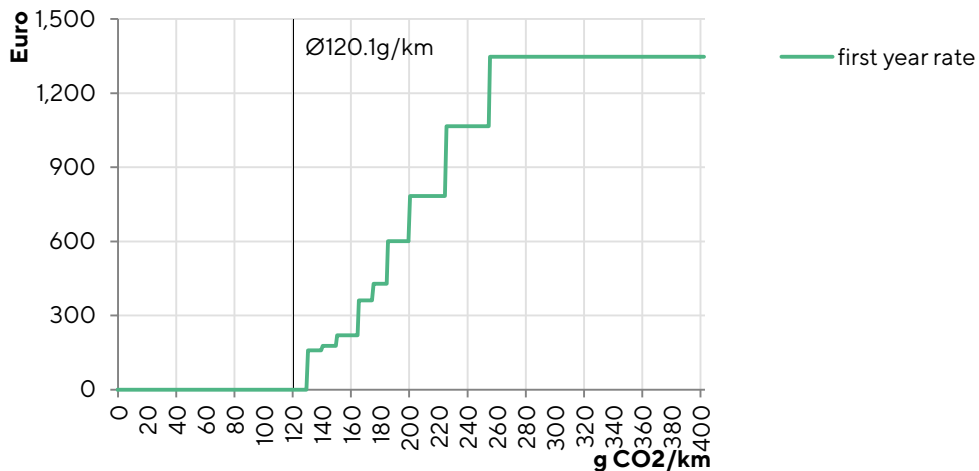
Figure 24: UK – standard rate, amount payable per year (converted to Euro); based on tax table



Source: graph based on ACEA (2016, 2017a), Government Digital Service (n.d.)

'First-year rates' apply for the first twelve months after registration. **Standard rates** have to be paid for all subsequent years. Both rates are based on type-approval CO₂ emissions (since the reform in 2017, the standard rate is no longer based on CO₂ but fuel type only). The first-year rate has been zero for diesel and petrol cars emitting 130g CO₂/km or less. The maximum amount payable in 2016 was €1,120 for more than 255g/km. The standard rate has been zero for petrol and diesel cars emitting 100g/km or less and €515 for cars with more than 255g/km. The first-year rate thus acts as an additional incentive for buying low-emission vehicles.

Figure 25: UK – first year rate, tax amount payable (converted to Euro); based on tax table



Source: graph based on ACEA (2016, 2017a), Government Digital Service (n.d.)

Privately used company cars and fuel is taxable as a benefit in kind. Tax computations are, among other things, based on CO₂ emission values.

For detailed information on vehicle taxation in the UK see e.g. ACEA (2010, 2012, 2014, 2015, 2016, 2017a) and Government Digital Service (n.d.).

Data and methodology

The underlying data and methodology for all countries is described in chapter 4. Data limitations and corresponding assumptions are described in chapter 4.1. Only country-specific assumptions and limitations are discussed here.

The EEA dataset does not provide the exact date of registration, only the year. Changes in VED however usually apply as of April. For our calculations, changes are therefore assumed to come into force as of 1 January the following year. This is likely to cause an underestimation of the tax deficits because tax rate increases are taken into account only with a lag of eight months. Also, first-year rates for new registrations were introduced on 1 April 2010, but are only incorporated in the calculations for the years 2011 and following.

Surcharges for monthly, half-annual payments or benefits for paying by direct debit are not taken into account. Currency conversions were made using average annual rates, as provided by the Canadian Foreign Exchange website.

6 Discussions of results

The country analyses show that the widening gap between type-approval and real-world CO₂ emission values has been leading to high and increasing tax deficits in all countries under consideration since 2010. The total deficit was above €10 billion in 2016 and somewhere in the region €40–50 billion for the whole period 2010–2016. Table 4 presents the main statistics and results.

Table 4: Summary statistics and results

	Passenger car fleet		New registrations 2016	Aver. CO ₂ emissions of new registrations in 2016		Tax Deficit 2016	Cumulated 2010–2016
	(year)			Type-approval	Adjusted*		
				in g/km		in million Euro	
Austria	4,748,048	(2015)	329,263	120.5	159.3	560	2,527
Belgium	5,623,579	(2015)	540,955	115.9	152.9	212	687
Denmark	2,580,000	(2008)	221,068	105.9	140.1	831	3,227
Finland	3,234,860	(2015)	115,317	119.9	158.4	273	1,315
France	32,326,000	(2015)	2,167,061	109.8	145.2	2,599	10,946
Germany	45,803,560	(2017)	3,317,930	127.0	167.8	1,189	4,090
Luxembourg	381,103	(2015)	49,462	126.1	166.7	27	110
Netherlands	7,932,000	(2013)	377,862	105.5	138.5	2,554	11,981
Spain	22,355,549	(2015)	1,185,296	114.4	151.2	>500	2,500–5,000
Sweden	4,668,262	(2015)	366,833	122.8	161.6	245	814
United Kingdom	30,250,294	(2015)	2,687,083	120.1	158.7	2,238	7,977
Total	159,903,255		11,358,130	118.7**	156.8**	>11,228	<46,174

Sources: Eurostat (2017) and EEA (2017) for fleet and registrations; own calculations based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), KBA (2017a), ICCT/TNO (2017)

* Adjusted to the divergence between type-approval and real-world CO₂ emission values by ICCT/TNO (2017) less a 10% gap (see chapter 4 on methodology); ** weighted average (weighted by new registrations 2016).

It is obvious that larger countries with larger passenger car fleets and more new car registrations tend to have larger deficits (see Figure 26). Germany's tax deficit, for example, is high in absolute terms but comparatively low, considering the large amount of cars liable for taxation. On the other hand, countries with progressive and high tax rates, like Denmark and the Netherlands, have high deficits relative to their small fleet size. France and the United Kingdom are above the trend line but still comparable to the Netherlands, whose fleet is about four times smaller.

In most countries, registration taxes account for the larger share of the deficit. Luxembourg, Sweden and Germany do not raise registration taxes at all, which partly explains why their deficits are rather low relative to their fleet sizes. The case of Spain is illustrated and described in more detail in Figure 28.

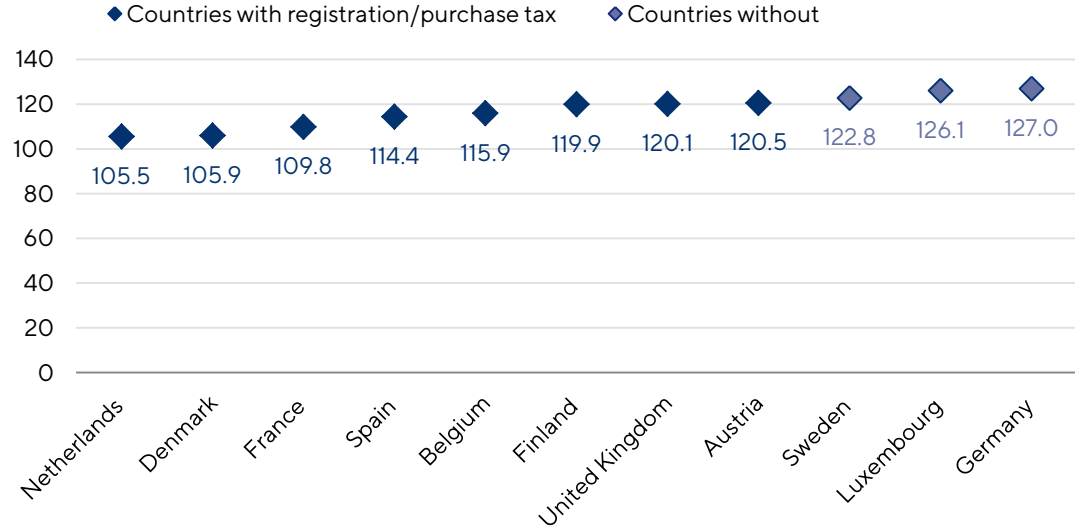
Figure 26: Tax deficit in 2016 (in million euros) and size of passenger car fleet (in million)



Source: Eurostat (2017) for passenger car fleet; own calculations for tax deficit based on ACEA (2010, 2012, 2014, 2015, 2016, 2017a), EEA (2017), KBA (2017a), ICCT/TNO (2017). The y-intercept of the linear trend line was set to zero.

It is noticeable that countries with ambitious, CO₂-based car taxation have the lowest average CO₂ emission values for new registrations (see Figure 27). The Netherlands, Denmark and France were the only countries in 2016 with type-approval averages below 110g CO₂/km. Registration taxes are very high for high-emission vehicles in the Netherlands. Denmark and France offer substantial tax reductions or bonuses for low-emission vehicles. The disadvantage of buying a vehicle with 140g/km instead of 100g/km, for instance, is worth more than €4,000 in the Netherlands and Denmark, creating a significant cost incentive. All three countries have car taxes that are very sensitive to CO₂ values (see tax curves in country chapters). On the other end of the spectrum, Sweden, Luxembourg and Germany do not raise registration taxes at all and reveal the highest averages.

Figure 27: Average type-approval CO₂ emission values of new car registrations in 2016



Sources: own calculations based on new passenger car registration data by the EEA (2017)

This observation does of course not imply a significant or causal relationship between taxation and emission values. But it adds to the growing evidence that upfront price signals, like registration taxes and bonus-malus systems, are effectively influencing consumer choices (see e.g. Adamou et al. 2014, Brand et al. 2013, D’Haultfœuille et al. 2014, Gerlagh et al. 2016, Kok 2015). Such upfront fiscal incentives are an important element of effective vehicle taxation. Of course, fiscal incentives need to be quite high, as is the case in the Netherlands, Denmark and

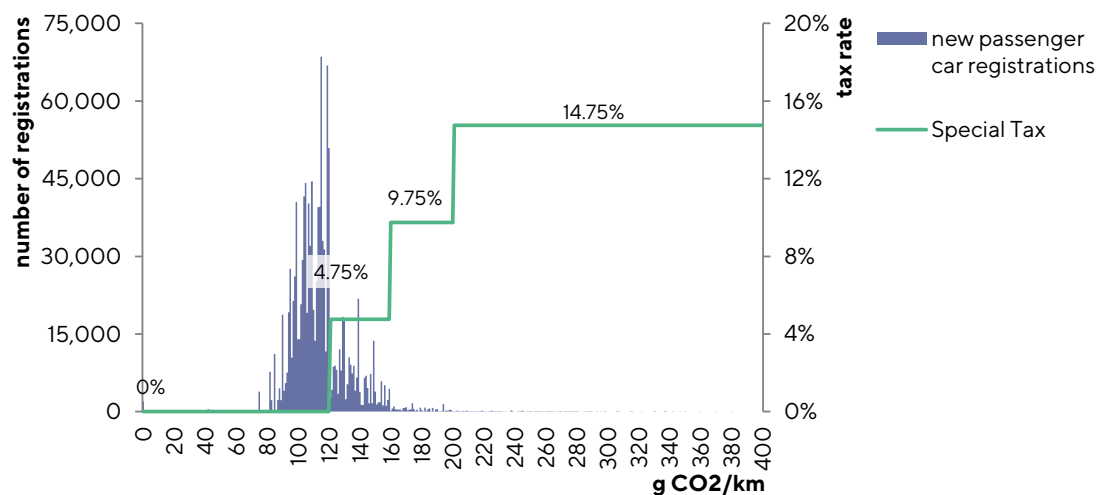
France, and well designed. They also need to be complemented with sound regulatory policies (see e.g. Yang et al. 2015).

In contrast, annual taxes and fees, are often found to be less effective than upfront costs (see e.g. Alberini/Bareit 2017, Gerlagh et al. 2016, Malina 2016). In other words, consumers are less sensitive to periodical vehicle taxes than they are to the non-recurring but usually high and salient cost component created by registration taxes. Their environmental effectivity is rather low. Annual vehicle taxes generate a constant and more predictable stream of revenues, which is more suitable for governments' fiscal goals.

Looking at the country chapters and the tax curves in the corresponding country chapters, several tax design elements stand out:

- In general, one-off **registration** and/or periodical **ownership taxes** differ in their price signal, their effectiveness to influence buying behaviour, their revenue streams, etc. In the best case they complement each other and are designed to target appropriate environmental and fiscal goals in the most efficient way. Interdependencies with other taxes should also be taken into account. Different externalities require a different approach. For example, registration and ownership taxes are no good instruments to address car usage or driving behaviour, which determines actual CO₂ emissions. Other instruments like energy taxes are more suitable for such goals, because they tax the actual fuel consumption. Other external costs from congestion, accidents, pollutant emissions etc. can be internalized with intelligent road charging systems.
- Looking at tax design more specifically, **tax curves** can have very different shapes depending on their underlying **formula** or **tax table**. In many cases do tax tables lead to steep and sometimes arbitrary increases in taxation from one tax bracket to the next (e.g. Malus in France, Special Tax in Spain, VED in the UK). This may lead to an incoherent and possibly adverse incentive scheme. In many cases, there is an incentive to stay below certain thresholds, but no further incentive to reduce emission values as much as possible. Tax tables may also contradict requirements of fair taxation, because arbitrary differences in taxation between one gram of CO₂ per kilometre and the next gram cannot be justified scientifically.
- Similarly, **zero rates**, **minimum** and **maximum rates** may lead to incoherencies and arbitrary thresholds. While minimum and zero rates may weaken the incentive to buy vehicles with even lower emission values (see e.g. France, Figure 13), maximum rates diminish the tax's steering effect for cars with very high emission levels (see e.g. Spain, Figure 20).
- The case of Spain clearly illustrates some of the points made so far (see Figure 28). The Special tax, a tax on first registration, is based on a tax table with four brackets. A zero rate applies up to and including 120g/km. The registration tax effectively achieves its implied goal of reducing emissions to that level. There were 66,886 and 50,919 new passenger car registrations in 2016 with emission values of exactly 119 and 120g/km, respectively, and only 2,767 with 121g/km. There is however no additional incentive to reduce emission values even further and, consequently, registrations cluster just right before the first threshold. Similar patterns occur at the following two thresholds. Also, the three thresholds are somewhat arbitrary, but they lead to sudden and extreme tax increases from one gram to another, which seems hardly justifiable. At the other extreme, the flat maximum rate makes no difference between vehicles with 200 and 400g/km or even more.

Figure 28: Number of new passenger car registrations and Special Tax in Spain in 2016



Source: graph and calculation based on ACEA (2017a), EEA (2017)

- In comparison to tax tables, **tax formulas** usually lead to more coherent incentives and reasonable increases in taxation from gram to gram. It is also easy to create different tax curves with different functional forms that can be aligned to individual demands. Linear, exponential and logistic functions, for example, are used in Germany, Belgium and Finland, respectively (see Figure 15, Figure 6, Figure 10). The resulting incentive schemes have their very own dynamics.
- Depending on the **position** of the curve, a tax can affect very different areas or ranges of emission values. **Continuous adjustments** are required to maintain effectivity. If the curves are too far to the right, they may not affect the average car buyer (see e.g. Figure 6, Figure 13, Figure 20, Figure 25). Average CO₂ emission values have been decreasing from year to year. Taxation should be aligned with its goals or at least keep up with technological advances.
- This study focuses on CO₂-based tax components. It is clear though that other **tax bases** can be useful depending on the intended outcome. Taxation is based e.g. on vehicle prices, horse power, cylinder capacity, weight or a combination of several attributes in many countries.
- Although this study has focused on diesel and petrol only, it is obvious that the **taxation of alternative fuels and technologies** is currently not well adapted. Most tax systems are shaped by temporary tax exemptions, which are obviously not a long-term solution. Other measures are needed for example for the taxation of electric or hybrid vehicles and the treatment of upstream emissions. This also requires adjustments of the regulatory framework.
- Additionally, the **taxation of company cars** is very important but could not be analysed systematically in this study. Kok (2015) for example finds that CO₂-based tax incentives for company cars have been especially effective in the Netherlands. The second-hand vehicle markets in many countries, and hence their vehicle fleet compositions, are significantly shaped by used company cars. An outline of the tax treatment of company cars in many countries and an estimation of its fiscal and environmental costs can be found in Harding (2014).

7 Policy Recommendations

As mentioned already in the introduction, the wide emissions gap is a problem for consumers, society as a whole, car manufacturers and governments. This analysis illustrates the fiscal dimension of incorrect CO₂ emission values and thereby underlines the urgency to fix and sharpen the regulatory framework for type-approval and market-surveillance of motor vehicles. It is essential to reduce the gap as much as possible. CO₂-based policy instruments, like vehicle taxes or the European Union's mandatory emission reduction targets, require reliable CO₂ emission values in order to operate effectively. This is also true for other pollutants like nitrogen oxides.

- To **minimize the emissions gap** ICCT/TNO (2017) recommend a general revision of the European type-approval framework and official, Europe-wide measurements of real-world CO₂ emissions. Also, EU efficiency labels should correctly reflect average on-road fuel consumption. Some steps in the right direction have been taken, but the framework remains inadequate. The introduction of the WLTP will reduce the emissions gap, but it will not resolve some fundamental problems. The gap will remain large and is expected to grow again (Stewart et al. 2015). In this regard, more research on real-world emissions of PHEV is necessary (ICCT/TNO 2017). Tax deficits will hence remain substantial without additional steps.
- Our analysis also reveals **untapped potential in the policy mix** and the design of motor vehicle taxes in the eleven EU member countries under consideration. The tax systems often create non-dynamic and incoherent incentive schemes that are not aligned with their goals. Different instruments should address different goals and externalities, and they have to be designed for this purpose. Registration taxes can effectively target purchase behaviour and vehicle choice, but they do not address driving behaviour and hence actual fuel consumption or CO₂ emissions. Energy taxes, or a carbon tax, are better equipped to achieve the objective of reducing CO₂ emissions. Internalization of other external costs from congestion, accidents, pollutant emissions etc. require intelligent road charging systems that are able to differentiate between time, place and other determining factors. In contrast, periodical taxes on ownership usually do not have a strong price signal and are hence less effective in achieving ecological goals. Their constant and predictable stream of revenues is more suitable for fiscal objectives.
- The many tax curves shown in this analysis illustrate some **fundamental elements of good tax design**. A tax curve's shape and position, the underlying tax calculations, minimum and maximum rates or other exemptions affect the resulting incentive scheme created by the tax. All elements have to be well thought-out in order to create an effective and coherent framework.
- Finally, **future changes and challenges demand an update of current taxation**. The framework of motor vehicle taxation was built for conventional technologies and is in many cases not suitable for alternative fuels and technologies. Additionally, the decarbonisation of the transport sector should be anchored in these instruments. More ambitious goals and appropriate policy instruments are required.

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