The Impact of Public Transport Subsidies on Highway Traffic: Evidence from Germany

Theresa Daniel[a], Maximilian Maurice Gail[a], Phil-Adrian Klotz[b,*]

[a] *Chair for Industrial Organization, Regulation and Antitrust, Department of Economics, Licher Strasse 62, Giessen, 35394, Germany*
[b] *Chair for Microeconomics, Department of Economics, Schloss Osthof-West, Stuttgart, 70599, Germany*

Abstract

We analyze the introduction of a nationwide and very low-cost local public transport ticket on highway passenger traffic in Germany. The German government has introduced the so-called *9-Euro-Ticket* in 2022 to give an incentive to individuals to switch to public transport and to save fuel (besides the general financial relief for citizens). Relying on an unique dataset of highway counting data and exploiting a difference-in-differences setting, we find a significant decrease in passenger traffic on German highways of more than 18%. An event study design provides empirical support for the parallel trend assumption and shows that the traffic decrease has been only temporary. Our results imply that large governmental subsidies to lower consumer prices for public transport can help to reach transport and climate politic goals, even though it is questionable whether such uniform demand-side expenses are target-oriented.

Keywords: Public transport subsidy, Intermodal competition, 9-Euro-Ticket, Difference-in-Differences

JEL: R48, R41, L91

Declarations of interest: None

*Corresponding author
Email address: philadrian.klotz@uni-hohenheim.de (Phil-Adrian Klotz)

1. Introduction

In 2022, the German Parliament has temporary introduced a nationwide local public transport ticket. The so-called *9-Euro-Ticket* has enabled travellers the unlimited usage of local public transport for 9€ per month between June and August 2022.[1] The direct costs for this governmental intervention have been 2.5 billion Euros. Even though the *9-Euro-Ticket* was primarily intended to relieve the financial burden on citizens, the intervention at the same time greatly simplifies the existing tariff structures of the tariff and transport associations for local public transport in Germany. Besides providing financial relief for citizens, the main goal of the German government was to give an incentive to switch to public transport and to save fuel.[2]

The temporary *9-Euro-Ticket* means the nationwide introduction of a uniform price setting for the local public transport. This might cause a missing price signal previously used to capture the value of services so that information about the demand side for the optimal formation of a capacity is also missing, which might lead to capacity problems and a lower service quality. Nevertheless, governments very often intervene in the market by means of subsidies in order to keep prices at a lower level than the market would actually allow. These subsidies might be reasonable when there is 1) a positive externality of a higher public transport frequency due to lower opportunity costs for the passengers (Button, 2010; Mohring, 1972) or 2) the public subsidies internalize the negative externality of the motorized individual traffic by making the public transport traffic relatively more appealing (Basso and Silva, 2014; Parry and Small, 2009).

In this paper, we want to identify the effect of the *9-Euro-Ticket* on highway passenger traffic in Germany. We want to find out whether such a type of very low-cost nationwide public transport tickets might have an impact on the decision of individuals to shift from

[1] See https://www.bmdv.bund.de/SharedDocs/DE/Artikel/K/9-euro-ticket-beschlossen.html.

[2] See https://www.bundestag.de/dokumente/textarchiv/2022/kw20-de-neun-euro-ticket-894660.

car to public transport. Therefore, we use an unique data set including traffic data for all German highways and employ a difference-in-differences approach with Austria being our control country. Our results imply that the introduction of the *9-Euro-Ticket* has significantly decreased the highway passenger traffic in Germany by more than 18%. In an event study design, we find empirical support for the necessary parallel trend assumption and evidence that the negative effect on traffic was only temporarily significant.

The rest of the paper is structured as follows. Section 2 presents related literature. We present our data set and descriptive statistics in Section 3. In Section 4, we explain our empirical strategy and then present the estimation results in Section 5. We conclude in Section 6 by discussing policy implications of our approach.

2. Related Literature

There is already some empirical evidence on the effect of uniform price settings in the public transport sector from earlier policies in Germany as well as from other countries. The city of Tallinn (Estonia) has introduced a fare-free public transport (FFPT) in 2013 to improve the mobility for its residents. Several empirical studies have identified only a small effect of this policy on passenger demand, but an improvement for the mobility of low-income residents, while transit ridership increase was lowest among working-age commuters (Cats et al., 2014, 2017; Hess, 2017). In an experimental study, Fujii and Kitamura (2003) show that offering auto drivers a temporary free bus ticket may convince them to shift to the public transport sector.

However, even though most of the previous papers find a demand increase in public transport usage after ticket price decreases, there is almost no evidence for mode substitution. Bull et al. (2021) investigate the effect of FFPT on travel behavior by randomly assigning an unlimited travel pass to workers in Santiago (Chile). They find a 23% rise in the total number of trips made during off-peak, which can be attributed to an increase in subway usage among individuals living close to a station, but the authors find no evidence of mode or period substitution. Busch-Geertsema et al. (2021) analyze the effect of the introduction of a FFPT in Hesse (Germany) by using survey data. Their results show a substantial increase in the use of public transport for commuting and other trip purposes, but the authors find no decrease in car use and availability.

With respect to the introduction of the *9-Euro-Ticket* in Germany in 2022, there is nearly solely some evidence from survey data and descriptive statistics. So far, one exception is the paper from Liebensteiner et al. (2024), in which the authors apply a DiD approach and an event study to analyze the effect of the ticket on mobility patterns. They (ibid.) find a limited substitution between transportation modes, a strong increase in leisure train journeys, and notable adverse effects on rail infrastructure quality.

In a market research study, the Association of German Transport Companies finds that 10% of the *9-Euro-Ticket* customers waived at least one of their daily car trips.[3] The German Federal Statistical Office finds an average increase in the public transport demand of 44%, but only a small decrease in the motorised private transport.[4] Relying on survey data, Loder et al. (2024) find that around 20% of the *9-Euro-Ticket* customers substituted at least some private transport trips with public transport. Aydin and Kürschner Rauck (2023) study the short-term effects of the *9-Euro-Ticket* on particulate matter and find a significant decrease. The authors interpret that a reduction in car usage is responsible for their findings. Gohl and Schrauth (2022) use a DiD design to estimate the effect of the *9-Euro-Ticket* on air pollution and find that this intervention reduced a benchmark air pollution index by more than six percent.

[3] See https://www.vdv.de/bilanz-9-euro-ticket.aspx.

[4] See https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/09/PD22_377_12.html.

3. Data and Descriptive Statistics

3.1. Data

We rely on counting data from the Federal Highway Research Institute (BASt) on all motor vehicles from Germany's motorways and extra-urban federal roads. All motor vehicles are permanently counted at automatic counting points and the data is available on a hourly basis for every traffic line and direction, while up to nine vehicle types can be distinguished. The counting point network on federal highways currently includes 2,108 counting points (1,227 on highways and 881 on extra-urban federal roads). This data is collected by Autobahn GmbH des Bundes (AdB) and the federal states and transmitted to BASt on a monthly basis. The data also forms an important basis for traffic or construction decisions and measures.[5]

The counting data for Austria is from the *Motorway and Expressway Financing Corporation (ASFiNAG)*. All motor vehicles are permanently counted at automatic counting points and the data is available on a monthly basis for every traffic line and direction, while two different vehicle types can be distinguished. The counting point network on federal highways in Austria currently includes 270 counting points.[6]

Moreover, we incorporate data on daily average gasoline (E5) consumer prices from the information platform *Fuelo* for Austria and Germany. *Fuelo* uses official sources as well as information from consumers, publishes this on its website and displays historical information on a daliy average level.[7]

3.2. Descriptive Statistics

Our data set contains highway traffic data for Austria and Germany. Even though we can distinguish between the different types of motor vehicles, we exclude all types except

[5] See https://www.bast.de/DE/Verkehrstechnik/Fachthemen/v2-verkehrszaehlung/zaehl_node.html.

[6] See https://www.asfinag.at/verkehr-sicherheit/verkehrszahlung/.

[7] See https://de.fuelo.net/.

passenger cars since we only expect an effect of the *9-Euro-Ticket* for this type. We aggregate this traffic data on a monthly basis from January 2022 to December 2023. Thus, our final panel data set contains 22,591 observations on counting point level, i.e. we have a panel data set including traffic counting information for 24 months. This data set includes traffic data for every highway in all federal states of Austria and Germany.

We illustrate the development of the overall highway traffic of passenger cars over time for Germany and Austria in Figure 1. The two vertical lines reflect the introduction and the end time of the *9-Euro-Ticket* in Germany. In general, Figure 1 shows that the development of the overall highway traffic of passenger cars hardly exhibits any seasonal fluctuations, even though there is slightly more traffic in the summer compared to the winter term in Germany. Naturally, the overall traffic of passenger cars is much higher in Germany compared to Austria. Nevertheless, the development of car passenger traffic over time is very similar.

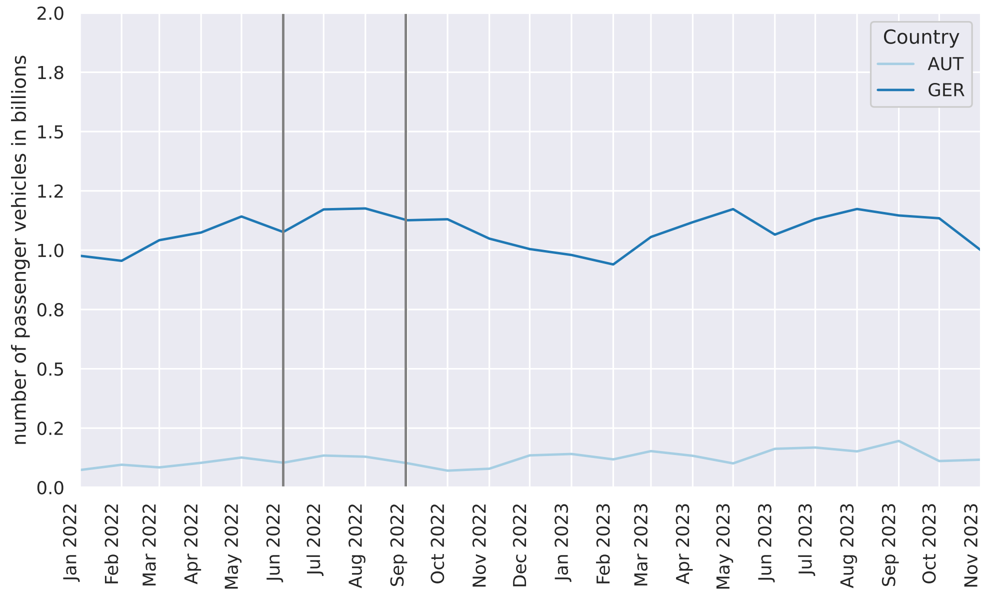

Figure 1: Development of the monthly overall highway traffic of passenger cars in Germany and Austria. The two vertical lines reflect the introduction and the end time of the *9-Euro-Ticket* in Germany.

Figure 1 also implies that the introduction of the *9-Euro-Ticket* has led to slight decrease in overall passenger car traffic at the beginning of its availability in June 2022. However, in the other two months of July and August 2022, traffic increased again to approximately the level of the previous May. We observe no similar pattern in Austria at the same time. In order to identify and measure an effect of the *9-Euro-Ticket*, we need a quasi-experimental design (see Sections 4 and 5).

We also include the gasoline price as a control variable in our approach. First, the current gasoline price might affect the choice of the transport mode (at least for price-elastic consumers) so that we have to take into account this variable when analyzing car passenger traffic. Second, The German government has additionally introduced an energy tax reduction (*Tankrabatt*) in June 2022 which we have to control for (Dovern et al., 2023; Fuest et al., 2022; Drolsbach et al., 2023). Figure 2 presents the development of the gasoline (E5) prices (monthly average) in Germany and Austria. The two vertical lines reflect the introduction and the end time of the *Tankrabatt* in Germany, which is obviously reflected in the consumer prices relatively quickly. Apart from that, the gasoline prices exhibit a very similar pattern in Austria and Germany over time.

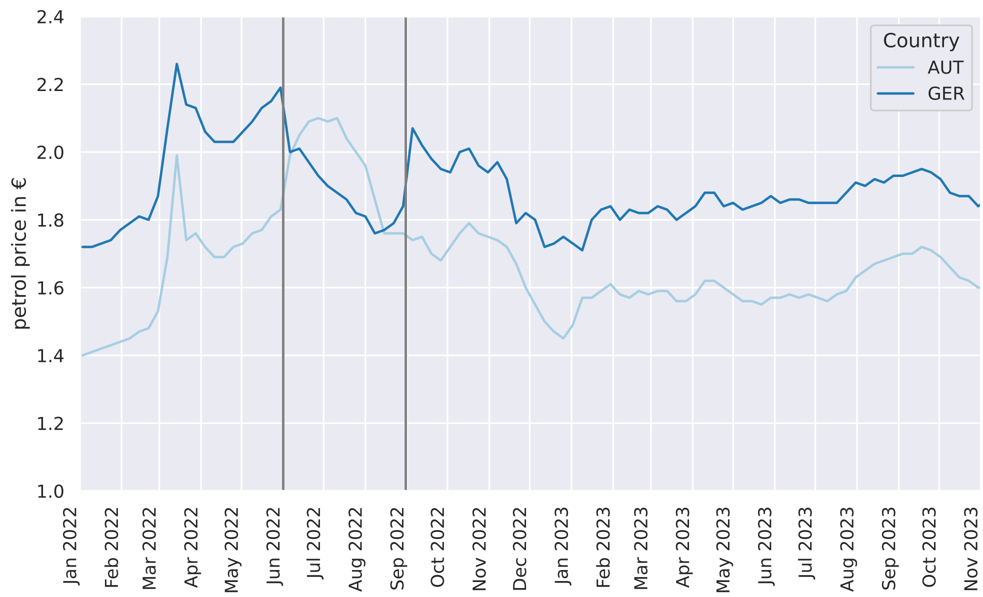

Figure 2: Development of the gasoline prices (monthly average) in Germany and Austria. The two vertical lines reflect the introduction and the end time of the *Tankrabatt* in Germany.

4. Methodology

In order to evaluate whether the introduction of the *9-Euro-Ticket* had a significant effect on highway passenger traffic in Germany, we apply a difference-in-differences (DiD) approach. The DiD design is a quasi-experimental identification strategy for estimating causal effects and is extremely popular in applied work in economics. We rely on Austria as the control group since it has very similar socio-economic conditions, a similar database and no similar introduction of a very low-cost nationwide public transport ticket.

Our baseline estimation approach is the following two-way-fixed-effects (TWFE) regression:

$$T_{ijt} = X'\beta + \tau \cdot Ticket_{it} + \eta_{ij} + \lambda_t + \epsilon_{ijt}. \tag{1}$$

In equation (1), T_{ijt} denotes the highway passenger traffic of counting point i in country j at month t (in logs). The dummy variable $Ticket_{it}$ is equal to one for the temporary introduction of the *9-Euro-Ticket* in Germany and 0 otherwise, so that τ gives the average treatment effect of the treated (ATT) for the introduction of the nationwide ticket. The vector X' contains the covariates for the lagged gasoline prices (in logs) as well as the introduction of the long-term *Germany ticket* in May 2023[8] and the variable η_{ij} corresponds to country-counting point fixed effects to control for any time-invariant differences between the two countries. Finally, λ_t gives the time fixed effects to control for traffic seasonality. The model in equation (1) is estimated using standard errors that are clustered at the country-counting point level.

Moreover, we also apply an event study approach (dynamic DiD) to check the key identification assumption of parallel trends in the absence of the *9-Euro-Ticket* introduction. The event study design is a frequently applied tool to evaluate policy treatments (see, e.g.,

[8] See https://www.dw.com/en/germany-launches-49-monthly-public-transport-ticket/a-65225055.

Cunningham (2021), ch. 9.4). Hence, we include a set of interaction terms comprised of an indicator for whether the country is Germany and indicators for some months before and after the introduction of the *9-Euro-Ticket*. We choose the month before the introduction of the ticket as the omitted group, yielding the following equation:

$$
\begin{aligned}
T_{ijt} = X'\beta + \eta_{ij} + \lambda_t + D_i \times [\sum_{k=-4}^{-2} \pi_k 1(Month_t = k) \\
+ \sum_{k=0}^{10} \tau_k 1(Month_t = k)] + \epsilon_{ijt}.
\end{aligned} \tag{2}
$$

Again, our dependent variable T_{ijt} denotes the logged highway passenger traffic of counting point i in country j at month t and the vector X' contains the covariates for the lagged gasoline prices as well as the introduction of the long-term *Germany ticket* in May 2023. The variable η_{ij} corresponds to country-counting point fixed effects to control for any time-invariant differences between the two countries and λ_t gives the time fixed effects to control for traffic seasonality. The coefficients π_k and ρ_k provide the estimated change in highway passenger traffic relative to the month before the *9-Euro-Ticket* introduction ($k = -1$). Estimates close to zero on the interaction term π_k in the pre-introduction months provide evidence against concerning pre-trends.

5. Results

The results of our difference-in-differences approach are outlined in Table 1. We estimate three different specifications using different fixed effects and covariates. The dependent variable in these regressions is the logged highway passenger traffic of counting point i in country j at month t. In the first specification (column (I)), we only control for time and country-counting point fixed effects. We find a significant and negative ATT of −0.179 (see variable *DiD*), which implies that the introduction of the *9-Euro-Ticket* has decreased the traffic on German highways by 17.9% compared to the counterfactual scenario.

In column (II) of Table 1, we also control for the introduction of the long-term *Deutschland-Ticket* in May 2023. As indicated by the variable *DiD*, this increases the negative effect of the *9-Euro-Ticket* on highway passenger traffic to 21.3%. The introduction of the long-term *Deutschland-Ticket* itself significantly decreases the highway passenger traffic in Germany by approx. 10%. Finally, we control for the lagged gasoline price (monthly average, in logs) in column (III), which leads to a slightly larger effect of the *Deutschland-Ticket* and a significant negative effect for the *9-Euro-Ticket* of 18.6%. The lagged gasoline price has a positive significant effect on highway passenger traffic, which might be counterintuitive at first glance. However, we actually observe a simultaneous increase of gasoline prices and highway traffic over time in both countries. This observation is supported by several empirical studies finding a relatively low price elasticity of gasoline for car drivers (Brons et al., 2008; Fridstrøm and Østli, 2021).

Dependent variable: $Traffic_{i,j,t}$			
	(I)	(II)	(III)
DiD	-0.179***	-0.213***	-0.186***
	(0.021)	(0.023)	(0.021)
Deutschland ticket		-0.101***	-0.100***
		(0.016)	(0.016)
Gasoline Price $(t-1)$			0.174**
			(0.078)
Constant	13.819***	13.851***	13.762***
	(0.003)	(0.006)	(0.048)
Time FE	Yes	Yes	Yes
Country Counting FE	Yes	Yes	Yes
Deutschland ticket	No	Yes	Yes
Gasoline Price $(t-1)$	No	No	Yes
R-squared	0.75	0.75	0.76
Obs.	22,570	22,570	21,535

Standard errors (in parentheses) are clustered at the country counting point level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1: Difference-in-Differences estimation with log car traffic as dependent variable.

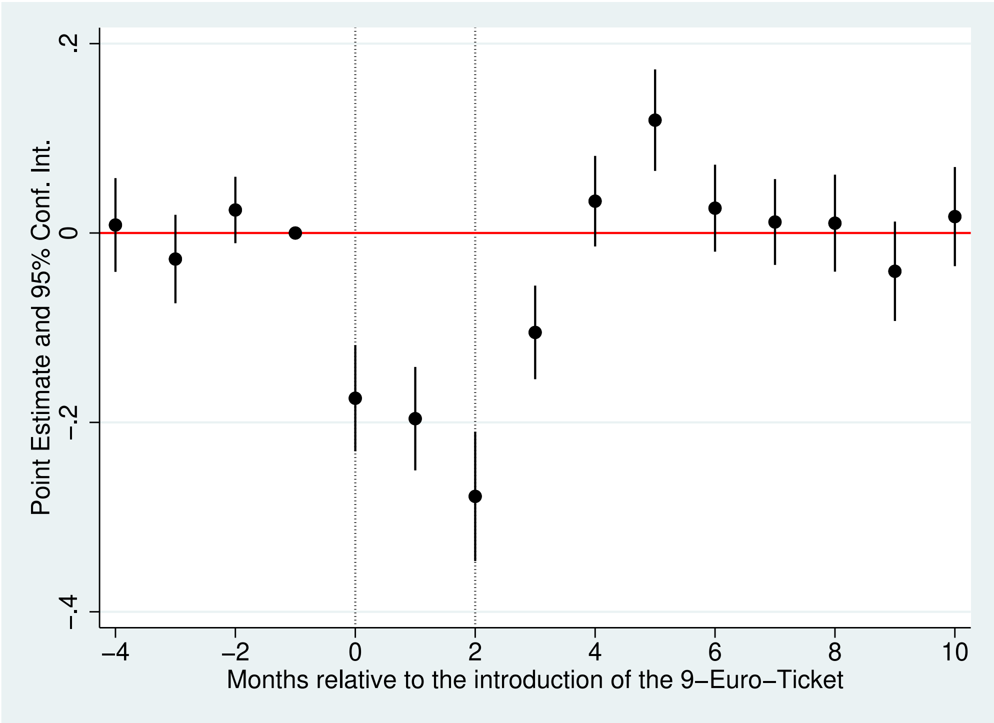

Figure 3: Event Study results based on Equation (2). The dependent variable is the logged car traffic on highways (using 95% confidence intervals). The vertical black lines indicate the duration of the *9-Euro-Ticket*.

The estimation results from our event study design in equation (2) are presented in Figure 3. The point estimator and their 95% confidence intervals are plotted and the estimated effects are relative to the month before the introduction of the *9-Euro-Ticket* in Germany (May 2022). The results in Figure 3 imply that the introduction of this nationwide public transport ticket has significantly decreased the highway passenger traffic in Germany during its availability. There is a significant and negative effect of the *9-Euro-Ticket* on highway passenger traffic in the months June ($t = 0$) to August 2022, which is still prevalent in September 2022 before getting insignificant.

Moreover, the pre-treatment coefficients in Figure 3 are close to the zero line and statistically insignificant, providing empirical support for the necessary identification assumption of parallel trends in the absence of the *9-Euro-Ticket* introduction. Taken together, our event study design qualitatively supports the results of our basic DiD approach.

6. Conclusion and Policy Implications

In this paper, we analyzed the effect of the temporary introduction of a nationwide local public transport ticket, known as the *9-Euro-Ticket*, on highway passenger traffic in Germany. The *9-Euro-Ticket*, introduced by the German government from June to August 2022, aimed to provide financial reliefs for citizens while incentivizing the shift from private car usage to public transport, thereby reducing fuel consumption and traffic congestion.

Our analysis employing a difference-in-differences approach revealed that the introduction of the *9-Euro-Ticket* led to a significant decrease in highway passenger traffic in Germany by more than 18%. This effect was robust across different model specifications. Additionally, an event study design implies that the significant traffic decrease on German highways has been only temporary and provides empirical support for the key identification assumption of parallel trends.

Our findings have important policy implications in the fields of transport and climate policies. First, they suggest that temporary, low-cost public transport initiatives like the *9-Euro-Ticket* can effectively stimulate modal shift from private cars to public transport, very likely contributing to reduced traffic congestion and environmental benefits through decreased fuel consumption and emissions (see, e.g., Aydin and Kürschner Rauck (2023)). Second, the results highlight the potential effectiveness of simplified and uniform price settings in public transport, which can encourage usage and facilitate decision-making for travelers.

Nevertheless, the efficiency of this governmental intervention as a whole remains questionable. The direct costs alone for this temporary demand-side intervention have been 2.5 billion Euros. It might be more sustainable to use these tax revenues for long-term and supply-side investments into the public transport sector. Moreover, this introduction of a uniform price setting has temporary caused a missing price signal on the demand side and has triggered some capacity issues at peak times. From the viewpoint of a government, it seems to be more efficient to let the price mechanism operate and to internalize the negative external effects of private car driving by pricing carbon dioxide and simultaneously supporting low-income citizens via direct transfers.

In the end, the introduction of a nationwide low-cost public transport ticket can have positive impacts on traffic congestion and environmental sustainability. Moving forward, policymakers should consider similar initiatives in designing comprehensive strategies to promote sustainable mobility and address the challenges of urban transportation. However, policymakers should carefully monitor the long-term sustainability and financial implications of such temporary initiatives and also take into account the effect of such a ticket on the price mechanism in this market.

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