

Cross-Border Competition, Tax Pass-Through, and Price Spillovers: Evidence from Germany's 2022 Fuel Tax Cut

Mats Petter Kahl^{1 2 3 4}

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Abstract

Can a national tax cut reorganize prices on both sides of a border? I study Germany's 2022 fuel-tax cut using station-level price paths and driving distances to French competitors. German diesel stations within 10 km of France cut prices by 0.96 cents per liter more than stations over 50 km inland (95% CI: 0.43–1.49), a 5.8-percentage-point pass-through premium. The differential begins with the reform, remains negative, and is stable at 8, 10, and 12 km thresholds. Five of six weekly leads are individually indistinguishable from zero, although the six leads reject jointly. In untreated France, diesel prices within 30 km of Germany fall by 0.73–1.14 cents relative to inland France and by about 3.1–3.4 cents in the weeks when German diesel becomes cheaper. A three-station model separates shared-cost competition from foreign feedback; model accounting shows that foreign feedback alone cannot explain the German premium. The findings demonstrate that tax incidence follows economic market boundaries, not only fiscal jurisdictions.

Keywords: tax pass-through; spatial spillovers; fuel prices; border markets; retail competition

JEL classification: H22; L13; L41; R32

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¹Universidad Carlos III de Madrid, Department of Economics. Email: mkahl@eco.uc3m.es. ORCID: 0000-0003-3387-6386.

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1 Introduction

Can a national tax cut lower prices in a country that does not enact it? In a border market, a unilateral tax change alters both the local price level and the relative price across the frontier. Consumers can redirect purchases, so firms on each side face a different competitive constraint. Tax incidence is therefore spatial: pass-through may differ between border and inland firms, and prices may respond where the tax itself is unchanged.

Germany's 2022 fuel discount provides a useful setting. From 1 June through 31 August, the federal government reduced the energy-tax rate by 29.55 cents per liter for gasoline and 14.04 cents for diesel. Including the associated value-added-tax saving, full pass-through implied price reductions of 35.16 cents for gasoline and 16.71 cents for diesel ([Bundesministerium der Finanzen, 2022](#)). France maintained a separate 18-cent tax-inclusive rebate throughout the German policy window ([République française, 2022c,a](#)). The German reform therefore changed the bilateral price gap without a contemporaneous change in the French statutory rebate.

I combine the reform with granular geography and timing. The German data cover reported price changes in Baden-Württemberg, Rheinland-Pfalz, and Saarland; the French data come from the official station-price registry. Stations are matched to driving distance from the nearest competitor across the French–German border. The principal specification compares country-by-distance groups before and during the reform while absorbing permanent station differences and common daily shocks. Because each record identifies when a posted price became valid, I reconstruct duration-weighted daily price paths rather than average irregularly timed quotes.

The central result is a within-Germany contrast. Diesel prices at stations within 10 km of France fall by 14.18 cents per liter relative to inland France, while prices more than 50 km from a French competitor fall by 13.22 cents. The 0.96-cent difference has a 95% confidence interval of 0.43–1.49 cents and equals 5.8 percentage points of the tax-inclusive cut. The differential appears when the reform begins, remains negative, and is stable when the near-border threshold is set to 8 or 12 km. It is not a generic border effect: for E5 and E10 gasoline, pass-through is high but the nearest-ring estimates are 1.8–1.9 percentage points below the inland estimates and are not statistically distinguishable from them.

The event study supports a reform-linked interpretation. Five of six pre-reform coefficients are individually indistinguishable from zero and move on both sides of zero, although the six leads reject jointly. All post-reform coefficients are negative. Re-normalizing the event study to the penultimate pre-reform week shows no differential movement in the final week before the cut. The late-August estimates are not interpreted as a reversal: they precede both the expiry of the German cut and an announced increase in the French rebate on 1 September.

French prices reveal the second side of the same market response. Relative to inland France, diesel prices within 30 km of Germany fall by 0.73–1.14 cents on average, even though those stations receive no German tax cut. The decline reaches 3.09–3.36 cents in the weeks when German diesel becomes cheaper than French diesel. Its localization, sign, and timing constitute evidence of cross-border price transmission. Because French placebo estimates are nonzero, I reserve the cleanest causal interpretation for the German near-versus-inland contrast and treat the French estimates as a

distinct, state-dependent spillover result.

The paper contributes to work on tax incidence under imperfect competition ([Anderson et al., 2001](#); [Weyl and Fabinger, 2013](#); [Ritz, 2024](#)) and to evidence that own- and rival-cost shocks pass through differently ([Muehlegger and Sweeney, 2022](#)). Border studies generally find that access to a lower-tax jurisdiction reduces pass-through in the treated market ([Doyle and Samphantharak, 2008](#); [Harding et al., 2012](#)); [Bajo-Buenestado and Borrella-Mas \(2019\)](#) instead document a price response outside the taxing jurisdiction after a Portuguese fuel-tax increase. This paper’s contribution is to show both forces in one tax-cut episode. It identifies a positive within-treated-country premium for diesel, an opposite-signed but statistically insignificant gasoline contrast when the bilateral price gap reverses, and a state-dependent response in the untreated French market. French card transactions independently show that fuel demand at this border is highly responsive to relative prices ([Adam et al., 2024](#)).

The paper also differs from the author’s related work. [Kahl \(2024a\)](#) studies static price levels at the German–Polish border, while [Kahl \(2024b\)](#) estimates national and regional average pass-through of the same German reform. The present paper estimates a within-Germany border differential, links it to price movements across the French border, and develops a model in which treated domestic rivals and untreated foreign rivals exert opposing effects on incidence.

Section 2 describes the policy setting. Section 3 develops the model, Sections 4 and 5 present the data and design, Section 6 reports the results, and Section 7 evaluates identification and robustness. Section 8 concludes.

2 Institutional setting and related evidence

2.1 The German tax cut and the French rebate

Germany’s reform temporarily lowered statutory energy-tax rates to the European minimum. Because value-added tax is levied on the tax-inclusive base, the consumer-price cost wedge fell by 16.71 cents per liter for diesel and 35.16 cents for E5 and E10 gasoline. The original rates returned on 1 September 2022 ([Bundesministerium der Finanzen, 2022](#)). Retail prices were not administratively regulated.

France operated a separate rebate. In metropolitan France it equaled 15 cents before tax, or 18 cents including tax, from 1 April through 31 August 2022 ([République française, 2022c,a](#)). A decree issued on 22 August raised the tax-inclusive rebate to 30 cents on 1 September, the same day the German cut expired ([République française, 2022b](#)). The final treatment weeks can therefore reflect expectations about two imminent policy changes and are not used to argue that the initial response reversed.

2.2 Cross-border choice

Let a motorist’s generalized cost of buying abroad equal the posted foreign price plus travel and time costs. Whether the foreign station constrains a domestic seller therefore depends on distance and

on the bilateral price gap, not distance alone (Kanbur and Keen, 1993; Chandra et al., 2014; Jansen and Jonker, 2018). This extensive margin is absent from the covered-market Hotelling benchmark, in which distance changes markups but need not change cost pass-through (Hotelling, 1929). The model below allows the local cross-border substitution slope to vary with the market state without imposing a global functional form.

2.3 Evidence on the 2022 fuel discount

Published estimates generally indicate substantial average pass-through, with variation by fuel, period, and design (Dovern et al., 2023; Drolsbach et al., 2023; Bernhardt et al., 2023; Schmerer and Hansen, 2023; Seiler and Stöckmann, 2023; Kahl, 2024b). Freitas and Syga (2022) and Frondel et al. (2026) document pronounced time and spatial heterogeneity. von Waldow and Link (2026) relate pass-through to horizontal and vertical market structure, while Genakos and Paglierio (2022) show in isolated fuel markets that pass-through rises with the number of competitors. The present design asks a different question: how does incidence change when some nearby rivals receive the tax cut and others, across the border, do not?

3 A model of border tax incidence

3.1 Treated and untreated rivals

Consider a German border station G , a nearby German rival D , and a French rival F . For each station $j \in \{G, D, F\}$, p_j is the consumer price and q_j is quantity sold. If v is the value-added-tax rate, c_j is resource cost, and t_j is the excise tax, define tax-inclusive marginal cost as $m_j = (1 + v)(c_j + t_j)$. Multiplying profit by $1 + v$ does not change the price choice, so station j maximizes $(p_j - m_j)q_j$. Let $\Delta t > 0$ denote Germany's excise-tax reduction and $\Delta \tau = (1 + v)\Delta t$ its tax-inclusive value. The reform changes both German stations' marginal costs by $-\Delta \tau$; French marginal cost is unchanged.

Around a given market state, demands take the local linear form

$$\begin{aligned} q_G &= a_G - bp_G + b\delta_B p_D + b\rho p_F, \\ q_D &= a_D - bp_D + b\delta_B p_G, \\ q_F &= a_F - bp_F + b\rho p_G, \end{aligned} \tag{1}$$

Here a_j is a local demand intercept and $b > 0$ is the common own-price slope. The normalized slope $\delta_B \in [0, 1)$ measures substitution between the two treated German stations, while $\rho \in [0, 1)$ is the local cross-price slope between the German border station and the untreated French station. The common ρ is consistent with the symmetry of an integrable quasi-linear demand system: the same marginal motorists move between G and F in either direction. The specification is a parsimonious local version of differentiated-products Bertrand competition (Singh and Vives, 1984) and the associated incidence problem (Anderson et al., 2001); it differs from a two-firm model by

distinguishing a rival that shares the German cost shock from one that does not.

The cross-price slope is not the share of motorists who buy abroad. Let x denote driving distance to the foreign alternative and $z = p_G^e - p_F^e$ the expected German-minus-French price gap. In a smooth random-utility or travel-cost model, the foreign purchase share is governed by a distribution function, whereas $\rho(x, z)$ is proportional to the density of motorists at the switching margin. It can therefore vary with distance and the price gap and can be hump-shaped in z ; no global monotonicity is assumed. French card transactions confirm that the relevant switching margin responds strongly to relative fuel prices at this border (Adam et al., 2024). Appendix A gives the stability condition for the local equilibrium.

3.2 Pass-through and the border premium

The first-order conditions, divided by b , are

$$\begin{aligned} 2p_G - \delta_B p_D - \rho p_F &= a_G/b + m_G, \\ 2p_D - \delta_B p_G &= a_D/b + m_D, \\ 2p_F - \rho p_G &= a_F/b + m_F. \end{aligned} \tag{2}$$

Let τ index the common tax-inclusive component of the two German stations' marginal costs, and let $d\tau$ be an increase in that component, holding the local slopes fixed. Solving the system gives

$$\Pi_B \equiv \frac{dp_G}{d\tau} = \frac{2 + \delta_B}{4 - \delta_B^2 - \rho^2}, \quad \frac{dp_F}{d\tau} = \frac{\rho}{2} \Pi_B. \tag{3}$$

Prices are strategic complements, so an exposed French station lowers its price even though its own cost is unchanged (Bulow et al., 1985). This is the model's direct cross-border spillover and parallels the price transmission outside the taxing jurisdiction documented by Bajo-Buenestado and Borrella-Mas (2019). The French response is first order in ρ ; the feedback from F to German pass-through enters through ρ^2 . Price data alone cannot separate the underlying demand diversion from the French best response.

For comparison, let an inland German station face a treated domestic rival with substitution weight δ_I and no foreign rival. Its common-shock pass-through is

$$\Pi_I = \frac{1}{2 - \delta_I}. \tag{4}$$

Unlike the two-firm model, this benchmark permits pass-through between one-half and one as treated domestic competition strengthens. Comparing (3) and (4), border pass-through exceeds inland pass-through if and only if

$$\rho^2 > (2 + \delta_B)(\delta_I - \delta_B). \tag{5}$$

Equation (5) isolates two opposing forces. If the foreign station is additional competition and treated domestic exposure is unchanged ($\delta_B = \delta_I$), cross-border feedback raises pass-through. If access to the foreign station replaces treated domestic competition ($\delta_B < \delta_I$), the border station faces fewer rivals whose costs fall; this lowers pass-through unless cross-border feedback is strong enough. Evidence that own- and rival-cost shocks pass through differently supports this distinction (Muehlegger and Sweeney, 2022).

Proposition 1 (Border incidence). *At a stable local equilibrium, a German tax cut lowers p_G and weakly lowers p_F , with a strict French decline when $\rho > 0$. Holding domestic competition δ_B fixed, cross-border substitution raises German pass-through because $\partial \Pi_B / \partial \rho > 0$ for $\rho > 0$. The border premium is positive if and only if (5) holds. If $\delta_B = \delta_I$, any $\rho > 0$ generates a positive but second-order premium; if $\rho = 0$, the sign of the premium is the sign of $\delta_B - \delta_I$.*

The proposition separates two empirically distinct margins. A French response is the first-order implication of an untreated rival's best response. A German border premium is a net object: it combines that foreign feedback with differences in treated domestic competition and therefore does not, by itself, identify the strength of cross-border substitution. Previous tax studies find lower pass-through near a lower-tax border (Doyle and Samphantharak, 2008; Harding et al., 2012); in the model, such a pattern arises when weaker treated-rival exposure dominates foreign feedback.

Quantitative discipline. Taking the estimated average responses as a local approximation, the published 0–10 km diesel estimates imply $\widehat{\Pi}_I = 13.22/16.7076 = 0.791$ and $\widehat{\Pi}_B = 14.18/16.7076 = 0.849$. Mechanically matching the nearest French decline to the nearest German decline gives $\widehat{\rho} \simeq 2(0.81/14.18) = 0.114$. Within the model, these moments correspond to $\widehat{\delta}_I \simeq 0.736$ and $\widehat{\delta}_B \simeq 0.817$. If domestic competition were instead held at the inland value, $\rho = 0.114$ would raise border pass-through by only about 0.3 percentage points, compared with the observed 5.8-percentage-point premium. Within this accounting, foreign feedback therefore cannot be the sole quantitative explanation; most of the German premium is accounted for by the composition of treated domestic competition. This is model accounting, not structural estimation: the ring coefficients average heterogeneous stations, and the French-to-German response ratio need not identify one invariant demand parameter.

3.3 Empirical predictions and scope

The model organizes the evidence into three disciplined comparisons. First, an untreated French price response in the direction of the German cost shock is the sharpest sign prediction. Second, the German near-minus-inland coefficient measures the net of foreign feedback and treated domestic competition; theory does not impose its sign. Third, effects can differ across fuels and policy phases because $\rho(x, z)$ is a local slope evaluated at different price gaps, but the model deliberately does not sign that state dependence. The observed concentration of the French diesel response when Germany becomes cheaper is therefore consistent with marginal cross-border switching, not a separately identified structural prediction.

Equations (3)–(5) are local comparative statics. For a finite tax reduction from τ_0 to $\tau_1 < \tau_0$, the price changes are

$$p_G(\tau_1) - p_G(\tau_0) = - \int_{\tau_1}^{\tau_0} \Pi_B(\tau) d\tau, \quad p_F(\tau_1) - p_F(\tau_0) = - \int_{\tau_1}^{\tau_0} \frac{\rho(\tau)}{2} \Pi_B(\tau) d\tau. \quad (6)$$

Thus the reform may move the price gap and the local slope along the equilibrium path; holding ρ fixed over the full 16.71-cent diesel cut would be an additional approximation. More general demand curvature can also alter the competition gradient (Weyl and Fabinger, 2013; Ritz, 2024). The model is used to discipline mechanisms, not to fit every ring coefficient with one parameter. It abstracts from multiproduct ownership, wholesale contracts, dynamic search, and intertemporal refueling. The appendix reports an ancillary hourly analysis, but posted prices without quantities or traffic cannot identify an hourly demand mechanism.

4 Data and price construction

4.1 Sources and sample

German price changes come from the Market Transparency Unit for Fuels and are distributed as historical files by Tankerkönig under a Creative Commons license (Tankerkönig, nd). The reporting system covers E5, E10, and diesel prices at stations subject to the German reporting obligation. French prices come from the official *prix-carburants.gouv.fr* open-data portal (Ministère de l'Économie, des Finances et de la Souveraineté industrielle, nd). The analysis covers 14 April–31 August 2022: 48 pre-policy days and the full 92-day treatment period.

The spatial sample contains stations in Baden-Württemberg, Rheinland-Pfalz, and Saarland and mainland French stations used by the routing procedure. Each German station is linked to the nearest French station by driving distance; French stations are analogously linked to Germany. Figure 1 makes the resulting market geography visible. Stations are dense on both sides of the Rhine, but feasible cross-border alternatives are unevenly distributed along the frontier. The design therefore uses driving distance to an actual foreign station rather than distance to the political border. The map also displays Luxembourg and Switzerland because routes and local market geography are not confined to the bilateral border. Prices from those countries are not used in estimation.

The diesel estimation sample contains 400,250 German and 107,541 French station-days, or 507,791 observations. The E5 and E10 samples contain 437,324 and 467,452 observations. A further 1,078 German diesel station-days have no valid routing distance: they enter the broad descriptive series but not the regressions. Appendix Tables 1 and 2 report descriptive statistics for E5 and E10.

4.2 Duration-weighted daily prices

German retail prices can change repeatedly within a day (Haucap et al., 2017; Kahl and Wein, 2025); French stations adjust less frequently on average (Gautier and Le Saout, 2015). A simple mean of

posted quotes would therefore overweight intervals with frequent changes. I reconstruct a piecewise-constant price path for every station, fuel, and day. The last valid quote observed by 06:00 seeds the daily path; subsequent quotes update it. The daily outcome is the duration-weighted mean from 06:00 through 22:00,

$$\bar{p}_{id} = \frac{1}{16} \int_{06:00}^{22:00} p_i(t) dt.$$

The primary sample requires all 16 hours to be covered. It excludes 201 incomplete station–fuel–days across the underlying panels, including 60 German diesel days. Missing same-day quotes are carried forward from the last valid quote, without an age cap in the primary specification; 3-, 7-, and 14-day caps are reported as sensitivity checks. Quotes outside €0.50–€3.00 per liter are removed before constructing the path.

Equal timestamps with different prices are treated as ambiguous rather than resolved by file order. Germany has no such conflicts; France has three ambiguous timestamps. The affected intervals are excluded from the primary measure, and first- and last-record rules serve as sensitivities. The same rule applies to diesel, E5, and E10.

4.3 Ancillary hourly evidence

The appendix examines hourly price profiles constructed from the same piecewise-constant paths. Each station-hour is retained only when an unambiguous price covers the full hour, and the balanced daily sample contributes all sixteen hours from 06:00 through 22:00. Because the data contain posted prices but not hourly sales or traffic, this evidence describes intraday pricing heterogeneity; it does not identify a demand mechanism.

4.4 Geography and other covariates

Distance bands are defined by driving distance to the nearest station across the border: 0–10, 10–20, 20–30, 30–40, 40–50, and more than 50 km. The final category is the inland benchmark. Public- and school-holiday indicators capture predictable demand shifts. German stations are assigned to 2022 municipalities by coordinates and then to Eurostat’s NUTS-3 urban–rural typology (Eurostat, nd). All 2,880 German stations are classified; one station 96.7 meters outside a polygon boundary is assigned to the nearest polygon edge. Appendix Table 3 reports the state and urban–rural composition.

Table 1. Diesel prices before and during the German tax cut

Country	Period	Mean price	Median	SD	Holiday share	N
France	Pre	1.897	1.894	0.075	0.334	36,830
France	Post	1.990	1.985	0.110	0.609	70,711
Germany	Pre	2.022	2.014	0.073	0.201	136,990
Germany	Post	1.985	1.972	0.079	0.497	264,338

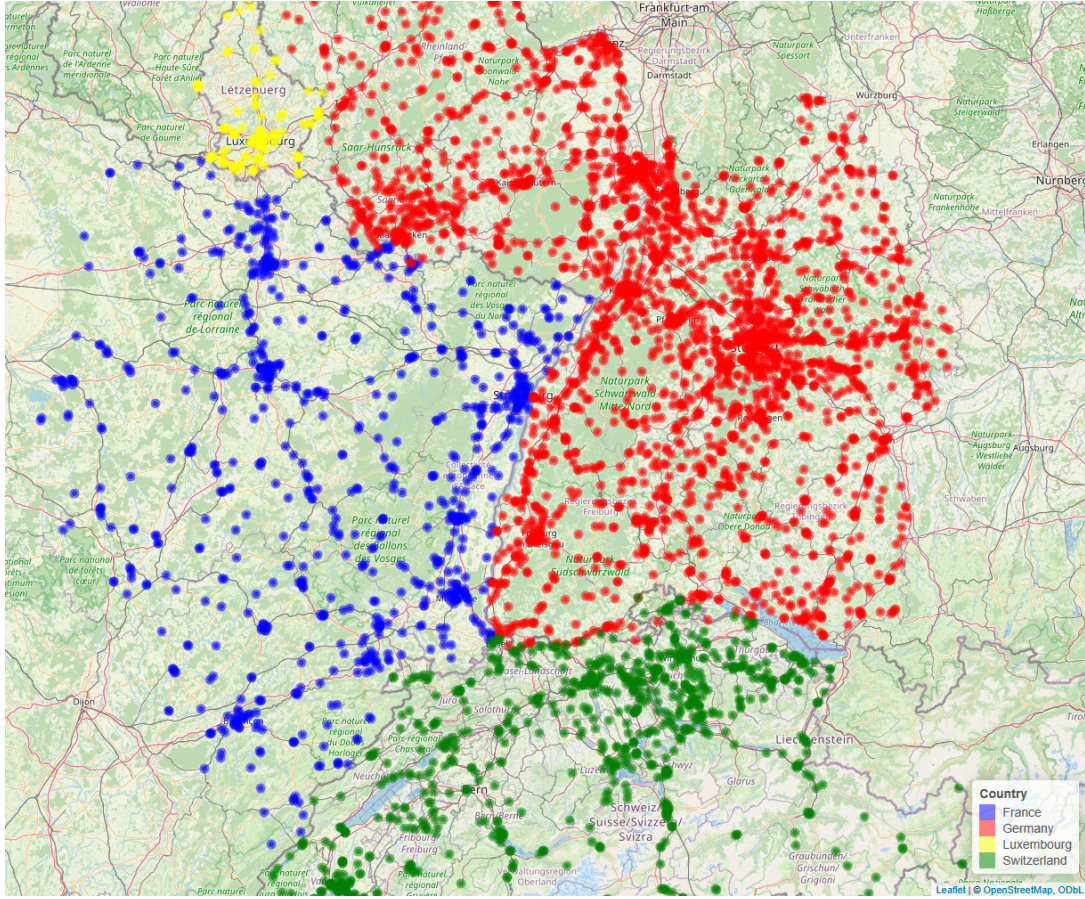


Figure 1. Fuel stations in the four-country border region

Notes: German stations are red, French stations blue, Luxembourg stations yellow, and Swiss stations green. Estimation uses German and French prices. Basemap © OpenStreetMap contributors, ODbL.

Notes: Prices are euros per liter. “Pre” is 14 April–31 May 2022; “Post” is 1 June–31 August 2022. N is station-days. The German counts include 1,078 station-days without a valid routing distance; regressions exclude them. The holiday share is the mean of an indicator for a public or school holiday.

5 Empirical design

5.1 Ring specification

Following the grouping logic of spatial difference-in-differences designs (Butts, 2023), the primary regression is

$$p_{id} = \alpha_i + \mu_d + \sum_{g \neq (FR, > 50)} \beta_g (\mathbf{1}\{i \in g\} \times Post_d) + H'_{id} \chi + \varepsilon_{id}. \quad (7)$$

Here p_{id} is the duration-weighted price at station i on date d , α_i and μ_d are station and date fixed effects, and H_{id} contains public- and school-holiday indicators. The eleven non-omitted groups combine country with driving-distance rings; French stations more than 50 km from Germany are the reference group. $Post_d$ equals one from 1 June through 31 August 2022. Standard errors are clustered by station in the primary specification.

For a German group, β_g is its post-policy price change relative to inland France, conditional on the fixed effects and holiday controls. I report diesel pass-through as $-\beta_g/0.167076$ and gasoline pass-through as $-\beta_g/0.351645$. For French rings, no German tax was remitted; the same normalization is only a tax-equivalent scale for comparing magnitudes and is not literal French tax pass-through.

The coefficient difference $\beta_{DE,0-10} - \beta_{DE,>50}$ isolates the additional near-border response relative to inland German stations. It removes any France-wide counterfactual component common to both German rings. Under parallel untreated trends across German distance groups, it is the paper's principal spatial contrast. This within-Germany comparison is also insulated from France-wide movements that could otherwise contaminate cross-country estimates, an important concern in contemporaneous evidence on the reform (Montag et al., 2023).

5.2 Continuous and dynamic specifications

Restricted cubic splines with knots at 10, 20, 30, 40, and 50 km provide a continuous summary of the German distance gradient. Weekly interactions trace adjustment during the policy. Event-study interactions compare the 0–10 km German ring with German stations more than 50 km from France. Event time is measured in seven-day intervals: 1–7 June is week 0, and 25–31 May (week -1) is omitted. Week 11 pools 17–31 August. An anticipation sensitivity instead omits week -2 and estimates the final pre-policy week; cutoff sensitivities replace 10 km with 8 or 12 km. These specifications test whether the ring result reflects a sharp bin choice, whether spatial differences predate the reform, and whether demand postponement immediately before 1 June affects the comparison.

Identification requires that, absent the German cut, the included groups would have followed the omitted inland-French trend after conditioning on fixed effects and holidays. The German near-versus-inland contrast requires the weaker assumption of parallel trends across German distance groups. Cross-border commuting, tourism, local demand, procurement, or other shocks that change differentially at the border can violate these assumptions. Section 7 evaluates these possibilities with dynamic estimates, placebo timing, alternative cutoffs, and alternative inference.

Figure 2 shows the aggregate price paths that motivate the design. German prices fall sharply when the tax cut begins, and French prices also move over the policy period. The final weeks combine the expiration of the German cut with an increase in the French rebate from 1 September and are therefore not given a stand-alone causal interpretation. These national series establish timing and scale, not the spatial counterfactual: identification comes from differences across the pre-specified distance groups.

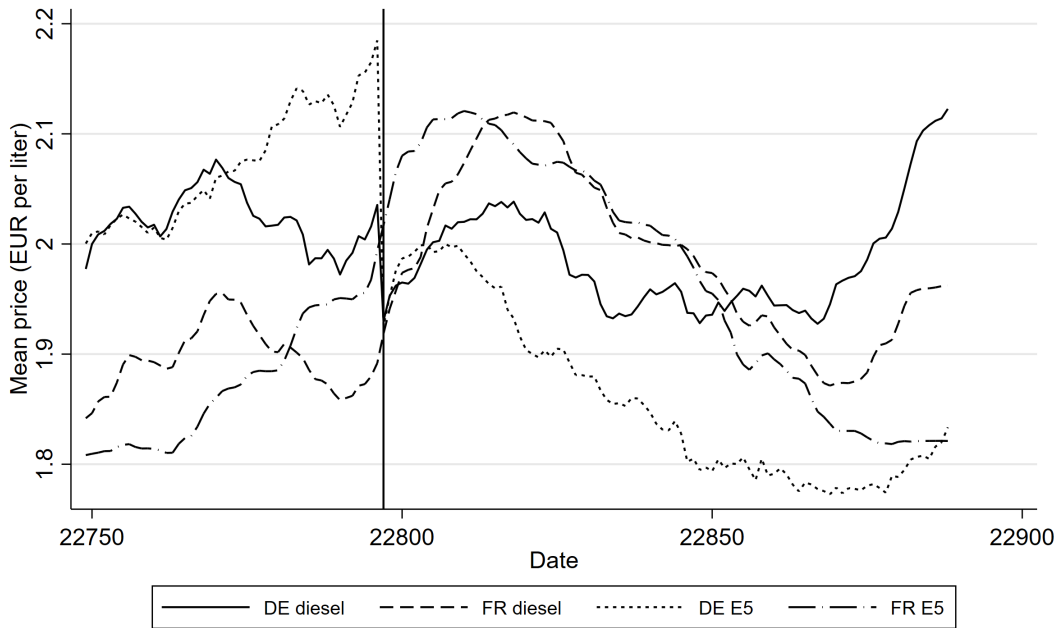


Figure 2. French and German country-average diesel and E5 prices

Notes: Vertical lines delimit the German tax-cut period.

6 Results

6.1 Diesel: border premium and foreign spillover

Table 2 reports the primary ring estimates. German diesel prices fall by 14.18 cents per liter within 10 km of France, equivalent to 84.9% pass-through, compared with 13.22 cents, or 79.1%, more than 50 km inland. The near-border premium is 0.96 cents per liter (95% CI: 0.43 to 1.49; $p < 0.001$), or 5.8 percentage points of the tax-inclusive cut. This economically meaningful local difference is the paper's central result. Responses elsewhere are also heterogeneous: the 20–30 and 30–40 km rings exceed the inland response, whereas the 10–20 and 40–50 km estimates are closer to it. Cross-border exposure is therefore important but not summarized by a monotone gradient.

The untreated French market moves in the same direction. Relative to French stations more than 50 km inland, diesel prices fall by 0.81 cents in the 0–10 km ring, 1.14 cents in the 10–20 km ring, and 0.73 cents in the 20–30 km ring. All three estimates are significant at 5%. The 30–40 km estimate is -0.87 cents ($p = 0.082$); only the 40–50 km estimate is small and positive. Three adjacent near-border rings therefore identify a localized foreign price response during a tax change that applied only in Germany. Section 7 shows that the response is concentrated in part of the policy period and that French placebo estimates are nonzero. Those diagnostics limit attribution of its exact magnitude to the German reform, but they do not erase the spatial spillover in posted prices.

The two sides of the border identify different competitive margins. The negative French estimates match the model's direct best-response prediction for an untreated rival. The larger German response is a net competition effect, not evidence that foreign feedback alone is strong: the model accounting

in Section 3 shows that the observed French-to-German response ratio makes feedback too small to generate the 5.8-percentage-point premium by itself. The nonmonotone ring profile reinforces this interpretation because driving distance, treated domestic competition, and the mass of marginal cross-border shoppers all vary across local markets. Figure 3 displays the diesel estimates on both sides of the border.

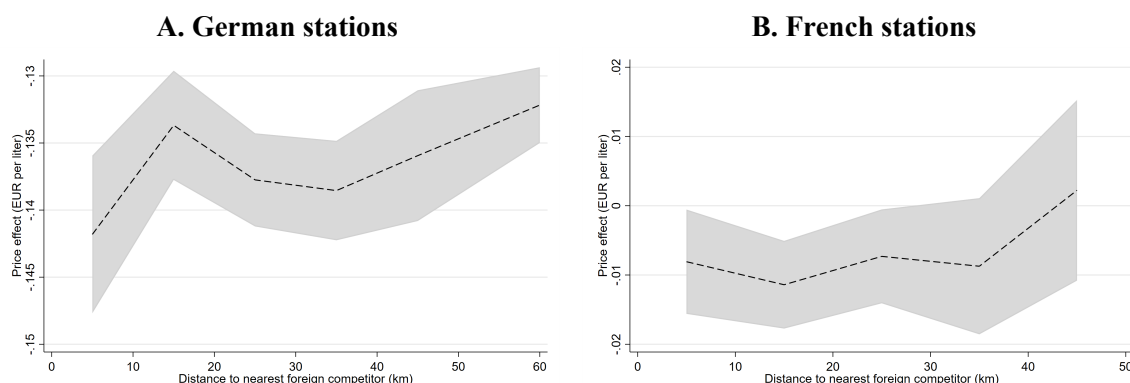


Figure 3. Diesel price responses by distance on both sides of the border

Notes: Points are regression coefficients in euros per liter and bars are 95% confidence intervals. Both panels use French stations more than 50 km inland as the omitted group; vertical scales differ across panels.

Table 2. Spatial price responses to the German fuel-tax cut: diesel

Country and distance	Price change (cents/liter)	SE	<i>p</i>	Tax-equivalent response (%)
Germany, >50 km	-13.22	0.14	<0.001	79
Germany, 0–10 km	-14.18	0.30	<0.001	85
Germany, 10–20 km	-13.37	0.21	<0.001	80
Germany, 20–30 km	-13.77	0.18	<0.001	82
Germany, 30–40 km	-13.85	0.19	<0.001	83
Germany, 40–50 km	-13.59	0.25	<0.001	81
France, 0–10 km	-0.81	0.38	0.035	5
France, 10–20 km	-1.14	0.32	<0.001	7
France, 20–30 km	-0.73	0.35	0.035	4
France, 30–40 km	-0.87	0.50	0.082	5
France, 40–50 km	0.22	0.67	0.738	-1

Notes: The dependent variable is reported in cents per liter. The omitted group is French stations more than 50 km from Germany. The model includes station and date fixed effects plus public- and school-holiday controls. Standard errors are clustered by station. The final column divides the negative coefficient by the 16.7076-cent tax-inclusive diesel cut; for French rings it is a tax-equivalent response, not French tax pass-through. $N = 507,791$.

6.2 Gasoline and continuous distance

German gasoline pass-through is high across the distance distribution. For E5, it is 89.7% in the nearest ring and 91.5% inland; for E10, 88.9% and 90.8%. Thus the nearest-ring responses are 1.8 and 1.9 percentage points lower, respectively, and neither difference is statistically significant ($p =$

0.197 for E5; $p = 0.176$ for E10). The diesel premium therefore does not arise mechanically from proximity. Consistent with the model's price-gap channel, Germany was initially more expensive than France by about 12.5 cents for diesel, 19.9 cents for E5, and 19.0 cents for E10. During the reform, the diesel gap nearly closed, whereas the gasoline gaps reversed to roughly -11 to -13 cents (Appendix Figures 1 and 2). Cross-border competitive exposure can consequently differ by fuel even at the same location.

Several French gasoline coefficients are negative, but their spatial ordering is uneven. For E5, the 10–20 and 30–40 km coefficients are significant at 5%, while the 0–10 km estimate narrowly misses that threshold. For E10, the 0–10, 10–20, and 20–30 km coefficients are significant. These estimates support cross-border price co-movement but not a single smooth decay function (Appendix Tables 6 and 7).

Restricted cubic splines summarize rather than resolve this heterogeneity. Diesel has a distinct near-border peak; the gasoline curves are nonmonotone and generally rise away from the border. Because spline coefficients are basis-dependent, the estimated curves—not individual basis terms—are the economically interpretable objects. Appendix Figure 3 places the three curves on one page.

6.3 Evolution over the policy period

Pass-through varies substantially over time. Weekly diesel estimates are high during the early and middle policy weeks, and the distance rings comove closely (Figure 4). Most temporal variation is therefore national, with a smaller spatial differential superimposed on the common adjustment path. The final weeks are not interpreted separately because the German cut expired as France increased its rebate on 1 September. Related evidence likewise documents pronounced time variation in average pass-through (Freitas and Syga, 2022; Dovert et al., 2023; Frondel et al., 2026).

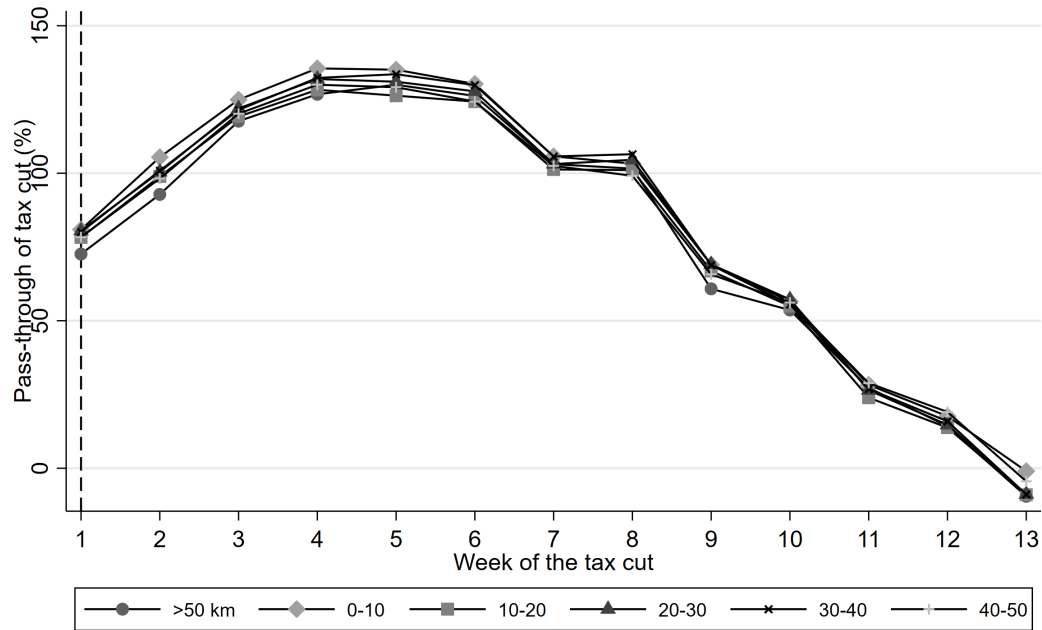


Figure 4. Weekly diesel pass-through by German distance ring

Notes: Coefficients are normalized by the 16.7076-cent diesel tax-inclusive cut.

Appendix Figure 4 reports ancillary within-day price profiles. They are deliberately not used to identify the paper's mechanism: every primary dynamic pretrend test rejects, and posted prices contain no information on hourly quantities or traffic.

7 Identification and robustness

7.1 Pre-trends and placebo estimates

Figure 5 compares the 0–10 km German diesel ring with German stations more than 50 km inland, using the final pre-policy week as the omitted period. The differential turns negative exactly when the tax cut begins, equals -1.47 cents in week 0 and -1.98 cents in week 1, and remains negative throughout the policy period. Ten of twelve post-reform coefficients are individually significant at 5%, and they are jointly significant ($p < 0.001$). The same profile appears with 8 km and 12 km cutoffs. These facts make the reform-aligned break difficult to reconcile with a smooth continuation of the pre-period path.

The normalization and anticipation checks further strengthen confidence in the plotted timing. Re-normalizing the event study to week -2 estimates the final pre-policy week directly; its 0.24-cent coefficient is small and statistically insignificant ($p = 0.366$). Excluding 25–31 May also leaves the post-reform profile intact. Thus neither the choice of omitted week nor detectable last-week demand postponement explains the break. Appendix Figure 6 reports the 8 km and 12 km cutoffs, and Appendix Figure 7 reports the alternative normalization.

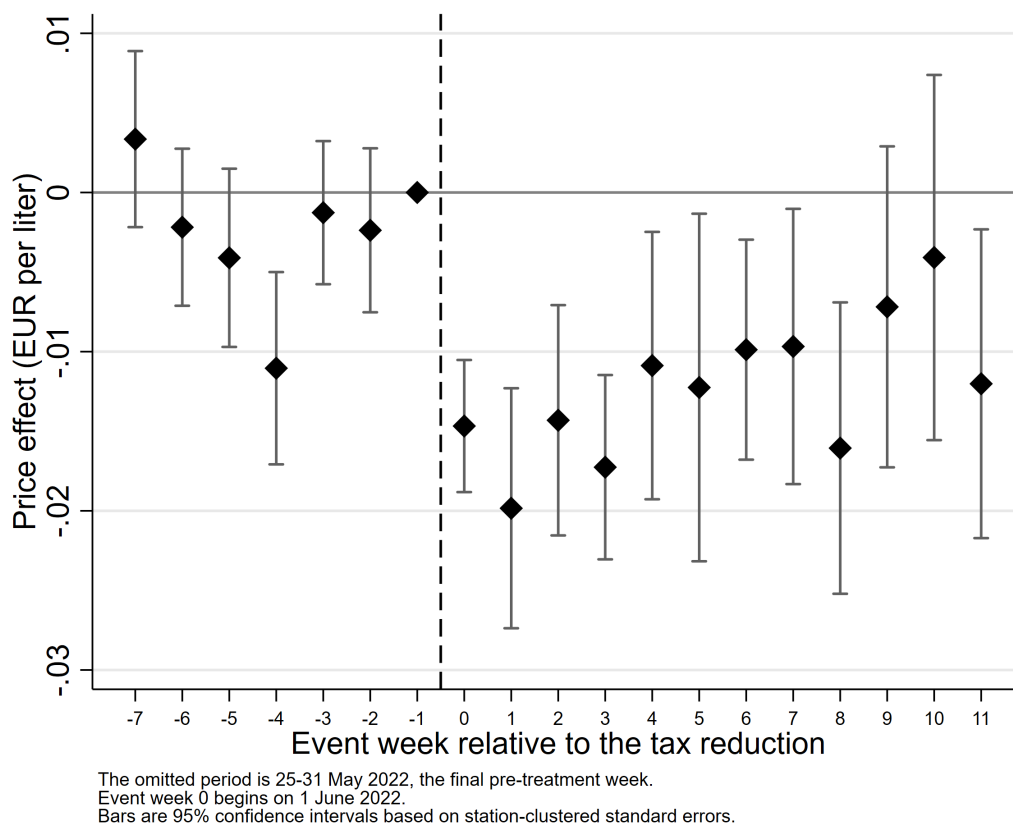


Figure 5. Event study: German 0–10 km diesel ring relative to inland Germany

Notes: Event week 0 is 1–7 June 2022; week 11 pools 17–31 August. The omitted period is week -1 (25–31 May). Bars are 95% confidence intervals. Five of six leads are individually insignificant; the six leads are jointly significant ($F = 11.05$, $p < 0.001$).

The pre-period evidence warrants precision rather than agnosticism. Five of six leads are individually insignificant; the exception is week -4, at -1.10 cents. The six leads are nevertheless jointly significant ($F = 11.05$, $p < 0.001$), so the strongest version of parallel pretrends is rejected. Crucially, they neither drift toward the post-reform level nor reproduce its persistent sign pattern. The event study therefore supports a discrete reform-aligned change while cautioning against treating the full 0.96-cent average as an assumption-free causal parameter.

The placebo exercise supplies the same qualification without mimicking the main result. Assigning a false treatment date of 18 May yields a +0.61-cent coefficient for the nearest German ring ($p = 0.050$), opposite in sign to the reform-period premium, while four French rings are negative (Appendix Table 11). The French estimates therefore receive less causal weight. More generally, translating the German policy-period contrast into a causal magnitude requires restrictions on how residual pre-period differences could have evolved (Rambachan and Roth, 2023; Roth, 2022).

Taken together, the timing, sign, persistence, alternative cutoffs, and absence of final-week anticipation establish a robust reform-linked spatial response. The jointly significant leads counsel against interpreting 0.96 cents as an assumption-free structural parameter, but they do not reproduce the post-reform shift.

7.2 Alternative inference and price construction

The near-versus-inland diesel premium is stable across inference choices. It equals 0.96 cents with a station-clustered standard error of 0.27 cents, 0.96 cents with a region-clustered standard error of 0.40 cents, 0.99 cents with a brand-clustered standard error of 0.25 cents, and 0.97 cents after aggregation to group-date cells with a date-clustered standard error of 0.11 cents (Appendix Table 12).

Results also survive reasonable price-construction variants. Using the full day yields 83.5% pass-through in the nearest German ring and 78.0% inland. Limiting carried quotes to 3, 7, or 14 days raises levels somewhat but retains the nearest-ring differential. First-record and last-record rules at ambiguous French timestamps leave diesel and E5 unchanged and affect only three E10 station-days. Appendix Tables 13 and 14 report the sensitivities and panel construction.

7.3 Concentration of the French spillover

The French spillover is economically concentrated between 13 June and 3 July. Outside that interval, the French ring estimates are near zero; within it, the 0–40 km estimates range from -3.09 to -3.36 cents (Appendix Table 8). This is also when German diesel becomes relatively cheap, as Appendix Figure 1 shows. The alignment is consistent with a larger mass of marginal cross-border shoppers at that market state. Because the interval also overlaps intensified German border controls and other calendar-specific shocks, timing alone does not isolate the mechanism. The localized French price response remains a salient spillover fact; its decomposition requires quantity or travel data.

7.4 Scope

The data measure posted prices, not quantities, margins, station-level wholesale costs, or consumer trips. The design therefore cannot separate cross-border shopping from correlated local demand, procurement, or market-structure changes. Driving distance is measured precisely, but the nearest foreign station need not be every motorist's relevant alternative. The paper identifies spatial price responses and assesses whether they comport with competition; it does not estimate welfare or a structural demand system.

8 Conclusion

National average incidence conceals a meaningful local response to Germany's 2022 fuel-tax cut. Diesel pass-through was 84.9% within 10 km of France and 79.1% more than 50 km inland, a precisely estimated premium of 0.96 cents per liter (95% CI: 0.43 to 1.49). The differential appears when the reform begins, remains negative throughout the policy, survives 8 km and 12 km cutoffs, and is not explained by detectable anticipation in the final pre-policy week. Although the six leads reject jointly, they do not display the sign or persistence of the reform-period break. The evidence therefore establishes a robust reform-linked spatial response while stopping short of treating 0.96

cents as an assumption-free structural parameter.

A model with a treated border station, a treated domestic rival, and an untreated foreign rival clarifies the economics. The French best response is first order in cross-border substitution, whereas feedback into German pass-through is second order and competes with differences in treated domestic competition. Model accounting makes this distinction consequential: the observed French response is too small for foreign feedback alone to explain the German premium. The premium instead reflects the broader composition of competition at the border. Gasoline, for which the bilateral price gap reverses, has high pass-through but no corresponding German border premium.

The untreated French response completes the economic picture. Diesel prices within 30 km of Germany decline by 0.73–1.14 cents relative to inland France and by roughly 3.1–3.4 cents when German diesel is relatively cheap. Localization across three adjacent rings, the direction of the response, and its timing provide compelling evidence that a domestic fiscal intervention can transmit into a neighboring market. Placebo estimates prevent a clean causal reading of the exact French magnitude, but not the central finding that prices moved across the fiscal border.

The central lesson is consequential for tax incidence and policy evaluation. Firms and consumers near a national border face a different competitive environment from national averages, and an untreated neighboring market can respond to a domestic fiscal intervention. Incidence therefore need not stop at the jurisdiction that changes the tax. Accounting for economically relevant market boundaries—rather than administrative boundaries alone—is essential for evaluating place-based tax policy.

A Model derivations

Dividing the firms' first-order conditions by b yields equation (2). Strict own-price concavity follows immediately because

$$\frac{\partial^2 \pi_j}{\partial p_j^2} = -2b < 0 \quad (j \in \{G, D, F\}).$$

The coefficient matrix of the price system is

$$A = \begin{pmatrix} 2 & -\delta_B & -\rho \\ -\delta_B & 2 & 0 \\ -\rho & 0 & 2 \end{pmatrix}, \quad \det(A) = 2(4 - \delta_B^2 - \rho^2).$$

Thus a unique interior equilibrium exists under the maintained stability condition

$$\Delta_B \equiv 4 - \delta_B^2 - \rho^2 > 0, \quad (8)$$

together with positive equilibrium quantities. A sufficient primitive restriction is $\delta_B, \rho \in [0, 1)$, which makes the best-response map a contraction. Nonsingularity alone requires $\Delta_B \neq 0$; the stronger condition (8) fixes the economically relevant signs of the comparative statics. Symmetry of the off-diagonal G – F terms follows from the integrable local demand system in equation (1). In the two-firm special case, restoring the unnormalized cross-price slope $\gamma = b\rho$ gives the first-order-condition matrix

$$\begin{pmatrix} 2b & -\gamma \\ -\gamma & 2b \end{pmatrix},$$

whose determinant is $4b^2 - \gamma^2$. The expression is therefore the determinant condition for a unique local price equilibrium, not an additional behavioral assumption.

To derive pass-through, let $g = dp_G/d\tau$, $d = dp_D/d\tau$, and $f = dp_F/d\tau$, where $d\tau$ raises both German marginal costs by one unit. Differentiating the first-order conditions gives

$$\begin{aligned} 2g - \delta_B d - \rho f &= 1, \\ 2d - \delta_B g &= 1, \\ 2f - \rho g &= 0. \end{aligned} \quad (9)$$

The second and third equations imply $d = (1 + \delta_B g)/2$ and $f = \rho g/2$. Substitution into the first gives

$$g = \frac{2 + \delta_B}{4 - \delta_B^2 - \rho^2}, \quad f = \frac{\rho}{2} g,$$

which proves equation (3). For an inland German station and its treated rival, the derivative system is $2i - \delta_I j = 1$ and $2j - \delta_I i = 1$. Symmetry gives $i = j = 1/(2 - \delta_I)$, proving (4).

Finally, $\Pi_B > \Pi_I$ is equivalent, under positive denominators, to

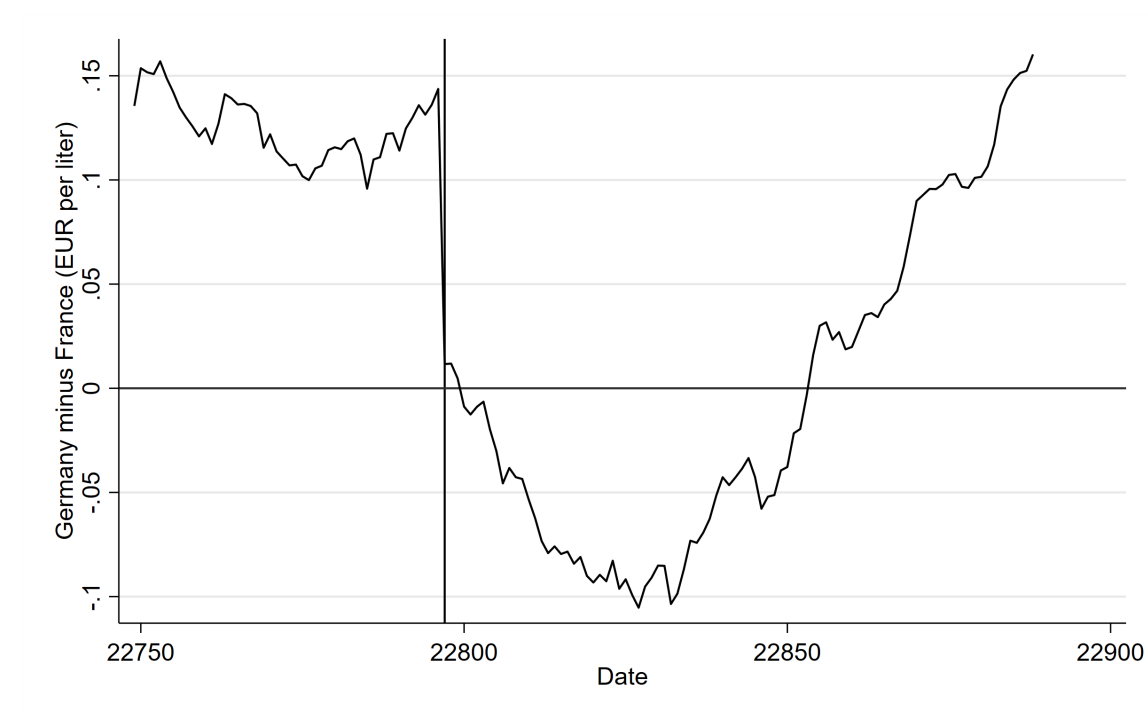
$$\begin{aligned}(2 + \delta_B)(2 - \delta_I) &> 4 - \delta_B^2 - \rho^2, \\ \rho^2 &> (2 + \delta_B)(\delta_I - \delta_B),\end{aligned}$$

which is condition (5). The foreign response $f = (\rho/2)g$ is linear in ρ around $\rho = 0$, whereas

$$\frac{\partial \Pi_B}{\partial \rho} = \frac{2\rho(2 + \delta_B)}{(4 - \delta_B^2 - \rho^2)^2}$$

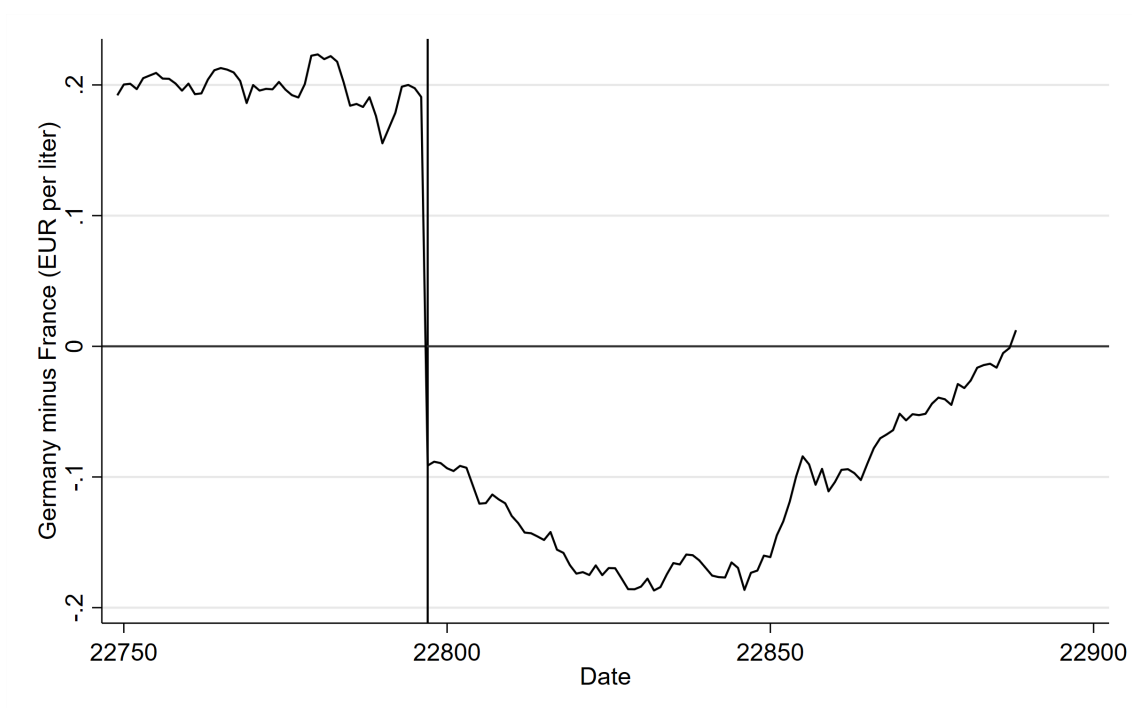
equals zero at $\rho = 0$. Hence foreign feedback affects German pass-through only at second order near zero. If $\delta_B = \delta_I$, condition (5) reduces to $\rho^2 > 0$; if $\rho = 0$, $\Pi_B = 1/(2 - \delta_B)$, so the premium has the sign of $\delta_B - \delta_I$.

Finally, equation (3) differentiates an equilibrium at a fixed local slope. When the finite reform changes z and therefore $\rho(x, z)$, the total price changes are the path integrals in equation (6). No derivative of a postulated logistic share is required: in any smooth heterogeneous-choice model, the cross-price derivative is governed by the density at the switching threshold and need not be monotone in the price gap.

B Additional figures

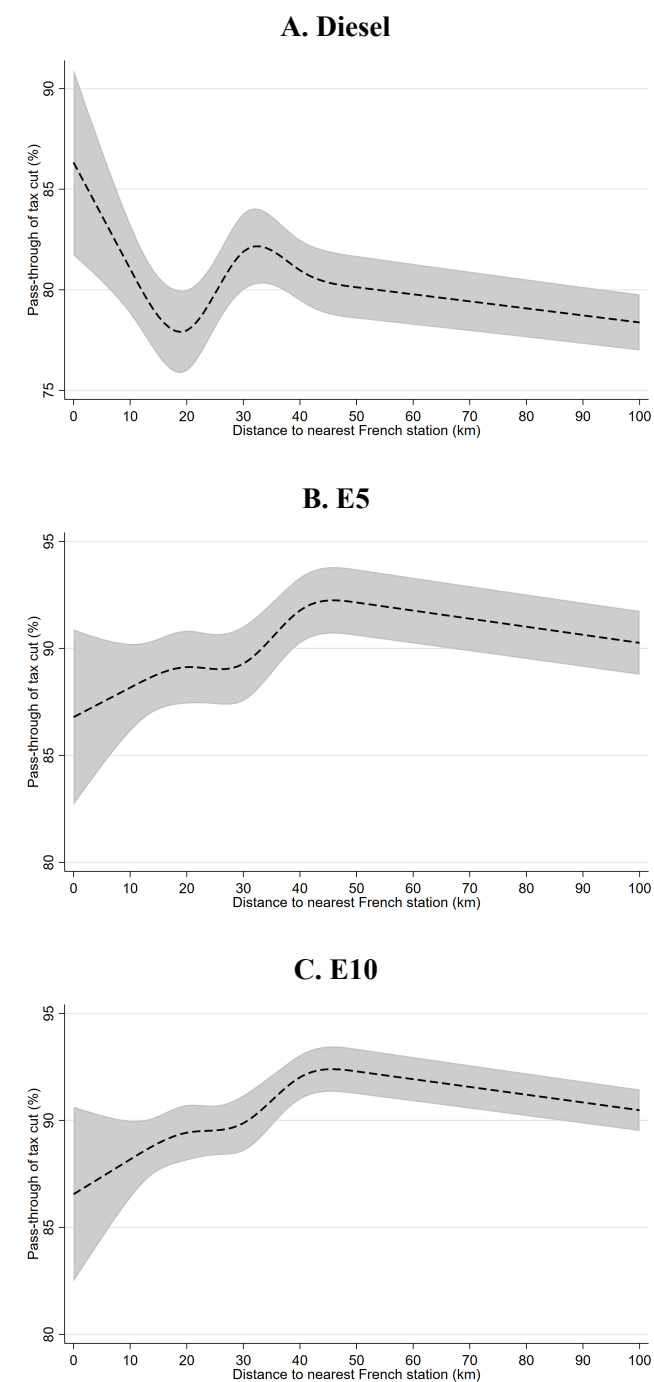
Appendix Figure 1. Mean diesel-price difference between Germany and France

Notes: Daily country-average difference.



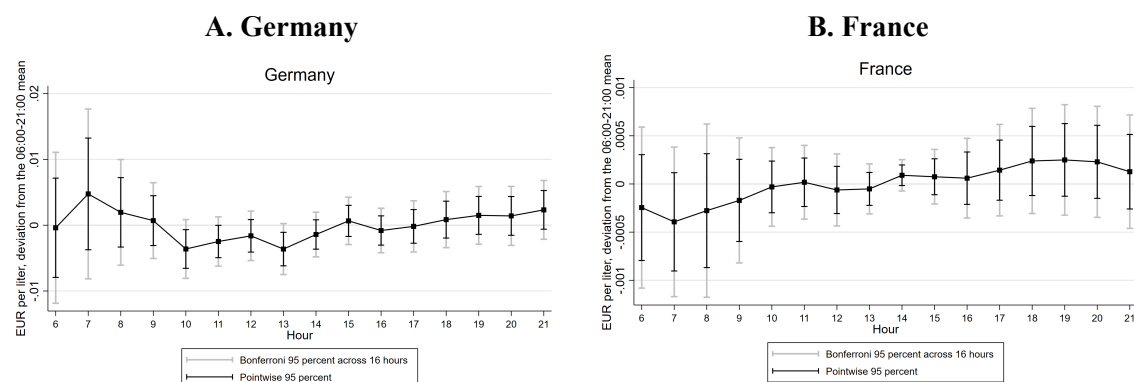
Appendix Figure 2. Mean E5-price difference between Germany and France

Notes: Daily country-average difference.



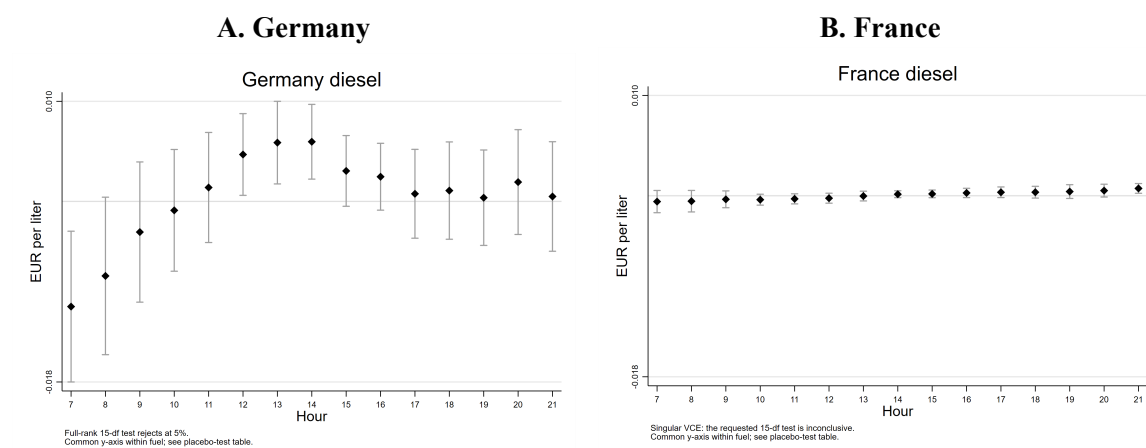
Appendix Figure 3. Predicted German pass-through versus distance by fuel

Notes: Restricted cubic splines use knots at 10, 20, 30, 40, and 50 km. Diesel exhibits a distinct near-border peak; the gasoline curves are nonmonotone and generally rise away from the border. The plotted curves, rather than individual basis coefficients, are the economically interpretable objects.



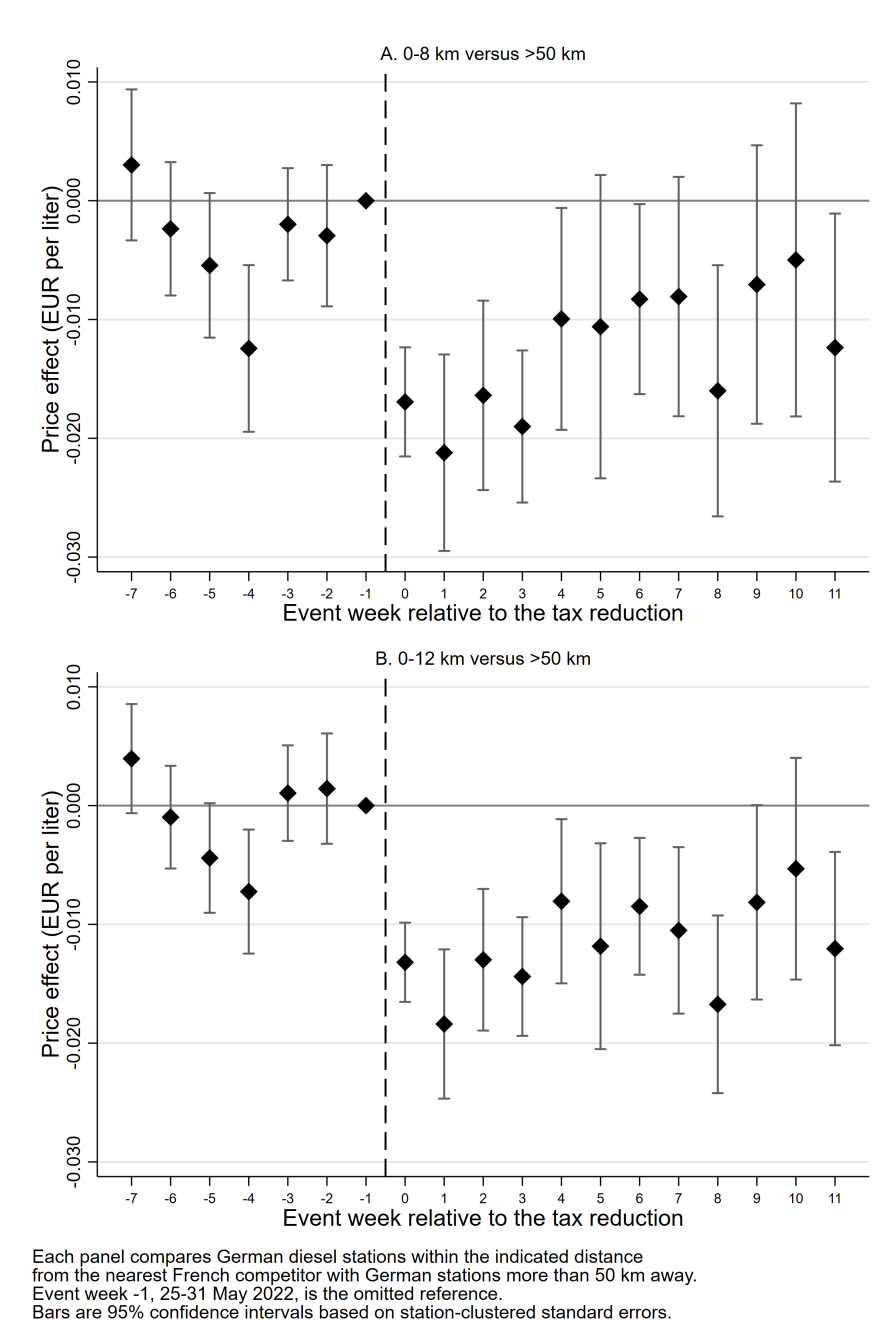
Appendix Figure 4. Mean-centered post-policy within-day contrasts: diesel

Notes: Each panel compares the 0–10 km ring with stations more than 50 km inland in the same country. Coefficients are centered on their sixteen-hour mean. Thin intervals are pointwise 95% intervals; thick intervals are Bonferroni family-wise intervals. These profiles are descriptive because the corresponding dynamic pretrend tests reject.



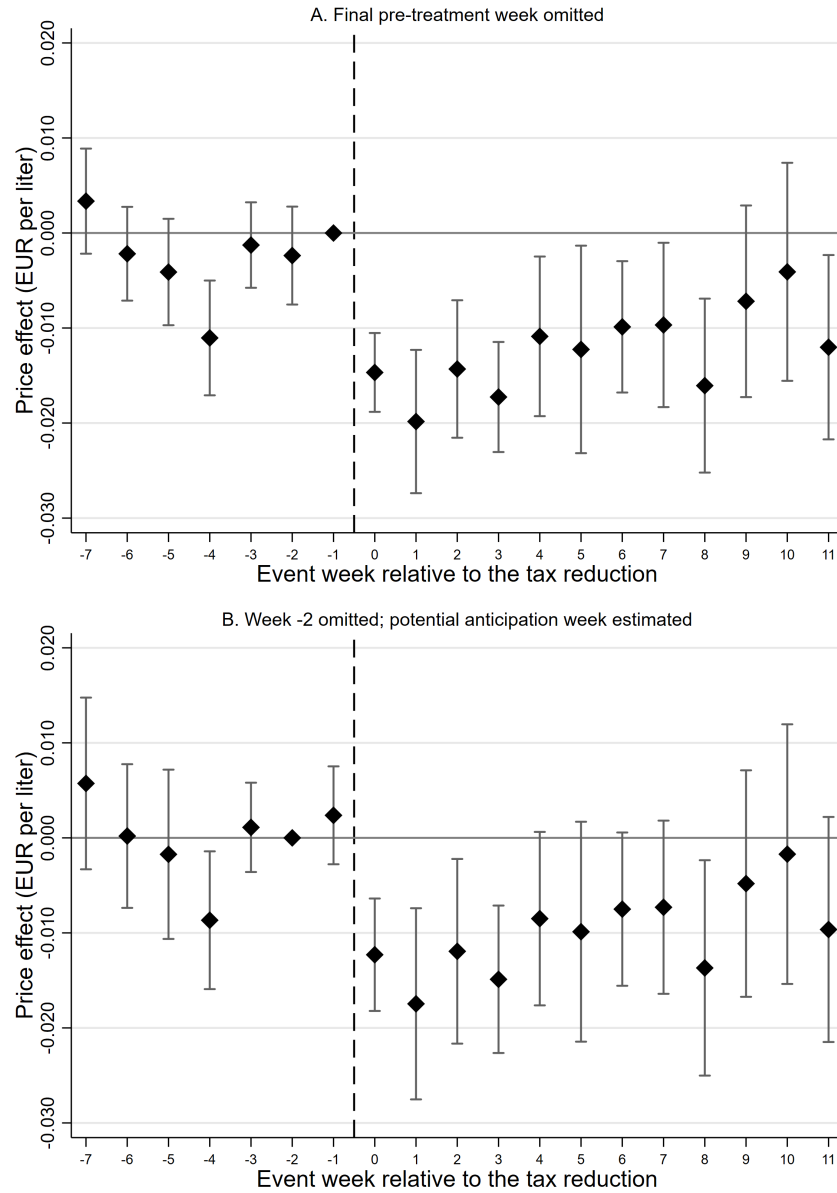
Appendix Figure 5. Within-day placebo profiles before the reform: diesel

Notes: The placebo date is 18 May 2022 and the estimation window is 1–31 May. The German joint profile test rejects at 5%. The French covariance matrix is singular for the complete 15-restriction test, so that test is inconclusive.



Appendix Figure 6. Event-study sensitivity to the near-border cutoff: German diesel

Notes: Panels replace the primary 0–10 km group with 0–8 km and 0–12 km groups; the comparison group remains German stations more than 50 km from France. Event week -1 is omitted. The near groups contain 53, 67, and 90 stations at the 8, 10, and 12 km cutoffs, respectively. All three specifications reject the joint null for the six pre-policy coefficients and for the post-policy coefficients.



Panel A omits the final pre-treatment week.
 Panel B omits week -2 and estimates the potential anticipation week.
 Labels are weeks relative to the 1 June 2022 tax reduction.
 Bars are 95% confidence intervals using station-clustered standard errors.

Appendix Figure 7. Event-study normalization and anticipation sensitivity: German diesel

Notes: The conventional specification omits event week -1 (25–31 May). The anticipation specification omits week -2 and estimates the final pre-policy week explicitly. Its week -1 coefficient is 0.0024 euros per liter (SE 0.0026; $p = 0.366$), providing no evidence of a differential last-week anticipation effect. Re-normalization changes the reference point, not fitted values.

C Additional tables

Appendix Table 1. E5 descriptive statistics

Country	Period	Mean price	Median	SD	Holiday share	N
France	Pre	1.874	1.869	0.083	0.340	13,757
France	Post	1.973	1.988	0.146	0.613	26,816
Germany	Pre	2.073	2.062	0.082	0.201	135,455
Germany	Post	1.859	1.844	0.106	0.497	261,296

Notes: Prices are euros per liter; N is station-days.

Appendix Table 2. E10 descriptive statistics

Country	Period	Mean price	Median	SD	Holiday share	N
France	Pre	1.827	1.809	0.093	0.332	28,103
France	Post	1.929	1.937	0.136	0.610	54,399
Germany	Pre	2.017	2.006	0.087	0.200	131,402
Germany	Post	1.803	1.787	0.112	0.497	253,548

Notes: Prices are euros per liter; N is station-days.

Appendix Table 3. German stations by state and Eurostat urban–rural typology**Panel A. Federal states**

State	Stations
Baden-Württemberg	1,940
Rheinland-Pfalz	773
Saarland	167

Panel B. Eurostat urban–rural typology

NUTS-3 typology	Stations
Intermediate	1,263
Predominantly rural	595
Predominantly urban	1,022

Notes: Coordinate-to-municipality assignment uses the 2022 VG5000 geometry and Eurostat’s NUTS-3 typology. All 2,880 stations are classified. One station is assigned to the nearest polygon edge (96.7 m); no station has multiple interior matches.

Appendix Table 6. Spatial price responses: E5

Country and distance	Coefficient	SE	<i>p</i>	Tax-equivalent response (%)
Germany, >50 km	-0.3218	0.0029	<0.001	92
Germany, 0–10 km	-0.3155	0.0056	<0.001	90
Germany, 10–20 km	-0.3195	0.0032	<0.001	91
Germany, 20–30 km	-0.3223	0.0033	<0.001	92
Germany, 30–40 km	-0.3243	0.0035	<0.001	92
Germany, 40–50 km	-0.3189	0.0037	<0.001	91
France, 0–10 km	-0.0295	0.0152	0.052	8
France, 10–20 km	-0.0228	0.0073	0.002	6
France, 20–30 km	-0.0191	0.0112	0.088	5
France, 30–40 km	-0.0276	0.0114	0.015	8
France, 40–50 km	-0.0187	0.0171	0.274	5

Notes: See Table 2. The final column divides the negative coefficient by 0.351645. *N* = 437,324. Equality of Germany 0–10 km and Germany more than 50 km: *p* = 0.197.

Appendix Table 7. Spatial price responses: E10

Country and distance	Coefficient	SE	<i>p</i>	Tax-equivalent response (%)
Germany, >50 km	-0.3194	0.0022	<0.001	91
Germany, 0–10 km	-0.3126	0.0054	<0.001	89
Germany, 10–20 km	-0.3163	0.0029	<0.001	90
Germany, 20–30 km	-0.3208	0.0026	<0.001	91
Germany, 30–40 km	-0.3223	0.0029	<0.001	92
Germany, 40–50 km	-0.3169	0.0032	<0.001	90
France, 0–10 km	-0.0116	0.0056	0.039	3
France, 10–20 km	-0.0219	0.0053	<0.001	6
France, 20–30 km	-0.0100	0.0040	0.013	3
France, 30–40 km	-0.0082	0.0067	0.226	2
France, 40–50 km	0.0051	0.0100	0.611	-1

Notes: See Table 2. The final column divides the negative coefficient by 0.351645. *N* = 467,452. Equality of Germany 0–10 km and Germany more than 50 km: *p* = 0.176.

Appendix Table 8. Timing of the French diesel response**Panel A. Outside the interval**

Country and distance	Coefficient	SE	<i>p</i>	Tax-equivalent response (%)
Germany, >50 km	-0.1054	0.0014	<0.001	63
Germany, 0–10 km	-0.1146	0.0032	<0.001	69
Germany, 10–20 km	-0.1077	0.0022	<0.001	64
Germany, 20–30 km	-0.1111	0.0018	<0.001	66
Germany, 30–40 km	-0.1120	0.0020	<0.001	67
Germany, 40–50 km	-0.1096	0.0027	<0.001	66
France, 0–10 km	-0.0012	0.0038	0.755	1
France, 10–20 km	-0.0058	0.0032	0.070	3
France, 20–30 km	-0.0010	0.0034	0.768	1
France, 30–40 km	-0.0024	0.0050	0.633	1
France, 40–50 km	0.0065	0.0071	0.359	-4

Panel B. During the interval

Country and distance	Coefficient	SE	<i>p</i>	Tax-equivalent response (%)
Germany, >50 km	-0.2249	0.0022	<0.001	135
Germany, 0–10 km	-0.2359	0.0034	<0.001	141
Germany, 10–20 km	-0.2240	0.0026	<0.001	134
Germany, 20–30 km	-0.2300	0.0024	<0.001	138
Germany, 30–40 km	-0.2298	0.0025	<0.001	138
Germany, 40–50 km	-0.2260	0.0027	<0.001	135
France, 0–10 km	-0.0336	0.0054	<0.001	20
France, 10–20 km	-0.0326	0.0051	<0.001	20
France, 20–30 km	-0.0309	0.0054	<0.001	18
France, 30–40 km	-0.0324	0.0075	<0.001	19
France, 40–50 km	-0.0144	0.0097	0.138	9

Notes: Coefficients are generated in one interacted model. Calendar time and border-control status are not separately randomized.

Appendix Table 11. Placebo treatment beginning 18 May: diesel

Country and distance	Coefficient	SE	<i>p</i>
Germany, >50 km	0.0010	0.0017	0.563
Germany, 0–10 km	0.0061	0.0031	0.050
Germany, 10–20 km	0.0018	0.0020	0.374
Germany, 20–30 km	0.0021	0.0019	0.257
Germany, 30–40 km	0.0002	0.0023	0.925
Germany, 40–50 km	0.0012	0.0023	0.616
France, 0–10 km	-0.0114	0.0055	0.039
France, 10–20 km	-0.0162	0.0054	0.003
France, 20–30 km	-0.0103	0.0047	0.027
France, 30–40 km	-0.0191	0.0063	0.002
France, 40–50 km	-0.0000	0.0086	0.998

Notes: Sample restricted to 14 April–31 May 2022; placebo post is 18–31 May. Station and date fixed effects; standard errors clustered by station.

Appendix Table 12. Inference robustness for differential German diesel effects

German ring vs >50 km	Coefficient	Station SE	Region SE	Brand SE	Group-date SE
0–10 km	-0.0096	0.0027	0.0040	0.0025	0.0011
10–20 km	-0.0015	0.0016	0.0025	0.0016	0.0011
20–30 km	-0.0056	0.0012	0.0017	0.0015	0.0011
30–40 km	-0.0064	0.0014	0.0017	0.0015	0.0010
40–50 km	-0.0038	0.0021	0.0027	0.0032	0.0007

Notes: Coefficients are relative to German stations more than 50 km from France. Region clustering uses 1,254 clusters and brand clustering 249 clusters. The group-date model uses data aggregated to group-by-date cells and standard errors clustered by date.

Appendix Table 13. Price-construction sensitivity: tax-equivalent diesel response (%)

Group	Primary	00:00–24:00	3-day cap	7-day cap	14-day cap
Germany, >50 km	79.1	78.0	83.1	80.9	80.5
Germany, 0–10 km	84.9	83.5	89.6	87.2	86.6
France, 0–10 km	4.8	4.9	7.3	5.9	5.2
France, 30–40 km	5.2	5.3	3.5	4.2	4.3

Notes: The primary price averages 06:00–22:00 and has no carry-age cap. Sample sizes are 507,791 (primary), 507,790 (00:00–24:00), 450,130 (3 days), 485,267 (7 days), and 498,864 (14 days).

Appendix Table 14. Diesel panel construction

Construction step	Station-days
German complete 06:00–22:00 station-days	401,328
German days using a carried price	29,502
German days excluded for missing route	1,078
German estimation sample	400,250
German partial-coverage days excluded	60
French estimation sample	107,541

Notes: The German complete-spell count precedes routing exclusions. The final French count comes from the same preferred-corrected build. Across Germany and France, the raw files contain 25,484,414 valid price events. France has three ambiguous timestamps (six rows); Germany has none.

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