Almost Fare Free: Impact of a Cheap Public Transport Ticket on Mobility Patterns and Infrastructure Quality

Mario Liebensteiner[1] **Jakob Losert**[2] Sarah Necker[1 3] Florian Neumeier[4] Jörg Paetzold[2 5] Sebastian Wichert[4]

Data Challenge: Mobile Phone Data

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[1]University of Erlangen–Nürnberg (FAU)
[2]University of Salzburg
[3]ifo Institute, Fürth
[4]ifo Institute, Munich
[5]Liechtenstein-Institut

The German 9-Euro Ticket: A unique policy experiment in public transport

In 2022, Germany reduced the monthly fare for all local & regional public transport to 9 EUR

- A number of (European) countries currently discuss or have introduced fare-free public transport (e.g. LUX, SP, FR)
- Knowledge about the effects of such ticket schemes is scarce:
  - Most cited 'real-world' fare-free program from Tallinn shows only modest increase in public transport use and limited mode choice changes (Cats et al. 2017)
  - RCTs on fare-free public transport find large(r) increases in public transport usage but effects on mode choice unclear (Bull et al. 2021; Brough et al. 2022)

⇒ Germany as the first large-area country to introduce (almost) fare-free public transport

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Genesis of the 9-Euro Ticket in Germany

- February 2022: Russian invasion of Ukraine - sharply rising energy prices
- May 2022: German government (SPD, FDP, Greens) decides to implement the 9-Euro Ticket to combat cost-of-living crisis
- June 2022: Start of the 9-Euro Ticket - monthly ticket for all local and regional public transport (train, bus, metro, etc.) for 9 EUR
- September 2022: End of the 9-Euro Ticket - 52 million tickets sold; 2.5 billion Euros in subsidies

⇒ **Examine the effect of the ticket on mobility behavior, mode choice, and infrastructure quality**

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The 9-Euro Ticket: Impact on Sylt

Punks camping on Sylt: A striking contrast brought by the 9-Euro-Ticket
Source: ZDF

The 9-Euro Ticket: Data

- GPS cellphone data (*Teralytics*): Measures hourly number of car/train trips between all German counties (incl. all trips > 30 km; approx. 10 million trips per day)
- Traffic volume monitoring stations (*BASt*): Hourly measure of traffic volume, allows differentiation by vehicle type such as cars, trucks, etc. (2,108 monitoring stations with approx. 60 million vehicles per day) ▸ Map
- Train delay data from Deutsche Bahn: Daily number/proportion of delayed trains per station (approx. 20,000 train connections per day)

Observation period: May-September 2019 & 2022 (due to Covid-19 & budget restrictions)

▸ Covid-19 Restrictions

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Event-Study Analysis

$$Y_{swy} = \eta_{sy} + \alpha_w + \sum_{w \neq x} \beta_w \cdot D^j_{w|y=2022} + \gamma \mathbf{X}_{swy} + \varepsilon_{swy} \quad (1)$$

- Y_{swy}: traffic volume measured at station s in week w of year y
- $D^j_{w|y=2022}$: dummy variables equal to 1 in week w of the year 2022 and 0 otherwise – omitted for the last week in May (reference week x) before the event date
- β_w: weekly deviations in traffic volume between 2022 and 2019 relative to the deviation measured for the reference week x
- η_{sy} (station-year FEs); α_w (week FEs); X' (temperature, precipitation, school holidays)

Percentage Effects (see Kleven et al. 2021):

$$p\%_w = \frac{\hat{\beta}_w}{E[\tilde{y}_w]} \quad (2)$$

- $\tilde{y}_w$: counterfactual outcome net contribution of event-study dummies

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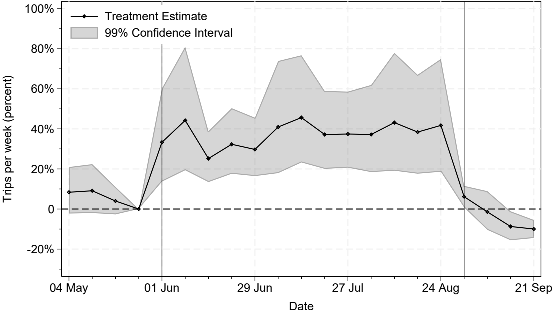
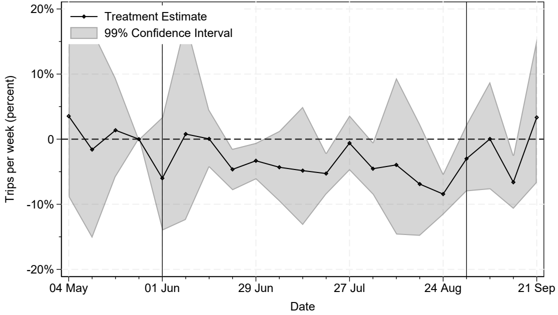
Train vs. Car Trips using Cell Phone-based Mobility Data

Event-Study



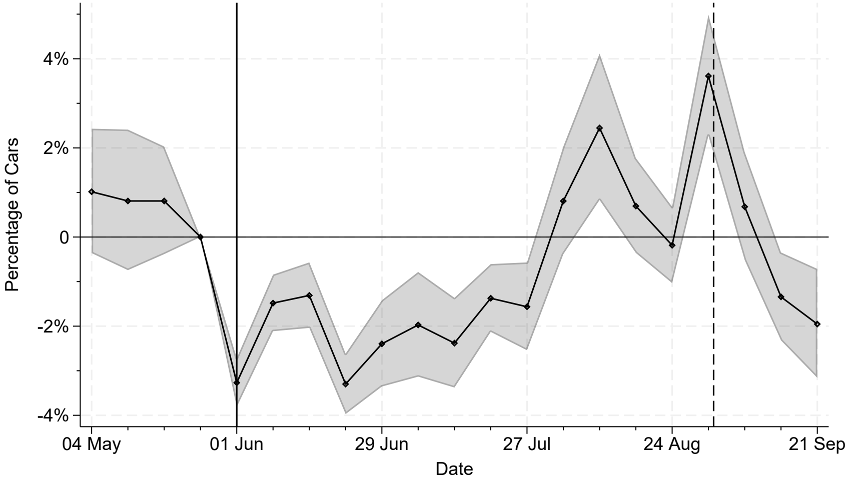
(a) Train trips 2022 vs. 2019



(b) Car trips 2022 vs. 2019

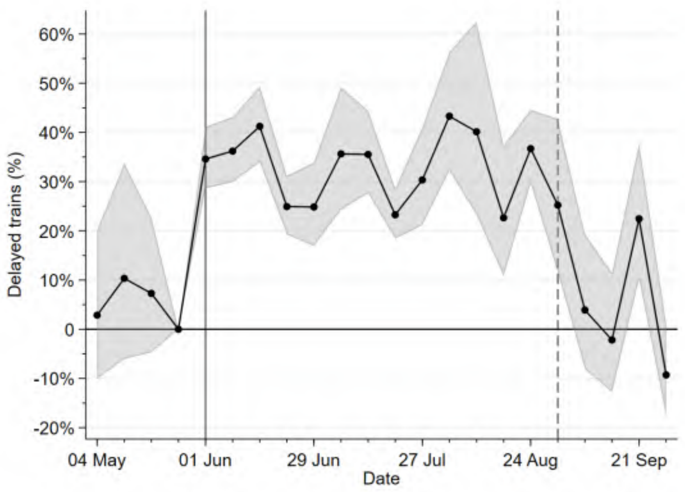
Results from Traffic Volume Data

Event Study



Results from Train Delay Data

Event Study

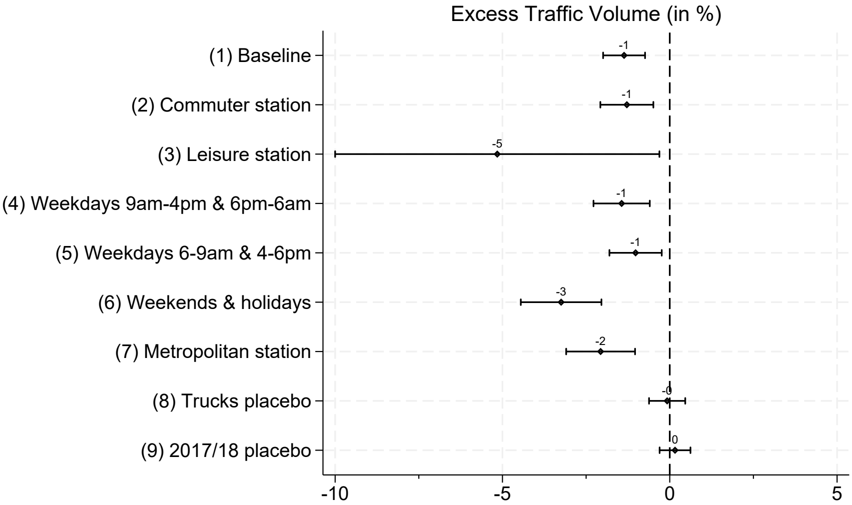


Difference-in-Difference Estimation of Overall Treatment Effect

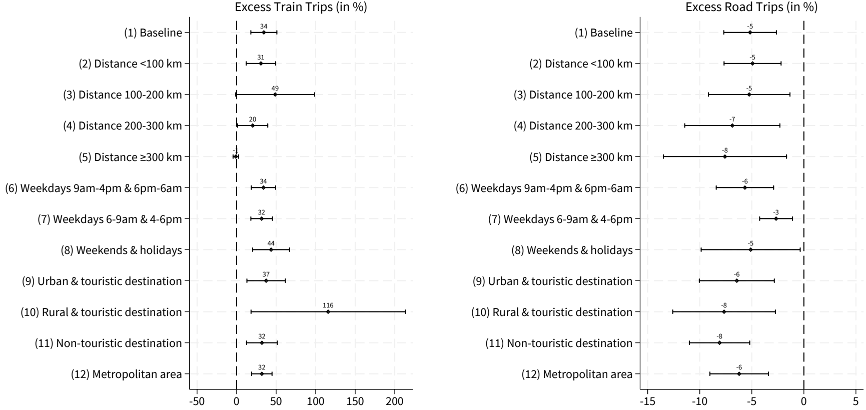
Table: Results from DiD Estimation

	(1) Train	(2) Car	(3) Traffic Volume	(4) Train delay
Treatment effect	122.461	-36.006	-5111.090	0.0423
	[64.112,180.809]	[-53.855,-18.157]	[-7458.816,-2763.365]	[0.032,0.053]
Treatment effect (in %)	34.465	-5.124	-1.365	29.90
Counterfactual	355.319	702.650	374424.957	0.14

Heterogeneity: Traffic Volume Data



Heterogeneity: Cell Phone-based Mobility Data



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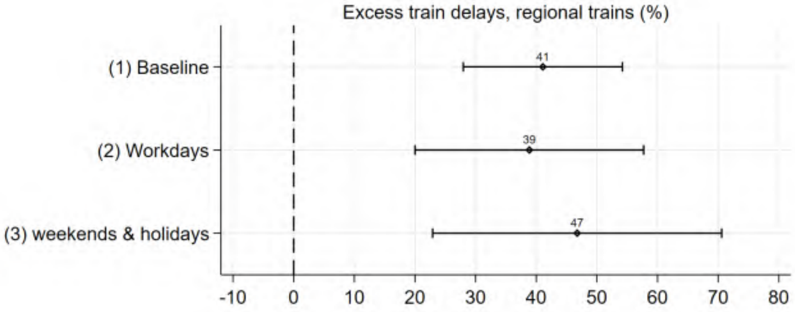

Summary

In 2022, Germany became the first large-area country to introduce fare-free public transport

- Car traffic decreased by ca. 1-5% while public transport trips increased by ca. 35%

  $\Rightarrow$ Suggests large increase in overall mobility

  $\Rightarrow$ Suggests only little substitution between individual and public transport

- Especially leisure train trips increased substantially
- Commuter car trips decreased the least
- Quality of public transport decreased significantly (ca. 30% increase in delays)

$\Rightarrow$ Calls for some caution regarding environmental benefits of fare-free 'go-anywhere' public transport tickets
(Andor et al. estimate abatement cost of 9-Euro Ticket of €2,800 per t/CO^2)

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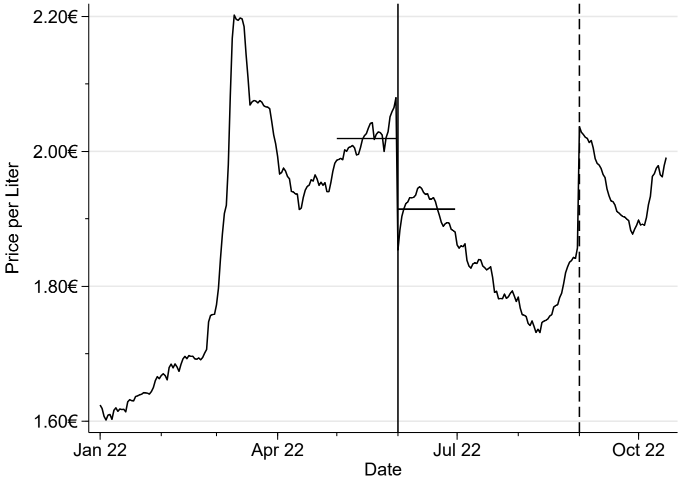
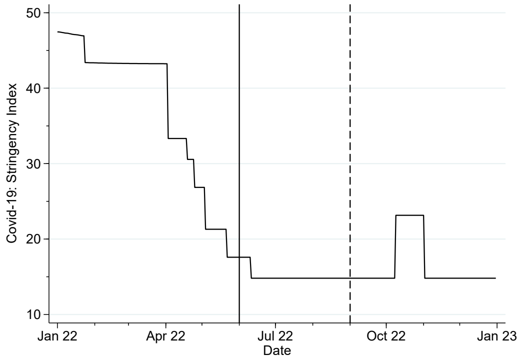
Thanks for listening!

Appendix: Fuel prices 2022



◂ Return

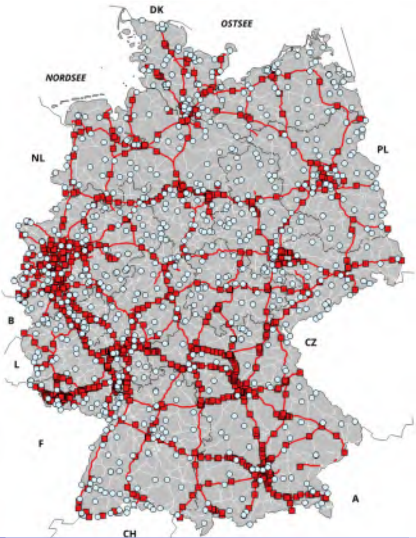
Appendix: Covid-19 Restrictions in Germany



Return

Appendix: Traffic Volume Monitoring Stations

Return



Appendix: Summary Statistics - GPS-based Mobility Data

Table: Summary Statistics – GPS-based Mobility Data

	Train trips			Car trips		
	Year 2019	Year 2022	Total	Year 2019	Year 2022	Total
Observations	1,972,951	1,652,412	3,625,363	4,032,897	3,806,539	7,839,436
Mean	115.6	126.2	120.4	455.5	389.9	423.6
Std. Dev.	963.2	887.0	929.3	2584.3	2179.3	2396.4

Difference-in-Difference Estimation

$$Y_{swy} = \eta_{sy} + \alpha_w + \beta_{treat} \cdot D_{treat} + \beta_{post} \cdot D_{post} + \gamma \mathbf{X}_{swy} + \varepsilon_{swy} \tag{3}$$

- Y_{swy}: traffic volume measured at station s in week w of year y
- $\eta_{s,y}$: station-year-fixed effects
- α_w: week-fixed effects
- D_{treat}: dummies indicating treatment period (June-August 2022)
- D_{post}: dummies indicating post treatment period (September 2022)
- X_{swy}: matrix of covariates (temperature, precipitation, school holidays)
- ε_{swy}: Standard errors clustered at station level. Regression weighted by traffic volume

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Appendix: Potential Effect of the "Tankrabatt" on Estimation Results

Solving for the hypothetical number of car trips without "Tankrabatt" $\Delta y_{\text{no tr}}$ and elasticity $e = -0.2$ (Frondel et al. 2021):

$$\Delta y_{\text{no tr}} = \Delta y_{\text{with tr}} \cdot [1 + (1 - \frac{p_{\text{with tr}}}{p_{\text{no tr}}}) \cdot e] \tag{4}$$

Table: Counterfactual excluding 'Tankrabatt'

	Car use (elasticity)				Train use (cross elasticity)	
	GPS mobility data		Traffic volume data		GPS mobility data	
	Level	Percent	Level	Percent	Level	Percent
Main estimate	-36.006	-5.124	-5111.090	-1.365	122.461	34.465
Corrected estimate	-36.864	-5.246	-5233.664	-1.397	123.899	35.870
Change in %	-2.4	-2.4	-2.4	-2.4	1.2	1.2