Fuel pricing in Belgium: Is the current formula the way forward?

Auteur : Collignon, Mathilda
Promoteur(s) : Jousten, Alain
Faculté : HEC-Ecole de gestion de l'Université de Liège
Diplôme : Master en sciences économiques, orientation générale, à finalité spécialisée en economic, analysis and policy
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Jury:
Suervisor:
Alain JOUSTEN
Readers:
Axel GAUTIER
Henry-Jean GATHON

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Mathilda COLLIGNON
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Contents

1 List of Abbreviations

APETRA: Agence de Pétrole - Petroleum Agentschap / Petroleum Agency

ARDL : Autoregressive Distributed Lags

BMWK: Bundesministerium für Wirtschaft und Klimaschutz / Federal Ministry for Economic Affairs and Climate Action

BOFAS: Bodemsaneringsfonds voor Tankstations / Soil Remediation Fund for Petrol Stations

EU: European Union

EUR: Euro

IEA: International Energy Agency

MLR: Multiple Linear Regression

MTU: Market Transparency Unit

SPF / FPS : Service Public Fédéral / Federal Public Service

USD: U.S. Dollar

VAT: Value Added Tax

2 Introduction

The retail fuel pricing strategy in Belgium is rooted in an approach structured around a maximum price determined by the government. This method lies within a category that is not fully liberated or fixed, a common practice found in many middle-income countries. Such mechanisms often aim to safeguard consumers from the volatility of prices, a vital consideration in regions where purchasing power tends to be lower.

While these methods serve their purpose in certain nations, they usually are costly for governments. Furthermore, they inadvertently inhibit the transition from fuel-based energy to renewable sources by artificially maintaining affordability of fuels relative to cleaner alternatives. This issue gains significance in high-income countries like those within the European Union, where most Member States have transitioned to market-based pricing, fostering competition and innovation.

Belgium's pricing formula has faced critique from various institutions for its lack of discernible advantages while impeding the broader adoption of renewable energy sources. This departure from the established norms in high-income countries prompts a fundamental inquiry into the suitability of Belgium's current pricing mechanism. This thesis aims to address whether a high-income nation like Belgium should persist with such government intervention in retail fuel prices or pivot toward a more conventional approach.

To explore this question, an analysis will be conducted, comparing Belgian fuel prices over the long term with those in Germany. Germany, known for its market-driven fuel prices closely mirroring fluctuations in crude oil prices, serves as an apt counterpart due to its proximity to Belgium. Evaluating how retail fuel prices in both countries respond to variations in Brent crude oil prices will shed light on the responsiveness of Belgium's formula, purportedly sensitive to crude oil market shifts.

Another critical aspect of examination pertains to the energy crisis stemming from the war in Ukraine, which started in 2022. Many European Union nations resorted to short-term interventions like reduced excise duties and fuel taxes to manage soaring energy prices. Given the consumer shielding function expected of not entirely liberated or fixed pricing mechanisms, did Belgium's pricing formula offer any advantages during this crisis? A comparative analysis with selected EU countries will help address this query.

In essence, this thesis endeavors to scrutinize whether Belgium's current fuel pricing mechanism aligns with the demands of today's economy or if transitioning to a more conventional approach better suits a country of its income stature.

3 Literature review

3.1 General Overview of Pricing Methodologies

Pricing methodologies vary across the globe and are often contingent upon a country's economic context and its approach to regulating consumer prices. These methodologies can be categorized into three primary groups.

Before evaluating the appropriateness of a particular pricing mechanism, it is imperative to conduct a thorough analysis of the economic conditions in a given country. This is because a pricing mechanism suitable for one nation may not be optimal for another due to variations in economic circumstances. The objective of this overview is to shed light on the various approaches adopted in diverse economic contexts.

3.1.1 Fixed Retail Price

When the retail fuel price is fixed, it is typically subsidized by the government. This practice aims to protect consumers from the price fluctuations linked to the global crude oil market, which significantly influences national fuel prices. Fixed pricing is commonly implemented in low-income countries with a primary goal of ensuring that their citizens have access to an adequate level of fuel consumption. This approach is frequently adopted in countries such as Ethiopia, Mali and the Democratic Republic of Congo which are part of the low income group (IEA, 2021), (World Bank, 2023).

3.1.2 Retail Price Not Fully Fixed or Liberated

Some pricing mechanisms involve allowing prices to fluctuate while retaining a degree of government control. The primary objective here is to shield consumers from sudden shifts in the global crude oil market, offering protection against short-term market volatility. Such methods, while less financially burdensome for governments compared to fully fixed pricing, still incur intervention costs (IEA, 2021).

Governments often transition from fixed pricing to this approach to decrease subsidies and protect tax revenues, aiming for gradual reflection of international fuel price changes in domestic prices over the medium term. It is essential to view this mechanism as an initial step toward a fully liberalized pricing and supply system (Coady et al., 2012).

This pricing model is commonly seen in middle-income countries, where consumers usually possess greater purchasing power than in lower-income nations, enabling them to tolerate some price fluctuations while necessitating protective measures. Notably, Brazil, Peru, and China implement this pricing mechanism. Belgium, despite its classification as a high-income country, also falls into this category of pricing mechanism (IEA, 2021), (World Bank, 2023).

Upon initial examination, one might question the reasons behind Belgium's placement in this category. A following section will delve deeper into the Belgian pricing formula, offering a detailed explanation of its origins and the factors contributing to its unique position.

3.1.3 Fully Liberalized Retail Price

In this case, the government does not set or control the retail prices. This approach harnesses the power of competition and aims to minimize government intervention in price regulation. Fully liberalized retail prices are typically adopted in high-income countries where individuals' purchasing power is considered sufficient to ensure access to essential quantities of fuel without relying on government subsidies. This method finds widespread usage in many high-income regions, including European Union Member States, Canada, and the United States (IEA, 2021), (World Bank, 2023).

3.2 Overview of the Belgian Formula

Before 1974, Belgium used a rigid pricing mechanism for fuel, requiring the approval of a Price Committee to apply any changes to prices. During the oil crisis, this procedure created a disparity between the prices for oil on international markets and the price at which these oil products were sold in Belgium, which endangered the country's oil supply.

In response to this oil crisis and the challenges posed by the existing pricing mechanism, the Belgian government introduced a new system for setting fuel prices. Under this system, the Directorate-General for Energy of the Federal Public Service Economy, on each working day, calculates the maximum pump prices in line with the stipulations of the Programme Agreement. This agreement emerged as a a strategic initiative to address the fuel crisis. It is a joint effort between the Ministers of Economy and Energy and the Belgian federation "Energia", which outlines maximum prices for common fuel types and the mechanisms for price adjustments, specifically aimed at end-user sales. Comprising a core agreement providing the pricing framework and a Technical Annex defining the pricing formulas, which ensures that Belgium can quickly adapt its pricing structure for petroleum products to reflect evolving market conditions (FPS Economy, 2022).

However, recent assessments from specialists expose the ongoing issues associated with the current formula. In its most recent report on Belgium's energy policies, the IEA (2022) reaffirms that the formula imposes administrative burdens and costs on both the federal government and Belgium’s oil companies, with no discernible benefits.

Furthermore, another issue associated to this formula has been exposed during the recent energy crisis. Indeed, in March 2022, certain oil companies found themselves compelled to sell their products at a loss, due to the maximum prices being set too low to account for the surge in prices (Carter, 2022). As explained in section 3.1.2, the Belgian formula pertains to the category of fuel pricing mechanism which smooths out short-term volatility. However, even in such scenarios, the margins of distributors should be protected because suppliers should always receive prices reflecting the actual import and distribution costs agreed in the formula, and therefore be indifferent to the choice of mechanism (Coady et al., 2012).

Additionally, according to IEA (2022), the Belgian formula does not facilitate the introduction of renewable fuels. This is because the type of mechanism present in Belgium might suppress incentives for consumers to substitute away from fuel when prices are high and towards fuel when they are low. In essence, while the governmental control of the maximum prices can offer stability, such mechanism may have unintended consequences on consumer behavior and economic efficiency (Coady et al., 2012).

In the case of Belgium, this method presents unique considerations. Given that consumers in Belgium may not require the same level of protection from price fluctuations as those in middle-income countries, and taking into account the associated government costs, the suitability of this approach warrant furthers examination. Understanding the multifaceted dynamics shaping Belgium's fuel pricing landscape is crucial, necessitating an examination of the diverse elements constituting fuel retail prices in the country.

3.3 Elements of Retail Fuel Price

3.3.1 Price of the Refined Product

The primary factor influencing the cost of refined products is the price of crude oil. Crude oil is sourced from global underground reservoirs, predominantly in oil fields. This raw material significantly influences the final fuel cost. (European Commission. Eurostat, 2023).

Belgium's oil supply originates from the Rotterdam port, a global hub for crude oil distribution and refining. Rotterdam, with a capacity of 58 million tonnes, supplies crude oil to Belgium and Germany via the Rotterdam-Antwerp route. Tankers from various regions, including the North Sea, Russia, and the Middle East, contribute to the port's refineries, consolidating its global significance in the oil market (Port of Rotterdam, nd).

Since Belgium gets supplied unrefined oil, then comes the cost of refining. Ultimately, the refined product comprises the cost of crude oil and the expenses associated with its refinement FPS Economy (2022).

3.3.2 Maximum Gross Distribution Margin

Under the Programme Agreement, a defined maximum gross distribution margin covers distribution and logistics costs incurred by oil companies in delivering products to end-users. These costs span transport from the refinery to the warehouse, storage, transport to gas stations, distribution at gas stations, delivery of gas oil for heating, marketing, and promotional expenses. The margin undergoes biannual indexation on April 1 and October 1 (FPS Economy, 2022).

3.3.3 Legal Contributions and Taxes

Several legal charges are added to the daily price, including contributions for:

- **Contribution for APETRA**: Supporting Belgium's strategic reserves of crude oil and petroleum products to ensure supply during crises. It undergoes indexing four times a year.
- **Contribution for BOFAS**: Financing the BOFAS fund, aiding petrol stations in soil remediation.
- **Contribution for the Social Heating Oil Fund**: Partially subsidizing heating costs for families with modest incomes.

Excise duties on energy products, fixed taxes irrespective of the finished product's price, constitute a significant portion of the overall maximum price, particularly for petrol and diesel. Additionally, a 21% Value Added Tax (VAT) is applied to the sum of all components, including excise duties (FPS Economy, 2022).

Having gained a comprehensive understanding of Belgium's unique pricing approach, including the various factors integrated into its formula for setting maximum prices, and considering the critiques of this formula, the study now seeks to identify an appropriate counterpart for analysis, with the aim of comparing Belgium's pricing mechanism to that of another country. The ideal choice for this comparison is Germany's fuel system. Germany's relevance stems from its status as a high-income country that employs a fully liberalized approach to fuel pricing. Additionally, Germany, like Belgium, sources its oil supply from the Rotterdam market, making it a particularly pertinent comparison for this study.

3.4 Overview of Germany's Fuel Pricing Mechanism

In Germany, the prices of Petrol and Diesel at retail outlets are primarily determined by market forces, aligning with a "fully liberalized" pricing approach discussed in section 3.1.3. Added on top of these market-driven rates are specific taxes: an Energy Tax of 47.04 cents per litre for Diesel and 65.45 cents per litre for Petrol. Moreover, a Value Added Tax (VAT) of 19% is applied to the overall price.

Beyond these taxes, the final price includes expenses related to blending bio-components into the fuel to meet biofuels quotas. It also accounts for costs tied to fuel transportation, storage, and distribution (BMWK-Federal Ministry for Economics Affairs & Climate , nda).

Additionally, in 2021, Germany introduced a new carbon pricing system. This led to an approximate increase of 7 cents per litre for petrol and 8 cents per litre for diesel. The carbon pricing steadily rises, reaching 8 cents per litre for petrol and 10 cents per litre for diesel in 2022. These rates remained constant through 2023 and are set to gradually increase until 2027 (Wettengel, 2019).

In the dynamic fuel market of Germany, prices at the pump are subject to constant fluctuations throughout the day, changing multiple times to closely align with the ever-shifting market dynamics. This stands in sharp contrast to Belgium's pricing system, where prices are set on weekdays based on a government-mandated maximum, rather than fluctuating according to actual market dynamics. For instance, during rush hours in Germany, prices are likely to surge, while they may dip during periods of reduced traffic, responding directly to shifts in consumer demand. This pricing model closely aligns with the principles of a free market under perfect competition, where supply and demand determine prices (Benzinpreis-Aktuell.de, 2024). To uphold this ideal of perfect competition, the Market Transparency Unit for Fuels (MTU Fuels) plays a crucial role.

The Market Transparency Unit for Fuels (MTU Fuels), operating under the Federal Cartel Office, acts as an autonomous competition authority with the primary mission of upholding fair competition in Germany. One of its core functions is to diligently monitor and assess fuel prices at various filling stations, specifically to identify potential breaches of cartel laws—agreements among businesses aimed at manipulating prices or restricting competition. Cartel laws, in this context, serve as regulatory measures to prevent such anti-competitive practices.

In the pursuit of its objectives, MTU Fuels engages in a proactive approach. Notably, it collaborates with authorized private providers of consumer information services, sharing the tracked fuel prices to enhance market transparency and provide consumers with more accurate information. This collaborative effort is grounded in the assumptions of perfect competition, where a multitude of buyers and sellers ensures no single entity can unduly influence prices.

Consumer information service providers, authorized by MTU Fuels, are mandated to consistently report the latest fuel prices on a nationwide platform. To further strengthen the reliability of information and address concerns, these providers appoint a government official functioning as an ombudsman. This ombudsman plays a crucial role in receiving and investigating complaints filed by private citizens against other officials or government agencies. This mechanism empowers consumers to report inaccuracies and seek resolution, reinforcing the commitment to fair competition (BMWK-Federal Ministry for Economics Affairs & Climate , ndb).

In examining the German pricing mechanism alongside Belgium's approach, notable distinctions and shared elements emerge, rendering Germany an alluring counterpart for comparative analysis in the empirical study. Both nations encounter analogous impacts from the Rotterdam oil market's fluctuations, shaping a fundamental component of the retail price. However, Germany's dynamic, market-driven pricing model, responsive to real-time shifts in consumer demand, stands in stark contrast to Belgium's regulated system with predetermined maximum prices, less responsive to immediate market dynamics.

Furthermore, Germany's inclusion of a carbon price in fuel incentivizes mindful consumption by considering environmental harm, while Belgium's absence of such pricing lacks this incentive and does not directly account for the environmental impact of fuel usage.

Hence, the proposed comparison between these countries presents a robust avenue for evaluating the strengths and limitations of the Belgian pricing formula. This approach offers an opportunity to discern the divergences in pump prices stemming from distinct pricing mechanisms, yet grounded in shared fundamental price elements.

3.5 Insights and Future Directions

Before diving further into the research and examining the recent geopolitical conditions which have disrupted energy markets on a global level, some preliminary insights can already provide perspective to answer the research question.

As the formula creates administrative burden and costs on both the government and oil companies, as well as fails to support the introduction of renewable energy sources, it is valid to question its suitability. When comparing the Belgian formula to Germany's approach, it can be seen that the costs for the government and oil companies are not an issue there, due to the fully liberalized prices. Furthermore, as the German prices encompass a carbon tax, they take into account the negative externality produced by fuel consumption and incentivize the substitution of fuel with lower environmental impact goods.

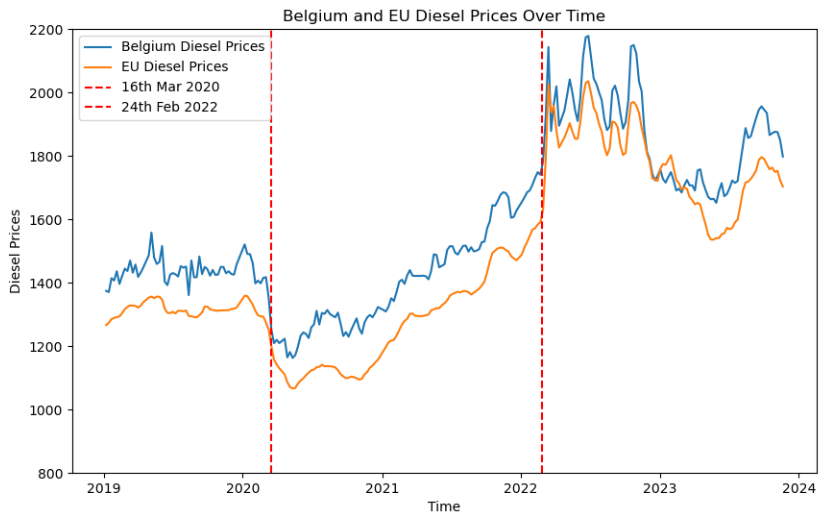
Furthermore, the formula, initially designed for adaptability and responsiveness to global market fluctuations following the oil crisis of the 1970s, seemed to lack the required responsiveness in the face of the 2022 crisis. In contrast, the German system, which permits daily price fluctuations in line with market conditions, did not face similar challenges. This situation highlights the need to reevaluate the suitability of the Belgian formula.

At this stage, understanding the historical reason for Belgium's fuel pricing formula, along with recent criticisms, it can be preliminarily concluded that this formula may not be the best way forward. This leads to the question, "Why is the formula still maintained?". When looking at the distinctions between the German system and the Belgian one, it can be seen that Germany harnesses the power of competition through close monitoring of the market. This monitoring is set in place to avoid collusion, which would harm consumers for the benefit of sellers. One possibility is that the Belgian formula offers a straightforward approach to regulate competition, since a maximum price could prevent collusion. However, this approach might be less effective than a system that leverages the benefits of competition and market liberalization, such as the model employed in Germany.

This consideration leads to the empirical analysis component of this research. This thesis aims to compare Belgium's regulated pricing mechanism with Germany's liberalized approach. The German model, characterized by frequent price adjustments in response to market conditions, ensures responsive pricing while monitoring competition. A long-term comparison of fuel prices between Belgium and Germany would reveal the effectiveness of Belgium's pricing formula. If Belgian prices demonstrate responsiveness and adaptability similar to the German model, it would indicate that the maximum price is appropriate during normal market conditions, effectively preventing collusion and maintaining market responsiveness. Conversely, if Belgian prices are found to be less responsive, it could suggest that the formula is smoothing out prices excessively, thereby shielding consumers from market realities. This outcome would imply that Belgium's current pricing mechanism might not be well-suited to its economic situation, indicating a need for a transition towards a more liberalized approach with effective monitoring to ensure the market's competitiveness.

3.6 Recent Developments in Fuel Prices in the EU

This section revisits recent geopolitical events that have significantly influenced global fuel markets. It sets the stage for understanding the fuel pricing interventions in select European Union countries. This background is crucial for a deeper analysis to follow, focusing on evaluating the effectiveness of Belgium's fuel pricing formula.



Note: Graph based on own computations using data from the European Commission's Weekly Oil Bulletin.

Figure 1: Diesel Price Fluctuations in the EU and Belgium (January 2019 - November 2023)

Figure 1 focuses solely on Diesel prices per 1000 litres, in order to view how retail fuel prices responded to the various events. It starts in the pre-pandemic period, where Diesel prices were stable, ranging between €1265.88 per 1000 litres and €1358.66 per 1000 litres in the European Union, and €1360.4 per 1000 litres and €1557.8 per 1000 litres in Belgium.

The onset of the pandemic caused a substantial drop in energy commodity prices, particularly in crude oil, owing to the decreased demand (Kuik et al., 2022). As can be seen in Figure 1, this decline seems to have affected retail fuel prices across the European Union, followed by a progressive recovery and reaching pre-pandemic levels by February 2021. The progressive increase continued until the onset of the Ukraine conflict.

However, the surge in oil prices, already influenced by the pandemic recovery, was further intensified by the war in Ukraine (European Commission, Directorate-General for Economic and Financial Affairs, 2022). The resulting short-term fluctuations and rapid price increases were exacerbated by EU sanctions imposed on Russia. These sanctions aimed to hold Russia accountable for its actions and restrict its ability to continue aggressive behavior. Concerns emerged regarding Russia's potential supply cuts to the EU, contributing to the rise in Brent crude oil prices (Council of the European Union, 2023). In turn, this resulted in price surges and higher volatility in Diesel prices across the European Union. Throughout 2022, fuel prices remained higher than pre-pandemic prices, ranging from €1535.32 per 1000 litres and €2035.24 per 1000 litres for Diesel in EU, and €1651.65 per 1000 litres and €2178.01 per 1000 litres in Belgium.

Addressing supply security became a paramount concern for the EU, leading to decisions to reduce dependency on Russian imports. Consequently, since December 2022, the EU halted crude oil imports from Russia, followed by a restriction on refined petroleum products since February 2023, with limited exceptions (Council of the European Union, 2023).

In a time of global turmoil, the European Union faced significant upheaval in energy prices. This led to soaring inflation rates across the EU, impacting the purchasing power of households. To counter the impact of these surging energy costs, Member States implemented measures aimed at supporting consumers.

3.6.1 Belgium

The alignment between Belgium's trend in Figure 1 and that of the entire European Union stems from the widespread impact of the pandemic and the war in Ukraine across the EU. Belgium, like the rest of the union, has been affected by these circumstances, contributing to the similarity in their trends.

In March 2022, when fuel prices surged in the EU, compelling some sellers to operate at a loss, as exposed in section 3.2. Figure 1 shows these high prices alongside rising EU inflation, which diminished household purchasing power. Two key issues emerge: the maximum price formula did not shield consumers from crude oil market fluctuations and struggled to adapt to market changes, leading to reduced profits or losses for retailers.

Recognizing the persistent challenges, policymakers sought further intervention to address these issues. From the 19th of March until the 31st December 2022, excise duties have been temporarily reduced by 17.5 cents per litre, VAT included (SPF Economie, 2023). This had a cost of 2 million euros per day for Diesel and 1.26 million euros per day for petrol. It was planned that as soon as the maximum price dropped below 1.7 euros per litre, the excise duties would come back to their original level (De Croo, 2022).

3.6.2 Interventions in Selected Countries

To combat surging inflation and shield consumers from significant erosion in purchasing power, most Member States took action by subsidizing energy prices. These interventions entailed adjustments in fuel prices, achieved through reductions in excise duties. In this thesis, the focus is on the interventions put in place in some countries neighboring Belgium, namely the Netherlands, Germany and Luxembourg.

The Dutch government proposed a 21% reduction in excise duty on petrol and diesel from April 1st, 2022, until the year's end. This reduction translates to a decrease of 17.3 cents per liter for petrol and 11.1 cents per liter for diesel (Zaken, 2022).

Germany also enacted fuel tax cuts effective June 1st, 2022, reducing taxes to the European minimum for a three-month period, until September 1st, 2022. Petrol tax decreased by 29.55 cents per liter, and diesel tax dropped by 14.04 cents per liter. This move involved a reduction in additional tax income by 3.1 billion euros (Federal Government, 2022).

On April 8, 2022, Luxembourg implemented a temporary reduction in excise duties on gasoline and diesel. Starting April 13, 2022, and lasting until July 31, 2022, this action decreased the prices of diesel and unleaded gasoline for consumers by 7.5 cents per liter, inclusive of taxes (Groupement Pétrolier Luxembourgeois, 2022).

Since the energy crisis has led to government interventions across the EU, it would be oversimplified to directly conclude that the fuel pricing formula was the sole issue through this time in Belgium. Yet, the significant concern is the formula's impact on suppliers, reducing their ability to turn profit or causing them to sell at a loss. This aspect is critical in evaluating the formula's effectiveness. An upcoming section will examine Belgium's fuel pricing strategy in the broader context of the energy crisis within the European Union. This analysis aims to offer a detailed assessment of Belgium's approach compared to other EU countries, considering the unique challenges posed by the energy crisis.

4 Methodology and Data

4.1 Data

In this section and in the empirical analysis in section 5, the terms 'pre-tax diesel prices' and 'fuel prices' are used synonymously. This is to enhance the clarity of the sentences within the analysis. The focus on pre-tax diesel is because the findings for this fuel type are expected to be indicative of broader trends in other fuels, simplifying the discussion and aligning with the study's objectives.

4.1.1 Data Source

This study utilizes weekly time series data from the European Commission's Weekly Oil Bulletin for pre-tax Diesel prices in euro (EUR) in Germany and Belgium, and daily Brent Crude oil prices in U.S. Dollar (USD) from FRED Economic Data of the St. Louis Fed. The exchange rate data is sourced from the European Central Bank. The analysis period spans from January 2013 to December 2018, avoiding distortions from the COVID-19 pandemic and geopolitical events like the Russian war.

Brent crude oil prices serve as substitutes for the Rotterdam oil market quotations in this analysis, due to data availability constraints. Since the Rotterdam market prices closely mirror Brent crude trends, this relationship suggests that Brent crude oil prices are a reasonable proxy for Rotterdam prices (S&P Global Platts, 2019).

Data preparation included converting Brent crude prices from USD to EUR for consistency with the fuel prices, which are recorded in EUR. This step also helps eliminate the confounding effects of exchange rate fluctuations. The daily time series of Brent crude was aggregated into a weekly series using the average weekly price. Then, the week-to-week price differences for Brent and diesel price in both countries have been calculated.

Subsequently, two dummy variables were created to categorize the weekly changes in Brent crude oil prices. The first dummy variable is assigned a value of 1 for weeks where there is a positive change in Brent prices, indicating an increase. The second dummy variable is set to 1 for weeks where the change in Brent prices is negative, signifying a decrease. This approach aids in analyzing the directional impact of Brent crude price fluctuations on diesel prices.

The resultant dataset includes columns for changes in Belgian and German fuel prices, as well as changes in Brent crude oil prices, all expressed in EUR. The data transformation is mathematically represented as

$$change\_price = price_t - price_{t-1}$$

4.2 Preprocessing the Data

The analysis of time series data often requires careful consideration of its inherent components, which typically include trend and seasonality. These elements can significantly influence the behavior and interpretation of the data, and thus, their identification and appropriate treatment are crucial for accurate analysis.

4.2.1 Stationarity

The process of addressing the inherent components of the data is initiated by performing an Augmented Dickey-Fuller (ADF) test to study the stationarity of the time series. The test is performed on the three variables of interest, namely the changes in pre-tax diesel price in Belgium, the changes in pre-tax diesel price in Germany and the changes in Brent crude oil price. The ADF test centers around a null hypothesis positing the existence of a unit root, indicative of a persistent trend and non-stationarity. Looking at the results in Table 4, which can be found in the Annex, it can be seen that the p-value for each variable is below the standard level of significance of 0.05. Consequently, there is evidence to reject the null hypothesis, indicating evidence that the time series is stationary.

4.2.2 Seasonality

According to the findings presented in Khan et al. (2023), Brent crude oil prices are not influenced significantly by the month-of-the-year effect. While day-of-the-week effects have been noted, these are not relevant for the analysis due to the utilization of weekly data. Consequently, this suggests an absence of seasonality in the Brent crude oil price variable for the purposes of this study.

Furthermore, an empirical investigation into seasonality was conducted by generating Autocorrelation Function (ACF) plots for each year under study. These plots were analyzed for both German and Belgian price changes. The analysis did not reveal any consistent seasonal patterns in these ACF plots. The absence of regular, repeating spikes at specific lags across different years indicates that seasonality is not a significant factor in these time series.

Based on these comprehensive assessments, both from the literature and the empirical analysis, it is concluded that seasonality does not play a substantial role in the variables under consideration. This conclusion allows for the progression of subsequent analyses without the need for seasonal adjustments.

4.3 Model Selection

4.3.1 Autoregressive Distributed Lags

This study adopts an Autoregressive Distributed Lags (ARDL) model to investigate the responsiveness of fuel pricing to Brent crude oil price fluctuations in Belgium and Germany. The model's selection is inspired by its use in similar studies, particularly Silva et al. (2013)'s research on Portugal's fuel market. This methodological choice is made with the objective to assess the responsiveness of the Belgian pricing formula compared to Germany's approach.

The ARDL model's utility lies in its capacity to capture both immediate and lagged responses of fuel prices, offering a comprehensive view of the pricing dynamics. This is crucial for evaluating the Belgian formula, especially considering its historical context following the oil crisis of the 1970s. The formula was designed for greater market responsiveness while the supply of petroleum products was compromised during this crisis (see more details in section 3.2), and this analysis seeks to test its effectiveness in the current market scenario.

This methodology emphasizes analyzing both current and lagged effects of Brent crude oil prices on Belgian fuel prices, in line with the thesis question: "Is the current Belgian fuel pricing formula the way forward?". The study compares Belgium's fuel price adjustments to Germany's model, which adjusts frequently in response to the Rotterdam market trends, closely linked to Brent prices. Germany's approach serves as a benchmark to evaluate the effectiveness and suitability of Belgium's pricing system in today's market conditions.

The findings are expected to provide empirical evidence on whether the Belgian pricing mechanism remains suitable in today's dynamic market. This will be crucial in determining if Belgium should continue with its existing formula or move towards a more liberalized pricing mechanism, akin to Germany's model.

4.3.2 Determining the Lag Lengths

The optimal number of lags in the ARDL model is determined using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The process involves:

1. Generating lagged versions of the independent variables up to a specified maximum lag length.

2. Fitting an Ordinary Least Squares (OLS) regression model for each possible lag length, using the lagged independent variables to predict the dependent variable.

3. Calculating the AIC and BIC values for each model. These criteria assess the model's fit while penalizing for increased complexity due to additional lags.

4. Selecting the lag length that minimizes both the AIC and BIC, balancing the goodness of fit with the simplicity of the model.

In determining the optimal lag structure for the ARDL model, an iterative procedure was employed to identify the lag combination that concurrently minimizes the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). This data-driven approach ensures a robust selection of lags, tailored to the underlying dynamics of the dataset. The exploration revealed that a single lag for the dependent variable is optimal based on both criteria.

However, the iterative process did not yield a conclusive lag length for the independent variable, as increasing the number of lags consistently lowered both AIC and BIC values. As the number of lags increased, a consistent decrease in both AIC and BIC was observed, prompting concerns over the risk of overfitting due to an excessive model complexity.

In response to this, attention was directed towards the empirical relationships within the dataset, as evidenced by the correlation matrix presented in Table 5 in the Annex. It was observed that the correlation between pre-tax diesel prices and changes in Brent crude oil prices became negligible after the sixth lag. This lack of correlation at lag six implies a limited association with the changes in diesel prices, suggesting that additional lags beyond this point would not significantly enhance explanatory power.

Consequently, a six-period lag has been adopted, based on its economic plausibility and its alignment with previous research, such as the study conducted by Silva et al. (2013). This lag length strikes a balance between capturing the relevant price dynamics and maintaining model parsimony, avoiding the pitfalls of overfitting.

4.3.3 Model Specification

Now that the best model is defined, the next step is to specify the model. Keep in mind that the following equation is a general model and will be applied to both Belgium and Germany.

$$Y_t = \alpha + \beta_i Y_{t-1} + \sum_{j=0}^{6} \gamma_j X_{t-j} + \sum_{j=0}^{6} \delta_j P_{t-j} + \sum_{j=0}^{6} \theta_j N_{t-j} + \epsilon_t \tag{1}$$

Where

- Y_t represents the change in pre-tax diesel price between the previous week $t-1$ and the week t,
- Y_{t-1} is the lagged dependent variable (to account for autoregression),

- X_{t-j} represents the change in brent crude oil price between the previous week $t-1$ and the current week t, lagged up to 6 periods back,
- P_{t-j} and N_{t-j} are dummy variables representing positive or negative changes in Brent crude oil prices, also lagged up to 6 periods.
- α, β, γ_j, δ_j and θ_j are the coefficients to be estimated,
- ϵ_t is the error term.

4.4 OLS Assumptions

4.4.1 Linearity

To assess the linearity assumption, residual plots for both models were examined. These plots 3 and 4 revealed that the residuals were randomly dispersed around the mean, indicating a linear relationship between the variables.

4.4.2 No Autocorrelation

The Durbin-Watson test was employed to investigate autocorrelation in both countries' models. The test results are shown in Table 6 in the Annex. Both Durbin-Watson statistics are close to 2, indicating no significant autocorrelation, and therefore, this assumption is satisfied.

4.4.3 Homoscedasticity

The assessment of homoscedasticity was conducted using the Breusch-Pagan test, for which the results can be found in the Annex in Table 8. Since the p-values for both countries are higher than the standard significance level of 0.05, the null hypothesis of homoskedasticity is not rejected. Thus, the assumption of homoscedasticity is upheld for both models.

4.4.4 Zero Conditional Mean

The absence of heteroscedasticity and the absence of patterns in the residual plots in Figure 3 and Figure 4 suggest that this assumption is met.

Additionally, a Ramsay RESET test was performed to check for model misspecification, for which the results can be found in Table 7 in the Annex. The low test statistics and high p-values (greater than 0.05) indicate no evidence of model misspecification, confirming the fulfillment of the Zero Conditional Mean assumption.

4.4.5 Normality of Errors

Given the large sample size (over 200 observations for both countries), the Central Limit Theorem applies, ensuring that the normality of errors assumption is met.

4.4.6 No Endogeneity

The analysis specifically utilizes pre-tax fuel price data. This methodological choice is made to eliminate the impact of potential tax changes over the period under study. By focusing on pre-tax figures, the analysis aims to remove a calculable element of retail fuel pricing, thereby sharpening the focus on capturing the relationship between Brent oil price changes and retail fuel price changes in the Belgian and German markets.

The distribution of gross margins and refinement costs, not being directly observed and presumed to be either constant or experiencing minimal changes, may represent a potential source of omitted variable bias. However, as highlighted in Section 3.3, the primary determinant of fuel prices is identified as the price of oil. Therefore, the regression analysis is expected to effectively demonstrate the relationship between oil prices and fuel prices, notwithstanding these potential omissions.

4.4.7 No Measurement Errors

In the collection and processing of data, meticulous methodology has been rigorously applied to minimize the possibility of measurement errors. Robust data quality checks and validation procedures were implemented to ensure the accuracy and reliability of the data used in this analysis. These measures contribute to the confidence that the assumption of no measurement errors is met (see Section 4.1 for details on data processing and quality assurance).

4.4.8 No Outliers

The period selected for analysis has been strategically chosen to align with phases of stability in the oil market. This approach aims to minimize the presence of extreme values, ensuring that the data more accurately reflects typical market behavior without significant disruptions.

Upon examining Figure 5, which can be found in the Annex, it is observed that for changes in Brent oil prices, unusual data points are noticeable in early 2015. In the case of Belgium, there are wider fluctuations. To mitigate the impact of extreme values, data points exceeding 65 or falling below -55 have been excluded. Similarly, for Germany, data points above 35 and below -35 have been omitted.

4.4.9 No Multicollinearity

Multicollinearity was assessed using a correlation matrix, presented in Table 5 in the Annex. While some multicollinearity is evident due to lagged variables and the influence of Brent variations on pre-tax figures in both countries, there is no perfect collinearity.

5 Empirical Results

5.1 Interpretation of the Results in Belgium

The regression results for Belgium, displayed in Table **??**, indicate that the previous week's pre-tax Diesel price change 'lag_change_belgium' anf 'change_brent_eur_lag1' are significant predictors of the current week's pre-tax diesel price changes, at the 5% level. Furthermore, 'positive_change_dummy', 'negative_change_dummy', 'change_brent_eur_lag4', 'positive_change_dummy_lag5' and 'negative_change_dummy_lag5' are also significant predictors at the 10% level.

Table 1: Regression on 'change_belgium' as dependent variable

change_belgium	coef	p-value
const	-0.0728	0.8297
change_brent_eur	0.3047	0.7406
lag_change_belgium	-0.3758	0.0000
positive_change_dummy	4.1362	0.0985
negative_change_dummy	-4.2090	0.0927
change_brent_eur_lag1	2.8629	0.0024
change_brent_eur_lag2	-0.1434	0.8802
change_brent_eur_lag3	1.5378	0.1020
change_brent_eur_lag4	-1.6129	0.0894
change_brent_eur_lag5	-0.1840	0.8447
change_brent_eur_lag6	0.2098	0.8168
positive_change_dummy_lag1	-2.7354	0.2712
positive_change_dummy_lag2	0.7486	0.7662
positive_change_dummy_lag3	-2.5515	0.3081
positive_change_dummy_lag4	2.8505	0.2565
positive_change_dummy_lag5	4.2607	0.0903
positive_change_dummy_lag6	-2.2129	0.3796
negative_change_dummy_lag1	2.6626	0.2842
negative_change_dummy_lag2	-0.8214	0.7436
negative_change_dummy_lag3	2.4787	0.3216
negative_change_dummy_lag4	-2.9233	0.2438
negative_change_dummy_lag5	-4.3335	0.0847
negative_change_dummy_lag6	2.1401	0.3954
R-squared	0.2526	

Note: This table displays the results of an ARDL regression, computed using the dataset described in section 4.1

5.1.1 Interpretation of Dummy Variables at Time t

The coefficients for the positive and negative change dummies indicate a rapid adjustment in the Belgian diesel market to fluctuations in Brent crude oil prices. Increases in oil prices result in an approximate €4.14 increase in diesel prices, while decreases lead to a reduction of about €4.21. This could indicate that fuel prices in Belgium react in the same way to increases than to decreases of Brent crude oil prices of the current week.

However, the 'change_brent_eur' coefficient's insignificance complicates the interpretation of these dummies. This insignificance suggests that the Brent price changes in week t do not significantly explain the variation in Belgium's pre-tax diesel price for the same week.

While lagged dummies aim to capture the delayed response of diesel prices to Brent price changes, the presence of consecutive periods of rising or falling Brent prices can still influence the immediate response dummies at time t. This influence might stem from the market's anticipation of ongoing trends, which is not captured by the lagged dummies. Therefore, decisions made at time t could be influenced by expectations of future trends, based on past trends. This is a factor that lagged dummies do not encompass and a plausible interpretation.

In examining the consecutive sequences of Brent price increases and decreases, the analysis uncovers distinct patterns: periods of consistent price drops or rises over several weeks. The data shows a range of consecutive increases from a minimum of one week to a maximum of 10 weeks, and for decreases, from one to 20 weeks. This pattern suggests that the insignificance of the 'change_brent_eur' coefficient at time t may imply that immediate changes in Brent prices do not significantly impact the current week's pre-tax diesel prices. This further reinforces the idea that the dummies at time t capture the expectations about future trends.

However, the significance of the dummies, contrasted with the insignificance of the continuous variable for Brent price changes at time t, might also indicate immediate market responses to Brent price changes within the same week. The lack of significance for 'change_brent_eur', while the dummies remain significant, could be attributed to the magnitude of the changes. It is possible that only changes in Brent prices at time t above or below a certain threshold have a noticeable impact on Belgian pre-tax diesel prices. The dummies, being discrete variables, might better capture the influence of significant magnitude changes in Brent prices on the pre-tax price of diesel, while the continuous variable 'change_brent_eur' might fail to capture this due to the variety of change magnitudes in the dataset, where larger changes could be averaged out. Therefore, the use of weekly data may not be precise enough to discern the responsiveness of prices that change every working day.

The significant dummy variables, in contrast to the non-significant continuous variable, make it challenging to determine if weekly Brent price changes influence variations within the same week. However, it is conceivable that both interpretations hold some truth. As detailed in section 3.2, the Programme Agreement sets the maximum price daily, reflecting the Rotterdam quotation. It is likely that the formula considers both the current Rotterdam quotation and past price trends to predict future prices, blending immediate market responses with longer-term trends.

5.1.2 Interpretation of the Lagged Dependent Variable

In examining the autoregressive nature of the regression, attention is drawn to the lagged variable that tracks the changes in pre-tax diesel prices from the previous week. This variable is highly significant at the 1% level, with a coefficient of -0.4010. The magnitude and significance of this coefficient imply that for each 1 euro increase in pre-tax diesel prices in the previous week, there is an associated decrease of 0.4010 euros in the following week. To contextualize these figures, consider a 100 euro increase per 1000 liters in week $t - 1$. This increase correlates to a decrease of 40.10 euros in week t, which, when broken down to a per-liter basis, translates to a decrease of approximately 4 cents per liter following a 10 cents per liter increase in the prior week. This represents a substantial change and suggests that the coefficient is not only statistically significant but also of economic significance.

Several factors could explain this observed relationship:
The Belgian pricing formula might incorporate previous price changes, leading to automatic adjustments in the subsequent week. For instance, an increase in prices could trigger a decrease in the following week as a measure to protect consumers from the volatility typically observed in fuel markets. This interpretation suits the fact that the Belgian formula is a price smoothing mechanism as discussed in details in section 3.1.2 and that these mechanisms are often made to protect consumers from market volatility.

The concept of mean reversion suggests that prices tend to return to a long-term average following substantial deviations (Xiong et al., 2001). After a notable increase in diesel prices, a subsequent decrease could be the market's way of re-aligning prices to their long-term mean.

Consumer behavior in response to price changes could also play a role. A higher price in week t-1 might lead to reduced consumption, leading to a supply adjustment that results in a price decrease in week t. To thoroughly understand this mechanism, conducting a demand elasticity analysis could provide deeper insights, which presents another avenue for future research.

5.1.3 Interpretation of lagged Brent price changes

The other significant variables identified in the analysis were 'change_brent_eur_lag1' at the 5% level and 'change_brent_eur_lag4', 'positive_change_dummy_lag5' and 'negative_change_ dummy_lag5' at the 10% level.

These findings not only emphasize Belgium's delayed response to changes in Brent crude oil prices but also indicate that the diesel price at time t is influenced by Brent price changes extending back to four weeks prior (time $t - 4$) if only the continuous variables are taken into account, and time ($t - 5$) if the dummy variables are also taken into account. This suggests a prolonged window of influence, where past Brent prices, up to a month earlier, continue to affect current diesel pricing decisions in Belgium.

In this scenario, the noticeable impact of the lagged dummies, contrasted with the lack of significance in 'change_brent_eur_lag5', aligns with previous interpretations. The variable 'change_brent_eur_lag5' may not adequately reflect the effects of substantial fluctuations. This is because it tends to average the magnitude of different changes over time, whereas the dummies merely indicate the direction of change. This pattern implies that the influence of past Brent oil prices on current diesel prices might be diminishing until being non significant.

5.1.4 Interpretation of the R-squared

An R^2 value of 0.2526 in the regression indicates that approximately 25% of the variance in the dependent variable is explained by the independent variables. This level of explanation can be attributed to the multifaceted nature of fuel markets, where various unobserved factors might play a role. These factors may include changes in gross margins, refinement costs, distribution expenses, and supply-demand shifts. Because of these potential unobserved variables and the use as a proxy for the Rotterdam market quotation, the model presents limitations, while not being completely ineffective. Its focus on pre-tax figures effectively isolates the impact of Brent oil price changes. While it does not capture every aspect influencing fuel prices, the model still provides valuable insights into the relationship between oil prices and fuel prices, making it a significant tool in understanding market dynamics.

5.2 Interpretation of the Results in Germany

In the study of diesel price variations in Germany, an ARDL regression is conducted, paralleling the analysis carried out for Belgium. This regression focuses on 'change_germany' as the dependent variable, representing the difference in pre-tax diesel prices in euros between two consecutive time points (t and $t-1$). The aim is to compare the findings of this regression with those obtained from the Belgian case.

Table 2: Merged Regression on 'change_germany' as dependent variable

'change_germany'	Coef (MLR)	p-value (MLR)	Coef (ARDL)	p-value (ARDL)
const	0.0453	0.9230	0.0463	0.7710
lag_change_germany	-	-	0.0709	0.2624
positive_change_dummy	1.5317	0.1874	1.5931	0.1751
negative_change_dummy	-1.4863	0.1998	-1.5468	0.1879
change_brent_eur	2.2546	0.0000	2.1902	0.0000
change_brent_eur_lag1	-	-	0.0504	0.9132
change_brent_eur_lag2	-	-	0.1883	0.6708
change_brent_eur_lag3	-	-	-0.3448	0.4368
change_brent_eur_lag4	-	-	0.1804	0.6852
change_brent_eur_lag5	-	-	0.4582	0.2990
change_brent_eur_lag6	-	-	-0.0061	0.9887
positive_change_dummy_lag1	-	-	-1.0932	0.3532
positive_change_dummy_lag2	-	-	-0.0952	0.9357
positive_change_dummy_lag3	-	-	0.6641	0.5741
positive_change_dummy_lag4	-	-	0.4390	0.7108
positive_change_dummy_lag5	-	-	0.1054	0.9288
positive_change_dummy_lag6	-	-	0.1496	0.8990
negative_change_dummy_lag1	-	-	1.1395	0.3334
negative_change_dummy_lag2	-	-	0.1415	0.9046
negative_change_dummy_lag3	-	-	-0.6178	0.6013
negative_change_dummy_lag4	-	-	-0.3928	0.7400
negative_change_dummy_lag5	-	-	-0.0591	0.9600
negative_change_dummy_lag6	-	-	-0.1033	0.9302
R-squared	0.3058	-	0.3312	-

Note: This table displays the results of a MLR and an ARDL regression, computed using the dataset described in section 4.1

The outcomes of the German regression are summarized in the last two rows of the provided table. A critical observation from these results is the statistical significance of the variable 'change_brent_eur'. This variable stands out as the only predictor with a high level of significance, specifically at the 1% level. Interestingly, all the lagged variables in this ARDL model do not exhibit statistical significance. This suggests that, while the ARDL model was effectively applied to the Belgian data, it does not efficiently explain the variations in Germany's diesel prices, and the inclusion of these lags adds unnecessary complexity.

Given the limitations of the ARDL model in the German context, a Multiple Linear Regression

(MLR) was also performed. In the MLR model, 'change_brent_eur' again emerges as the sole statistically significant predictor, indicating a direct and substantial impact of Brent crude oil price fluctuations on Germany's pre-tax diesel prices. This finding implies a strong and immediate responsiveness of the German fuel market to changes in oil prices. The lack of significance of the lagged variables in the ARDL model reinforces the conclusion that past changes in Brent prices do not significantly influence current diesel prices in Germany.

However, it is crucial to acknowledge the constraints of the data aggregation method used in this analysis. The data, aggregated on a weekly basis, may not fully capture the dynamic nature of fuel pricing in Germany, where changes can occur several times within a single day. Consequently, this aggregation could obscure the subtleties and immediate impacts of daily price fluctuations. This aspect might explain why the dummy variables, intended to reflect more detailed price movements, did not show significant results in the analysis. Such considerations highlight the importance of choosing an appropriate data aggregation level to accurately capture market dynamics in future studies.

Acknowledging the constraints of using weekly data aggregation in capturing daily price fluctuations in Germany's fuel market, the primary goal of this empirical analysis is to compare the fuel pricing dynamics between Belgium and Germany. While this approach may not reveal more subtle variation, it still achieves a sufficient level of detail to effectively compare the pricing patterns of the two countries.

5.3 Assessing Belgium's Responsiveness Versus Germany's Agile Model

The objective of this empirical analysis was to evaluate the reactivity of the Belgian fuel pricing mechanism to changes in Brent crude oil prices and to compare this with the German model. Considering Germany's market-based approach, with frequent adjustments in fuel prices throughout the day, a high level of responsiveness was expected in the German case. This analysis, therefore, provides an interesting contrast when comparing the Belgian mechanism against a reactive model.

As detailed in sections 5.1 and 5.2, the analysis reveals a stark contrast between the two countries. Although the initial purpose of the Belgian formula was to enhance adaptability to global market fluctuations, it appears that its alignment with this primary objective may not be as effective as intended in the current market context.

In conclusion, the analysis reveals a compelling contrast: Belgium, a high-income EU country, employs a fuel pricing formula pertaining to a category of mechanisms commonly seen in middle-income countries, whose objective is to shield consumers from market volatility, and the analysis through the ARDL model seems to go in this direction, since Belgium's formula displays adjustments spanning over multiple weeks. This is particularly evident when compared to the more agile approach of another high-income EU nation like Germany.

The lack of responsiveness in the Belgian model suggests that its pricing mechanism is not optimal, especially considering that for a country like Belgium, shielding from oil price volatility might not be as critical. A shift to a fully liberalized pricing mechanism could be more appropriate. This comparison not only underscores the feasibility of a more responsive system in countries similar to Belgium but also questions the continued relevance of Belgium's unaltered pricing mechanism in a dynamically evolving global oil market.

6 Recent Developments Analysis

This section explores the 2022 energy crisis, building on the previous section's empirical analysis of Belgium's fuel pricing formula and discussions from section 3.6 about recent geopolitical events affecting EU fuel markets. It aims to examine the crisis's impact and assess the formula's effectiveness during such periods of market instability. This exploration will offer further insights, enriching the answer to the research question with specific details and context.

6.1 Data

The data sources used in this section are consistent with those employed in the initial dataset. The primary sources include the European Commission's Weekly Oil Bulletin for fuel prices, and FRED for Brent crude oil prices, once again, used as a proxy for the Rotterdam oil market quotations. The key difference in this section lies in the timeframe of the data, which spans from 2022 to 2023. Additionally, the data encompasses not only Belgium and Germany but also extends to include the Netherlands and Luxembourg. This broader comparison facilitates an analysis of the tax reduction strategies implemented to mitigate the impact on household purchasing power during the crisis.

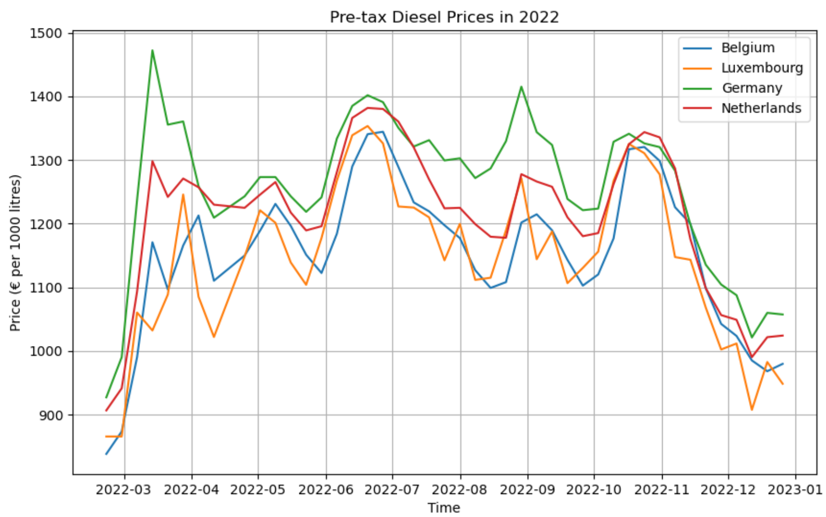
6.2 Descriptive Statistics

6.2.1 Correlation Matrix

Analyzing the correlation matrix in Table 12, strong positive correlation among diesel prices in Belgium, Luxembourg, the Netherlands, and Germany is observed, reflecting the similar economic influence, within the European Union. Luxembourg and the Netherlands display notable correlations with Brent crude oil prices, although to a slightly lesser degree than Germany. This suggests their market pricing is somewhat influenced by global oil prices, albeit less directly than Germany's more liberalized system. Belgium's notably lower correlation with Brent crude underscores the unique impact of its pricing formula, acting as a mitigating factor against rapid market fluctuations.

6.2.2 Line-chart and Variance

Figure 2: Pre-tax Diesel Prices in 2022



<u>Note</u>: Graph based on own computations using data from the European Commission's Weekly Oil Bulletin.

Figure 2 visually charts the pre-tax diesel prices across Belgium, Germany, Luxembourg, and the Netherlands throughout 2022. The x-axis represents time, from February 21st, 2022, to December 31st, 2022, while the y-axis showcases the cost per 1000 liters in euro. Each line delineates the fluctuation in pre-tax diesel prices for the respective countries over this period.

All countries experience similar price fluctuations, driven by crude oil price changes throughout the year. However, the extent of these fluctuations and the absolute price levels vary. The graph reveals a significant spike in prices between the 2nd and 3rd weeks, reflecting the market's reaction to the war's impact on crude oil.

During the specific period between the second and third weeks on Figure 2, which captures the immediate impact of the Ukraine war, the percentage variation in pre-tax diesel prices for each country was as follows:

Table 3: pre-tax diesel price variance

Country	Percentage Variation (%)
Belgium	13.37%
Netherlands	16.16%
Luxembourg	22.52%
Germany	24.95%

Note: This table displays the results of percentage variation calculations, based on the dataset described in section 6.1.

This spike in prices, triggered by the onset of the war in Ukraine, reveals Belgium's relatively low percentage variation of 13.37%, which is significantly less than Germany's 24.95%. This difference suggests that Belgium's pricing formula may have contributed to mitigating the immediate impact of the crisis, in contrast to Germany's more volatile response. Luxembourg and the Netherlands exhibit intermediate levels of variation, indicating varying degrees of responsiveness to the crisis.

In comparing Belgium's fuel pricing response to that of other countries, the first significant spike in diesel prices and Belgium's comparatively low percentage variation stand out. This slower responsiveness, a characteristic of Belgium's pricing formula, came at a cost for sellers, as some of them were compelled to sell at a loss during this period. If the pricing mechanism had been more agile and responsive to the high volatility, it would have adjusted to the immediate changes in crude oil prices more effectively. Such a reactive mechanism would have prevented the issue of sellers incurring losses. This situation underscores that the slower responsiveness of the Belgian pricing formula is an ongoing problem, similar to the challenges faced with the previous mechanism used before the first oil crisis in the 1970s.

When examining the variance in diesel prices over the entire year of 2022, the scenario shifts:

Country	Variance
Netherlands	27.81
Belgium	32.79
Germany	38.60
Luxembourg	53.35

Note: This table presents the variance computation results, utilizing the dataset outlined in section 6.1.

In this year-long view, Luxembourg shows the highest variance (53.35), indicating greater overall price instability, while the Netherlands records the least (27.81). Belgium, with a variance of

32.79, remains among the lower fluctuation countries, suggesting that its pricing formula may have provided a more stable market environment. Germany's higher variance of 38.60 aligns with its greater percentage variation, reflecting a market more sensitive to crude oil price variations.

The analysis indicates that the less reactive nature of Belgium's fuel pricing mechanism to immediate market shifts may have contributed to greater price stability during the energy crisis. A key principle of such mechanisms, as outlined in the guidelines on price smoothing by Coady et al. (2012), is that governments are expected to shoulder the financial burden associated with mitigating price volatility, ensuring that suppliers are not disadvantaged compared to a fully liberalized approach. However, in the context of this crisis, it remains somewhat ambiguous whether the Belgian government effectively managed the financial consequences associated with this pricing formula.

6.3 Comparison of pre-tax Diesel Prices in 2022

Table 11 in the Annex represents pre-tax diesel prices across Belgium, Luxembourg, the Netherlands, and Germany during 2022, which provides valuable insights into the pricing dynamics in these countries. The pre-tax diesel price forms the foundation of the total retail price. Since taxes are typically fixed charges per volume, fluctuations in the pre-tax price significantly influence the final retail price. Understanding these price movements is crucial for policy interventions or tax adjustments aimed at managing the consumer impact of fuel price changes.

Comparison of Average Prices:
Germany and the Netherlands consistently exhibit the highest average pre-tax diesel prices throughout the year, with Germany leading at €1257.75 and the Netherlands at €1211.15. Luxembourg and Belgium follow closely, with average prices of €1144.36 and €1152.66, respectively. This ranking indicates that Germany and the Netherlands have a higher base cost for diesel, which could be due to various market factors, including supply chain dynamics, demand patterns, and underlying costs.

Pre-War Price Analysis:
Just before the outbreak of the war, each country recorded its lowest diesel prices for the year. Belgium had the lowest pre-war price at €838.13, followed by Luxembourg, the Netherlands, and Germany. This suggests that the onset of the war significantly influenced diesel prices, leading to a noticeable increase from these baseline figures.

End-of-Year Prices:
By the end of 2022, although prices began to stabilize, they did not return to pre-war levels. The lowest prices recorded in December 2022 for each country were still notably higher than

their respective pre-war prices. Belgium maintained the lowest price at €968.06, while Germany had the highest at €1021.20. This indicates a lasting impact of the year's events on diesel prices, with no full reversion to the pre-crisis pricing situation.

Implications:
The data suggests that while all countries experienced increased diesel prices due to the crisis, the extent of the increase and the ability to return to pre-war levels varied. Belgium's pricing mechanism, which appears to have moderated the spike in prices during the crisis, also shows a relatively lower increase from pre-war to end-of-year prices compared to Germany. This could imply a more effective buffering against extreme market fluctuations, possibly due to Belgium's specific regulatory approach to fuel pricing. In summary, the absolute pre-tax diesel prices in these countries not only reflect the direct impact of the 2022 energy crisis but also highlight the differences in how each country's pricing mechanisms responded to these external shocks.

6.4 Tax Interventions Timeframes

The comparative analysis of excise duty reductions across Belgium, the Netherlands, Germany, and Luxembourg, as outlined in Table 10 in the Annex, highlights the different strategic approaches each country has adopted in response to the energy crisis. These varied strategies seem not only driven by economic needs but also significantly shaped by each nation's political and cultural context.

Belgium and the Netherlands opted for a prolonged intervention, extending throughout the majority of 2022. This extended approach suggests a preference for a more stable and predictable market environment, reflecting a political culture that prioritizes long-term consumer protection and market stability (Crédit Agricole Group, 2022), (Gompel, 2021). In contrast, Luxembourg and Germany implemented shorter-term interventions but reduced excise duties closer to the EU's legal minimum of 33 cents per liter (European Commission, 2024). This strategy indicates a different set of priorities, tilting towards immediate economic relief over extended interventions, with a focus on balancing the goals of economic stimulus and maintaining public debt sustainability. (Pearce, 2022).

When considering the average income levels in these countries, which are relatively similar with Belgium being on the higher end, it becomes even more evident that the differing approaches to fuel pricing interventions are less about economic capacity and more about the underlying political and cultural frameworks guiding economic policy. These distinctions in economic policy choices are clearly reflected in the excise duty rates of these countries, displayed in the second row of Table 10 in the Annex, which shows each country's standard excise duty rate before any adjustments driven by the energy crisis are applied.

This analysis directly contributes to answering the research question by highlighting that the suitability and effectiveness of Belgium's pricing formula during the crisis cannot be assessed in isolation. Undeniably, as stated by Whitehead (2022) and confirmed by the empirical analysis in section 5, the lack of responsiveness has put sellers in difficult positions. Nevertheless, it must be understood within the broader context of political influences that drive economic policy. The comparison with neighboring countries, which faced similar economic conditions but chose different levels of interventions underscores the complexity of policy-making and the intricate nature of economic interventions.

Moreover, the initial criticism of Belgium's pricing mechanism for its poor responsiveness, along with calls for a fully liberalized system, warrants careful consideration. The Programme Agreement, which cannot be terminated without a 12-month notice, has been instrumental in reducing volatility for consumers. Even if it had been possible to remove the maximum price cap at the crisis's onset, significant social unrest might have followed. This is supported by Drabo et al. (2023), which found a positive correlation between fuel price changes and social unrest, particularly anti-government demonstrations, with an amplified effect during economic downturns. Therefore, eliminating the price cap abruptly during the crisis could have had adverse consequences.

Additionally, Drabo et al. (2023) sheds light on the potential challenges and public perception issues related to transitioning to a fully liberalized pricing system. Given the complexities revealed, it appears politically prudent to maintain the current pricing approach, even in more stable periods. This insight suggests a strategic balancing act between market liberalization and maintaining political stability and consumer confidence.

6.5 Conclusion of the Recent Developments Analysis

The analysis of Belgium's fuel pricing during the 2022 energy crisis reveals its potential effectiveness in shielding consumers from market shocks. The correlation data as well as the previous empirical analysis in section 5 both suggest that Belgium's response to crude oil price changes is less immediate compared to neighboring countries, implying a stabilizing effect of its pricing formula. This is further supported by the lower variance in the year, and lower spike in prices during the critical early weeks of the crisis, indicating a moderated response to market upheaval. This suggests that the empirical analysis performed on another time frame still holds relevance here.

The Belgian fuel pricing formula, indeed offered some level of price smoothing for consumers during the 2022 crisis. This effect, however, was limited and not entirely effective in fully shielding consumers from the shock. While it provided a degree of stability, the formula also significantly hindered market responsiveness. This lack of flexibility placed fuel sellers in a difficult position, often obliging them to sell at a loss. The slow response to rapidly changing market conditions, particularly evident in the first spike in diesel prices, underscores the formula's limitations. This analysis suggests that while the Belgian formula had the potential to moderate market volatility, its effectiveness was compromised by its inherent rigidity, which ultimately outweighed its benefits. The dual impact on both consumers and sellers indicates that the formula's design needs reassessment to better balance market responsiveness with consumer protection, especially in times of crisis.

7 Conclusion

This thesis aimed to evaluate the appropriateness of the Belgian formula for maximum fuel prices. Such pricing mechanism, traditionally implemented in middle-income countries to mitigate market volatility, may not be the most suitable for a high-income nation like Belgium. The empirical analysis conducted in this study highlights that this pricing strategy has a dampening effect on market responsiveness, which can lead to negative implications for market dynamics. These protective measures may impede progress towards sustainable energy solutions and impose financial burdens on both fuel retailers and the government.

Moreover, the prolonged application of this policy in Belgium, which has lasted nearly half a century, contradicts current economic recommendations, suggesting price smoothing mechanisms as transitional measures towards more liberalized pricing mechanisms. This could suggest that the formula's continuation may be influenced more by political considerations than economic efficiency. The findings indicate that for a high-income country like Belgium, a fully liberalized pricing model might be more appropriate. The recent crisis, triggered by the Russian conflict, has exposed severe shortcomings in the formula's design. Its lack of responsiveness has not only negatively impacted sellers' profits but also failed to offer adequate consumer protection, necessitating government interventions such as the reduction of excise duties, further increasing the costs for the government.

This thesis also acknowledges certain limitations in its analysis. The primary constraint is the nature of the available data. The analysis relies on weekly data, whereas Belgian fuel prices are adjusted daily. This limitation restricts a more detailed examination of daily price responsiveness. Additionally, while comparing Belgium's regulated market with Germany's liberalized market yields valuable insights, it is challenging to attribute the observed differences exclusively to the Belgian pricing formula. Factors such as regular market fluctuations may also play a significant role. In particular, the significant coefficient for 'change_belgium_lag' observed in the study could be indicative of normal market movements rather than being solely a result of the Belgian formula. A more in-depth study of fuel demand elasticity in Belgium is recommended for a clearer understanding of these market behaviors.

In conclusion, while this thesis provides an in-depth analysis of Belgium's current fuel pricing formula, it also highlights the need for further research in several areas. These include exploring the transition to a fully liberalized market and conducting a more granular analysis of market dynamics using more detailed data, as well as using the Rotterdam oil market quotations instead of the Brent crude oil proxy. The findings point towards the potential benefits of adopting a liberalized pricing model for Belgium, aligning with its economic status and environmental goals.

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A Tables and Figures

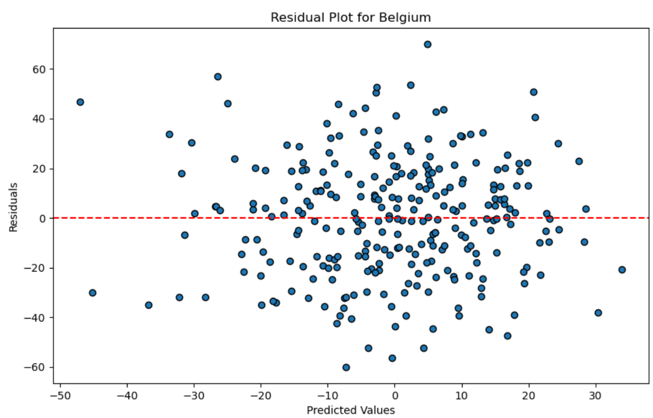
A.1 Methodology

Table 4: ADF Test Results

Variable	ADF Statistic	p-value
Belgian Prices	-24.1792	0.0000
German Prices	-10.2592	4.2805e-18
Brent Prices	-11.1122	3.6359e-20

Note: This table presents the results of an Augmented Dickey-Fuller (ADF) test for stationarity, computed using the data presented in section 4.1

Figure 3: Residual plot for the regression on 'change_belgium'



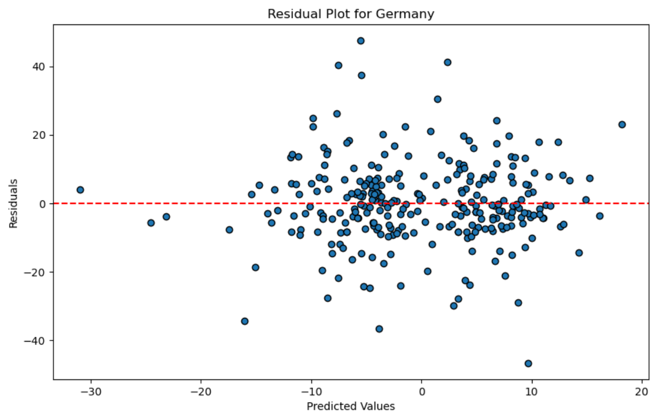
Note: This figure depicts the residual plot from the ARDL regression analysis for Belgium, based on the data detailed in section 4.1.

Table 5: Correlation matrix

	brent_eur	belgium	germany	brent_lag1	brent_lag2	brent_lag3	brent_lag4	brent_lag5	brent_lag6
brent_eur	1.000000	0.230444	0.556039	0.398554	0.151200	0.079399	0.050033	0.032955	0.047652
belgium	0.230444	1.000000	0.237149	0.253099	0.081861	0.053230	-0.038623	0.039518	-0.012880
germany	0.556039	0.237149	1.000000	0.233730	0.123867	0.088033	0.094999	0.102647	0.078725
brent_lag1	0.398554	0.253099	0.233730	1.000000	0.402538	0.150439	0.076950	0.044747	0.033942
brent_lag2	0.151200	0.081861	0.123867	0.402538	1.000000	0.407132	0.156497	0.078837	0.053228
brent_lag3	0.079399	0.053230	0.088033	0.150439	0.407132	1.000000	0.403359	0.150096	0.074342
brent_lag4	0.050033	-0.038623	0.094999	0.076950	0.156497	0.403359	1.000000	0.396323	0.141704
brent_lag5	0.032955	0.039518	0.102647	0.044747	0.078837	0.150096	0.396323	1.000000	0.386418
brent_lag6	0.047652	-0.012880	0.078725	0.033942	0.053228	0.074342	0.141704	0.386418	1.000000

Note: This correlation matrix is computed based on data described in section 4.1.

Figure 4: Residual plot for the regression on 'change_germany'



Note: This figure depicts the residual plot from the ARDL regression analysis for Germany, based on the data detailed in section 4.1.

Table 6: Durbin-Watson Test Results for Autocorrelation

Country	Durbin-Watson Statistic	Interpretation
Belgium	2.1441	Slight Negative Autocorrelation
Germany	1.9564	Slight Positive Autocorrelation

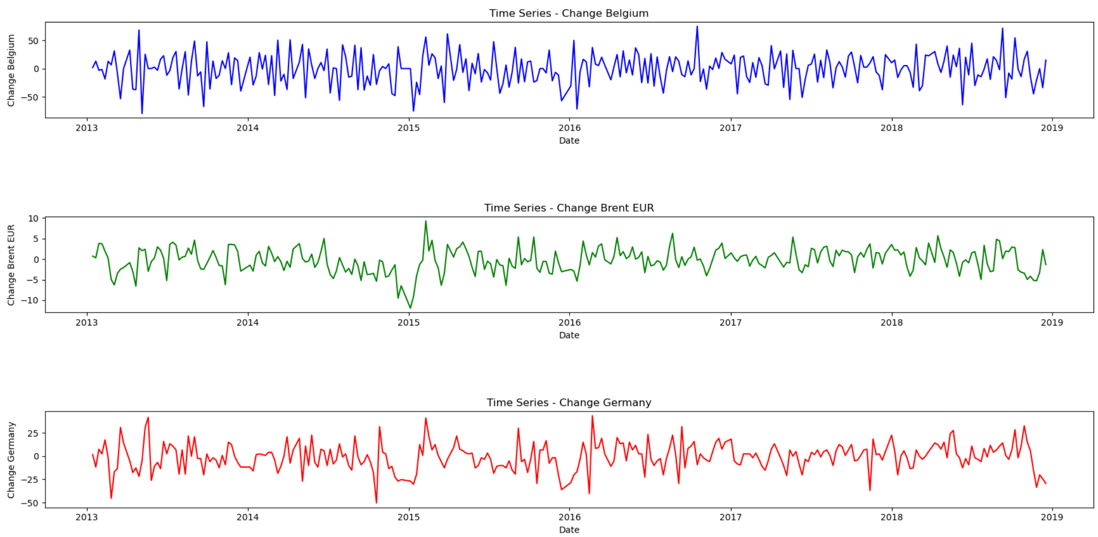
Note: This table displays the results of a Durbin-Watson Test for autocorrelation, computed using the data in section 4.1.

Table 7: Ramsay RESET Test Results

Country	RESET Test Statistic	P-value
Belgium	0.6784	0.5083
Germany	0.4454	0.6410

Note: This table displays the results of a Ramsay RESET test, aimed at assessing misspecification, for which the computations are based on the data described in section 4.1.

Figure 5: Time series visualisation



Note: This figure represents the three time series utilized in the empirical analysis, and has been created using the data in section 4.1.

Table 8: Breusch-Pagan Test Results for Homoscedasticity

Country	Breusch-Pagan Test Statistic	p-value
Belgium	11.8658	0.2941
Germany	16.5927	0.0839

Note: This table displays the results of a Breusch-Pagan test for homoscedasticity, for which the computations are based on the data described in section 4.1.

A.2 Recent Developments Analysis

Table 9: percentage variation from week to week

	Belgium	Germany	Luxemburg	Netherlands
2022-02-21 to 2022-02-28	4.21	6.80	0.00	3.83
2022-02-28 to 2022-03-07	13.37	24.95	22.52	16.16
2022-03-07 to 2022-03-14	18.25	19.02	-2.66	18.75
2022-03-14 to 2022-03-21	-6.33	-7.93	5.47	-4.33
2022-03-21 to 2022-03-28	6.30	0.37	14.45	2.33
2022-03-28 to 2022-04-04	4.04	-7.47	-12.90	-1.09
2022-04-04 to 2022-04-11	-8.45	-3.94	-5.83	-2.17
2022-04-11 to 2022-04-25	3.57	2.78	12.38	-0.40
2022-04-25 to 2022-05-02	3.39	2.43	6.33	1.69
2022-05-02 to 2022-05-09	3.55	0.00	-1.61	1.59
2022-05-09 to 2022-05-16	-2.81	-2.38	-5.19	-3.79
2022-05-16 to 2022-05-23	-3.79	-1.96	-3.08	-2.31
2022-05-23 to 2022-05-30	-2.49	1.86	6.66	0.56
2022-05-30 to 2022-06-06	5.51	7.45	7.69	7.12
2022-06-06 to 2022-06-13	8.92	3.84	5.59	6.64
2022-06-13 to 2022-06-20	3.93	1.21	1.09	1.15
2022-06-20 to 2022-06-27	0.28	-0.78	-2.02	-0.12
2022-06-27 to 2022-07-04	-4.11	-2.90	-7.48	-1.44
2022-07-04 to 2022-07-11	-4.32	-2.18	-0.14	-2.98
2022-07-11 to 2022-07-18	-1.14	0.76	-1.26	-3.82
2022-07-18 to 2022-07-25	-1.79	-2.40	-5.58	-3.58
2022-07-25 to 2022-08-01	-1.68	0.26	5.01	0.07
2022-08-01 to 2022-08-08	-4.29	-2.39	-7.34	-2.09
2022-08-08 to 2022-08-15	-2.47	1.19	0.31	-1.65
2022-08-15 to 2022-08-22	0.83	3.33	6.67	-0.14
2022-08-22 to 2022-08-29	8.45	6.45	6.90	8.49
2022-08-29 to 2022-09-05	1.08	-5.05	-10.02	-0.91
2022-09-05 to 2022-09-12	-2.07	-1.50	3.81	-0.65
2022-09-12 to 2022-09-19	-3.91	-6.41	-6.84	-3.81
2022-09-19 to 2022-09-26	-3.54	-1.42	2.16	-2.46
2022-09-26 to 2022-10-03	1.59	0.21	2.27	0.42
2022-10-03 to 2022-10-10	5.05	8.58	9.61	6.48
2022-10-10 to 2022-10-17	11.91	0.95	4.59	4.98
2022-10-17 to 2022-10-24	0.28	-1.13	-1.10	1.43
2022-10-24 to 2022-10-31	-1.66	-0.44	-2.54	-0.61
2022-10-31 to 2022-11-07	-5.61	-2.80	-10.17	-3.65
2022-11-07 to 2022-11-14	-2.12	-6.61	-0.37	-8.67
2022-11-14 to 2022-11-21	-8.46	-5.26	-6.58	-6.54
2022-11-21 to 2022-11-28	-5.09	-2.74	-6.16	-3.84
2022-11-28 to 2022-12-05	-1.82	-1.52	0.94	-0.70
2022-12-05 to 2022-12-12	-3.76	-6.10	-10.31	-5.59
2022-12-12 to 2022-12-19	-1.72	3.78	8.29	3.17
2022-12-19 to 2022-12-26	1.20	-0.24	-3.48	0.24

Note: This table displays the percentage variation from week to week, computed on the data described in 6.1.

Table 11: Comparison of Diesel Prices in 2022

Country	**Average Price (€)**	**Pre-war Price (€)**	**Lowest Dec 2022 Price (€)**
Belgium	€1152.66	€838.13	€968.06
Luxembourg	€1144.36	€865.51	€982.61
Netherlands	€1211.15	€906.52	€990.24
Germany	€1257.75	€927.08	€1021.20

Source: own computations based on data described in section 6.1.

Table 12: Correlation matrix

	belgium	luxembourg	germany	netherlands	brent_eur
belgium	1.0000	0.8965	0.8288	0.9552	0.5960
luxembourg	0.8965	1.0000	0.8223	0.8900	0.6364
germany	0.8288	0.8223	1.0000	0.9233	0.7195
netherlands	0.9552	0.8900	0.9233	1.0000	0.6958
brent_1000liters	0.5960	0.6364	0.7195	0.6958	1.0000

Note: This correlation matrix is computed based on data described in section 6.1.

Table 10: Comparison of Excise Duty Reductions and Average Income in Response to the Energy Crisis (Diesel)

Country	**Intervention Timeframe**	**Total Excise Duty (€/L)**	**Reduction Excise Duties (€/L)**	**Average Income 2022 (€)**
Belgium	March 19, 2022 - December 31, 2022	0.6	0.175	61,586.15
Netherlands	April 1, 2022 - December 31, 2022	0.52	0.111	60,044.78
Germany	June 1, 2022 - September 1, 2022	0.49	0.1404	55,975.32
Luxembourg	April 13, 2022 - July 31, 2022	0.41	0.075	74,371.01

Source: own computations based on database described in 4.1

Abstract

This thesis critically analyzes whether Belgium's current formula for maximum fuel prices is suitable in a high-income country context or if a transition to a fully liberalized approach is needed. The study compares Belgian fuel prices with Germany's market-driven prices, focusing on responsiveness to crude oil price fluctuations. Additionally, it investigates the impact of the 2022 energy crisis on the Belgian formula, considering governmental interventions and comparing them with selected EU countries. The thesis aims to provide empirical evidence to evaluate the appropriateness of Belgium's fuel pricing strategy.