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The rise of refinery margins: The case of energy tax cut in Germany

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The Rise of Refinery Margins: The Case of the Energy Tax Cut in Germany*

Leonard Gregor[†], Justus Haucap[‡]

October 2025

Abstract

This paper evaluates the temporary reduction in energy taxes implemented by the German government between June and September 2022. We use pricing and quantity data from the wholesale market for crude oil, gasoline, and diesel and find an average pass through of 80% to 85% of the tax cut, which amounts to a 3.7 cents per liter increase in wholesale prices net of tax. We do, however, document significant treatment heterogeneity over time and across regions within Germany. When weighting price effects by quantities sold, the estimated pass-through of the tax cut decreases to about 70% for gasoline and 58% for diesel, suggesting that refinery margins increased significantly during times of higher demand.

Keywords: Pass-through, Tax reduction, Fuel prices, Wholesale markets

JEL Classification: H22, L13, L71, Q48

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1 Introduction

Following the Russian invasion of Ukraine, energy prices in many countries, especially in Europe, surged. This came at a time when demand for road fuels had recovered from COVID-19 related lockdowns. To ease consumer burdens, several European governments temporarily reduced the energy tax on road fuels.

In Germany, retail fuel prices rose by more than 0.5 Euro per liter in March and April 2022, exceeding 2.00 Euro per liter. In reaction to this sharp increase, the government implemented an “energy tax cut” from June to September 2022, lowering the energy tax on gasoline and diesel to the minimum rate mandated by European Union law.

This paper examines pass-through rates in German energy markets by exploiting this temporary reduction in energy taxes on wholesale gasoline and diesel prices during the summer of 2022. We employ a difference-in-differences (diff-in-diff) framework, comparing German wholesale prices and quantities with benchmark spot market prices for road fuels in the Amsterdam–Rotterdam–Antwerp (ARA) region, which serves as a reference for European wholesale and retail fuel prices.

Given the wholesale market’s dependence on crude oil prices, we first outline the supply chain of German refineries. Germany relies almost entirely on imported crude oil, with negligible domestic production. Using geographical data on pipelines and international trade, we demonstrate that each German refinery’s crude oil supply depends heavily on its location. Technical constraints prevent refineries from easily switching their crude blend or transportation mode, reinforcing regional dependencies. We further establish that transportation costs limit the geographic scope of wholesale fuel markets. Consequently, our econometric model controls for regional variation in crude oil input costs and distinguishes between different German regions.

We also show that the market for road fuels is characterized by structures that support collusive tendencies. Therefore, the market for road fuels has been under scrutiny before in a number of different countries worldwide. In Germany, five major vertically integrated firms dominate the market and employ swap agreements to minimize transportation costs. Independent suppliers lack bargaining power, as they are depended on these five major companies and demand is highly fragmented. The pricing mechanism on the wholesale market has recently become the subject of an ongoing investigation by the German Federal Cartel Office (Federal Cartel Office, 2025a). Daily and intraday price information services aggregate participant quotes into a published market price. These market prices are the benchmark price for longstanding contracts between wholesalers and retailers. The Federal Cartel Office, however, questions the reliability and unbiasedness of these prices. Our empirical strategy relies on price and quantity data covering all three levels of the supply chain. First, we use daily price data for different crude oil blends as input prices for refineries. Second, we employ daily price quotes from the German and ARA spot

markets for gasoline and diesel. Third, we draw on retail fuel prices reported by the Market Transparency Unit of the German Federal Cartel Office. Finally, we use monthly quantity data on national production and consumption of crude oil, gasoline, and diesel from the Joint Organizations Data Initiative (JODI).

Descriptive analysis reveals pronounced price spikes for both gasoline and diesel following the Russian invasion, unexplained by crude oil price movements. This effect is more pronounced in Germany than it is in the ARA region. This trend persisted during the tax cut: While ARA spot market prices for gasoline and diesel stabilized and even declined, German spot market prices increased further, widening the gap between German and ARA prices.

Applying a diff-in-diff approach, we find a modest but statistically significant positive ATT of the tax cut on net wholesale fuel prices. While dynamic analysis indicates near-complete initial pass-through of the tax cut, pass-through rates declined over time, as price decreases on the ARA spot market might have not been passed through in Germany. This is possibly due to heightened media attention at the beginning of the tax cut. We, further, identify significant treatment heterogeneity across regions, especially between eastern and southern part of Germany. We attribute this to regional differences in crude oil input costs, demand, and competition. Time-varying regional estimates support these findings.

We also explore the tax cut’s effect on quantities using the entire European Economic Area (EEA) as a control group, finding evidence of increased demand consistent with economic theory, as gross retail prices including taxes decreased. Finally, we quantify the monthly impacts of the tax cut: Due to higher demand towards the end of the tax cut only 70 % of the gasoline tax reduction and 58 % of the diesel tax cut were passed through to retail prices. We estimate total fiscal costs of approximately 3.7 billion Euro and a non-negligible increase in CO₂ emissions.

The results of this paper contribute to three distinct strands of the literature. First, and most broadly, we contribute to the empirical literature on the pass-through of tax changes. Weyl and Fabinger (2013) provides a comprehensive overview of theoretical pass-through rates under imperfect competition, summarizing findings from various studies. Several studies exploit changes in VAT to estimate the effect on consumer prices. Blundell (2009), Crossley et al. (2009) and Barrell and Weale (2009) examine a temporary VAT reduction in the UK from 17.5% to 15%. These studies generally find uneven and incomplete, yet substantial, pass-through rates. Frey and Haucap (2024) investigate a VAT reduction on menstrual hygiene products prompted by a fairness debate, finding a pass-through rate exceeding 100%, attributed to extensive media coverage and rounding effects.

A growing body of literature further examines temporary VAT reductions implemented in response to COVID-19 lockdowns. In Germany, the standard VAT rate was reduced from 19% to 16%, and the reduced rate from 7% to 5%, from July to December 2020.

Bachmann et al. (2021) use survey and scanner data to document highly heterogeneous and incomplete pass-through, alongside significantly increased consumer spending. Fuest et al. (2020) utilize data from an online supermarket and find an almost complete pass-through of the tax cut. Clemens and Röger (2022) demonstrate that the pass-through for durable goods is significantly higher and nearly complete compared to that for non-durable goods, using consumption, investment, and GDP data from the German Federal Statistical Office.

Second, we contribute to the literature on the response of fuel prices to changes in input prices. Most notably, Bacon (1991) examined asymmetric pricing behavior, demonstrating that retail fuel prices in the UK adjust more quickly to increases than to decreases in input costs. This so-called “rockets and feathers” phenomenon has since been confirmed by numerous studies (among others: Borenstein and Shepard (2002); Bachmeier and Griffin (2003); Chen et al. (2005); Grasso and Manera (2007); Blair and Rezek (2008); Meyler (2009); Honarvar (2009); Lewis (2009); Atil et al. (2014); Gautier and Le Saout (2015); Auer and Schoenle (2016); Blair et al. (2017); Sun et al. (2022); Kilian and Zhou (2024)). However, relatively few contributions account for multiple stages along the supply chain. Farkas and Yontcheva (2019); Severin et al. (1997); Verlinda (2008) explicitly consider the full vertical structure of the market. Li and Stock (2019) takes a different approach by analyzing prices for bioethanol. Haucap et al. (2017) account for the heterogeneity of fuel stations and find high pass-through rates of crude oil price changes.

Jiménez et al. (2025) and Balaguer and Ripollés (2024) examine a fuel price subsidy of 20 cents per liter (c/l) introduced in Spain in the summer of 2022 in response to rising fuel prices following the Russian invasion of Ukraine. The subsidy was structured as a negative tax and was explicitly itemized on fuel receipts. Both studies find an almost complete pass-through of the subsidy to gasoline prices, while the pass-through to diesel prices amounted to only 70% to 80%.

Finally, we contribute to the emerging empirical analysis of the energy tax cut implemented in Germany during the summer of 2022. Several studies employ a simple diff-in-diff approach to estimate the pass-through of the tax cut. Fuest et al. (2022) use France as a control group and report a full pass-through of the tax cut for diesel and a partial pass-through of 85% for gasoline. Schmerer and Hansen (2023) use Austria as a control group and find slightly more than 100% pass-through for both fuel types. Both studies, however, restrict their analysis to the first two weeks following the implementation of the tax cut. Consequently, their results largely coincide with ours for that specific period. In the subsequent weeks, however, the pass-through rate declines significantly. Kahl (2024) uses multiple control groups composed of various European countries. He reports pass-through rates below 90% for both fuel types. However, similar to our results, he documents significant heterogeneity in treatment effects across time and regions. Specifically, the tax cut was nearly fully passed through at the beginning of the intervention, but the

rate declined by about 10% by August. Spatial heterogeneity in pass-through is also consistent with our findings: the highest rates are observed in southern Germany, with significantly lower rates in the eastern regions. Drolsbach et al. (2023) investigate various energy tax cuts across several European countries using a staggered diff-in-diff design based on retail margins. Similar to our findings, they report heterogeneous treatment effects over time, across regions, and by fuel type. In contrast to our results, however, they observe consistently very high pass-through rates across all fuel types. Both studies use retail prices and comprise their control group of a mixture of European countries, whereas we use wholesale prices and can limit our control group to ARA spot market prices.

A number of studies apply synthetic diff-in-diff methods, constructing counterfactuals for German price developments from weighted combinations of European countries. Bernhardt et al. (2023) and Dovert et al. (2023) both find robust pass-through rates of nearly 100% for gasoline, but only partial pass-through rates for diesel, in the range of 75% to 85%. Like us, Dovert et al. (2023) also identify a decline in pass-through rates over the duration of the tax cut, with lower effects in the second half of the intervention. Freitas and Syga (2022) report similar evidence, finding nearly full pass-through rates for both fuel types, though with lower rates at the beginning and end of the tax cut period. Seiler and Stöckmann (2023), using an augmented synthetic control method, find robust pass-through rates of 85% for gasoline and 65% for diesel. Most relevant for our analysis is Montag et al. (2023), who study both the VAT reduction and the energy tax cut that we also exploit. Their findings are particularly insightful, as they document heterogeneous pass-through rates depending on the type of fuel and the specific tax intervention. The authors report generally high pass-through rates for diesel in response to both policy shocks, whereas they find only partial pass-through for gasoline. They further show that the pass-through of the energy tax cut was generally higher as the pass-through of the change in VAT rates.

Unlike all aforementioned studies, we use wholesale rather than retail pricing data. This allows us to examine the specific market level at which the tax cut was implemented, as energy taxes are collected at the wholesale level. Consequently, we can estimate the effects without distortion from wholesale margins, retail markups, or freight costs. Additionally, we use ARA spot market prices as a control group, providing a direct European benchmark without relying on a synthetic control group. This arguably makes our control group the most credible counterfactual available. We are also among the few studies that examine heterogeneous pass-through rates over time and across regions, which proves to be significant in both regards. Finally, to our knowledge, ours is the only study to estimate volume effects of the tax cut, allowing us to estimate volume-weighted effects which we use to calculate the absolute impact of the tax cut. Our results reflect the distinct approach we employ. As outlined above, most studies report nearly

full pass-through rates, whereas our estimates are substantially lower, particularly when weighted by volume. Findings of higher pass-through rates for gasoline than for diesel are consistent with our results, and evidence on regional variation also broadly aligns with our analysis. However, while most studies conclude that the markets for diesel and gasoline are competitive, our results instead raise significant doubts about their competitiveness. The remainder of the paper is structured as follows: Section 2 outlines the institutional background of the market. Section 3 presents our data. Section 4 provides descriptive evidence, followed by Section 5, which introduces our econometric framework and presents the results. Section 6 concludes.

2 Institutional Setting

In this section, we study the institutional framework governing the crude oil market, the refining process, and the wholesale markets for gasoline and diesel. Additionally, we examine the pricing mechanisms in the wholesale markets for crude oil, gasoline, and diesel. Finally, we outline the market structure in Germany and its neighboring countries.

2.1 Supply Chain

Germany’s reliance on crude oil imports is substantial, as domestic crude oil production accounts for only 2% of the nation’s total demand (AG Energiebilanzen, 2022). Due to the large volumes required by refineries and the standardized nature of crude oil as a commodity, approximately 72% of these imports are transported via pipelines, while the remaining 27% are delivered by oil tankers (Federal Cartel Office, 2022). Consequently, as illustrated in Figure 1, Germany’s crude oil supply can be divided into four distinct regions based on their primary sources of supply.

The southern part of Germany is predominantly supplied by the Transalpine Pipeline (TAL), which connects Italy, Austria, the Czech Republic, and Germany. Originating at the marine terminal in Trieste, Italy, the TAL traverses the Alps to reach Ingolstadt, where it diverges into two branches: A western route terminating in Karlsruhe and an eastern route extending through Kralupy to Litvínov in the Czech Republic. Seven refineries, including five in Germany, depend exclusively or predominantly on the TAL for their crude oil supply. These include Austria’s sole refinery, OMV Schwechat, near Vienna, as well as the OMV refinery in Burghausen, located near the German-Austrian border, the Gunvor refinery in Ingolstadt, and the Bayernoil refineries in Vohburg and Neustadt, all in the vicinity of Ingolstadt. Additionally, Germany’s largest refinery, MiRO in Karlsruhe, relies primarily on the TAL, with only 1% of its crude oil sourced domestically from the Palatinate region. Historically, MiRO also utilized the South

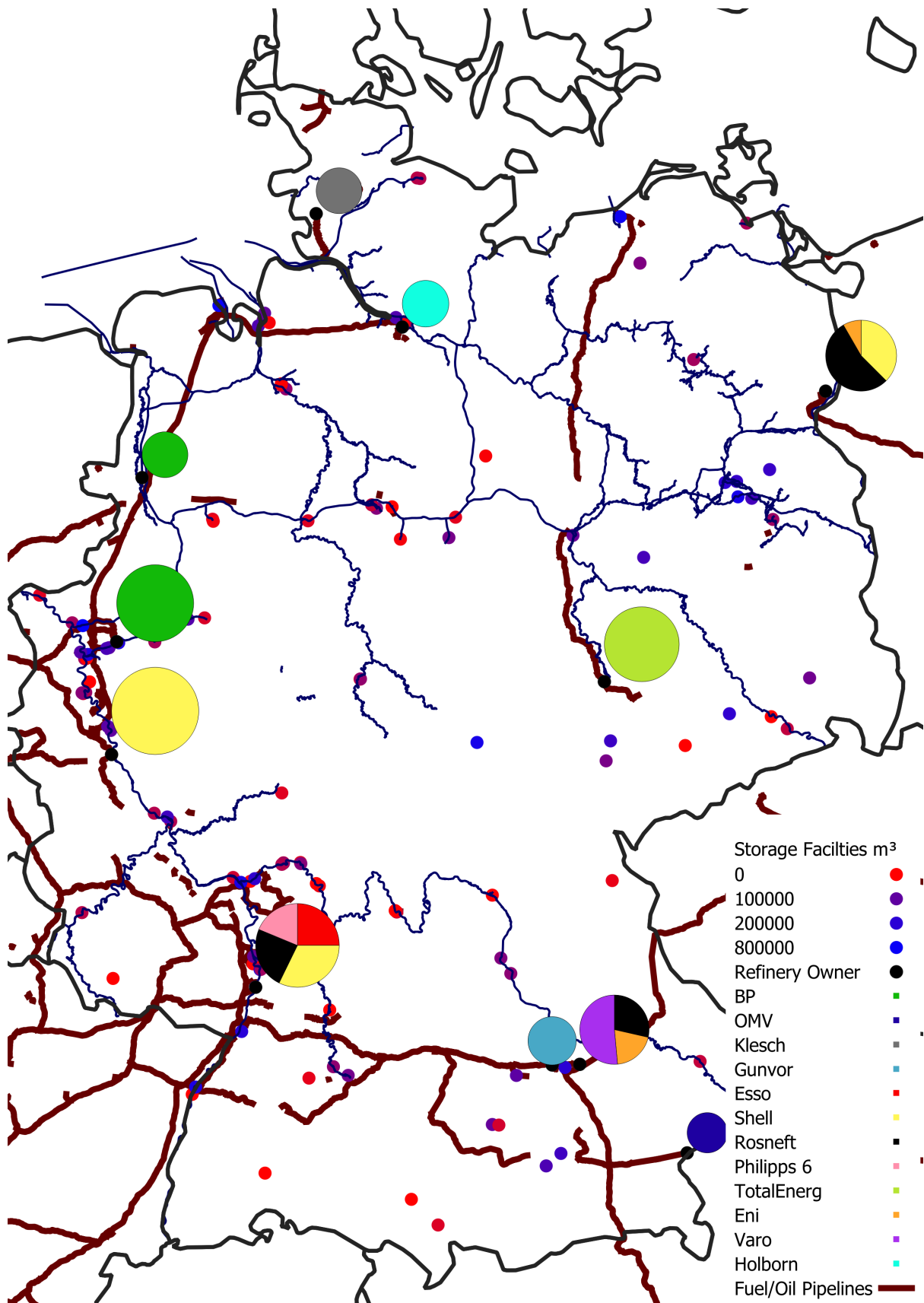


Figure 1: Refineries, Pipelines, Facilities and Waterways in Germany

European Pipeline originating in France (Transalpine Pipeline, 2024; Bayernoil, 2024; OMV, 2016, 2024; MiRo, 2024). Moreover, the eastern branch of the TAL supplies the only two crude oil refineries in the Czech Republic, which produce gasoline and diesel. These Czech refineries also have access to the Druzhba Pipeline (Orlen Unipetrol, 2024a,b).

As shown in Figure 1, the western part of Germany has two main supply chains. The Rotterdam-Rhine-Pipeline connects the marine terminal in Rotterdam with the “Shell Energy and Chemicals Park Rheinland”, which consists of two neighboring refineries close to Cologne. It also links to the “Ruhr Oel” refinery, operated by BP in Gelsenkirchen. Both of these refineries are further connected to the “Nord-West Ölleitung” (NWO), which originates from the marine terminal in Wilhelmshaven (Shell, 2024; BP, 2024a).

The NWO also serves as a major supply line for most refineries in the northern part of Germany. The BP Refinery in Lingen, located in the Emsland region, receives crude oil from the NWO but also processes domestic crude oil from nearby fields. Similarly, the Holborn Europa Raffinerie in Hamburg-Harburg is supplied by the NWO. Northern Germany is additionally served by a marine terminal on the Kiel Canal in Brunsbüttel. The “Raffinerie Heide” comprises two facilities, one adjacent to the Brunsbüttel terminal and the other in Hemmingstedt, connected by a 32-km pipeline. It sources about 15% of its crude oil requirements from domestic production in Mittelplate and Dieksand, which are also connected via pipeline, with the remainder supplied through the marine terminal in Kiel (BP, 2024b; Holborn Raffinerie, 2024).

The eastern part of Germany, i.e. the former German Democratic Republic (GDR) or East Germany has historically been supplied by the Druzhba Pipeline, an extensive network stretching over nearly 9,000 kilometers from West Siberia. In 2021, this pipeline provided approximately 90% of the crude oil needs for the PCK Schwedt refinery and the Total Energies Refinery Mitteldeutschland in Leuna. Residual demand was met by the APR Pipeline, which connects the marine terminal in Rostock to the PCK Schwedt (Puls, 2022). Following the Russian invasion of Ukraine and the subsequent ban on Russian crude oil imports starting 1 January 2023, the supply from Russia ceased. As a result, the APR Pipeline is now operating at full capacity, but can only meet 50–60% of the demand for both refineries. Throughout 2023, alternative supply chains were established, including crude oil imported via the marine terminal in Gdańsk, Poland, and small volumes sourced from Kazakhstan through the Druzhba Pipeline. By the end of 2023, refinery utilization in the region increased to approximately 80% (Pfister, 2022; Kimani, 2022; Jamestown Foundation, 2022; dpa, 2022).

As Germany’s overall crude oil supply network is highly diversified, so are the countries exporting crude oil to Germany. The Federal Office of Economics and Export Control (BAFA) published data on the origin countries of Germany’s crude oil imports on a monthly basis until the end of 2023 (BAFA, 2025). Figure 2 illustrates the share of crude

oil imports into Germany by country of origin. Russia was predominantly the single largest supplier of crude oil to Germany. North Sea countries like Denmark, the United Kingdom, and Norway were, however, the second largest supply market for Germany. In addition, Africa and the Middle East have historically played a more significant role in importing crude oil into Germany, but they have become less relevant. In recent years the United States also became an increasingly important supplier.¹ Figure 2, therefore underscores the global scope of crude oil imports into Germany.

As illustrated in Figures 1 and 2, Germany’s crude oil supply network is characterized by a high degree of diversification, comprising four major independent transportation systems for crude oil imports and a wide array of supplier countries. Individual refineries, however, exhibit significant dependence on specific supply systems due to infrastructural constraints, such as pipelines and terminals, as well as the compatibility requirements associated with particular crude oil blends. Refineries in the eastern part of Germany, for example, are specifically configured to process Russian ural crude oil blends and face considerable challenges in transitioning to alternative crude blends, as will be elaborated in the subsequent section (Federal Cartel Office, 2022).

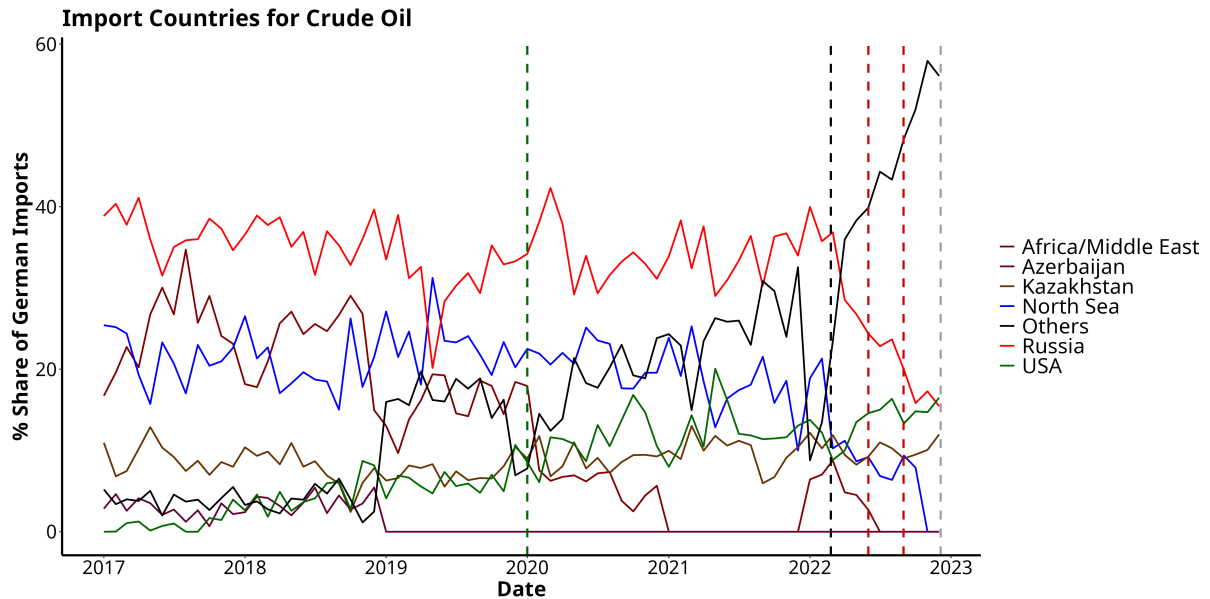


Figure 2: Crude Oil Imports into Germany by Country

¹With the decline in Russian crude oil imports, the share of imports classified under the category “Others” gained substantial importance. According to BAFA, this categorization reflects data protection considerations. Following the Russian invasion of Ukraine, firms either withheld information on continued crude oil imports from Russia or chose not to disclose the identities of their new crude oil suppliers.

2.2 Production

In this section, we provide a brief overview of the production steps within a crude oil refinery, focusing on details relevant to the scope of this paper.

Refinery production processes typically involve joint production, meaning multiple products are derived from a single production process. Although refining crude oil is inherently complex, the following section provides a general outline. First, the crude oil is heated and mixed with water. An electric current is then applied so that the moresaline water, which accumulates on the surface, can be removed, thereby extracting salts from the oil. Second, the crude oil is processed in a distillation unit, where it is heated to approximately 400°C, causing it to vaporize and subsequently condense. Through this process, the crude oil can be separated into its various components, as illustrated in Figure 3. During atmospheric distillation, which takes place at normal atmospheric pressure, products such as gases, gasoline, petroleum, kerosene, diesel, and light and heavy heating oils are obtained. The remaining substances are then processed via vacuum distillation to yield other products, including various lubricants and bitumen (Federal Cartel Office, 2022).

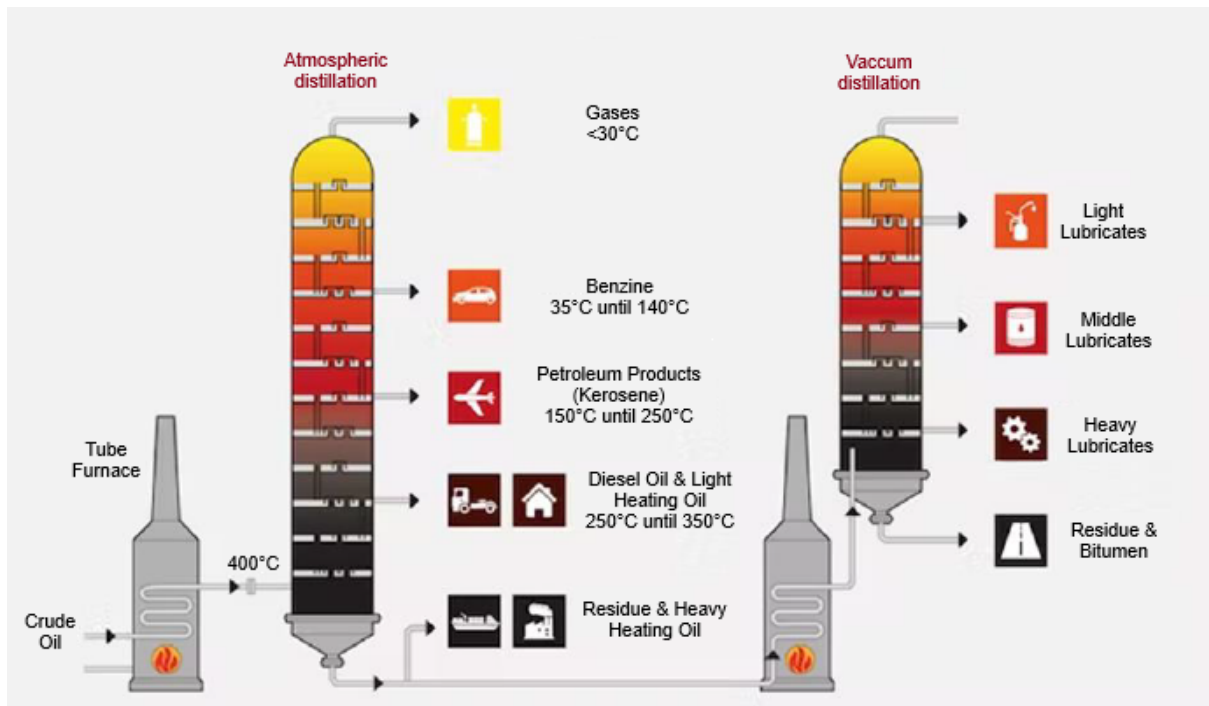


Figure 3: Joint-Product Production in a Refinery (Gunvor Raffinerie Ingolstadt, 2016)

Third, most refineries also operate additional units that further improve product quality, such as desulfurization, cracking, catalytic reforming, pyrolysis, and blending facilities. Desulfurization, for example, is essential for removing sulfur compounds from lubricants and heating oil to produce lighter heating oil, diesel, and gasoline. Since the demand for gasoline, diesel, and light heating oil is substantial, refineries commonly employ cracking to cut down heavy, long-chain hydrocarbons (such as heavy heating oil) into lighter,

shorter-chain hydrocarbons like gasoline, diesel, and light heating oil. Various cracking techniques exist, each influencing the final product mix differently (Federal Cartel Office, 2022).

A refinery will adjust their processes based on the specific crude oil blend, the refineries facilities and the desired final product mix. Every refinery maintains a set repertoire of crude oil blends it can efficiently process. Switching between blends within this repertoire involves minimal costs and can be accomplished within a few hours. In contrast, processing a crude oil type not currently in the refinery’s repertoire is both time-consuming and expensive, potentially requiring years to fully implement. Consequently, the operational flexibility of a refinery is well-defined by the crude oil blends it can process. Blends within its established repertoire are readily usable, whereas those outside it are not. Therefore, the yield of specific refineries can differ significantly (Federal Cartel Office, 2022).

Table 1, however, illustrates the average product yield of refineries in Europe and the United States (U.S.). In both regions, approximately 75% of production consists of road fuels, including gasoline and diesel, while all other products collectively account for the remaining 25%. Notably, 10% of the output is allocated to kerosene for aviation. The table further highlights that European refineries produce a significantly higher proportion of diesel compared to their U.S. counterparts. This difference is driven by comparatively higher gasoline demand relative to diesel in the United States than in Europe.

Products	Europe	U.S.
Diesel	~ 40.2%	~ 25%
Gasoline	~ 18.7%	~ 50%
Fuel oil	~ 10%	~ –
Naphta	~ 6.9%	~ –
Kerosene	~ 7.7%	~ 9%
LPG	~ 2.5%	~ 6%
Other	~ 14%	~ 10%

Table 1: Average Refinery Production (FuelsEurope, 2024; EIA, 2025)

2.3 Ex-Refinery Transportation

The distribution of refined petroleum products is considerably more intricate than that of crude oil, owing to substantial variation across different product types. In general, refineries sell their outputs in bulk to wholesalers, major retailers, and large-scale consumers. Niche products, such as kerosene and intermediate chemical feedstocks, are often sold directly to specialized buyers (e.g., airlines, the chemical industry, and pharmaceutical manufacturers). Diesel and gasoline are typically sold directly to retail outlets (i.e., petrol

stations), with wholesalers and very large individual consumers making up only a small portion of sales.

However, as illustrated by Figure B.4 and Table C.1, there is no strict division among these vertical market segments. Many firms operate across multiple segments of the supply chain; some span several levels, whereas others are active solely in one. Consequently, determining the specific market level to which a given product is ultimately sold can be challenging (Federal Cartel Office, 2022; Bundeswettbewerbsbehörde, 2022).

The physical delivery of refined products also varies widely, employing multiple modes of transportation. Figure 1 shows that additional pipelines transport refined products from refineries to storage facilities or shipping terminals. Barges then convey large volumes of products along inland waterways, while the final distribution step - reaching petrol stations or large consumers - commonly relies on truck transport. The exact terms of transportation, as well as the responsibility for associated costs, can differ across transactions (Federal Cartel Office, 2022; Bundeswettbewerbsbehörde, 2022).

Despite the complexity of these arrangements, transportation costs are a significant factor, rendering the distribution of refined products more geographically constrained than that of crude oil. Consequently, German refineries primarily sell within a relatively localized radius. As shown in Table 2, 90% of gasoline (diesel) sales occur within 300 km (350 km) of the refinery, while the radius for heating oil is even smaller, at about 200 km.

Product	70% of Sales	80% of Sales	90% of Sales
Diesel	ca. 200km	ca. 250km	ca. 350km
Gasoline	ca. 150km	ca. 200km	ca. 300km
Heating Oil	ca. 100km	ca. 150km	ca. 200km

Table 2: Regional Extent of Refinery Sales according to Federal Cartel Office (2022)

2.4 The ex-Refinery Market for Diesel and Gasoline

Since this paper focuses on road fuels - specifically diesel and gasoline - we constrain our analysis in the following section to the ex-refinery and wholesale markets for these products. In line with European Commission (2002, 2015); Federal Cartel Office (2017), we treat diesel and gasoline as distinct markets, separate from other refinery outputs, because consumers cannot substitute between different fuel types.

2.4.1 Refinery Capacity

According to Federal Cartel Office (2022); Bundeswettbewerbsbehörde (2022), there is conflicting evidence concerning the availability of refining capacity. Media outlets have reported a global reduction in refining capacity, largely driven by declining profitability, a

trend exacerbated by the drop in demand during the COVID-19 pandemic and the global trend towards a more sustainable lifestyle.²

Nevertheless, Figure 4 indicates that, in historical terms, global refining capacity has grown. While Europe and Germany have experienced a reduction in capacity, this decline has not been substantial during the period examined (2017 - 2025). Global capacity, however, is still growing. The discrepancy can be explained by the strategy adopted by many refinery operators: Anticipating a future decrease in demand for crude oil products, refinery owners have begun reducing refining capacity and shifting production toward renewable energy sources, such as hydrogen and synthetic fuels. Because German and European refineries tend to be older, more complex, and less efficient, they were among the first to shut down (Argus Media, 2024a; World-Energy, 2021). These observations are consistent with the findings of Federal Cartel Office (2022); Bundeswettbewerbsbehörde (2022), which suggest that, despite the mixed evidence on the development of refining capacity, refineries are not operating at full capacity and could feasibly expand their output.³ Therefore, there seems not to be an issue with capacity constraints within refineries, generally.

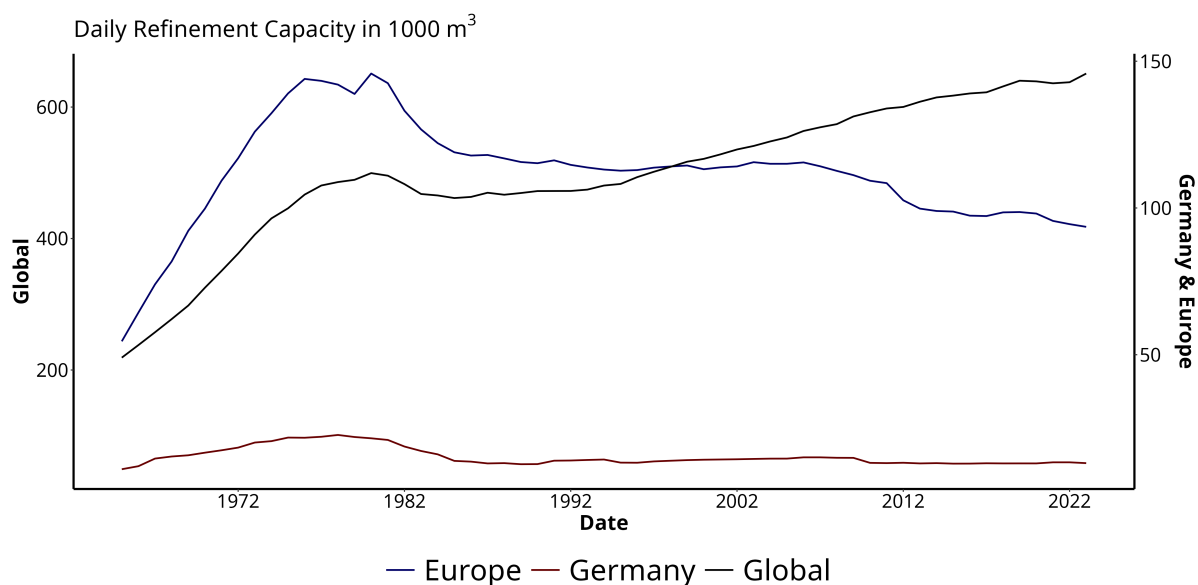


Figure 4: German, European and Global Refinement Capacity according to EIA (2025)

Concerns persist that German refineries may struggle to meet domestic diesel demand, as Germany maintains a negative trade balance for diesel and a positive trade balance for gasoline. As noted in the preceding section, refineries cannot freely adjust the proportions of products they produce; rather they operate within the constraints imposed by their

²See, for instance, Deutsche Wirtschafts Nachrichten (2022); Sanicola (2022); The Washington Post (2022a).

³See Figure 7 in Bundeswettbewerbsbehörde (2022) and p.74 in Federal Cartel Office (2022).

crude oil mix and technical capabilities. According to Federal Cartel Office (2022), it remains unclear whether these limitations are due to capacity constraints. Consequently, the following subsection examines the import and export of gasoline and diesel in greater detail.

2.4.2 International trade

Figure 1 shows that most refineries in Germany are close to a country border and that they are mostly connected via pipelines and waterways to at least one neighboring country. These means of transportation are used not only for the supply of crude oil but also for the distribution of refined products, as they represent the most cost-effective option. Figure 5 shows that significant quantities of diesel and gasoline are traded across German borders. About 10% of the German gasoline production is additionally imported, but more than 20% of the production is exported, whereas Germany imports between 20-25% of its diesel production additionally and exports only 10%. Figure 5 therefore shows that there is a significant import surplus of diesel and a smaller export surplus of gasoline. According to Federal Cartel Office (2022), this is not, however, a necessary consequence of capacity constraints in the production of diesel, but it can be explained by a number of reasons, like regional price differences or cross-border exchange of refinery capacity.

Due to the significance of transportation costs, Germany primarily trades with its neighboring countries, as illustrated in Figures B.1 and B.2, which show regional import and export shares of gasoline and diesel. Most gasoline exports are directed to Austria, likely supplied by the Burghausen refinery, owned by the Austrian oil company OMV and located directly on the Austrian border (see Figure 1). Additional exports go to Switzerland, the Benelux countries, France, and Poland. Export destinations, however, vary considerably over time. Gasoline imports are more stable, largely originating from the Benelux countries and other global suppliers, with smaller volumes arriving from Austria and Switzerland. Since Germany maintains a gasoline export surplus, no shortages were expected during the tax cut period.

A similar pattern holds for diesel, as shown in Figure B.2. Exports vary substantially across neighboring countries, with Austria again receiving the largest share, most likely due to the Burghausen refinery. Additional flows are directed to Switzerland, the Benelux countries, and France. At the same time, Germany imports considerable quantities of diesel from the Benelux countries, reflecting both the exchange of refinery capacities and established trade flows. Until the imposition of European sanctions, substantial diesel imports originated from Russia, but these ceased thereafter. A shortage in Germany was nevertheless unlikely, as the reduction in Russian supply was fully offset by increased imports from other regions worldwide. Moreover, this discontinuity occurred only after the implementation of the tax cut and is therefore not relevant for our analysis.

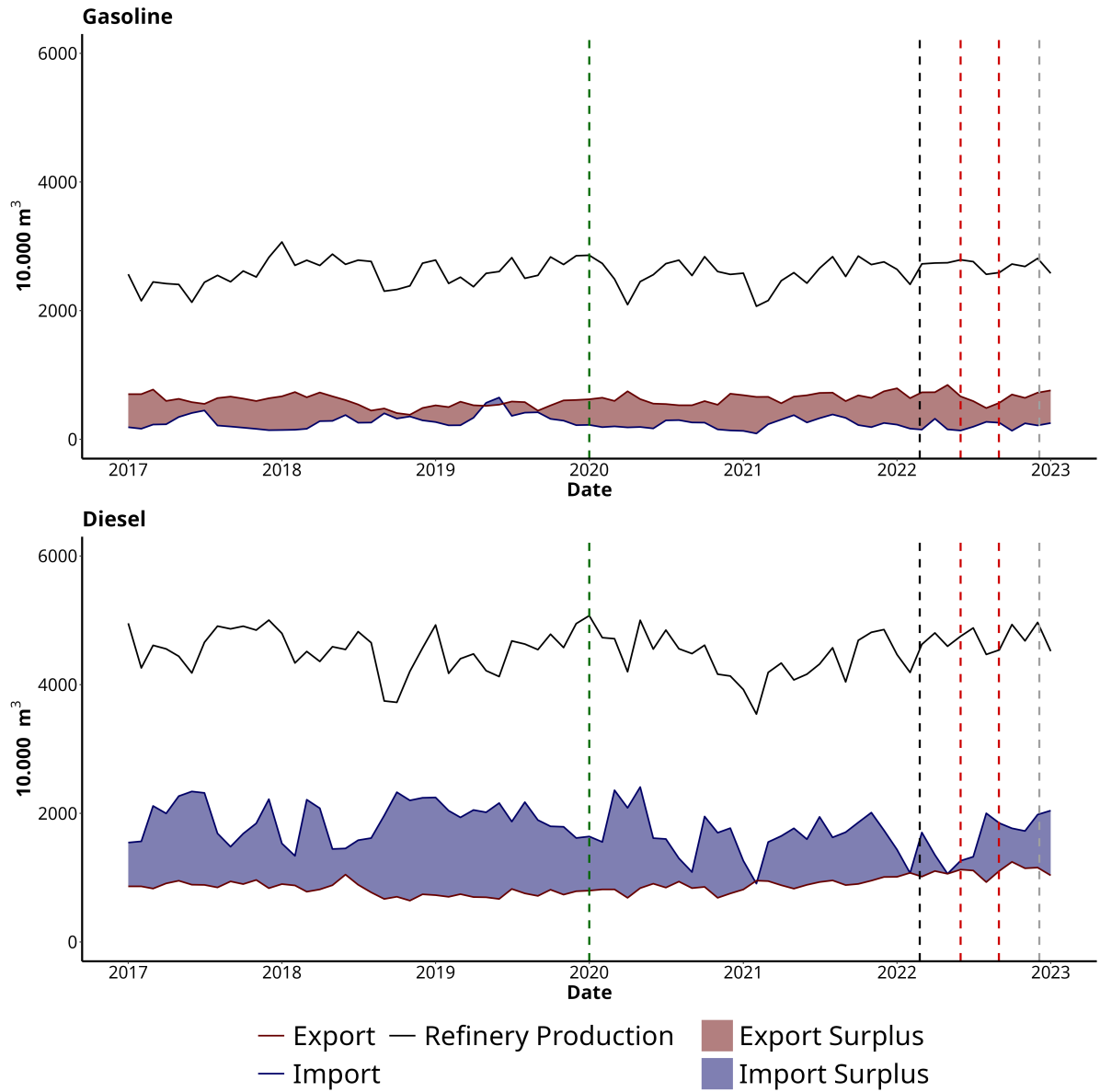


Figure 5: German Diesel and Gasoline Imports, Exports and Refinery Production

Even though, the wholesale market for road fuels is not national but international in nature, transportation costs play a significant role in the distribution of gasoline and diesel, as previously discussed. Figure B.4 illustrates that these fuels are primarily sold on a regional basis. Nevertheless, as Figures B.1 and B.2 show, these regional markets often transcend national borders and are shaped by the availability of river routes and existing pipeline infrastructure, as depicted in Figure 1. As a result, regional market boundaries are more plausibly defined by the proximity to a refinery and competing refineries. Accordingly, we utilize price data from 11 German regions, as outlined in Section 3, to analyze regional variation in the pass-through effects of the tax cut, which is in line with Federal Cartel Office (2025b).

2.4.3 Market Structure

As outlined in Section 1, the market for road fuels has repeatedly been scrutinized by antitrust authorities in various countries. One frequently voiced concern is the dominance of a small number of large companies in the vertical structure of the market, extending from crude oil exploration to retail distribution. These companies were - or still are - fully vertically integrated, meaning they extract, transport and refine crude oil, while also selling the refined products at both the wholesale and retail levels. Table C.1 shows that, historically, six out of twelve companies operating refineries were fully vertically integrated. Since 2018, Esso, OMV, and Total Energies have sold their networks of petrol stations in Germany (EG Group, 2018; OMV, 2016; TotalEnergies, 2024). At present, four of these twelve companies are engaged in operations ranging from exploration to refining. Two operate refineries and petrol stations (with Philipps66 announcing plans to sell its network Argus Media (2024b)), while three companies focus solely on refining. These companies also collaborate at various stages of the supply chain. First, as illustrated in Figure 1, they jointly own and operate refineries, pipelines and storage facilities. Second, although these fully integrated companies could supply their own refineries exclusively, they do so only partially. Generally, firms without exploration capacity depend on external sources for their crude oil supply, while those with exploration capacity also procure crude oil from third parties. The extent of internal versus external supply remains unclear. Third, a system of swap agreements is in place among most of the companies. Most companies offer their products nationwide, even though they do not possess refining capacity in every region. Consequently, they rely on swap agreements to exchange products across different regions, thereby reducing transportation costs. Approximately 25% of all fuel sold in Germany is contracted through these arrangements, which are particularly widespread among the (former) fully integrated companies ⁴ (Federal Cartel Office, 2011).

Although Federal Cartel Office (2022) concludes that significant joint market power cannot yet be definitely established, the report observes that many of the factors mentioned above have the potential to limit competition in the wholesale and ex-refinery markets. Furthermore, it highlights that independent refineries, i.e. those not vertically integrated, are wholly reliant on third-party procurement and marketing, just as independent wholesalers and petrol stations depend on refineries. Potential competition at all three vertical stages is limited: A partial market entry would necessitate dependence on existing market players, while a full-scale entry across the entire supply chain would entail substantial investment costs. Finally, because demand at both the retail and wholesale stages is highly fragmented, there is no effective countervailing buyer power (Federal Cartel Office, 2011).

⁴Namely Shell, Aral/BP, TotalEnergies, Esso/ExxonMobile, and Jet/Philipps66 (formerly ConocoPhilipps)

2.4.4 Pricing Mechanism

The procurement of crude oil and the marketing of refined products does not happen on the level of the refinery operators, but of the owners of a refinery. This means that jointly-owned refineries do not procure or sell together, but each shareholder is responsible to procure and sell his part of the refineries demand/product. As highlighted above not every vertically integrated company sells/procures goods within their company, but also uses third parties. Generally, two types of contracts are used when trading crude oil and refined products: In the short run, customers can buy crude oil and refined products on the spot market, with different delivery times. Quantities and the distribution of transportation costs varies by contract. Long-term contracts are usually negotiated in fall and run for the following year. These contracts use price indexes by price information services, like “Argus Media” and “S&P Global Platts” as a benchmark. These price indexes in turn are based on spot market prices (Federal Cartel Office, 2022).

These price benchmarks are developed by gathering information from market participants throughout the day and calculating a market price. Argus Media states that they *“are informed by information received from a wide cross-section of market participants, including producers, consumers and intermediaries. Argus Media reporters engage with the industry by proactively polling participants for market data. Argus Media will contact and accept market data from all credible market sources including front and back office of market participants and brokers. Argus Media will also receive market data from electronic trading platforms and directly from the back offices of market participants. Argus Media will accept market data by telephone, instant messenger, email or other means.”* Even though Argus Media also publishes real-time data, after the market closes they will publish a so-called end of day-value. As prices can vary significantly over the day, according to Argus Media, this is supposed to represent the price on the open spot market during the day, as reporters verify all transactions of the day (Argus Media, 2024b). As these prices can also vary strongly, most long-run contracts will use a weekly or monthly price average as their underlying price benchmark. Usage of the contract type varies between companies. Some companies only use long-term contracts for procurement while others almost exclusively use spot market transactions for procurement (Federal Cartel Office, 2011).

Federal Cartel Office (2025b), however, questions the reliability of the pricing data, noting that price quotes were published even when no or only very few transactions had been reported. They further criticize the potential for market participants to manipulate price quotes to their advantage. Finally, they argue that reports from sellers were heavily overrepresented relative to buyers in the sample used to generate the price quotes. We further discuss the data used in the following section.

Overall, we find that Germany relies on crude oil imports from a wide range of countries.

Individual refineries, however, face more restrictive procurement options, determined by their location and their technical capacity to process specific crude oil types. Production is characterized by the joint output of multiple refined products, and the flexibility of refineries to adjust their product mix is limited. We conclude that the wholesale market for road fuels is geographically constrained, with refineries likely exercising market power within their respective regions. These regions, however, often extend beyond national borders. Within the period under study, we find no evidence of supply shortages in road fuels. Despite the discontinuation of substantial diesel imports from Russia, our analysis indicates that suppliers were able to compensate for this loss between the onset of the invasion and the implementation of European import bans on Russian oil products. Finally, we find that the oligopolistic market structure and prevailing pricing mechanisms may impede effective competition in the market.

3 Data

Our data set consists of a unique combination of price, supply and demand data from all three market levels, as described in Section 2. Additionally, we use a number of control variables to control for demand and supply side characteristics as well as economic cycles. First, to account for crude oil price inputs, we use the daily “ICE Brent 1-minute month” indicator from Argus Media, like Federal Cartel Office (2022). This daily indicator from the “London Intercontinental Exchange” (ICE) represents the daily settlement price at 16:30 London Time for future contracts with delivery of 1.000 barrels of Brent Blend in the month after next. This price quota is highly relevant, as Brent Blend is the benchmark price for European oil trading. Furthermore, trading volume is high and the price is not regionally limited, unlike a spot price.

For robustness reasons we also use ARA spot market prices for Brent Blend as it is a more accurate input price for refineries in the western part of Germany along the river Rhine. For refineries in the eastern part of Germany we additionally use an ICE Future for Ural Crude Oil, as these refineries are build to process Ural Blends. Likewise, we use an ICE Future for Sahara Crude Oil for southern refineries in Germany. All three price indexes come from “Refinitiv Datastream”. Refinitiv also reports data on refinery capacity, which includes the long-term technically possible volume a refinery can produce and the capacity that is online at any given day, which might differ due to maintenance work or repairs. It is, however not the actually produced or sold quantity.

Second, we use data on the German wholesale market for refined products. As described in Section 2 no commodity exchange exists on this market level, instead there is an open spot market. In the following we use data from the price information service Argus Media. They publish daily data for “95 Ron E5” and “diesel EN 590 10 ppm”, which we call gasoline and diesel. The data includes a volume weighted average price and a grouped

volume indicator for each region, which represents the quantity reported to Argus Media on a given day.

Argus Media publishes these data for eleven regions in Germany: North, Seefeld, Emsland, Magdeburg, East, West, Cologne, Rhine-Main, Southeast, Southwest, and South. Each region is linked to one or more designated spotsat refineries, harbors, or large storage facilities, where the majority of trades occur. Figure B.3 illustrates the geographical extent of these eleven regions within Germany, along with their corresponding spots. The colored dots on the map represent all gasoline retail stations in Germany, each assigned to the nearest trading location and thus to the respective regional market.

Furthermore we use so-called “ARA import parities” from Argus Media. According to Argus Media these are the *“calculatory costs to import gasoline and diesel from northwest Europe to German regional markets.”* These import costs are calculated by adding up Argus Media price quotation of diesel or gasoline in the ARA region and freight costs. Note that these import parities are published for different regional markets as the German wholesale prices above, namely: Duisburg, Dortmund, Cologne, Frankfurt and Karlsruhe, as shown in Figure B.3 (Argus Media, 2024b).

Third, we use gasoline retail prices collected by the Market Transparency Unit for Fuels (MTU) at the German Federal Cartel Office and access it via “tankerkoenig.de”.⁵ As petrol stations in Germany are obliged by law to report every price change to the MTU in real-time, we have access to virtually all price changes. Similarly to the wholesale market, we use data on gasoline and diesel prices.

Lastly, we use data from the Joint Organizations Data Initiative (JODI), which is an initiative of the international energy forum (IEF). JODI publishes monthly quantity data for nearly 100 countries, covering significantly more than 90% of the global supply and demand. Participating countries all report data directly to JODI by filling out a standardized survey. JODI defines all the quotation, definitions and insures the quality of the published data. As they report actual quantities sold and are provided by the governments of the participating states, they likely represent the most reliable quantity measure available. However, the data are only reported on a monthly basis and at the national level.

The data itself reports monthly quantity data on thirteen product categories, from which we use Crude Oil, gasoline and diesel. The data itself includes the supply as well as the demand side and follows this logic:

⁵<https://tankerkoenig.de/> is a website that provides all historic prices published since the start of the MTU.

$$\begin{aligned}
& \textit{Production} + \textit{From other Sources} + \textit{Imports} + \textit{Products transferred/Backflows} \\
& - \textit{Exports} - \textit{Direct Use} - \textit{Stock Change} - \textit{Statistical difference} \\
& = \textit{Refinery Intake},
\end{aligned} \tag{1}$$

$$\begin{aligned}
& \textit{Refinery Output} + \textit{Receipts} + \textit{Imports} - \textit{Exports} + \textit{Interproduct transfers} \\
& - \textit{Products transferred} - \textit{Stock Change} - \textit{Statistical difference} \\
& = \textit{Demand},
\end{aligned} \tag{2}$$

where Equation (1) describes the logic of the data on crude oil quantities and Equation (2) describes the logic of the data on the quantity of all refined crude oil products. *Production* in Equation (1) and *Refinery Output* in Equation (2) denote the marketable output of crude oil and oil products, *From other sources* marks the input of additives like biofuel, lubricants etc. *Products transferred/Backflows* describes backflows from the petrochemical industry and “imported petroleum products which are reclassified as feedstocks for further processing in the refinery, without delivery to final consumers” (JODI, 2025). *Direct Use* means direct usage of crude oil, for example burning it for electricity, whereas *Receipts* are mostly recycled products. *Interproduct transfers* describe the reclassification of products, because their specification has changed or they have been blended into another product. *Stock Change* is the change in stocks. The *Statistical Difference* is the difference between the reported *demand* or *refinery intake* and all supply side parameters, which can occur due to inaccurate reporting of the data to JODI. Lastly, *Refinery Intake* describes the observed refinery throughput in a country. *Demand* of a country is the sum of all deliveries or sales to the domestic consumption, refinery consumption and marine and aviation bunkers (JODI, 2025).

Timeline of events As shown in Figure 6 our analysis includes a large data set, starting 1 January 2017 and ending 31 December 2022. Within this time frame, five different exogenous discontinuities significantly impact the prices for gasoline and diesel. First, in the summer 2018, the water level of the Rhine was very low, significantly increasing freight prices for barges along the Rhine, impacting crude oil and oil product prices in the south of Germany (Die Zeit, 2018a). Second, the COVID-19 pandemic and associated lockdowns decreased demand in road fuels and thereby demand for crude oils. Also, in reaction to the COVID-19 pandemic the value-added tax (VAT) in Germany was reduced from 19% to 16% from 1 July 2020 until the end of 2020 (Die Zeit, 2018b). We do not exploit these exogenous shocks, but we correct for it.

On 24 February 2022, the beginning of the Russian invasion of Ukraine prices again increased significantly, leading to the so-called “Tankrabatt”, which we call tax cut through-

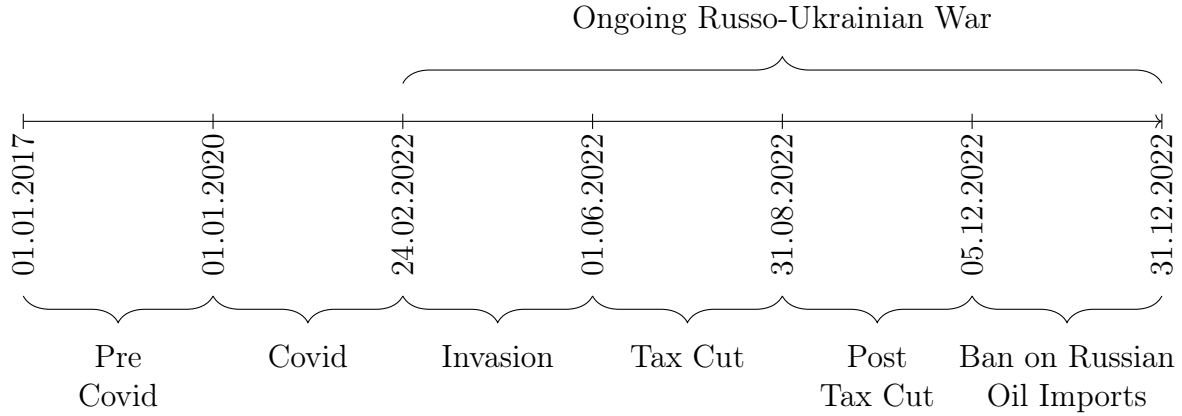


Figure 6: Timeline of Events

out the paper. In reaction to continuously high gasoline retail prices, Germany, among other countries in Europe, introduced a temporary energy tax reduction for gasoline and diesel. For gasoline (diesel), the energy tax rate is reduced by 29,55 (14,04) cents per liter from 65,45 (47,04) cents per liter to 35,9 (33) cents per liter. This discontinuity began on 1 June 2022 and was limited until 31 August 2022. Last, the European Union imposed a ban on Russian crude oil imports by ship on 5 December 2022. This import ban was extended to pipelines on 1 January 2023. On 5 February 2023, the European Union banned all imports of oil products, including diesel, gasoline and other lubricants.

4 Descriptive Evidence

Before estimating the impact of the tax cut on refinery margins and fuel demand in Germany, this section provides a detailed discussion of the available data. As outlined in Section 3, the period surrounding the tax cut was marked by several exogenous shocks. Consequently, we will examine the entire time frame for which data is available.

4.1 Price Data

Figure 7 shows the trajectory of the absolute prices per liter for crude oil, gasoline and diesel net of taxes and fees in both the wholesale and retail market from 2017 until 2024. The figure captures all external shocks discussed in Section 3. The first green dotted line represents 1 January 2020, marking the onset of the COVID-19 outbreak in China, which initially caused a sharp decline in crude oil prices and subsequently reduced demand for crude oil products in Germany during various lockdowns. The second black dotted line indicates the Russian invasion of Ukraine on 24 February 2022. The two red lines mark the start and end of the energy tax cut. Lastly, the gray dotted line represents the date

when European sanctions against Russian crude oil and crude oil products as described in Section 3, came into effect.

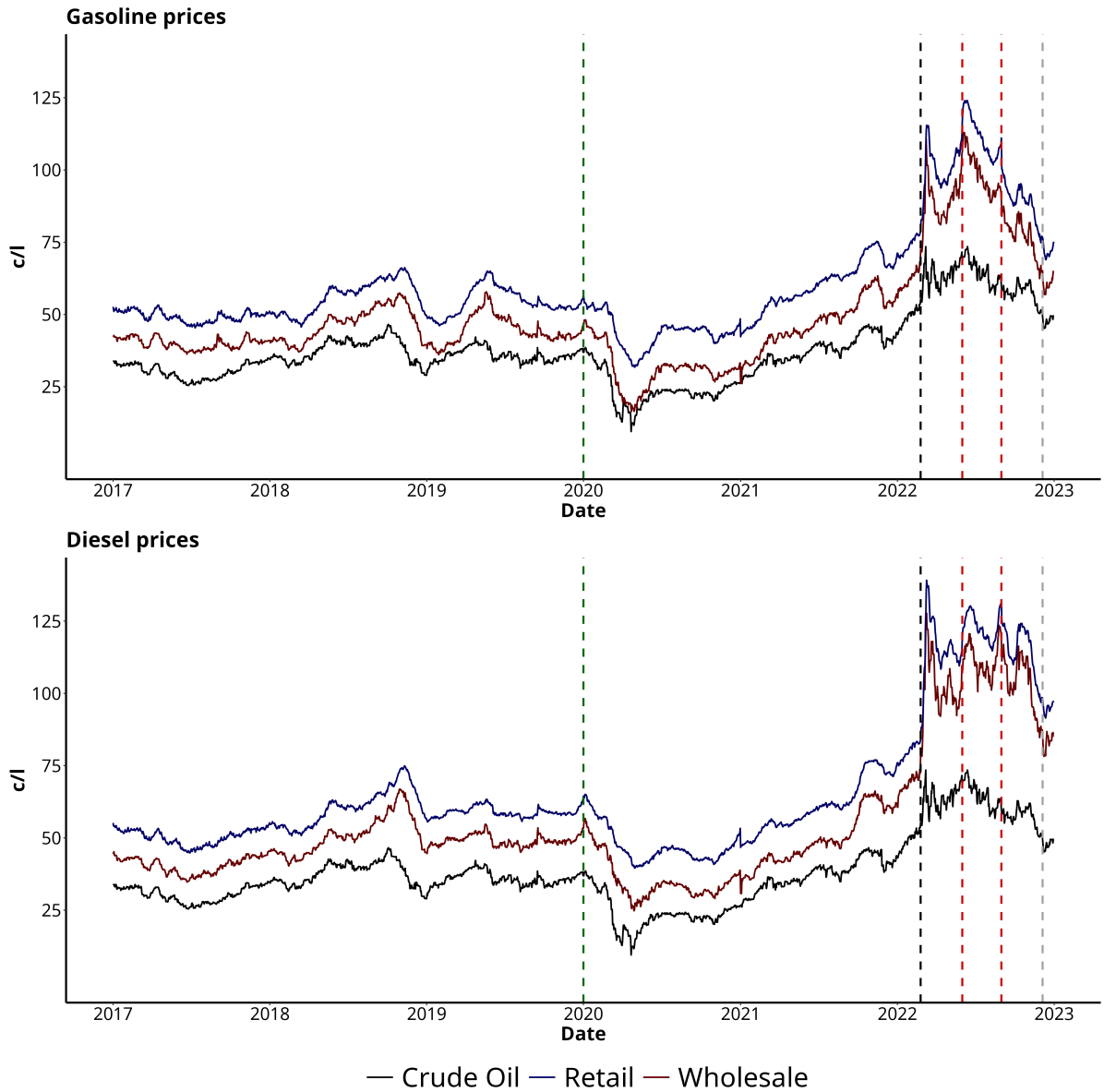


Figure 7: Crude Oil, Diesel and Gasoline Prices on the Wholesale and Retail Market

The development of crude oil, gasoline, and diesel prices remained relatively stable prior to the onset of the COVID-19 pandemic. However, during the pandemic, global demand for crude oil and its derivatives experienced an unprecedented decline, resulting in lower-than-normal prices throughout 2020 and 2021. Even before the Russian invasion of Ukraine in February 2022, prices had begun to rise. This increase was driven by two factors: a post-pandemic recovery in demand and market anticipation of an escalation in the Russo-Ukrainian conflict, which had been expected since at least late 2021 when Russia again increased its military buildup along the Ukrainian border (The Washington Post, 2022b).

A significant surge in prices occurred following the invasion, with the rise in diesel and gasoline wholesale prices notably outpacing that of crude oil. This discrepancy suggests an increase in the difference between crude oil and gasoline and diesel prices, which we call refinery margin. Although refinery margins appear to have slightly decreased since then, they remain above pre-war levels by the end of 2023. Moreover, it is evident that station margins, the difference between wholesale and retail gasoline (and diesel) prices, have remained relatively constant during this period.

Table C.2 validates these findings and shows a similar pattern in price development. Additionally, it provides a more detailed analysis of refinery and station margins. In Germany, average refinery margins remained stable at approximately 9 (12) cents per liter for gasoline (diesel) during the pre-COVID and COVID periods. However, following the invasion, average refinery margins for gasoline nearly tripled, and refinery margins for diesel more than tripled. This trend persisted during the tax cut period, with gasoline (diesel) margins increasing by an additional 9 (8) cents per liter. Notably, in the post-tax cut period, refinery margins for gasoline significantly declined by about 14 cents per liter, while diesel margins remained unchanged. However, in the subsequent period following the implementation of sanctions, diesel margins caught up, experiencing a noticeable decrease, whereas gasoline margins remained constant.

Figure B.9 provides an initial graphical assessment of refinery margins in Germany and the ARA region. Historically, these margins have exhibited a strong correlation over time, which is in line with the substantial cross-border trade in refined products between Germany, the Netherlands, and Belgium, as detailed in Section 2. Following the onset of the Russian invasion of Ukraine, however, this correlation weakens, particularly for gasoline. This divergence becomes more pronounced during the tax cut period: While refinery margins in the ARA region decline, those in Germany remain relatively stable. Table C.2 confirms this and shows that during the tax cut, average refinery margins in Germany increased by 9 (8) cents per liter for gasoline (diesel), relative to the preceding period. In contrast, the corresponding increases in the ARA region were only 6 and 7 cents per liter, respectively. This differential suggests that refinery margins rose more sharply in Germany than in the ARA region, providing preliminary evidence that the tax cut was not fully passed through to consumer prices.

The results discussed above are, however, national averages for Germany. Figures B.7 and B.8 reveal considerable regional heterogeneity in refinery margins throughout 2022. Figure B.7 illustrates that refinery margins for gasoline in the ARA region declined during the tax cut. A similar, albeit less pronounced, decline is observed in several German regions, including East, Magdeburg, North, Seefeld, and Southwest. In contrast, the regions of Cologne, Emsland, Rhine-Main, and West exhibit a different pattern: Refinery margins declined during the first half of the tax cut but subsequently increased. In the regions South and Southeast, refinery margins remained elevated throughout the tax cut.

Figure B.8 reveals a similarly heterogeneous pattern in refinery margins for diesel across German regions. In the ARA region, which serves as a benchmark, margins declined during the first half of the tax cut and increased in the second half. A comparable trend is observed in the German regions of Cologne, East, Emsland, Magdeburg, North, and Seefeld. By contrast, in the regions of Rhine-Main, South, Southeast, Southwest, and West, refinery margins exhibit a continuous upward trend throughout the entire duration of the tax cut. These patterns suggest substantial regional variation in the impact of the tax cut on refinery margins, indicating that the treatment effect of the policy may differ significantly across regions.

Furthermore, Table C.2 indicates that the station margin has remained remarkably steady over time, ranging between 10 and 14 ct./L for both gasoline and diesel. Consequently, we will focus our primary analysis on the ex-refinery and wholesale markets, as the station margin shows limited variation.

4.2 Quantity Data

Using monthly quantity data from JODI, we analyze the aggregated demand for gasoline and diesel over time. Similar to prices, the quantities of road fuels are highly volatile during the period of the Russian invasion and the tax cut. Therefore, we use price data from the ARA region as a benchmark for European prices. However, demand data from Belgium and the Netherlands alone would be insufficient for this purpose. We therefore aggregate demand across the entire European Economic Area (EEA). To account for the fact that absolute demand in the EEA is orders of magnitude higher than in Germany, we normalize the series to the average demand level of 2016, which is set to 100% in Figure 8.

The figure shows that prior to the COVID-19 pandemic, gasoline demand in Germany and the EEA followed a broadly similar trend, although demand in Germany was on a higher level since 2018, compared to 2016. During the pandemic and subsequent lockdowns, particularly in the winter of 2020/2021, demand declined markedly in both Germany and the EEA. In the recovery phase of the second half of 2021, however, gasoline demand rebounded more strongly in the EEA than in Germany relative to 2016 levels. The Russian invasion in February 2022 does not appear to have had an immediate impact on demand. During the tax cut, demand increased more strongly in Germany than in the EEA, suggesting that the tax cut stimulated demand. This interpretation is consistent with economic theory, since gross gasoline retail prices would have declined even with incomplete pass-through. Additional support for this is provided by the sharp drop in gasoline demand following the expiration of the tax cut in September 2022.

Figure 8 also shows the development of normalized diesel demand. Compared to gasoline, diesel demand exhibits substantially lower variance and largely fluctuates around 2016

levels in the years preceding the pandemic. Overall, demand trends in Germany and the EEA appear broadly similar. The impact of the pandemic on diesel demand is far less pronounced than on gasoline. Moreover, the dynamics differ: While diesel demand in the EEA declined in early 2020 and recovered relatively quickly, demand in Germany initially increased, then fell in the winter of 2020/2021. Demand for diesel in Germany, however, never fully returned to pre-pandemic levels, remaining about 10–20% below 2016 levels thereafter. The Russian invasion in February 2022 does not appear to have had an immediate impact on demand. During the tax cut, demand increased in both regions, though the rise was slightly more pronounced in Germany than in the EEA.

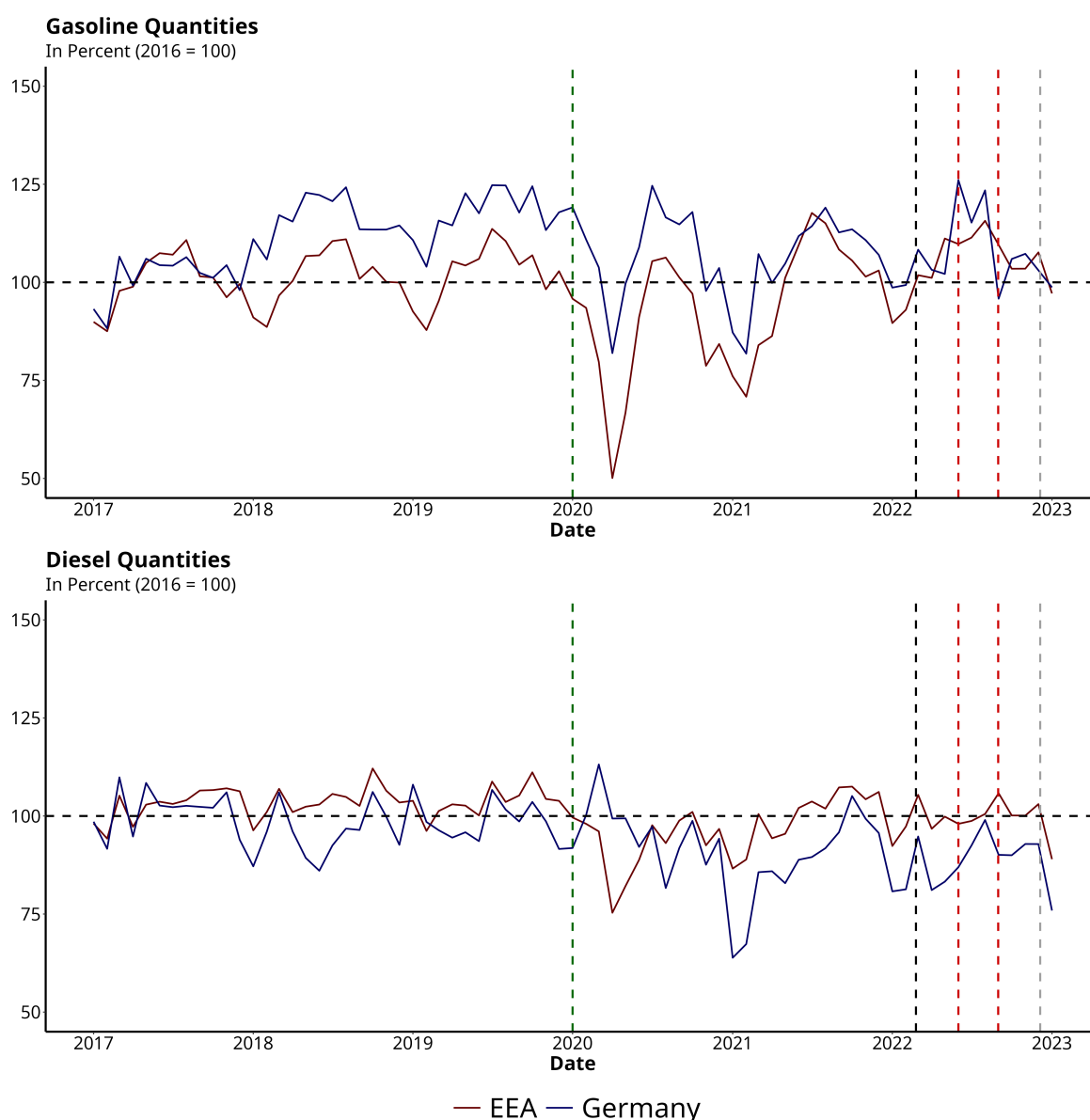


Figure 8: Normalized Development of Gasoline and Diesel Demand in Germany and the EEA

Table C.3 further analyzes the demand for crude oil and road fuels. It shows the

components of demand according to the logic of the data described in Equation (1) and (2), while aggregating multiple components as “Other”. Refinery intake of crude oil in Germany and the EEA follows a similar trend over time, as to be expected. While being significantly lower during the pandemic, the intake in Germany increased in all periods since, whereas it is highest during the tax cut in the EEA and decreasing in the four months after. These could be either seasonal effects or a post-invasion increase in refinery production to compensate banned Russian imports.

Table C.3 further backs up our findings from above: Generally the demand for gasoline in Germany and the EEA follow a similar trend. However, the pandemic-induced reduction in demand is less pronounced in Germany than it is in the EEA and demand for gasoline increases during the Tax Cut in both Germany and the EEA. The Table does, however, also show that Germany only slightly increased production and mostly offset the increase in demand by reducing its gasoline exports and taking from stock. It also shows, however, that these changes are barely outside one standard deviation within the data.

As described above demand for diesel in Germany and the EEA fluctuates a lot less, with most changes well within a standard deviation of the data. For example, the reduction of demand during the pandemic is not significant in either Germany or the EEA. The increase of demand in Germany during the tax cut does, however, stand out, as demand for diesel in the EEA decreased during the tax cut. Refineries in Germany did not increase production during the tax cut, but mostly fulfilled the additional demand by taking from stock and importing more.

5 Treatment Effects of the Energy Tax Cut

In this section, we study how the temporary energy tax cut between June and August 2022 affected the wholesale price and the quantity of diesel and gasoline sold in Germany. As described in Section 1 previous literature shows that the tax cut has been largely passed through, but not fully. Therefore, we expect wholesale prices net of tax to increase. Even with only partial pass-through gross retail prices decreased significantly and therefore we expect that demand increased during the tax cut.

5.1 Empirical Design

In a first step we apply the canonical version of the diff-in-diff estimator, following Ashenfelter (1978) and Card and Krueger (1994). We compare the post- to pre-tax cut price in Germany and the ARA spot market prices, which were not directly affected by the tax cut. The corresponding empirical model is given by:

$$P_{it} = \alpha + \lambda Germany_i + \gamma Tax_t + \beta[Germany_i \times Tax_t] + \rho X_{it} + \epsilon_{it}, \quad (3)$$

where P_{it} refers to the price of gasoline and diesel in cents per liter. Tax equals 1 in the time period of the tax cut, between 1 June and 31 August 2022. The dummy variables $Germany_i$ indicates whether an observation is from Germany or not. The coefficient of interest is β , the average treatment effect of the treated (ATT) of the tax cut on the price for a liter of diesel or gasoline net of taxes and fees. In other words the ATT in this case measures the difference in net wholesale prices between Germany and the ARA region during the tax cut. A complete pass-through would correspond to an effect of zero, as the net price would not change. Incomplete pass-through would be reflected in a positive ATT. In a next step, we control for location and time fixed effects by including dummy variables for each location and each date in the data. The following model is given by:

$$P_{it} = \alpha \sum_{i=1}^I \lambda_i Region_i + \sum_{t=1}^T \gamma_t Period_t + \beta[Germany_i \times Tax_t] + \rho X_{it} + \epsilon_{it}, \quad (4)$$

where we essentially replace $\lambda Germany_i$ with $\sum_{i=1}^I \lambda_i Region_i$ and γTax_t with $\sum_{t=1}^T \gamma_t Period_t$, to allow for variation between dates and locations. Note that the coefficient of interest stays the same in this modified model.

Baseline Sample As highlighted in Section 3, the tax cut was the result of significantly increasing prices for gasoline and diesel, following the Russian invasion of Ukraine. In order to rule out effects of the initial shock of the invasion and the announcement of the tax cut, we exclude all data preceding the 1 April 2022 in the baseline estimation. Furthermore, we exclude all data postceeding the end of the tax cut in September 2022, as equilibrium prices could have been affected. We relax these assumptions later and use a longer control period.

Identification The causal interpretation of the treatment effect as estimated by Equation 3 relies on three main assumptions, namely that: (i) treatment and behavior in Germany did not affect the treatment and outcome of the ARA spot market, corresponding to the stable unit treatment value assumption (SUTVA) (ii) the treated group did not anticipate the tax cut and adjust their behavior accordingly in the pre-treatment period, and (iii) in the absence of the tax cut, the ARA spot market and the wholesale market in Germany would have followed parallel trends. In other words, the wholesale price on the ARA spot market and the German wholesale market would have developed identical in the absence of the tax cut.

The first assumption is unlikely to be violated due to the fixed tax cut in Germany and a strict geographical separation between treatment and control group. The ARA spot

market, furthermore, does not represent demand and supply of a single country, but the aggregate of most European countries. It also correlates significantly with global demand and supply of gasoline and diesel. It is, therefore unlikely that the ARA spot market prices are significantly influenced by the tax cut and subsequent behavior in Germany. Lastly, we argue that even if ARA spot market prices increase due to larger demand from Germany, our estimations would show a lower bound, as the counterfactual price would be biased upwards.

The second assumption is also unlikely to be violated, as consumers were probably unable to adjust their behavior in anticipation of the policy. Although the tax cut was likely anticipated, as it has been publicly discussed since at least mid-March 2022 and passed by parliament in May, consumers could not easily postpone refueling and compensate during the tax reduction period (FDP, 2022), (Deutscher Bundestag, 2024). It is therefore highly improbable that consumers significantly changed their behavior in the months preceding the tax cut. Table C.3 confirms this, showing that demand for both diesel and gasoline did not significantly change in the three months prior to the policy change. Similarly, fuel stock levels exhibited no signs of pre-adjustment; in fact, stock increases became more pronounced in the months leading up to the tax reduction.

To provide evidence on the plausibility of the parallel trend assumption underlying our empirical design, we follow Lichter and Schiprowski (2021) and expand the simple diff-in-diff strategy from equation (3) to allow for varying treatment effects over the survey period. The dynamic Diff-in-Diff specification reads as follows:

$$P_{it} = \alpha + \sum_{t=1}^T \gamma_t Period_t + \lambda_i Germany_i + \sum_{t=1}^T \beta_i t (Germany_i \times Period_t) + X_{it} + \varepsilon_{it} \quad (5)$$

This approach essentially replaces the term Tax_t from Equation (3) with the term $\sum_{t=1}^T \gamma_t Period_t$, which refers to a variable indicating weeks (months). We omit the week (month) just before the treatment to serve as a baseline period. Compared to Equation (4) the coefficient of interest β_k also changes here, measuring the difference in wholesale prices between Germany and the ARA region in every period, relative to the baseline. Evidence of flat pre-trends i.e. the absence of significant effects on wholesale prices, would provide support of the parallel trends assumption. The specification also allows analyzing the dynamic effects of the tax cut between June and August 2022. Therefore, we estimate this approach twice: First, with monthly periods covering the whole available data to analyze the parallel trends assumption and second, with weekly periods covering the year 2022 to analyze the dynamic effects of the tax cut.

Regional treatment heterogeneity As described in Section 3, we have pricing data for eleven different regions in Germany. In order to fully utilize the data at hand, we analyze

the regional heterogeneity of the energy tax cut in Germany, by estimating the following approach:

$$P_{it} = \alpha + \sum_{i=1}^I \lambda_i \text{Region}_i + \gamma \text{Tax}_t + \sum_{i=1}^I \beta_i [\text{Region}_i \times \text{Tax}_t] + \rho X_{it} + \epsilon_{it}. \quad (6)$$

In this approach we essentially replace the term Germany_i from Equations (3) and (5) with the term $\sum_{i=1}^I \text{Region}_i$, which refers to dummy variables indicating the different regions within Germany. We exclude the ARA region, which then serves as the benchmark region. The coefficients of interest β_k , therefore measures the wholesale price in every region relative to the ARA region.

Lastly, we combine the above approaches and analyze the dynamic effects of the tax cut for different regions within Germany. The corresponding empirical specification, therefore looks like this:

$$P_{it} = \alpha + \sum_{i=1}^I \lambda_i \text{Region}_i + \sum_{t=1}^T \gamma_t \text{Period}_t + \sum_{i=1}^I \sum_{t=1}^T \beta_{it} [\text{Region}_i \times \text{Period}_t] + \rho X_{it} + \epsilon_{it}, \quad (7)$$

In this approach we have replaced both terms Tax_t and Germany_i with a number of dummy variables indicating different regions in Germany and different periods. The coefficients of interest β_{it} indicate the wholesale price in every period t relative to the baseline in every region i compared to the ARA region. This gives us the possibility to analyze the dynamic nature of the effects in every region post treatment.

Quantity effects To analyze the treatment effect of the tax cut on fuel demand in Germany, we use the available quantity data to estimate an additional diff-in-diff model. Applying the same logic as in (3), we adjust it as follows:

$$\log(Q_{it}) = \alpha + \lambda \text{Germany}_i + \gamma \text{Invasion}_t + \beta [\text{Germany}_i \times \text{Invasion}_t] + \rho X_{it} + \epsilon_{it}, \quad (8)$$

where $\log(Q_{it})$ denotes the relative change in quantity demanded. $\lambda \text{Germany}_i$ indicates the difference between Germany and the control group, which in this case includes the entire EEA. Because the data are only available at the national level, a European benchmark for quantities cannot be constructed as before, and using only data from the Netherlands and Belgium would be insufficient. We therefore aggregate demand across the entire EEA as the control group. $\gamma \text{Invasion}_t$ still indicates the period of the tax cut and the control period. As the data are only available on a monthly basis, we use

observations from 2017 through the end of the tax cut in August 2022. The coefficient of interest, $\beta[Germany_i \times Invasion_t]$, represents the ATT and captures the difference in the change in quantity demanded from the pre- to the post-tax-cut period between Germany and the rest of the EEA.

To analyze the dynamic treatment effect of the tax cut, we also estimate a dynamic diff-in-diff model following the framework of Equation (5), using the specification:

$$\log(Q_{it}) = \alpha + \sum_{t=1}^T \gamma_t Period_t + \lambda_i Germany_i + \sum_{t=1}^T \beta_i t (Germany_i \times Period_t) + X_{it} + \varepsilon_{it}, \quad (9)$$

where $\log(Q_{it})$ denotes the relative change in quantity demanded. As the data are only available on a monthly basis, the analysis can include only three estimators within the tax cut period, making the estimation of dynamic effects necessarily coarse. Moreover, a regional analysis is not feasible, as the data are only available at the national level.

5.2 Price effects

The following section outlines the results of the models presented in Section 5.1. We show the effect of the energy tax cut on wholesale prices for gasoline and diesel in Germany. In this framework, a full pass-through of the tax cut would correspond to an ATT of zero. A positive ATT implies that German wholesale prices net of taxes rose relative to those in the ARA region during the tax cut period.

Baseline Results Given the restrictions described above in Section 5.1, we estimate a diff-in-diff model on the period spanning 1 April to 31 August 2022. This period consists of 152 days, covering both the pre-tax cut and tax cut periods, with 92 days falling within the tax cut period and 60 days preceding it. Further, we cluster the standard errors on the level of the Argus Media regions and the ARA import parity spot markets, as described in Section 3.

Table 3 presents the baseline results using the models given in Equations (3) and (4). Our baseline model demonstrates that the tax cut led to a strictly positive impact on wholesale prices. The canonical diff-in-diff model in Equation (3) shows a 6.5 c/l increase in gasoline wholesale prices and 6.2 c/l in diesel wholesale prices. When controlling for oil and freight costs, the treatment effect for gasoline becomes insignificant, while the diesel treatment effect decreases to 3.4 c/l. Additionally, we control for location and time fixed effects, and explain the variation stemming from different regions in Germany and temporal effects. The treatment effect from this estimation is 2.4 c/l for gasoline and 2.9 c/l for diesel. This finding suggests that about 8% of the gasoline tax cut and about 20% of the diesel tax cut were not passed through to consumers. The 95% confidence

interval further indicates that the true effect likely falls within the range of 0.5 to 4.4 c/l for gasoline and 0.77 to 5.04 c/l for diesel in this setting. Since the estimated ATT is positive, we can reject the null hypothesis of complete pass-through of the tax cut, meaning that the tax cut was only partially passed through to consumers. In other words, wholesale prices for road fuels rose relative to those in the ARA region during the tax cut period. In the following, we show that these results are robust using data from an extended sample.

	Gasoline Wholesale Prices in c/l			Diesel Wholesale Prices in c/l		
Intercept	84.23***	412.03***		89.44***	141.12**	
	[84.23; 84.23]	[256.39; 567.68]		[89.44; 89.44]	[17.14; 265.10]	
Tax Cut	3.65***	8.32***		6.24***	8.50***	
	[3.65; 3.65]	[5.64; 11.00]		[6.24; 6.24]	[7.12; 9.88]	
Germany	4.54***	-7.29***		9.77***	5.62***	
	[3.01; 6.06]	[-11.93; -2.65]		[9.07; 10.46]	[3.61; 7.63]	
Tax Cut:Germany	6.45***	-0.16	2.43**	6.21***	3.39***	2.90**
	[4.36; 8.54]	[-2.96; 2.64]	[0.44; 4.41]	[4.02; 8.41]	[1.24; 5.55]	[0.76; 5.04]
Location FE			✓			✓
Date FE			✓			✓
Crude Oil		✓	✓		✓	✓
Freight Costs		✓	✓		✓	✓
Num. obs.	2736	2736	2736	2736	2736	2736
R ²	0.287	0.636	0.932	0.620	0.683	0.934
Adj. R ²	0.286	0.635	0.928	0.619	0.682	0.930
Num. Dates			152			152
Num. Locations			18			18

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 3: Diff-in-Diff Estimation of the Tax Cut on Gasoline and Diesel Wholesale Prices

Extended Sample Using the entire available period from 1 January 2017 up to the end of the tax cut on 31 August 2022, we estimate the diff-in-diff model from Equation (3). This allows us to control for seasonal effects like holiday traffic and demand side control variables, like population density and average income, which are only available on a yearly basis. The first column of Table 4 shows the treatment effect without using additional control variables, whereas the second estimation includes the crude oil and freight input costs. Both estimations show treatment effects that are biased upwards, compared to Table 3. This is mostly because we do not control for regional and time fixed effects, as well as several major external disruptions during the sample period, that affected the price difference between the ARA region and Germany, as described in Section 4.

Gasoline Wholesale Prices in c/l						
Germany:Tax Cut	10.69*** [6.06; 15.31]	9.43*** [6.77; 12.08]	4.47*** [2.98; 5.97]	0.17 [−1.42; 1.76]	3.98*** [2.01; 5.95]	3.66*** [1.64; 5.68]
Germany	0.50 [−0.59; 1.61]	2.73** [0.60; 4.87]				
Tax Cut	21.57*** [9.61; 33.54]	27.24*** [14.81; 39.66]				
Crude Oil		✓	✓	✓	✓	✓
Freight Costs		✓	✓	✓	✓	✓
Location FE			✓	✓	✓	✓
Date FE			✓	✓	✓	✓
War FE				✓	✓	✓
Invasion FE					✓	✓
Covid FE						✓
Demand controls						✓
Num. obs.	37242	37242	37242	37242	37242	37242
R ²	0.642	0.671	0.987	0.988	0.989	0.990
Adj. R ²	0.642	0.671	0.986	0.987	0.988	0.990
Num. Locations			18	18	18	18
Num. Dates			2069	2069	2069	2069

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 4: Diff-in-Diff Estimation of the Energy Tax Cut on Gasoline Wholesale Prices

Diesel Wholesale Prices in c/l						
Germany:Tax Cut	15.28*** [10.85; 19.71]	14.67*** [11.98; 17.35]	6.64*** [5.33; 7.95]	−1.07 [−2.54; 0.40]	4.17*** [2.47; 5.88]	3.76*** [2.03; 5.49]
Germany	4.04*** [2.72; 5.36]	7.82*** [5.95; 9.68]				
Tax Cut	23.33*** [10.60; 36.07]	27.42*** [13.77; 41.06]				
Crude Oil		✓	✓	✓	✓	✓
Freight Costs		✓	✓	✓	✓	✓
Location FE			✓	✓	✓	✓
Date FE			✓	✓	✓	✓
War FE				✓	✓	✓
Invasion FE					✓	✓
Covid FE						✓
Demand controls						✓
Num. obs.	37242	37242	37242	37242	37242	37242
R ²	0.676	0.691	0.987	0.989	0.991	0.993
Adj. R ²	0.676	0.691	0.987	0.989	0.990	0.993
Num. Locations			18	18	18	18
Num. Dates			2069	2069	2069	2069

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 5: Diff-in-Diff Estimation of the Energy Tax Cut on Diesel Wholesale Prices

The last four estimations in Tables 4 and 5 show the results of the diff-in-diff model in Equation (4). We control for time and regional fixed effects, which decreases the treatment effect significantly, as expected. The estimated treatment effect is still higher as in Table 3, because the model essentially compares post-invasion prices to pre-invasion prices, thus attributing invasion-related prices increases to the tax cut. Therefore, we first control for the ongoing Russo-Ukrainian War, by adding a time fixed effect and an interaction with the regional group fixed effect (distinguishing all regions from another) to allow their impacts to differ by region. This leads to a very low and insignificant treatment effect. This occurs because, after the invasion, there is only a short pre-tax cut window for comparison, and the model still fails to account for the transient spike in prices immediately following the invasion (as discussed in Section 4). Second, we introduce a

dedicated time fixed effect to capture the invasion’s transitory shock, ending on 1 April 2022 and again interact it with the region dummy. This leads to treatment effects that are similar to those estimated in the first model. Lastly, we introduce a similar control for the COVID-19 pandemic and multiple demand side controls.

With these extended controls in place, the results in Tables 4 and 5 remain slightly higher in magnitude to those of our baseline model (Table 3). Wholesale prices were 3.67 c/l higher for gasoline and 3.76 c/l higher for diesel relative to the counterfactual scenario without the tax cut. In other words, about 12 % of the gasoline tax cut and about 27 % of the diesel tax cut were not passed on.

Dynamic Diff-in-Diff Figure 9 presents the results from the extended diff-in-diff design as laid out in Equation (5). We include a relatively long pre-treatment period from 2017 until 2022, for which we have reliable data. However, the figure also indicates the presence of differential trends in wholesale price developments, potentially violating the parallel trends assumption.

The first spike in late 2018 can be attributed to a severe drought in Germany, which led to extremely low water levels in the Rhine. As a result, ships were unable to operate at full capacity, causing freight prices to rise. More importantly, the low water levels created a binding capacity constraint, reducing shipping availability and ultimately leading to a supply shortage in parts of the German wholesale market. ARA spot markets are not affected by this, as they are mostly supplied by ocean shipping. While we control for freight costs, both linearly and non-linearly, these measures cannot fully account for this variation. We can, however, exclude the possibility that this was the case during the tax cut in 2022.

The second spike, occurring in 2020, corresponds to the onset of the COVID-19 pandemic. We do, however, account for this shock in the simple diff-in-diff estimations.⁶

The third spike in the estimates follows the onset of the Russo-Ukrainian War. This event is also controlled for in the simple diff-in-diff framework. Figure 10 provides a more detailed examination of this period. It shows that once we control for the transient shock at the start of the invasion, the pre-treatment trends, especially for diesel, are relatively flat. Even if we do not fully account for this exogenous shock, the resulting bias would work against our hypothesis: The model would assign an upward-biased control period, leading us to underestimate the true effect of the tax cut.

⁶Since the dynamic diff-in-diff specification includes interactions between the treatment group indicator (*Germany*) and each month, it is not possible to include additional interactions between *Germany* and specific events without introducing perfect multicollinearity.

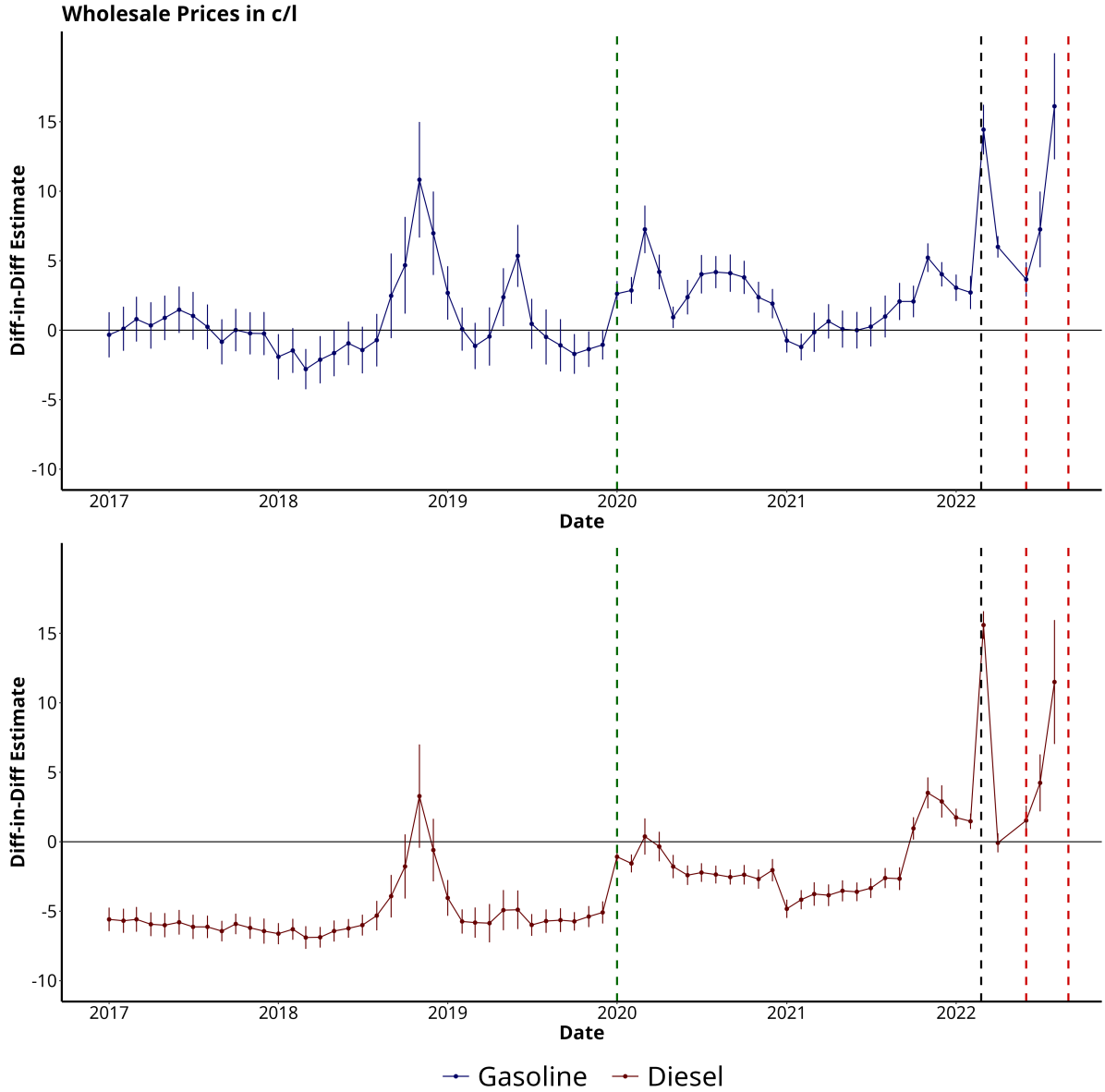


Figure 9: Coefficients of a Dynamic Diff-in-Diff Estimation

Lastly, Figure 9 shows that the pre-trend in diesel prices lies below zero in the years preceding the invasion. This implies that the coefficient for May 2022 is already biased upward. Since this coefficient defines the reference point (zero), all preceding coefficients appear below zero. This effect is, however, expected, as the invasion already increased the differential between German and ARA wholesale prices for diesel.

Treatment Heterogeneity over time Figure 10 provides insights into the heterogeneity of the treatment effect over time. In this context the treatment effect is the difference in wholesale prices net of taxes between Germany and the ARA region, relative to the last week before the tax cut. A treatment effect of zero implies full pass-through of the tax cut and a positive treatment effect implies impartial pass-through.

It is evident that the tax cut for diesel was almost fully passed through initially, as

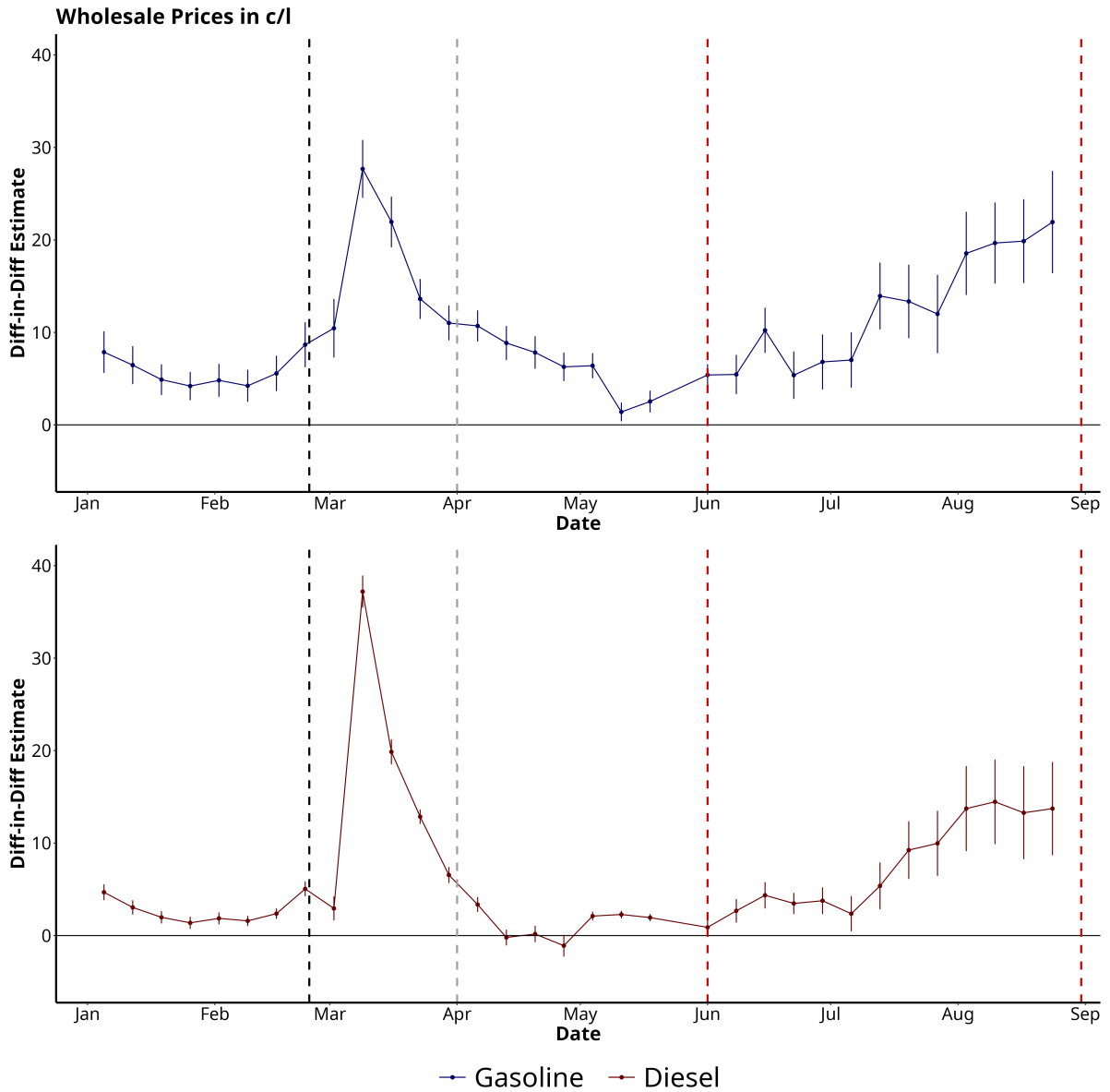


Figure 10: Coefficients of a Dynamic Diff-in-Diff Estimation

the coefficients for diesel prices remained close to zero during the first six weeks. Only in the final six weeks of the tax cut did the coefficients begin to rise, suggesting that wholesale diesel prices increased relative to those in the ARA region. By contrast, wholesale gasoline prices exhibited an earlier and more pronounced increase immediately following the introduction of the tax cut, although a further significant rise relative to ARA prices is still observable over time.

Figure B.6 offers a potential explanation for this pattern. It displays wholesale gasoline and diesel prices in Germany and the ARA region throughout 2022. Both diesel and gasoline prices declined during the tax cut period, following a modest decrease in crude oil prices. Notably, the decline in ARA wholesale prices was particularly pronounced in the latter part of the tax cut. Although German wholesale prices typically track those

in the ARA region closely, this decrease in wholesale prices was not fully passed through to the German market. This observation is striking, as Figure B.6 demonstrates that the correlation between German and ARA prices remained strong during the remainder of 2022. Thus, it can be concluded that while the tax cut was initially fully passed through to consumers, subsequent declines in input costs (i.e., crude oil prices) were not reflected in wholesale prices to the extent typically observed.

Treatment heterogeneity in different regions Unlike the previous analysis, we do not utilize a group-fixed effects estimator that merely differentiates between Germany and the ARA region. Instead, our estimator accounts for all eleven regions within Germany and the ARA region, as described in Equation (6). The ATT are derived from the interaction term between these fixed effects estimators and the tax cut dummy variable, which then measure the difference between a given region in Germany and the ARA region during the tax cut. Meaning that again an estimated ATT of zero indicates full pass-through of the tax cut and a positive effect implies incomplete pass through. To avoid the dummy variable trap, we exclude the ARA region as our benchmark, thereby interpreting each region relative to it.

Figure 11 shows the ATT in each of the eleven German regions and reveals substantial heterogeneity across regions and fuel types.⁷ In general, the lowest ATT occur in the eastern part of Germany eastern regions and the highest in the southern parts of Germany. In the two regions Seefeld and East, the tax cut had no statistically significant effect on diesel wholesale prices. Similarly, the tax cut on gasoline wholesale prices had no significant effect in Seefeld and East, as well as in the Southwest and Cologne regions. This outcome is somewhat unexpected because market competition tends to be at least partially regional (see Section 4). Notably, the highest ATT for gasoline are concentrated in the Southeast and South regions, whereas the strongest effects for diesel are observed across all three southern regions (Southwest, Southeast, and South). The case of Cologne is particularly notable, as the adjacent regions (West, Rhine-Main, and Emsland) experienced significant positive treatment effects. This is also surprising given that ATT for gasoline and diesel generally correlate strongly within each region.

As previously outlined, we measure the the highest ATT for both fuel types, amounting to 7.3 c/l for gasoline and 8.6 c/l for diesel in the South region. These figures imply that 24.7% of the gasoline tax cut and 59% of the diesel tax cut were not passed through to consumers. Elevated effects are also recorded in the adjacent Southwest region, with the exception of gasoline, for which the effect is marginally negative (-0.5 c/l), while diesel shows a significant effect (4.55 c/l). In the Southeast, the effects amount to 2.9 c/l for gasoline and 4.6 c/l for diesel.

In the remaining regions, treatment effects for both fuels are close to the national average.

⁷We report the complete estimation results in Tables C.4 and C.5 in the Appendix.

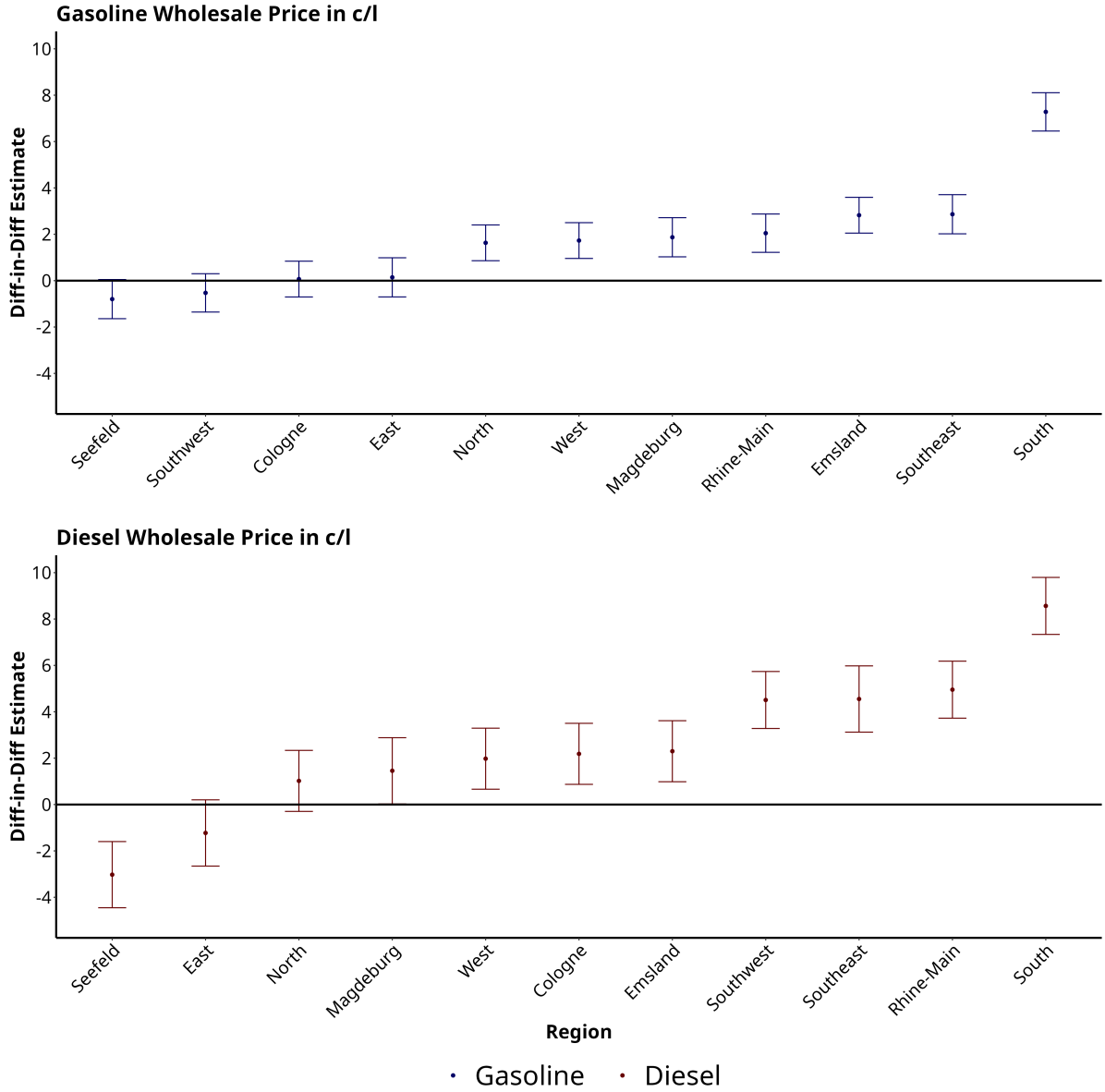


Figure 11: Regional Diesel and Gasoline Treatment Effects

For gasoline, these effects are as follows: 2.8 c/l in Emsland, 1.9 c/l in Magdeburg, 1.6 c/l in North, 2.0 c/l in Rhine-Main, and 1.7 c/l in West. For diesel, the corresponding treatment effects are: 2.2 c/l in Cologne, 2.3 c/l in Emsland, 1.5 c/l in Magdeburg, 5.0 c/l in Rhine-Main, and 2.0 c/l in West.

These patterns suggest that the treatment effects of the diesel tax cut exhibit greater heterogeneity than those of gasoline. One potential explanation is regional variation in Germany's dependence on diesel imports from Russia, as discussed in Section 4. Additionally, diesel demand may be more regionally differentiated than gasoline demand, leading to a wider range of treatment effects. For instance, Montag et al. (2023) provide strong evidence that diesel consumers are more price-sensitive than gasoline consumers due to higher fuel consumption, which could amplify the observed treatment effects. Finally, as

explained in Section 4, we account for differing oil price inputs by employing various underlying crude oil benchmarks. Accordingly, we proceed to analyze the temporal variation in treatment effects across regions.

Treatment heterogeneity over time in different regions Figures 12 and 13 show the treatment effect over time in different regions. Consistent with earlier sections, we omit the ARA region and the last week before the tax cut as a benchmark. Therefore, all other regions are interpreted relative to the ARA region and with respect to the last week before the tax cut. The estimated treatment effect therefore reflects the difference between wholesale prices in the respective region and the ARA spot market, relative to the week preceding the tax cut. As before, a coefficient of zero indicates full pass-through of the tax cut, while a positive treatment effect denotes incomplete pass-through.

Gasoline Wholesale Prices in c/l

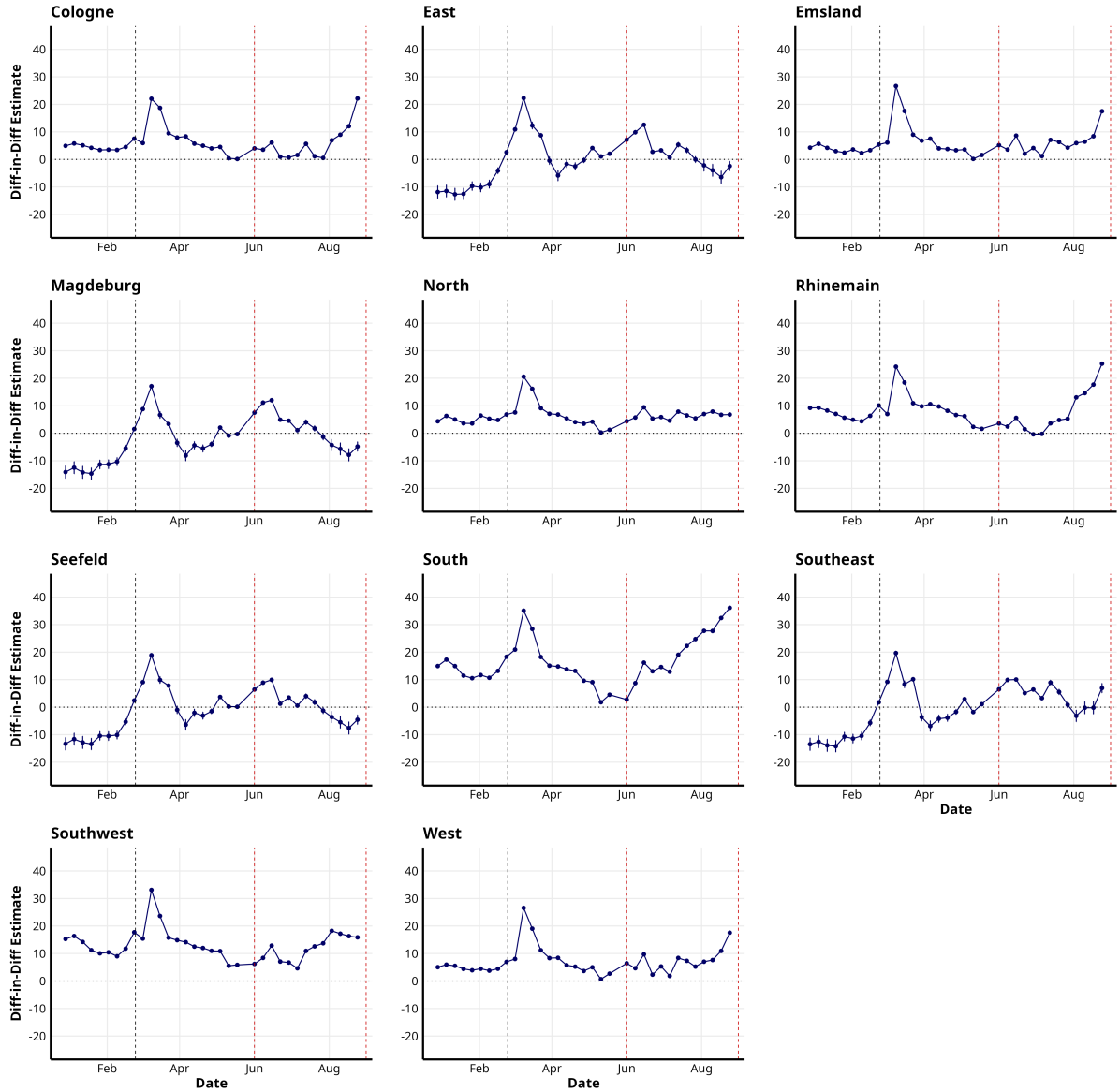


Figure 12: Regional Treatment Effects over Time on Gasoline Wholesale Prices

Diesel Wholesale Prices in c/l

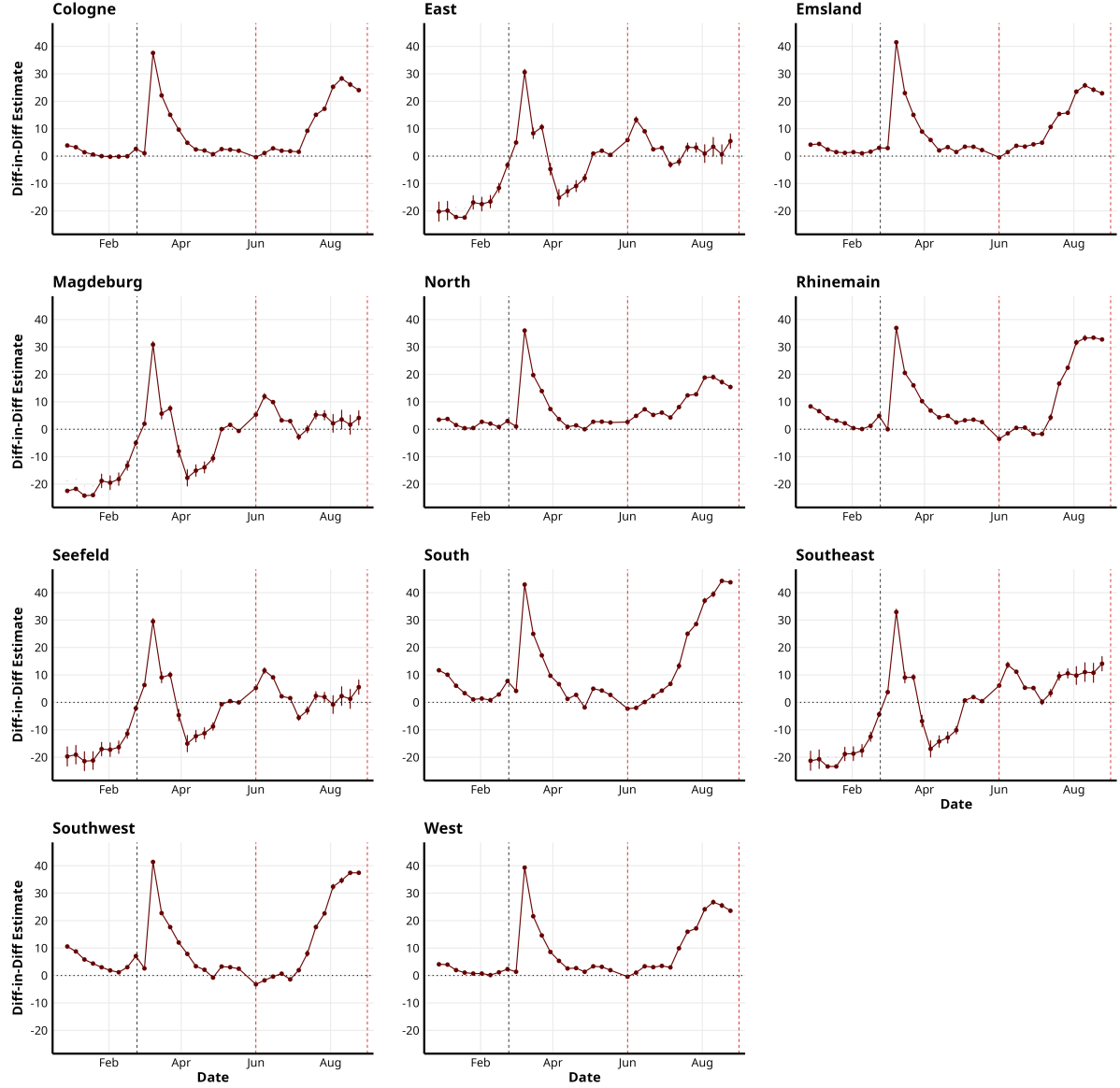


Figure 13: Regional Treatment Effects over Time on Diesel Wholesale Prices

First, we observe that the shock of the Russian invasion of Ukraine affected gasoline and diesel wholesale prices in all regions. Second, we confirm our previous finding that there is significant treatment heterogeneity over time and across regions. Finally, we further investigate the reasons behind this treatment heterogeneity. In all regions, the treatment effect at the beginning of the tax cut was close to zero, but positive. In Rhine-Main, South, and Southwest, the treatment effect increased significantly over time. As previously discussed, the Southeast region is an exception: the treatment effect there decreases slightly over time, remaining roughly constant. In the East, Seefeld, and Magdeburg regions, we observe a clear decreasing pattern over time, which explains the previously described null effect. The remaining regions stay more or less constant over time, with a slight tendency to increase toward the end of the tax cut.

Figure 13 shows the treatment effects for diesel, confirming that treatment heterogeneity for diesel is much more volatile, as noted earlier. Again, the effect is most significant in the South of Germany (South, Southeast, and Southwest). The effect increases strongly over time, whereas it is nearly zero at the beginning. The same pattern holds for the Cologne, Emsland, North, and West regions. In the East, Magdeburg, and Seefeld regions, the effect is consistently near zero and remains stable over time.

As mentioned previously, we can partly explain the differences in treatment heterogeneity by analyzing changes in oil prices. Figure B.5 illustrates that Ural oil prices were initially lower at the start of the tax cut but increased over time, while Brent and Sahara blend prices were relatively higher and exhibited a declining trend. These price trends might explain the missing treatment effects in the East of Germany. Specifically, when Ural prices rise during the tax cut, this price effect may obscure the impact of the tax cut itself, whereas the South of Germany experienced the largest decline in Sahara blend prices, potentially amplifying the treatment effect. However, this explanation does not account for heterogeneous treatment effects between fuel types within the same region. It also cannot explain the relatively significant treatment effect in the Southeast, which probably results from competition with the southern regions. Oil price changes likewise cannot explain the absence of a treatment effect in Cologne.

5.3 Quantity effects

In this section, we present the results of the diff-in-diff estimation on quantity data, following Equations (8) and (9). We estimate the models on data from 2017 through August 2022, comprising 68 months. This interval covers both the pre-tax cut and tax cut periods, with the latter spanning three months during the tax cut. Standard errors are clustered at the national level. Since the tax cut induced a reduction in fuel prices, we anticipate that fuel quantities demanded would increase during the three months of reduced energy tax.

Tables 6 and 7 report the ATT of the energy tax cut on gasoline and diesel quantities, respectively, with sequential controls for fixed effects and input costs. The ATT captures the difference in demand between Germany and the ARA region during the tax cut period. An ATT of zero indicates no change in relative demand, while a positive ATT shows an increase in demand in Germany compared to the ARA region during the tax cut. Controlling for the impacts of the Russian invasion and the Russo-Ukrainian War, we find that gasoline consumption increased by approximately 6-7%.⁸ Diesel consumption increases by about 8%. This effect remains largely stable when controlling for the invasion and the Russo-Ukrainian War. Both treatment effects are consistent with our

⁸We note that the final specification is likely endogenous, as crude oil and freight costs, significant components of gasoline prices, also increase with demand. It is, however, reassuring that the estimated difference in the treatment effect is only 0.005%.

expectations, given that the energy tax cut produced a negative absolute price effect, even though this effect was not fully passed through to consumers.

Figure B.10 presents the results of the dynamic diff-in-diff estimation for quantity. The coefficients indicate that demand for gasoline increases over time, whereas demand for diesel initially declines before rising. However, the pre-trend (i.e., the difference in demand between Germany and the EEA in the pre-tax cut period) is not flat, and the magnitude of this variation significantly exceeds the effect of the tax cut itself; hence, a causal interpretation of the model is not supported.

Tax Break:Germany	Log Gasoline Quantity					
	−0.006 [−0.051; 0.040]	−0.011 [−0.058; 0.035]	0.052** [0.009; 0.094]	0.070*** [0.028; 0.113]	0.070*** [0.028; 0.113]	0.075*** [0.028; 0.123]
Country FE		✓	✓	✓	✓	✓
Months FE		✓	✓	✓	✓	✓
War FE			✓	✓	✓	✓
Invasion FE				✓	✓	✓
Covid FE					✓	✓
Demand controls					✓	✓
Crude Oil						✓
Freight Costs						✓
Num. obs.	1968	1968	1968	1968	1968	1968
R ²	0.148	0.988	0.988	0.988	0.988	0.988
Adj. R ²	0.147	0.987	0.987	0.987	0.987	0.987
Num. Countries		29	29	29	29	29
Num. Months		68	68	68	68	68

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 6: Diff-in Diff Estimation of the Energy Tax Cut on Gasoline Quantity

Tax Break:Germany	Log Diesel Quantity					
	−0.012 [−0.067; 0.043]	0.078*** [0.039; 0.117]	0.081*** [0.042; 0.120]	0.081*** [0.042; 0.120]	0.081*** [0.042; 0.121]	0.091*** [0.043; 0.138]
Country FE		✓	✓	✓	✓	✓
Months FE		✓	✓	✓	✓	✓
War FE			✓	✓	✓	✓
Invasion FE				✓	✓	✓
Covid FE					✓	✓
Demand controls					✓	✓
Crude Oil						✓
Freight Costs						✓
Num. obs.	1970	1970	1970	1970	1970	1970
R ²	0.119	0.985	0.985	0.985	0.985	0.985
Adj. R ²	0.117	0.984	0.984	0.984	0.984	0.984
Num. Countries		29	29	29	29	29
Num. Months		68	68	68	68	68

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 7: Diff-in Diff Estimation of the Energy Tax Cut on Diesel Quantity

Nevertheless, from a descriptive perspective, demand in Germany increased relative to that in the rest of the EEA during the tax cut period; it remains unclear whether this effect is attributable to the tax cut. It is, however, plausible that at least part of this effect is due to the tax cut, given the significant decrease in gross retail prices.

Outcome of the treatment In order to assess the effects just estimated, we present some back-of-the-envelope calculations. Using monthly JODI data and the treatment effects for gasoline and diesel, we calculate the absolute effects of the tax cut.

Month	June	July	August	Total
Demand in (Million l)	2,588	2,365	2,534	7,487
Treatment effect in c/l	3.6577	7.2523	16.1151	
Taxes not passed through	94,661,276	171,516,895	408,356,634	674,534,805
Taxes passed through	670,092,724	527,340,605	340,440,366	1,537,873,695
Tax revenue not collected	766,754,000	698,857,500	748,797,000	2,214,408,500
Quantity increase (7%)	181.16	165.55	177.38	524.09
Additional Taxes	65,036,440	59,432,450	63,679,420	188,148,310
Tax loss	701,717,560	639,701,480	685,117,580	2,026,536,620

Table 8: Absolute Costs and Pass-Through of the Tax Cut on Gasoline Wholesale Prices

Month	June	July	August	Total
Demand in (Million l)	4,703	5,003	5,354	15,060
Treatment effect in c/l	1.5327	4.2369	11.4963	
Taxes not passed through	72,082,881	211,972,107	615,511,902	899,566,890
Taxes passed through	588,218,319	490,449,093	136,189,698	1,214,857,110
Tax revenue not collected	660,301,200	702,421,200	751,701,600	2,114,424,000
Quantity increase (8%)	376.24	400.24	428.32	1204.8
Additional Taxes	124,159,200	132,079,200	141,345,600	397,584,000
Tax loss	536,142,000	570,342,000	610,356,000	1,716,840,000

Table 9: Absolute Costs and Pass-Through of the Tax Cut on Diesel Wholesale Prices

Tables 8 and 9 show that according to the JODI data, 7.487 billion liters of gasoline and 15.06 billion liters of diesel were consumed during the tax cut. The tax revenue not collected due to the tax cut amounts to 29.55 c/l for gasoline and 14.04 c/l for diesel. As a result, 2.214 billion Euro in gasoline tax revenue and 2.114 billion Euro in diesel tax revenue were not collected. It is noteworthy, however, that the foregone tax revenue is lower than that. The tax cut stimulated additional demand, which partially offsets the loss through increased tax revenue from higher fuel consumption.

Using the monthly treatment effect estimates, we can determine the portion of the tax cut that was passed through to retail fuel prices versus the portion that was not passed through. Nearly 675 million Euro of the gasoline tax cut was not passed on to consumers, which is equivalent to 30.5 % of the total tax cut for gasoline. Similarly, nearly 900 million Euro of the diesel tax cut was not passed on to consumers, representing about 42.5 % of the diesel tax cut. These figures are significantly higher than those observed earlier during

the tax cut, because the pass-through rate declined over time as consumers demanded more fuel in later periods of the tax cut.

Lastly, we use our estimate of the demand increase to calculate the tax revenue loss due to the tax cut. It should be noted that our estimate of the tax cut’s effect on quantity demanded is not causal but merely descriptive. Therefore, these figures should be interpreted with caution. We use our best estimate of a demand increase of 7% for gasoline and 8% for diesel. This corresponds to an increase of 524.09 million liters in gasoline consumption and 1.204 million liters in diesel consumption. Using the reduced tax rates of 35.9 c/l for gasoline and 33 c/l for diesel, we estimate that this additional demand generated an extra 188.148 million Euro in gasoline tax revenue and 397.584 Euro in diesel tax revenue. Therefore, our best estimate of the total tax revenue lost due to the tax cut is 2.027 billion Euro for gasoline and 1.716 billion Euro for diesel, adding up to 3.743 billion Euro. This combined loss is 593.338 million Euro higher than the cost estimated in the legislative draft (Deutscher Bundestag, 2024)

Furthermore, we use these figures to estimate the climate impact of the tax cut. The additional consumption of 524 million liters of gasoline and 1.204 billion liters of diesel corresponds to approximately 5.335 million tons of CO₂. This represents about 0.71 % of total German CO₂ emissions, or roughly 3.75 % of the CO₂ emissions from German traffic in 2022 (Umweltbundesamt, 2024). It remains unclear whether these additional emissions were caused by the tax cut or if demand would have increased regardless. However, it is likely that the tax cut was responsible for at least a portion of the observed demand increase.

6 Conclusion

This paper estimates the effects of a temporary reduction in energy taxes on gasoline and diesel wholesale prices in Germany, as well as on demand. We find that the tax cut was not fully passed through to consumers, with significant heterogeneity in pass-through rates across regions and over time.

Using detailed pricing and quantity data at all three market levels and a diff-in-diff approach, we first show that the tax cut led to a significant decrease in wholesale prices. However, the tax cut was only partially passed through. On average, about 80 to 85% of the tax reduction was passed on. Therefore, wholesale prices net of the tax increased on average by about 15 to 20 %, which is roughly 3.7 cents per liter for gasoline and 3.7 cents per liter for diesel.

Second, we find considerable heterogeneity in treatment effects over time and across regions. Our dynamic diff-in-diff results show that the tax cut was nearly fully passed through within the first six weeks, although the effect on gasoline prices rose more sharply initially than the effect on diesel. During the final six weeks of the tax cut, net diesel

prices increased significantly. One possible explanation for this pattern could be the significant media attention that accompanied the introduction of the tax cut, which then waned over time.

Third, we show that the treatment effect varied significantly across regions in Germany. In the eastern part of Germany, the tax cut was nearly fully passed through, whereas in the southern parts the treatment effect was largest, raising net gasoline and diesel prices by nearly 10 cents per liter. However, there are exceptions to this general pattern in certain areas. We suggest that these regional pricing patterns might be explained by differences in market power, underlying crude oil input costs, and the intensity of competition between wholesalers and refineries.

Lastly, we analyzed the effect of the tax cut on diesel and gasoline demand. Although we cannot provide a causal interpretation, our findings are in line with economic theory: We observe an increase in quantity demanded during the tax cut period.

In total, we calculate that 4.3 billion Euro in energy taxes was not collected due to the tax cut, of which more than 1.5 billion Euro (about 35%) was not passed through to consumers. The difference between this figure and the relative pass-through rate is due to higher fuel consumption during periods of lower pass-through. Furthermore, accounting for the observed increase in demand, we estimate the effective cost of the tax cut to be around 3.7 billion Euro, which is approximately 550 million Euro more than initially estimated by the German government. We estimate that fuel demand increased by about 7 – 8 %, which corresponds to a 0.75% increase in German CO₂ emissions in 2022.

By identifying sizable effects of this tax cut on wholesale prices and demand, we highlight the importance of tax policy and its potential unintended consequences. Furthermore, our results deviate substantially from the existing literature, which mostly finds much higher pass-through rates. A key difference is that those studies examine pass-through at the retail level (which is not the point of taxation) and do not use quantity data to weight their estimates. These findings are especially relevant for policy, as they indicate that significant underlying price increases occurred during the tax cut.

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A Data Preparation

To make the data from all market levels comparable, we follow four steps. First, we convert all prices to eurocents per liter (price per volume) and all quantities to 10,000 m^3 . For prices reported in metric tons or by weight, we convert them using a density of 0.775 kg per liter for gasoline and 0.845 kg per liter for diesel.

Second, we deduct all taxes and fees from German retail and wholesale prices. From retail prices we deduct the VAT of 19% (16% from 1 July 2020 until 31 December 2020). From retail prices net of VAT and wholesale prices we further deduct the Germany energy tax, namely: 65.45 (47.04) cents per Liter of gasoline (diesel). From 1 June 2022 until 31 August 2022 we deduct 35.9 (33) cents per liter. We deduct the carbon tax of 7 (8) cents per liter in 2021, 8.4 (9.5) cents per liter in 2022 and 2023 and 12.7 (14.2) cents per liter in 2024. Last, we deduct 2.7 (3) cents per liter in fees for the “*Erdölbervorratungsverband*” (EBV). The ARA import parities only include energy taxes and EBV fees.

Third, we need to unify the regions in the wholesale data over time. Argus Media only started publishing price quotes for the regions East and Emsland in June 2020. Therefore, we fill the missing data with the mean of the three neighbouring regions. For Emsland we use the regions North, Magdeburg and West and for the region Emsland we use Seefeld, Magdeburg and South to fill up the missing data. Then we have a consistent price quote from 2017 until the end of 2024 for all eleven regions in Germany.

Last, we geomatch all three market levels to each other. As described in Section 2 has each region of Germany its own crude oil supply chain. Therefore, we use brent blend crude oil as an input cost for the regions of West, Cologne, Emsland and North. For the regions of Southwest, South and Rhine-Main we use Sahara blend crude oil as an input cost and for the regions Southeast, East, Magdeburg and Seefeld we use Ural Oil as crude oil input costs. As we use ARA import prices as an counterfactual for our wholesale gasoline and diesel prices, we use brent blend crude oil as an input cost for the control group. Then we match each petrol station to one of the eleven Argus Media regions. For that, we use the main locations Argus Media uses for each regional price, as stated in their methodology (Argus Media, 2024b). Based on these locations we calculate the distance, as the crow flies, to each petrol stations and choose the closest location i.e. region. Figure B.3 shows all petrol stations in Germany and their allocation to each region. The black triangles represent the locations stated by Argus Media for each location. The ARA import parities have different locations, marked by the red triangles.

B Figures

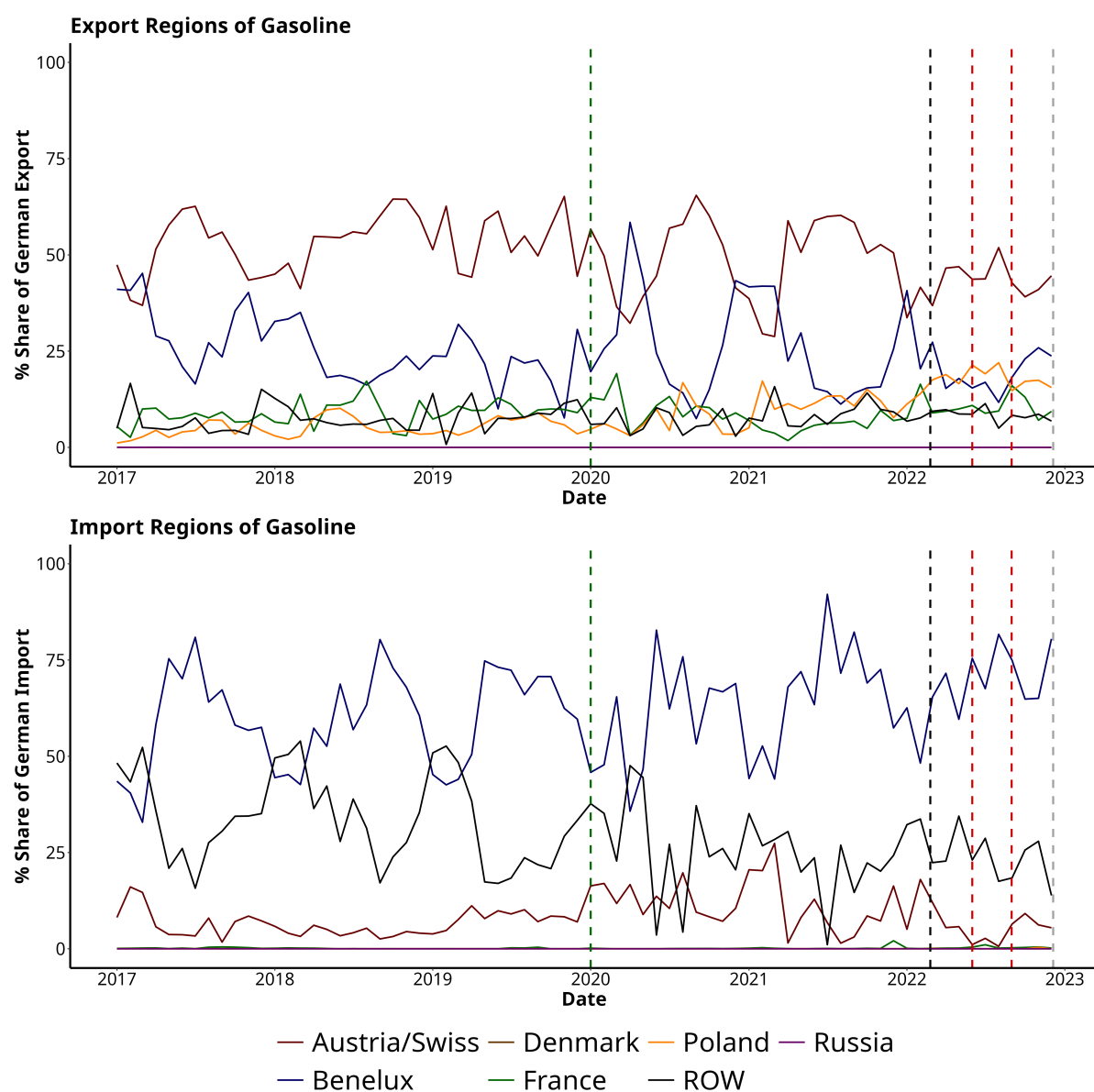


Figure B.1: German Gasoline Imports and Exports by Country (Statistisches Bundesamt, 2025)

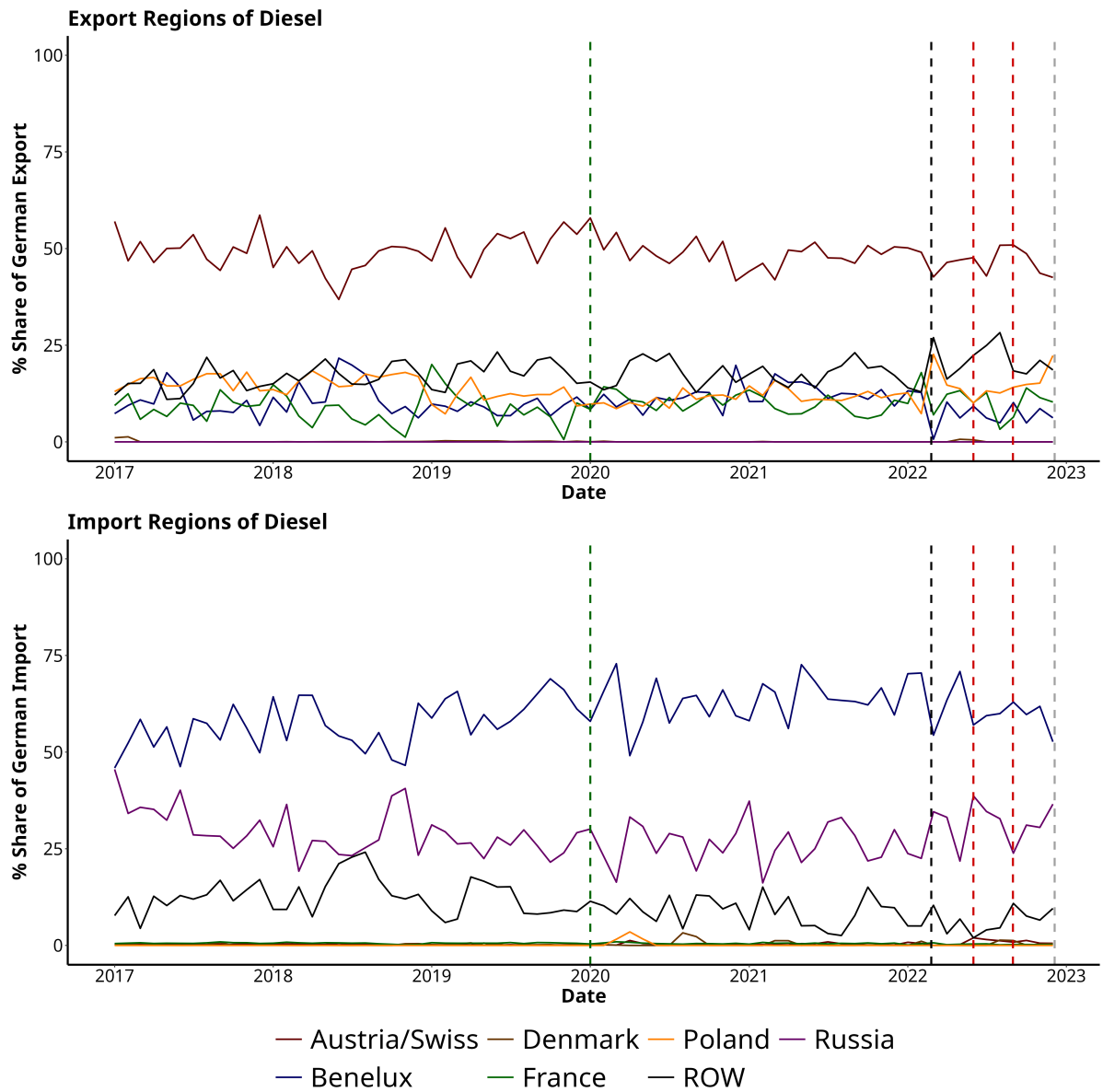


Figure B.2: German Diesel Imports and Exports by Country (Statistisches Bundesamt, 2025)

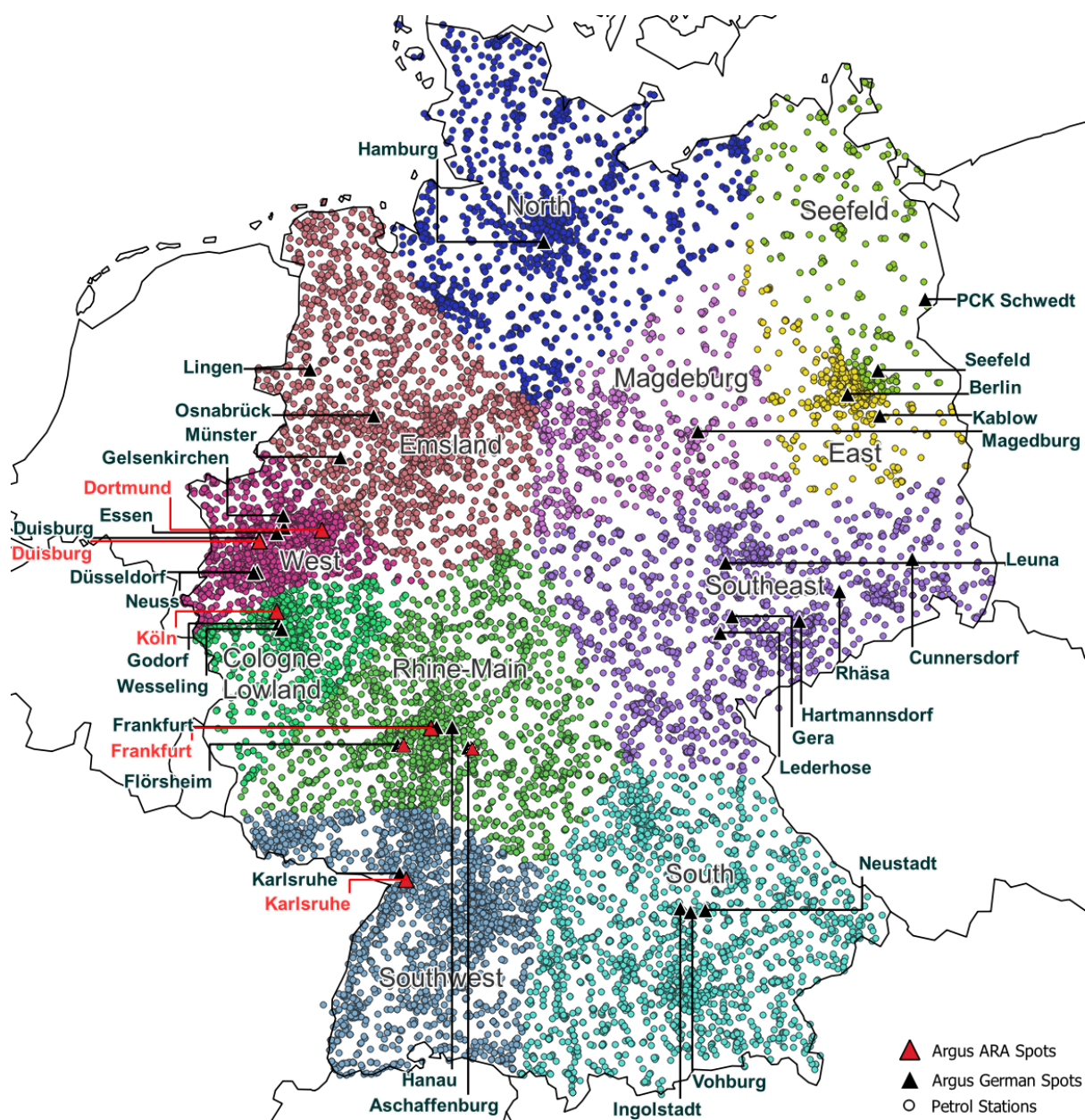


Figure B.3: Visualization of the Geographical Extent of the Argus Media Data

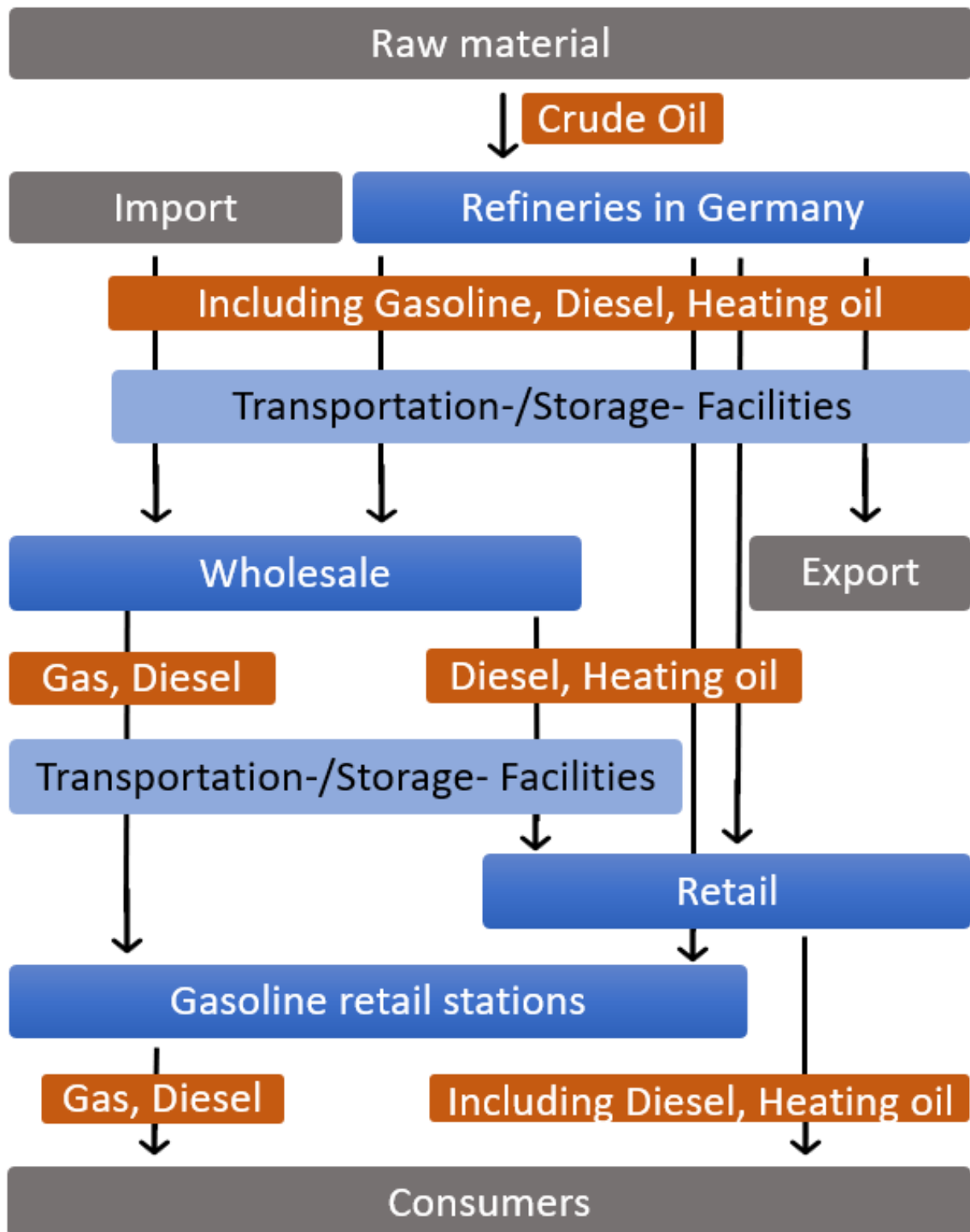


Figure B.4: Vertical Market Structure according to Federal Cartel Office (2022)

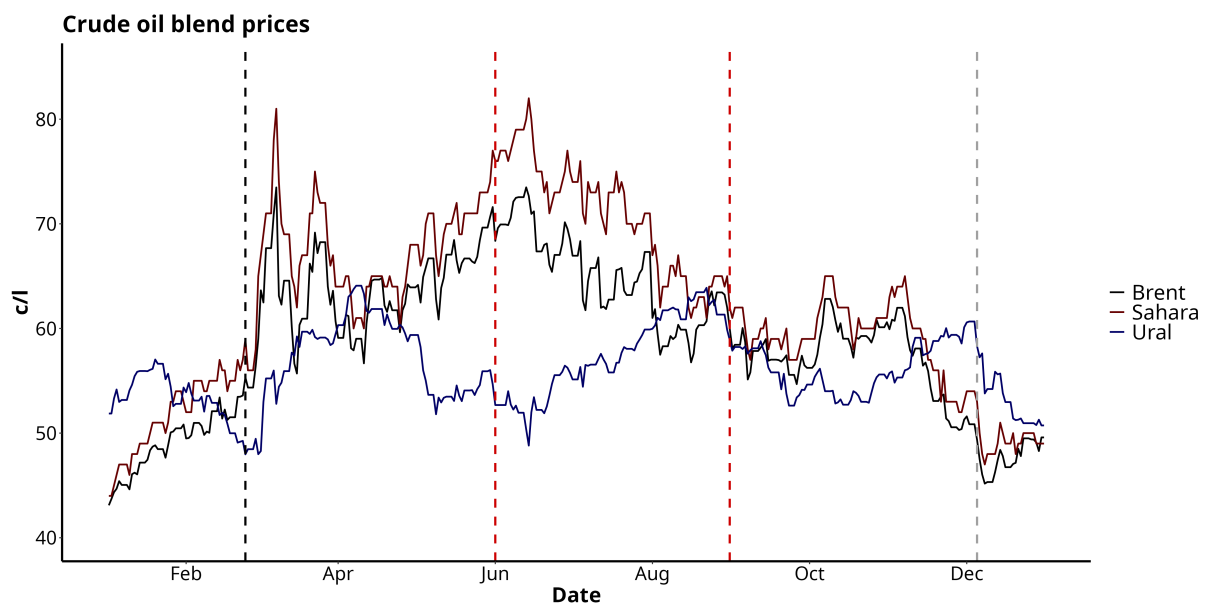


Figure B.5: Brent, Sahara and Ural Oil Prices in 2022

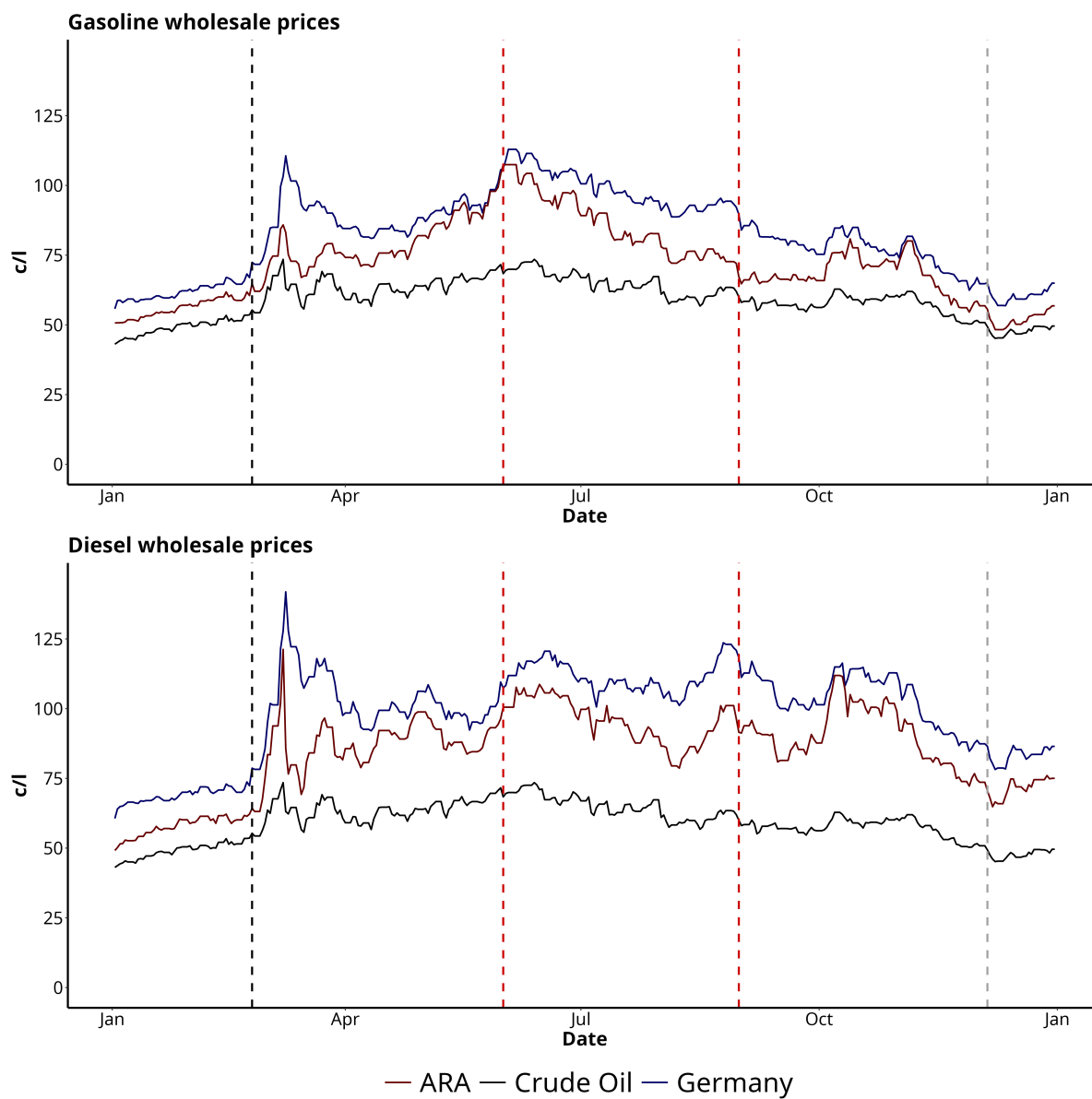


Figure B.6: German and ARA Wholesale Prices for Gasoline and Diesel

Gasoline refinery margins

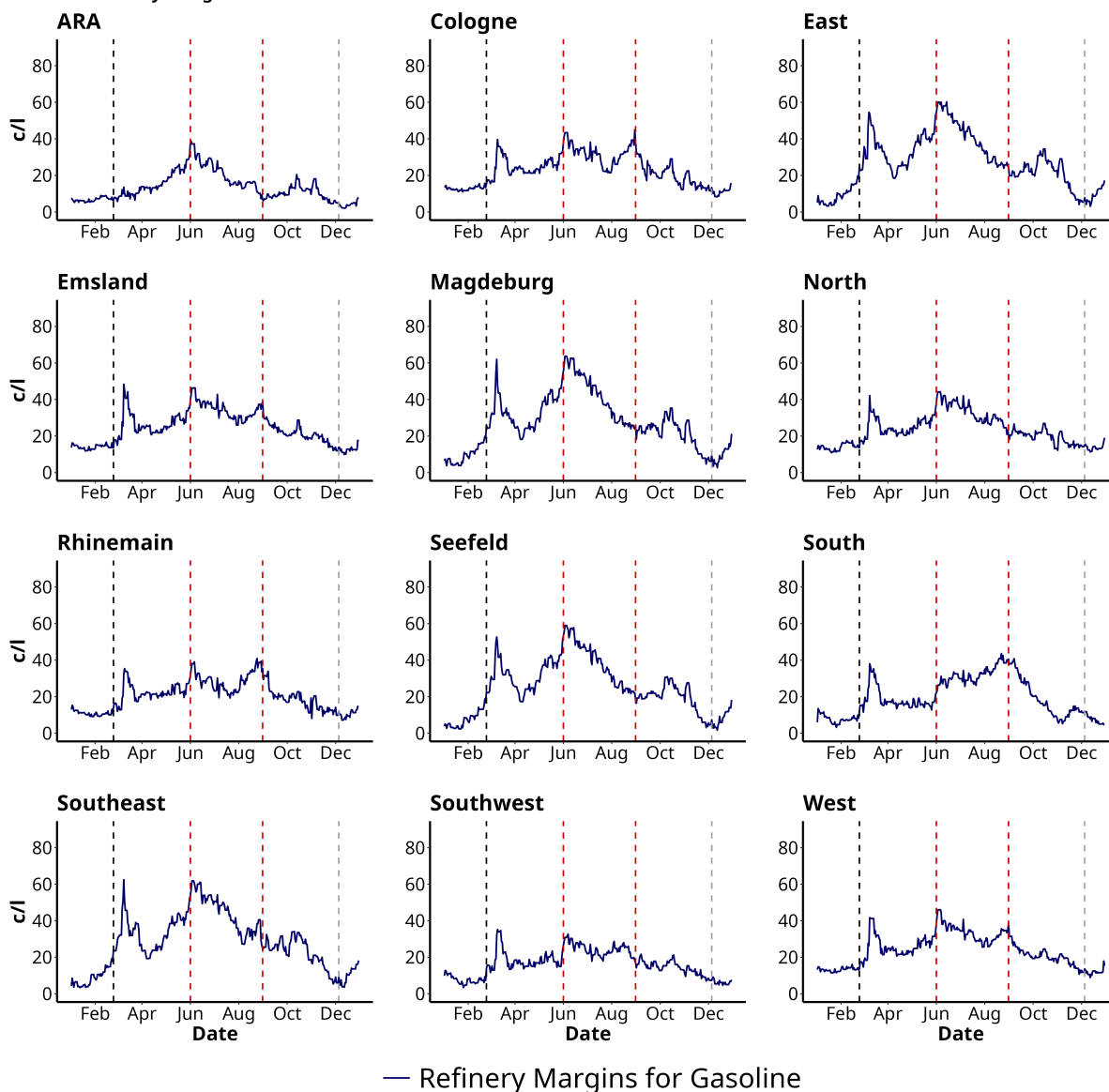


Figure B.7: Gasoline Refinery Margins in Different Regions

Diesel refinery margins

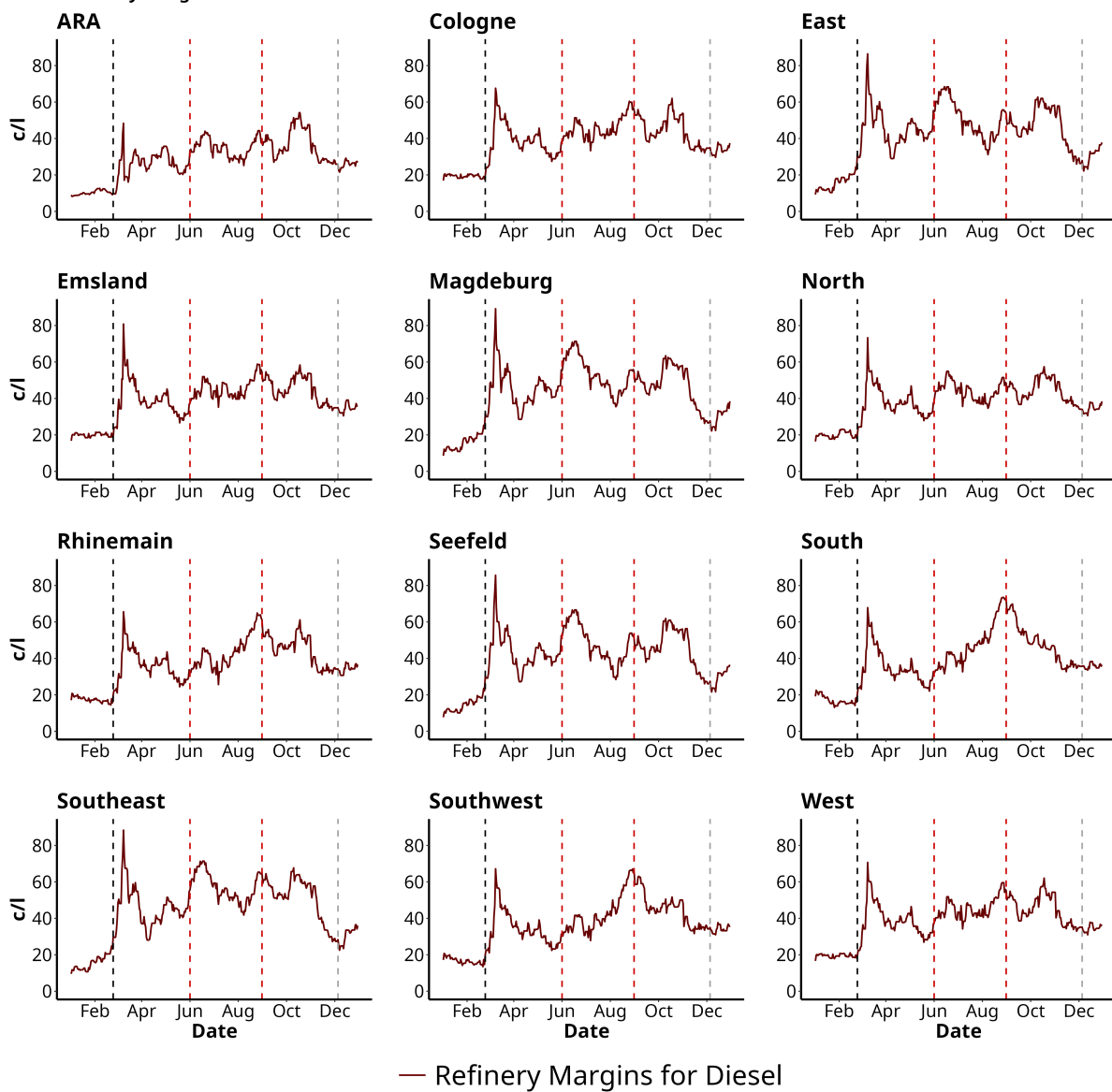


Figure B.8: Diesel Refinery Margins in Different Regions

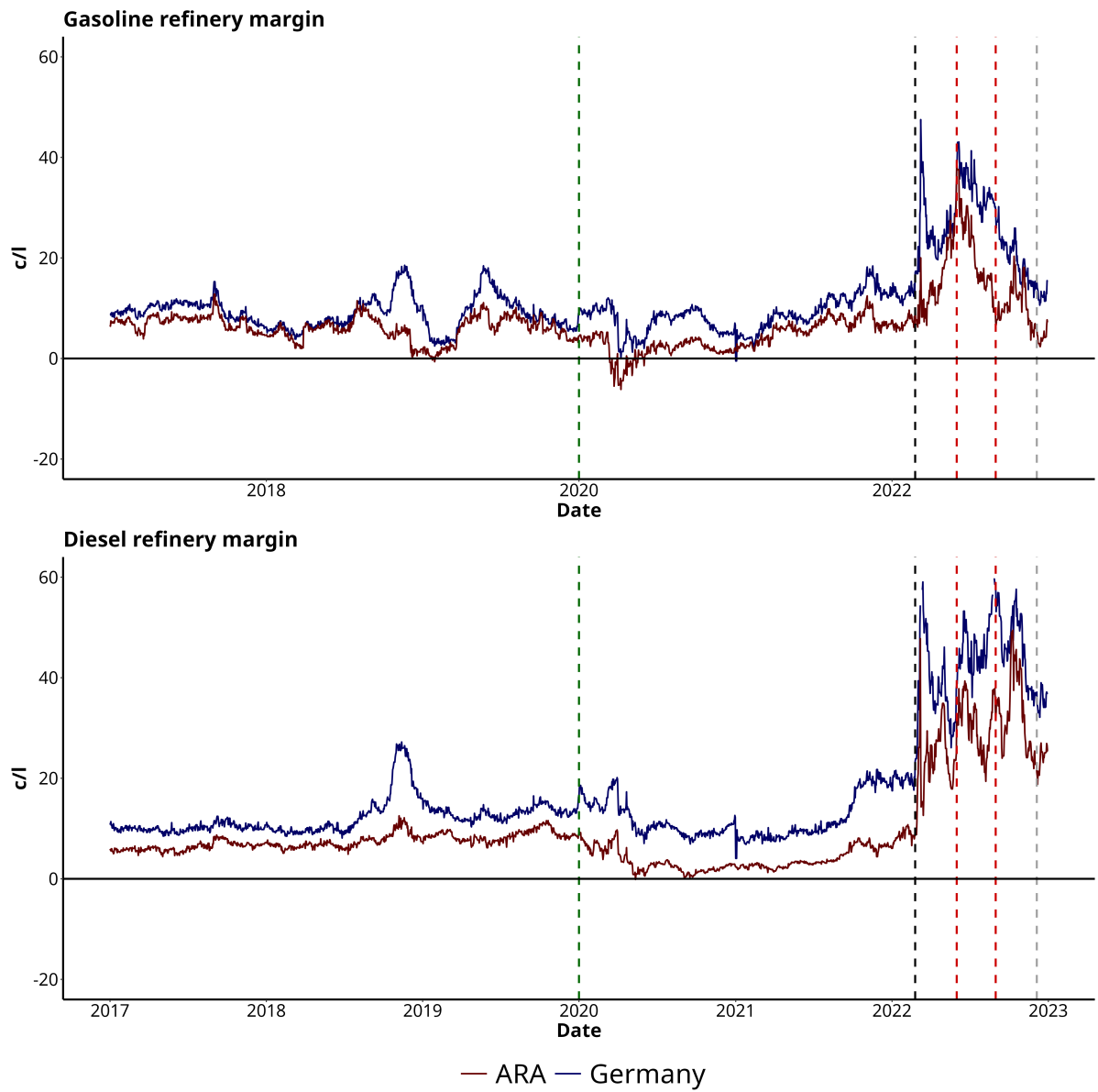


Figure B.9: Refinery Margins in Germany and ARA for Diesel and Gasoline

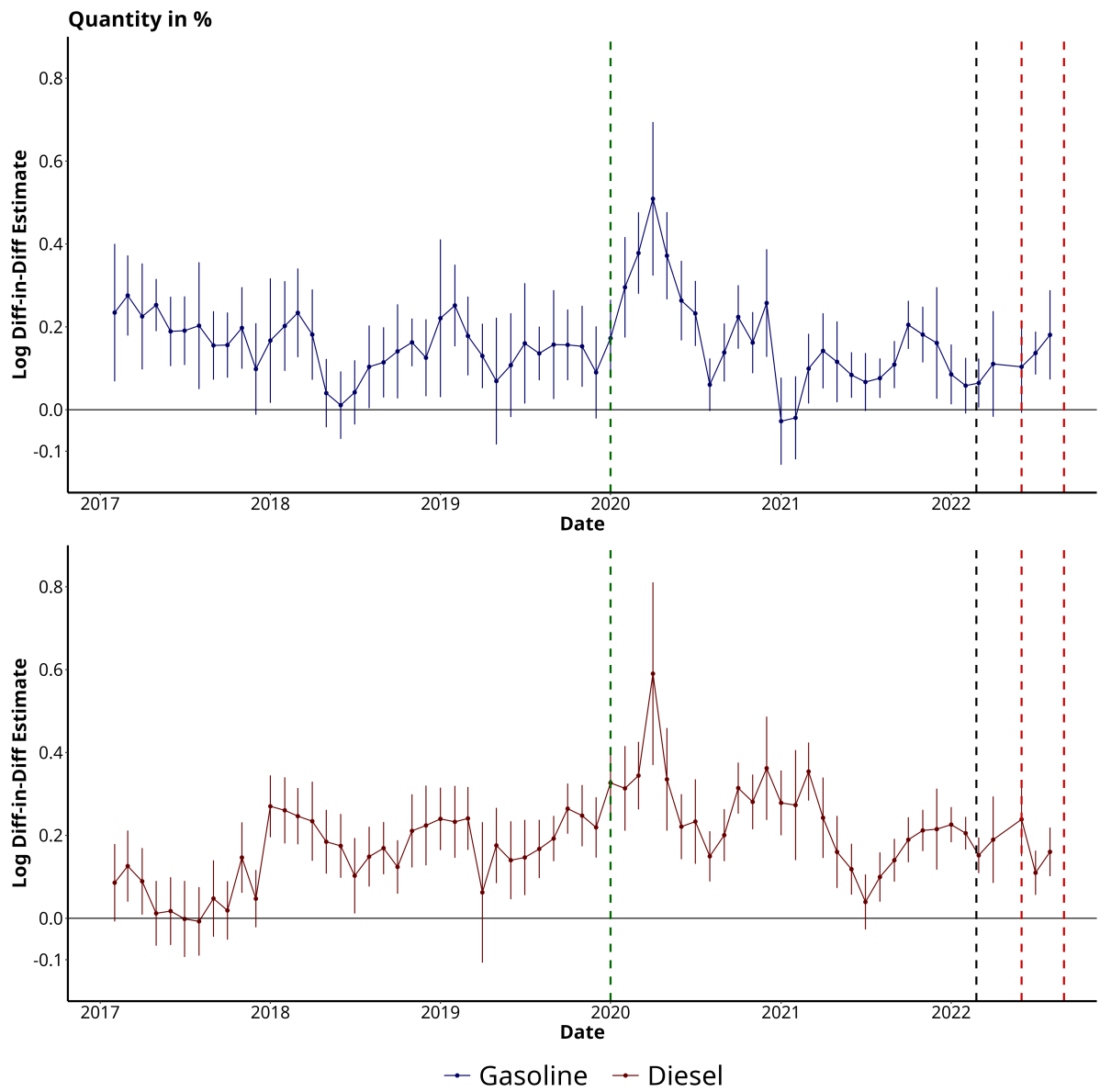


Figure B.10: Dynamic Diff-in-Diff on Gasoline and Diesel Quantity

C Tables

Company	Level of vertical integration	Refineries
BP	Fully integrated	Gelsenkirchen Lingen
Shell	Fully integrated	Rheinland MiRO (partially) PCK (partially)
ENI	Fully integrated	Bayernoil (partially) PCK (partially)
Total Energies	From exploration to refinery (German petrol stations sold in 2023)	Leuna
Rosneft	From exploration to refinery Under trust management by the German Bundesnetzagentur since 09/2022	PCK (partially) MiRO (partially) Bayernoil (partially)
OMV	From exploration to refinery (German petrol stations sold in 05/2022)	Burghausen
Esso	From exploration to refinery (German petrol stations sold in 10/2018)	MiRO (partially)
Philipps66	Refinery and gasoline stations (German petrol stations offered for sale)	MiRO (partially)
Oilinvest Group	Refinery and gasoline stations	Holborn Europa
Varo Energy	Only Refineries	Bayernoil (partially)
Gunvor	Only Refineries	Ingolstadt
Klesch	Only Refineries	Heide

Table C.1: Companies active in German Fuel Production, table according to Federal Cartel Office (2022); OMV (2022); TotalEnergies (2024); Bundesministerium für Wirtschaft und Klimaschutz (2022); EG Group (2018); Argus Media (2024c)

	Pre COVID	COVID	Invasion	Tax Cut	Post Tax Cut
Observations/Days	1094	785	97	92	122
A. Crude Oil Prices					
Brent	34.74 (4.43)	31.88 (9.61)	63.60 (4.10)	64.84 (4.27)	55.14 (4.95)
Sahara	34.75 (4.66)	31.84 (10.73)	67.35 (4.73)	70.72 (5.41)	57.07 (5.13)
Ural	32.57 (8.57)	57.16 (4.81)	57.09 (4.03)	57.43 (3.82)	55.52 (2.72)
B. Wholesale Prices					
Gasoline	43.86 (5.29)	40.64 (12.21)	88.99 (7.56)	98.89 (7.02)	73.37 (8.94)
Diesel	46.88 (6.25)	44.11 (12.25)	102.25 (10.72)	111.67 (5.61)	98.95 (11.76)
Gasoline (ARA)	41.67 (4.82)	36.73 (12.69)	80.51 (9.35)	87.89 (12.55)	66.05 (9.16)
Diesel (ARA)	42.18 (5.06)	35.91 (11.19)	87.16 (8.91)	95.68 (7.89)	86.05 (12.09)
C. Retail Prices					
Gasoline	53.40 (5.28)	53.46 (11.75)	100.51 (7.73)	111.94 (7.05)	85.15 (8.93)
Diesel	56.59 (6.10)	55.90 (11.87)	115.36 (10.69)	123.12 (4.68)	110.31 (11.12)
D. Refinery Margins					
Gasoline	9.12 (3.15)	8.76 (3.46)	25.39 (5.75)	34.05 (3.76)	18.23 (4.77)
Diesel	12.14 (3.38)	12.23 (4.29)	38.65 (9.70)	46.83 (5.59)	43.81 (7.42)
Gasoline (ARA)	6.93 (2.53)	4.86 (3.38)	16.91 (6.59)	23.05 (8.95)	10.91 (4.97)
Diesel (ARA)	7.44 (1.48)	4.03 (2.41)	23.56 (6.44)	30.84 (5.10)	30.91 (7.90)
E. Station Margins					
Gasoline	9.54 (1.02)	12.83 (1.72)	11.52 (3.22)	13.05 (2.17)	11.78 (1.84)
Diesel	9.71 (1.04)	11.79 (1.23)	13.11 (5.62)	11.45 (2.91)	11.36 (2.57)
F. Cost of Freight					
Gasoline	1.51 (1.04)	1.08 (0.40)	1.77 (0.41)	3.40 (1.91)	2.97 (0.87)
Diesel	1.67 (1.18)	1.14 (0.46)	1.93 (0.46)	3.77 (2.17)	3.28 (0.99)

Table C.2: Summary Statistics of Daily Data in c/l

	Pre COVID	COVID	Invasion	Tax Cut	Post Tax Cut
Observations (Months)	36	26	3	3	4
A. Crude Oil Quantities in Germany					
Oil Production	201.03 (14.56)	180.35 (11.90)	168.77 (3.10)	162.91 (4.23)	164.96 (2.00)
Oil Trade Balance	8525.00 (615.69)	8017.74 (599.83)	8620.06 (303.72)	8577.48 (253.37)	8868.82 (492.90)
Oil Stock Change	10.74 (254.25)	9.47 (262.86)	-46.88 (491.82)	62.12 (89.42)	2.64 (390.00)
Oil Other	-18.69 (78.58)	-1.89 (112.97)	-78.13 (266.31)	55.87 (60.15)	-85.85 (150.39)
Oil Refinery Intake	8718.05 (623.50)	8205.85 (576.73)	8663.03 (293.90)	8858.76 (279.41)	8950.56 (121.24)
B. Crude Oil Quantities in the EEA					
Oil Production (EEA)	13591.68 (814.70)	13989.08 (810.00)	13333.06 (462.50)	12480.24 (1202.82)	12979.61 (662.88)
Oil Trade Balance (EEA)	36133.35 (2167.46)	28500.34 (2924.59)	31064.64 (2912.34)	34455.63 (1184.36)	32148.25 (2652.33)
Oil Stock Change (EEA)	-43.82 (1364.74)	146.77 (1634.53)	-622.33 (724.68)	199.24 (944.95)	-167.01 (1962.88)
Oil Other (EEA)	151.22 (568.60)	-289.39 (755.52)	517.63 (648.65)	45.71 (704.45)	0.29 (1163.15)
Oil Refinery Intake (EEA)	49829.11 (2512.48)	42346.25 (2829.23)	44294.57 (1856.76)	47177.30 (1708.94)	44962.90 (1830.89)
C. Gasoline Quantities in Germany					
Gasoline Production	2279.74 (158.95)	2172.82 (201.49)	2286.00 (8.25)	2358.90 (73.77)	2331.11 (46.59)
Gasoline Trade Balance	-293.62 (182.32)	-408.74 (107.42)	-560.70 (140.64)	-381.15 (158.64)	-444.15 (113.87)
Gasoline Stock Change	3.75 (156.02)	3.89 (166.90)	-49.50 (45.31)	157.50 (162.69)	-116.78 (109.06)
Gasoline Other	300.38 (88.24)	417.05 (58.14)	468.90 (124.04)	361.80 (82.35)	344.93 (68.14)
Gasoline Demand	2290.31 (192.42)	2184.92 (226.68)	2146.05 (67.89)	2495.70 (116.20)	2114.78 (104.95)
D. Gasoline Quantities in the EEA					
Gasoline Production (EEA)	11597.59 (676.25)	10040.31 (1063.64)	10874.25 (283.19)	11182.05 (567.46)	10524.60 (664.72)
Gasoline Trade Balance (EEA)	-6299.21 (574.01)	-5429.03 (781.33)	-6076.80 (645.11)	-6021.90 (237.58)	-5567.74 (630.48)
Gasoline Stock Change (EEA)	15.30 (664.00)	-14.49 (718.40)	158.85 (488.91)	108.00 (428.58)	51.30 (291.32)
Gasoline Other (EEA)	1835.51 (595.73)	1995.77 (593.97)	2688.30 (269.49)	2830.50 (247.67)	2578.84 (570.86)
Gasoline Demand (EEA)	7405.61 (511.03)	6779.60 (1163.02)	7653.60 (409.57)	8207.55 (223.73)	7750.35 (223.24)
E. Diesel Quantities in Germany					
Diesel Production	4143.95 (304.87)	3999.33 (323.79)	4265.25 (92.34)	4271.58 (190.15)	4365.37 (174.26)
Diesel Trade Balance	1093.72 (355.06)	783.44 (401.98)	311.92 (346.89)	473.61 (517.69)	667.12 (140.32)
Diesel Stock Change	15.06 (345.14)	31.79 (411.11)	-52.18 (271.70)	190.55 (147.93)	-163.67 (193.07)
Diesel Other	77.09 (81.60)	97.57 (105.64)	146.67 (148.59)	82.62 (70.38)	77.68 (33.75)
Diesel Demand	5329.92 (330.61)	4912.05 (578.87)	4672.05 (397.31)	5019.55 (325.89)	4946.21 (87.68)
F. Diesel Quantities in the EEA					
Diesel Production (EEA)	21781.68 (1041.68)	19335.91 (1098.98)	19313.22 (250.40)	20399.20 (1122.94)	19872.62 (1102.37)
Diesel Trade Balance (EEA)	1721.02 (831.35)	1894.59 (898.07)	2531.71 (751.43)	1726.03 (465.74)	3649.03 (548.51)
Diesel Stock Change (EEA)	124.53 (1424.99)	112.94 (1389.40)	456.21 (1293.56)	-43.09 (987.71)	-549.41 (1796.66)
Diesel Other (EEA)	912.00 (425.70)	1607.21 (701.77)	1652.49 (204.50)	1492.38 (193.40)	1357.38 (405.59)
Diesel Demand (EEA)	24616.52 (921.69)	22951.70 (1829.45)	23950.48 (1042.61)	23575.70 (308.05)	24333.16 (648.32)

Table C.3: Monthly Quantity Data in 10.000 m^3

Gasoline Wholesale Prices in c/l						
Tax Cut:Cologne	6.10*** [6.10; 6.10]	3.57*** [3.32; 3.83]	1.50** [0.19; 2.82]	-3.18*** [-3.96; -2.41]	0.61 [-0.16; 1.38]	0.07 [-0.70; 0.84]
Tax Cut:East	6.69*** [6.69; 6.69]	12.98** [3.15; 22.82]	1.62** [0.21; 3.04]	-3.01*** [-3.92; -2.10]	0.79* [-0.05; 1.62]	0.14 [-0.70; 0.99]
Tax Cut:Emsland	8.85*** [8.85; 8.85]	6.32*** [6.07; 6.58]	4.25*** [2.94; 5.57]	-0.43 [-1.20; 0.35]	3.36*** [2.59; 4.13]	2.82*** [2.05; 3.59]
Tax Cut:Magdeburg	8.42*** [8.42; 8.42]	14.71*** [4.87; 24.55]	3.35*** [1.94; 4.77]	-1.28** [-2.19; -0.37]	2.51*** [1.68; 3.35]	1.87*** [1.03; 2.72]
Tax Cut:North	7.66*** [7.66; 7.66]	5.13*** [4.88; 5.39]	3.07*** [1.75; 4.38]	-1.62*** [-2.39; -0.85]	2.17*** [1.403; 2.94]	1.63*** [0.86; 2.40]
Tax Cut:Rhine-Main	7.67*** [7.67; 7.67]	2.99 [-1.94; 7.93]	3.49*** [2.27; 4.72]	-1.22*** [-1.94; -0.51]	2.57*** [1.75; 3.39]	2.05*** [1.22; 2.88]
Tax Cut:Seefeld	5.75*** [5.75; 5.75]	12.04** [2.21; 21.88]	0.69 [-0.73; 2.10]	-3.95*** [-4.86; -3.04]	-0.15 [-0.99; 0.68]	-0.79* [-1.64; 0.05]
Tax Cut:South	12.90*** [12.90; 12.90]	8.22*** [3.29; 13.16]	8.73*** [7.50; 9.95]	4.01*** [3.30; 4.72]	7.80*** [6.98; 8.62]	7.28*** [6.45; 8.11]
Tax Cut:Southeast	9.41*** [9.41; 9.41]	15.70*** [5.87; 25.54]	4.35*** [2.93; 5.76]	-0.29 [-1.19; 0.62]	3.51*** [2.68; 4.34]	2.87*** [2.02; 3.71]
Tax Cut:Southwest	5.10*** [5.10; 5.10]	0.41 [-4.52; 5.35]	0.918 [-0.31; 2.14]	-3.80*** [-4.51; -3.09]	-0.01 [-0.82; 0.81]	-0.53 [-1.35; 0.30]
Tax Cut:West	7.76*** [7.76; 7.76]	5.23*** [4.98; 5.49]	3.13*** [1.85; 4.48]	-1.52*** [-2.30; -0.75]	2.27*** [1.50; 3.04]	1.73*** [0.96; 2.50]
Crude Oil		✓	✓	✓	✓	✓
Freight Costs		✓	✓	✓	✓	✓
Date FE			✓	✓	✓	✓
War FE				✓	✓	✓
Invasion FE					✓	✓
Covid FE						✓
Demand controls						✓
Num. obs.	24816	24816	24816	24816	24816	24816
R ²	0.414	0.616	0.992	0.992	0.992	0.993
Adj. R ²	0.413	0.615	0.991	0.991	0.991	0.992
Num. groups: date			2068	2068	2068	2068

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table C.4: Diff-in-Diff Estimation of the Energy Tax Cut on Regional Gasoline Wholesale Prices

Diesel Wholesale Prices in c/l						
Tax Break:Cologne	9.13*** [9.13; 9.13]	11.01*** [10.85; 11.16]	5.35*** [3.722; 6.98]	-2.63*** [-4.05; -1.21]	2.61*** [1.32; 3.89]	2.19*** [0.87; 3.50]
Tax Break:East	6.15*** [6.15; 6.15]	20.08*** [8.71; 31.45]	2.04*** [0.37; 3.70]	-5.86*** [-7.44; -4.28]	-0.62 [-2.07; 0.82]	-1.23* [-2.65; 0.20]
Tax Break:Emsland	9.24*** [9.24; 9.24]	11.12*** [10.97; 11.27]	5.47*** [3.84; 7.10]	-2.52*** [-3.94; -1.10]	2.72*** [1.44; 4.01]	2.30*** [0.99; 3.62]
Tax Break:Magdeburg	8.83*** [8.83; 8.83]	22.76*** [11.38; 34.12]	4.72*** [3.05; 6.38]	-3.18*** [-4.76; -1.60]	2.06*** [0.61; 3.51]	1.46** [0.03; 2.88]
Tax Break:North	7.96*** [7.96; 7.96]	9.84*** [9.69; 9.99]	4.19*** [2.56; 5.82]	-3.78*** [-5.22; -2.38]	1.44** [0.16; 2.73]	1.02 [-0.30; 2.34]
Tax Break:Rhine-Main	11.53*** [11.53; 11.53]	9.53*** [3.86; 15.19]	8.11*** [6.54; 9.68]	0.07 [-1.25; 1.40]	5.31*** [4.10; 6.52]	4.95*** [3.73; 6.18]
Tax Break:Seefeld	4.35*** [4.35; 4.35]	18.28*** [6.91; 29.65]	0.24 [-1.43; 1.90]	-7.66*** [-9.24; -6.08]	-2.42*** [-3.87; -0.98]	-3.03*** [-4.45; -1.60]
Tax Break:South	15.14*** [15.14; 15.14]	13.14*** [7.47; 18.80]	11.72*** [10.15; 13.29]	3.69*** [2.36; 5.01]	8.92*** [7.71; 10.13]	8.57*** [7.34; 9.80]
Tax Break:Southeast	11.92*** [11.92; 11.92]	25.85*** [14.48; 37.23]	7.81*** [6.15; 9.48]	-0.08 [-1.66; 1.50]	5.16*** [3.71; 6.60]	4.55*** [3.12; 5.98]
Tax Break:Southwest	11.08*** [11.08; 11.08]	9.08*** [3.41; 14.74]	7.66*** [6.09; 9.23]	-0.37 [-1.70; 0.96]	4.87*** [3.65; 6.08]	4.51*** [3.28; 5.74]
Tax Break:West	8.92*** [8.92; 8.92]	10.80*** [10.65; 10.95]	5.14*** [3.51; 6.77]	-2.84*** [-4.26; -1.42]	2.40*** [1.11; 3.68]	1.98*** [0.66; 3.29]
Crude Oil		✓	✓	✓	✓	✓
Freight Costs		✓	✓	✓	✓	✓
Date FE			✓	✓	✓	✓
War FE				✓	✓	✓
Invasion FE					✓	✓
Covid FE						✓
Demand controls						✓
Num. obs.	24816	24816	24816	24816	24816	24816
R ²	0.431	0.633	0.993	0.994	0.994	0.995
Adj. R ²	0.430	0.632	0.993	0.993	0.994	0.995
Num. groups: date			2068	2068	2068	2068

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table C.5: Diff-in-Diff Estimation of the Energy Tax Cut on Regional Diesel Wholesale Prices

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