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Emission Effects of Germany's Vehicle Taxation: Recent Empirical Evidence

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Emission Effects of Germany's Vehicle Taxation: Recent Empirical Evidence

Abstract

In 2021, Germany adjusted its vehicle taxation scheme, resulting in a disproportionate increase in the tax burden for vehicles with high carbon emission intensity. This article presents empirical evidence on the impact of Germany's vehicle taxation and its reforms on automobile emissions. To this end, we refer to a series of recent studies by Klier and Linn (2015), Malina (2016), Alberini and Horvath (2021), and Flintz, Frondel, and Horvath (2022) on the reforms of Germany's motor vehicle taxation since 2009, when an emissions-differentiated vehicle tax scheme came into force. The empirical results unanimously indicate that Germany's vehicle taxation does not have the steering effect that is needed to substantially reduce greenhouse gas emissions.

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Keywords: Registration tax; circulation tax; greenhouse gas emissions

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1 Joschka Flintz, RUB and RWI; Manuel Frondel, RUB and RWI; Marco Horvath, RWI; Colin Vance, RWI and Jacobs University Bremen. *- We are grateful to the German Federal Ministry of Education and Research for financial support of this contribution within Kopernikus project Ariadne (FKZ 03SFK5C0) and the projects License (FKZ 01UT1701A) and Eval-Map II (FKZ 01LA1823A).* *– All correspondence to: Manuel Frondel, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: frondel@rwi-essen.de*

1 Introduction

Private automobile traffic is responsible for approximately 60% of the pollutant emissions of the transport sector in Germany (Destatis 2020), making it a major contributor to the transport-related emissions of carbon dioxide (CO_2) in Europe's largest car market. A key reason for the growth in carbon emissions from private automobile transport is the increase in mileage, which rose by 20% since 1995, more than outweighing the improvements in the environmental performance of passenger cars (UBA 2021). This is one of the reasons why motor vehicle taxation in Germany, consisting of an annual circulation tax, was recently reformed once again. As of January 1, 2021, the circulation tax no longer increases linearly with the CO_2 emission rate, but progressively, such that vehicles with high emission intensity face a higher tax burden.

The effectiveness of this tax reform was promptly called into question by politicians and by environmental associations. But even beforehand, Germany's vehicle taxation scheme faced criticism for its restraint, which, unlike in other European countries, relies exclusively on circulation taxes. Car purchasers in Germany pay no registration taxes, but just a small registration fee of only €26, contrasting with tremendous registration taxes in some other European countries. For example, in 2021, the registration tax in Denmark was 85% of the purchase price for cars valued at less than around 27,000 euros, with an additional 150% luxury tax paid on the amount above that threshold (ACEA 2021).

Against this background, this article summarizes the empirical evidence on the impact of Germany's circulation tax and its reforms on the emissions originating from automobile transport. To this end, we refer to a series of recent studies by Klier and Linn (2015), Malina (2016), Alberini and Horvath (2021), and Flintz, Frondel, and Horvath (2022) on the reforms of Germany's circulation tax since 2009, when an emissions-differentiated vehicle tax scheme came into force. The empirical results unanimously indicate that Germany's vehicle taxation does not have the steering effect that is needed to substantially reduce carbon emissions.

In the following section, we concisely describe Germany's car taxation system and its revisions since 2009, while Section 3 provides relevant statistics on car registrations in Germany during the period spanning from January 2011 to April 2019, which is determined by data availability. The penultimate section presents the recent empirical evidence on the

impact of Germany's vehicle taxation scheme. The last section summarizes and draws conclusions.

2 Germany's Motor Vehicle Taxation Scheme

Following the recommendation of the European Commission and the example of numerous European member states that had already integrated an emissions component into their vehicle tax regimes, a CO_2-differentiated vehicle tax scheme came into force in Germany on July 1, 2009. Since then, the circulation tax for newly registered vehicles is dependent on the vehicle's engine capacity, engine type and CO_2 emission rate. In detail, a payment of 2 euros was levied for each gram of CO_2 emitted per kilometer above a certain threshold. Initially, in 2009, this threshold was set at 120 g/km, but has been reduced twice so far: As of January 1, 2012, and January 1, 2014, the thresholds in place were 110 g/km and 95 g/km, respectively. Vehicles with emissions below the threshold were not affected by the CO_2 component of the circulation tax. It bears noting that owners of electric cars benefit from a waiver of the circulation tax for the first 10 years after the purchase of the car. In contrast, for every 100 cubic centimeters of engine capacity, owners of a gasoline-powered vehicle must pay 2 euros per year; owners of a diesel pay 9.50 euros.

The most recent revision of vehicle taxation came into force on January 1, 2021. While the taxation of engine capacity and the threshold of the CO_2 component of 95 g CO_2 /km remained unchanged, the tax amount no longer increases linearly with the emission rate, but progressively in discrete jumps for vehicles registered after January 1, 2021. For the first 20 g/km above the 95 g/km threshold, vehicle owners pay 2 euros per g/km each year, with increasing amounts of 2.20, 2.50, 2.90 and 3.40 euros for the subsequent 20 g/km intervals (see Table 1). For each additional gram above the upper threshold of 195g/km, there is an annual charge of 4 euros. For example, for a vehicle with per-kilometer carbon emissions of 140 g/km, the emissions-dependent part of the vehicle tax is calculated as follows: 20 times 2 euros per g/km for the CO_2 emissions in the interval of 96-115 g/km plus 20 times 2.20 euros per g/km for the interval of 116-135 g/km plus 5 times 2.50 euros per g/km between 136 and 140 g/km.

In the period spanning from 2011 to 2019, in addition to the two threshold reductions from 2012 and 2014, a new emissions test procedure was introduced that may have affected the emissions of the car fleet: the Worldwide Harmonized Light Duty Vehicles Test Procedure (WLTP). This procedure replaced the outdated New European Driving Cycle (NEDC) as the method for determining vehicle emissions. It has been mandated by law throughout the EU since September 1, 2017.

Table 1: **Emission Component of Germany's Circulation Tax valid as of 2021**

Emissions intervals	Tax rate
Below 96 g/km CO2:	0.0€
96-115 g/km CO2:	2.0€
116-135 g/km CO2:	2.2€
136-155 g/km CO2:	2.5€
156-175 g/km CO2:	2.9€
176-195 g/km CO2:	3.4€
Over 195 g/km CO2:	4.0€

In Germany, however, the vehicle tax burden has been based on the WLTP values only since September 1, 2018. Due to a more detailed test procedure with longer test duration and distance, as well as higher speeds, both on average and at peak, the WLTP method allows for a more realistic measurement of fuel consumption and pollutant emissions than the NEDC method. Consequently, the tax burden increased for most car types (ADAC 2022).

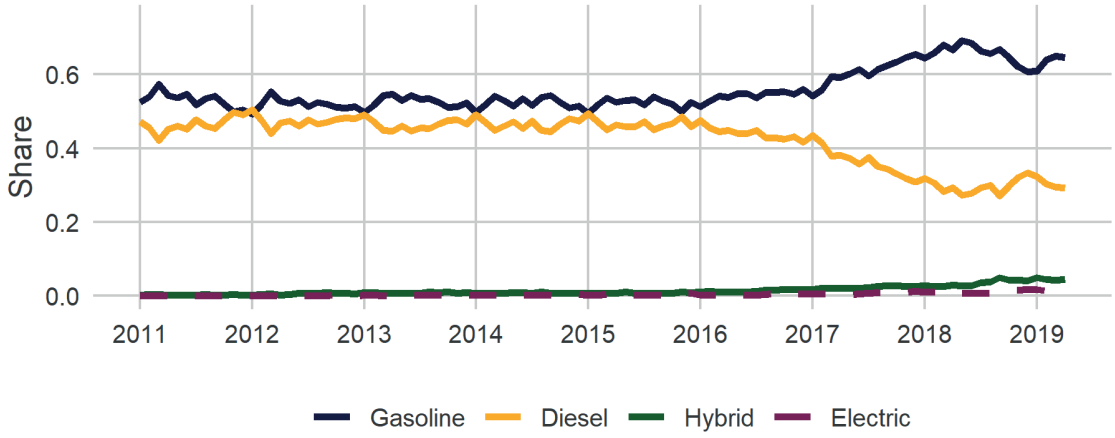
3 Vehicle Registrations between 2011 and 2019

In the last decade, the number of cars sold in Germany increased slightly: While well under 3 million cars were sold in 2011, sales figures rose to around 3.4 million vehicles in 2018. The share of diesel vehicles was stable at around 46% for a long time, but began to fall as a result of the diesel scandal in early 2016, to a share of around 30% in 2018. Mirroring the decline in the share of diesel vehicles, the share of gasoline vehicles in new registrations increased from 53% in 2016 to 64% in 2018. Accompanied by the introduction of premia of 3,000 and 4,000 euros for the purchase of hybrid and electric cars, respectively, their shares in new registrations moderately increased (Figure 1), to around 3.5% and 1% in 2018, respectively.

While these shares are small, the upward trend has continued at an accelerated pace in recent years.

Of further note is the upward trend in average engine horsepower (hp), which increased from 135 hp in 2011 to approximately 152 hp in 2018. Along with a sustained reduction in the average engine size by approximately 120 cubic centimeters, from 1,750 in 2011 to 1,630 in 2018, the performance improvement suggests that automakers are able to build vehicles with more power despite smaller engines.

Figure 1: Shares of Gasoline, Diesel, Hybrid and Electric Vehicles in Monthly Vehicle Registrations (Source: Own calculations based on data from IHS Markit Global Sarl)



In line with decreasing engine sizes, Figure 2 shows a substantial decline in the average carbon emissions of newly registered cars: Per-kilometer emissions fell from an average of about 143 g/km in 2011 to 124 g/km in 2016. This decline was followed by stagnation in 2016 and 2017, largely due to the falling share of diesel vehicles. Figure 2 also illustrates the strong discrepancy between the emission values determined on an NEDC basis and those based on the new WLTP. On average, the WLTP emission values are almost 30 g/km higher than those from the NEDC. This difference implies a higher tax burden of around 60 euros per year on average.

Figure 3 shows the average circulation tax burden for newly purchased cars and illustrates the large difference in the tax burden for owners of diesel vehicles and gasoline-

powered cars. Despite their higher carbon emissions, gasoline-powered cars are subject to almost 160 euros less in average circulation tax amounts per year than diesel-powered cars. The reason for this is the significantly higher taxation of the engine capacity of diesel cars.

Figure 2: Average Carbon Emissions (in grams per kilometer) for Newly Registered Passenger Cars between January 2011 and April 2019 (Source: Own calculations)

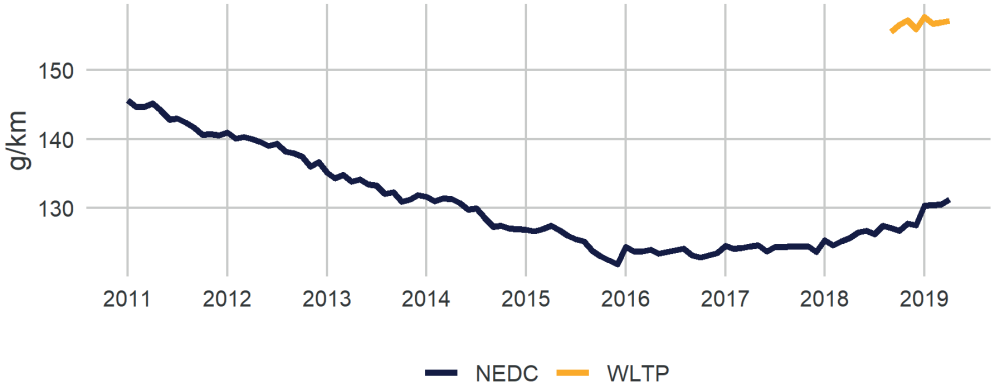
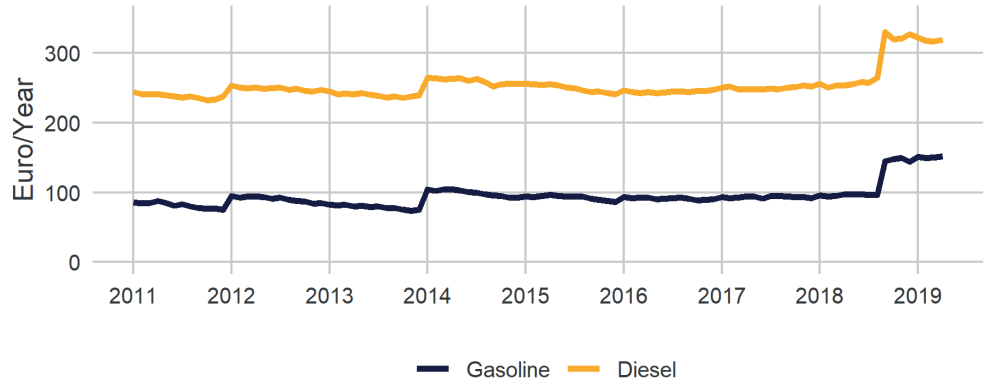


Figure 3: Average Circulation Tax Burden of Newly Registered Gasoline and Diesel Vehicles from January 2011 to April 2019 (Source: Own calculations).



In addition, Figure 3 illustrates the impact of the two tax revisions of 2012 and 2014. For example, the reduction in the threshold in 2012 resulted in an increase in the circulation tax of about 20 euros. The tax increase in 2014 amounted to about 30 euros for cars with emissions above 95 g/km. These increases in the circulation tax were roughly offset in the

years following the tax reform by a reduction in the CO_2 emission rate and the engine size of new passenger cars. A particularly sharp increase in the average vehicle tax burden can be seen with the introduction of the WLTP as the exhaust gas determination method in September 2018. The corresponding kink in Figure 3 reflects the large discrepancy between the NEDC and WLTP values.

Overall, despite decreasing engine size and carbon emissions, the average annual circulation tax for the owner of a newly registered car increased by approximately 21% between January 2011 and April 2019, from 162 to 196 euros, due to tax changes and the introduction of the more realistic WLTP. It bears noting, however, that the burden of vehicle tax represents only a small cost factor for car owners in Germany, most notably compared to fuel costs: On average, buyers of a new car paid 196 euros in vehicle taxes in 2019, while annual fuel costs averaged approximately 1,148 euros.

4 Recent Empirical Evidence

This section summarizes the recent empirical evidence on the effect of the German vehicle tax scheme and its reforms on the carbon emissions originating from automobile transport. Klier and Linn's (2015) analysis focuses on the effect of the introduction of the emissions-dependent tax component in Germany in 2009. They estimate a moderate reduction of 1.67 g/km in the average CO_2 emissions of newly purchased vehicles. In a similar vein, in a simulation based on a nested-logit model, Malina (2016) estimates that the revision of the vehicle taxation in 2014 would have reduced the average number of new passenger car registrations by 9,500 per year and, hence, would lead to a decrease in the carbon emissions from the passenger car fleet of just 0.1%. This implies an absolute reduction in carbon emissions of 35,000 metric tons, compared with 2008, the year before the emissions component was introduced in vehicle taxation.

Using monthly new car sales from Germany from January 2011 to March 2019, the period during which the tax was revised two times and the new testing procedure, the WLTP was adopted, Alberini and Horvath (2021) find that the tax revisions would lead to a reduction in new car sales of 2–5%. The dampening effect on the average carbon emissions rate is, however, small. When the authors separate the tax amount into the previous tax plus the shock

due to the switch to the WLTP, they find that the market is insensitive to the tax shock, but processes fully the corresponding change in the fuel economy of the vehicle.

The most recent study originates from Flintz, Frondel, and Horvath (2022), who empirically analyze the effectiveness of the 2021 reform of Germany's motor vehicle taxation with respect to its carbon emissions saving potential. To this end, the authors also draw on the panel data set employed by Alberini and Horvath (2021) that includes the number of monthly new vehicle registrations for Germany in the period spanning from January 2011 to April 2019, as well as a variety of car characteristics. The comparison of a counterfactual scenario with the actual values for the year 2018 indicates a very small effect of the most recent reform of the vehicle tax system (Table 2): If under the counterfactual scenario the circulation tax of 2021 had already been in effect in 2018, there would have been a decrease in annual new vehicle registrations of about 21,000 vehicles, or some 0.7% given that the number of cars sold in 2018 was just over three million.

Table 2: **Results of the Simulation of Flintz, Frondel, and Horvath (2022).**

	Year 2018	Counterfactual Scenario
Number of cars sold (million)	3.026	3.006
Average CO2 intensity (g/km)	126.6	125.9
Share of electric cars (%)	1.07	1.09
Share of hybrid (%)	1.41	1.43
Share diesel (%)	30.8	30.9
Share of gasoline (%)	66.8	66.6
Annual CO2 emissions (million t)	5.2	5.1
Annual tax revenue (€ million)	433.1	463.1
Average annual tax (€)	143.1	154.1

Along with a reduction in average CO_2 emissions of 0.7 g/km, this leads to an estimated decrease in annual carbon emissions of under 100,000 metric tons per year, that is, by less than 2%. A key reason for these moderate effects, which corroborate the criticism of the recent reform of the vehicle tax, is the small increase in the average tax burden by around 11 euros for vehicle purchasers in Germany, which is unlikely to have the incentive effect needed to substantially reduce carbon emissions. More pronounced than the emission reduction effect is the impact of the 2021 reform on annual tax revenues, which are estimated

to increase by about 7%. This corresponds to an absolute increase of 30 million euros, pushing total annual tax revenues to 463 million euros.

It is important to emphasize that these results are conservative in that they only reflect the impact of vehicle tax changes on new vehicles purchased in the single year 2018, not the tax reform's total impact over time. Similar emission savings will apply to subsequent years, as well. Moreover, the vehicle tax reform ensures a reduction in the number of new cars sold in subsequent years, as well as improved energy efficiency of newly registered cars. As a result, the emissions savings effect of the vehicle tax reform increases year by year.

Nevertheless, a comparison with the annual emissions of the car fleet in Germany of around 100 million tons makes it clear that the effects of vehicle taxation would be limited, even with higher tax rates. A key reason for the low emissions reduction potential from vehicle taxation is the fact that any vehicle tax reform applies only to new cars, yet not to already registered cars nor to sales on the used car market. Accordingly, it can take many years before the effect of a vehicle tax change substantially reduces the emissions caused by the passenger car fleet. In sum, while the studies of Klier and Linn (2015), Malina (2016), Alberini and Horvath (2021), and Flintz, Frondel, and Horvath (2022) find some climate mitigation potential of an emissions-differentiated car taxation for the German car market, the associated effect sizes and emission savings are small.

5 Summary and Conclusions

In 2021, Germany once again revised its vehicle taxation scheme, resulting in a disproportionate increase in the tax burden for vehicles with high emission intensity: With the revision, the annual circulation tax burden of newly registered vehicles no longer rises linearly with the emissions per kilometer driven, but progressively. The higher tax burden for cars with high per-kilometer carbon emission values is intended to encourage the purchase of more environmentally benign vehicles, a doubtful intention given that the increase in the annual tax burden is quite small, averaging around 11 euros.

This article has presented empirical evidence on the impact of Germany’s vehicle taxation and its reforms on the carbon emissions originating from private automobile

transport, thereby drawing on a series of recent studies: Klier and Linn (2015), Malina (2016), Alberini and Horvath (2021), and Flintz, Frondel, and Horvath (2022). The empirical evidence unanimously indicates that Germany's vehicle taxation scheme does not have the steering effect that is needed to substantially reduce carbon emissions. Yet, to fully analyze the emissions savings potential of vehicle taxation, the used car market and the scrappage rate of old vehicles should be considered in addition to the new car market (see, e.g., Bento et al. 2009).

There are alternatives to vehicle taxation that are likely to be more effective in reducing carbon emissions in the transport sector. One such alternative is dynamic, i.e. load-dependent, pricing of scarce road capacities (Frondel 2019), following Vickrey's (1963, 1969) seminal scholarship recommending dynamic road pricing to avoid traffic congestion. Efficient road pricing would have many additional benefits arising from more efficient traffic flow (Cramton, Geddes, Ockenfels 2019: 127), including reduced local and global air pollutants and increased traffic safety. Dynamic pricing would also provide valuable information to direct ever-scarce investment funds to those projects where they are most valued by road users. At the same time, dynamic pricing would provide the financial resources needed to maintain roads.

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