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Pass-through of Temporary Fuel Tax Reductions: Evidence from Europe

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Abstract

Several European countries have implemented temporarily fuel tax reductions in 2022 to relieve the financial burden on their citizens. This paper provides estimates of the pass-through rates as well as the effect on retail margins for France, Germany and Italy. Using a unique data set containing daily consumer prices for gasoline and diesel, we employ a staggered Difference-in-Differences (DiD) design. Our results show a heterogeneous pass-through of the fuel tax reductions depending on the country and on the type of fuel. Nevertheless, we find a full- or even over-shifting of the tax cuts in all three countries. These findings also have important implications for the effective design of unconventional fiscal policy as well as for competition policy in the fuel market.

Keywords: Fuel Prices, Pass-through, Environmental taxes, Staggered DiD

JEL: H23, L13, L91, Q48

Declarations of interest: None

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1. Introduction

More than two years after the beginning of the COVID-19 pandemic many countries worldwide exhibit very high inflation rates. The reasons are a recovering demand in combination with ongoing supply chain problems as well as the war of aggression in the Ukraine.

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In April 2022, the inflation rate of Germany has reached 7.4%, the highest rate since 1981. Other western countries have similar rates: the inflation rate of the whole EU has been 8.1%, the US even had a rate of 8.3% in April 2022. In autumn 2022, inflation in some countries has already risen to around 10%.[1]

In this situation many governments try to relieve their citizens with tax reductions or transfer payments. On April 27, 2022, the German government announced a (second) stimulus package worth 14-16 billion Euro.[2] Beside new transfer payments and a cheap, nationwide public transport ticket (*€9 ticket*), it also included a temporary reduction of the energy tax rate from June 1 to August 31, 2022 at an estimated cost of 3.15 billion Euro.[3] Since the energy tax is levied on fuel products in Germany, this might also have had an effect on retail fuel prices. However, the consumers would only benefit from this regulation if the petroleum companies pass-through the tax reduction sufficiently.

Also other countries of the EU as France or Italy have implemented a temporary fuel tax reduction. In France, the government introduced a fixed fuel discount between April 1 and August 31, which later has been extended until the end of the year 2022. The Italian government had already approved a subsidy program in March including a fuel tax reduction from March 22 until the end of April. Also this intervention has later been extended until 31 December 2022. Those government actions provide us with ideal exogenous shocks, which we can use as a natural experiment.

In this paper, we estimate the pass-through rate and the effect on the retail margins of the temporary fuel tax reductions in the three largest countries of continental Europe (measured by GDP), namely France, Germany and Italy. Austria, Estonia, Lithuania, and

[1]See `https://www.global-rates.com/de/wirtschaftsstatistiken/inflation/inflation.aspx`. (Last accessed: October 19, 2022).

[2]See `https://www.bundesfinanzministerium.de/Content/DE/Pressemitteilungen/Finanzpolitik/2022/04/2022-04-27-zweites-entlastungspaket.html`. (Last accessed: October 19, 2022). The package was approved by the German parliament on May 13.

[3]See `https://www.bundestag.de/dokumente/textarchiv/2022/kw20-de-energiesteuersenkungsgesetz-894664`. (Last accessed: October 19, 2022).

Latvia are being selected as appropriate control countries for the purpose of this analysis because these nations did not introduce any fuel tax reduction measures during the year 2022. Using a unique data set containing daily consumer prices for gasoline and diesel on service station chain level, we compute the pass-through rates and changes in the margins by employing a staggered Difference-in-Differences (DiD) approach.

Our results imply a heterogeneous passing on of the fuel tax reductions depending on the country as well as on the type of fuel. However, we find the following two key results. First, the average pass-through rates are very high so that there is a full- or even over-shifting of the temporary tax reductions, indicating highly competitive markets. Second, the estimated pass-through rates are higher for gasoline than for diesel, which results from the special situation on the European energy markets in 2022 following the Russian invasion of Ukraine and a relating high demand of (heating) diesel.

The results of our paper have implications for the effective design of unconventional fiscal policy and are also relevant for competition policy. Unconventional fiscal policy can only be effective in stimulating demand if consumers expect tax reductions to be passed through by firms. Besides, such fuel tax reductions also have distributional- and climate-economical effects. While the discount may act like a redistribution from bottom to top as particularly high-income consumers with large cars are benefiting, it is generally questionable whether subsidizing fossil fuels is a good idea in times of climate change.

The rest of the paper is structured as follows. Section 2 presents related literature, followed by a description of retail fuel markets in Section 3. We present our data set and descriptive statistics in Section 4. In Section 5, we explain our empirical strategy and then present the estimation results in Section 6. We conclude in Section 7 by discussing policy implications and limitations.

2. Related Literature

Since gasoline markets are typically characterized by a very specific cyclical pricing pattern, academia as well as competition authorities are highly interested in analyzing this industry sector. The leading theory to explain price cycles in gasoline markets are Edgeworth price cycles. This theory has been formalized by Maskin and Tirole (1988) and assumes a dynamic oligopoly game where firms compete in prices and sell homogeneous goods. Starting at a supra-competitive price, firms undercut each other until the price reaches marginal costs. Given that there is no gain to lowering prices further, firms play a war of attrition. After one firm relents the price back to a high level, the other follow and the cycle begins anew (see Noel et al. (2011)).

In contrast to the literature mentioned above, other authors discuss the possibility of tacit collusion in gasoline markets. Since petrol stations can easily observe and monitor price changes as well as learn the price setting behavior of their competitors, an explicit agreement is not necessary to establish such an behavior. Evidence for collusion in gasoline markets has been found for Australia (Byrne and De Roos (2019)) and Norway (Foros and Steen (2013)). With respect to Germany, Dewenter et al. (2017) show that the introduction of the 'Markttransparenzstelle für Kraftstoffe' (market transparency unit for fuels, MTS-K)[4] in 2013 has increased both gasoline and diesel prices. Assad et al. (2020) find that algorithmic pricing has a significant effect on competition in the German gasoline market.

Another strand of the literature analyzes the effects of changes in the crude oil price on refined petroleum products. Here, most of the papers are focused on the oil-gasoline relationship. It has been shown that downstream prices seem to respond to increases in upstream prices more rapidly than their responses to decreases in upstream prices, so that

[4]The MTS-K is an independent unit of the German competition authority. All petrol stations in Germany are legally bound to inform the MTS-K about price changes in real time (see https://www.bundeskartellamt.de/EN/Economicsectors/MineralOil/MTU-Fuels/mtufuels_node.html;jsessionid=0E947D4936B3B12872C630A4005CED95.2_cid378).

there is a potentially asymmetric pass-through of increasing and decreasing costs ('rockets and feathers') (e.g., Grasso and Manera (2007); Noel (2009); Noel (2015)). In this context, similar studies explore the causes for this asymmetric relation between crude oil and gasoline. They identify refinery utilization rates and inventories as a main driver of those asymmetries (e.g., Kaufmann and Laskowski (2005); Perdiguero-Garcia (2013))

Recent papers also analyze the pass-through of taxes and excise duties on fuel prices. In general, pass-through rates depend on consumer behavior as well as on competition parameters (e.g., Montag et al. (2021); Genakos and Pagliero (2022); Harju et al. (2022)). The effect of tax changes on market prices primarily depends on supply and demand elasticities (Edgeworth (1897)). In a perfectly competitive market, the pass-through rate will increase in the elasticity of supply and decrease in the elasticity of demand. However, if competition is not perfectly competitive, the pattern of tax incidence becomes more complex and several degrees of tax shifting are possible: under-, full- and over-shifting to consumers (see Appendix A). Besides, not only the horizontal market structure but also vertical market power has to be considered (Fuest et al. (2020)).

Some empirical results indicate that the coefficient associated with taxes on gasoline prices is not statistically different from one (or slightly less than one) (e.g., Marion and Muehlegger (2011); Bello and Contín-Pilart (2012); Li et al. (2014)). In contrast, other studies find that a higher percentage of a tax increase is passed to consumers than a tax reduction (Doyle Jr and Samphantharak (2008); Silvia and Taylor (2014)) or identify state-specific rates of pass-through (Kaufmann (2019)).

3. The Retail Fuel Market

The fuel market is characterized by a vertical structure, with refineries producing fuels from crude oil in the upstream market and selling them to fuel stations, which in turn distribute the fuels to end customers (downstream market). In our study, we focus on the analysis of retail prices on the service station chain level, however, an understanding of the upstream sector is still relevant, especially for the calculation of margins. During fuel production a barrel (42 gallons) of crude oil can be refined into 19 gallons of gasoline, 12 gallons of diesel and 13 gallons of other products.[5] In addition to crude oil, refineries also add other oils and liquids to the finished products that are sold to the petrol stations.

After significant increases in the European retail fuel prices at the beginning of 2022, several countries adopted measures with the aim of relieving consumers. For our analysis, we focus on the three largest economies in continental Europe that have introduced reductions of excise duties on fuel or similar measures, explicitly Germany, France, and Italy. To choose appropriate control countries for our staggered DiD approach, we need to find countries of the European Union (EU) which have not implemented any regulations in the fuel market in 2022. Table 1 presents an overview of policies introduced in all member states of the EU. It is obvious, that there are numerous overlaps in timing (i.e., measures came into force on the same day), which prevent a comparison. Apart from that, there are several countries that have chosen VAT reductions or price caps as policy measures, which also reduces comparability (due to varying magnitude of actual discounts over time). The consideration of all countries shows that by these criteria the majority of all EU countries are not eligible as control countries for our analysis.[6] Yet, Austria, Estonia, Latvia, and Lithuania, as countries that have not introduced any regulations, are considered suitable for comparison.

[5]See https://www.eia.gov/energyexplained/oil-and-petroleum-products/refining-crude-oil-inputs-and-outputs.php (Last accessed: October 19, 2022).

[6]Belgium, Croatia, Hungary, Poland, Portugal, and Slovenia have introduced regulations other than a fixed tax reduction/discount. Bulgaria, Czech Republic, Ireland, the Netherlands, Spain, and Sweden were excluded as additional treated countries for timing reasons. Due to their specific geographical location, data unavailability and/or a currency other than the Euro we decided not to consider Cyprus, Denmark, Finland, Greece, Malta, Romania, and Slovakia.

Country	Country Code	Type of Measure	Date (mm/dd/yy)	Tax reduction		in Sample?
				E5	Diesel	
Austria	AT	–	–	–	–	Control
Belgium	BE	VAT reduction + Fuel tax reduction	02/01 + 03/19/22	15% + 17.5ct/l	15% + 17.5ct/l	–
Bulgaria	BG	Fixed discount	07/09/22	13ct/l	13ct/l	–
Croatia	HR	Price cap	10/17/21			–
Cyprus	CY	–	–	–	–	–
Czech Republic	CZ	Fuel tax reduction	06/01/22	1.5CZK/l	1.5CZK/l	–
Denmark	DK	–	–	–	–	–
Estonia	EE	–	–	–	–	Control
Finland	FI	–	–	–	–	–
France	FR	Fixed discount	04/01/22	15ct/l	15ct/l	Treatment
Germany	DE	Fuel tax reduction	06/01/22	29.55ct/l	14.04ct/l	Treatment
Greece	GR	–	–	–	–	–
Hungary	HU	Price cap	11/11/21			–
Ireland	IE	Fuel tax reduction	03/10/22	20ct/l	15ct/l	–
Italy	IT	Fuel tax reduction	03/22/22	25ct/l	25ct/l	Treatment
Latvia	LV	–	–	–	–	Control
Lithuania	LT	–	–	–	–	Control
Luxembourg	LU	Fuel tax reduction	03/31/22	7.5ct/l	7.5ct/l	-
Malta	MT	–	–	–	–	-
Netherlands	NL	Fuel tax reduction	04/01/22	17.3ct/l	11.1ct/l	–
Poland	PL	VAT reduction	02/01/22	15%	15%	–
Portugal	PT	"Autovoucher" (limited to 50l/month)	11/01/21	10ct/l	10ct/l	–
Romania	RO	–	–	–	–	–
Slovenia	SI	Price cap	03/15/22	–	–	–
Slovakia	SK	–	–	–	–	–
Spain	ES	Fixed discount	04/01/22	20ct/l	20ct/l	–
Sweden	SE	Fuel tax reduction	06/01/22	17ct/l	17ct/l	–

Table 1: Overview of fuel tax reductions in all EU member states. In the case of fuel tax reductions given values are excl. associated VAT reduction. Sources: https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices (last accessed on 07/08/2023).

The retail fuel markets in all countries of our sample are characterized by an oligopoly. Those oligopolists operate nationwide, while there are also smaller suppliers with a single or small number of service stations that operate on a regional basis. For instance, in Germany five firms (Shell, BP/Aral, Esso, Total, and Jet) combine a market share of 67%. In the other countries, the market shares of the oligopolists are within a comparable range (see Table 2). Differences in the total number of service stations are primarily related to country size and population.

In contrast, the upstream markets in the individual countries of our sample have larger differences. In Austria, for example, there is only one refinery, and the majority of fuel is imported from Germany. France also has a relatively small number of refineries and refining capacity in relation to the market size, resulting in a more inelastic supply side compared to

Germany and Italy. Estonia, Latvia, and Lithuania do not have any (or only one) refinery and are therefore also strongly dependent on fuel imports. However, we incorporate these observable differences between countries by including the refinery utilization, imports of crude oil and petroleum products, and the number of gas stations per chain as control variables into our empirical analysis (see Sections 4 and 5).

		Austria	**Estonia**	**France**	**Germany**	**Italy**	**Latvia**	**Lithuania**
Downstream	**Number of fuel stations**	2,759	515	11,040	14,452	21,700	600	765
	Oligopoly members	BP, ENI, Jet, OMV, Shell	Alexela Oil, Neste, Circle K, Olerex, Saare Kütus	Shell, Aral, Esso, Total, Jet	Shell, Aral, Esso, Total, Jet	Eni, Q8, Esso, Tamoil	Circle K, Neste, Viada, Virsi-A	Viada, Circle K, Neste, Baltic Petroleum
	Market share of oligopolists	67%	≈ 54%	62%	67%	49%	≈ 52%	≈ 51%
Upstream	**Number of refineries**	1	0	6	11	10	0	1
	Refinery capacity (in Mt/a)	9.80	0	58.20	100.90	83.90	0	9.60

Table 2: Overview of relevant market characteristics in all countries considered. When market share values were not publicly available, they were approximated based on the stations in our dataset relative to all stations (denoted by ≈). Sources: Statistical Report 2023, FuelsEurope, https://www.fuelseurope.eu/publications/publications/statistical-report-2023.

Considering retail fuel prices, it becomes clear that the price of crude oil accounts for an important share of prices and their fluctuations. Yet, taxes and other duties account for the largest share. Table 3 summarizes the excise duties on gasoline and diesel for the countries in our data set. All countries levy a lower excise duty on diesel than on gasoline, with Germany having the largest diesel privilege (at least without taking into account the temporary fuel tax reductions). Without considering any temporary tax reductions, Austria has the lowest excise duties for fuel and Italy has the highest ones. All countries also levy an additional Value-added tax (VAT) on gasoline and diesel.[7] In Germany, an additional fuel carbon tax of 7.2 cents (8.03 cents) on gasoline (diesel) and an additional fuel storage fee of 0.27 cents (0.30 cents) on gasoline (diesel) are levied.

[7] VAT rates are as follows: 19% in Germany, 20% in Austria, Estonia, and France, 21% in Latvia and Lithuania, and 22% in Italy. To calculate margins and pass-through rates we include VAT reductions associated with the energy tax reductions/discounts to consider the overall reductions.

In Germany, the excise duty on fuel ("energy tax") has been lowered by 29.55 cents per liter for gasoline (35.20ct incl. VAT) and by 14.04 cents per liter for diesel (16.70ct incl. VAT) for the period between June 1 and August 31, 2022.[8] With this reduction, Germany has lowered the excise duty on fuel to the minimum level permitted in the EU. In Italy, a reduction of the excise duty on gasoline and diesel by 25 cents per liter (30.50ct incl. VAT) has been introduced from March 22, 2022 on.[9] This measure was initially limited until April 30, but was extended shortly after and ultimately lasted until the end of 2022. The French government has passed a law that introduced a discount for all important fuel products by 15 cents per liter (18.00ct incl. VAT) from April 1, 2022 on.[10] On September 1, the fuel discount has even been increased from 15 to 25 cents per liter and in addition has been extended until December 31, 2022.[11] This discount was paid as a subsidy for quantities sold to the distributor at the second-last distribution level. Based on the termination of the tax reduction in Germany on August 31, 2022 and the simultaneous change of the discount in France, we have chosen an observation period until August 31, 2022.

Even though technically the introduced discount in France is different compared to the tax reductions in Germany and Italy, basically it has a similar effect on the costs of the retailers (i.e., service stations). For this reason, it is referred to as a reduction of excise duties paid on the retail-level in the following. In our empirical analysis (see Section 5 and 6), we compare our estimated coefficients with the overall tax reductions (also including the associated VAT changes), which are also given in Table 3. With regard to the imple-

[8]See: https://www.bundestag.de/dokumente/textarchiv/2022/kw20-de-energiesteuersenkungsgesetz-894664 (Last accessed: July 10, 2023).

[9]See: https://www.gazzettaufficiale.it/eli/id/2022/03/21/22G00032/sg and https://www.loc.gov/item/global-legal-monitor/2022-05-31/italy-new-law-reduces-excise-taxes-and-vat-on-fuels-to-ameliorate-financial-crisis-caused-by-war-in-ukraine/ (Last accessed: July 10, 2023).

[10]See: https://www.legifrance.gouv.fr/download/pdf?id=Yhu9yt95Vn93t_PqwVk79FdAV-pqnhpuwM5LZBeTr90= (Last accessed: July 10, 2023).

[11]See https://www.connexionfrance.com/article/French-news/How-the-French-government-fuel-discount-will-change-from-September-1 (Last accessed: July 12, 2023)

mented measures, it is important to note that these represented a one-time reduction in all treated countries. In Austria, Estonia, Latvia, and Lithuania, the tax rate remained constant throughout the whole observation period (see Figure 8 in Appendix C).

		Gasoline (E5)				Diesel			
Country	Treatment	Pre	Post	Difference	Diff. incl. VAT	Pre	Post	Difference	Diff. incl. VAT
Austria	–	48.00		–	–	40.00		–	–
Estonia	–	42.277		–	–	39.292		–	–
France	04/01/2022	68.29	53.29	- 15.00	- 18.00	59.40	44.40	- 15.00	- 18.00
Germany	06/01/2022	65.45	35.90	- 29.55	- 35.20	47.04	33.00	- 14.04	- 16.70
Italy	03/22/2022	72.84	47.84	- 25.00	- 30.50	61.74	36.74	- 25.00	- 30.50
Latvia	–	41.121		–	–	33.295		–	–
Lithuania	–	43.443		–	–	33.017		–	–

Table 3: Excise Taxes on Gasoline (E5) and Diesel in cents per liter. Source: https://ec.europa.eu/taxation_customs/tedb/

4. Data and Descriptive Statistics

4.1. Data Collection

Our analysis is based on five different data sources. First, we scraped data on daily average gasoline (E5) and diesel consumer prices on a service station chain level from the information platform *Fuelo*. These prices on *Fuelo* are the basis of our analysis. *Fuelo* uses official sources as well as information from consumers, publishes this on its website and displays historical information on a daily average level. Real-time price updates are not considered relevant for our analysis as the platform only provides the historical price averages at the service station chain level.[12] The data from *Fuelo* also provides information on the number of fuel stations per service chain. Incorporating this measure serves a dual purpose. Firstly, it helps control for variations in the number of stations across different countries. Secondly, it takes into account the fact that the average fuel prices displayed on the Fuelo website are constructed based on different numbers of chain stations in each

[12] Example for German prices from February 2, 2022, https://de.fuelo.net/prices/date/2022-2-2?lang=en. (Last accessed: July 11, 2023). Statement from Fuelo on their sources: https://de.fuelo.net/prices/last_updated?lang=de. (Last accessed: July 11, 2023).

country.[13]

Second, we use data on the crude oil price Brent from *Onvista* and exchange rates from Dollar into Euro by the Federal Reserve Bank of St. Louis (FRED) to highlight the relation between consumer prices and the Brent price.[14] The Brent price is also a crucial part to determine retail margins.

Third, we incorporate data on refinery capacities and convert them into a measure of refinery utilization, which indicates how efficiently the refineries are utilizing their maximum capacity. It is crucial to control for refinery utilization in our analysis, since gasoline and diesel can either be produced domestically within the country or imported from other countries. To assess this, we utilize data from both *Concawe* and *Eurostat*.[15] *Concawe* provides annual national-level data on refinery capacities, measured in mega tonnes per annum (Mt/a). With the assistance of *Eurostat* data on the supply (and transformation) of oil and petroleum products, we convert these capacities into a measure of refinery utilization.

Exact calculation of the utilization rate needs some clarification. Before the utilization rate can be determined the domestic production must be calculated from several variables, i.e. the stream of raw oil, loss from refining the crude oil, changes in stock, releases of strategic reserve or inflow from marine bunkers.[16]

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[13] See, Appendix B, Table 8 for the distribution of number of service chain stations in the data. Note: Data from Fuelo has a large market coverage. Example: Germany had 14,452 stations in 2022. Our scraped data covers 10,600 stations.

[14] See historical Brent prices, https://www.onvista.de/rohstoffe/db-Oelpreis-Brent-26262975 and exchange rates from FRED, https://fred.stlouisfed.org/series/DEXUSEU. (Last accessed: July 11, 2023).

[15] See information from Concawe, https://www.concawe.eu/refineries-map/ and Eurostat https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_oilm/default/table?lang=en. (Last accessed: July 11, 2023).

[16] *Eurostat* provides information from the Monthly Oil and Gas questionnaire at page 10, No. 11 on how the gross inland deliveries are determined and we will use this to rearrange this equation for domestic production (https://ec.europa.eu/eurostat/documents/38154/42198/MOS_v2012.1.pdf/f4a7a75c-b0d1-4370-802a-560ca5f86f4d#:~:text=Gross%20inland%20deliveries%20(Observed)%3A,.)%20to%20the%20inland%20market. (Last accessed: July 11, 2023)). From the data of *Eurostat* we calculate domestic production for petroleum products with the formula: Domestic Production = Gross inland deliveries - Primary product receipts - Recycled products + Refinery fuel - Imports + Exports

The capacities provided by *Concawe* and *Eurostat* are available on a yearly basis, while the data for refinery utilization is required on a monthly level. To bridge this gap, the yearly capacities are converted into monthly capacities by dividing them by 12. Dividing the monthly domestic production by monthly available capacity determines the utilization of the refinery on a monthly level. Controlling for these refinery utilization possesses the opportunity to rule out differences at the supply side from the local refinery level, i.e. from breakdown in the refinery or loss of access to crude oil.

Fourth, to account for variations in the total imports of oil and petroleum products, we incorporate national-level data from *Eurostat* specifically related to the imports of these products. These imports are measured in thousands of tonnes. By controlling for changes in imports, we aim to capture another aspect of supply-side changes that are likely to be significantly influenced by the outbreak and ongoing war in Ukraine.[17]

4.2. Descriptive Statistics

Our final data set includes consumer price data in Euro per liter for seven European countries Germany, France, Italy, Austria, Lithuania, Estonia and Latvia during the period from January 3 to August 31, 2022.

Table 7 in Appendix C presents the summary statistics divided by countries. To calculate the margins, we simply subtract taxes and duties as well as the share of the crude oil price (Brent price) attributable to the production of diesel and gasoline from the gross consumer prices.[18] Even though these margins still contain different cost types (e.g., cost of refining,

+ International marine bunkers - Interproduct transfers + Products transferred + Stock changes. Note: Refinery gross output denotes what we call domestic production. Statistics from *Eurostat* regarding what they refer to as *indigenous production* is not available.

[17] See: *Eurostat*, imports of oil and petroleum products by partner country, https://ec.europa.eu/eurostat/databrowser/view/NRG_TI_OILM__custom_6837161/default/table?lang=en. (Last accessed: July 11, 2023).

[18] An important note is that our measure of retail margins includes the refinery margin, the station margin, as well as different cost types such as the cost of refining or the cost of transportation. For a detailed description on the calculation of margins see Appendix B.

transportation costs), with the crude oil price we can eliminate the main source of input cost variation.

The data set contains 12,515 observations on a service station chain level. For each country we observe a different number of chains present in the data (see Table 8 in Appendix C).[19] For instance, Germany has 15 different service station chains present in the data, whereas Austria has six. Overall, there are 30 chains in the treated country's data and 22 chains in the non-treated data.[20] Countries display variations in terms of refinery utilization, the number of stations per chain, and total imports of oil and petroleum products. To illustrate this point, a comparison of Germany and Austria serves as an examples. When comparing these two countries, we observe differences in the magnitude of imports of oil and petroleum products (mean: 10,191 v. 987; measured in thousand tonnes), refinery utilization (mean: 0.91 v. 0.55; represented by decimal units) and the number of fuel stations operated per chain (mean: 706 vs. 196). By incorporating these covariates into our analysis, we aim to account for and capture differences in the pre-existing trends and characteristics across countries. These factors help us consider the unique features and dynamics of each country's fuel market.[21]

[19] Fuelo's market coverage per service station chain varies and total market coverage is different across countries. However, it is worth mentioning that the geographic coverage within countries comprises almost their entirety, which can be substantiated through visual inspection. Nevertheless, the goal of this study is to analyze the overall pass-through rate. In this respect, our identification strategy relies on the comparison of the evolution of country-wide large chains average prices, such as most important players Shell, Esso, or Total rather than analyzing the entire market.

[20] The estimation will utilize the not-yet-treated characteristics of the data. During the time periods when part of the data is not yet treated these chains will be used as a comparison group.

[21] Estonia and Latvia do not have a refinery. For regression purpose the values are set to zero. For E5 in Lithuania (Estonia) there are 9 (2) observations missing which are filled by the last available value of the respective chain to complete the series. For some months in Lithuania refinery utilization is sometimes slightly larger than 1. This probably comes from data accuracy and calculations from an annual capacity to a monthly levels.

	Country	Austria	Estonia	France		Germany		Italy		Latvia	Lithuania
		Pre	Pre	Pre	Post	Pre	Post	Pre	Post	Pre	Pre
Fuel Price	E5	1.783	1.857	1.916	2.038	1.947	1.861	1.948	1.983	1.803	1.738
	Diesel	1.815	1.759	1.886	2.065	1.881	1.968	1.840	1.960	1.753	1.726
Fuel Margin	E5	0.273	0.392	0.257	0.392	0.204	0.352	0.228	0.372	0.347	0.270
	Diesel	0.386	0.342	0.323	0.505	0.326	0.465	0.253	0.467	0.387	0.367
Relative Fuel Margin/Lerner-Index	E5	0.260	0.345	0.278	0.330	0.220	0.310	0.260	0.320	0.318	0.262
	Diesel	0.337	0.310	0.324	0.392	0.309	0.374	0.277	0.374	0.338	0.329

Table 4: Summary statistics of fuel prices and margins by country before (pre) and after (post) the tax decrease (Numbers in Euro per liter, except the relative margins).

Despite these differences across countries, Table 4 reports that the average price level of diesel and gasoline is very similar across the seven countries, although prices are smaller in Austria, which is mainly driven by the low fuel taxes in this country. Concentrating on the treated countries (France, Germany, Italy), we mostly observe higher average consumer prices after the fuel tax reductions (compare *Pre* and *Post* in Table 4).[22] Even though this seems to be counterintuitive at first glance, this is mainly driven by the increasing price for crude oil during our observation period (see development of the Brent prices in Figure 1), which has mostly overcompensated the decreased fuel taxes. Table 4 also shows that the absolute as well as the relative retail margins for diesel and gasoline have increased in Italy and Germany after the fuel tax reductions, while they started to decrease in France after the introduction (on average).[23]

Figure 1 visualizes the development of the average median consumer prices and Figure 2 shows the daily average retail margins. The figures are divided into sub figures to point out the development of gasoline (upper) and diesel (middle) of the seven European countries during our observation period. The Brent price (lower) is also depicted to highlight the strong link to the market price for crude oil. The vertical lines reflect the introduction of the respective tax reductions in Italy (March 22, yellow), France (April 1, blue), and Germany (June 1, red). In fact, the prices as well as the margins in the seven countries tend

[22] It is worth mentioning that the definition of the *Pre* and *Post* periods is distinct for the three treated countries due to the different implementation dates of the fuel tax reductions.

[23] Relative retail margin reflects the simple Lerner-Indices formula, dividing the absolute margins by net prices.

to follow the same trend before the policy changes. In all countries, there is also a noticeable increase in both, prices and margins, at the end of February when the war in the Ukraine has started.

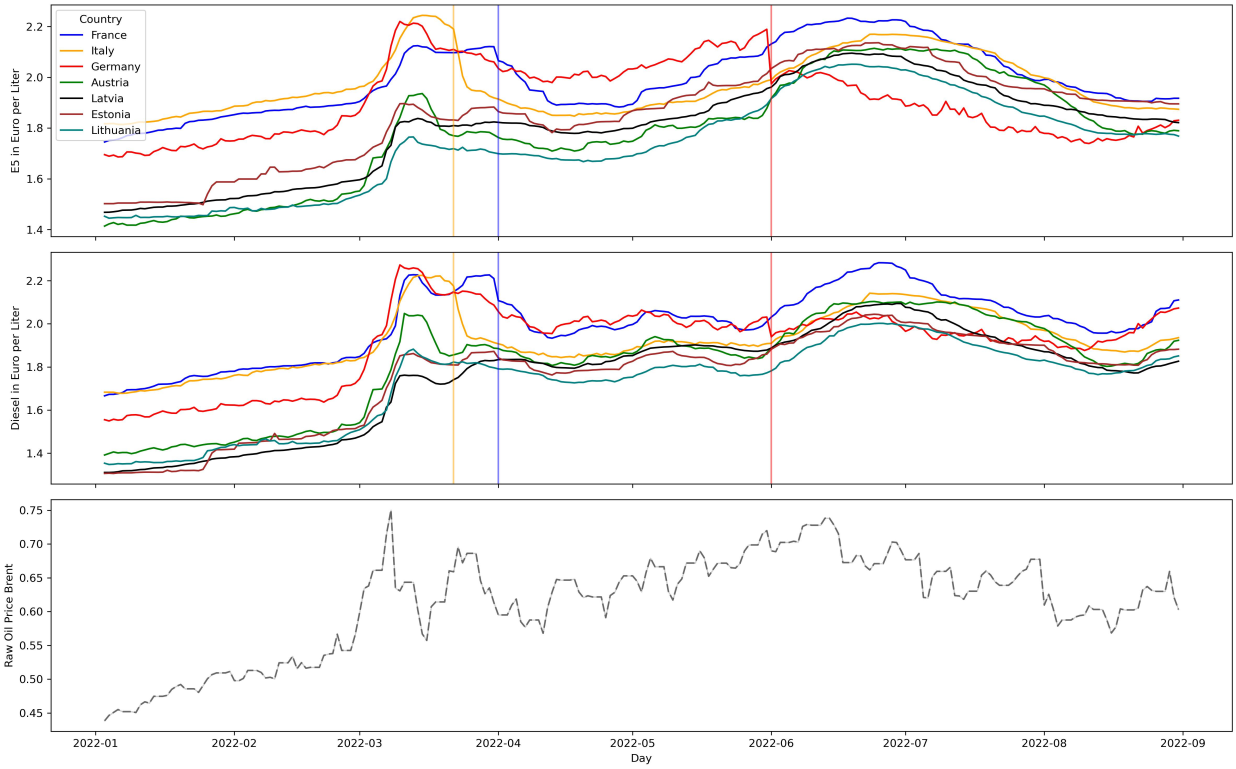

Figure 1: Development of consumer prices for gasoline (upper) and diesel (middle). The vertical lines reflect the introduction of the respective tax reductions in Italy (March 22, yellow), France (April 1, blue), and Germany (June 1, red). Brent prices (lower) in Euro per Liter is denoted in dashed grey.

With respect to the diesel and gasoline consumer prices, Figure 1 shows that both have decreased in the first phase after the respective fuel tax cuts in the three treated countries. However, they tend to increase again after a while which is mainly driven by the price increase for crude oil (depicted in dashed grey in the lower sub figure).[24].

Simultaneously, the absolute (and also the relative) effect on retail margins exhibits similar trends between the three treated countries (see Figure 2). Gazing upon the margins reveals a slight difference between the countries. While the margins have increased

[24]To have a better understanding of the individual consumer price curves, we additionally present the gasoline and diesel price development for the seven countries separately in Figure 7 of Appendix C.

in Germany for diesel and gasoline, in France and Italy they immediately started to decrease after the temporary tax reduction. In relative terms these margins (see Figure 10 in Appendix B) reflect the Lerner-Indices (Lerner, 1934; Giocoli, 2012) which ranges from 0 (no market power) to 1 (monopoly market power). Interpretation of this crude measure of market power is problematic, especially without deep knowledge about the exact cost structure on all parts of the vertical chain within the fuel market and should be carried out with caution (Elzinga and Mills, 2011). Therefore, the large increase and long-term shift in the margins seen in the mid of March 2022 may be prominent but the exact cause cannot be determined without detailed market information on costs and is not part of this paper. In this regard, our empirical analysis will show that these changes in margins are on average not affected by the tax reductions.

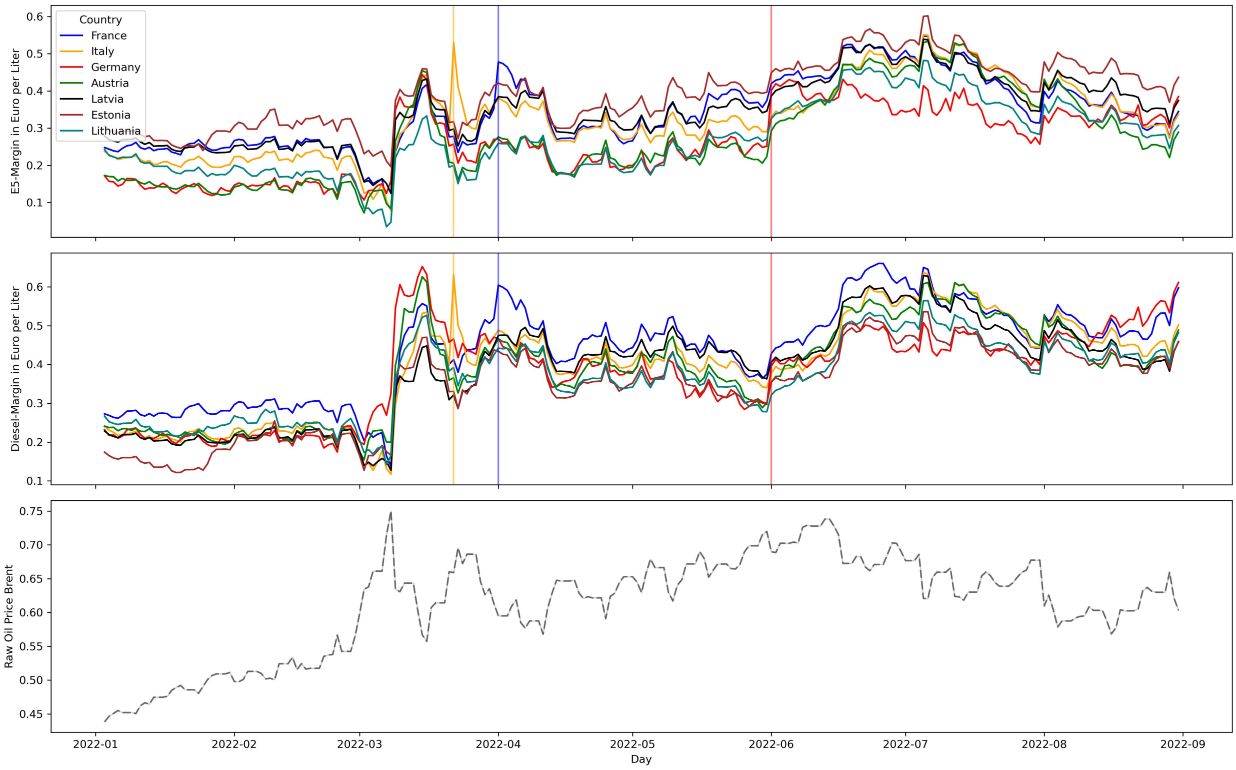

Figure 2: Development retail margins for gasoline (upper) and diesel (middle). The vertical lines reflect the introduction of the respective tax reductions in Italy (March 22, yellow), France (April 1, blue), and Germany (June 1, red). Brent prices (lower) in Euro per Liter is denoted in dashed grey. See relative retail margins in Figure 10 in Appendix B.

5. Methodology

In our empirical analysis, we estimate the impact of the temporary fuel tax reductions on fuel prices and retail margins. In order to do this, we compare the evolution of consumer prices and retail margins at fuel stations in Germany, France, Italy, Austria and the Baltic States, before and after the reductions of the fuel taxes.

We apply a staggered Difference-in-Differences (DiD) design to causally estimate the effect of the temporary fuel tax reduction on fuel prices and retail margins. In contrast to the canonical DiD setup, the staggered design allows to estimate the unbiased average treatment effect on the treated (ATT) when there are more than two time periods and variation in timing of the treatment. This design is more credible and robust than the canonical DiD with a single treatment period because including multiple treatments plausibly alleviates concerns that contemporaneous trends drive the observed treatment effects (see, e.g., Baker et al. (2022)). Goodman-Bacon (2021) shows that time-varying treatment effects can create a bias in the static two-way fixed effects (TWFE) DiD estimate since earlier-treated units act as effective controls for later-treated units so that the resultant DiD estimates could reflect differences in treatment effects over time between different treatment groups.

Hence, more recent papers propose alternative DiD estimators that do not suffer from the pitfalls associated with TWFE described above (De Chaisemartin and d'Haultfoeuille (2020); Sun and Abraham (2021); Callaway and Sant'Anna (2021)). We follow the recent DiD methodology developed by Callaway and Sant'Anna (2021) as it allows to estimate a time-varying and cohort-specific ATT using not-yet-treated or never-treated as clean controls. Specifically, we estimate the following stylized regression:

$$y_{ijt} = X'\beta + \tau_{it} \cdot TAX_{it} + \eta_{ij} + \lambda_t + \epsilon_{it}, \tag{1}$$

where y_{ijt} denotes the consumer price (or retail margin) of gasoline or diesel sold by gas station chain j in country i at date t, and TAX_{it} is a dummy variable that equals one when country i implements a temporary fuel tax reduction at date t (note that France, Italy and Germany implemented there reductions at different dates, see Section 3). The vector X' contains our control variables refinery utilization rate, total imports of oil and petroleum imports and number of gas stations.[25] The variable η_{ij} corresponds to state-gas station chain fixed effects and controls for any time-invariant differences between the countries in our dataset. Finally, λ_t gives the day fixed effects, which capture the transitory shocks that identically affect the individual countries, such as fluctuations in the price of crude oil or the conflict in the Ukraine.

Let us further assume that G_i contains i different states treated at different points of time and C_i is a set of never treated states. Then, under the parallel trend and anticipation assumptions (Wooldridge (2021)) we can estimate the ATT for a treatment-timing group g at a point in time as the group-time average treatment effect using never-treated (2) or not-yet-treated (3) units as controls by using the R package as provided by Callaway and Sant'Anna (2021):[26]

$$ATT(g, t) = E[Y_t - Y_{g-1}|G = g] - E[Y_t - Y_{g-1}|C = 1]. \tag{2}$$

$$ATT(g, t) = E[Y_t - Y_{g-1}|G = g] - E[Y_t - Y_{g-1}|D_t = 0, G \neq g]. \tag{3}$$

In the Equations (2) and (3), t indexes the time in days, g gives the period in which country i is treated and Y_{it} is the fuel price or retail margin of country i.

Finally, we can also average the $ATT(g, t)$ over all countries:

[25]Note that we can add time-invariant variables when using the approach from Callaway and Sant'Anna (2021) because those variables are interacted with the day fixed effects. Thus, the covariates are not collinear with our state fixed effects, but act more like state-specific time trends. Technically, we use an inverse probability weighting (IPW) to rebalance the distribution of covariates and estimate reweighted ATTs (Abadie, 2005).

[26]See https://bcallaway11.github.io/did/index.html.

$$\Theta_S(g) = \frac{1}{T-g+1}\sum_{t=2}^{T} 1\{g \leq t\} ATT(g,t). \quad (4)$$

Equation (4) then gives the time-average for each group and the overall average respectively. As already mentioned above, we use the fuel prices of seven different European countries to causally identify the effect of the temporary fuel tax reductions. Thereby, Germany, Italy, and France are the treated countries and Austria as well as the Baltic States are the never-treated countries in our staggered DiD approach.

We also want to estimate the treatment effect heterogeneity over time as the effect of the temporary fuel tax reductions on the retail prices might be dynamic. Using an event study design we can prove the process of tax pass-through over time to check whether there is an effect, how many periods it takes to have an effect, and how long it lasts. Moreover, we can test the parallel trend assumption checking the pre-treatment estimators. Hence, based on Equation (4) we will also calculate a group-averaged event study:

$$\Theta_D(e) = \sum_{g=2}^{T} 1\{g+e \leq T\} ATT(g, g+e) P(G=g|G+e \leq T). \quad (5)$$

Equation (5) then gives the average effect of the tax pass-through in time period e (across the countries that have introduced the temporary tax reduction by period e).

The countries in our data set should be very comparable in general. They are all members of the European Single Market, which implies harmonized border checks, common customs policy, and identical regulatory procedures on the movement of goods within the European Union (EU). Beyond, the seven countries are relatively similar in their geographic location and have highly correlated public and school holidays. In our observation period, also the travel restrictions put in place due to the COVID-19 crisis were similar and no major reforms, which could also affect fuel prices, were implemented.

To causally identify an unbiased ATT of the temporary fuel tax reductions on fuel prices, there should also be no other transitory shocks that would differently affect fuel prices in the individual countries before and after the tax reduction. Due to their geographic proximity the petroleum companies in the seven countries procure most of their crude oil from similar sources. Finally, we also focus on a relatively narrow window around the tax reductions, which should alleviate concerns on transitory shocks differently affecting the seven countries.

6. Results

6.1. Baseline Results

Table 5 presents the results of estimating regression equation (2) using the consumer price for gasoline and diesel as outcome variables. The coefficients in columns (I) and (II) correspond to the average treatment effect of the temporary fuel tax reductions on gasoline and diesel in France, Italy and Germany without any other control variables. Columns (III) and (IV) show the effect on consumer prices when we additionally control for the supply side parameters refinery utilization, number of gas stations and the total imports of oil and petroleum products.

	(I)	(II)	(III)	(IV)
	Gasoline	Diesel	Gasoline	Diesel
Italy	-0.32*** (0.02)	-0.30*** (0.02)	-0.35*** (0.02)	-0.30*** (0.02)
France	-0.19*** (0.02)	-0.18*** (0.01)	-0.20*** (0.02)	-0.19*** (0.01)
Germany	-0.36*** (0.02)	-0.15*** (0.01)	-0.39*** (0.02)	-0.18*** (0.01)
Simple Weighted Average	-0.31*** (0.01)	-0.20*** (0.01)	-0.33*** (0.01)	-0.21*** (0.01)
Pass-Through Italy	106.09%	98.67%	114.27%	100.00%
Pass-Through France	104.65%	99.91%	111.37%	105.99%
Pass-Through Germany	103.52%	89.73%	110.32%	106.69%
Time FE	Yes	Yes	Yes	Yes
Country and Chain FE	Yes	Yes	Yes	Yes
Supply Parameters	No	No	Yes	Yes
Observations	12,515	12,515	12,515	12,515

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Staggered DiD approach with consumer prices as outcome variable. Bootstrapped (robust) standard errors provided in parenthesis are clustered on the country and service station chain level.

In general, the results in Table 5 show that the fuel tax reductions led to a statistically significant decline in the consumer prices of both fuel types for all three countries treated ($p < 0.001$). For our model without any covariates, in Germany the average price for diesel decreases by 15 cents per liter after the fuel tax reduction (column (I)), whilst the average price for gasoline decreases by about 36 cents per liter (column (II)). Also for France the price decrease for diesel (-18 cents per liter) is slightly lower compared to the one for gasoline (-19 cents per liter). With a price drop of more than 30 cents per liter for diesel and 32 cents per liter for gasoline, also the estimated pass-through rates in Italy are very high. Including additional control variables (columns (III) and (IV)) only quantitatively changes our estimation results, even though we apparently underestimate the average treatment effects without controlling for the supply side.

In a next step, we can calculate the average pass-through rates of the fuel tax reductions. Therefore, we divide the estimated coefficients by the actual tax reductions in the three countries.[27] The estimated pass-through rates in Table 5 mostly imply a full- or even an over-shifting of the temporary fuel tax reductions. In our baseline estimations (columns (I) and (II) in Table 5), there is an over-shifting for gasoline and almost a full-shifting for diesel. With an estimated pass-through rate of approx. 106%, Italy has the highest passing on of the temporary fuel tax reduction for gasoline and France the highest one for diesel (approx. 100%). Overall, the estimated rates are very similar in the three countries, even though the estimated pass-through rate for diesel is slightly lower in Germany (approx. 90%). Including the control variables for the supply side (columns (III) and (IV) in Table 5) into our regression model generally increases the estimated pass-through rates so that we also find a full- or over-shifting for diesel now. In general, the high pass-trough rates might be explained by the inelastic demand for fuel products and particularly by the high public awareness as well as the threat of policymakers to pursue antitrust measures. The

[27] For instance, in our baseline estimation for diesel (column (I) of Table 5) the pass-through rate for Germany can be calculated as follows: $passthrough = \frac{EstCoeff}{TaxReduction} = \frac{15}{16.7} = 0.8973 = 89.73\%$.

2022 fuel tax reductions had great political and economic implications so that there was a high attention in the public debate (Kahl, 2023).

Beside the general high pass-through rates, a second interesting finding is that the effects of the tax reductions are mostly higher for gasoline compared to diesel in our estimations. This is in sharp contrast to the literature that finds a more inelastic demand for diesel compared to gasoline (Ajanovic et al., 2012; Karagiannis et al., 2011; Fridstrøm and Østli, 2021). However, the Russian invasion of Ukraine led to a high uncertainty of consumers in the energy markets in 2022, which was combined by an unusually high demand for heating diesel in spring and summer 2022. Households increased their heating diesel stocks out of fear of continuously rising prices, because they expected even higher prices in the future. This phenomena was particularly present in Germany.[28] As heating diesel is a close substitute for diesel (whereas gasoline is not), this might explain the lower pass-through rates for diesel in our results.

6.2. Pre-Treatment Trends and Dynamic Effects

To check whether the estimated results are causal effects, we will present an event study design next. The crucial assumption to interpret the results as causally is the parallel trends assumption. Event though this assumption is not directly testable, the event study design does lead to a formal test of pre-treatment trends. With this approach, we can also observe the treatment effects of the fuel tax reductions over time.

Figure 3 presents the group-time average treatment effects from Equation (5) for gasoline in the three treated countries.[29] We use the regression model including all control variables and compute bootstrapped 95% confidence intervals. Moreover, we apply a varying base period which means that a pseudo-ATT is computed in each treatment period by comparing

[28] See `https://www.dw.com/en/german-residents-make-plans-amid-fears-of-a-winter-gas-shortage/a-62482737`.

[29] In Figure 11 of Appendix C, we present the same dynamic analysis but without including any covariates. The results there are qualitatively very similar.

the changes in outcomes for a particular group relative to the comparison group in the pre-treatment periods.[30] This just means that we compute changes in the pre-treatment periods from period $t-1$ to period t, but repeatedly change the value of t (Callaway and Sant'Anna, 2021). The pre-treatment coefficients are close to zero and mostly insignificant in all three countries providing supportive evidence for the common trend assumption. An exception is the time of the beginning of Russia's invasion in the Ukraine, which leads to a short divergence in the pre-trends for Italy and France. However, the pre-trends converge back to the zero line and are statistically insignificant shortly before the exogenous shocks of the tax cuts in all three countries.

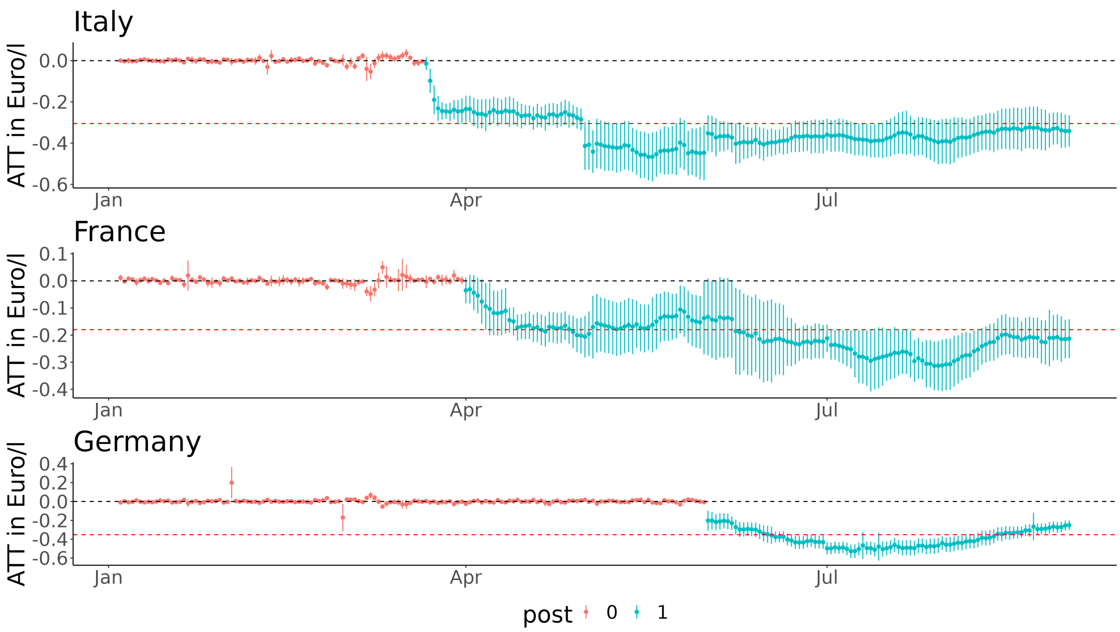

Figure 3: Event Study of prices with gasoline (E5) and all covariates. Bootstrapped (robust) standard errors are clustered on the country and service station chain level. Error bars represent 95% confidence intervals.

In Figure 3 we can also observe that the treatment effects over time are negative and mostly statistically different from zero. In Germany, there is an immediate drop at the day of the fuel tax reduction with almost full pass-through (red dashed horizontal line). There

[30]Pseudo-ATT means that we estimate the effect of participating in the treatment if the treatment had occurred in that period (instead of when it acutally occurred).

is a similar development in Italy, where full pass-trough is already reached three days after the tax cut. In the following, there is an over-shifting in both countries. On the contrary, in France it takes almost two weeks until there is a full pass-through. This is in line with our theoretical predictions, since France has a more inelastic supply side compared to the two other treated countries (see Section 3). Overall, Figure 3 suggests that the treatment effects are relatively stable over time in all three countries.

Figure 4 shows the group-time average treatment effects for diesel from Equation (5).[31] The pre-treatment coefficients are again close to zero and mostly insignificant (except during the begin of the Ukraine conflict for Italy and France). The pattern of the treatment effects over time is very similar compared to the event study for gasoline in Figure 3. While Italy has a relatively fast full pass-through again, it takes some time in France until there is a significant effect and even longer for a full-pass through. In Germany, we again observe an immediate drop in the treatment effects at the day of the fuel tax reduction. Again, the treatment effects are relatively stable over time, even though the effects get insignificant for Germany in the end of August. This can be explained by the drought in Germany throughout the summer of 2022. The very high temperatures led to exceptional low water levels in German rivers which, in turn, raised the transportation costs for diesel imports (Dovern et al., 2022).

[31] In Figure 12 of Appendix C, we present the same dynamic analysis but without including any covariates. The results there are again qualitatively very similar.

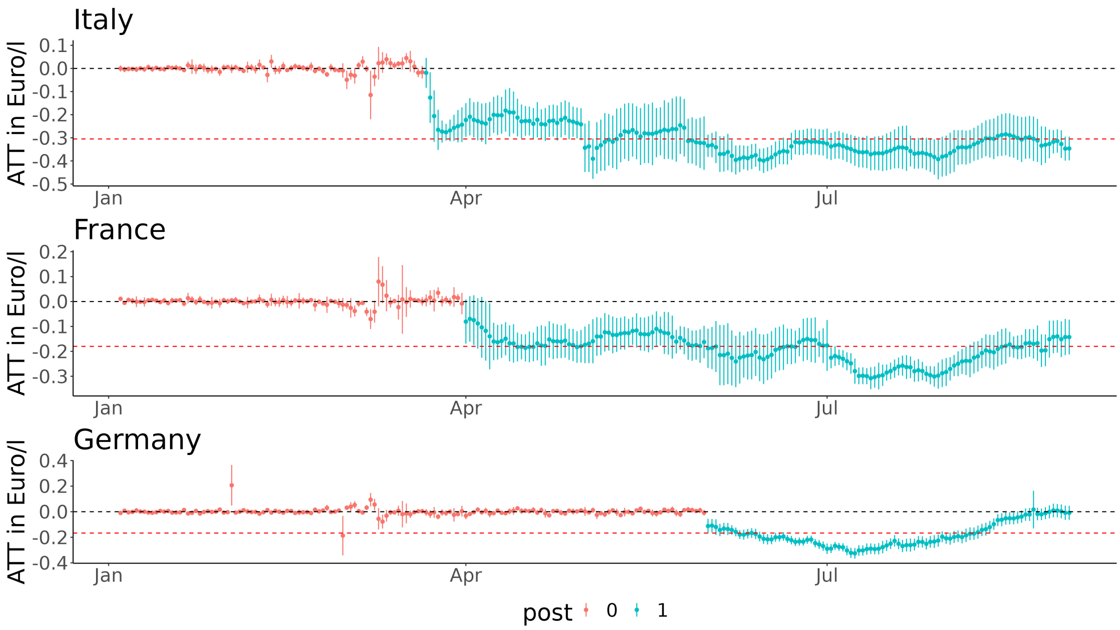

Figure 4: Event Study of prices with diesel and all covariates. Bootstrapped (robust) standard errors are clustered on the country and service station chain level. Error bars represent 95% confidence intervals.

6.3. Retail Margins

Table 6 shows the results of estimating regression equation (1) using the retail margins for gasoline and diesel as outcome variables. The results indicate that the reduction in fuel taxes had no significant effect on the average margins in the three countries. This is in line with our results from Section 6.1 as we mostly find a full-shifting of the temporary fuel tax reductions which, on average, should not have an effect on the retail margins.

	(I)	(II)	(III)	(IV)
	Gasoline	Diesel	Gasoline	Diesel
Italy	-0.02 (0.01)	0.00 (0.01)	-0.01 (0.02)	0.02 (0.01)
France	-0.01 (0.02)	0.00 (0.01)	-0.01 (0.02)	-0.00 (0.01)
Germany	-0.01 (0.02)	0.02 (0.01)	-0.02 (0.02)	0.00 (0.01)
Simple Weighted Average	-0.01 (0.01)	0.01 (0.01)	-0.01 (0.01)	0.00 (0.01)
Time FE	Yes	Yes	Yes	Yes
Country and Chain FE	Yes	Yes	Yes	Yes
Supply Parameters	No	No	Yes	Yes
Observations	12,515	12,515	12,515	12,515

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Staggered DiD approach with retail margins as outcome variable. Bootstrapped (robust) standard errors provided in parenthesis are clustered on the country and service station chain level.

However, performing an event study design for the outcome variable retail margins implies that there are some positive margins for diesel as well as gasoline in the first days after the fuel tax reductions. Figure 5 presents the event study results for gasoline in the three treated countries. The margins are significantly positive in the first days after the tax cuts for Italy and France, but insignificantly for Germany. This is in line with our findings in Figure 3 because it takes some days in Italy and France until the tax reduction is passed through to consumers. Since those daily average treatment effects get insignificantly after a few days, the overall average treatment effects in Table 6 are still insignificant. In contrast, there is an immediate drop in Germany in the gasoline prices, which results in the insignificant margins also in the first days after the tax cut there.

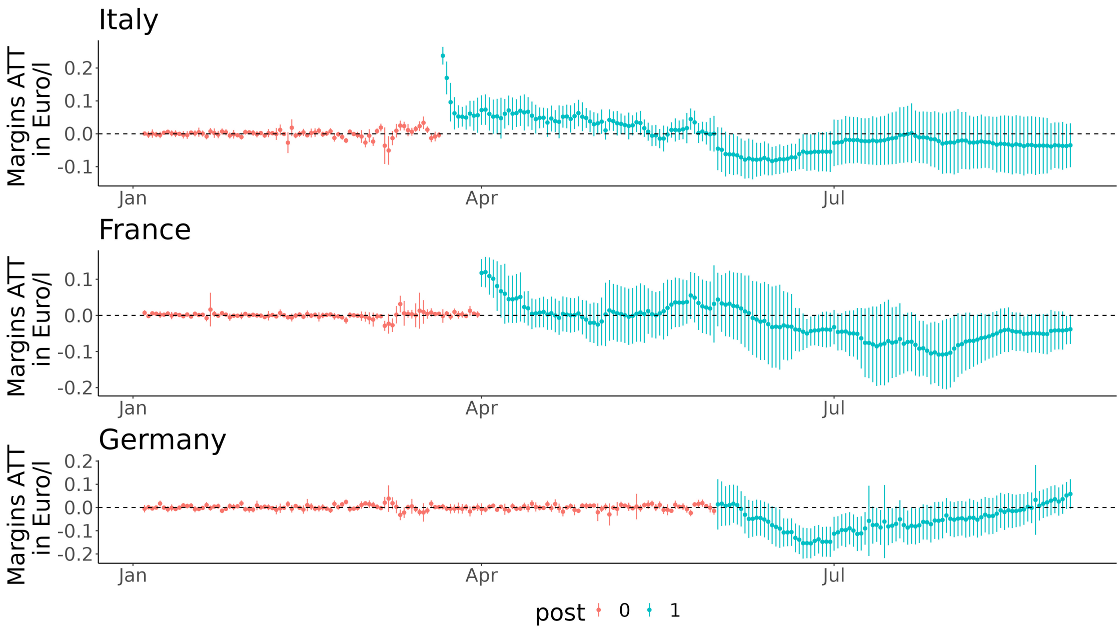

Figure 5: Event Study of Margins with gasoline (E5) and all covariates. Bootstrapped (robust) standard errors are clustered on the country and service station chain level. Error bars represent 95% confidence intervals.

Figure 6 shows the equivalent results for the retail margins of diesel. Beside the positive retail margins in Italy and France, we also find some positive diesel margins in the first days after the tax cut for Germany now. During the time of the over-shifting of the fuel tax reductions (see Figure 4), we even find some significant negative average treatment effects here. Overall, those effects over time cancel each other out so that we have no significant average effect in Table 6.

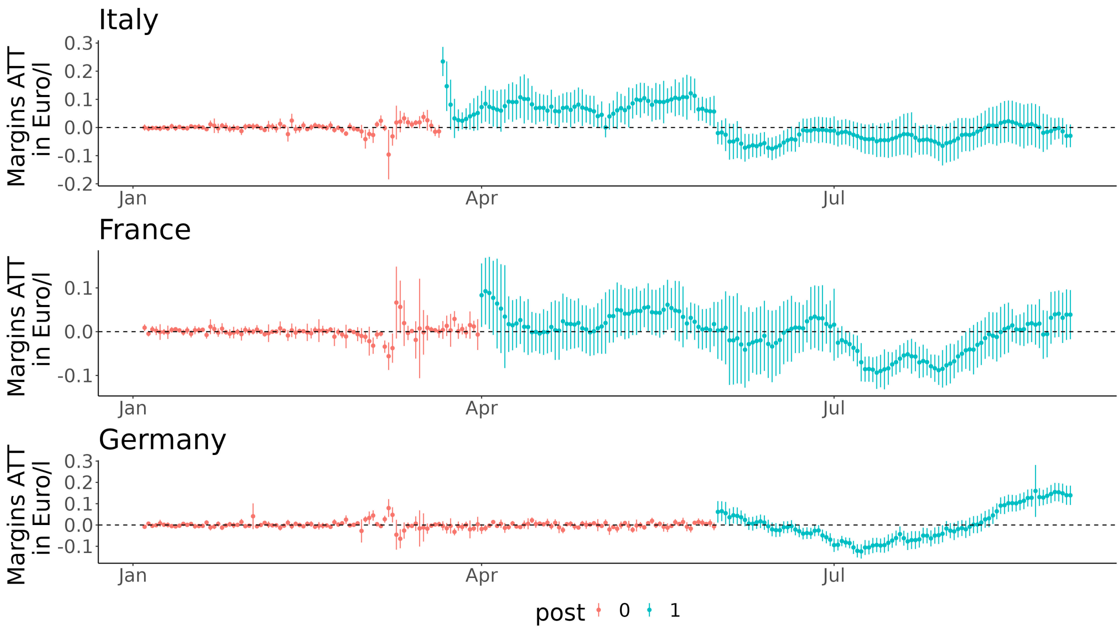

Figure 6: Event Study of Margins with diesel and all covariates. Bootstrapped (robust) standard errors are clustered on the country and service station chain level. Error bars represent 95% confidence intervals.

7. Conclusion and Policy Implications

This paper provides empirical evidence on the pass-through of temporary fuel tax reductions in the three largest European economies. The governments in Italy, France and Germany introduced relief packages to mitigate the effects of increasing energy prices in the course of post-pandemic economic recovery and the Russian aggression towards the Ukraine. As a part of those packages, the three countries reduced the fuel taxes for several months in 2022. Since the individual fuel tax reductions have taken place at different points of time, we apply a staggered DiD design to causally estimate pass-through rates as well as changes in retail margins.

Our results imply a heterogeneous pass-through of the fuel tax reductions depending on the country and the type of fuel. We find a full- or even over-shifting of the temporary fuel tax reductions so that the estimated average pass-through rates are mostly close to 100% or larger. This identifies the total fuel markets in the three countries as highly competitive, where the consumers enjoy all of the tax reliefs. High pass-through rates can be explained by the general inelastic demand for fuel products and particularly by the high public awareness as well as the threat of policymakers to pursue antitrust measures during the 2022 tax cuts.

A second key finding of our paper is that the pass-through rates are generally higher for gasoline compared to diesel. While this is in contrast with the previous literature, which finds a more inelastic demand for diesel compared to gasoline, this might be explained by the unusual market situation in 2022. The Russian invasion of Ukraine led to a high uncertainty of consumers in the European energy markets, which (among others) resulted in a higher demand for heating diesel, a close substitute for diesel.

With respect to the margins, we find no significant effect different from zero on the average retail margins in the three countries. This is in line with the estimated pass-through rates because the tax reductions were mostly passed on to the consumers one-for-one, which does not change the retail margins of the petroleum companies. However, performing an event study design suggests that the petroleum companies have made some positive retail margins at least in the first days after the fuel tax reductions as it has taken some days until the tax reduction has been fully passed-through to the consumers.

A key takeaway from our paper for policymakers is that temporary fuel tax reductions seem to be a suitable measure to lower consumer prices for diesel and gasoline, even though it may take some time until full pass-through is reached. Hence, the primary goal of the governments to relieve their citizens by achieving lower consumer prices for petroleum products has been met. Whether the corrective goal of a Pigouvian tax or subsidy can be achieved generally depends on whether the consumers also bear the incidence of the measure. In this context, the fuel markets in the three countries seem to be competitive enough so that environmental taxes are passed on to the consumers. However, due to the distributional- and climate-economical shortcomings as well as the relatively high fiscal burden of fuel tax reductions it is debatable whether a temporary fuel tax reduction is an suitable intervention at all.

From a competition policy perspective, our results hardly allow any conclusions to be drawn about whether there are competition restrictions in the fuel market at all. However, the estimated pass-through rates in the three countries imply that the alleged restrictions can at least not hinder a high pass-through of the tax reductions. In general, comprehensive sector analyses by the competition authorities to find the mildest means of competition policy seem to be more appropriate than short-term government interventions in the fuel market.

Apart from already mentioned limitations regarding policy implications, data limitations do not allow to make any statements on welfare effects, as we cannot observe the traded volumes. Furthermore, due to the aggregated price data at service chain level, it is not possible to look at regional effects within individual countries. However, the geographic location of the service stations included in the dataset shows that we observe a balanced geographic coverage, which implies that the average effects within countries are robust. With regard to our observation period and the design of the measures studied, only temporary effects are analyzable. For further studies, it would be interesting to extend the period and also examine the end of the measures and the associated tax increases under the subject of asymmetric pass-through of increasing and decreasing costs, i.e. rockets and feathers. Overall, it is crucial to emphasize that the obtained results are not readily transferable or applicable to other industries. The retail fuel market (and any other market) is characterized by unique features and therefore an own empirical assessment of the pass-through of tax reductions in other industries would be necessary. Nevertheless, our work provides new and important insights into the transmission of tax reductions in a dynamic and much studied industry, using the most recent methods.

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Appendix A.

Economic theory implies that the elasticities of demand and supply as well as the competitive situation in a market determine the level of pass-through. Following Weyl and Fabinger (2013), we denote p as the retail price and t as the quantity tax rate, so that the pass-through rate is given by $\rho = \frac{dp}{dt}$. We further define the elasticity of demand ($\epsilon_D \equiv -(D'p/Q)$) and supply ($\epsilon_S \equiv S'p/Q$). In this framework, Weyl and Fabinger (2013) postulate that the solution of the firm maximization problem can be described by the conduct parameter $\theta = (p - mc(q))/p\epsilon_D$. θ maps the degree of competition in a market. For instance, θ is equal to 0 in perfect and Bertrand competition, equal to 1 in a monopolistic market, and equal to $1/n$ in Cournot competition. Then, the pass-through rate ρ is independently of the specific model given by

$$\rho = \frac{1}{1 + \frac{\theta}{\epsilon_\theta} + \frac{\epsilon_D - \theta}{\epsilon_S} + \frac{\theta}{\epsilon_{ms}}}. \tag{A.1}$$

Aside from the conduct parameter θ, formula (A.1) implies that the pass-through of a marginal cost increase also depends on the elasticity of demand ϵ_D, the elasticity of the inverse marginal cost curve (the elasticity of supply)[32] ϵ_S, the curvature of the demand function ϵ_{ms}[33], and the variation of θ in changes of production ϵ_θ[34].

Even though formula (A.1) suggests that the sign and magnitude of the pass-through is ambiguous, we can simplify the expression for ρ in some special cases. If there is perfect competition in a market ($\theta = 0$), then $\rho = \frac{1}{1+(\epsilon_D/\epsilon_S)}$ so that the pass-through only depends on the ratio of demand and supply elasticity. More generally, if the marginal cost were constant, demand were linear, and θ were constant, expression (A.1) would simplify to $\rho = 1/(1+\theta)$.

[32]The monopolist determines the price based on demand and its costs, there is, just like in an oligopoly, no supply curve and accordingly, no supply elasticity in the sense of perfect competition.

[33]Given by $\epsilon_{ms} = \frac{ms}{ms'q}$, where ms is the negative of the marginal consumer surplus ($ms = -p'q$). If demand is linear, then $\epsilon_{ms} = 1$, if concave, $\epsilon_{ms} < 1$, and if convex, $\epsilon_{ms} > 1$ (and the opposite is also true) (Genakos and Pagliero, 2022).

[34]Given by $\epsilon_\theta = (\theta/q(d\theta/dq))$.

A rise in the conduct parameter θ (less competition) would lead to lower pass-through in this situation (Genakos and Pagliero, 2022). For instance, in a monopolistic market ($\theta = 1$) the pass-through would be lower ($\rho = 0.5$) compared to a market with perfect competition ($\theta = 0$) where we would have full pass-through ($\rho = 1$).

However, in general, the sign of the effect of an increase in the conduct parameter θ on the pass-through remains ambiguous. This is especially the case for an oligopolistic market, which should be the most appropriate market form to model the fuel industry in Europe. The impact of the conduct parameter on the pass-through can either be positive or negative, depending on the actual market situation. Under certain assumptions also pass-through rates larger than one are possible. Hence, the impact of the intensity of competition on the pass-through rate in an oligopolistic market remains an empirical problem (Genakos and Pagliero, 2022).

Appendix B.

To compute the daily average retail margins for the five countries in our data set, we subtract a fuel share of the crude oil price (major input cost) as well as the country-specific taxes and duties (see Montag et al. (2021)). For each country in our raw data set, we observe a daily average gross consumer price. In a first calculation step, we calculate the average consumer prices without VAT taxes for every day and country.[35] To get the daily average net price, we then also subtract the excise duties for the individual countries (see Table 3). Thereby, for the treated countries we have to differentiate between the period before and after the fuel tax reductions.

In a final step, we have to subtract the input cost of crude oil (Brent) from the daily net price. Therefore, we use the information that around 54% of the Brent oil price per barrel corresponds to the production of 19 gallons of gasoline and around 34% to the production of 12 gallons of diesel.[36] We further transform these measures into the input cost per liter of gasoline and diesel. The retail margins of gasoline and diesel are then computed as the average gross consumer price per liter adjusted to VAT taxes and excise duties minus the share of crude oil price per liter of a corresponding fuel product.

[35] The VAT taxes are very heterogeneous in the five countries: 22% in Italy, 20% in Austria and France, 19% in Germany, and 7.7% in Switzerland.

[36] See https://www.eia.gov/energyexplained/oil-and-petroleum-products/refining-crude-oil-inputs-and-outputs.php. (Last accessed: October 19, 2022)

Appendix C.

Country	Statistic / Variable	count	mean	std	min	25%	50%	75%	max
Austria	Diesel	1,446	1.81	0.23	1.28	1.67	1.87	1.99	2.15
	E5	1,446	1.78	0.22	1.29	1.61	1.79	1.95	2.16
	Margin of Diesel in Euro/l	1,446	0.39	0.13	0.06	0.26	0.40	0.48	0.67
	Margin of E5 in Euro/l	1,446	0.27	0.13	-0.01	0.18	0.25	0.37	0.56
	Number of Stations per Chain	1,446	196.17	104.28	8.00	117.00	229.50	281.00	312.00
	Relative Margin/Lerner-Index of Diesel	1,446	0.34	0.07	0.08	0.29	0.34	0.39	0.50
	Relative Margin/Lerner-Index of E5	1,446	0.26	0.08	-0.01	0.21	0.25	0.32	0.43
	Total Imports of Oil and Petroleum Products	1,446	987.21	212.86	745.05	779.82	887.39	1,156.51	1,328.22
	Utilization of Capacity	1,446	0.55	0.27	0.25	0.26	0.37	0.78	0.93
Estonia	Diesel	1,190	1.76	0.22	1.26	1.67	1.83	1.90	2.06
	E5	1,188	1.86	0.19	1.45	1.74	1.90	1.98	2.16
	Margin of Diesel in Euro/l	1,190	0.34	0.11	0.06	0.24	0.37	0.43	0.55
	Margin of E5 in Euro/l	1,188	0.39	0.09	0.13	0.32	0.40	0.46	0.61
	Number of Stations per Chain	1,190	55.78	30.58	9.00	34.00	59.00	79.00	95.00
	Relative Margin/Lerner-Index of Diesel	1,190	0.31	0.07	0.09	0.27	0.32	0.36	0.43
	Relative Margin/Lerner-Index of E5	1,188	0.35	0.05	0.13	0.32	0.35	0.38	0.45
	Total Imports of Oil and Petroleum Products	1,190	135.61	24.04	103.00	120.00	131.00	147.00	190.00
	Utilization of Capacity	0							
France	Diesel	1,687	2.00	0.18	1.52	1.86	2.01	2.13	2.51
	E5	1,687	1.99	0.16	1.60	1.88	1.97	2.11	2.50
	Margin of Diesel in Euro/l	1,687	0.44	0.14	0.05	0.34	0.45	0.54	0.84
	Margin of E5 in Euro/l	1,687	0.34	0.12	0.00	0.25	0.33	0.42	0.74
	Number of Stations per Chain	1,687	426.29	216.77	97.00	197.00	419.00	685.00	736.00
	Relative Margin/Lerner-Index of Diesel	1,687	0.37	0.07	0.06	0.33	0.37	0.42	0.52
	Relative Margin/Lerner-Index of E5	1,687	0.31	0.07	0.00	0.27	0.31	0.36	0.49
	Total Imports of Oil and Petroleum Products	1,687	6,749.68	454.79	6,041.00	6,395.00	6,965.00	6,987.00	7,486.00
	Utilization of Capacity	1,687	0.73	0.09	0.60	0.69	0.71	0.85	0.90
Germany	Diesel	3,615	1.91	0.19	1.51	1.81	1.97	2.03	2.49
	E5	3,615	1.91	0.16	1.65	1.77	1.90	2.04	2.40
	Margin of Diesel in Euro/l	3,615	0.38	0.12	0.01	0.26	0.40	0.47	0.96
	Margin of E5 in Euro/l	3,615	0.26	0.10	-0.07	0.17	0.26	0.34	0.84
	Number of Stations per Chain	3,615	706.67	683.04	13.00	188.00	458.00	980.00	2,597.00
	Relative Margin/Lerner-Index of Diesel	3,615	0.33	0.06	0.01	0.28	0.33	0.38	0.57
	Relative Margin/Lerner-Index of E5	3,615	0.25	0.06	-0.09	0.20	0.25	0.31	0.53
	Total Imports of Oil and Petroleum Products	3,615	10,191.52	321.37	9,391.28	10,161.25	10,305.77	10,483.69	10,507.72
	Utilization of Capacity	3,615	0.91	0.04	0.84	0.89	0.92	0.95	0.96
Italy	Diesel	1,928	1.92	0.15	1.62	1.82	1.89	2.03	2.37
	E5	1,928	1.97	0.13	1.75	1.86	1.94	2.07	2.35
	Margin of Diesel in Euro/l	1,928	0.40	0.14	0.07	0.31	0.40	0.50	0.80
	Margin of E5 in Euro/l	1,928	0.33	0.11	0.04	0.24	0.31	0.39	0.71
	Number of Stations per Chain	1,928	2,109.50	1,511.06	176.00	1,017.50	1,973.00	3,054.25	4,437.00
	Relative Margin/Lerner-Index of Diesel	1,928	0.34	0.07	0.07	0.30	0.35	0.39	0.52
	Relative Margin/Lerner-Index of E5	1,928	0.30	0.07	0.04	0.26	0.29	0.35	0.49
	Total Imports of Oil and Petroleum Products	1,928	6,446.63	540.48	5,701.19	5,993.60	6,614.20	6,986.43	7,182.83
	Utilization of Capacity	1,928	0.86	0.09	0.70	0.82	0.92	0.93	0.97
Latvia	Diesel	1,444	1.75	0.23	1.28	1.51	1.82	1.90	2.13
	E5	1,444	1.80	0.19	1.44	1.61	1.83	1.93	2.13
	Margin of Diesel in Euro/l	1,444	0.39	0.13	0.06	0.24	0.42	0.47	0.64
	Margin of E5 in Euro/l	1,444	0.35	0.09	0.03	0.27	0.35	0.41	0.57
	Number of Stations per Chain	1,444	64.63	22.20	30.00	41.00	70.00	88.00	89.00
	Relative Margin/Lerner-Index of Diesel	1,444	0.34	0.07	0.06	0.28	0.35	0.39	0.47
	Relative Margin/Lerner-Index of E5	1,444	0.32	0.05	0.03	0.29	0.32	0.35	0.44
	Total Imports of Oil and Petroleum Products	1,444	184.64	49.18	125.43	154.16	180.90	202.69	298.02
	Utilization of Capacity	0							
Lithuania	Diesel	1,205	1.73	0.20	1.29	1.55	1.79	1.85	2.04
	E5	1,196	1.74	0.19	1.38	1.58	1.74	1.88	2.10
	Margin of Diesel in Euro/l	1,205	0.37	0.10	0.10	0.28	0.38	0.45	0.59
	Margin of E5 in Euro/l	1,196	0.27	0.10	-0.02	0.19	0.25	0.34	0.53
	Number of Stations per Chain	1,205	81.40	25.40	44.00	74.00	76.00	91.00	122.00
	Relative Margin/Lerner-Index of Diesel	1,205	0.33	0.06	0.10	0.29	0.33	0.38	0.45
	Relative Margin/Lerner-Index of E5	1,196	0.26	0.07	-0.02	0.22	0.26	0.31	0.41
	Total Imports of Oil and Petroleum Products	1,205	747.42	245.31	327.60	438.80	764.90	1,059.60	1,061.10
	Utilization of Capacity	1,205	0.81	0.35	0.20	0.24	1.02	1.06	1.07

Table 7: Summary statistics of Austria, France, Germany, Italy, Latvia, Lithuania and Estonia on the service station chain level.

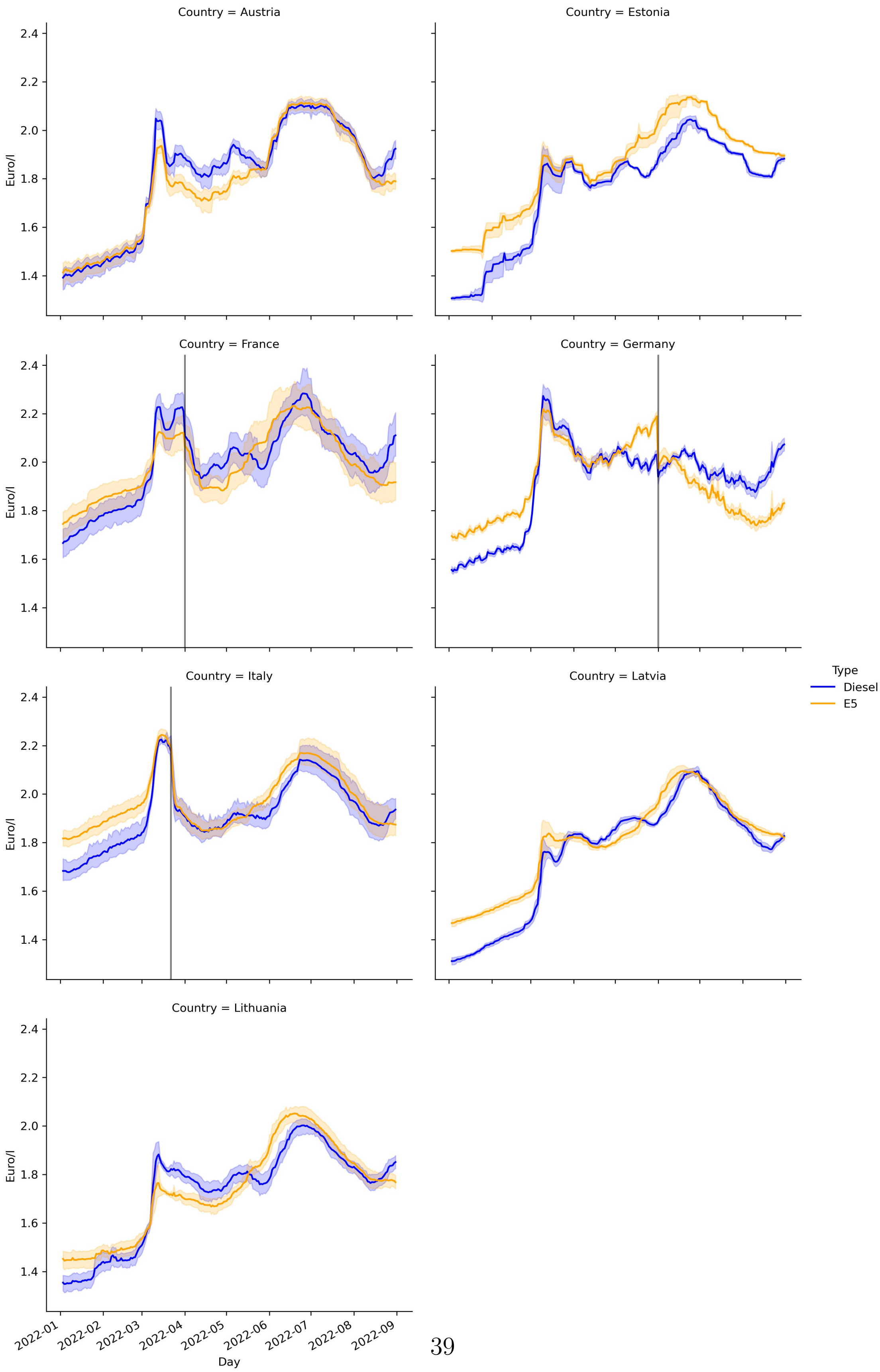

Figure 7: Development of gasoline and diesel consumer prices for the seven countries in our data set. The vertical lines reflect the introduction of the respective tax reductions. Confidance band is shown to highlight that data varies on the service station chain level.

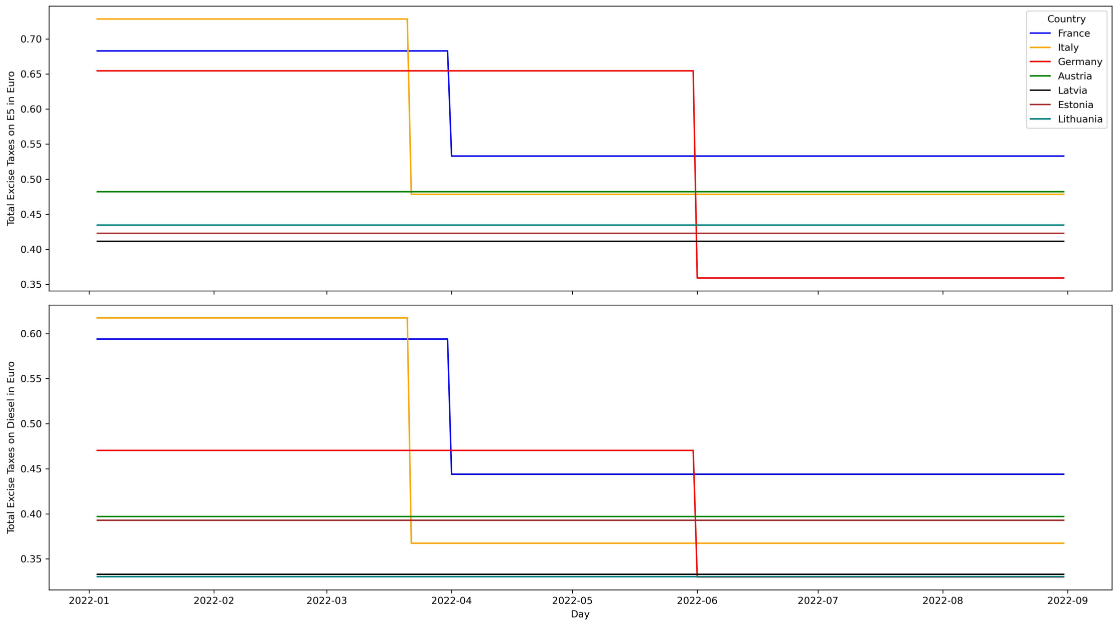

Figure 8: Development of gasoline and diesel excise duties (inclusive of further duties) for the seven countries in our data set.

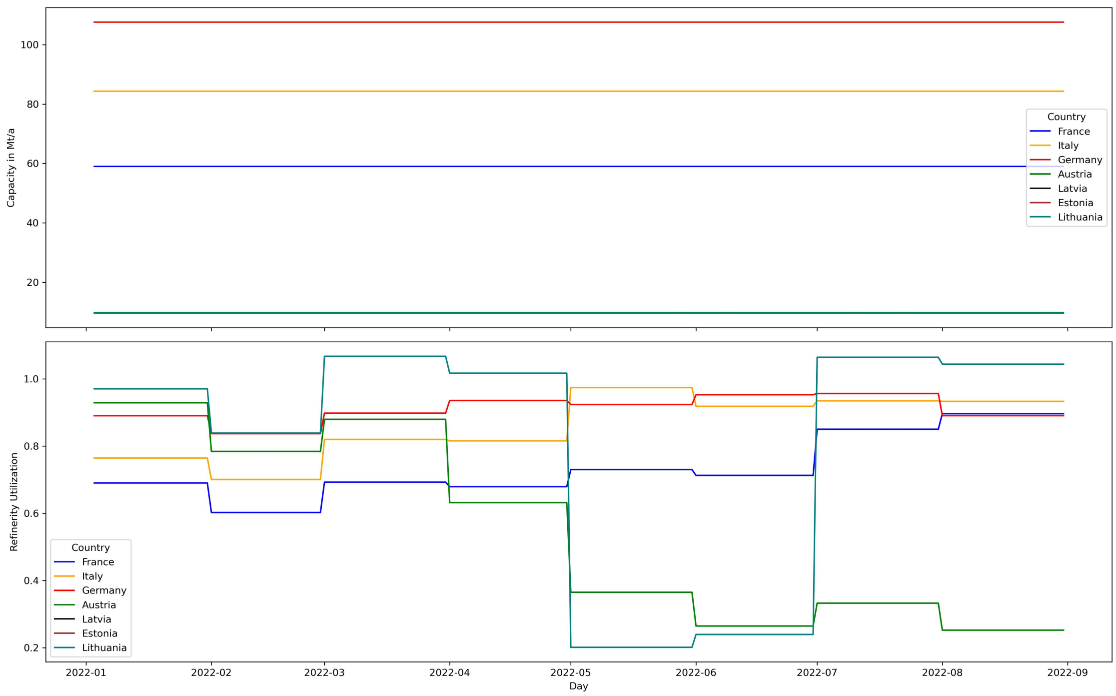

Figure 9: Development of Capacity and Refinery Utilization.

Country	Provider	Number of Stations per Chain
Austria	Eni	312
	BP	281
	Shell	248
	OMV	211
	AVIA	117
	Mol	8
Estonia	Terminal	34
	Premium7	9
	NESTE	59
	Circle K	79
	Olerex	95
France	Esso	474
	Shell	97
	Eni	197
	BP	376
	Total	419
	Avia	685
	E.Leclerc	736
Germany	Aral	2,597
	Shell	1,791
	Esso	1,112
	Total	951
	Avia	980
	Gulf	47
	ED	107
	Tamoil	13
	OMV	332
	HEM	383
	agip	437
	Tankpool24	458
	Star	572
	Jet	632
	Westfalen	188
Italy	Esso	2,394
	Repsol	176
	IES	206
	TotalErg	1,288
	Tamoil	1,552
	Q8	2,697
	Eni	4,437
	IP	4,126
Latvia	VIRŠI	70
	Viada	89
	Circle K	88
	NESTE	70
	LN	41
	Astarte	30
Lithuania	Viada	122
	Circle K	91
	Baltic Petroleum	74
	EMSI	44
	NESTE	76

Table 8: Summary statistics for number of service stations per chain present in the data. Overall coverage: Austria 1177/2748 ≈ 43%, Germany 10600/14500 ≈ 73%, France 2984/11151 ≈ 27%, Italy 16876/21700 ≈ 78%, Estonia 276/491 ≈ 56%, Latvia 388/605 ≈ 64% and Lithuana 407/718 ≈ 56%. Visual inspection of the stations displayed on the map provided by Fuelo reveals the extent of geographical coverage within the national markets. Source: Fuelo.net, https://de.fuelo.net/gasstations?lang=en.

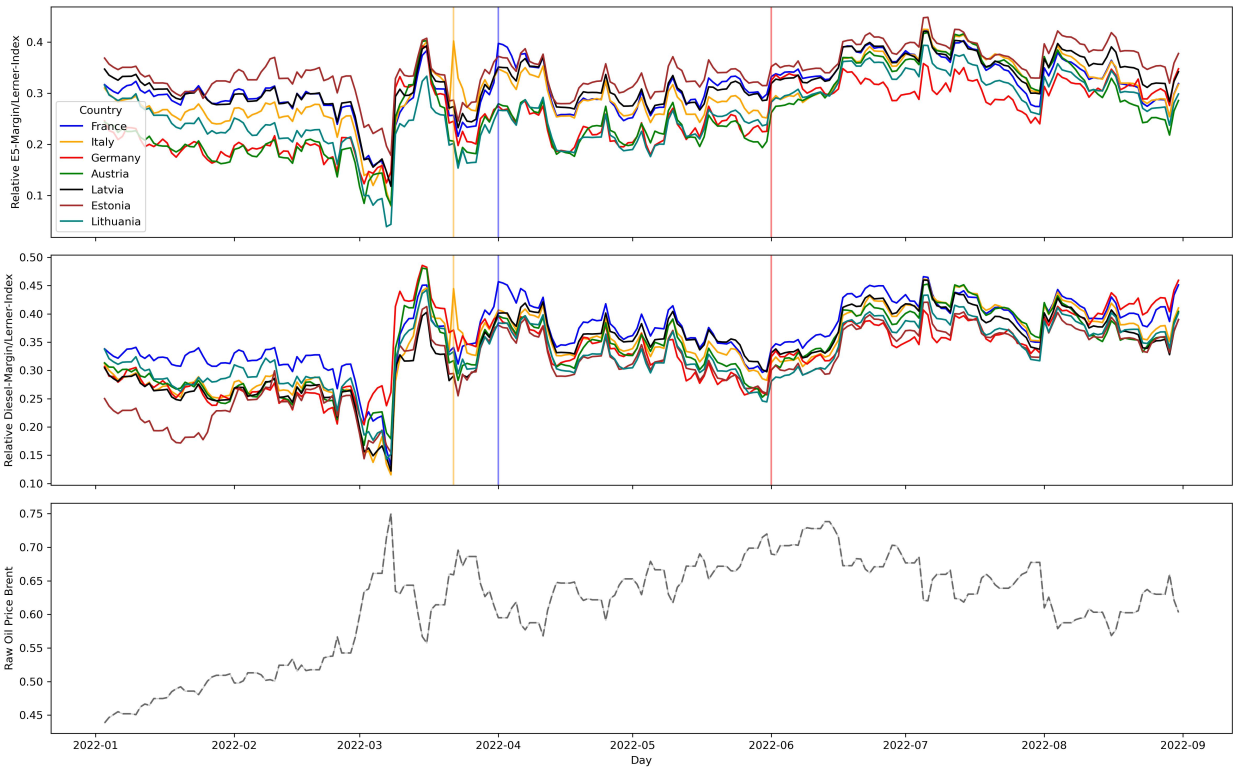

Figure 10: Development relative retail margins for gasoline (upper) and diesel (middle). The vertical lines reflect the introduction of the respective tax reductions in Italy (March 22, yellow), France (April 1, blue), and Germany (June 1, red). Brent prices (lower) in Euro per Liter is denoted in dashed grey.

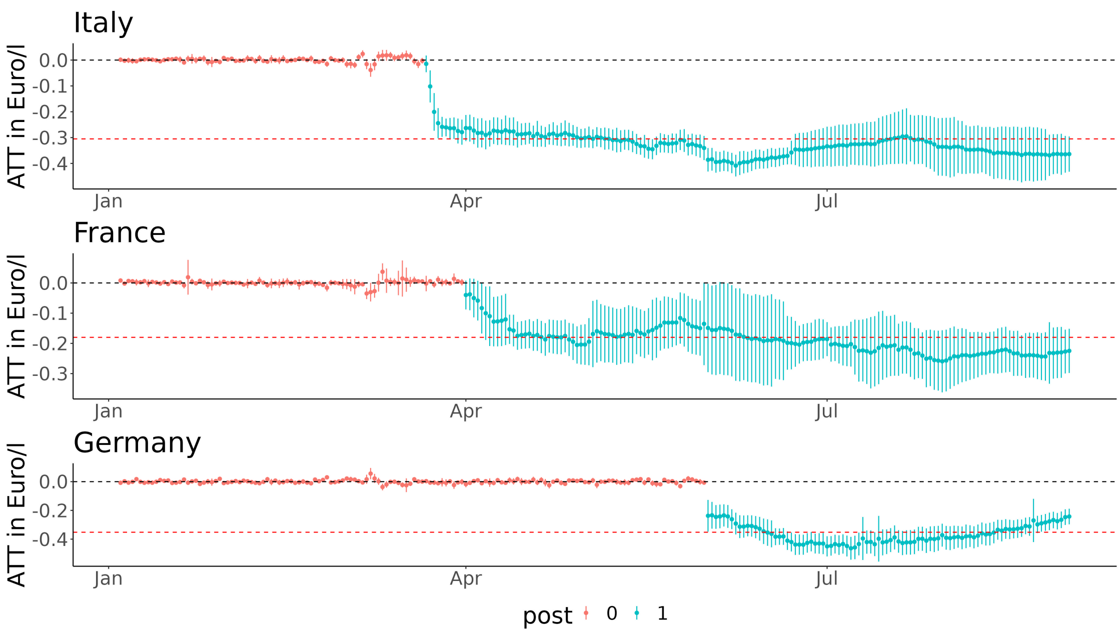

Figure 11: Event Study of prices with gasoline (E5) and no covariates. Bootstrapped (robust) standard errors are clustered on the country and service station chain level. Error bars represent 95% confidence intervals.

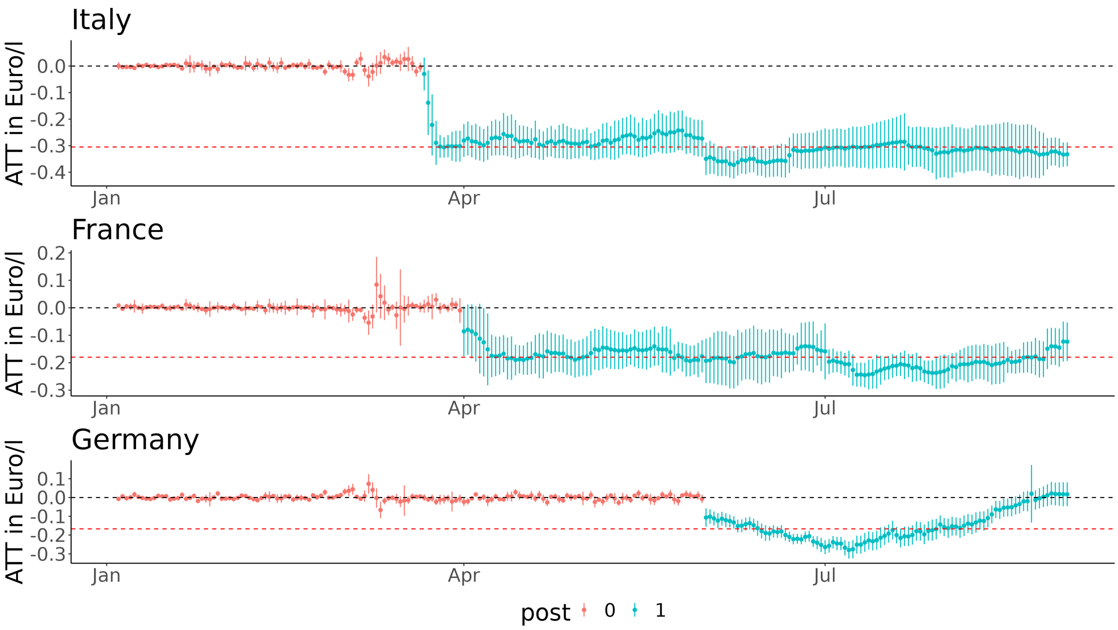

Figure 12: Event Study of prices with diesel and no covariates. Bootstrapped (robust) standard errors are clustered on the country and service station chain level. Error bars represent 95% confidence intervals.