Does tax policy work when consumers have imperfect price information? Theory and evidence

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Motivation

Design of optimal tax policy requires understanding of tax pass-through

Tax incidence determines

- corrective effect of Pigouvian taxes
- effectiveness of unconventional fiscal policy to stimulate the economy
- excess burden and distributional consequences of any commodity tax

Research Question

Oftentimes: oligopolistic markets with imperfect information

- Little theoretical evidence on how lack of price transparency affects pass-through
- In general, scarce empirical evidence on what determines commodity tax pass-through

    data-intensive task: requires granular information on prices

Understand the pass-through of commodity taxes in markets where consumers have imperfect information about prices

This project: commodity tax pass-through with imperfect information

1. Develop a theoretical search model, in which some consumers know all available prices and others need to sequentially acquire price information at a cost
   - Novel notion of price sensitivity: The larger the share of informed consumers, the higher is the price sensitivity of demand, as experienced by sellers
   - Derive predictions on the effects of price sensitivity and number of firms in a market on commodity tax pass-through

This project: commodity tax pass-through with imperfect information

2. Test theoretical predictions by studying pass-through of two tax changes in Germany

    - Exploit rich data on fuel prices & use France as a control
    - Analyse tax increase and decrease, as well as ad-valorem and per unit taxes
    - Explore heterogeneity in pass-through for fuel types with differently price sensitive consumer groups
    - Estimate how pass-through varies with the number of rival fuel stations

Related Literature

Theory

- consumer search model (Stahl 1989); tax pass-through with imperfect competition and complete information (Weyl & Fabinger 2013)

Cost and tax pass-through

- higher cost or tax pass-through for competitive tariffs or more visible services (Duso et al. 2017; Kosonen 2015)
- heterogeneity in pass-through with intensity of competition (Genakos & Pagliero 2019; Miller et al. 2017)

Pass-through of value-added taxes

- under-shifting (Benzarti et al. 2019; Carbonnier 2007), over-shifting (Besley & Rosen 1999), full pass-through (Buettner et al. 2020; Fuest et al. 2020)
- asymmetric pass-through for tax increases and decreases (Benzarti et al. 2020)

Outline

1. Introduction
2. Theory
3. Data & descriptive evidence
4. Empirical strategy & results
5. Conclusion

Setup

Demand

- Each consumer has valuation v for homogenous good; demand inelastic
- Fraction ϕ shoppers: fully informed and buy from the lowest price seller
- $(1 - \phi)$ non-shoppers: sequentially draw prices at a search cost s

Supply

- Infinite number of symmetric firms that can potentially enter
- Fixed entry cost F; marginal cost c; ad-valorem tax τ

Two-stage game:

1. Firms decide whether to enter the market
2. Firms choose prices. Consumers make search and purchase decisions

Price equilibrium in mixed strategies

Tax pass-through & price elasticity

Common wisdom from theoretical setup with perfect information:

> The higher the price elasticity of aggregate demand, the lower the commodity tax pass-through

Tax pass-through & price sensitivity

In this model:

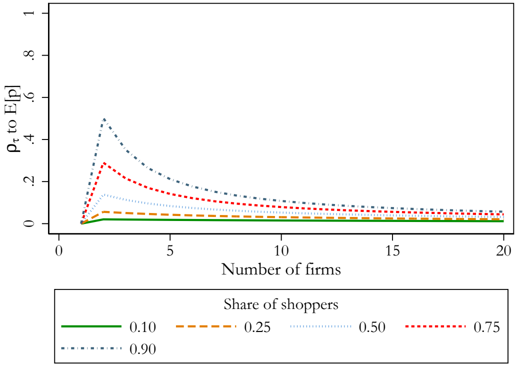
- aggregate demand fixed for prices below reservation price
- residual demand per seller depends on price sensitivity of consumers, reflected by the share of shoppers & search cost of non-shoppers
- higher price sensitivity intensifies competition

$\Rightarrow$ ***The more price sensitive consumers are on average, the higher is the pass-through rate***

Intuition The more price sensitive consumers are on average, the closer is the expected price to marginal cost

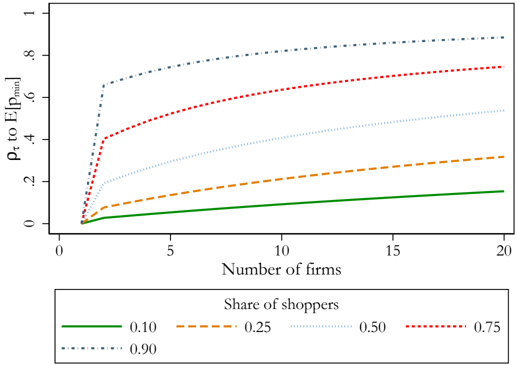
Tax pass-through & number of firms in a market

Pass-through of τ to $E[p]$



Parameter values: $v = 2.5$, $c = 0.4$, $\tau = 0.2$ and $\hat{\tau} = 0.22$.

Pass-through of τ to $E[p_{min}]$



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Tax changes in Germany

Tax decrease

- Temporary decline in the value-added tax from 19 to 16 percent between 1 July and 31 December 2020 (2020 Coronavirus Tax Assistance Act)

Tax increase

- Increase in the value-added tax back to 19 percent on 1 January 2021
- Simultaneous introduction of the carbon price of 25 Euro per emitted tonne of CO_2 on oil, gas and fuel (2020 Fuel Emissions Trading Act)

Theoretical predictions on the determinants of pass-through are qualitatively the same for ad-valorem taxes and per unit taxes

Data sources & fuel products

Data sources

administrative data on *E5*, *E10* and diesel prices and fuel stations in Germany and France

Gasoline: E5

ethanol share of 5%

81.7% of the gasoline market in Germany (2019)

Gasoline: E10

ethanol share of 10%, introduced in Germany in 2011

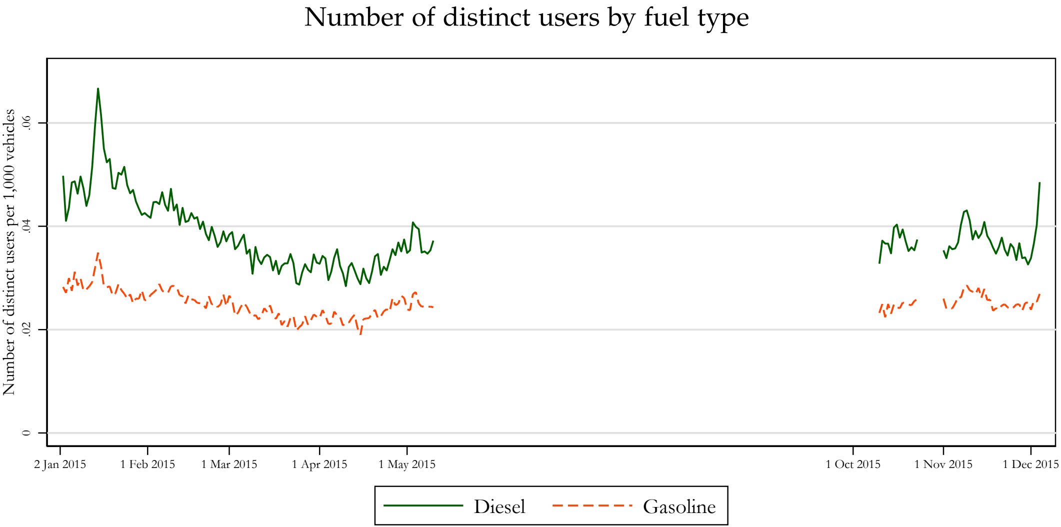
13.7% of the gasoline market (2019)

Diesel

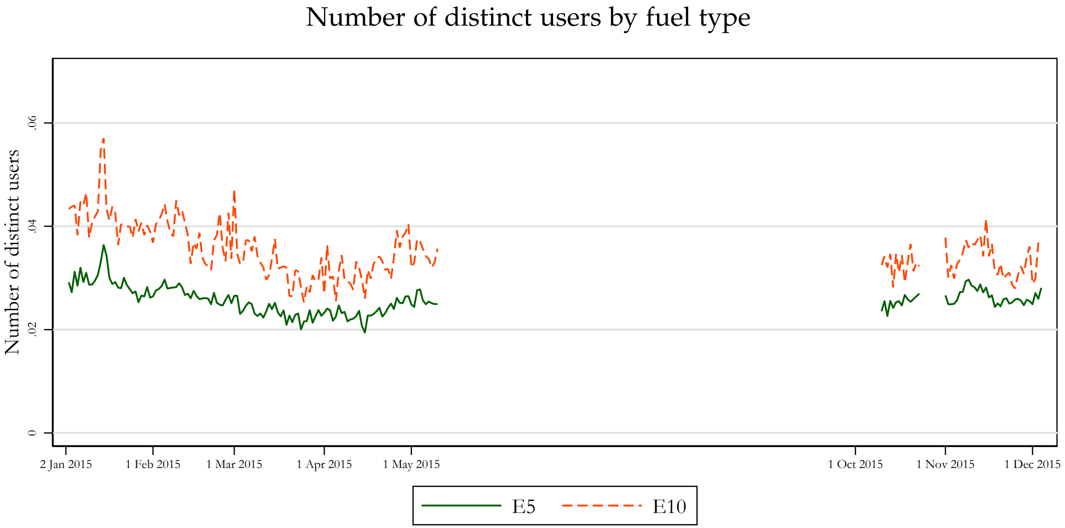
used in ca. 32% of passenger cars in Germany (2018)

annual mileage about two times higher than for gasoline vehicles
(Federal Ministry of Transportation)

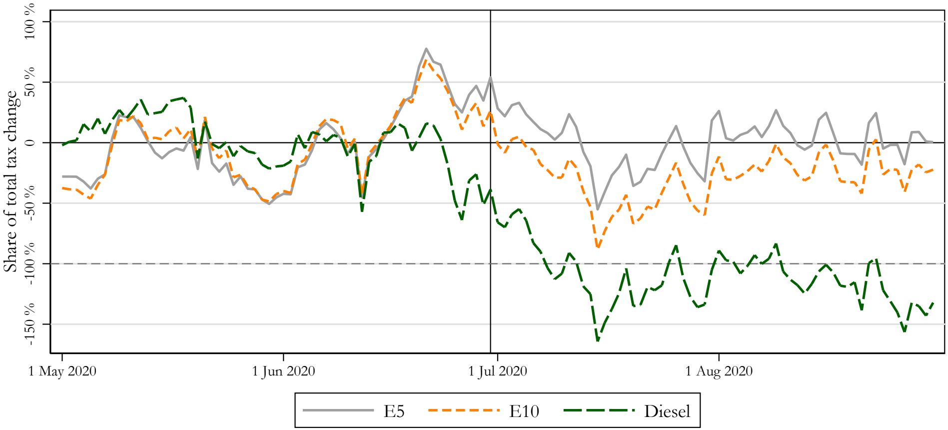
More diesel drivers search for a fuel price than gasoline drivers



More E10 drivers search for a fuel price than E5 drivers

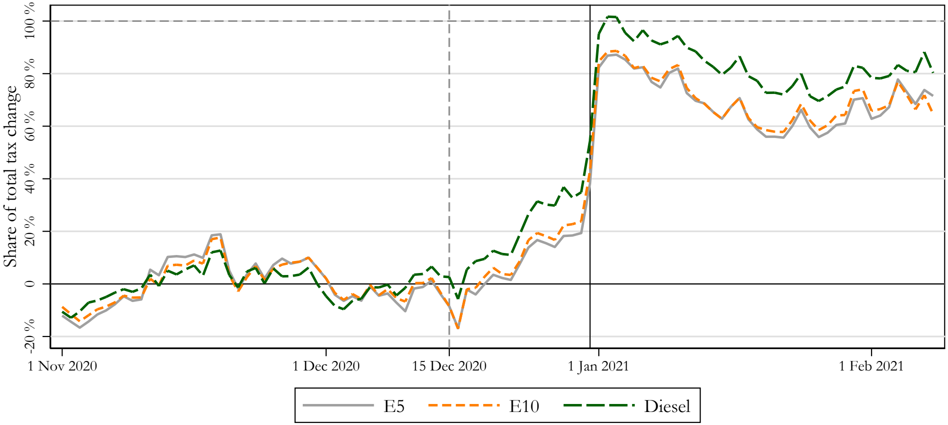


Tax decrease: price change as share of total tax change



Retail margins

Tax increase: price change as share of total tax change



Retail margins

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Empirical strategy

Synthetic difference-in-differences design (SDiD) [Arkhangelsky et al. 2020]:

$$(\hat{\tau}^{sdid}, \hat{\mu}, \hat{\alpha}, \hat{\beta}) = \underset{\tau,\mu,\alpha,\beta}{\arg\min} \left\{ \sum_{i=1}^{N} \sum_{t=1}^{T} (Y_{it} - \mu - \alpha_i - \beta_t - Tax_{it}\tau)^2 \, \hat{w}_i^{sdid} \hat{\lambda}_t^{sdid} \right\} \tag{1}$$

- $\hat{\tau}^{sdid}$: estimated effect of the tax change
- $\hat{w}_i^{sdid}$ and $\hat{\lambda}_t^{sdid}$: SDiD unit and time weights
- Y_{it}: log weighted average price at a station i and in a day t
- Tax_{it}: dummy that equals one for German stations after 1 July 2020 or 1 January 2021
- α_i and β_t: station and day fixed effects

SDiD algorithm | Station weights

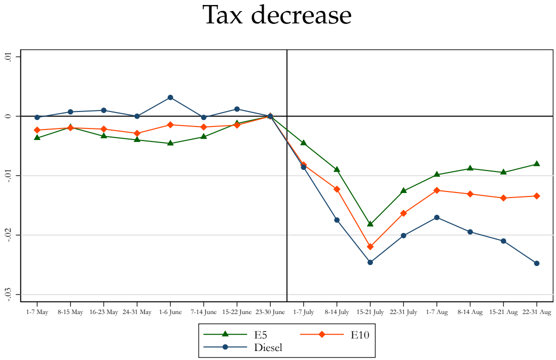
Effect of the tax change on log prices (SDiD)

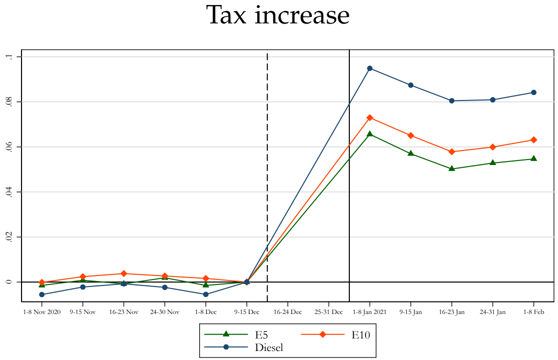
	E5	E10	Diesel	E5	E10	Diesel
	(1)	(2) Tax decrease	(3)	(4)	(5) Tax increase	(6)
Tax change	-.0085*** (.0013)	-.0130*** (.0013)	-.0199*** (.0015)	.0554*** (.0012)	.0627*** (.0019)	.0872*** (.0013)
Pass-through rate	34% [24%, 43%]	52% [42%, 62%]	79% [67%, 91%]	68% [65%, 71%]	75% [70%, 79%]	90% [88%, 93%]
Date fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Station fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,736,145	1,968,984	2,176,362	1,218,168	1,399,776	1,594,320

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

DiD

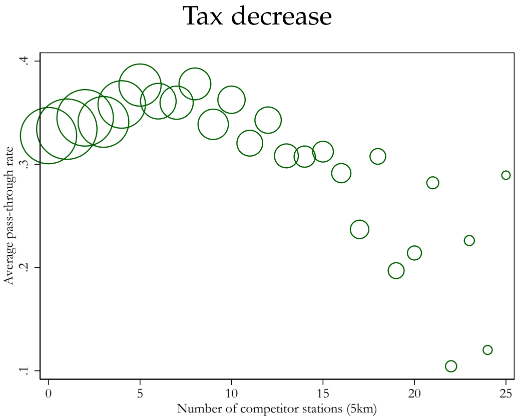
Dynamic effects of the tax change on log fuel prices

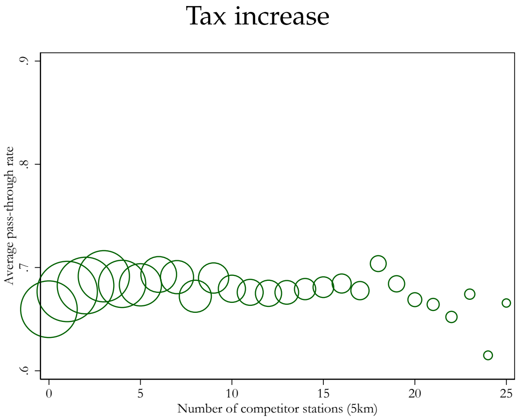




Retail margins

Average pass-through by number of competitor stations, E5





Conclusion

1. Theoretical prediction: Higher pass-through for more price sensitive consumers

Related: Stahl (1989), Weyl and Fabinger (2013)

2. Empirical finding: Pass-through increases in price sensitivity of consumers; hump-shaped relationship between pass-through and number of sellers

Related: Fabra and Reguant (2014), Dubois, Griffith, and O'Connell (2020), Harding, Leibtag, and Lovenheim (2012), Benzarti and Carloni (2019), Carbonnier (2007), Benedek, De Mooij, Keen, and Wingender (2019), Besley and Rosen (1999), Benzarti et al. (2020), Büttner and Madzharova (Forthcoming), Fuest, Neumeier, and Stöhlker (2020), Ganapati, Shapiro, and Walker (2020), Duso and Szücs (2017), Genakos and Pagliero (2019), Kosonen (2015), Miller, Osborne, and Sheu (2017)

Implications for public policy

The extent to which commodity taxes are passed through depends on

- the price sensitivity of consumers
- as well as the price elasticity of aggregate demand

How should this affect different policy areas?

- Use unconventional fiscal policy targeted at markets with high degree of price transparency
- Account for incomplete pass-through when estimating optimal Pigouvian taxes
- Account for how imperfect information affects tax incidence to assess distributional consequences

Comments welcome!

Stage 2: equilibrium price distribution

The lowest price firms may draw in equilibrium:

$$\underline{p} = \frac{p_r}{\frac{\phi N}{1-\phi} + 1} + c\frac{1+\tau}{1 + \frac{1-\phi}{\phi N}} \tag{2}$$

The CDF of the equilibrium pricing strategy:

$$F(p_i) = 1 - (\frac{p_r - p_i}{p_i - c(1+\tau)} \frac{1-\phi}{N\phi})^{\frac{1}{N-1}} \tag{3}$$

Stage 2: expected price & expected minimum price

The expected price:

$$E[p] = \underline{p} + \left(\frac{1-\phi}{N\phi}\right)^{\frac{1}{N-1}} \int_{\underline{p}}^{p_r} \left(\frac{p_r - p}{p - c(1+\tau)}\right)^{\frac{1}{N-1}} dp \tag{4}$$

The expected minimum price:

$$E[p_{min}] = \frac{1-\phi}{\phi} \left[p_r - E[p] + (p_r - c(1+\tau))c(1+\tau) \int_{\underline{p}}^{p_r} \frac{1}{(p - c(1+\tau))^2} F(p) dp\right] \tag{5}$$

Stage 1: equilibrium entry Back

The equilibrium number of entrants N^*:

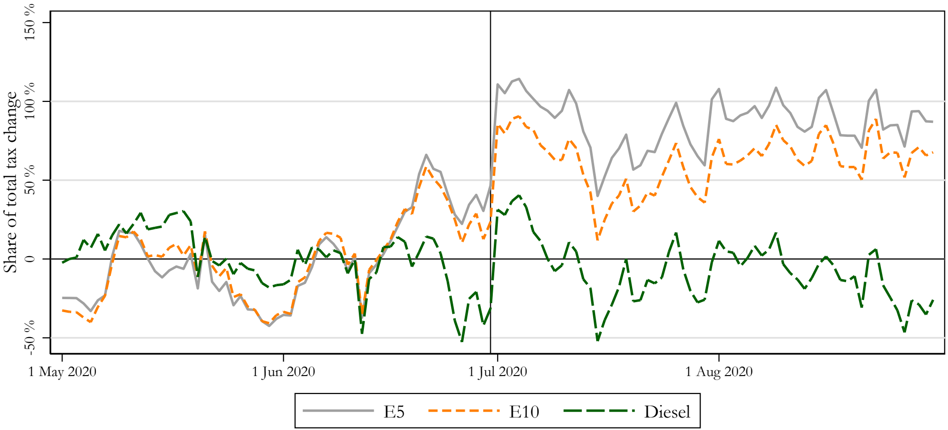
$$(\frac{p_r}{1+\tau} - c)\frac{1-\phi}{F}M - 1 < N^* \leq (\frac{p_r}{1+\tau} - c)\frac{1-\phi}{F}M\,. \tag{6}$$

This study: assume that there is no entry, since six-month temporary VAT reduction is unlikely to result in entry

Summary statistics Back

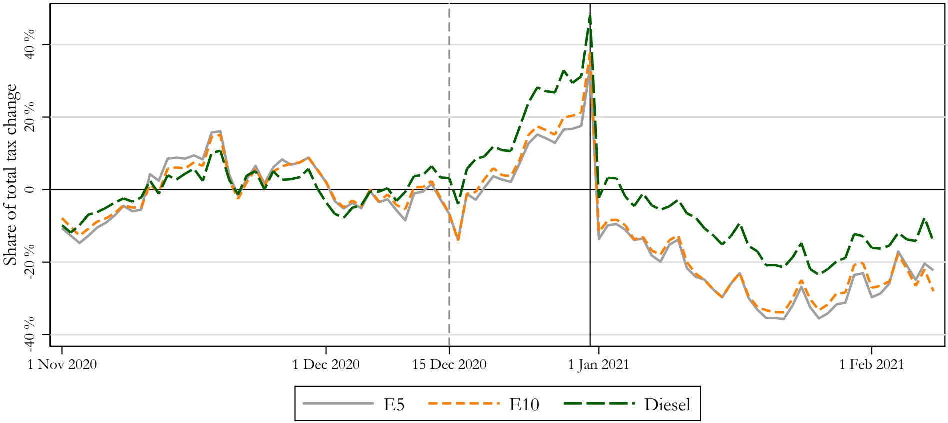
	Germany pre-treatment	Germany post-treatment	France pre-treatment	France post-treatment
A. Station characteristics				
Number of stations	14,554	14,490	8,832	9,104
Median comp. nr. (5km markets)	4	4	2	2
Share of local monopolists	13%	13%	19%	19%
B. Prices, *E5*				
Mean price	1.23	1.39	1.35	1.43
Mean price net of taxes and duties	.41	.45	.44	.51
Mean retail margin	.13	.11	.16	.17
C. Prices, *E10*				
Mean price	1.19	1.34	1.32	1.40
Mean price net of taxes and duties	.37	.41	.43	.49
Mean retail margin	.09	.07	.15	.16
D. Prices, diesel				
Mean price	1.05	1.22	1.23	1.32
Mean price net of taxes and duties	.43	.48	.42	.49
Mean retail margin	.16	.15	.14	.15
E. Mobility data				
Retail & recreation	-28.8%	-60.1%	-40.7%	-39.3%
Workplaces	-16.1%	-31.4%	-25.1%	-23.1%

Tax decrease: margin change as share of total tax change Back



Tax increase: margin change as share of total tax change

Back



SDiD algorithm Back

1. Compute the regularization parameter;
2. Compute the unit weights $\hat{\omega}_i^{sdid}$;
3. Compute the time weights $\hat{\lambda}_t^{sdid}$;
4. Compute the SDID estimator $\hat{\tau}^{sdid}$ via

$$(\hat{\tau}^{sdid}, \hat{\mu}, \hat{\alpha}, \hat{\beta}, \hat{\gamma}) = \underset{\tau,\mu,\alpha,\beta,\gamma}{\arg\min} \left\{ \sum_{i=1}^{N} \sum_{t=1}^{T} (Y_{it} - \mu - \alpha_i - \beta_t - X_{it}\gamma - W_{it}\tau)^2 \, \hat{\omega}_i^{sdid} \hat{\lambda}_t^{sdid} \right\}$$

SDiD algorithm Back

Unit weights:

$$(\hat{w}_0, \hat{w}^{sdid}) = \underset{w_0 \in \mathbb{R}, w \in \Omega}{\arg\min}\ l_{unit}(w_0, w), \text{ where} \tag{7}$$

$$l_{unit}(w_0, w) = \sum_{t=1}^{T_{pre}} \left(w_0 + \sum_{i=1}^{N_{co}} w_i Y_{it} - \frac{1}{N_{tr}} \sum_{i=N_{co}+1}^{N} Y_{it} \right)^2 + \xi^2 T_{pre} ||w||_2^2,$$

$$\Omega = \left\{ w \in \mathbb{R}_+^N : \sum_{i=1}^{N_{co}} w_i = 1, w_i = N_{tr}^{-1} \text{ for all } i = N_{co}+1, .., N \right\}.$$

SDiD algorithm Back

Regularization parameter:

$$\zeta^2 = \frac{1}{N_{co}T_{pre}} \sum_{i=1}^{N_{co}} \sum_{t=1}^{T_{pre}} (\Delta_{it} - \bar{\Delta})^2, \text{ where} \tag{8}$$

$$\Delta_{it} = Y_{i,(t+1)} - Y_{it}, \text{ and } \bar{\Delta} = \frac{1}{N_{co}(T_{pre}-1)} \sum_{i=1}^{N_{co}} \sum_{t=1}^{T_{pre}-1} \Delta_{it}.$$

SDiD algorithm Back

Time weights:

$$(\hat{\lambda}_0, \hat{\lambda}^{sdid}) = \underset{\lambda_0 \in \mathbb{R}, \lambda \in \Lambda}{\arg\min}\, l_{time}(\lambda_0, \lambda), \text{ where} \tag{9}$$

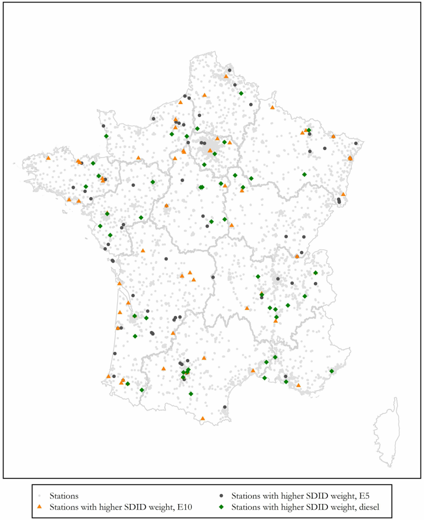
$$l_{time}(\lambda_0, \lambda) = \sum_{i=1}^{N_{co}} \left(\lambda_0 + \sum_{t=1}^{T_{pre}} \lambda_t Y_{it} - \frac{1}{T_{post}} \sum_{t=T_{pre}+1}^{T} Y_{it} \right)^2,$$

$$\Lambda = \left\{ \lambda \in \mathbb{R}_+^T : \sum_{t=1}^{T_{pre}} \lambda_t = 1, \lambda_t = T_{post}^{-1} \text{ for all } t = T_{pre}+1, .., T \right\}.$$

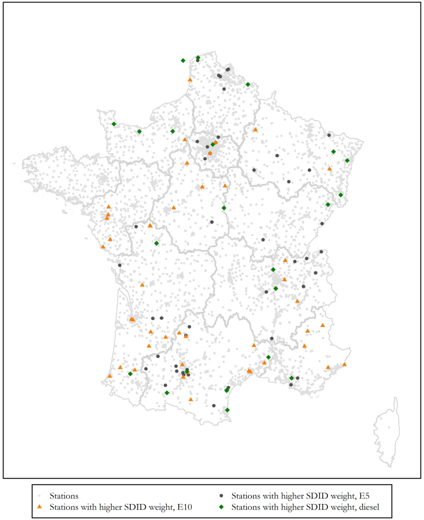
Station weights SDID

Back

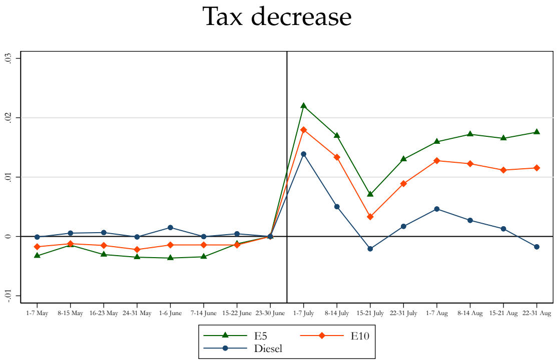
(a) Summer 2020

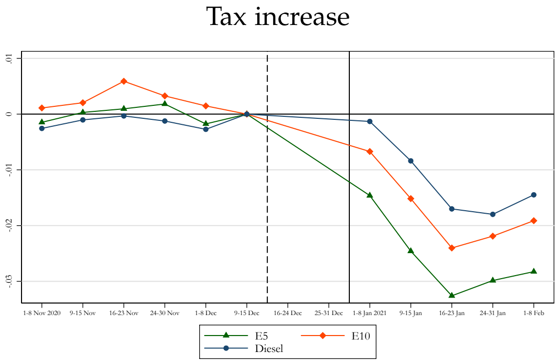


(b) Winter 2020/21



Dynamic effects of the tax change on retail margins Back





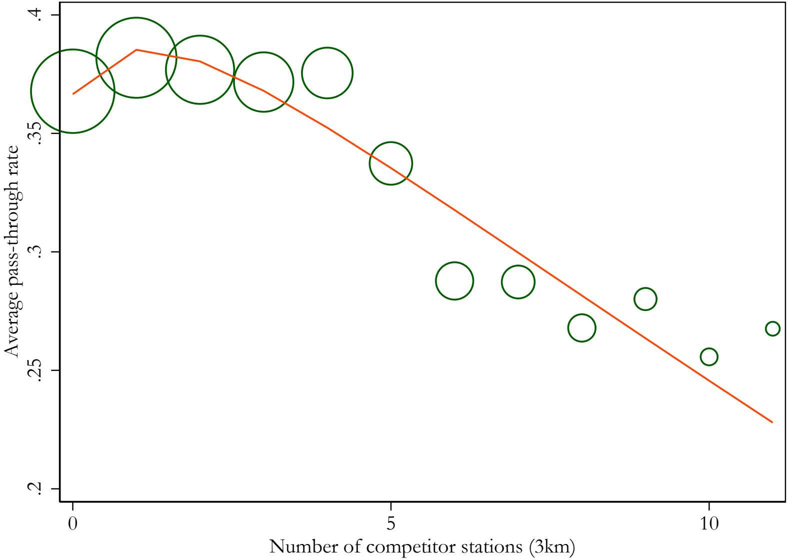
Effect of the tax decrease on log prices (DiD) Back

	E5	E10	Diesel	E5	E10	Diesel
VAT reduction	-.0069***	-.0115***	-.0237***	-.0079***	-.0123***	-.0233***
	(.0003)	(.0002)	(.0002)	(.0003)	(.0002)	(.0002)
Retail & recreation				.0016***	.0033***	.0039***
				(.0005)	(.0004)	(.0003)
Workplaces				.0131***	.0115***	-.0017***
				(.0004)	(.0004)	(.0003)
DE $\times$ oil price	.1952***	.1624***	.0394***	.2245***	.1919***	.0451***
	(.0053)	(.0033)	(.0030)	(.0053)	(.0033)	(.0031)
Pass-through rate	27%	46%	94%	31%	49%	93%
Date fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Station fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,150,748	2,332,890	2,725,295	2,149,177	2,329,576	2,721,105
Adjusted R^2	0.889	0.887	0.952	0.890	0.887	0.952
Mean price	1.24	1.21	1.06	1.24	1.21	1.06

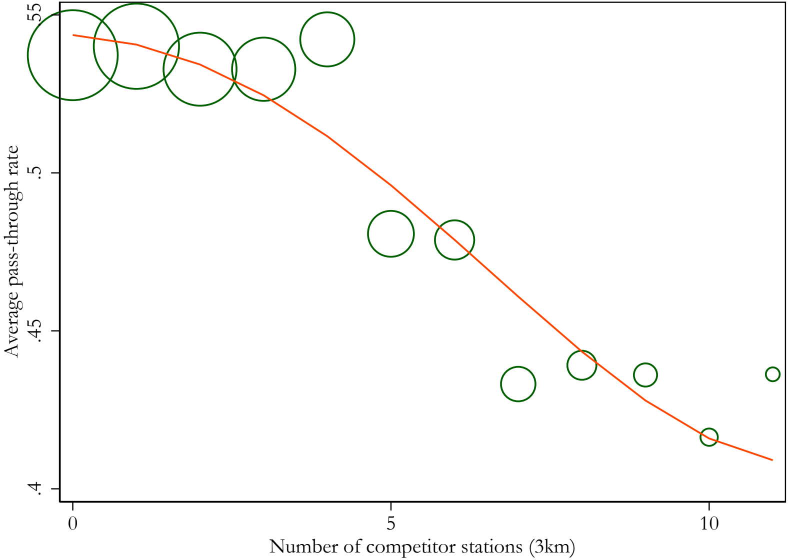
Effect of the tax increase on log prices (DiD) Back

	E5	E10	Diesel	E5	E10	Diesel
VAT increase & CO2 tax	.0581***	.0613***	.0824***	.0576***	.0606***	.0810***
	(.0004)	(.0003)	(.0002)	(.0004)	(.0003)	(.0002)
Retail & recreation				-.0044***	-.0051***	-.0054***
				(.0004)	(.0003)	(.0003)
Workplaces				.0012***	-.0005	-.0068***
				(.0004)	(.0004)	(.0004)
DE × oil price	.0439***	.0258***	.0963***	.0307***	.0085**	.0708***
	(.0068)	(.0041)	(.0030)	(.0061)	(.0038)	(.0028)
Pass-through rate	71%	73%	85%	71%	72%	84%
Date fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Station fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,456,883	1,600,333	1,871,204	1,455,899	1,598,098	1,868,287
Adjusted R^2	0.942	0.948	0.970	0.942	0.948	0.971
Mean price	1.30	1.26	1.13	1.30	1.26	1.13

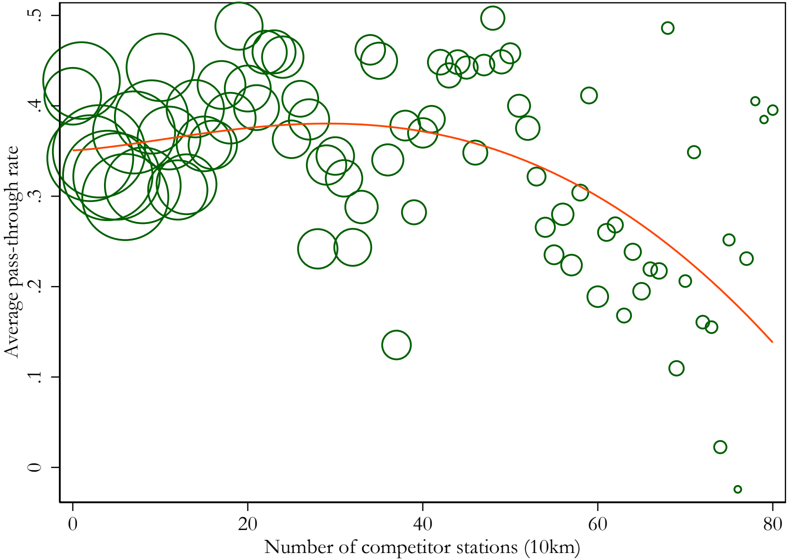
Average pass-through by number of competitor stations, E5 Back



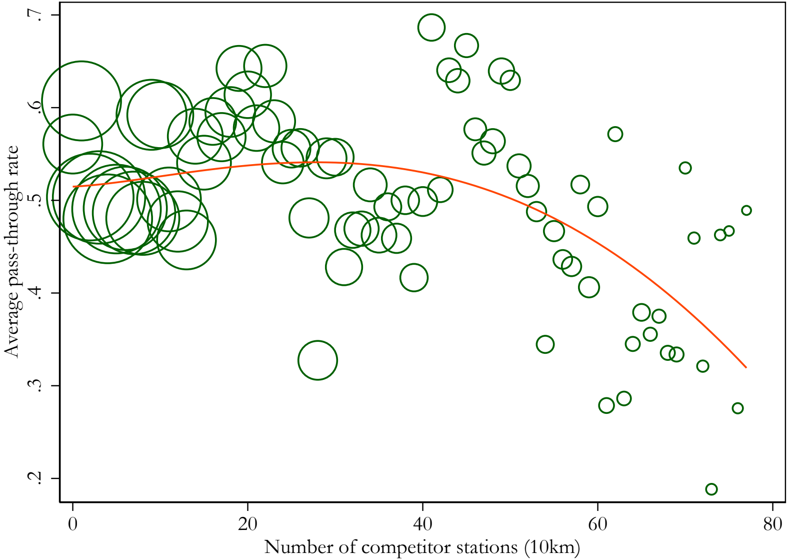
Average pass-through by number of competitor stations, E10 Back



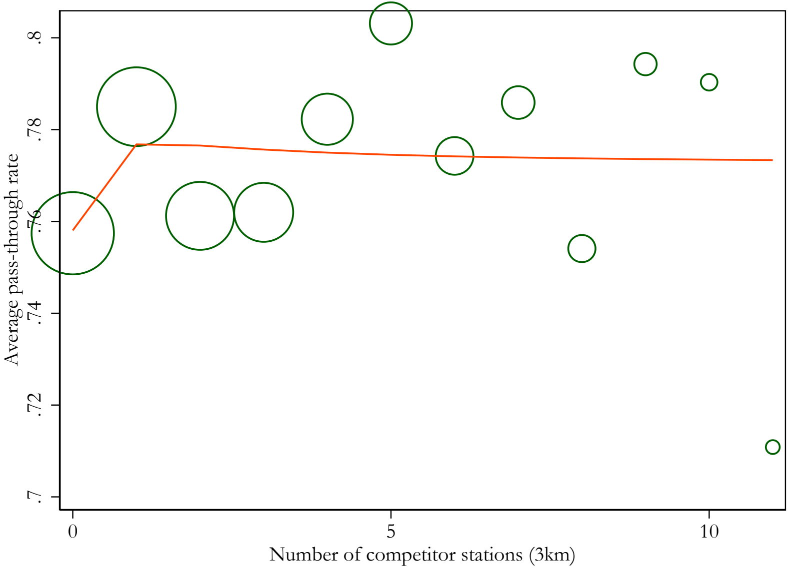
Average pass-through by number of competitor stations, E5 Back



Average pass-through by number of competitor stations, E10 Back



Average pass-through by number of competitor stations, diesel Back



Average pass-through by number of competitor stations, diesel Back