# Spatial Competition and Pass-Through of Fuel Taxes - Evidence from a quasi-natural Experiment in Germany

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This appendix provides comprehensive supplementary material to support the main analysis. It includes a detailed documentation of data construction procedures, extended descriptive statistics, and additional empirical results that reinforce the robustness of the findings. Specifically, Appendix A elaborates on data processing steps and presents visualizations of the spatial distribution of roadside fuel stations, intraday pricing patterns, alternative market delineations, and spatial competition metrics. It also reports supplementary regression results from robustness and sensitivity analyses employing alternative model specifications. Appendix B presents corresponding regression estimates for Super E10 fuel, while Appendix C contains average pass-through estimates for highway service stations.

# A Appendix

*Price Data* – The study employs a comprehensive dataset of historical fuel price changes provided by Tankerkönig (2023), an authorized consumer information service with real-time access to the Market Transparency Unit's (MTU) database. To ensure continuous price coverage for our analysis, hourly average prices are computed for each station by weighing all price fluctuations within an hour according to the time elapsed between consecutive price changes. In instances where no price change occurs within a given hour, the most recent price is carried forward to reflect the current price level. To ensure that the observed prices align with actual market activity, we take gasoline station operating hours into consideration. Opening times are primarily sourced from the Tankerkönig (2023) dataset, which is based on mandatory reports from gasoline stations. To address missing information, additional data from OpenStreetMap (OSM, 2024) is incorporated through a matching process based on geo-location and brand consistency. For roadside stations lacking valid opening hours from both sources, we assume 03:00 to 24:00 and 05:00 to 24:00 based on common business practices during the week and on the weekend, respectively. In the case of highway stations, we assume 24/7 opening times when no opening time data is available. Only price records corresponding to hours during which a gasoline station is open are retained, ensuring that the dataset accurately reflects fuel price dynamics during active market transactions.

*Station Data* – Fuel stations were geolocated using the geographic coordinates and address data provided by Tankerkönig (2023). As part of an extensive data cleaning process, implausible or inaccurate coordinates were corrected using a forward geocoding procedure via the OpenCage API (Zeigermann, 2018). Station locations were then validated against their corresponding addresses and assessed for proximity to highways, allowing for classification into either highway or roadside stations. Furthermore, brand affiliations were standardized by

accounting for variations in spelling and common misspellings to ensure consistency across the dataset.

*Weather Data* – To account for the impact of weather conditions on retail prices we utilize a comprehensive dataset of hourly temperature and precipitation measures obtained from the Climate Data Centre operated by the German Weather Service (DWD, 2022). The dataset comprises records from 5,558 temperature stations and 493 precipitation stations, continuously collected throughout the year 2022. These measurements are georeferenced to their respective counties using a spatial join (i.e., a point-in-polygon operation) (Picard, 2015). Subsequently, the raw data are aggregated into daily averages at the NUTS-3 level. To address instances of missing observations, we implement an imputation algorithm that assigns valid measurements from the nearest available weather station for each single day, based on the geodetic distance between the county's geographic center and surrounding stations (Picard, 2019). Finally, each gasoline station is linked to the weather data of its corresponding county.

*Traffic Volume Data* – We incorporate hourly traffic volume data from a network comprising 2,114 traffic counting stations managed by the Federal Highway Research Institute (BASt, 2022). Traffic volumes of federal roads are aggregated at the county level, while highway traffic volumes are averaged at the state level. This distinction reflects the functional differences between these road types: federal roads facilitate inter-regional traffic, whereas highways are designed exclusively for high-speed travel and do not uniformly cover all counties. Missing data points are imputed using the same nearest-station algorithm described above, ensuring that each NUTS classification receives data corresponding to the categorization as either a federal road or highway station. Finally, we merge aggregates for federal roads and highways to roadside and highway gasoline stations, respectively.

# Appendix References

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Picard, R. (2015) 'GEOINPOLY: Stata module to match geographic locations to shapefile polygons.'

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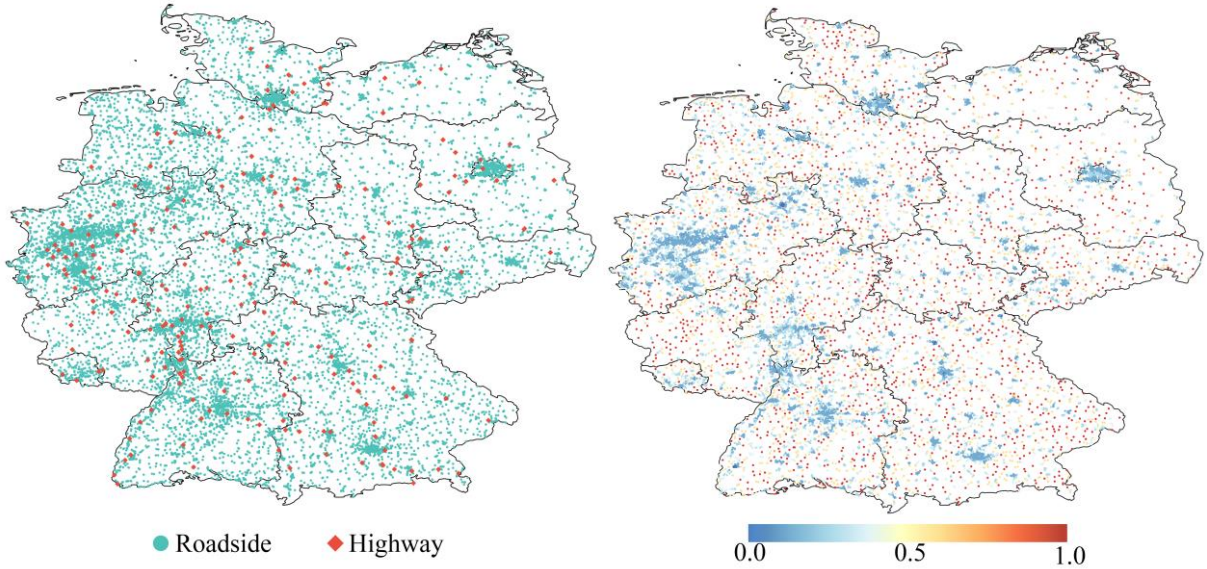
Zeigermann, L. (2018) 'OPENCAGEGEO: Stata module for forward and reverse geocoding using the OpenCage Geocoder API.'

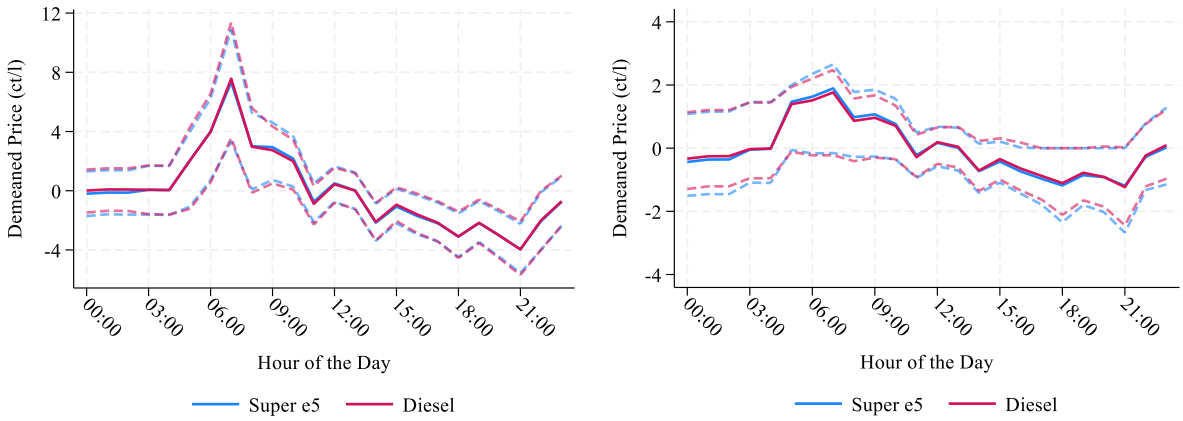
*Figure A.1:* Observed Gas Stations across Germany 2022




(a) Roadside and Highway Stations (a) Herfindahl-Hirschman-Index (4 km)

*Note:* Visual representation of (a) all roadside and highway stations and (b) Herfindahl-Hirschman-Index (HHI) of roadside stations during the months of May and June. The HHI is based on a 4-kilometer market delineation.

*Figure A.2:* Intra-Day Price Cycles




(b) Roadside Stations (b) Highway Stations

*Note:* Visual representation of intra-day price cycles of (a) roadside and (b) highway stations. The solid lines denote average hourly deviation of daily mean prices during the months of May to September. The differences between the upper and lower dashed lines represent the interquartile range.

*Table A.1:* Spatial Competition between Roadside Stations in Germany 2022

| | Full Sample | | Region Type | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Urban | | Intermediate | | Rural | |
| *3km Radius* | | | | | | | | |
| Brand Count | 4.24 | [ 4.23 ] | 5.74 | [ 5.70 ] | 3.74 | [ 3.74 ] | 2.92 | [ 2.89 ] |
| | (2.74) | [(2.72)] | (2.74) | [(2.72)] | (2.54) | [(2.54)] | (1.96) | [(1.93)] |
| Competitor Count | 4.25 | [ 4.21 ] | 6.85 | [ 6.77 ] | 3.33 | [ 3.32 ] | 2.10 | [ 2.06 ] |
| | (4.27) | [(4.22)] | (4.85) | [(4.76)] | (3.53) | [(3.54)] | (2.24) | [(2.20)] |
| HHI | 0.41 | [ 0.41 ] | 0.28 | [ 0.28 ] | 0.45 | [ 0.45 ] | 0.53 | [ 0.54 ] |
| | (0.30) | [(0.30)] | (0.21) | [(0.21)] | (0.30) | [(0.30)] | (0.32) | [(0.32)] |
| *5km Radius* | | | | | | | | |
| Brand Count | 6.41 | [ 6.38 ] | 9.20 | [ 9.13 ] | 5.53 | [ 5.53 ] | 3.86 | [ 3.83 ] |
| | (3.94) | [(3.93)] | (3.63) | [(3.63)] | (3.50) | [(3.51)] | (2.41) | [(2.39)] |
| Competitor Count | 9.05 | [ 8.96 ] | 16.32 | [ 16.13 ] | 6.35 | [ 6.33 ] | 3.28 | [ 3.23 ] |
| | (9.20) | [(9.10)] | (10.56) | [(10.42)] | (6.15) | [(6.17)] | (2.96) | [(2.92)] |
| HHI | 0.29 | [ 0.29 ] | 0.19 | [ 0.19 ] | 0.32 | [ 0.32 ] | 0.41 | [ 0.41 ] |
| | (0.24) | [(0.29)] | (0.13) | [(0.13)] | (0.24) | [(0.24)] | (0.28) | [(0.28)] |
| Observations | 14,257 | [14,200] | 4,791 | [4,765] | 6,451 | [6,429] | 3,015 | [3,006] |

*Note:* Average values for various measures of spatial competition during May and June. Values for August and September are included in squared brackets. Standard errors are in parentheses.

*Table A.2:* Tax Pass-Through – Tax Reduction (Omitted Hourly FE)

| | | Time Window | | | |
|---|---|---|---|---|---|
| | Full Sample | 5am - 11am | 11am - 5pm | 5pm - 11pm | 11pm - 5am |
| | (1) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | |
| TR | -27.34*** | -28.57*** | -27.30*** | -25.33*** | -27.21*** |
| | (0.03) | (0.04) | (0.03) | (0.04) | (0.07) |
| Constant | 13.14*** | 15.65*** | 12.14*** | 11.39*** | 13.14*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.04) |
| Observations | 5,489,722 | 1,498,836 | 2,011,836 | 1,637,812 | 341,238 |
| *Super E10* | | | | | |
| TR | -27.38*** | -28.63*** | -27.34*** | -25.36*** | -27.24*** |
| | (0.03) | (0.04) | (0.03) | (0.04) | (0.07) |
| Constant | 13.14*** | 15.68*** | 12.13*** | 11.39*** | 13.16*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.04) |
| Observations | 5,297,838 | 1,443,877 | 1,943,789 | 1,582,427 | 327,745 |
| *Diesel* | | | | | |
| TR | -13.11*** | -15.12*** | -12.76*** | -10.23*** | -10.93*** |
| | (0.03) | (0.03) | (0.03) | (0.03) | (0.05) |
| Constant | -0.51*** | 4.48*** | -2.35*** | -3.97*** | -1.74*** |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.04) |
| Observations | 5,605,432 | 1,532,743 | 2,048,726 | 1,672,449 | 351,514 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Average and conditional pass-through estimates for specific daily time periods. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as weekday and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Table A.3:* Tax Pass-Through – Tax Increase (Omitted Hourly FE)

| | | Time Window | | | |
|---|---|---|---|---|---|
| | Full Sample | 5am - 11am | 11am - 5pm | 5pm - 11pm | 11pm - 5am |
| | (1) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | |
| TR | 24.51*** | 26.78*** | 23.93*** | 24.34*** | 26.15*** |
| | (0.05) | (0.05) | (0.05) | (0.06) | (0.11) |
| Constant | -6.41*** | -4.19*** | -6.93*** | -8.37*** | -8.31*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.05) |
| Observations | 5,352,625 | 1,516,968 | 2,035,457 | 1,657,091 | 343,969 |
| *Super E10* | | | | | |
| TR | 24.41*** | 26.70*** | 23.82*** | 24.22*** | 26.09*** |
| | (0.05) | (0.05) | (0.05) | (0.06) | (0.11) |
| Constant | -6.23*** | -3.99*** | -6.76*** | -8.19*** | -8.18*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.05) |
| Observations | 5,352,625 | 1,459,571 | 1,964,373 | 1,599,373 | 329,308 |
| *Diesel* | | | | | |
| TR | 8.36*** | 9.55*** | 8.07*** | 8.06*** | 8.91*** |
| | (0.03) | (0.03) | (0.03) | (0.04) | (0.07) |
| Constant | 5.52*** | 6.35*** | 5.30*** | 4.95*** | 4.36*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.04) |
| Observations | 5,670,471 | 1,551,300 | 2,072,832 | 1,692,139 | 354,200 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Average and conditional pass-through estimates for specific daily time periods. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as weekday and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Table A.4:* Robustness - Tax Reduction

| Bandwidth | 10 days | 12 days | 14 days | | | 16 days |
|---|---|---|---|---|---|---|
| Donut | 9 hours | 9 hours | 0 hours | 9 hours | 18 hours | 9 hours |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | | |
| TR | -27.43*** | -27.24*** | -27.01*** | -26.84*** | -26.36*** | -26.05*** |
| | (0.02) | (0.02) | (0.03) | (0.03) | (0.04) | (0.04) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 11.91*** | 12.53*** | 13.20*** | 12.78*** | 12.69*** | 12.43*** |
| | (0.03) | (0.03) | (0.02) | (0.02) | (0.03) | (0.02) |
| Observations | 3,895,232 | 4,665,649 | 5,614,951 | 5,489,722 | 5,266,268 | 6,307,555 |
| Adjusted $R^2$ | 0.820 | 0.806 | 0.790 | 0.800 | 0.784 | 0.794 |
| *Super E10* | | | | | | |
| TR | -27.49*** | -27.29*** | -27.10*** | -26.88*** | -26.38*** | -26.08*** |
| | (0.02) | (0.03) | (0.03) | (0.03) | (0.04) | (0.04) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 11.92*** | 12.53*** | 13.21*** | 12.78*** | 12.69*** | 12.43*** |
| | (0.03) | (0.03) | (0.02) | (0.02) | (0.03) | (0.02) |
| Observations | 3,758,599 | 4,502,731 | 5,418,252 | 5,297,838 | 5,082,575 | 6,086,944 |
| Adjusted $R^2$ | 0.821 | 0.808 | 0.792 | 0.801 | 0.784 | 0.795 |
| *Diesel* | | | | | | |
| TR | -13.09*** | -12.71*** | -13.06*** | -12.52*** | -10.85*** | -12.31*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.03) | (0.03) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | -0.96*** | -0.98*** | -0.53*** | -0.89*** | -1.57*** | -0.99*** |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| Observations | 3,977,444 | 4,763,780 | 5,733,715 | 5,605,432 | 5,377,625 | 6,440,629 |
| Adjusted $R^2$ | 0.403 | 0.391 | 0.423 | 0.401 | 0.331 | 0.424 |

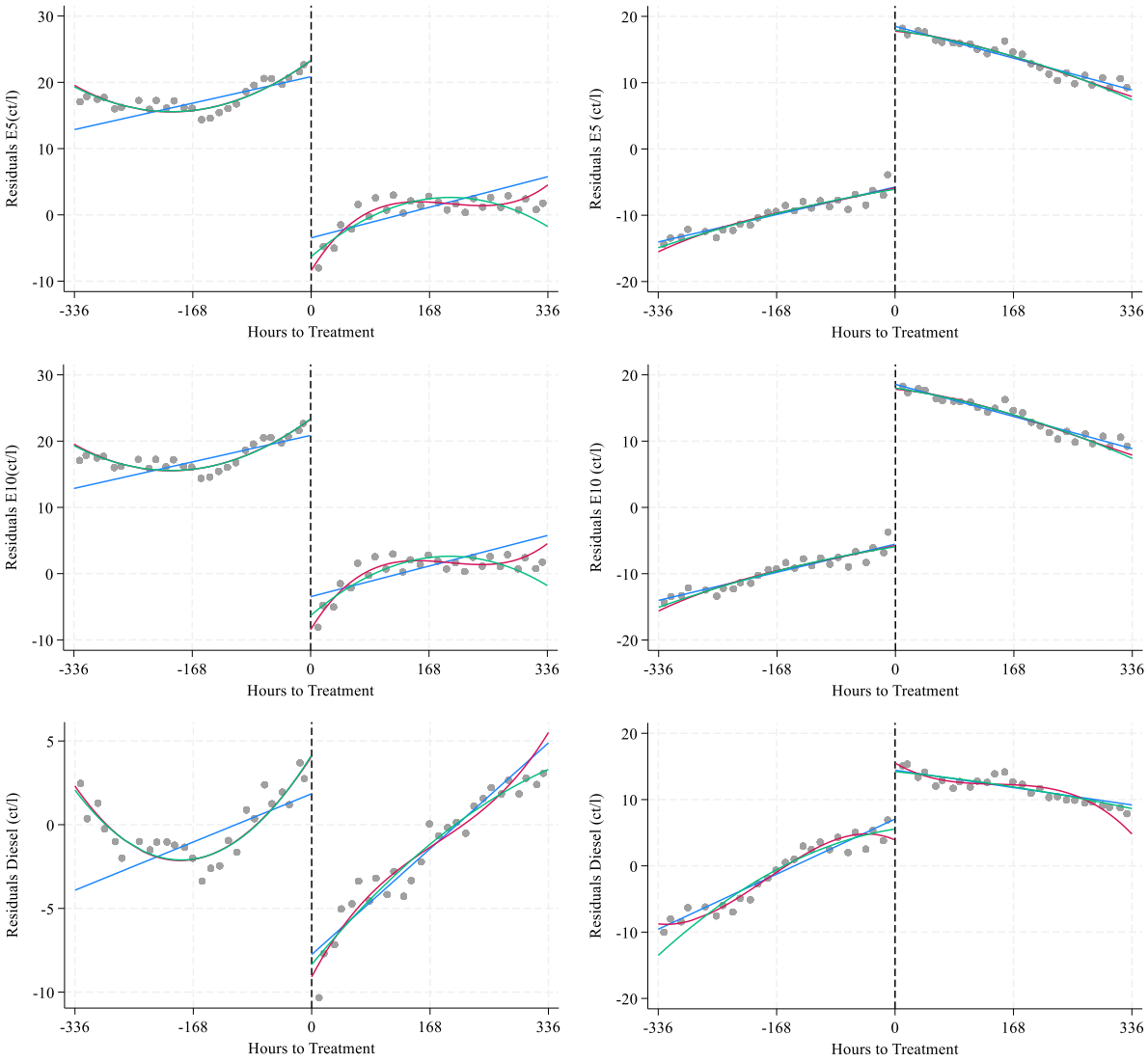
*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Pass-through estimates for alternate bandwidth and donut sizes. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Table A.5:* Robustness - Tax Increase

| Bandwidth | 10 days | 12 days | 14 days | | | 16 days |
|---|---|---|---|---|---|---|
| Donut | 9 hours | 9 hours | 0 hours | 9 hours | 18 hours | 9 hours |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | | |
| TR | 22.98*** | 24.32*** | 23.93*** | 25.13*** | 26.62*** | 25.05*** |
| | (0.03) | (0.04) | (0.05) | (0.05) | (0.06) | (0.04) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | -5.61*** | -6.56*** | -5.77*** | -6.72*** | -7.48*** | -6.35*** |
| | (0.02) | (0.03) | (0.02) | (0.02) | (0.03) | (0.03) |
| Observations | 3,955,455 | 4,704,683 | 5,679,521 | 5,553,485 | 5,329,393 | 6,401,964 |
| Adjusted $R^2$ | 0.702 | 0.695 | 0.683 | 0.692 | 0.690 | 0.690 |
| *Super E10* | | | | | | |
| TR | 22.90*** | 24.24*** | 23.88*** | 25.03*** | 26.52*** | 24.93*** |
| | (0.03) | (0.04) | (0.04) | (0.05) | (0.06) | (0.04) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | -5.46*** | -6.40*** | -5.61*** | -6.54*** | -7.29*** | -6.15*** |
| | (0.02) | (0.03) | (0.02) | (0.02) | (0.03) | (0.03) |
| Observations | 3,811,176 | 4,535,245 | 5,473,745 | 5,352,625 | 5136869 | 6169601 |
| Adjusted $R^2$ | 0.697 | 0.691 | 0.680 | 0.688 | 0.686 | 0.687 |
| *Diesel* | | | | | | |
| TR | 9.82*** | 9.60*** | 8.02*** | 8.83*** | 8.50*** | 7.76*** |
| | (0.02) | (0.02) | (0.03) | (0.03) | (0.04) | (0.03) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 4.45*** | 4.52*** | 5.98*** | 5.25*** | 5.30*** | 5.92*** |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.03) | (0.02) |
| Observations | 4,038,793 | 4,803,165 | 5,799,516 | 5,670,471 | 5,442,129 | 6,537,377 |
| Adjusted $R^2$ | 0.314 | 0.355 | 0.382 | 0.389 | 0.384 | 0.422 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Pass-through estimates for alternate bandwidth and donut sizes. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Figure A.3:* RDiT Plot– Alternative Polynomials




(a) Tax Reduction (b) Tax Increase

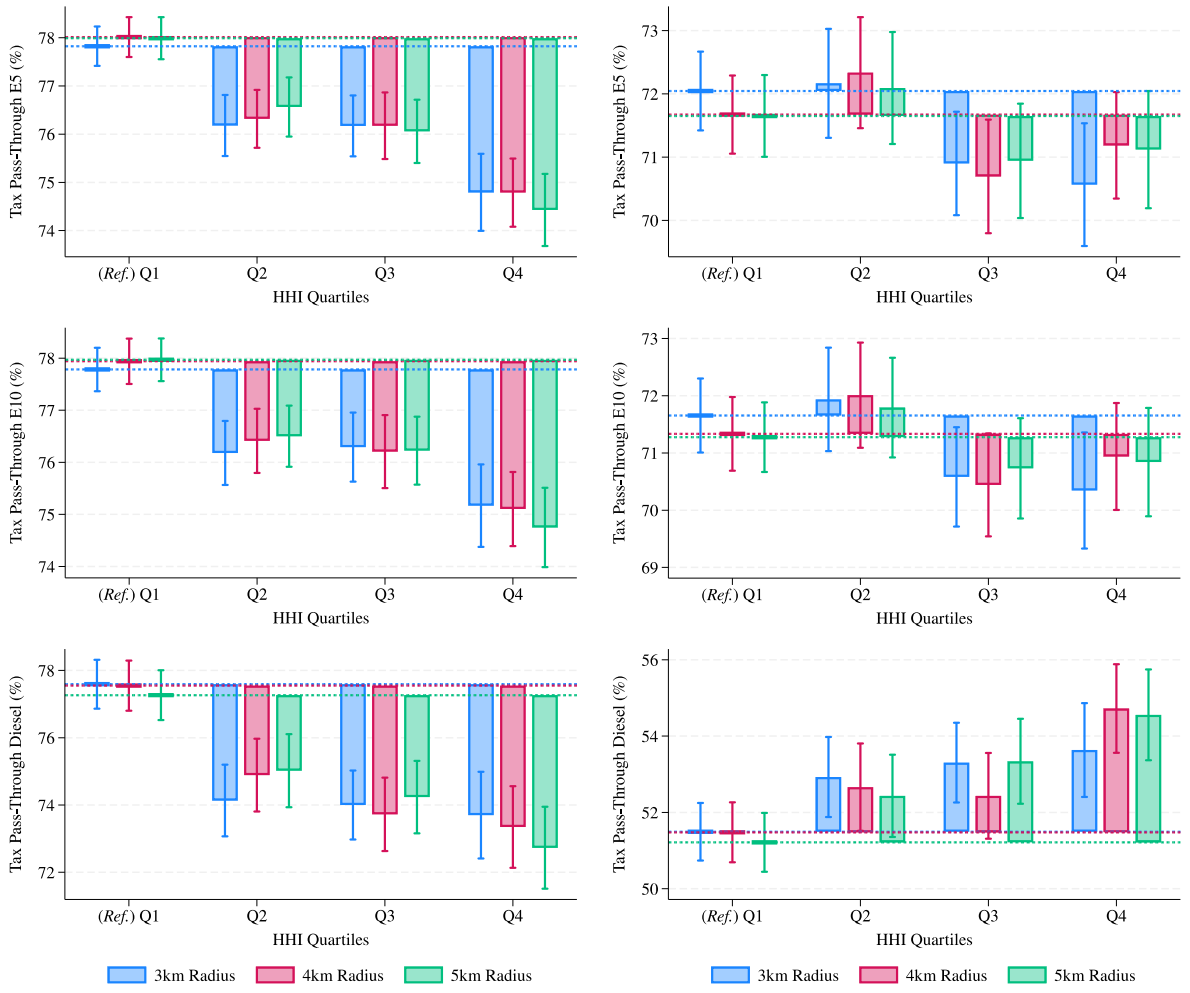
*Note:* Alternate polynomial time trends for the (a) tax reduction and (b) tax increase. The blue, green, and red lines represent a first, second, and third order polynomial for the pre- and post-tax change period of 336 hours, respectively. Each point represents average residuals within equally spaced bins across roadside stations, accounting for hour of day and weekday fixed effects.

*Table A.6:* Pass-Through of the German Fuel Discount by selected Brand Affiliation

| | Tax Reduction | | | Tax Increase | | |
|---|---|---|---|---|---|---|
| | Super E5 | Super E10 | Diesel | Super E5 | Super E10 | Diesel |
| *Oligopolistic* | | | | | | |
| ARAL | -26.92*** | -26.93*** | -12.79*** | 25.81*** | 25.81*** | 9.53*** |
| | (0.07) | (0.07) | (0.06) | (0.12) | (0.12) | (0.07) |
| | [76.6%] | [76.6%] | [76.5%] | [73.4%] | [73.4%] | [57.0%] |
| SHELL | -27.21*** | -27.22*** | -11.85*** | 26.24*** | 26.22*** | 9.02*** |
| | (0.07) | (0.07) | (0.06) | (0.14) | (0.14) | (0.08) |
| | [77.4%] | [77.4%] | [70.9%] | [74.6%] | [74.6%] | [54.0%] |
| TOTAL Energies | -27.34*** | -27.33*** | -13.14*** | 26.58*** | 26.57*** | 10.47*** |
| | (0.10) | (0.11) | (0.10) | (0.20) | (0.20) | (0.12) |
| | [77.8%] | [77.7%] | [78.6%] | [75.6%] | [75.6%] | [62.7%] |
| *Other Vertically Integrated* | | | | | | |
| ESSO | -26.91*** | -26.90*** | -12.48*** | 24.08*** | 22.56*** | 7.06*** |
| | (0.10) | (0.11) | (0.10) | (0.18) | (0.19) | (0.14) |
| | [76.5%] | [76.5%] | [74.7%] | [68.5%] | [64.2%] | [42.3%] |
| JET | -26.00*** | -26.01*** | -11.89*** | 24.36*** | 24.36*** | 8.34*** |
| | (0.12) | (0.12) | (0.11) | (0.23) | (0.25) | (0.14) |
| | [73.9%] | [74.0%] | [71.2%] | [69.3%] | [69.3%] | [49.9%] |
| *Independent* | | | | | | |
| BFT | -26.79*** | -26.86*** | -12.94*** | 23.97*** | 23.73*** | 8.14*** |
| | (0.22) | (0.25) | (0.17) | (0.29) | (0.31) | (0.17) |
| | [76.2%] | [76.4%] | [77.4%] | [68.2%] | [67.5%] | [48.7%] |
| AVIA | -25.58*** | -25.52*** | -11.50*** | 22.66*** | 22.50*** | 7.82*** |
| | (0.18) | (0.19) | (0.13) | (0.24) | (0.25) | (0.15) |
| | [72.8%] | [72.6%] | [68.8%] | [64.4%] | [64.0%] | [46.8%] |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
RDiT estimates indicate the effect of the tax intervention on retail prices in cents per liter. Average Pass-Through in squared brackets is given by $\hat{\rho} = 100 \times \widehat{\beta^{RD}} / \Delta tax$. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Figure A.4:* Tax Pass-Through (%) by HHI over Market Boundaries




(a) Tax Reduction (b) Tax Increase

*Note:* Heterogeneous pass-through levels for E5 and Diesel of the tax (a) reduction and (b) subsequent increase by market concentration quartiles over alternative market delineations. Each bar indicates the pass-through difference $\Delta\hat{\rho}_{HHI_Q} = 100 \times \widehat{\beta_{HHI_Q}}/\Delta tax$ with 95% confidence intervals relative to the bottom HHI quartile. Analogous regression results are presented in table A.7.

*Table A.7:* Heterogeneous Pass-Through across Alternative Market Delineations

| | Tax Reduction | | | Tax Increase | | |
|---|---|---|---|---|---|---|
| | 3 km | 4 km | 5 km | 3 km | 4 km | 5 km |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | | |
| TR | -27.36*** | -27.43*** | -27.42*** | 25.33*** | 25.20*** | 25.19*** |
| | (0.07) | (0.07) | (0.08) | (0.11) | (0.11) | (0.12) |
| TR × HHI $Q_2$ | 0.58*** | 0.60*** | 0.50*** | 0.04 | 0.23 | 0.16 |
| | (0.11) | (0.11) | (0.11) | (0.15) | (0.16) | (0.16) |
| TR × HHI $Q_3$ | 0.58*** | 0.65*** | 0.68*** | -0.40*** | -0.34** | -0.25 |
| | (0.11) | (0.12) | (0.12) | (0.15) | (0.16) | (0.16) |
| TR × HHI $Q_4$ | 1.07*** | 1.13*** | 1.25*** | -0.52*** | -0.17 | -0.19 |
| | (0.14) | (0.13) | (0.13) | (0.17) | (0.15) | (0.17) |
| Constant | 13.02*** | 13.08*** | 13.07*** | -6.71*** | -6.63*** | -6.52*** |
| | (0.04) | (0.04) | (0.04) | (0.06) | (0.06) | (0.06) |
| Observations | 5,489,722 | 5,489,722 | 5,489,722 | 5,553,485 | 5,553,485 | 5,553,485 |
| *Super E10* | | | | | | |
| TR | -27.35*** | -27.40*** | -27.41*** | 25.19*** | 25.08*** | 25.06*** |
| | (0.07) | (0.08) | (0.07) | (0.12) | (0.12) | (0.11) |
| TR × HHI $Q_2$ | 0.56*** | 0.54*** | 0.52*** | 0.10 | 0.24 | 0.18 |
| | (0.11) | (0.11) | (0.11) | (0.16) | (0.16) | (0.16) |
| TR × HHI $Q_3$ | 0.52*** | 0.61*** | 0.61*** | -0.38** | -0.31* | -0.19 |
| | (0.12) | (0.13) | (0.12) | (0.16) | (0.16) | (0.16) |
| TR × HHI $Q_4$ | 0.92*** | 1.00*** | 1.13*** | -0.46** | -0.14 | -0.15 |
| | (0.14) | (0.13) | (0.14) | (0.18) | (0.17) | (0.17) |
| Constant | 13.00*** | 13.06*** | 13.06*** | -6.56*** | -6.51*** | -6.38*** |
| | (0.04) | (0.04) | (0.04) | (0.06) | (0.06) | (0.06) |
| Observations | 5,297,838 | 5,297,838 | 5,297,838 | 5,352,625 | 5,352,625 | 5,352,625 |

*Table A.7. continued*

| | Tax Reduction | | | Tax Increase | | |
|---|---|---|---|---|---|---|
| | 3 km | 4 km | 5 km | 3 km | 4 km | 5 km |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Diesel* | | | | | | |
| TR | -12.97*** | -12.96*** | -12.91*** | 8.60*** | 8.60*** | 8.56*** |
| | (0.06) | (0.06) | (0.06) | (0.06) | (0.07) | (0.07) |
| TR × HHI $Q_2$ | 0.58*** | 0.44*** | 0.38*** | 0.24*** | 0.20** | 0.20** |
| | (0.09) | (0.09) | (0.09) | (0.09) | (0.10) | (0.09) |
| TR × HHI $Q_3$ | 0.60*** | 0.64*** | 0.51*** | 0.30*** | 0.16* | 0.35*** |
| | (0.09) | (0.09) | (0.09) | (0.09) | (0.10) | (0.09) |
| TR × HHI $Q_4$ | 0.65*** | 0.70*** | 0.76*** | 0.36*** | 0.54*** | 0.56*** |
| | (0.11) | (0.10) | (0.10) | (0.10) | (0.10) | (0.10) |
| Constant | -0.61*** | -0.59*** | -0.64*** | 5.16*** | 5.21*** | 5.33*** |
| | (0.04) | (0.05) | (0.05) | (0.05) | (0.05) | (0.05) |
| Observations | 5,605,432 | 5,605,432 | 5,605,432 | 5,670,471 | 5,670,471 | 5,670,471 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Heterogeneous pass-through estimates by market concentration quartiles over alternative market delineations. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Table A.8:* Heterogeneous Pass-Through by HHI over Vertical Integration

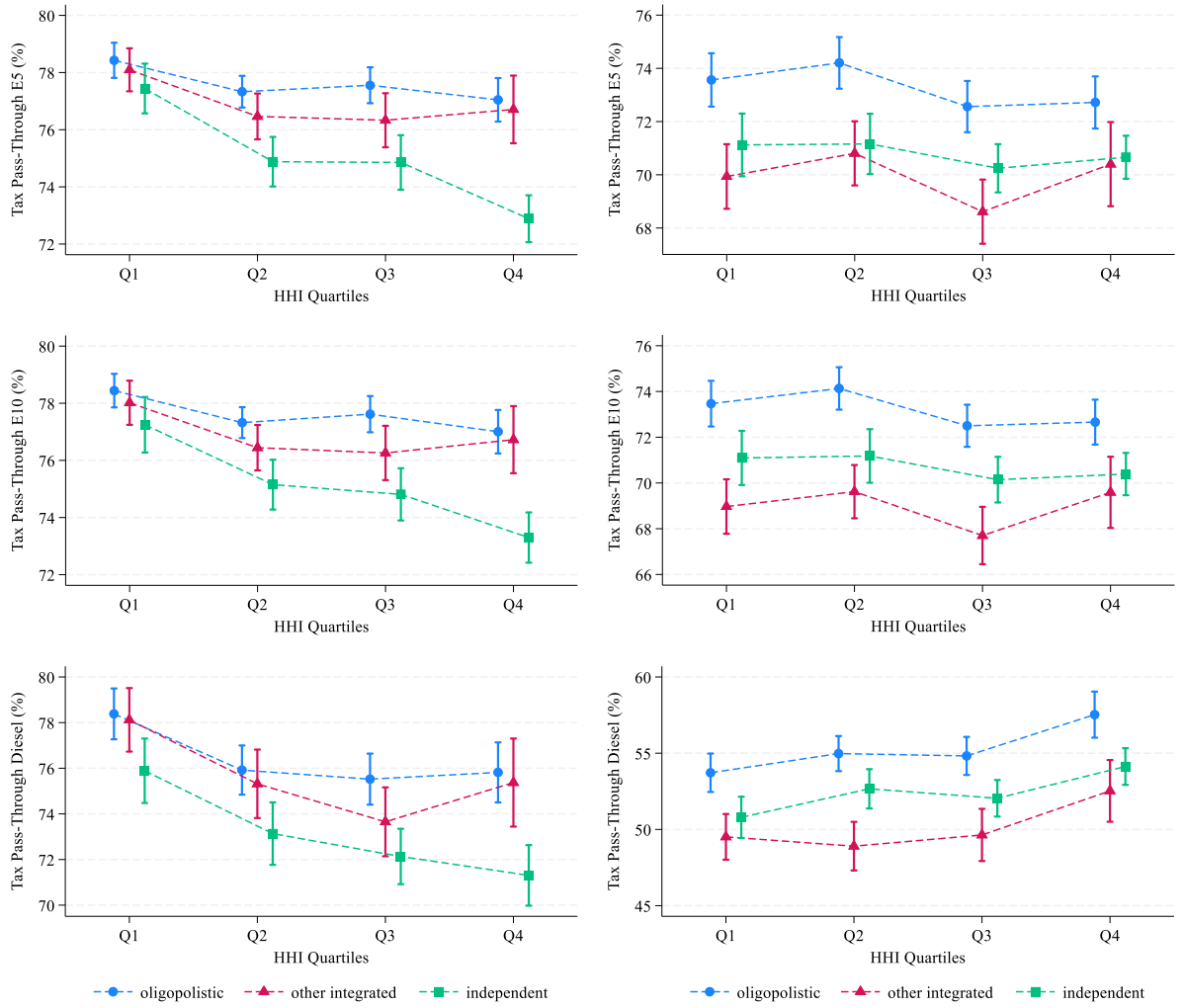
| | Tax Reduction | | | Tax Increase | | |
|---|---|---|---|---|---|---|
| | oligopol. | oth. int. | indep. | oligopol. | oth. int. | indep. |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | | |
| TR | -27.38*** | -27.50*** | -27.39*** | 26.18*** | 24.29*** | 24.92*** |
| | (0.10) | (0.13) | (0.15) | (0.18) | (0.21) | (0.20) |
| TR × HHI $Q_2$ | 0.38*** | 0.56*** | 0.92*** | 0.23 | 0.29 | 0.00 |
| | (0.15) | (0.20) | (0.22) | (0.25) | (0.32) | (0.29) |
| TR × HHI $Q_3$ | 0.28* | 0.62*** | 0.92*** | -0.35 | -0.48 | -0.33 |
| | (0.16) | (0.21) | (0.25) | (0.24) | (0.32) | (0.27) |
| TR × HHI $Q_4$ | 0.46*** | 0.49* | 1.60*** | -0.31 | 0.15 | -0.20 |
| | (0.18) | (0.26) | (0.22) | (0.26) | (0.35) | (0.26) |
| Constant | 13.01*** | 12.99*** | 13.18*** | -7.28*** | -6.46*** | -6.09*** |
| | (0.06) | (0.07) | (0.09) | (0.09) | (0.10) | (0.11) |
| Observations | 2,032,509 | 1,328,239 | 2,128,974 | 2,031,915 | 1,350,051 | 2,171,519 |

*Table A.8. continued*

| | Tax Reduction | | | Tax Increase | | |
|---|---|---|---|---|---|---|
| | oligopol. | oth. int. | indep. | oligopol. | oth. int. | indep. |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E10* | | | | | | |
| TR | -27.39*** | -27.47*** | -27.33*** | 26.17*** | 23.96*** | 24.88*** |
| | (0.11) | (0.14) | (0.16) | (0.18) | (0.21) | (0.21) |
| TR × HHI $Q_2$ | 0.39** | 0.54*** | 0.75*** | 0.24 | 0.22 | 0.02 |
| | (0.16) | (0.21) | (0.23) | (0.25) | (0.30) | (0.30) |
| TR × HHI $Q_3$ | 0.27 | 0.62*** | 0.86*** | -0.34 | -0.45 | -0.36 |
| | (0.17) | (0.23) | (0.23) | (0.25) | (0.31) | (0.27) |
| TR × HHI $Q_4$ | 0.48*** | 0.46* | 1.39*** | -0.30 | 0.21 | -0.29 |
| | (0.18) | (0.26) | (0.23) | (0.26) | (0.36) | (0.27) |
| Constant | 13.02*** | 12.97*** | 13.12*** | -7.32*** | -6.00*** | -6.07*** |
| | (0.06) | (0.07) | (0.09) | (0.09) | (0.11) | (0.11) |
| Observations | 2,017,091 | 1,315,624 | 1,965,123 | 2,012,190 | 1,338,688 | 2,001,747 |
| *Diesel* | | | | | | |
| TR | -12.80*** | -13.11*** | -12.92*** | 9.25*** | 7.95*** | 8.46*** |
| | (0.09) | (0.12) | (0.12) | (0.11) | (0.12) | (0.12) |
| TR × HHI $Q_2$ | 0.40*** | 0.47*** | 0.47*** | 0.22 | -0.11 | 0.30* |
| | (0.14) | (0.18) | (0.17) | (0.14) | (0.19) | (0.17) |
| TR × HHI $Q_3$ | 0.45*** | 0.76*** | 0.63*** | 0.19 | 0.01 | 0.20 |
| | (0.14) | (0.19) | (0.16) | (0.15) | (0.19) | (0.16) |
| TR × HHI $Q_4$ | 0.39** | 0.47** | 0.76*** | 0.64*** | 0.50** | 0.54*** |
| | (0.15) | (0.21) | (0.17) | (0.17) | (0.21) | (0.16) |
| Constant | -0.41*** | -0.58*** | -0.87*** | 4.36*** | 5.82*** | 5.56*** |
| | (0.07) | (0.08) | (0.09) | (0.08) | (0.09) | (0.09) |
| Observations | 2,032,750 | 1,328,246 | 2,244,436 | 2,032,344 | 1,350,050 | 2,288,077 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Heterogeneous pass-through estimates by market concentration quartiles over brand categories. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level. The HHI is based on a 4-kilometer market delineation.

*Figure A.5:* Tax Pass-Through (%) by HHI and Vertical Integration




(a) Tax Reduction (b) Tax Increase

*Note:* Heterogeneous pass-through rates during the (a) tax reduction and (b) subsequent tax increase, shown by market concentration quartiles and brand categories. Each point represents a pass-through estimate $\hat{\rho}_{kj} = 100 \times \widehat{\beta_{kj}}/\Delta tax$ for brand category $k$ and HHI quartile $j$, calculated as a linear combination of regression coefficients. The 95% confidence intervals are derived by the delta method. The HHI is based on a 4-kilometer market delineation. Corresponding regression results are reported in Tables A.9.

*Table A.9:* Heterogeneous Pass-Through by HHI and Vertical Integration

| | Tax Reduction | | | Tax Increase | | |
|---|---|---|---|---|---|---|
| | Super E5 | Super E10 | Diesel | Super E5 | Super E10 | Diesel |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| TR | -27.58*** | -27.58*** | -13.10*** | 25.87*** | 25.83*** | 8.98*** |
| | (0.11) | (0.11) | (0.09) | (0.18) | (0.18) | (0.11) |
| TR × oth. vert. int. | 0.12 | 0.15 | 0.04 | -1.28*** | -1.58*** | -0.70*** |
| | (0.18) | (0.17) | (0.16) | (0.29) | (0.27) | (0.17) |
| TR × indep. | 0.35* | 0.42** | 0.42*** | -0.86*** | -0.83*** | -0.49*** |
| | (0.20) | (0.21) | (0.15) | (0.28) | (0.28) | (0.16) |
| TR × HHI $Q_2$ | 0.39** | 0.39*** | 0.41*** | 0.23 | 0.23 | 0.21 |
| | (0.15) | (0.14) | (0.13) | (0.25) | (0.24) | (0.15) |
| TR × HHI $Q_3$ | 0.31* | 0.29* | 0.48*** | -0.35 | -0.34 | 0.18 |
| | (0.16) | (0.16) | (0.14) | (0.25) | (0.24) | (0.15) |
| TR × HHI $Q_4$ | 0.49*** | 0.51*** | 0.43*** | -0.30 | -0.28 | 0.64*** |
| | (0.18) | (0.17) | (0.15) | (0.26) | (0.26) | (0.17) |
| TR × oth. vert. int. × HHI $Q_2$ | 0.19 | 0.16 | 0.06 | 0.08 | -0.01 | -0.31 |
| | (0.25) | (0.24) | (0.22) | (0.41) | (0.38) | (0.24) |
| TR × oth. vert. int. × HHI $Q_3$ | 0.31 | 0.33 | 0.27 | -0.11 | -0.11 | -0.16 |
| | (0.26) | (0.27) | (0.23) | (0.39) | (0.40) | (0.25) |
| TR × oth. vert. int. × HHI $Q_4$ | 0.00 | -0.05 | 0.03 | 0.46 | 0.50 | -0.13 |
| | (0.31) | (0.31) | (0.26) | (0.45) | (0.43) | (0.28) |
| TR × indep. × HHI $Q_2$ | 0.51* | 0.34 | 0.05 | -0.21 | -0.20 | 0.10 |
| | (0.29) | (0.28) | (0.21) | (0.39) | (0.39) | (0.21) |
| TR × indep. × HHI $Q_3$ | 0.60** | 0.57* | 0.15 | 0.04 | 0.01 | 0.02 |
| | (0.28) | (0.29) | (0.21) | (0.37) | (0.37) | (0.21) |
| TR × indep. × HHI $Q_4$ | 1.12*** | 0.88*** | 0.34 | 0.13 | 0.04 | -0.08 |
| | (0.28) | (0.30) | (0.23) | (0.35) | (0.37) | (0.23) |
| Constant | 13.12*** | 13.11*** | -0.21*** | -7.25*** | -7.29*** | 4.35*** |
| | (0.06) | (0.06) | (0.07) | (0.10) | (0.10) | (0.09) |
| Observations | 5,489,722 | 5,297,838 | 5,605,432 | 5,553,485 | 5,352,625 | 5,670,471 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Heterogeneous pass-through estimates by market concentration quartiles and brand categories. Standard errors are derived by the delta method. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level. The HHI is based on a 4-kilometer market delineation.

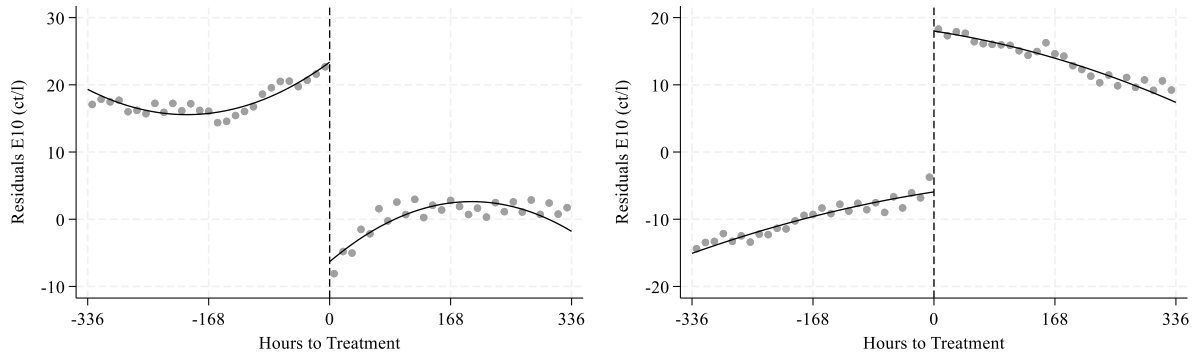
# B Appendix

*Table B.1:* Average Pass-Through of the German Fuel Discount - Super E10

| | Tax Reduction | | | | Tax Increase | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| TR ($\widehat{\beta_{RD}}$) | -29.70*** | -25.84*** | -28.06*** | -26.88*** | 23.94*** | 23.32*** | 25.60*** | 25.03*** |
| | (0.04) | (0.03) | (0.04) | (0.03) | (0.05) | (0.04) | (0.07) | (0.05) |
| Constant | 23.38*** | 14.55*** | 15.60*** | 12.78*** | -5.93*** | -6.20*** | -5.87*** | -6.54*** |
| | (0.02) | (0.02) | (0.03) | (0.02) | (0.03) | (0.02) | (0.05) | (0.02) |
| Seasonality | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Supply Shifter | | ✓ | | ✓ | | ✓ | | ✓ |
| Demand Shifter | | | ✓ | ✓ | | | ✓ | ✓ |
| TR ($\hat{\rho}$) | [84.5%] | [73.5%] | [79.8%] | [76.5%] | [68.1%] | [66.3%] | [72.8%] | [71.1%] |
| Observations | 5,738,903 | 5,545,793 | 5,448,532 | 5,297,838 | 5,786,799 | 5,603,801 | 5,493,507 | 5,352,625 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
RDiT estimates indicate the effect of the tax intervention on retail prices in cents per liter. Average Pass-Through in squared brackets is given by $\hat{\rho} = 100 \times \widehat{\beta^{RD}}/\Delta tax$. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Figure B.1:* RDiT Plot (E10) - Average Nationwide Effect of the Fuel Discount in Germany 2022




(a) Tax Reduction (b) Tax Increase

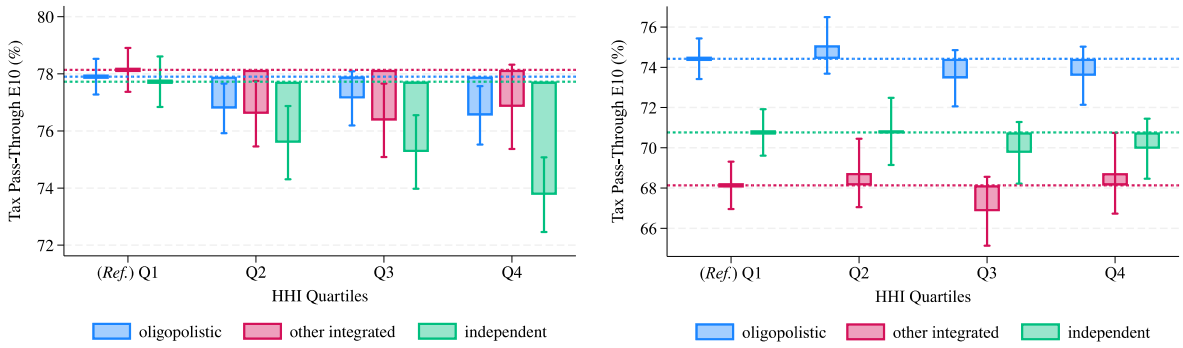
*Note:* Graphical representation of the RDiT during the (a) tax reduction and (b) tax increase. Each point represents average residuals within equally spaced bins across roadside stations, accounting for hour of day and weekday fixed effects. The solid line represents the quadratic time trend before and after the treatment, each for a period of 336 hours.

*Table B.2:* Heterogeneous Pass-Through of the German Fuel Discount - Super E10

| | Tax Reduction | | | | Tax Increase | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| TR | -27.30*** | -27.47*** | -27.01*** | -27.40*** | 25.76*** | 25.08*** | 25.12*** | 25.08*** |
| | (0.05) | (0.06) | (0.05) | (0.08) | (0.09) | (0.09) | (0.08) | (0.12) |
| *Brand Category* | | | | | | | | |
| TR × oth. vert. int. | 0.24** | | | | -1.51*** | | | |
| | (0.10) | | | | (0.15) | | | |
| TR × indep. | 0.94*** | | | | -0.92*** | | | |
| | (0.10) | | | | (0.13) | | | |
| *Regional Typology* | | | | | | | | |
| TR × intermed. | | 0.59*** | | | | -0.10 | | |
| | | (0.09) | | | | (0.12) | | |
| TR × rural | | 1.67*** | | | | -0.06 | | |
| | | (0.13) | | | | (0.16) | | |
| *Dist. Next Cxomp.* | | | | | | | | |
| TR × (1≤dist.<3) | | | 0.04 | | | | -0.09 | |
| | | | (0.10) | | | | (0.13) | |
| TR × (3≤dist.) | | | 0.78*** | | | | -0.42** | |
| | | | (0.15) | | | | (0.17) | |
| *Herfindahl-Index* | | | | | | | | |
| TR × HHI $Q_2$ | | | | 0.54*** | | | | 0.24 |
| | | | | (0.11) | | | | (0.16) |
| TR × HHI $Q_3$ | | | | 0.61*** | | | | -0.31* |
| | | | | (0.13) | | | | (0.16) |
| TR × HHI $Q_4$ | | | | 1.00*** | | | | -0.14 |
| | | | | (0.13) | | | | (0.17) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 13.01*** | 13.47*** | 12.84*** | 13.06*** | -7.24*** | -6.46*** | -6.49*** | -6.51*** |
| | (0.03) | (0.03) | (0.03) | (0.04) | (0.05) | (0.05) | (0.04) | (0.06) |
| Observations | 5,297,838 | 5,297,838 | 5,297,838 | 5,297,838 | 5,352,625 | 5,352,625 | 5,352,625 | 5,352,625 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level. The HHI is based on a 4-kilometer market delineation.

*Figure B.2:* Tax Pass-Through (%) by HHI over Vertical Integration for E10




(a) Tax Reduction (b) Tax Increase

*Note:* Heterogeneous pass-through levels for E10 of the tax (a) reduction and (b) subsequent increase by market concentration quartiles over brand categories. Each bar indicates the pass-through difference $\Delta\hat{\rho}_{HHI_Q} = 100 \times \widehat{\beta_{HHI_Q}}/\Delta tax$ with 95% confidence intervals relative to the bottom HHI quartile. The HHI is based on a 4-kilometer market delineation Analogous regression results are presented in table B.2.

# C Appendix

*Table C.1:* Average Pass-Through of the German Fuel Discount - Super E5 (Highway Stations)

| | Tax Reduction | | | | Tax Increase | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *Super E5* | | | | | | | | |
| TR ($\widehat{\beta_{RD}}$) | -32.61*** | -25.66*** | -30.92*** | -27.04*** | 29.33*** | 27.52*** | 31.09*** | 29.33*** |
| | (0.31) | (0.38) | (0.31) | (0.37) | (0.43) | (0.33) | (0.56) | (0.35) |
| Constant | 27.07*** | 15.88*** | 19.39*** | 14.51*** | -14.12*** | -13.61*** | -13.40*** | -13.69*** |
| | (0.31) | (0.31) | (0.25) | (0.30) | (0.34) | (0.28) | (0.56) | (0.21) |
| TR ($\hat{\rho}$) | [92.7%] | [73.0%] | [87.9%] | [76.9%] | [83.4%] | [78.3%] | [88.4%] | [83.4%] |
| Observations | 137,515 | 113,346 | 132,555 | 109,888 | 147,019 | 132,130 | 141,800 | 128,100 |
| *Super E10* | | | | | | | | |
| TR ($\widehat{\beta_{RD}}$) | -32.69*** | -25.68*** | -30.98*** | -27.09*** | 29.36*** | 27.53*** | 31.09*** | 29.29*** |
| | (0.31) | (0.40) | (0.32) | (0.37) | (0.43) | (0.32) | (0.57) | (0.37) |
| Constant | 27.05*** | 15.90*** | 19.37*** | 14.52*** | -14.03*** | -13.49*** | -13.23*** | -13.49*** |
| | (0.31) | (0.33) | (0.26) | (0.30) | (0.35) | (0.29) | (0.56) | (0.22) |
| TR ($\hat{\rho}$) | [93.0%] | [73.0%] | [88.1%] | [77.0%] | [83.5%] | [78.3%] | [88.4%] | [83.3%] |
| Observations | 134,132 | 110,022 | 129,304 | 106,676 | 143,575 | 128,726 | 138,491 | 124,811 |
| *Diesel* | | | | | | | | |
| TR ($\widehat{\beta_{RD}}$) | -14.69*** | -11.61*** | -14.00*** | -12.42*** | 11.84*** | 9.43*** | 13.26*** | 10.39*** |
| | (0.14) | (0.20) | (0.14) | (0.19) | (0.27) | (0.22) | (0.38) | (0.32) |
| Constant | 6.02*** | -0.07 | 1.98*** | -0.81*** | 1.24*** | 1.92*** | 1.79*** | 2.15*** |
| | (0.16) | (0.17) | (0.17) | (0.17) | (0.21) | (0.18) | (0.33) | (0.20) |
| TR ($\hat{\rho}$) | [87.9%] | [69.5%] | [83.8%] | [74.3%] | [70.9%] | [56.4%] | [79.4%] | [62.2%] |
| Observations | 137,534 | 113,365 | 132,573 | 109,906 | 147,019 | 132,130 | 141,800 | 128,100 |
| Seasonality | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Supply Shifter | | ✓ | | ✓ | | ✓ | | ✓ |
| Demand Shifter | | | ✓ | ✓ | | | ✓ | ✓ |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
RDiT estimates indicate the effect of the tax intervention on retail prices in cents per liter. Average Pass-Through in squared brackets is given by $\hat{\rho} = 100 \times \widehat{\beta^{RD}}/\Delta tax$. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard errors are block-bootstrapped sampled 1,000 times at the station level.

*Table C.2:* Robustness - Tax Reduction (Highway Stations)

| Bandwidth | 10 days | 12 days | 14 days | | | 16 days |
|---|---|---|---|---|---|---|
| Donut | 9 hours | 9 hours | 0 hours | 9 hours | 18 hours | 9 hours |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | | |
| TR | -25.97*** | -26.56*** | -27.16*** | -27.04*** | -27.20*** | -26.88*** |
| | (0.30) | (0.32) | (0.32) | (0.37) | (0.39) | (0.35) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 12.76*** | 13.89*** | 14.40*** | 14.51*** | 15.13*** | 14.44*** |
| | (0.32) | (0.33) | (0.28) | (0.30) | (0.33) | (0.30) |
| Observations | 80,044 | 94,483 | 112,856 | 109,888 | 105,789 | 125,041 |
| Adjusted $R^2$ | 0.767 | 0.758 | 0.747 | 0.754 | 0.752 | 0.751 |
| *Super E10* | | | | | | |
| TR | -26.04*** | -26.62*** | -27.22*** | -27.09*** | -27.28*** | -26.90*** |
| | (0.31) | (0.34) | (0.34) | (0.37) | (0.41) | (0.36) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 12.80*** | 13.92*** | 14.40*** | 14.52*** | 15.15*** | 14.44*** |
| | (0.33) | (0.35) | (0.28) | (0.30) | (0.33) | (0.31) |
| Observations | 77,782 | 91,755 | 109,562 | 106,676 | 102,685 | 121,339 |
| Adjusted $R^2$ | 0.764 | 0.755 | 0.744 | 0.751 | 0.749 | 0.748 |
| *Diesel* | | | | | | |
| TR | -12.23*** | -12.08*** | -13.16*** | -12.42*** | -11.26*** | -12.49*** |
| | (0.19) | (0.18) | (0.18) | (0.19) | (0.24) | (0.20) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | -1.05*** | -1.06*** | -0.82*** | -0.81*** | -1.11*** | -0.76*** |
| | (0.19) | (0.18) | (0.17) | (0.17) | (0.19) | (0.17) |
| Observations | 80,055 | 94,494 | 11,2874 | 109,906 | 105,807 | 125,060 |
| Adjusted $R^2$ | 0.434 | 0.418 | 0.440 | 0.413 | 0.369 | 0.416 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Pass-through estimates for alternate bandwidth and donut sizes. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard Errors are block-bootstrapped sampled 1,000 times at the station level.

*Table C.3:* Robustness - Tax Increase (Highway Stations)

| Bandwidth | 10 days | 12 days | 14 days | | | 16 days |
|---|---|---|---|---|---|---|
| Donut | 9 hours | 9 hours | 0 hours | 9 hours | 18 hours | 9 hours |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Super E5* | | | | | | |
| TR | 26.42*** | 28.13*** | 28.97*** | 29.33*** | 29.53*** | 29.44*** |
| | (0.31) | (0.32) | (0.32) | (0.35) | (0.46) | (0.31) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | -12.21*** | -13.30*** | -13.36*** | -13.69*** | -14.00*** | -13.57*** |
| | (0.22) | (0.21) | (0.20) | (0.21) | (0.25) | (0.25) |
| Observations | 92,332 | 109,191 | 131,254 | 128,100 | 123,785 | 147,258 |
| Adjusted $R^2$ | 0.704 | 0.694 | 0.684 | 0.686 | 0.681 | 0.679 |
| *Super E10* | | | | | | |
| TR | 26.40*** | 28.11*** | 28.92*** | 29.29*** | 29.47*** | 29.37*** |
| | (0.34) | (0.33) | (0.32) | (0.37) | (0.43) | (0.33) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | -11.99*** | -13.10*** | -13.15*** | -13.49*** | -13.81*** | -13.35*** |
| | (0.23) | (0.22) | (0.20) | (0.22) | (0.25) | (0.27) |
| Observations | 90,000 | 106,398 | 127,883 | 124,811 | 120,604 | 143,473 |
| Adjusted $R^2$ | 0.702 | 0.692 | 0.682 | 0.684 | 0.679 | 0.677 |
| *Diesel* | | | | | | |
| TR | 10.87*** | 10.99*** | 10.78*** | 10.39*** | 9.59*** | 9.30*** |
| | (0.21) | (0.23) | (0.27) | (0.32) | (0.38) | (0.26) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Constant | 1.38*** | 1.41*** | 2.15*** | 2.15*** | 2.54*** | 2.80*** |
| | (0.16) | (0.17) | (0.16) | (0.20) | (0.24) | (0.23) |
| Observations | 92,332 | 109,191 | 131,254 | 128,100 | 123,785 | 147,258 |
| Adjusted $R^2$ | 0.330 | 0.363 | 0.387 | 0.389 | 0.385 | 0.410 |

*Note:* Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.
Pass-through estimates for alternate bandwidth and donut sizes. First stage covariates include crude oil prices, exchange rates, traffic volumes, weather, holiday indicators, as well as hour of the day, weekday, and station fixed effects. Standard Errors are block-bootstrapped sampled 1,000 times at the station level.