Impact of diesel bans on traffic flows

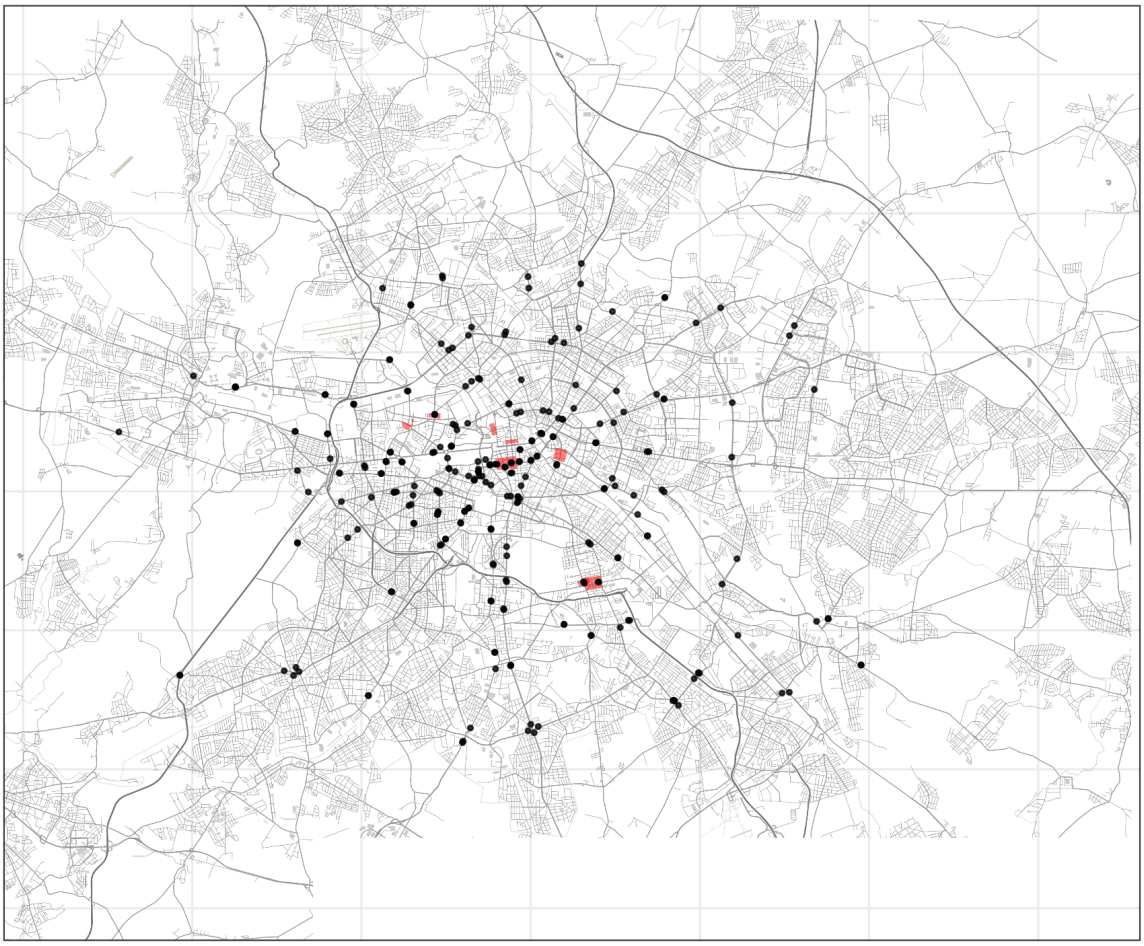
August 28, 2023

1 Berlin traffic data

Traffic monitor locations (MQ - Messquerschnitt) with separate detectors (DET - detektors) for each lane → focus on monitor locations, 2016 - 2021

- tag - Datum
- stunde - Stunde des Tages für die die Messwerte ermittelt wurden (8 =¿ 08:00 - 08:59).
- qualitaet - gibt den Anteil der für die Stunde vorliegenden einwandfreien Messintervalle wieder: 1.0 = 100%
- Anzahl aller Kraftfahrzeuge in der Stunde.
- Anzahl aller Pkw in der Stunde.
- Anzahl aller Lkw in der Stunde.
- Mittlere Geschwindigkeit [km/h] über alle Kraftfahrzeuge in der Stunde.
- Mittlere Geschwindigkeit [km/h] über alle Pkw in der Stunde.
- Mittlere Geschwindigkeit [km/h] über alle Lkw in der Stunde.

Figure 1: Monitors and diesel bans in Berlin



1.1 Hourly data

Figure 2: Number of monitor locations (MQs) and sum of vehicles per month

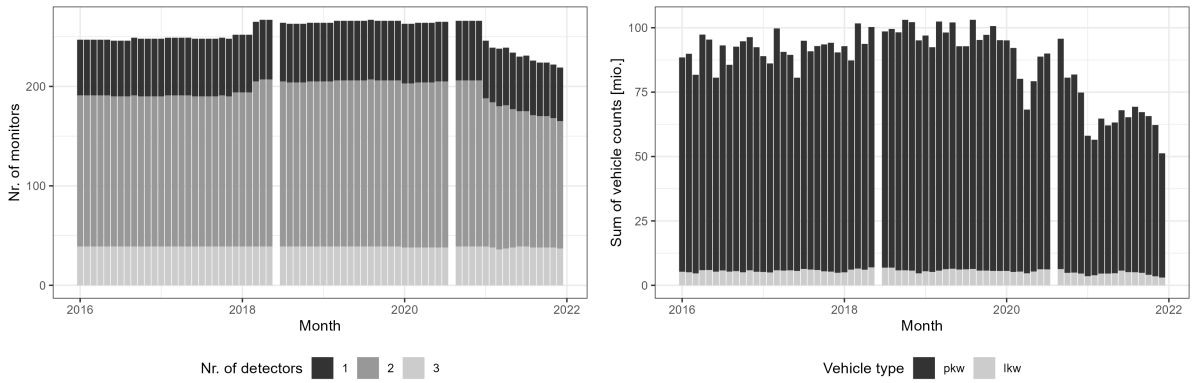


Figure 3: Average hourly vehicle counts and velocity per month

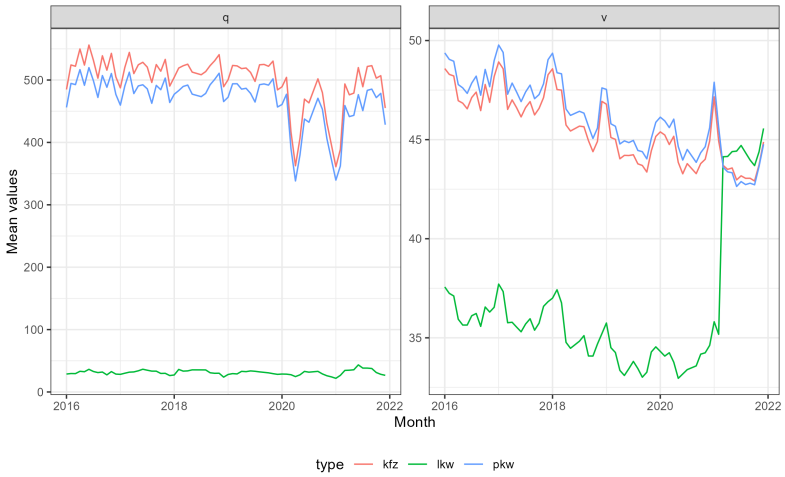
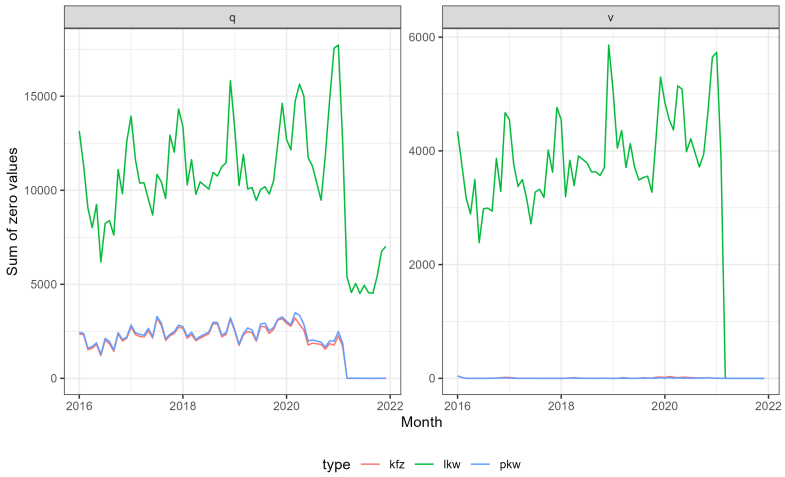


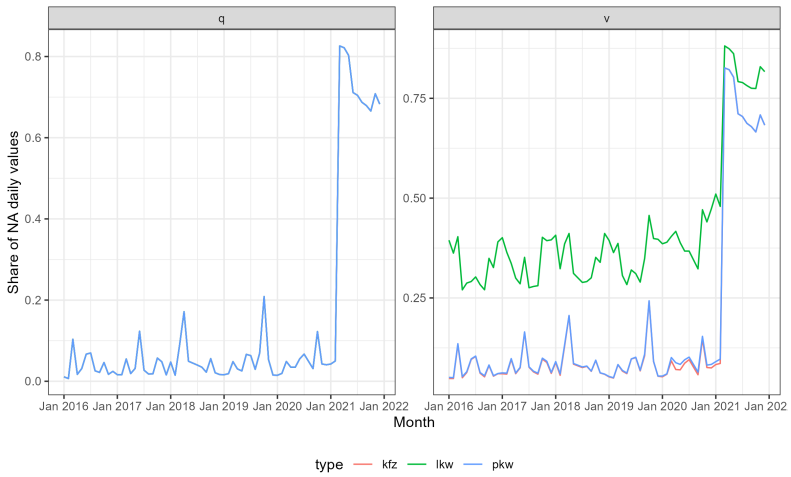
Figure 4: Number of zero-valued hours per month



1.2 Daily aggregation

Aggregate hourly to daily → Sum counts; average velocities; NA if < 24h of available data

Figure 5: Share of incomplete daily measurements per month



2 Data on diesel bans

- List of diesel bans obtained from UBA's website: `https://gis.uba.de/website/umweltzonen/index.php#dfv`
- Note: Diesel ban in Munich's inner city center since 01.01.2023 (Diesel (außer Lieferverkehr und Anwohner) erst ab Euro 5/VI frei)

Table 1: List of diesel bans

bl_name	name	stringency	start_date	end_date	length
Baden-Württemberg	Stuttgart (Gebiet der Umweltzone Stuttgart)	alle Fahrzeuge mit Dieselmotoren bis Euro 4/IV	2019-01-01		0.00
Baden-Württemberg	Stuttgart - Abschnitt "B14 (Am Neckartor)"	Diesel-Pkw bis Euro 5	2020-01-01		327.70
Baden-Württemberg	Stuttgart - Abschnitt "B14 (Hauptstätter Straße)"	Diesel-Pkw bis Euro 5	2020-01-01		703.25
Baden-Württemberg	Stuttgart - Abschnitt "B27 (Charlottenstraße, Hohenheimer Straße, Neue Weinsteige)"	Diesel-Pkw bis Euro 5	2020-01-01		3828.35
Baden-Württemberg	Stuttgart - Abschnitt "B27 (Heilbronner Straße)"	Diesel-Pkw bis Euro 5	2020-01-01		947.61
Baden-Württemberg	Stuttgart (kleine UWZ)	Diesel-Pkw bis Euro 5	2020-07-01		0.00
Berlin	Berlin - Abschnitt "Alt-Moabit"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01		162.64
Berlin	Berlin - Abschnitt "Hermannstraße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01		240.07
Berlin	Berlin - Abschnitt "Leipziger Straße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01		822.66
Berlin	Berlin - Abschnitt "Silbersteinstraße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01		679.20
Hamburg	Hamburg - Abschnitt "Max-Brauer-Allee"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2018-05-31		569.83
Hamburg	Hamburg - Abschnitt "Stresemannstraße"	Diesel-Lkw über 3,5 t bis Euro V	2018-05-31		3003.28
Hessen	Darmstadt - Abschnitt "Heinrichstraße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V und Pkw mit Ottomotoren bis Euro 2	2019-06-01		667.91
Hessen	Darmstadt - Abschnitt "Hügelstraße"	Diesel-Pkw bis Euro 5 und Pkw mit Ottomotoren bis Euro 2	2019-06-01		307.64
Berlin	Berlin - Abschnitt "Brückenstraße, Jannowitzbrücke"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01	2021-06-01	470.86
Berlin	Berlin - Abschnitt "Friedrichstraße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01	2021-06-01	152.20
Berlin	Berlin - Abschnitt "Reinhardtstraße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01	2021-06-01	197.00
Berlin	Berlin - Abschnitt "Stromstraße"	alle Fahrzeuge mit Dieselmotoren bis Euro 5/V	2019-11-01	2021-06-01	193.98

3 Weather data

- Daily weather readings from DWD:
  - Temperature (mean, min, max) [°C]
  - Precipitation [mm]
  - Sunshine [h]
  - Relative humidity [%]
  - Wind speed (mean, max) [m/s]

  - Atmospheric pressure [hPa]

- Interpolate weather at the location of pollution monitors via Inverse Distance Weighting (r = 100km, p = 2)

4 Sample selection and descriptives

Sample selection

- Discard 2021 due to incomplete data (zero values eliminated?) → 2016-2020

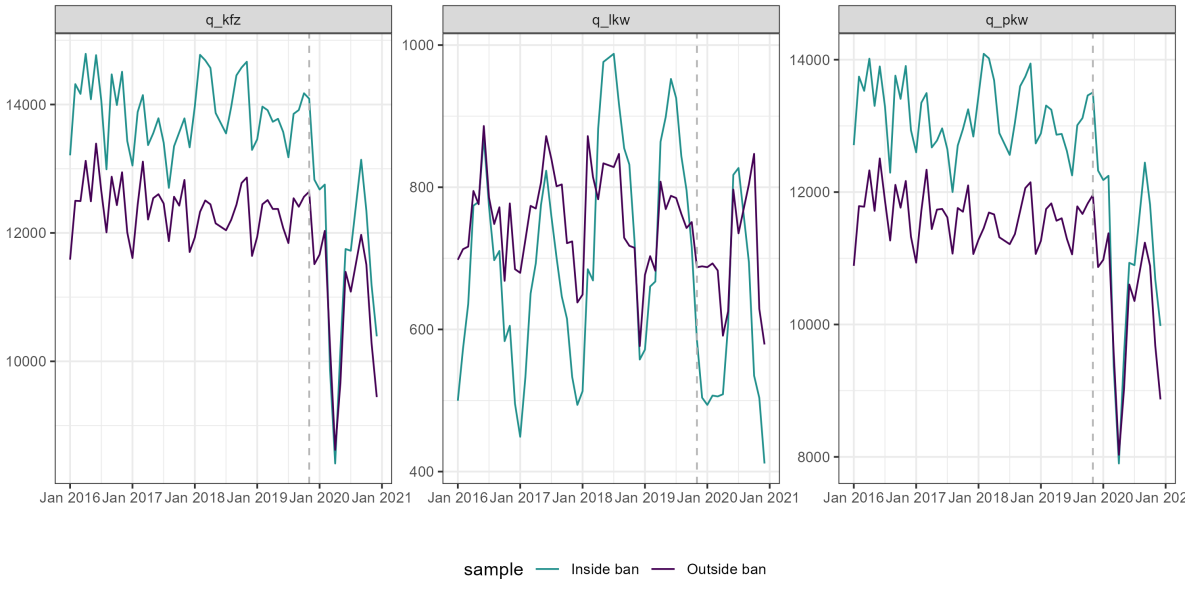
Treatment definition

- Monitor locations within pre-specified distance to diesel ban (preferred 25m, robustness 15m, 75m, 150m)

Table 2: Descriptives on traffic and weather for treated and control samples (monthly avg.)

	Inside ban			Outside ban	Outside > 1500m
variable	Total	Pre	Post	Total1	Total2
Intensity KFZ [thsd. vehicles per day]	13.359	13.886	11.641	12.068	12.143
	(5.517)	(5.594)	(4.900)	(6.410)	(5.711)
Intensity PKW [thsd. vehicles per day]	12.674	13.168	11.064	11.334	11.436
	(5.123)	(5.175)	(4.615)	(6.085)	(5.441)
Intensity LKW [thsd. vehicles per day]	0.685	0.718	0.577	0.743	0.708
	(0.501)	(0.527)	(0.387)	(0.908)	(0.675)
Speed KFZ [km/h]	39.632	40.313	37.407	46.288	47.059
	(5.525)	(5.599)	(4.646)	(8.946)	(8.998)
Speed PKW [km/h]	40.078	40.770	37.818	47.039	47.728
	(5.620)	(5.688)	(4.756)	(9.084)	(9.102)
Speed LKW [km/h]	29.868	30.340	28.276	35.527	36.342
	(6.872)	(7.234)	(5.193)	(8.951)	(8.863)
Dist. to ban [m]	4.495	4.434	4.694	3541.262	4602.644
	(3.159)	(3.137)	(3.236)	(2817.742)	(2673.737)
Rain [mm]	1.464	1.523	1.273	1.472	1.471
	(1.079)	(1.181)	(0.605)	(1.081)	(1.082)
Temperature [C]	10.810	11.113	9.823	10.721	10.718
	(6.783)	(7.145)	(5.344)	(6.739)	(6.734)
Sunshine [h]	4.978	5.137	4.458	5.038	5.056
	(2.989)	(2.967)	(3.012)	(2.992)	(2.996)
Wind speed [m/s]	3.621	3.629	3.596	3.659	3.672
	(0.508)	(0.486)	(0.575)	(0.537)	(0.545)
Humidity [%]	72.819	72.316	74.463	73.548	73.642
	(10.352)	(9.979)	(11.378)	(10.256)	(10.260)
N.Observations	499	382	117	14437	10292
N.Units	9	9	9	258	185

Figure 6: Monthly average traffic intensity at monitor locations inside vs. outside bans



5 Empirical model and results

Two-way fixed effect model

$$Y_{it} = \beta D_{it} + W'_{it}\gamma + \lambda_i + \tau_t + \epsilon_{it} \tag{1}$$

- Y_{it} - Average daily (log) vehicle count at location i in month t
- D_{it} - Treatment indicator equal to 1 after ban implementation
- W'_{it} - Average weather at location i in month t (temperature, rain, sunshine, windspeed, rel. humidity)
- λ_i - Monitor-location fixed effects
- τ_t - Month fixed effects

Table 3: Impact of diesel bans on traffic intensity

	KFZ			PKW			LKW		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Post	−1250**	−1219*	−1213*	−1135**	−1112*	−1096*	−155*	−153*	−170*
	(472)	(476)	(480)	(434)	(437)	(444)	(72)	(75)	(77)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	No	Quadr.	Quint.	No	Quadr.	Quint.	No	Quadr.	Quint.
Nobs	12767	12767	12767	12767	12767	12767	12767	12767	12767
N	229	229	229	229	229	229	229	229	229
Adj.R2	1	1	1	1	1	1	0	0	0

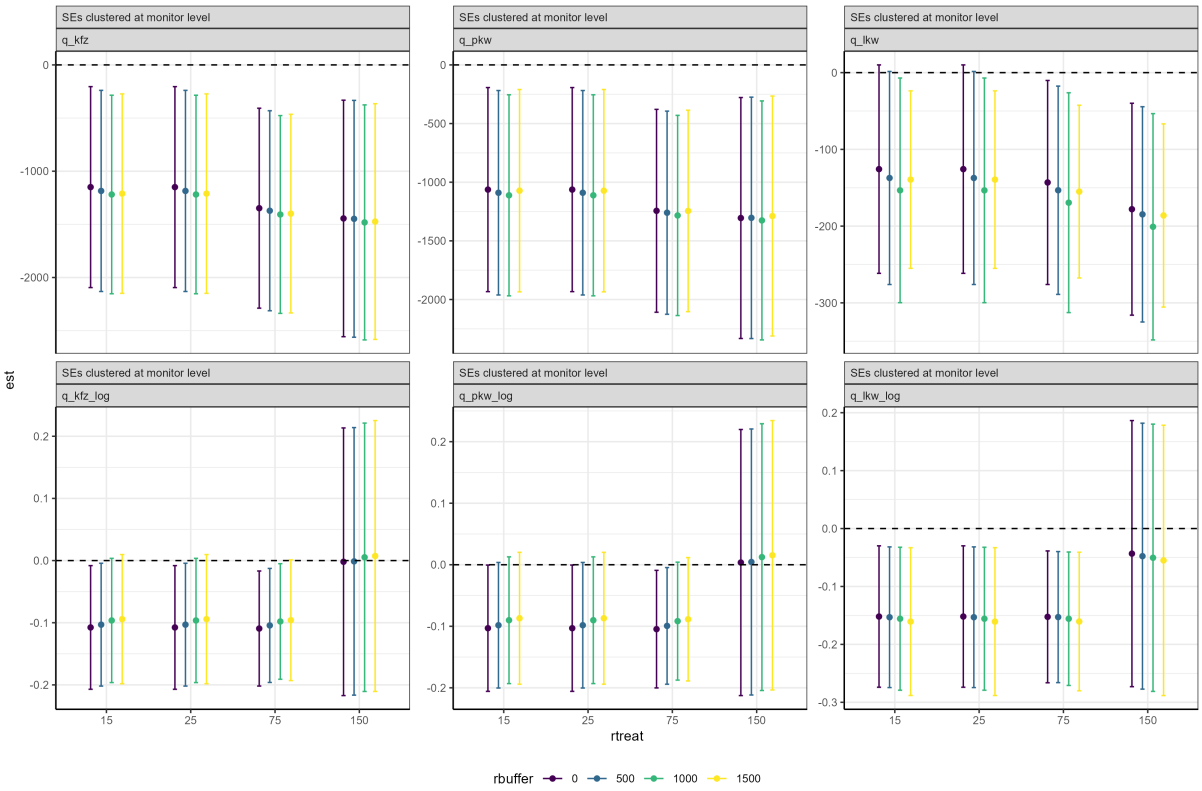
Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 4: Impact of diesel bans on traffic intensity (log)

	Log KFZ			Log PKW			Log LKW		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Post	−0.102*	−0.096	−0.095	−0.095	−0.090	−0.088	−0.163*	−0.156*	−0.161*
	(0.051)	(0.051)	(0.051)	(0.052)	(0.053)	(0.053)	(0.063)	(0.063)	(0.064)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	No	Quadr.	Quint.	No	Quadr.	Quint.	No	Quadr.	Quint.
Nobs	12767	12767	12767	12767	12767	12767	12767	12767	12767
N	229	229	229	229	229	229	229	229	229
Adj.R2	0.887	0.887	0.887	0.888	0.888	0.888	0.799	0.800	0.799

Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

Figure 7: Impact of diesel bans on traffic intensity across different treatment and buffer distances



Notes: rtreat - treatment radius; rbuffer - buffer radius; controls for temp., rain, sunshine, windspeed, rel. humidity with second order polynomials; monitor and year-month FEs; 95% CIs

Table 5: Weather robustness: Impact of diesel bans on KFZ intensity

	KFZ				Log KFZ			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Post	−1194.456*	−1182.903*	−1172.883*	−1213.492*	−0.092	−0.090	−0.085	−0.096
	(479.890)	(484.738)	(477.510)	(472.658)	(0.052)	(0.052)	(0.054)	(0.051)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mun-year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	Cubic	Quint.	Dec.	All	Cubic	Quint.	Dec.	All
Nobs	12767	12767	12767	12767	12767	12767	12767	12767
N	229	229	229	229	229	229	229	229
Adj.R2	0.927	0.927	0.927	0.927	0.887	0.887	0.887	0.887

Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 6: Weather robustness: Impact of diesel bans on PKW intensity

	PKW				Log PKW			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Post	−1087.025*	−1073.184*	−1061.213*	−1105.829*	−0.085	−0.083	−0.078	−0.089
	(439.971)	(447.644)	(440.142)	(432.919)	(0.053)	(0.054)	(0.056)	(0.053)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mun-year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	Cubic	Quint.	Dec.	All	Cubic	Quint.	Dec.	All
Nobs	12767	12767	12767	12767	12767	12767	12767	12767
N	229	229	229	229	229	229	229	229
Adj.R2	0.921	0.921	0.921	0.921	0.888	0.888	0.888	0.888

Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 7: Weather robustness: Impact of diesel bans on LKW intensity

	LKW				Log LKW			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Post	−153.372*	−166.488*	−167.867*	−150.995*	−0.152*	−0.152*	−0.151*	−0.151*
	(76.464)	(79.933)	(79.726)	(74.104)	(0.063)	(0.064)	(0.065)	(0.063)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mun-year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	Cubic	Quint.	Dec.	All	Cubic	Quint.	Dec.	All
Nobs	12767	12767	12767	12767	12767	12767	12767	12767
N	229	229	229	229	229	229	229	229
Adj.R2	0.457	0.457	0.456	0.457	0.800	0.800	0.800	0.800

Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 8: Impact of diesel bans on traffic intensity (w.o. Covid)

	KFZ			PKW			LKW		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Post	−770.4***	−809.1***	−794.7***	−608.3**	−646.5**	−627.7**	−185.1*	−184.8*	−189.3*
	(223.8)	(228.4)	(225.1)	(222.9)	(227.1)	(224.5)	(74.9)	(77.7)	(74.6)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	No	Quadr.	Quint.	No	Quadr.	Quint.	No	Quadr.	Quint.
Nobs	10732	10732	10732	10732	10732	10732	10732	10732	10732
N	229	229	229	229	229	229	229	229	229
Adj.R2	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.6	0.6

Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 9: Impact of diesel bans on traffic intensity (w.o. Covid, log)

	Log KFZ			Log PKW			Log LKW		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Post	−0.041	−0.026	−0.035	−0.032	−0.017	−0.026	−0.218*	−0.186*	−0.202*
	(0.050)	(0.057)	(0.053)	(0.050)	(0.058)	(0.054)	(0.089)	(0.089)	(0.088)
Monitor FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather	No	Quadr.	Quint.	No	Quadr.	Quint.	No	Quadr.	Quint.
Nobs	10732	10732	10732	10732	10732	10732	10732	10732	10732
N	229	229	229	229	229	229	229	229	229
Adj.R2	0.892	0.892	0.892	0.892	0.892	0.892	0.813	0.814	0.814

Treated monitors within 25m distance to a diesel ban. Control monitors in cities with diesel ban further away than 1000m from the ban. Standard errors clustered at the monitor level. Significance levels $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

6 Pre-trends

Figure 8: Event study regressions via TWFE

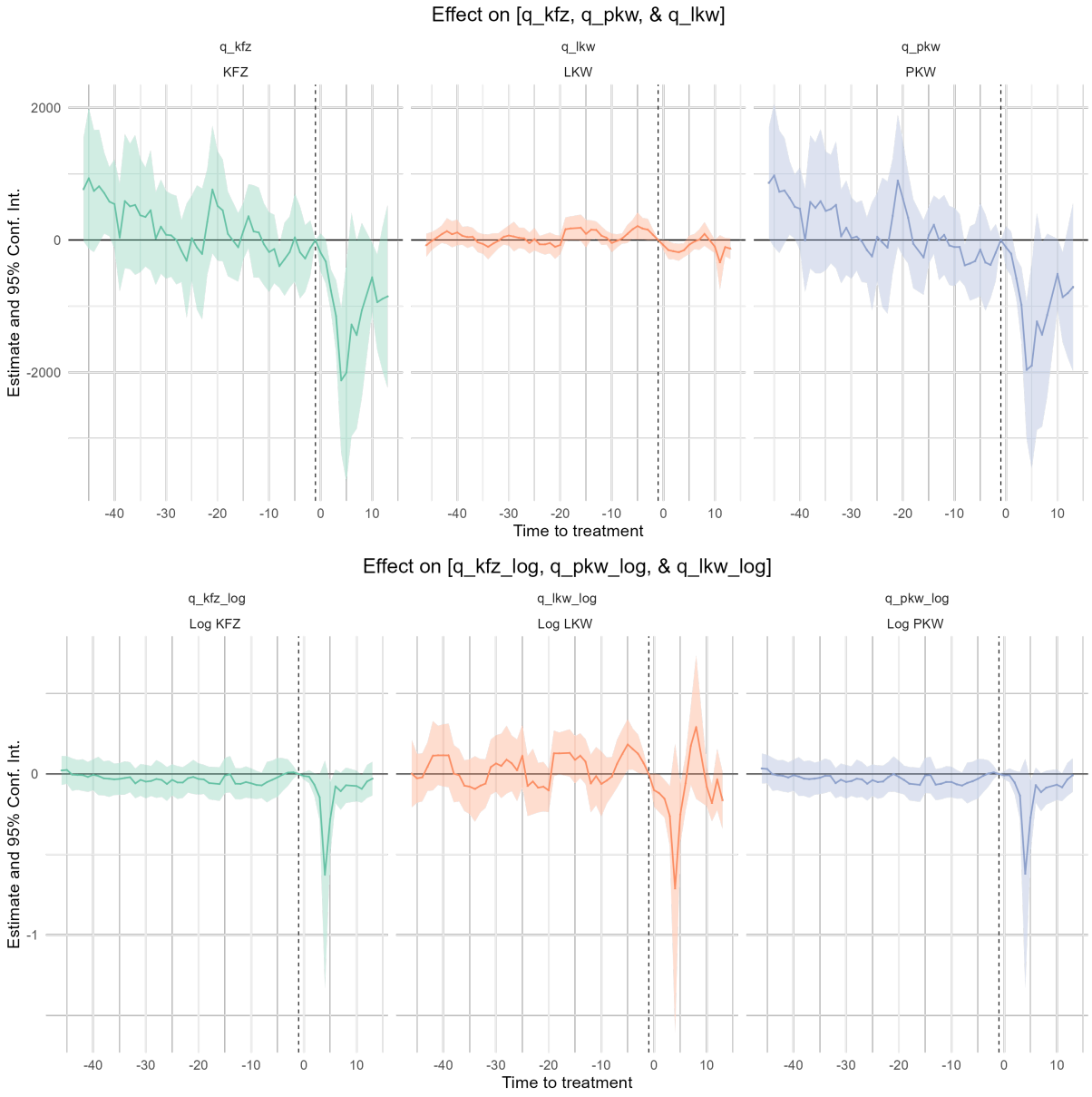


Figure 9: Event study regressions via TWFE (w.o. Covid)