Torun International Studies

2025, Vol 1, No. 22, pp. 60-79

Published online December, 2025

DOI: http://dx.doi.org/10.12775/TIS.2025.011

Bartosz Totleben*

0000-0003-3187-2285

ASYMMETRIC RESPONSE OF RETAIL DIESEL AND GASOLINE PRICES TO CHANGES IN WHOLESALE AND MARKET PRICES IN POLAND IN 2007–2024

ABSTRACT:

Purpose: The aim of this article is to examine whether there were asymmetric price transmissions between the market prices of crude oil and wholesale prices, as well as between wholesale and retail fuel prices in Poland between 2007 and 2024.

Methodology/approach: Cointegration analysis was conducted to determine the presence of a stable, long-term relationship between market, wholesale, and retail prices of liquid fuels (diesel and gasoline) in Poland. Additionally, asymmetric error correction models were estimated to assess whether retail and wholesale prices respond differently to increases and decreases in wholesale and market prices.

Findings: The analysis confirms the presence of asymmetric price transmission from wholesale to retail fuel prices in Poland. Retail prices exhibit a stronger response to wholesale price increases than to decreases. Specifically, retail diesel

* Poznan University of Economics and Business, Poland,
barosz.totleben@ue.poznan.pl

prices rise 2.91 times more when wholesale prices increase than they fall when wholesale prices decline, while for gasoline, this effect is even stronger (4.42 times). Notably, no asymmetry is observed in the transmission from crude oil to wholesale prices. These findings suggest that price rigidity in the retail market contributes to slower price reductions, potentially due to market power or demand inelasticity.
Originality/value: This study contributes to the literature by providing new insights into asymmetric price transmission in Poland's liquid fuels market, which is characterized by a dominant state-owned enterprise and strong political influences. By analysing an extended time series (2007–2024), it confirms the presence of asymmetry in retail price adjustments to wholesale price changes while finding no such effect between market and wholesale prices, refining prior mixed evidence.

Keywords*: Asymmetric price transmission, Wholesale and retail prices, Rocket and feather effect, Fuel pricing dynamics, Cointegration analysis, Error correction model*

1. INTRODUCTION

In recent years, the economies of many countries have faced multiple macroeconomic shocks of various origins, such as the 2007–2008 financial crisis, the 2020–2021 recession caused by COVID-19-related restrictions, and the outbreak of war in Ukraine in 2022. These events have affected all markets, including commodity markets. One of the key commodities in the global economy—despite increasingly ambitious commitments to transition from fossil fuels to renewable energy sources—is crude oil. This is a strategically important resource, the valuation of which is strongly influenced by various factors, such as supply and demand, the exchange rate of the U.S. dollar, decisions (as well as announcements and statements) made by oil-producing countries, and the level of economic uncertainty. Crude oil is refined into liquid fuels, including diesel and gasoline.

The price of crude oil is highly volatile, fluctuating significantly not only due to macroeconomic conditions but also geopolitical factors. These price changes also affect the wholesale and retail markets for liquid fuels. However, existing analyses do not provide a clear answer regarding the extent of this impact, although most studies offer evidence of asymmetric price transmission. The presence of this mechanism implies that the price response of a given product varies depending on changes in costs. In the case of liquid fuels, this means that the magnitude of wholesale price changes differs depending on whether the market price is rising or falling. Similarly, retail prices adjust with varying intensity and delays in response to changes in wholesale prices.

The aim of this article is to examine whether such asymmetric reactions occurred between market and wholesale prices, as well as between wholesale and retail prices in Poland from 2007 to 2024. The secondary data used in the study include retail prices of diesel and gasoline, wholesale prices of these fuels published by PKN Orlen, and the market price of Brent crude oil. Based on the literature, the following hypotheses have been tested:

- H1: The time series of retail and wholesale fuel prices in Poland, as well as market crude oil prices, are cointegrated.
- H2: Retail fuel prices in Poland respond asymmetrically to increases and decreases in their wholesale prices.
- H3: Wholesale fuel prices in Poland respond asymmetrically to increases and decreases in market crude oil prices.

The structure of the article is as follows. The second section presents a literature review on the determinants of market, wholesale, and retail fuel prices, as well as the conditions of asymmetric price transmission. The third section describes the research methodology and the data used in the quantitative analysis. The fourth section discusses the results and findings. Finally, the conclusion summarizes the study and suggests directions for future research.

2. DETERMINANTS OF WHOLESALE AND RETAIL FUEL PRICES – LITERATURE REVIEW

Crude oil, from which both diesel fuel and gasoline are produced, is the most consumed energy source globally. Approximately 31% of the world's energy consumption comes from crude oil, followed by coal at 26.6% and natural gas at 23.8%. It is important to emphasize that crude oil plays a crucial role in transportation, making it a key commodity for nearly all countries worldwide. However, its supply is not evenly distributed across the globe. In 2023, four countries accounted for nearly half (49.3%) of the annual crude oil production: the United States (20.1%), Saudi Arabia (11.8%), Russia (11.5%), and Canada (5.9%) (Energy Institute, 2024).

Crude oil is not a commodity whose price depends solely on supply and demand dynamics in competitive markets. Since the end of World War II, and particularly since the oil crises of the 1970s (Barsky & Kilian, 2004), crude oil has been used as an instrument in the geopolitical struggle for global dominance (Colgan, 2013; Painter, 2014), as a means of coercion in trade wars (Cai et al., 2022), and as a tool for exerting pressure on specific countries, such as those violating human rights or breaching international agreements (Gutmann et al., 2018). As a result, identifying the determinants of crude oil prices—and subsequently, wholesale and retail fuel prices—is a complex task.

The market price of crude oil is influenced by multiple factors simultaneously (Salem et al., 2022). One key determinant is the value of the U.S.

dollar (Wang et al., 2024); Fratzcher et al. (2014) found that a 1% depreciation of the USD leads, on average, to a 0.73% increase in oil prices. Another crucial factor is the strategy and communication of the Organization of the Petroleum Exporting Countries (OPEC) (Loutia et al., 2016). The mere occurrence of OPEC meetings significantly increases uncertainty and price volatility for up to 9–10 days following the meeting (Pescatori & Nazer, 2022), while decisions made during these meetings raised oil prices by an average of 6% between 2017 and 2020 (Quint & Venditti, 2020).

Additionally, oil prices are affected by economic uncertainty (van Robas, 2012; Feng et al., 2020) and political instability (Karkowska & Urjasz, 2024). Furthermore, crude oil prices are strongly influenced by speculation and the derivatives market (Robe & Wallen, 2016), as well as gold prices (Huseynli, 2023). Regardless of the specific cause(s) of fluctuations in market oil prices, it can be expected that wholesale diesel and gasoline prices will follow a similar trend (Bumpass et al., 2015), which formally implies that the time series of these variables are cointegrated.

Retail fuel prices are primarily determined by the level of wholesale prices. For example, Borenstein & Shepard (1996) demonstrated that wholesale prices explain most of the variability in retail prices. Additionally, retail prices are influenced by market structure and the margin of sellers. Furthermore, these prices are also affected by the country's tax policy (Bor & Ismihan, 2013) and environmental policy (Davis, 2021; Carballo & Sisco, 2024). However, these factors change very slowly, so their explanatory power in modelling price changes is limited.

All of this leads to significant volatility in retail prices. However, the speed and magnitude of these changes are not always symmetric. Retail fuel prices sometimes respond more quickly and more strongly when wholesale/market prices increase, compared to the decreases in prices when wholesale/market prices fall (Zlatcu et al., 2015; Qin et al. 2016; Martín-Moreno et al., 2019; Bakhat et al., 2022; Raeder et al., 2022; Zhang et al., 2023), although this can occasionally occur at earlier stages in the production and supply chain (Schweikert, 2019). This phenomenon is referred to as asymmetric price transmission, or the "rocket and feather effect".

The study of the liquid fuels market in Poland is interesting for at least several reasons. First, Poland is a rapidly growing economy with increasing demand for crude oil. However, according to data from the Polish Geological Institute (n.d.), it produces only a small portion (around 5%) of the oil it needs. Second, this market is heavily influenced by decisions made by a single state-owned enterprise: ORLEN, which is responsible for most of the wholesale sales of diesel and gasoline and is also the largest retailer of these fuels (according to data from the Polish Organization of the Oil Industry and Trade (2024), ORLEN stations account for over 24% of all fuel stations in Poland). This means that, at least potentially (Totleben et al., 2019), prices could be influenced by political decisions. Third, existing studies do not conclusively confirm asymmetric changes in retail prices in response to changes in wholesale prices. Laszkiewicz-Kędzior & Welfe (2014) and Złoty (2023) demonstrated the presence of asymmetric price transmission from wholesale to retail prices for both gasoline and diesel. Surprisingly, Socha (2014) showed the existence of this asymmetry for diesel (and LPG), but not for gasoline. Furthermore, Laszkiewicz-Kędzior (2014) found no asymmetry in the changes in market and wholesale prices.

The conducted study helps fill this research gap, particularly due to the application of advanced quantitative methods, as well as the use of a long time series and the latest data.

The literature review showed that both theoretical and empirical research suggests the existence of relationships between retail, wholesale, and market prices of liquid fuels. Moreover, some authors indicate that this relationship is not symmetric, and retail markets react to changes in wholesale prices with different delays, depending on the direction of these changes. For this reason, an empirical verification of the following hypotheses was proposed:

- H1: The time series of retail and wholesale fuel prices in Poland, as well as the market prices of crude oil, are cointegrated.
  - H1a: Retail prices of liquid fuels (diesel and gasoline) are cointegrated with their wholesale prices.
  - H1b: Wholesale prices of liquid fuels (diesel and gasoline) are cointegrated with market prices of crude oil.
- H2: Retail prices of liquid fuels in Poland change asymmetrically in response to increases and decreases in their wholesale prices.
  - H2a: Retail prices of diesel fuel in Poland increase faster when the wholesale price of diesel fuel rises, and decrease more slowly when the wholesale price falls.
  - H2b: Retail prices of gasoline in Poland increase faster when the wholesale price of gasoline rises, and decrease more slowly when the wholesale price falls.
- H3: Wholesale prices of liquid fuels in Poland change asymmetrically in response to increases and decreases in market prices of crude oil.
  - H3a: Wholesale prices of diesel fuel in Poland increase faster when the market price of crude oil rises, and decrease more slowly when the price of crude oil falls.
  - H3b: Wholesale prices of gasoline in Poland increase faster when the market price of crude oil rises, and decrease more slowly when the price of crude oil falls.

3. DATA AND METHODOLOGY

The cointegration analysis and potential asymmetric response of retail fuel prices to changes in wholesale and market prices were conducted using secondary data. The time series of retail fuel prices (diesel fuel (ON) and gasoline (PB95)) in Poland includes averaged and weighted data from 250 representative fuel stations, spaced at least 5 km apart, with a weekly interval. The time period spans from May 2007 to December 2024.

Data on wholesale fuel prices, due to the dominant market position of PKN ORLEN, were obtained from PKN ORLEN (daily data aggregated to weekly averages, in PLN per liter). Market prices for fuel include daily data (also aggregated to weekly averages) on Brent crude oil, converted into PLN per liter according to the exchange rate provided by the National Bank of Poland. Table 1 presents selected descriptive statistics.

Table 1.
Descriptive statistics of retail, wholesale, and market prices (in PLN)

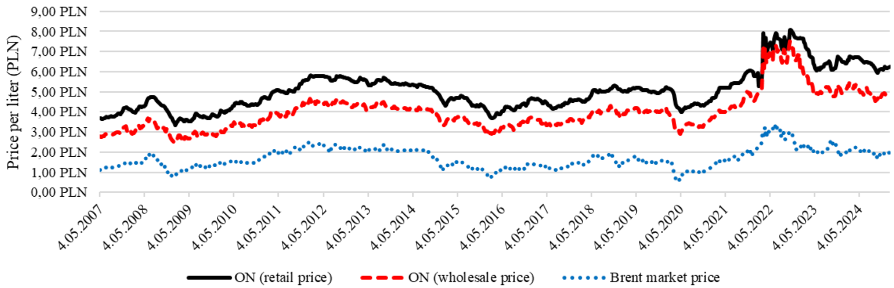
Variable	N	Time scope	Average	SD	Min	Max	Stationarity	
							ADF statist.	Conclusion
ON (retail price)	913	05/2007-12/2024	5.07	0.99	3.35 8.1.2009	8.08 13.10.2022	-1.781 (0.390)	non-stationarity
PB95 (retail price)			5.13	0.81	3.34 8.1.2009	7.97 9.6.2022	-1.780 (0.390)	
ON (wholesale price)			4.00	0.94	2.46 30.12.2008	7.54 13.10.2022	-1.868 (0.347)	
PB95 (wholesale price)			4.02	0.78	2.45 30.12.2008	7.52 2.6.2022	-2.129 (0.233)	
Brent market price			1.71	0.50	0.57 23.04.2020	3.36 9.6.2022	-2.381 (0.147)	

p-values are provided in parentheses
Note: Own elaboration based on data from BM Reflex, PKN ORLEN, and investing.com.

In the studied time period, the average retail price of diesel fuel was 5.07 PLN/l with a standard deviation of ± 0.99 PLN (70.43% of observations fell within this range). The price was more often below the average (54% of observations) than above it (46%). On the other hand, the average price of gasoline was 5.13 PLN/l ± 0.81 PLN (72.29% of observations), with more observations below the average (57%). Diesel fuel prices exhibited greater variability (coefficient of variation: 19.6%) compared to gasoline prices (15.8%).

Figure 1

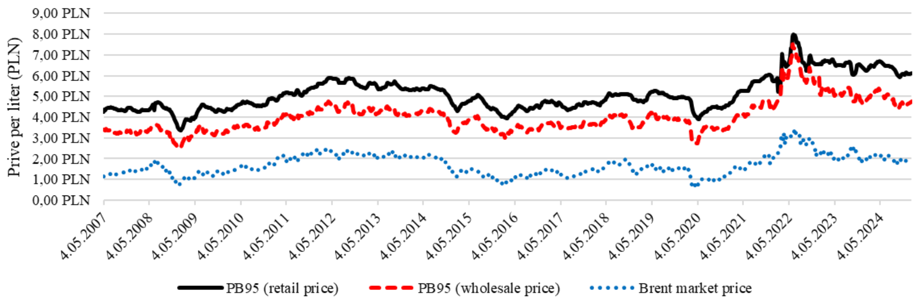
Retail and wholesale diesel prices in Poland and Brent crude oil market prices from 2007 to 2024



Note: Own elaboration based on data from BM Reflex, PKN ORLEN, and investing.com.

Figure 2

Retail and wholesale prices of PB95 in Poland and Brent crude oil market prices from 2007 to 2024



Note: Own elaboration based on data from BM Reflex, PKN ORLEN, and investing.com.

The direction of variability in retail prices of diesel and gasoline during the analysed period was similar. Long-term upward trends were observed in the following periods: 02.2009 - 05.2012, 02.2016 - 11.2019, and 05.2020 - 05.2024 (with a particularly significant price increase and higher volatility during the early stages of the Russian aggression against Ukraine). Long-term declines were observed from May 2012 to February 2016. Significant short-term declines were also recorded during macroeconomic shocks, particularly following the 2007/2008 financial crisis and the outbreak of the COVID-19 pandemic (early 2020). Similar changes during similar periods were also observed for wholesale and market prices, as shown in Figures 1 and 2.

Due to the formulated research hypotheses, methods were employed to verify the existence of cointegration among time series (H1) and the asymmetric impact of changes in the explanatory variable on the dependent variable (H2 and H3).

In the first step, it was necessary to check if there exists a stable, long-term relationship between two (or more) time series, such as retail, wholesale, and market prices. The procedures used to detect this relationship differ depending on whether the series are stationary or non-stationary. For stationary time series, vector autoregression (VAR) models are typically used to examine the dynamics of the relationship between the series, as well as Granger causality tests (which help identify if lagged values of one series can predict another time series) and analyses using impulse-response functions. Given that the fuel price series are not stationary (Table 1), a different procedure was applied, namely the time series cointegration test. Cointegration means that two series maintain a long-term stable relationship, even if they exhibit a trend (i.e., they are non-stationary). To verify the existence of cointegration, a two-step procedure proposed by Granger and Engle (1987) was used. In the first step, a function was estimated using the classical least squares method (OLS):

$$y_t = \alpha_0 + \alpha_1 x_t + \varepsilon_t \quad (1),$$

where: y and x – the time series being analysed (e.g., retail and wholesale prices), t – time, α_0 – constant, α_1 – estimated parameter, ε – random error.
In the second stage, it was tested (using the ADF test) whether the residual series from equation (1) is stationary by estimating the parameters of the following function (Dickey, Fuller, 1979):

$$\Delta\varepsilon_t = \gamma_0 + \beta t + \theta\varepsilon_{t-1} + \sum_{i=1}^{n}\gamma_i\Delta\varepsilon_{t-i} + \mu_t \quad (2),$$

where: $\Delta\varepsilon_t$ is the first difference of the series ε (i.e., $\Delta\varepsilon_t=\varepsilon_t-\varepsilon_{t-1}$), γ_0 is the constant term, β is the parameter of the linear time trend, θ is the parameter of the unit root, $\sum_{i=1}^{n} \gamma_i \Delta\varepsilon_{t-i}$ is the component of n-lagged differences[†], and μ_t is the random error term.

If the parameter of the unit root, θ, is significantly different from zero, it indicates that the residual series is stationary, which in turn suggests the presence of cointegration between the series y and x, i.e., the existence of a long-term relationship between them.

In the second step, the asymmetric impact of the explanatory variable *x* (e.g., wholesale prices, hereafter referred to as "$price_{wholesale}$") on the dependent variable *y* (e.g., retail prices, hereafter referred to as "$price_{retail}$") was examined. For this purpose, using the classical least squares method again, equation (1) was estimated, and then the parameters of the asymmetric error correction model were estimated (see: Enders & Siklos, 2001):

$$\Delta y_t = \rho_0 + \varepsilon_{t-1} + \rho_1 \Delta x_{increase_{t-1}} + \rho_2 \Delta x_{decrease_{t-1}} + \tau_t \quad (3),$$

where: ρ_0 – constant, $\Delta x_{increase_{t-1}} = \max(0; \Delta x_{t-1})$, $\Delta x_{decrease_{t-1}} = \min(0; \Delta x_{t-1})$, τ – random error.

The parameters ρ_1 and ρ_2 indicate the response of the dependent variable to (respectively) increases and decreases in the independent variable. If these parameters are significantly[‡] different from each other (or more formally, according to the Wald test: their difference is significantly different from zero), it means that the dependent variable reacts differently (asymmetrically) to increases and decreases in the independent variable. However, this model may not be sufficient to fully capture the asymmetry of the response, as it assumes that the responses of retail prices to increases and decreases in wholesale prices are independent and constant. Consequently, it does not allow for the consideration of potential differences in the strength and direction of the effects of increases and decreases. As a result, the assessed asymmetry may be understated or, in the extreme case, incorrectly regarded as non-existent. For this reason, a model was estimated that takes into account the interactions between increases/decreases and the magnitude of these changes:

[†] In this study, the criterion of minimizing the Akaike Information Criterion (AIC) was used to determine the optimal number of lags.

[‡] The estimated regression was subjected to tests for the presence of heteroscedasticity (White's test (1980)) and autocorrelation (Breusch-Godfrey test (1978)). In the case of confirming the presence of at least one of these phenomena, the significance of the parameters was determined in accordance with the correction proposed by Newey & West (1987).

$$\Delta y_t = \rho_0 + \varepsilon_{t-1} + \rho_1 \Delta x_{increase_{t-1}} + \rho_2 \Delta x_{decrease_{t-1}} + \rho_3 interaction_{increase} + \rho_4 interaction_{decrease} + \tau_t \quad (4),$$

where[§]: $interaction_{increase} = z_1 \Delta x_{increase_{t-1}}$, $interaction_{decrease} = z_2 \Delta x_{decrease_{t-1}}$.

Similarly, the values of parameters ρ_3 and ρ_4 indicate the magnitude of the response of the dependent variable to increases and decreases in the explanatory variable, and demonstrating a significant difference between these parameters (using the Wald test) indicates the presence of asymmetry in the influence of increases and decreases in the explanatory variable on the dependent variable.

4. RESULTS AND DISCUSSION

4.1. Long-term Relationship between Retail, Wholesale, and Exchange Prices

As indicated in Section 3, the direction of changes in retail, wholesale, and market prices for both diesel oil and gasoline seems to be similar throughout most of the studied period. However, during certain periods—particularly during major macroeconomic shocks—this relationship is disrupted. This raises the question of whether, despite these deviations, it is reasonable to assert the existence of a stable, long-term relationship between these prices.

Therefore, cointegration analyses were conducted between two series: retail and wholesale prices, as well as wholesale and market prices. The results are presented in Table 2.

[§] The variables z_1 and z_2 are binary variables indicating the occurrence (respectively) of an increase and a decrease in the explanatory variable, formally: $\begin{cases} z_1 = 1 \ if \ \Delta x_t > 0 \\ z_1 = 0 \ if \ \Delta x_t \leq 0 \end{cases}$ and $\begin{cases} z_2 = 1 \ if \ \Delta x_t < 0 \\ z_2 = 0 \ if \ \Delta x_t \geq 0 \end{cases}$. This approach, on the one hand, omits situations where there is a reversal in the direction of changes in the explanatory variable (from increase to decrease and vice versa), but on the other hand, it allows for a more precise capture of the asymmetry of the impact, which is crucial for achieving the aim of the article.

Table 2.
Cointegration of selected time series from 2007 to 2024

Dependent variable	Independent variable	Linear regression (OLS)			ADF test for residuals		
		α_1	constant	R^2	No. of lags	Stat. test. (p-value)	Cointegr ation
ON (retail price)	ON (wholesale price)	1.032*** (0,000)	0.934*** (0,000)	0.954	3	-5.115*** (0.000)	✓
ON (retail price)	Brent market price	1.713*** (0,000)	2.146*** (0,000)	0.741	3	-3.535*** (0.007)	✓
PB 95 (retail price)	PB95 (wholesale price)	1.009*** (0,000)	1.071*** (0,000)	0.935	3	-5.108*** (0.000)	✓
PB 95 (retail price)	Brent market price	1.417*** (0,000)	2.174*** (0,000)	0.759	3	-3.899*** (0.002)	✓

p-values are provided in parentheses; *, **, *** indicate statistical significance at the 90%, 95%, 99% levels.
Note: Own calculations.

Wholesale prices are a strong and significant predictor of retail prices—both for diesel oil and gasoline (explaining 95.4% and 93.5% of the variability in these prices, respectively). Market prices of crude oil also allow for the estimation of retail prices, although the explained variability is lower (74.1% for diesel oil and 75.9% for gasoline). However, for the purpose of this article, the most important result is the cointegration test. All relationships are statistically significant at the 99% confidence level, indicating the presence of cointegration between the examined time series**. This means that there is a stable, long-term relationship between them, which provides no evidence to reject hypothesis H1.

4.2. Relationship between wholesale and retail fuel prices

Next, an analysis was conducted to examine the impact of changes in wholesale prices on changes in retail prices, as well as the impact of changes in crude oil prices on wholesale fuel prices in Poland. For this purpose, estimation was carried out following the procedure outlined in Section 3 ("Data and Methodology"), and the results are presented in Tables 3 and 4, respectively.

** An interesting question is whether there are subperiods in which cointegration does not occur, and if so, what the determinants of such a situation are. As indicated in the Conclusion, this is one of the proposed directions for future research.

Based on model (1), it can be stated that the wholesale price of crude oil is a strong predictor of the retail price of diesel fuel, explaining 95.4% of the variability ($R^2 = 0.954$). The application of the error correction model (2) reveals that there is no mechanism for a rapid return to a stable, long-term relationship between wholesale and retail prices – in the case of a deviation of 1.00 PLN, the difference is corrected by only 0.09 PLN in the next period. Given that this model exhibits heteroskedasticity, the Newey-West correction was applied to the estimation, and model (3) was used for inference. The parameters associated with both lagged increases and decreases in wholesale prices are statistically significant at the 90% level, suggesting that changes in wholesale prices influence changes in retail prices in the following period. The conducted test showed that there is no statistical difference between the response to increases and decreases in wholesale prices. Therefore, model (4) was estimated, which additionally includes interactions – in this case, the parameters associated with lagged increases and decreases in prices are not statistically significant (indicating that their inclusion is not sufficient to explain the variability of retail prices). However, the interactions are significant: both increases and decreases in wholesale prices contribute to different strengths of responses in retail prices. Increases in wholesale prices cause nearly 3 times stronger reactions ($\frac{intercation_{increase}}{interaction_{decrease}} = \frac{0{,}932}{0{,}320} = 2{,}91$) in the retail price level, compared to decreases. This indicates a statistically significant asymmetry in the transmission process of wholesale prices to retail prices for diesel fuel, and consequently, there is no evidence to reject hypothesis H2a. Moreover, the return to the long-term relationship between wholesale and retail prices is slow (a 1.00 PLN deviation is corrected by an average of 0.07 PLN in the following week).

Table 3.

Estimation Results for the Response of Retail Prices to Changes in Wholesale Prices

Model:		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fuel:		ON				PB95			
Method:		OLS	OLS	OLS (Newey-West correction)		OLS	OLS	OLS (Newey-West correction)	
Dependent variable:		$price_{retail}$	$\Delta price_{retail}$	$\Delta price_{retail}$	$\Delta price_{retail}$	$price_{retail}$	$\Delta price_{retail}$	$\Delta price_{retail}$	$\Delta price_{retail}$
Independent variable	$price_{wholesale}$	1.032*** (0.000)				1.009*** (0.000)			
	ε_{t-1}		-0.085*** (0.000)	-0.085*** (0.000)	-0.067*** (0.000)		-0.083*** (0.000)	-0.083*** (0.000)	-0.077*** (0.000)
	$\Delta price_{wholesale_{increase_{t-1}}}$		0.345*** (0.000)	0.345* (0.076)	-0.079 (0.619)		0.209*** (0.000)	0.209 (0.147)	-0.110 (0.338)
	$\Delta price_{wholesale_{decrease_{t-1}}}$		0.210*** (0.000)	0.210** (0.037)	0.044 (0.610)		0.259*** (0.000)	0.259*** (0.000)	0.144*** (0.009)
	$interaction_{increase}$				0.932*** (0.003)				0.716*** (0.003)
	$interaction_{decrease}$				0.320** (0.014)				0.162* (0.090)
	constant	0.934*** (0.000)	-0.002 (0.478)	-0.002 (0.680)	-0.005 (0.256)	1.071*** (0.000)	0.003 (0.261)	0.003 (0.503)	0.000 (0.938)
R^2		0,954	0.244			0.935	0.202		
Number of observations		913	912	912	912	913	912	912	912
Diagnostic tests	Autocorrelation of residuals (Breusch-Godfrey)		0.093 (0.761)				5.609** (0.018)		
	Heteroskedasticity (White)		525.80*** (0.000)				359.53*** (0.000)		
$\Delta price_{wholesale_{increase_{t-1}}} = \Delta price_{wholesale_{decrease_{t-1}}}$				YES (0.5034)				YES (0.7661)	
$interaction_{increase} = interaction_{decrease}$					NO* (0.066)				NO** (0.028)

p-values are provided in parentheses; *, **, *** indicate statistical significance at the 90%, 95%, 99% levels.

Note: Own calculations.

Table 4.

Estimation Results of the Response of Wholesale Prices to Changes in Market Prices

Model:		**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**
Fuel:		ON				PB95			
Method:		OLS	OLS	OLS (Newey-West correction)		OLS	OLS	OLS (Newey-West correction)	
Dependent variable:		$price_{wholesale}$	$\Delta price_{wholesale}$	$\Delta price_{wholesale}$	$\Delta price_{wholesale}$	$price_{wholesale}$	$\Delta price_{wholesale}$	$\Delta price_{wholesale}$	$\Delta price_{wholesale}$
Independent variable	$price_{market}$	1.626^{***} (0.000)				1.384^{***} (0.000)			
	ε_{t-1}		-0.031^{***} (0.000)	-0.031^{**} (0.033)	-0.032^{**} (0.023)		-0.028^{***} (0.002)	-0.028^{**} (0.040)	-0.032^{**} (0.015)
	$\Delta price_{market_{increase_{t-1}}}$		0.734^{***} (0.000)	0.734^{**} (0.041)	0.499 (0.254)		0.519^{***} (0.000)	0.519^{**} (0.027)	0.303 (0.300)
	$\Delta price_{market_{decrease_{t-1}}}$		0.250^{***} (0.002)	0.250 (0.126)	-0.150 (0.422)		0.383^{***} (0.000)	0.383^{***} (0.000)	0.018 (0.888)
	$interaction_{increase}$				0.592^{**} (0.056)				0.544^{**} (0.015)
	$interaction_{decrease}$				0.845^{***} (0.000)				0.761^{***} (0.000)
	constant	1.232^{***} (0.000)	-0.011^{**} (0.032)	-0.011 (0.366)	-0.014 (0.255)	1.663^{***} (0.000)	-0.003 (0.555)	-0.003 (0.748)	-0.005 (0.555)
R^2		0,745	0.129			0.788	0.136		
Number of observations		913	912	912	912	913	912	912	912
Diagnostic tests	Autocorrelation of residuals (Breusch-Godfrey)		42.085^{***} (0.000)				11.159^{***} (0.001)		
	Heteroskedasticity (White)		190.38^{***} (0.000)				145.03^{***} (0.000)		
$\Delta price_{market_{increase_{t-1}}} = \Delta price_{market_{decrease_{t-1}}}$				YES (0.316)				YES (0.662)	
$interaction_{increase} = interaction_{decrease}$					YES (0.442)				YES (0.394)

p-values are provided in parentheses; *, **, *** indicate statistical significance at the 90%, 95%, 99% levels.

Note: Own calculations.

Similar results were obtained when analysing the impact of wholesale crude oil prices on retail gasoline prices. Wholesale prices are also a good predictor (R^2 = 0.935) for retail prices (model 5). However, the error correction model regression (model 6) using the classical least squares method is affected by heteroskedasticity and additionally by autocorrelation of residuals. After applying the Newey-West correction (model 7), the parameter associated with lagged increases in prices became statistically insignificant, which significantly complicates inference. Therefore, a model with interactions (model 8) was re-estimated. The results indicate that these interactions are significant at the 90% level, and retail prices respond more strongly to increases than to decreases. This asymmetry is larger than in the case of diesel fuel ($\frac{interaction_{increase}}{interaction_{decrease}} = \frac{0,716}{0,162} = 4,42$) and remains statistically significant, indicating no evidence for rejecting hypothesis H2b. Similar to diesel fuel, the return to the long-term relationship between wholesale and retail prices is slow.

Wholesale prices of diesel fuel respond to changes in crude oil market prices differently. Based on model (11), it should be noted that the lagged change in crude oil prices significantly affects the current level of wholesale prices, which aligns with the earlier cointegration analysis. More importantly (model 12), the differences between the responses to increases and decreases in crude oil prices on wholesale price changes are not large (parameters are 0.592 and 0.845, respectively). The conducted test showed that these differences are not statistically significant, allowing for the conclusion that wholesale prices respond with a similar (same) intensity to changes in crude oil prices, regardless of whether those prices are increasing or decreasing. Similarly, it was shown (model 16) that there are no differences between the responses of wholesale gasoline prices to increases and decreases in crude oil prices. As a result, hypotheses H3a and H3b should be rejected.

In summary, based on the analysed data, it is reasonable to conclude that there is asymmetric transmission from wholesale prices to retail prices for liquid fuels, both crude oil and gasoline. Retail prices increase more when wholesale prices rise compared to the decrease in retail prices following a fall in wholesale prices. This asymmetry arises solely from the transmission of wholesale prices to retail prices, as no difference is observed in the response of wholesale prices to increases and decreases in crude oil prices.

5. CONCLUSIONS

The aim of this article was to examine whether there were asymmetric price transmissions between the market prices of crude oil and wholesale prices, as well as between wholesale and retail fuel prices in Poland between 2007 and 2024. Three main research hypotheses were tested:

- **H1**: The series of retail and wholesale fuel prices in Poland and the market price of crude oil are cointegrated.
- **H2**: Retail fuel prices in Poland change asymmetrically in response to increases and decreases in their wholesale prices.
- **H3**: Wholesale fuel prices in Poland change asymmetrically in response to increases and decreases in the market price of crude oil.

The quantitative analysis did not provide evidences for rejecting the first and second research hypotheses. The third hypothesis was rejected. This means that there was a long-term relationship between crude oil market prices and both wholesale and retail fuel prices in Poland. However, the response of retail prices to changes in wholesale prices was not symmetric. When wholesale diesel prices increased during the studied period, the retail price increase was 2.91 times stronger than the decrease in retail price when wholesale prices fell. This asymmetry was even greater in the gasoline market—prices changed 4.42 times more in response to an increase in wholesale price compared to a decrease. Leszkiewicz-Kędzior (2014) notes that gaining additional profits by gas stations in this manner is possible because fuels are basic goods with low price elasticity of demand. No asymmetric transmission of prices was observed between market prices and wholesale prices. The results are consistent with most studies conducted using different methods for shorter time periods (Laszkiewicz-Kędzior & Welfe, 2014; Złoty, 2023), although, for instance, Socha's (2014) findings of no asymmetry in the gasoline market were not confirmed.

The presented analysis can also serve as a starting point for further research. It would be interesting to investigate whether the observed asymmetric price transmission occurred in every subperiod or whether there were subperiods with symmetric price transmission. It would also be interesting to explore whether wholesale or retail fuel prices are dependent on the political cycle and whether politicians, who influence companies in this market, use this to gain votes from the electorate (see: Egli, Schmid, Schmidt, 2022). A comparative analysis of more countries could help identify the determinants of asymmetric price transmission in the liquid fuel market.

References

Bacon, R. W. (1991). Rockets and feathers: The asymmetric speed of adjustment of UK retail gasoline prices to cost changes. Energy Economics, 13(3), 211-218. https://doi.org/10.1016/0140-9883(91)90022-R

Bakhat, M., Rosselló, J., & Sansó, A. (2022). Price transmission between oil and gasoline and diesel: A new measure for evaluating time asymmetries.

Energy Economics, 106, 105766. https://doi.org/10.1016/j.eneco.2021.105766
Barsky, R. B., & Kilian, L. (2004). Oil and the macroeconomy since the 1970s. Journal of Economic Perspectives, 18(4), 115-134. https://doi.org/10.1257/0895330042632708
Ben Salem, L., Nouira, R., Jeguirim, K., & Rault, C. (2022). The determinants of crude oil prices: Evidence from ARDL and nonlinear ARDL approaches. Resources Policy, 79, 103085. https://doi.org/10.1016/j.resourpol.2022.103085
Bor, Ö., & İsmihan, M. (2013). Gasoline pricing, taxation and asymmetry: The case of Turkey. Discussion Paper, No. 2013/7. Turkish Economic Association, Ankara.
Borenstein, S., & Shepard, A. (1996). Dynamic pricing in retail gasoline markets. The RAND Journal of Economics, 27(3), 429–451. https://doi.org/10.2307/2555838
Breusch, T. S., & Godfrey, R. W. (1978). The asymptotic distribution of the estimators of the coefficients in simultaneous equations models when the errors are heteroskedastic. Econometrica, 46(4), 809–832. https://doi.org/10.2307/1913812
Bumpass, D., Ginn, V., & Tuttle, M. H. (2015). Retail and wholesale gasoline price adjustments in response to oil price changes. Energy Economics, 52(Part A), 49-54. https://doi.org/10.1016/j.eneco.2015.08.030
Cai, Y., Mignon, V., & Saadaoui, J. (2022). Not all political relation shocks are alike: Assessing the impacts of US-China tensions on the oil market. CEPII Working Paper, No. 2022-07. Retrieved from https://www.cepii.fr/PDF_PUB/wp/2022/wp2022-07.pdf
Caselli, F., & Tesei, A. (2016). Resource windfalls, political regimes, and political stability. The Review of Economics and Statistics, 98(3), 573–590. http://www.jstor.org/stable/24917035
Colgan, J. D. (2013). Fueling the fire: Pathways from oil to war. International Security, 38(2), 147-180. https://doi.org/10.1162/ISEC_a_00135
Davis, M. C. (2021). An examination of the effects of environmental regulations on retail gasoline price seasonality. Contemporary Economic Policy, 39, 178-193. https://doi.org/10.1111/coep.12491
Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a), 427–431. https://doi.org/10.1080/01621459.1979.10482531
Egli, F., Schmid, N., & Schmidt, T. S. (2022). Backlash to fossil fuel phase-outs: The case of coal mining in US presidential elections. Environmental Research Letters, 17(9), 094015. https://doi.org/10.1088/1748-9326/ac82fe

Enders, W., & Siklos, P. L. (2001). Cointegration and threshold adjustment. Journal of Business & Economic Statistics, 19(2), 166–176. https://doi.org/10.1198/073500101524622800

Energy Institute. (2024). Statistical review of world energy 2024. Retrieved from https://www.energyinst.org/__data/assets/pdf_file/0006/1542714/684_EI_Stat_Review_V16_DIGITAL.pdf

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. Econometrica, 55(2), 251–276. https://doi.org/10.2307/1913236

Feng, Y., Xu, D., Failler, P., & Li, T. (2020). Research on the time-varying impact of economic policy uncertainty on crude oil price fluctuation. Sustainability, 12(16), 6523. https://doi.org/10.3390/su12166523

Frey, G., & Manera, M. (2007). Econometric models of asymmetric price transmission. Journal of Economic Surveys, 21(2), 349-415.

Gutmann, J., Neuenkirch, M., Neumeier, F., & Steinbach, A. (2018). Economic sanctions and human rights: Quantifying the legal proportionality principle. ILE Working Paper Series, No. 12. University of Hamburg, Institute of Law and Economics (ILE).

Hernandez Carballo, I., & Sisco, M. R. (2024). Examining the effects of gasoline prices on public support for climate policies. Nature Energy, 9, 219–227. https://doi.org/10.1038/s41560-024-01449-2

Huseynli, N. (2023). Analyzing the relationship between oil prices and gold prices before and after COVID-19. International Journal of Energy Economics and Policy, 13(2), 373-378.

Karkowska, R., & Urjasz, S. (2024). Importance of geopolitical risk in volatility structure: New evidence from biofuels, crude oil, and grains commodity markets. Journal of Commodity Markets, 36, 100440. https://doi.org/10.1016/j.jcomm.2024.100440

Leszkiewicz-Kędzior, K. (2014). Asymetryczne dostosowania cenowe na rynku paliw w Polsce. Wydawnictwo Uniwersytetu Łódzkiego. https://doi.org/10.18778/7969-422-8

Leszkiewicz-Kędzior, K., & Welfe, A. (2014). Asymmetric price adjustments in the fuel market. Central European Journal of Economic Modelling and Econometrics, 6, 105–127.

Loutia, A., Mellios, C., & Andriosopoulos, K. (2016). Do OPEC announcements influence oil prices? Energy Policy, 90, 262-272. https://doi.org/10.1016/j.enpol.2015.11.025

Martín-Moreno, J. M., Pérez, R., & Ruiz, J. (2019). Evidence about asymmetric price transmission in the main European fuel markets: From TAR-ECM to Markov-switching approach. Empirical Economics, 56, 1383–1412. https://doi.org/10.1007/s00181-017-1388-1

Newey, W. K., & West, K. D. (1987). A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica, 55(3), 703–708. https://doi.org/10.2307/1913610

Painter, D. S. (2014). Oil and geopolitics: The oil crises of the 1970s and the Cold War. Historical Social Research, 39(4), 186-208. https://doi.org/10.12759/hsr.39.2014.4.186-208

Pangsy-Kania, S. (2017). Ropa naftowa jako strategiczny surowiec gospodarki światowej: przyczyny i skutki wahań cen w latach 1970-2017. W: M. Maciejewski, K. Wach (red.), Handel zagraniczny i biznes międzynarodowy we współczesnej gospodarce (s. 439-447). Kraków: Uniwersytet Ekonomiczny w Krakowie.

Polish Geological Institute. (n.d.). Ropa naftowa. Retrieved February 4, 2025, from https://www.pgi.gov.pl/surowce/energetyczne/ropa-naftowa.html

Pescatori, A., & Nazer, Y. F. (2022). OPEC and the oil market. IMF Working Papers, 2022(183), A001. Retrieved February 7, 2025, from https://doi.org/10.5089/9798400219788.001.A001

Polish Organization of the Oil Industry and Trade. (2024). Przemysł i handel naftowy 2023. Raport roczny. Retrieved February 3, 2025, from https://popihn.pl/wp-content/uploads/2024/05/RAPORT-ZA-ROK-2023-1.pdf

Qin, X., Zhou, C., & Wu, C. (2016). Revisiting asymmetric price transmission in the U.S. oil-gasoline markets: A multiple threshold error-correction analysis. Economic Modelling, 52(Part B), 583-591. https://doi.org/10.1016/j.econmod.2015.10.003

Quint, D., & Venditti, F. (2020). The influence of OPEC+ on oil prices: A quantitative assessment (ECB Working Paper No. 2467). European Central Bank.

Raeder, F. T., Rodrigues, N., & Losekann, L. D. (2022). Asymmetry in gasoline price transmission: How do fuel pricing strategy and the ethanol addition mandate affect consumers? International Journal of Energy Economics and Policy, 12(4), 517–527. https://doi.org/10.32479/ijeep.13211

Robe, M. A., & Wallen, J. (2016). Fundamentals, derivatives market information, and oil price volatility. Journal of Futures Markets, 36, 317-344. https://doi.org/10.1002/fut.21732

Schneider, D., Van Robays, I., & Fratzscher, M. (2014). Oil prices, exchange rates and asset prices (Working Paper No. 1689). European Central Bank.

Schweikert, K. (2019). Asymmetric price transmission in the US and German fuel markets: A quantile autoregression approach. Empirical Economics, 56, 1071–1095. https://doi.org/10.1007/s00181-017-1376-5

Totleben, B., Szarzec, K., & Kardziejonek, A. (2019). Rent-seeking by politicians in state-owned enterprises. Ekonomia I Prawo. Economics and Law, 18(4), 515–529. https://doi.org/10.12775/EiP.2019.034

Van Robays, I. (2012). Macroeconomic uncertainty and the impact of oil shocks. ECB Working Paper, No. 1479. European Central Bank (ECB), Frankfurt a. M.

Wang, P., Liu, X., Ho, T., & Li, Y. (2024). The effect of the US dollar exchange rate on oil prices: An oil financialization perspective. International Journal of Finance & Economics, 29(2), 1301–1317. https://doi.org/10.1002/ijfe.2736

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica, 48(4), 817–838. https://doi.org/10.2307/1912934

Zhang, W., Luckert, M., & Qiu, F. (2023). Asymmetric price transmission and impulse responses from U.S. crude oil to jet fuel and diesel markets. Energy, 283, 128425. https://doi.org/10.1016/j.energy.2023.128425

Złoty, M. (2023). Analiza rynku paliw płynnych w Polsce od stycznia 2019 r. do września 2022 r. Gospodarka Materiałowa i Logistyka. Material Economy and Logistics Journal, 75(2), 50–61. https://doi.org/10.33226/1231-2037.2023.2.6