Journal of
Risk and Financial Management

MDPI

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Asymmetric Price Transmission between Crude Oil and the US Gasoline Market

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Abstract: Gasoline and crude oil price movements have been the focus of many studies in the last decade. We use the asymmetric error correction model (ERM) to examine the hypothesis of asymmetric pricing for both regular and premium gasoline markets at the US national level and in the four states with the highest gasoline consumption. Using weekly crude oil and retail gasoline prices from June 2000 to February 2023, the results show an asymmetric response in the gasoline market for all four states and at the national level. However, the adjustment speed tends to differ for the types of gasoline and across states. The implications of these results for policy and welfare are discussed in this study.

Keywords: gasoline; crude oil; asymmetric pricing

1. Introduction

Crude oil price is categorized as one of the highest volatilities in recent decades. Since 1980, the inflation-adjusted price of crude oil has experienced two historical peaks in 2008 and 2011. Moreover, the Russia–Ukraine war caused the most recent price peak in 2022. Therefore, due to this high volatility in recent years, research in the oil market has gained new interest among economists (Le et al. 2023). On the other hand, crude oil is considered the main component of gasoline, and the price of gasoline is expected to follow the crude oil price. However, there has been an argument about the price-setting behavior of oil companies. The argument claims that retailers adjust the price of gasoline more quickly to cost increase or when the crude oil prices go up than to cost decrease or when the crude oil prices go down. In economics, the phenomenon whereby prices adjust differently depending on their direction is considered price asymmetry. The price asymmetry could imply important welfare and policy implications.

The existence of price asymmetry in the transmission mechanism between input prices and output is typical in many financial markets and agricultural products and is not exclusive to the energy market. This begs the question: do output prices follow changes in input prices symmetrically, or do they depend on the public's opinion? This price variation reminds us of the common belief in "the rockets and feathers" hypothesis that (Bacon 1991) introduces, reflecting the idea that retail gasoline prices rise like rockets for positive oil prices and drop like feathers for negative oil price shocks.

Researchers conducted various empirical studies to examine the connection between crude oil and gasoline prices, looking to see if there was an asymmetric pass-through. The primary focus of this pattern is on whether gasoline prices respond asymmetrically to positive and negative shock costs. However, the studies differ in the data frequency, model specification, and sample and time period. In an influential paper, (Borenstein et al. 1997) (hereafter BCG) study the US gasoline market using weekly data for 1986–1992. They apply a vector autoregression model to test the asymmetric adjustment behavior, and the result

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Citation: Kamyabi, Najmeh, and Benaissa Chidmi. 2023. Asymmetric Price Transmission between Crude Oil and the US Gasoline Market. *Journal of Risk and Financial Management* 16: 326. https://doi.org/10.3390/jrfm16070326

Academic Editor: Thanasis Stengos

Received: 12 May 2023
Revised: 29 June 2023
Accepted: 29 June 2023
Published: 11 July 2023

confirms that gasoline prices adjust faster when oil price increases than when oil price decreases. Johnson (2002) studies the gasoline and diesel market in the United States. He finds that the retail prices in the diesel market display more asymmetric responses than those in the gasoline market. (Honarvar 2009), (Atil et al. 2014), (Bremmer and Kesselring 2016), and (Bagnai and Ospina 2018) are similar studies with a focus on asymmetric price transmission in the energy market.

Investigations into the phenomenon of asymmetric pricing between gasoline and oil are not exclusive to the United States. (Bettendorf et al. 2003) analyzed the retail price adjustment in the Dutch gasoline market, (Contín-Pilart et al. 2009) in the Spain market, (Boroumand et al. 2016) in the French market, (Chou and Tseng 2016) for Taiwan, and (Chen and Sun 2021) in China. However, some other studies find no evidence of asymmetric price behavior due to a different model or data sources, for example, (Godby et al. 2000), (Galeotti et al. 2003), (Bachmeier and Griffin 2003). Finally, recent research conducted with large datasets of daily or weekly data has been exploring the relationship between dynamic pricing and Edgeworth cycles, such as (Eckert and West 2004), (Lewis and Noel 2011), (Zimmerman et al. 2013), and (Noel 2019). Again, the focus of these studies is independent of the rockets and feathers hypothesis.

This paper aims to determine whether an asymmetric price transmission exists between crude oil and gasoline prices in four US states and nationally from June 2000 to February 2023. We contrast this study with previous ones by focusing on state-level and weekly data instead of aggregate and monthly data. We examine both regular and premium gasoline markets to see if the price asymmetry differs between them and across states. To this end, we use an error correction model (ECM) to analyze the short-term and long-term interactions between crude oil and gasoline prices. We assume that gasoline prices will eventually reflect crude oil costs; however, we acknowledge that this may not be the case in the short run. Two main conclusions emerge from our results. First, the findings show an asymmetric price transmission in both regular and premium gasoline markets at both national and state levels. Second, the analysis reveals that the speed of adjustment tends to differ for the types of gasoline and across states.

The rest of the paper is structured as follows. Section 2 provides an overview of the empirical framework applied in this study. Section 3 details the data and the descriptive statistics of the variables used in the analysis. Section 4 discusses the results and draws some policy implications, and, finally, Section 5 concludes the article.

2. Methods

The common econometric specification of studying dynamic price adjustment is to use an error correction model. The retail gasoline price response to changes in the wholesale price is modeled via a lag adjustment model with an error correction term that imposes a long-run relationship between crude oil prices and retail prices. The error correction model (*ECM*) has appeared as the ideal approach for cointegrated modeling series.[1] In an *ECM*, the retail gasoline prices respond to the wholesale price through a lag adjustment model with an error correction term. The Engle–Granger two-step procedure considers first the relationship between variables. Assuming a linear relationship, the related equation becomes:

$$\ln G_t = \alpha + \beta \ln C_t + \varepsilon_t \quad (1)$$

where G indicates the retail price of gasoline per gallon at time t, C is the price of crude oil per barrel at time t, α is the constant term, and ε_t is the error term. These series must be integrated of order one and cointegrated to utilize an error correction model (Engle and Granger 1987). Equation (1) is the steady-state relationship among the variables and is part of an error correction model. In the second step, we consider the relationship between the gasoline price at the pump and the crude oil price in the dynamic error correction model as follows[2]:

$$\Delta g_t = \sum_{i=1}^{n} \beta_g \Delta g_{t-i} + \sum_{j=0}^{q} \beta_c \Delta c_{t-j} + \delta Z_{t-1} + \varepsilon_t \tag{2}$$

where

$$Z_{t-1} = (g_{t-1} - \hat{\alpha} - \hat{\beta} c_{t-1})$$

Δg refers to the change in the retail gasoline price, and Δc represents the change in the crude oil price. The β_g coefficients measure the short-run adjustment to the lagged gasoline price. β_c is interpreted as the short-run adjustment to the dynamic of crude oil prices, while the term Z_{t-1} is the stationary process and indicates a long-run equilibrium relationship between gasoline and crude oil prices. Therefore, δ shows the rate of adjustment toward the long-run equilibrium. n and q represent the number of lags for gasoline and crude oil prices. These numbers are determined by the (SIC) Schwarz information criterion (Schwarz 1978), which is a consistent lag selection criterion (Lutkepohl 1991). In order to examine the potential asymmetric behavior among gasoline and crude oil prices, Equation (2) is slightly revised. The short-run and long-run effects of the two variables, or changes in the gasoline price and crude oil price, are split into two positive and negative changes, as presented in Equation (3).

$$\begin{aligned} \Delta g_t = & \sum_{i=1}^{n} \beta_g^+ \Delta^+ g_{t-i} + \sum_{i=1}^{n'} \beta_g^- \Delta^- g_{t-i} + \sum_{j=0}^{q} \beta_c^+ \Delta^+ c_{t-j} + \sum_{j=o}^{q'} \beta_c^- \Delta^- c_{t-j} + \delta^+ Z_{t-1}^+ \\ & + \delta^- Z_{t-1}^- + \lambda_1 FinCrisis_t + \lambda_2 Covid19_t + \varepsilon_t \end{aligned} \tag{3}$$

β_g^+ applies when the change in gasoline price is positive; β_g^- applies when the change in gasoline price is negative. β_c^+ applies when the change in crude oil price is positive, β_c^- applies when the change in crude oil price is negative, and they show the impact of crude oil price changes on the gasoline price. δ^+ represents the speed of adjustment to long-run equilibrium when the retail price is above the equilibrium price, and δ^- represents the speed of adjustment to long-run equilibrium when the retail price is below the equilibrium price. n is the number of lags for the gasoline price increases, n' is the number of lags for the gasoline price decreases, q is the number of lags for the crude oil price increases, and q' is the number of lags for the crude oil price decreases.[3] Two binary (dummy) variables are added to account for the 2008 financial crisis and the COVID-19 pandemic. We are interested in the following null hypothesis:

$$\begin{aligned} H_0 : \beta_c^+ = \beta_c^- \quad vs. \quad H_1 : \beta_c^+ \neq \beta_c^- \\ H_0 : \delta^+ = \delta^- \quad vs. \quad H_1 : \delta^+ \neq \delta^- \end{aligned} \tag{4}$$

Rejection of the first null hypothesis implies asymmetric price transmission in the short run, and rejection of the second null hypothesis confirms the asymmetric price transmission in the long run.

This paper estimates the model presented in Equation (3) under four data setups. First, we estimate the price transmission between regular gasoline and WTI crude oil prices for the entire United States (national level) and then estimate the model separately for each state. Second, we conduct the same estimation to find the nature of the price transmission between premium gasoline and WTI crude oil price at the national level and in each state.

3. Data

This paper studies the relationship between the price of regular and premium gasoline and the crude oil price in four US states[4] and at the national level. The dataset consists of weekly data on the wholesale and retail price of regular and premium gasoline nationally and for California, Florida, New York, and Texas between June 2000 and February 2023.

All prices are before taxes. There are two benchmark measures of crude oil prices. One is the price of West Texas Intermediate (WTI), a grade of crude oil that is both low in density and low in sulfur. The second important price for crude oil is Brent. However, the price of WTI is a more common benchmark than Brent in the United States. This study's crude oil data consist of the weekly average WTI sweet crude oil price at Cushing, Oklahoma. All prices are obtained from the US Energy Information Administration. Moreover, we include binary variables to account for the 2008 financial crisis and the COVID-19 pandemic. There are 1187 observations for the US and state levels. Table 1 reports descriptive statistics of the variables used in the analysis.

Table 1. Descriptive statistics.

	Variables	Obs	Mean	Std.Dev.	Min	Max
USA	Regular gasoline (USD/gallon)	1187	2.597	0.772	1.059	5.006
	Premium gasoline (USD/gallon)	1187	3.067	0.886	1.279	6.064
California	Regular gasoline (USD/gallon)	1187	3.092	0.949	1.100	6.271
	Premium gasoline (USD/gallon)	1187	3.332	0.980	1.302	6.643
Florida	Regular gasoline (USD/gallon)	1187	2.545	0.742	1.037	4.852
	Premium gasoline (USD/gallon)	1187	2.911	0.815	1.238	5.524
New York	Regular gasoline (USD/gallon)	1187	2.728	0.792	1.165	4.938
	Premium gasoline (USD/gallon)	1187	3.069	0.850	1.358	5.593
Texas	Regular gasoline (USD/gallon)	1187	2.400	0.735	0.996	4.642
	Premium gasoline (USD/gallon)	1187	2.758	0.787	1.178	5.285
	WTI crude oil price (USD/barrel)	1187	63.218	25.889	3.320	142.520

To better understand the price differences in different parts of the country, retail gasoline prices are analyzed nationally and in the four states with the highest gasoline consumption[5], including California, Florida, New York, and Texas. Most studies utilize aggregate-level data, but, by examining prices at state level, a more detailed analysis can be completed. Figures 1 and 2 display the weekly average price of regular and premium gasoline in the four states mentioned. The figures highlight the difference between the prices of gasoline across these states. For instance, the average price for regular gasoline across the four states varies from a low price of USD 2.4/gallon in Texas to a high price of USD 3.09/gallon in California. The common factors to explain the variation in gasoline prices across states could be taxes and the environmental requirement to use a higher-quality fuel to limit pollution. The data variation is also different across states. Florida and Texas have smaller standard deviations than the national average, and California and New York have larger variations.

At the national level, according to the Energy Information Administration (EIA), the United States is the largest oil consumer, accounting for more than 20% of the world's total consumption. On the other hand, gasoline consumption in the United States accounts for more than 45% of national petroleum consumption, with 97% of all gasoline used by light-duty vehicles (cars, sport utility vehicles, and light pick-up trucks). Crude oil is considered the main component of gasoline; therefore, it is unsurprising that the retail gasoline price follows a similar pattern to that of crude oil. The rest of what consumers pay at the pump depends on federal taxes, refinery, and distribution costs, which usually remain stable. Therefore, we expect gasoline prices to reflect the crude oil price fluctuations, as can be seen in Figure 3. The prices for crude oil are then passed on to consumers through the gasoline market, which is available at over 145,000 retail fuel outlets across the United States.

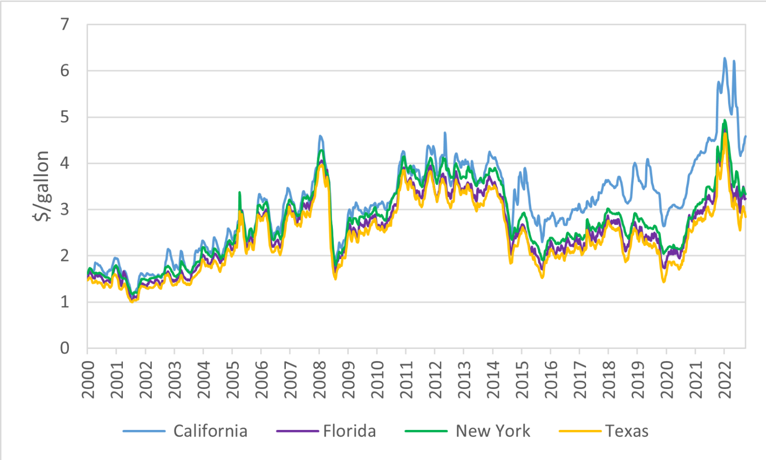

Figure 1. Weekly average price of regular gasoline, June 2000–February 2023. Source: Energy Information Administration.

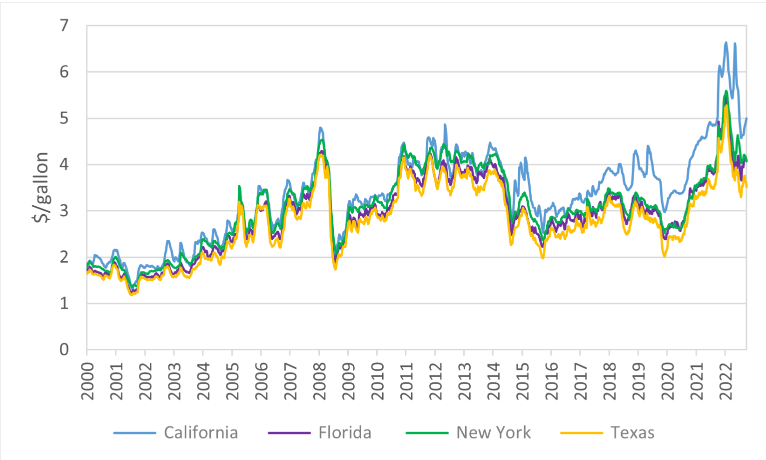

Figure 2. Weekly average price of premium gasoline, June 2000–February 2023. Source: Energy Information Administration.

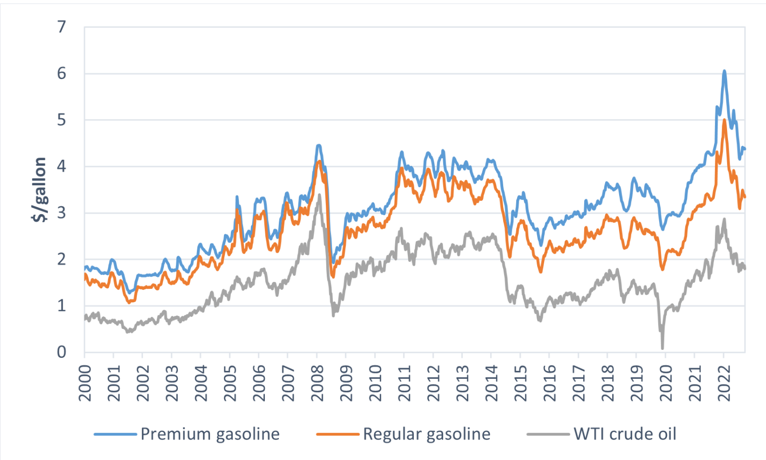

Figure 3. USA weekly average price of regular and premium gasoline and WTI crude oil price, June 2000–February 2023. Source: Energy Information Administration.

4. Results and Discussion

4.1. Granger Causality Test

A causal relationship between two variables implies that changes in one variable can forecast the changes in the other variable. We perform the Granger causality test (Granger

1969) to eliminate the concerns of simultaneity bias and the endogeneity problem between crude oil prices and regular and premium gasoline prices. Table 2 shows the results of the Granger causality test. The null hypothesis that crude oil prices do not affect gasoline prices is rejected for both the regular and premium gasoline at the 1% level. However, the null hypothesis that gasoline prices do not affect crude oil prices cannot be rejected. The results confirm that crude oil prices affect US regular and premium gasoline prices. However, the relationship does not go the other way.

Table 2. Results of Granger causality test.

Null Hypothesis	F-Statistic	*p*-Value
Crude oil prices do not Granger cause regular gasoline prices	29.471 ***	0.0000
Regular gasoline prices do not Granger cause crude oil prices	1.935	0.5134
Crude oil prices do not Granger cause premium gasoline prices	32.184 ***	0.0000
Premium gasoline prices do not Granger cause crude oil prices	2.066	0.5325

*** denotes significance at the 1% level.

4.2. Pass-Through of Crude Oil Prices to Regular Gasoline Prices

Table 3 summarizes the estimation result of Equation (3) for regular gasoline. The Wald test is applied to test for the asymmetric pattern in the short term and long term. The asymmetric long-run effect of crude oil prices on gasoline prices can be indicated by the error correction term. The null hypothesis is $\delta^+ = \delta^- \; vs \; \delta^+ \neq \delta^-$. All the parameter estimates with respect to the long-run adjustment have the expected sign and are statistically significant. Although the magnitudes of the increase and decrease for speed adjustment in the long term look similar, the Wald test result rejected the symmetry hypothesis $H_0 : \delta^+ = \delta^-$ at the national level and in almost all states, implying that stretched margins (corresponding to crude oil price decrease) are corrected differently as squeezed margins (corresponding to crude oil price increase). For instance, at the national level, the long-run speed of adjustment coefficient for the price increase or when the gasoline price is below the equilibrium price is −0.076. However, the long-run speed of adjustment coefficient for the price decrease or when the gasoline price is above the equilibrium price is −0.051. These findings reveal that gasoline retailers are quick to respond when their margins are squeezed compared to when they are stretched. We also observe a similar pattern for gasoline retailers in California, Florida, and New York. However, gasoline retailers in Texas have higher speed adjustments when their margins are stretched than when they are squeezed. Nevertheless, the Wald test could not reject the symmetry hypothesis for the long-run speed of adjustment in this state.

Moreover, the asymmetric pattern in the short run can be captured by testing $\beta_c^+ = \beta_c^- \; vs \; \beta_c^+ \neq \beta_c^-$, and the coefficients of $\Delta^+ c_t$ and $\Delta^- c_t$ are the main focus since they indicate the immediate impact of crude oil price increase and decrease, respectively. The β_g coefficients measure the impact of lagged retail gasoline prices. The Wald test strongly rejects the null equality or the short-run symmetry in all cases. A close look at the coefficients of $\Delta^+ c_t$ indicates that, at the national level, in Florida and Texas, gasoline retailers react strongly within the week to increases in crude oil prices. Texas's regular gasoline has the largest response to the crude oil price increase, with a value of 1.328, implying that a 10% increase in the price of crude oil causes an immediate (within a week) increase in the regular gasoline price by 13.28%. This reaction is 11.23% and 11.42% at the national level and in Florida, respectively. In contrast, California's regular gasoline has the smallest response (7.71%) to an increase in the price of crude oil. The gasoline retailers in the state of New York seem to have a proportionate reaction to crude oil prices. Hence, for regular gasoline, a 10% increase in crude oil prices induces a 9.74% (approximately 10%) increase in retail prices. Moreover, as mentioned earlier, the estimated coefficients of $\Delta^- c_t$ indicate the immediate impact of crude oil price decrease. Overall, the magnitude of the immediate impact of a crude oil price decrease is smaller than the price increase in all cases, with the smallest impact in California (5.06%) and New York (6.49%) and the highest impact in Texas (8.12%), Florida (7.70%), and the USA (7.34%). These findings indicate that gasoline retailers respond significantly faster to a spike in crude oil prices than to a drop. Moreover, the lagged reactions to crude oil price changes are weaker than their contemporaneous counterparts, with many statistically insignificant. Given the magnitude of the gasoline retailers' reaction to contemporaneous changes in crude oil prices, this result is expected. Overall, our findings at the national level are similar to some previous studies, for example, (Borenstein et al. 1997), (Johnson 2002). However, based on our knowledge, this is the first study that examines the pass-through pattern of crude oil prices to gasoline prices at the state level.

Table 3. Estimation results for regular gasoline/crude oil price.

Variable	USA	California	Florida	New York	Texas
$\Delta^+ c_t$	1.123 ***	0.771 ***	1.142 ***	0.974 **	1.328 ***
	(0.066)	(0.071)	(0.842)	(0.076)	(0.089)
$\Delta^- c_t$	0.734 ***	0.506 ***	0.770 **	0.649 **	0.812 **
	(0.068)	(0.089)	(0.071)	(0.088)	(0.101)
$\Delta^+ c_{t-1}$	0.248 **	0.105	0.137 **	0.226 **	0.352 *
	(0.063)	(0.071)	(0.078)	(0.064)	(0.079)
$\Delta^- c_{t-1}$	0.207 **	0.129 **	0.126 **	0.178 *	−0.282
	(0.065)	(0.074)	(0.075)	(0.092)	(0.066)
$\Delta^+ c_{t-2}$	0.003 *	0.003	0.025 **	0.016 *	
	(0.081)	(0.06)	(0.089)	(0.098)	
$\Delta^- c_{t-2}$	0.005 *	0.013	0.065 **	0.025 *	
	(0.041)	(0.02)	(0.045)	(0.052)	
$\Delta^+ c_{t-3}$			0.033 **		
			(0.013)		
$\Delta^- c_{t-3}$			0.014 ***		
			(0.011)		
$\Delta^+ g_{t-1}$	0.144 ***	0.341 ***	0.028 *	0.295 **	0.193 **
	(0.034)	(0.029)	(0.036)	(0.034)	(0.038)
$\Delta^- g_{t-1}$	0.342 ***	0.501**	0.214 **	0.457 ***	0.203 *
	(0.071)	(0.069)	(0.067)	(0.069)	(0.063)
$\Delta^+ g_{t-2}$	0.083 *	0.085 **	0.027 **	0.065 *	−0.072
	(0.031)	(0.034)	(0.036)	(0.033)	(0.037)
$\Delta^- g_{t-2}$	0.115 **	0.202 **	0.02	0.166 *	0.14 **
	(0.071)	(0.089)	(0.067)	(0.069)	(0.063)
$\Delta^+ g_{t-3}$		0.007 **			
		(0.048)			
$\Delta^- g_{t-3}$		0.0.092 *			
		(0.044)			
δ^+_{t-1}	−0.051 ***	−0.032 *	−0.055 **	−0.038 **	−0.061 **
	(0.006)	(0.009)	(0.006)	(0.004)	(0.038)
δ^-_{t-1}	−0.076 ***	−0.097 **	−0.085 **	−0.089 ***	−0.058 ***
	(0.013)	(0.008)	(0.019)	(0.01)	(0.016)
R^2	0.657	0.585	0.527	0.531	0.682
$H_0: \Delta^+ c_t = \Delta^- c_t$	3.371	2.462	2.935	3.142	4.192
p-value	0.000	0.005	0.000	0.001	0.000
$H_0: \delta^+_{t-1} = \delta^-_{t-1}$	4.217	3.514	4.163	3.772	2.966
p-value	0.005	0.000	0.012	0.004	0.235

***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

4.3. Pass-Through of Crude Oil Prices to Premium Gasoline Prices

The estimation results of Equation (3) with regard to the premium gasoline market are reported in Table 4. All the parameter estimates with respect to the long-run and the short-run adjustments have the expected sign and are statistically significant. The Wald test has rejected the null hypothesis of symmetric response in the long run for all cases, likewise to the regular gasoline market. However, the gap in response to the price increase and decrease is wider for the premium gasoline market. Moreover, the Wald test also rejects the null equality or the short-run symmetry in all cases. The finding suggests that the reaction to an immediate crude oil price decrease is smaller than the reaction to contemporaneous crude oil price increases. Hence, a 10% decrease in crude oil prices decreases premium retail prices by 5.36%, 6.07%, 7.21%, 7.44%, and 7.01% in California, New York state, Florida, USA, and Texas compared to 8.02%, 10.68%, 12.81%, 12.17%, and 13.15% for a 10% crude oil price increase. Compared to the regular gasoline market, the short-run speed of adjustments is stronger for crude price increases but milder for price decreases in almost all cases. Moreover, similar to the regular gasoline market, the lagged reactions to crude oil price variations are weaker, with many statistically insignificant compared to their contemporaneous counterparts. Moreover, the estimates for binary variables (the 2008 financial crisis and COVID-19 pandemic) are not included in the table since they are not statistically significant at national- and state-level datasets for both regular and premium gasoline.

Table 4. Estimation results for premium gasoline/crude oil price.

Variable	USA	California	Florida	New York	Texas
$\Delta^+ c_t$	1.217 ***	0.802 **	1.281 ***	1.068 ***	1.315 ***
	(0.016)	(0.016)	(0.02)	(0.014)	(0.019)
$\Delta^- c_t$	0.744 **	0.536 **	0.721*	0.607 **	0.701*
	(0.008	(0.009)	(0.011)	(0.008)	(0.01)
$\Delta^+ c_{t-1}$	−0.044	−0.006	0.04 *	0.003	−0.029
	(0.017)	(0.015)	(0.22)	(0.014)	(0.021)
$\Delta^- c_{t-1}$	0.149 ***	0.102 **	0.169 **	0.1 ***	0.221 ***
	(0.015)	(0.014)	(0.019)	(0.013)	(0.018)
$\Delta^+ c_{t-2}$	0.000	0.002	0.022 *	−0.1	−0.001
	(0.001)	(0.01)	(0.013)	(0.009)	(0.012)
$\Delta^- c_{t-2}$	−0.015	0.009	0.069 ***	0.014	0.005
	(0.015)	(0.014)	(0.019)	(0.013)	(0.18)
$\Delta^+ c_{t-3}$			0.042 ***		
			(0.015)		
$\Delta^- c_{t-3}$			0.0588 **		
			(0.019)		
$\Delta^+ g_{t-1}$	0.278 ***	0.454 ***	0.003	0.267 ***	0.168 **
	(0.033)	(0.032)	(0.037)	(0.033)	(0.034)
$\Delta^- g_{t-1}$	0.658 ***	0.922 **	0.708 **	0.706 ***	0.615 ***
	(0.059)	(0.068)	(0.07)	(0.074)	(0.068)
$\Delta^+ g_{t-2}$	0.11 *	0.094 **	−0.021	−0.005	−0.065 *
	(0.036)	(0.033)	(0.036)	(0.032)	(0.036)
$\Delta^- g_{t-2}$	0.093	−0.025	0.02	0.144 **	0.05
	(0.056)	(0.067)	(0.066)	(0.071)	(0.060)
$\Delta^+ g_{t-3}$		0.038 **			
		(0.023)			
$\Delta^- g_{t-3}$		0.020 **			
		(0.014)			

Table 4. *Cont.*

Variable	USA	California	Florida	New York	Texas
δ^{+}_{t-1}	−0.031 **	−0.013 *	−0.038 *	−0.016 *	−0.039 **
	(0.01)	(0.006)	(0.015)	(0.01)	(0.013)
δ^{-}_{t-1}	−0.088 **	−0.129 **	−0.081 **	−0.107 ***	−0.053 ***
	(0.013)	(0.009)	(0.018)	(0.011)	(0.016)
R^2	0.634	0.612	0.561	0.520	0.692
H_0 : $\Delta^{+}c_t = \Delta^{-}c_t$	4.381	3.041	1.983	4.737	3.046
p-value	0.003	0.001	0.024	0.018	0.000
H_0 : $\delta^{+}_{t-1} = \delta^{-}_{t-1}$	5.063	4.370	3.585	3.319	3.409
p-value	0.014	0.073	0.006	0.066	0.035

***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

4.4. Policy Implications

The result of this finding can have policy implications since asymmetric price transmission could be potentially linked to the exercise of market power, for example, (Peltzman 2000); (McCorriston et al. 2001); (Lloyd et al. 2006), with implications for consumer welfare. When there is a decrease in crude oil prices, the welfare gain is not evenly distributed among the gasoline retailers and consumers, as indicated by the less-than-proportionate pass-through (5% decline in regular gasoline retail prices for a 10% reduction in crude oil prices in California, for example). When there is a price increase, the welfare loss is also not evenly distributed among the buyers (consumers) and the sellers (gasoline retailers). In sum, the consumer will not fully benefit from a price reduction in the gasoline market and will incur more than a fair share of the welfare loss. Moreover, asymmetric price transmission can signal cooperative firm behavior and tacit collusion, which implies market failure. Furthermore, the welfare loss due to asymmetric price transmission could warrant policy intervention at the state level.

5. Conclusions

This paper investigates the asymmetric response of regular and premium retail gasoline to increases and decreases in crude oil prices in four states in the United States and at the national level. We apply an error correction model to examine the link and the price transmission. An asymmetric pattern in the regular and premium retail gasoline markets is found nationally and across four states. The asymmetric response occurs in both short-term and long-term adjustments.

The result suggests that the asymmetric pattern differs from state to state regarding speed adjustment at regular and premium retail gasoline markets. In addition, contemporaneous changes (within the week) in crude oil prices strongly affect retail gasoline prices in Florida and Texas. Additionally, the reaction to contemporaneous crude oil price decreases is smaller than the reaction to contemporaneous crude oil price increases. The asymmetric price transmission can affect consumer welfare since consumers cannot fully benefit from a price reduction. When there is a decrease in crude oil prices, the welfare gain is not evenly distributed among the gasoline retailers and consumers. Similarly, when there is a price increase, the welfare loss is also not evenly distributed among the buyers (consumers) and the sellers (gasoline retailers), providing a justification for policy interventions to address this market failure.

One of the limitations of this study is that the possibility of the impact of the impulse response functions and variance decomposition in the error correction model is not analyzed. It is worth applying impulse response and various decomposition in the context of price transmission, but it is left for future research.

Author Contributions: The authors contributed equally to this article. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data that support the findings of this study are openly available at http://www.eia.gov, accessed on 1 March 2023.

Conflicts of Interest: The authors declare no conflict of interest.

Notes

1. The alternative approach is the nonlinear autoregressive distributed lag (NARDL) model proposed by (Shin et al. 2014) for modeling asymmetric cointegration. The NARDL model has been used for asymmetry analysis in commodity and stock markets, for example, (Atil et al. 2014), (Kumar 2017), (Sadik-Zada and Niklas 2021).
2. A stable long-run relationship is required to estimate the ECM. First, the augmented Dickey–Fullerunit root tests (Dickey and Fuller 1979) on the price of gasoline and the price of crude oil strongly indicate that each series is integrated of order one for all datasets. As a second step, the Johansen cointegration test (Johansen 1988) is used to test for the number of cointegrating relations. The test statistics strongly indicate one cointegrating equation between all variables. As a last step, we test the hypothesis that the residuals are not stationary. In all cases, this hypothesis is rejected. Therefore, all variables are cointegrated, and Equation (1) represents a stable long-run relationship.
3. The Schwarz information criterion (Schwarz 1978) is used to determine the number of lags in each specification. Based on the SIC, two lags have been selected for both increases and decreases in the crude oil price and increases and decreases in retail gasoline price at the national level and in the state of New York. However, the optimal number of lags varies across other states, as can be seen in Tables 2 and 3.
4. The data of gasoline price series for other states were either suspended in 2011 or were inconsistent.
5. Source: Energy Information Administration.

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