RUHR
ECONOMIC PAPERS

Mark A. Andor
Fabian Dehos
Ken Gillingham
Sven Hansteen
Lukas Tomberg

Public Transport Pricing: An Evaluation of the 9-Euro Ticket and an Alternative Policy Proposal

rwi

#1045

Imprint

Ruhr Economic Papers

Published by

RWI – Leibniz-Institut für Wirtschaftsforschung
Hohenzollernstr. 1-3, 45128 Essen, Germany

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Editors

Editorial Office

Ruhr Economic Papers #1045

Responsible Editor: Manuel Frondel

ISSN 1864-4872 (online) – ISBN 978-3-96973-214-4

Ruhr Economic Papers #1045

Mark A. Andor, Fabian Dehos, Ken Gillingham, Sven Hansteen, and Lukas Tomberg

Public Transport Pricing: An Evaluation of the 9-Euro Ticket and an Alternative Policy Proposal

Bibliografische Informationen der Deutschen Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at **http://dnb.dnb.de**

RWI is funded by the Federal Government and the federal state of North Rhine-Westphalia.

http://dx.doi.org/10.4419/96973214
ISSN 1864-4872 (online)
ISBN 978-3-96973-214-4

Mark A. Andor, Fabian Dehos, Ken Gillingham, Sven Hansteen, and Lukas Tomberg[1]

Public Transport Pricing: An Evaluation of the 9-Euro Ticket and an Alternative Policy Proposal

Abstract

The pricing of public transportation is a frequently debated subject, and a notable current trend is leaning towards flat-rate pricing. In the previous year, Germany introduced a flat-rate ticket, enabling individuals to access public transportation across the entire country for just 9 euros per month during the months of June through August. In this paper, we first examine the extent to which the 9-Euro Ticket policy was able to induce a shift from cars to public transport. To this end, we evaluate the policy's impact on mobility behavior and emissions, and compare our results with other analyses of the policy that use different empirical approaches. The combined evidence shows that the flat-rate access induced only a marginal shift from car to public transport. The 9-Euro Ticket has primarily been used to expand personal mobility rather than to substitute between modes of transportation. In a further step, we subject the 9-Euro Ticket to a cost-benefit analysis based on its achieved carbon reduction. When compared to other climate policies, the costs appear disproportionately high. We use these results as a starting point to discuss flat-rate pricing for public transport in conjunction with evidence from programs in other European cities and insights from economic theory. Synthesizing the collected sources, we conclude that there are better options. Instead of a flat-rate ticket, we call for a cheap and dynamic public fare system that prices peak times higher than off-peak times to avoid overcrowding during peak hours. At the same time, a dynamic road pricing system should be introduced. This would further reduce the negative externalities of driving, generate revenues to support public transport, and provide a stronger incentive to switch from car to public transport.

JEL-Codes: R48, Q48, Q51

Keywords: Public transport; dynamic pricing; congestion charging; road pricing; flat-rate tariffs; 9-Euro ticket

October 2023

1 Mark A. Andor, RWI; Fabian Dehos, RWI; Ken Gillingham, Yale University, USA; Sven Hansteen, RWI; Lukas Tomberg, RWI. *- We thank David Card, David Rapson, Colin Vance as well as participants of the Agora Verkehrswende online seminar and the TUM lecture series for valuable comments. We gratefully acknowledge financial support from the Stiftung Mercator. Competing interests: The authors declare that they have no competing interests.* *- All correspondence to: Mark A. Andor, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: mark.andor@rwi-essen.de*

1. Introduction

Accelerated by surging inflation, policymakers in many countries have introduced cheap, flat-rate access to public transport. Such measures serve two aims: to cushion the social repercussions of inflation by reducing energy expenses, and to promote more sustainable mobility. Spain, for instance, has introduced a program that allows commuters free access to public transport for regular trips (Reuters 2022). Austria offers a nationwide ticket for 1,095 euros per year (One Mobility Ticketing 2023) and a regional ticket for the city of Vienna for 365 euros per year (Wiener Linien 2023). Luxembourg, Malta, and some cities in Europe and the United States have introduced free public transport (DW 2022). This global trend towards flat fares or free public transport is grounded in rationales such as simplification, uniformity, and ease-of-control. Germany recently followed suit with an unprecedented reduction in public transport fares. From June to August 2022, the German government granted nationwide access to public transport for just 9 euros per month, the so-called "9-Euro Ticket" (BReg 2022).

In this paper, we evaluate the impact of the 9-Euro Ticket on mobility behavior, conduct a cost-benefit analysis with a focus on the climate impact, and propose an alternative to the currently discussed subsidized flat-rate schemes to promote public transport. Our contribution is fourfold: First, we provide evidence on the impact of the availability of the 9-Euro Ticket on car and public transport use based on a panel of survey data we collected. Having data on mobility behavior, we use a difference-in-differences approach to compare the changes in distances traveled by car and public transport. Second, we contrast our analysis with results from other studies evaluating the impact of the 9-Euro Ticket on mobility behavior, as well as with the results of studies that evaluate previous programs to reduce or abolish public transport fares in different European countries or cities. Third, we evaluate the cost-effectiveness of the 9-Euro Ticket as a climate policy, by contrasting the climate benefits with the subsidy level that was needed to offer the 9-Euro Ticket. Fourth, we synthesize the collected empirical evidence, both ours and that from the literature, as well as insights from economic theory, to develop a clear policy recommendation that incentivizes more people to switch from cars to public transport, optimizes road and public transport utilization, and enables low-cost mobility.

There is a long strand of literature on how to reduce car use and promote sustainable mobility, in particular public transport. Studies range from behavioral economic studies (such as Gravert & Collentine 2021, Kristal & Whillans 2019) to regulatory requirements (such as low emission zones, Tarriño-Ortiz et al. 2022) to extensive research on optimal policy design (Hörcher & Tirachini 2021). The latter discusses, among other things, the pricing of public transport, public space, and the street. In particular, there has been a recent political trend towards cheap flat-rate or fare-free public transport, which is also reflected in research (see, for example, Kębłowski 2021). Our paper complements this literature by evaluating the 9-Euro Ticket and proposing a different pricing model.

We find that purchasers of the 9-Euro Ticket only slightly reduced their car use and mainly used public transport to expand their mobility. This expansion led to overcrowding on public transport in certain places and at peak times, reducing the quality of the service. Since the provision of the 9-Euro Ticket required a substantial public subsidy to compensate for the loss of revenue, the 9-Euro Ticket does not appear to be a cost-effective measure from a climate policy perspective. As an alternative, we call for subsidized and dynamic public transport tariffs that price peak times higher than off-peak times to avoid overcrowding during peak hours and enable low-cost mobility when buses and trains are underutilized. At the same time, a dynamic road pricing system should be introduced. This would internalize the negative externalities of driving, generate revenues to subsidize public transport fares, and provide a stronger incentive to switch from car to public transport.

The remainder of the paper is structured as follows: Section 2 describes the data and our approach of analysis. Section 3 delivers an overview of the results, which we then discuss, contextualize, and build upon to develop an alternative policy in Section 4. Section 5 concludes.

2. Data and method

We conducted two surveys on mobility behavior in Germany. The first of these surveys took place before the introduction of the 9-Euro Ticket (between March 25 and April 17, 2022), while the second was carried out in the first month of the ticket's availability (June 17 to 24). Survey respondents were recruited from a professionally managed panel that is representative of German-speaking internet users aged 14 and above. 9,947 people took part in the first survey, of whom 8,643 answered the survey completely. Of these, a sample size of roughly 5,000 follow-up respondents was targeted for the second survey. Thus, the final data set accounts for 5,046 respondents who participated in both surveys.[1] The descriptive statistics for this pool of participants are depicted in Table 1 below.

Table 1: Socioeconomic characteristics of the data

Variable name	Variable description	Mean
Household size	Household size (number of persons)	2.16
Income	Monthly net household income in euros	3,652
Age	Age of respondent in years	57.21
Higher education	Dummy: 1 if respondent has a university degree	0.30
Female	Dummy: 1 if respondent is a woman	0.45
Buyers	Dummy: 1 if respondent purchased a 9-Euro Ticket in June 2022 and did not have a public transport subscription ticket before	0.22
Prior subscribers	Dummy: 1 if respondent already had a public transport subscription ticket, automatically granting access to the 9-Euro Ticket's perks	0.15

Note: Household income was obtained using an interval scale and was converted to a continuous income measure for the empirical analysis.

Table 1 depicts a selection of socioeconomic characteristics collected as part of the survey. The average household of the sample consists of 2.16 persons and a net income of 3,652 Euros per month, which approximately corresponds to the population data from the German micro-census (see Table A1 in the Appendix). On average, our sample is slightly older than the mean of German citizens over 18 years (57.2 years compared to 49.4) and consists of a slightly lower proportion of women (45 vs. 51 percent).

In terms of mobility behavior, we specifically asked respondents to report the sum of all trips and distances they had traveled in the past seven days by various modes of transportation, including car and public transport (see Section 6.1 of the Appendix for details). Among the participants of our study, 15 percent owned monthly public transport subscription tickets, which were upgraded to 9-Euro Tickets by the transit agencies during the policy timeframe, with the price difference refunded in the process. When combined with those who newly bought the 9-Euro Ticket, this amounts to 37 percent of respondents with flat-rate public transport access in June 2022.

[1] Because of declined answers by some respondents and a removal of outliers, the sample size varies slightly across different analyses. We remove outliers by dropping all observations that fall below the 1% percentile and above the 99% percentile of the distribution of individual changes over time for the respective outcome variable.

We apply a differences-in-differences (DiD) approach; that is, we compare the mobility behavior of the 9-Euro Ticket purchasers to that of a reference group over time. Specifically, we compare the changes in mobility behavior of both groups between the first wave of the survey, which was conducted before the introduction of the 9-Euro Ticket, and the second wave of the survey, which was conducted during the availability of the 9-Euro Ticket. This approach allows us to identify the impact of the 9-Euro Ticket under the assumption that the changes in mobility of the reference group are indicative of how the group of 9-Euro Ticket purchasers ("buyers") would have behaved in the absence of the 9-Euro Ticket. We consider the most relevant reference group to be those who did not purchase the 9-Euro Ticket ("non-buyers"), since the mobility behavior of this group is unlikely to have been substantially influenced by the availability of the 9-Euro Ticket. We can therefore assume that the change in driving behavior of this group between the first and second survey wave provides information on the seasonal changes in car use, so that we can factor these out.

To assess the robustness of our approach, we also redefine the reference group by using respondents who held a public transport subscription prior to the introduction of the 9-Euro Ticket ("subscribers") as the reference group. Analogous to using the group of non-buyers as a proxy for the seasonality of car use, we use the group of subscribers – who have already previously integrated public transport into their mobility routines – as a proxy for the seasonality of public transport use. Yet, since the 9-Euro Ticket allowed the nationwide use of public transport, while the scope of conventional subscription tickets is limited to specific regions, prior subscribers also benefited from the 9-Euro Ticket due to lower costs and an extended scope. Assuming that this group has therefore also expanded its public transport use compared to the counterfactual situation, this means that our estimates using this reference group are rather conservative, since the reference group has likely changed its behavior in the same direction as the group of new public transport customers.

Equation (1) formalizes our DiD approach:

$$y_{it} = ß_0 + ß_1 T_t \times G_i + \pi_i + \tau_t + \varepsilon_{it} \quad (1)$$

with y_{it} indicating the respective outcome of individual i at time $t = 1$, i.e. right before the introduction of the policy, and time $t = 2$, i.e. after the introduction. In two separate regressions, we investigate both, the km-distance traveled by car as well as by public transport. In addition, we include a full set of individual fixed effects (π_i) to control for time invariant differences across individuals. τ_t captures period specific shocks that are common to all individuals. G_i indicates whether someone belongs to the treatment group, e.g. those who bought the 9-Euro Ticket. Dummy T_t indicates the time when the policy was in place, i.e. the second survey wave.

The interaction term $T_t \times G_i$ identifies the coefficient of interest, $ß_1$, indicating the mobility adjustments of the treatment group, compared to the predefined reference group. Through the selection of different reference groups, we aim to identify a range of effects instead of a single point estimate.

In addition to these effects, we also investigate other notable aspects of the 9-Euro Ticket. For example, we asked respondents about their experiences with bus or train travel while the ticket was available to gather an impression of the effect on public transport quality. Furthermore, the 9-Euro Ticket was part of a broader inflation relief package that also included a temporary reduction in the fuel tax. The possible confounding impact of this simultaneous fuel tax cut is investigated in Appendix 6.3.

3. Results

3.1. Effects on mobility behavior

In Table 2, we present our main results. Row (1) depicts the comparison of the change in car usage between 9-Euro Ticket buyers and non-buyers. The results are depicted for the first survey wave ("Pre", Column IV), second survey wave ("Post", Column V), and the difference ("Diff", Column VI). Compared to March/April, we find that car use increased in all groups in June, the first month the 9-Euro Ticket was available. Yet, this increase is 15 kilometers higher for the group of non-buyers ("Diff-in-diff", Column VII). This result is confirmed by the corresponding coefficient from the regression analysis following Equation (1) depicted in Column VIII ("Regression Diff-in-diff"). This coefficient amounts to -16.4 kilometers and is statistically significant at the 5% level.

Table 2: DiD results on the mobility behavior of buyers of the 9-Euro Ticket

(I) Row	(II) Outcome	(III) Group	(IV) Pre	(V) Post	(VI) Diff	(VII) Diff-in-diff	(VIII) Regression Diff-in-diff
(1)	Kilometers by car (last 7 days)	Buyers/Subscribers	113	135	22	**-15**	**-16.4**** **(6.6)**
		Non-buyers	174	211	37		
(2)	Kilometers by public transport (last 7 days)	Buyers/Subscribers	26	59	33	**32**	**32.3***** **(1.8)**
		Non-buyers	1	2	1		

*Standard errors are clustered at the individual level and reported in parentheses. ***, ** and * indicate statistical significance at the 1, 5 and 10% level, respectively. Number of observations / individuals: 9522 / 4761 (Row 1), 9540 / 4770 (Row 2).*

Thus, our results from Table 2 suggest that the 9-Euro Ticket is associated with a decrease in car use of 16 kilometers per week. For reference, average car use across groups prior to the policy was 151 kilometers per week, so the policy reduced car use by about 10 percent. With regard to public transport use, we find from Row (2) that buyers of the 9-Euro Ticket substantially increased their use of public transport by 32 kilometers, nearly doubling the decrease in car use.

Table 3: DiD results on the mobility behavior of buyers of the 9-Euro Ticket - alternative reference group (people who already had a public transport subscription ticket before the 9-Euro Ticket became available: "Prior subscribers")

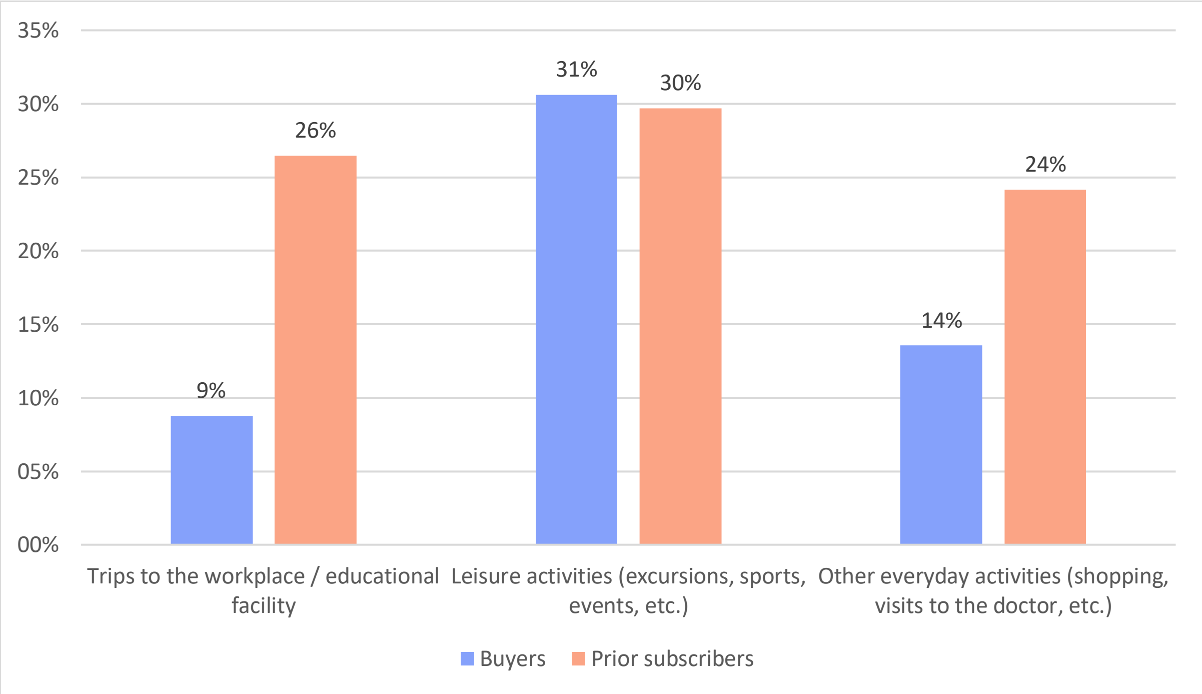
(I) Row	(II) Outcome	(III) Group	(IV) Pre	(V) Post	(VI) Diff	(VII) Diff-in-diff	(VIII) Regression Diff-in-diff
(1)	Kilometers by car (last 7 days)	Buyers	149	167	18	**-8**	**-8.3** **(9.9)**
		Prior subscribers	63	89	26		
(2)	Kilometers by public transport (last 7 days)	Buyers	9	49	40	**17**	**17.5***** **(3.6)**
		Prior subscribers	51	74	23		

*Note: Standard errors are clustered at the individual level and reported in parentheses. ***, ** and * indicate statistical significance at the 1, 5 and 10% level, respectively. Number of observations / individuals: 3560 / 1780 (Row 1), 3312/ 1656 (Row 2).*

In Table 3 we present the results using the alternative reference group of those who already had a public transport subscription ticket before the 9-Euro Ticket became available ("prior subscribers"), which we assume is the appropriate reference group to account for seasonal changes in public transport use, as discussed in Section 2. This group was previously merged with the group of buyers in our main specification in Table 2. We find that the pattern of a rather modest decline in car use and a nearly twofold increase in public transport use found in Table 2 is also found in Table 3, although the effects are about half as large.

The overall pattern is plausible given the stated occasions of use of the 9-Euro Ticket presented in Figure 1: In particular, those who had not previously owned a subscription ticket used the 9-Euro Ticket primarily for leisure activities and only few used it for commuting, e.g. trips to the workplace. Thus, it seems evident that the 9-Euro Ticket was primarily used to extend mobility in leisure time rather than to substitute everyday car trips, which is consistent with the results presented in Tables 2 and 3.

Figure 1: Stated occasions of use of the 9-Euro Ticket



Note: Respondents who bought the 9-Euro Ticket were asked "How often have you used the 9-Euro-Ticket for the following occasions?" and could respond on a five-point scale with the following option "(almost) always", "frequently", "rarely", "(almost) never". The graph depicts the percentages of those who indicated "(almost) always" or "frequently". Numbers of observations per bar: 1080, 563; 1089, 564; 1086, 563.

3.2. CO_2 reduction, abatement costs, and consideration of further studies on the 9-Euro Ticket

Besides providing financial relief, the 9-Euro Ticket was also intended to promote public transport as a climate friendly alternative to car use (BReg 2022). As such, the policy's cost-effectiveness should be evaluated in comparison with common climate policies. We approach this by calculating the CO_2 reduction implied by our main results presented in Table 2.

Based on multiple data sources described in Table A3 in the Appendix, we calculate CO_2 reduction and abatement costs using the following formulas:

$$CO_2\ Reduction = CO_2\ per\ kilometer\ of\ car\ use \times Reduction\ in\ car\ use\ per\ week \times Ticket\ availability\ (weeks) \times Group\ size\ (number\ of\ 9\ Euro\ Tickets\ in\ use) \quad (2)$$

$$Abatement\ Costs = \frac{Cost\ of\ the\ 9\ Euro\ Ticket\ policy}{CO_2\ Reduction} \quad (3)$$

Following the outlined approach, we find that short-run abatement costs of carbon reductions due to the 9-Euro Ticket amount to € 2,800 per ton of CO_2. Other studies have shown that even one of the most expensive alternative climate policy measures in the transportation sector, subsidizing electric vehicles, comes with lower abatement cost of € 320 to around € 1,000 per ton of CO_2 (Fournel 2022, Gillingham & Stock 2018, Heymann 2021), indicating that the 9-Euro Ticket was not cost-effective as a climate policy instrument due to the limited reduction in car use.

Other studies that have also examined the impact of the 9-Euro Ticket find a similarly modest shift from cars to public transport and a correspondingly modest reduction in CO_2 emissions, which further supports our conclusion. For instance, the Association of German Transport Companies (VDV) commissioned market researchers for an evaluation of the 9-Euro Ticket and concludes that 10% of trips with the 9-Euro Ticket would otherwise have been made by car. With this figure, they estimate a reduction of 1.8 million tons of CO_2 due to the 9-Euro Ticket (VDV 2022). While this figure is substantially larger than our result, it still implies very high CO_2 abatement costs of € 1,389 per ton of CO_2. Gaus et al. (2023) make use of mobile phone geolocation data to track public transport travel distances between May and September of 2022. Their results indicate a short-lived increase in public transport use immediately following the introduction of the 9-Euro Ticket, which however quickly declined in the later months of the 9-Euro Ticket's availability. Combining three survey waves with a smartphone-based travel diary, Loder et al. (2023) find a modal shift from cars to public transport of about five percentage points and likewise conclude that policies focusing on public transport prices, such as the 9-Euro Ticket, are not enough to incentivize a sufficient switch to sustainable mobility alternatives.

3.3. Free or flat-rate public transport – Similar experiences from different settings

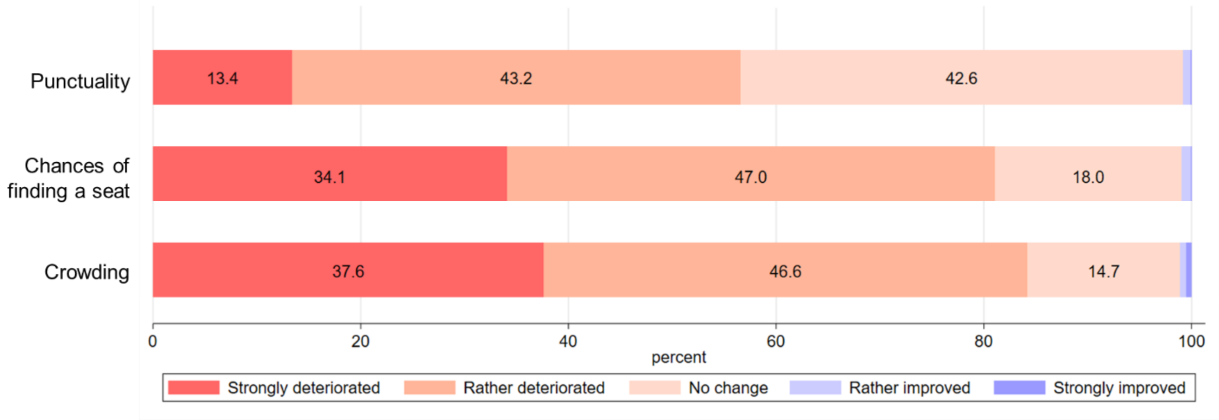
The finding of modest car use reductions through the 9-Euro Ticket is consistent with previous experiences of offering free public transport. Between 1998 and 2002, for instance, the German city of Templin provided free public transport. While its use increased by 750% after the free service began, only 10-20% of public transport users reported a shift away from car trips (Storchmann 2001). The Belgian city of Hasselt introduced free public transport in 1996. After its introduction, 37% of all public transport users were first-time users. Of these, 43% substituted car trips for public transport trips, while the remaining switchers were cyclists and pedestrians (van Goeverden et al. 2006). In the case of the Estonian capital Tallinn, the introduction of free public transport in 2013 was accompanied by a 14% increase in public transport trips. However, only 10% of this increase represents a substitution of car trips, while 40% of trips were previously made on foot (Cats et al. 2017).

3.4. Descriptive results on the quality of public transport

Our finding that the 9-Euro Ticket has led to many additional public transport trips (see Section 3.1) raises the question of whether these additional trips had an impact on public transport service quality. Therefore, we asked the participants in our second survey wave to indicate on a five-point scale ranging from "strongly deteriorated" to "strongly improved" how strongly they felt that several indicators of public transport quality, such as punctuality and crowding, had changed since the introduction of the 9-Euro Ticket.

Figure 2 shows that 56.6 percent of respondents report a deterioration in the punctuality of public transport. In addition, 46.6 percent of respondents reported that crowding on trains and in stations has worsened somewhat and 37.6 percent that it has worsened a lot. Consequently, respondents experienced a similar worsening in the chances of finding a seat. These reports of increased overcrowding in public transport are consistent with other studies and media reports (see, for example, Hille & Gather 2022 and Deutschlandfunk 2022), which also expressed problems with overcrowding during the availability of 9-Euro Ticket, especially at peak times.

Figure 2: Assessment of public transport quality



Note: The percentages exclude participants who selected the option "do not know / prefer not to say". These were 1,757, 1,587, and 1,612 responses from our sample of N=5,046 participants. The vast majority of those who selected this option were respondents who do not use public transport or use it very infrequently.

3.5. Assessment of the financial relief and benefits provided by the 9-Euro Ticket

As the 9-Euro Ticket was primarily intended to provide financial relief to cushion the social repercussions of inflation, our evaluation of the 9-Euro Ticket and potential alternative policies must naturally incorporate this dimension of the policy. As with many other subsidy programs it is especially important to consider the distributional impact of the policy to assess whether it tends to be regressive or progressive. To do so, we present the financial consequences induced by the 9-Euro Ticket separately for different income groups (see Table 4) and compare them to the incomes of the different groups.

From the perspective of public transport users, the 9-Euro Ticket had two main advantages. First, it provided financial savings: Since the 9-Euro Ticket was significantly cheaper than previous monthly subscription tickets, almost everyone who regularly used public transport before the introduction of the 9-Euro Ticket achieved financial savings. In Row 1 in Table 4, we depict the average public transport use before the introduction of the 9-Euro Ticket for the different income groups. Multiplying this by the average public transport costs of 24 Eurocent per km traveled (see e.g., VM 2022) yields an estimate of the financial relief provided by the 9-Euro Ticket.

Second, the design of the 9-Euro Ticket as a flat-rate ticket valid throughout Germany enabled additional public transport trips that did not incur any marginal costs for ticket holders. To quantify the value of these additional trips, we estimate the increase in public transport use due to the 9-Euro Ticket from DiD regressions that we conduct separately for different income groups (Row 3). Again, multiplying these additional distances with the average public transport cost yields the monetary value of the additional public transport use in terms of pre-9-Euro Ticket costs (Row 4).

In Row 5 we calculate how much each group would have spent for their total public transport use in June in absence of the 9-Euro Ticket, i.e. we take the sum of Rows 2 and 4. We then subtract the price of the 9-Euro Ticket to approximate the overall benefit due to the 9-Euro Ticket (Row 6). This benefit is finally depicted in relation to each group's respective mean income (Row 8).

We find that the benefit of the 9-Euro Ticket is about 4.7% of the monthly income of the group earning between 700 and 1700 euros per month. This share decreases steadily with increasing income, being lowest in the highest income group. This suggests that the 9-Euro Ticket was a progressive policy that benefited low-income households in particular. This finding is also reflected in the study by Hille and

Gather (2022), who conclude that the 9-Euro Ticket offered many low-income households new opportunities to participate in social life.

Table 4: Public transport use, potential expenses, and relative savings of 9-Euro Ticket owners by income group

Row	Income Group (in Euro)	700 - 1700	1700-2700	2700-3200	3200-4700	above 4700
	Financial relief due to the 9-Euro Ticket					
(1)	**Average public transport use** (in km per month)	116	137	94	89	110
(2)	**Financial relief due to the 9-Euro Ticket (Row 1 × 0.24 €)** (in euros per month)	28	33	23	21	26
	Benefit from additional public transport use enabled by the 9-Euro Ticket					
(3)	**Public transport increase due to 9-Euro Ticket** (in km per month)	155	161	126	156	154
(4)	**Monetary value of additional public transport trips (Row 3 × 0.24 €)** (in euros per month)	37	39	30	37	37
(5)	**Overall potential expenses for public transport in June (Row 2 + Row 4)**	65	72	53	58	63
(6)	**Monetary benefit due to the 9-Euro Ticket (Row 5 minus 9 €)** (in euros per month)	56	63	44	49	54
(7)	**Approximate income** (in euros per month)	1200	2200	2950	3950	4700
(8)	**Monthly benefit due to 9-Euro Ticket** wrt. monthly income **(Row 6 / Row 7)**	4.7%	2.9%	1.5%	1.2%	1.1%

4. Proposal of an alternative policy: Dynamic pricing

Based on our own panel of survey data on mobility behavior, as well as the results from other studies evaluating the 9-Euro Ticket or other programs of reduced or completely abolished public transport fares, we conclude that introducing highly discounted or free public transport access is probably not the optimal policy to trigger a large-scale switch to sustainable mobility behavior. This is because the reduction in car use as a response to such policies tends to be too modest, especially compared to the high cost required to subsidize ticket prices. In addition, the induced additional public transport trips may lead to overcrowding at peak times, which reduces public transport quality and could possibly require costly capacity expansions in the long run. Yet, the 9-Euro Ticket enjoyed great popularity, not least because it provided an equal opportunity for mobility irrespective of income.

Based on these findings, insights from economic theory and recent technological advancements, we propose an alternative to policies that provide cheap or free flat-rate access to public transport: Subsidized dynamic public transport fares that are higher during peak hours than during off-peak hours and that are linked to and financed (at least in part) by dynamic road pricing. This way, the proposed policy can lead to an optimal utilization of the road and public transport network, in particular reducing congestion and overcrowding, while at the same time providing an incentive to switch from car to public transport.

Specifically, the application of a dynamic road pricing scheme internalizes the external costs of car use (Cramton, Geddes & Ockenfels 2018, RWI & Stiftung Mercator 2019), thereby directly addressing road congestion and car-related pollution. A higher relative price of car use induces a shift to public transport (or other sustainable transport modes such as cycling or walking). In addition, road pricing generates revenues that can be used to subsidize public transport and improve its attractiveness.

Moreover, while a flat-rate ticket may exacerbate overcrowding of public transport, dynamic fares alleviate this problem by shifting public transport usage from peak to off-peak times (Glaister 1974, De Borger & Wouters 1998). Fares can be dynamic in the sense that they may change from hour to hour, or even from bus to bus or train to train, depending on demand. Importantly, ticket prices can still be lower than the cost of operating vehicles (see Glaister 1974, Parry & Small 2009). During off-peak times, they can be reduced even further. This allows cheap travel for low-income individuals, which in turn fosters social cohesion. Furthermore, the revenues from dynamic public transport and road pricing can be used to reduce capacity constraints and thus the number of peak times.

Potential concerns and skepticism

The idea of dynamic pricing was proposed in the 1960s (e.g. Vickrey 1963, Glaister 1974) and was regarded as an appealing theoretical idea but infeasible in practice. But due to technical progress and digitalization, feasibility is no longer a problem. Cities such as Singapore and Stockholm have already implemented electronic road charging systems (Cramton, Geddes & Ockenfels 2018, Börjesson & Kristoffersson 2018). Likewise, dynamic pricing for public transport has been successfully implemented in the aviation and long-distance train sector, as well as in mobility services like Uber and Lyft.

If low-income individuals are shifted away from peak hours to off-peak hours due to dynamic pricing of public transport, one might be concerned about social exclusion. However, dynamic pricing can grant low-income earners even cheaper access to public transport compared to flat-rate options. In addition, equity concerns could be further mitigated by a compensating lump-sum transfer to low-income earners that is financed by the dynamic road pricing scheme.

Politicians might nevertheless be worried about regional equity concerns that arise when car-dependent individuals in rural areas must pay more for mobility than people in cities. However, road pricing is specifically designed for areas with a lot of traffic, i.e. cities, while leaving rural areas unaffected due to lower congestion. Consequently, dynamic road prices would be low or even zero in rural areas. This is crucial from both an equity and an efficiency perspective: While aiming to reduce congestion on roads, our proposal tackles areas with the highest marginal return in terms of "environmental" savings (Anderson 2014). To provide rural residents with access to cities via public transport, it may be useful to further develop park and ride facilities or other infrastructure.

5. Conclusion

In this paper, we evaluate the 9-Euro Ticket's impact on car and public transport use based on large-scale surveys on mobility behavior. Our results indicate a limited shift between modes, which is confirmed by results from other analyses using different approaches. When considered as a climate policy, our cost-benefit analysis reveals that the 9-Euro Ticket did not lead to sufficient greenhouse gas reductions to reach cost-effectiveness compared to alternative climate policies.

While Germany introduced a permanent successor flat-rate ticket – the Deutschlandticket – for 49 euros per month in May 2023, we call for an alternative approach that also contrasts with the current discussion about implementing a flat-rate ticket in France and a potential pan-European ticket. We concur that a subsidized reduction of ticket prices is justified, but instead of a flat-rate fare, dynamic pricing should be adopted to optimize the utilization of public transport and to prevent overcrowding at peak times. At the same time, the public transport subsidy should at least in part be financed through dynamic road pricing to further reduce the negative externalities of car use and to provide a stronger incentive to switch from car to public transport.

We see numerous avenues for future research. For example, important questions arise about how high the prices should be in the public transport and road pricing schemes. Thus, studies to estimate the magnitude of the external costs of driving, following Parry & Small (2009), in many different regions could be especially fruitful. Accompanying evaluations could also examine the acceptance of such measures before, during and after a certain period of implementation. A consistent application of our policy recommendations has the potential to lead to significantly lower local and global emissions, less congestion, fewer accidents, quieter cities, and ultimately a better quality of life.

6. Appendix

6.1 Survey questions on mobility behavior

Question 1:
Now we are concerned with your driving behavior in general, i.e., both journeys to work/school/training/university and private journeys, e.g., for shopping, visiting friends, sport, etc.

Please think about your driving behavior in the last 7 days. Which of these modes of transportation did you use in the last 7 days?

- (Private) car
- Motorcycle/scooter
- car sharing or rental/loan car
- Public transport (bus, streetcar, regional trains, etc.)
- Bicycle / e-bike
- E-scooter
- Train (long distance)
- Bus (long-distance)
- Airplane
- Other: ___________
- none
- don't know / not specified

Question 2:
Please indicate how often you used these modes of transportation in the last 7 days.

Count outbound and return trips separately, as 2 trips.

Example: Suppose you drove your car to work yesterday morning, back home in the afternoon, and drove your car to and from sports in the evening. You then used the car four times.

Also, please indicate how many total kilometers you traveled by these modes of transportation in the last 7 days. If you do not know the exact values, please estimate.

Means of transport[2]	How often have you used the following modes of transportation in the last 7 days? If you do not know exactly, please estimate.	In the last 7 days, how many total kilometers did you travel by the following modes of transportation? If you do not know exactly, please estimate.
(Private) car	_____ trips	_____ km
…	_____ trips	_____ km

[2] This question has been programmed to show only the options selected by the respondent in Question 1.

6.2 Comparison of our sample with the German population

Table A1: Socioeconomic characteristics (means) of the survey in comparison to the German Microcensus

Variable	Description	Survey	Microcensus
Household size	Size of household in persons	2.16	1.99
Income	Monthly net household income in euros	3652.26	3831
Age	Age of respondent in years	57.21	49.45
Higher education	Dummy: Respondent has a university degree	0.30	0.30
Female	Dummy: Respondent is a woman	0.45	0.51

Note: The data was retrieved from Destatis (2023), using tables 12211-0001, 12211-0101, 12211-0302, and 63121-0001. Household income was obtained using an interval scale and was converted to a continuous measure for the empirical analysis. Since only German citizens aged 18 or older were eligible for participation, the census data was restricted to 18 and above as well.

6.3 Accounting for the fuel tax cut

As the 9-Euro Ticket was accompanied by a simultaneous fuel tax cut, the effect of the 9-Euro Ticket on mobility behavior may be confounded by the effect of the tax cut. Similarly, it could be confounded by any other changes in fuel prices between March/April and June, or by any other major policy change that happened at the same time. To the best of our knowledge, there are no other major policy adjustments. However, the tax cut and changes in fuel prices did occur and must be accounted for. Therefore, in the following we estimate what impact the changed fuel costs might have on our results. Our aim here is not to identify the precise effects – which is certainly a challenge – but to determine whether accounting for the fuel tax cut and changes in fuel prices could strongly change our conclusions. As we will see below, we can conclude that the effects are rather limited – also under conservative assumptions – and that our conclusions therefore stand up even when taking these effects into account.

First, some basic thoughts on the impact of changing fuel prices on our results. Our differences-in-differences approach means that our estimated results would not change if we assumed the same price elasticities of demand for all relevant groups. While the decrease in fuel prices compared to March/April clearly leads to an incentive to drive more, a uniform increase in driving across groups does not lead to any relevant changes. However, relevant effects on our estimated results could arise if the different groups (in particular buyers and non-buyers of the 9-Euro Ticket) have different price elasticities of car usage, which is not implausible. In the following, we will therefore assess what influence this could have on our results.

Leveraging daily fuel price data (Destatis 2022) differentiated with respect to the respondents' car engine types – Gasoline or Diesel – as well as recently published estimates on fuel price elasticities of car usage in Germany (Alberini et al. 2022), we approximate counterfactual car use in June, given the fuel price levels in April:

$$\widehat{Car\ use}_{june,i} = Car\ use_{june,i} \times \left[1 + \left(1 - \frac{p_{june,i}}{p_{april,i}}\right) \times \varepsilon_i\right], \tag{1}$$

where $\widehat{Car\ use}_{june,i}$ is respondent i's counterfactual car use in June, while $Car\ use_{june,i}$ is actual car use in June. $p_{june,i}$ is the fuel price for respondent i's engine type at the time of their survey response in June, while $p_{april,i}$ is the corresponding fuel price at the survey response in March/April. In detail,

$p_{june,i}$ and $p_{april,i}$ are the averages of fuel prices in the last 7 days prior to the respective survey response. ε_i depicts the fuel price elasticity. We do not alter the car use of those who own alternatively fueled cars (such as electric vehicles), such that $\widehat{Car\ use}_{june,i}$ is equal to $Car\ use_{june,i}$ for these persons.

While we assume an average fuel price elasticity of car use of -0.388 (Alberini et al. 2022), ε_i is indexed by i as we construct several scenarios allowing the elasticity to differ between 9-Euro Ticket buyers and non-buyers. We deem it possible that 9-Euro Ticket buyers have a higher fuel price elasticity than non-buyers.

To account for these potential differences in the car driving response to fuel price changes across groups, we gradually increase the fuel price elasticity of those who bought the 9-Euro Ticket while simultaneously decreasing the elasticity of those who did not buy it, such that the overall elasticity of -0.388 is preserved on average. Since we do not have a clear indication of how the fuel price elasticity of prior public transport subscribers differs from that of new purchasers of the 9-Euro Ticket or non-purchasers, we hold the elasticity for this group constant at -0.388.

In detail, we compute the altered elasticities of 9-Euro Ticket buyers (ε_{buyers}) and non-buyers ($\varepsilon_{non-buyers}$) as follows:

$$\varepsilon_{buyers} = -0.388\ \times (1 + \delta) \quad (2)$$

$$\varepsilon_{non-buyers} = \frac{-0.388 \times (1-(0.22 \times (1+\delta))}{1-0.22}, \quad (3)$$

where δ is the hypothetical increase in the fuel price elasticity of 9-Euro Ticket buyers and 0.22 is the share of 9-Euro Ticket buyers in our sample (when excluding those who had a prior ticket subscription, as we hold the price elasticity for this group constant). These formulas ensure that the weighted average of these two elasticities $(0.22 \times \varepsilon_{buyers} + (1 - 0.22) \times\ \varepsilon_{non-buyers})$ is equal to the average elasticity of -0.388 for all values of δ.

In this manner, Table A2 presents the results of our analysis under the assumption that the fuel price elasticity of 9-Euro Ticket buyers is about 10, 20, 30, 40, or 50 percent higher than the average elasticity of -0.388 (i.e. δ=0.1, 0.2, 0.3, 0.4, or 0.5), while the elasticity of non-purchasers is accordingly scaled down.

The results indicate that even if the fuel price elasticity of those who bought the 9-Euro Ticket is 50 percent larger than the average fuel price elasticity, the effect of the 9-Euro Ticket on car use increases only by 1.21 kilometers or around 8.5 percent (Column VI compared to Column I). Therefore, we conclude that the simultaneous fuel tax cut does not appreciably bias our estimated effects of the 9-Euro Ticket on car use.

Table A2: Effects of the 9-Euro Ticket on car use based on varying elasticities for ticket buyers

	I	II	III	IV	V	VI
δ	0	0.1	0.2	0.3	0.4	0.5
ε_{buyers} (see Eq. 2)	-0.388	-0.427	-0.466	-0.504	-0.543	-0.582
$\varepsilon_{non-buyers}$ (see Eq. 3)	-0.388	-0.377	-0.366	-0.355	-0.344	-0.333
Diff-in-diff Regression *(car km of last 7 days)*	-14.21 km	-14.45 km	-14.64 km	-14.86 km	-15.08 km	-15.30 km
Impact of fuel tax cut on treatment effect	n/a	0.24 km	0.43 km	0.65 km	0.87 km	1.09 km

6.6 Details on the analysis of the CO_2 reduction due to the 9-Euro Ticket

Table A3: Inputs for the estimates of CO_2 reduction and abatement costs

Variable	Value	Source
CO_2 per kilometer of car use	0.152 kg	German Environment Agency (2022)
CO_2 per additional kilometer of public transport use	We assume that due to the limited period in which the 9-Euro Ticket was available, only a few additional public transport services were offered, and existing services were predominantly used more extensively. We therefore assume a negligible increase in emissions of public transport. If the 9-Euro Ticket had led to an expansion of public transport services, this would further reduce the CO_2-reduction due to the ticket and thus increase abatement costs.	
Reduction in car use per week	Coefficient from the DiD Regression Main estimate: -16.4 km Conservative estimate when accounting for the fuel tax cut: Main estimate (-16.4 km) + Impact of fuel tax cut on treatment effect (-1.21 km) = 17.61 km	 Table 2 Column VI in Table A2
Ticket availability (weeks)	13 weeks (June 1 to August 31, 2022)	
Group size	Overall, 52,000,000 9-Euro Tickets have been sold. One 9-Euro Ticket is valid for one month, which means that the average number of tickets that were in use per month is 52,000,000 / 3 = 17,333,333. Moreover, there are roughly 10,000,000 ticket subscription holders in Germany, who also benefited from the introduction of the 9-Euro Ticket. Thus, we assume a group size of 27,333,333 9-Euro Ticket users per month.	VDV (2022)
Cost of the 9-Euro Ticket policy	€ 2,500,000,000	BReg (2022)

References

Anderson, M. L. (2014), Subways, strikes, and slowdowns: The impacts of public transit on traffic congestion. American Economic Review, 104(9), 2763-96.

Alberini, A., Horvath, M., & Vance, C. (2022), Drive less, drive better, or both? Behavioral adjustments to fuel price changes in Germany. Resource and Energy Economics, 68, 101292.

Börjesson, M., & Kristoffersson, I. (2018), The Swedish congestion charges: Ten years on. Transportation Research Part A: Policy and Practice, 107, 35-51.

[BReg] German Federal Government (2022) 9-Euro-Ticket 52 Millionen Mal verkauft. Fragen und Antworten. https://www.bundesregierung.de/breg-de/suche/faq-9-euro-ticket-2028756 (retrieved on November 2, 2022).

Cats, O., Susilo, Y.O., & Reimal, T. (2017), The prospects of fare-free public transport: Evidence from Tallinn. Transportation, 44(5), 1083–1104.

Cramton, P., Geddes, R. R., & Ockenfels, A. (2018), Set road charges in real time to ease traffic. Nature 560, 23-25.

De Borger, B., & Wouters, S. (1998), Transport externalities and optimal pricing and supply decisions in urban transportation: a simulation analysis for Belgium. Regional Science and Urban Economics, 28(2), 163-197.

[Deutschlandfunk] Thoms, K., & Nürnberger, D. (2022), ÖPNV: Bilanz und Zukunft des 9-Euro-Tickets. Deutschlandfunk. August 16, 2022. (retrieved on November 3, 2022).

[DW] Ünveren, B. (2022), Free public transport gains traction in Europe. Deutsche Welle (DW). May 5, 2022. https://www.dw.com/en/free-public-transport-in-europe/a-62031236 (retrieved on August 25, 2023).

[Destatis] Federal Statistical Office of Germany (2022), Kraftstoffpreise an öffentlichen Tankstellen. https://www.dashboard-deutschland.de/indicator/tile_1648135639982?origin=startpage (retrieved on November 22, 2022).

[Destatis] Federal Statistical Office of Germany (2023), Genesis-Online. https://www-genesis.destatis.de/genesis/online?operation=statistic&levelindex=0&levelid=1692782855982&code=12211#abreadcrumb, (retrieved on August 18, 2023).

Fournel, J. F. (2022), Electric Vehicle Subsidies: Cost-Effectiveness and Emission Reductions. Mimeo.

Gaus, D., Murray, N., & Link, H. (2023), 9-Euro-Ticket: Niedrigere Preise allein stärken Alltagsmobilität mit öffentlichen Verkehrsmitteln nicht. DIW Wochenbericht, 90(14/15), 163-171.

Gillingham, K., & Stock, J. H. (2018), The cost of reducing greenhouse gas emissions. Journal of Economic Perspectives, 32(4), 53-72.

Glaister, S. (1974), Generalised consumer surplus and public transport pricing. The Economic Journal, 84(336), 849-867.

Gravert, C., & Collentine, L. O. (2021), When nudges aren't enough: Norms, incentives and habit formation in public transport usage. Journal of Economic Behavior & Organization, 190, 1-14.

Heymann, E. (2021), Vorfahrt der E-Mobilität vom Staat teuer erkauft. Deutschland-Monitor. Deutsche Bank Research. August 5, 2021.

Hille, C., & Gather, M. (2022), „Das 9-Euro-Ticket hat mir gezeigt, dass man nicht alleine sein muss.“ Mit dem 9-Euro-Ticket zu mehr sozialer Teilhabe? Berichte des Instituts Verkehr und Raum, 29.

Hörcher, D., & Tirachini, A. (2021), A review of public transport economics. Economics of Transportation, 25, 100196.

Kębłowski, W. (2020), Why (not) abolish fares? Exploring the global geography of fare-free public transport. Transportation, 47(6), 2807-2835.

Kristal, A. S., & Whillans, A. V. (2020) What we can learn from five naturalistic field experiments that failed to shift commuter behaviour. Nature Human Behaviour, 4(2), 169-176.

Loder, A., Cantner, F., Adenaw, L., Nachtigall, N., Ziegler, D., Gotzler, et al. (2023) Germany's nationwide travel experiment in 2022: public transport for 9 Euro per month - First findings of an empirical study. arXiv preprint arXiv:2306.08297.

One Mobility Ticketing (2023) KlimaTicket Ö. Costs. https://www.klimaticket.at/en/#wieviel-kostet-das-klimaticket (retrieved on August 25, 2023).

Parry, I. W., & Small, K. A. (2009), Should urban transit subsidies be reduced? American Economic Review, 99(3), 700-724.

[Reuters] Trujillo M., & Thykjaer, C. (2022), Spain launches free rail travel passes to fight inflation. Reuters. August 31, 2022. https://www.reuters.com/world/europe/spain-launches-free-rail-travel-passes-fight-inflation-2022-08-31/ (retrieved on August 25, 2023).

RWI & Stiftung Mercator (2019), Weniger Staus, Staub und Gestank per sozial ausgewogener Städte-Maut: Gemeinsames Plädoyer initiiert von RWI-Leibniz-Institut für Wirtschaftsforschung und der Stiftung Mercator. RWI Positionen #74.

Storchmann, K.H. (2001), Nulltarife im öffentlichen Personennahverkehr – ein Paradigmenwechsel? Wirtschaftsdienst, 81(11), 651–657.

Tarriño-Ortiz, J., Gómez, J., Soria-Lara, J. A., & Vassallo, J. M. (2022), Analyzing the impact of Low Emission Zones on modal shift. Sustainable Cities and Society, 77, 103562.

[UBA] German Environment Agency (2022), Emissionsdaten. Last Update on September 9, 2022. https://www.umweltbundesamt.de/themen/verkehr-laerm/emissionsdaten#hbefa (retrieved on November 24, 2022).

[VDV] Association of German Transport Companies (2022), Bilanz eines Erfolgsmodells: Rund 52 Millionen verkaufte 9-Euro-Tickets. Berlin, August 29, 2022. https://www.vdv.de/220829-pm-bilanz-9-euro-ticket.pdfx (retrieved on November 2, 2022).

van Goeverden, C., Rietveld, P., Koelemeijer, J., & Peeters, P. (2006), Subsidies in public transport. European Transport, 32, 5–25.

Vickrey, W. S. (1963), Pricing in urban and suburban transport. American Economic Review, 53(2), 452-465.

[VM] Ministry of Transport of the State of North Rhine-Westphalia (2021), eezy.nrw kommt! [press release] https://www.land.nrw/pressemitteilung/eezynrw-kommt (retrieved on November 22, 2022).

Wiener Linien (2023). Home > Plan your trip > Tickets > Annual pass. https://www.wienerlinien.at/web/wl-en/annual-pass (retrieved on August 25, 2023).