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Test for asymmetry on the ex-pump price of premium gasoline in Ghana, Kenya, and Colombia

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Once again, the World has been faced with an oil price shock as a result of the SARS-CoV-2 coronavirus pandemic. This has resurrected an old debate of whether retail fuel prices adjust significantly to either increases or decreases in international crude oil prices. With many countries moving towards the deregulation of their petroleum sub-sector, the impact of the US dollar exchange rate on retail fuel prices cannot be overlooked.

This study investigates the rate at which positive and negative changes in international Brent crude oil prices and the US dollar exchange rate affected the increases or decreases in the ex-pump price of premium gasoline between February 2012 and December 2019. Using a non-linear auto-regressive distributed lag model, the exchange rate was found to play a significant role in fluctuations in the retail price of premium gasoline in Ghana and Colombia in the long run, however, the rate of adjustment between the negative and positive changes was not significant, dispelling the perception of price asymmetry. There was no significant relationship between the ex-pump price of premium gasoline and the international Brent crude oil price in Ghana and Kenya in the long run. This study recommends that the aforementioned countries prioritise the creation of exchange rate buffers to prevent exchange rate shocks that may affect retail fuel prices.

KEYWORDS: asymmetry, government policy, exchange rate

Demand for oil has all but dried up as lockdowns, due to the SARS-CoV-2 coronavirus pandemic, across the World have brought economic activities to their lowest point in recent times. The oil industry has been struggling with this tumbling

demand and infighting among producers about the reduction of output. This phenomenon, sharp increases or decreases, has been re-occurring over the course of history. Between December 2003 and June 2008, for example, nominal international fuel prices grew more than fourfold, with most of the increase occurring during 2007 and the first half of 2008 (*del Granado–Coady–Gillingham* [2012]).

Under such situations, governments are torn between the decision to either fully pass these sharp deviations on to domestic consumers or absorb them through subsidies or savings. Subsidies come with huge costs to the fiscal budget whereas savings deny domestic consumers the needed relief through price reductions (*del Granado–Coady–Gillingham* [2012]). Changes in oil prices are the result of a combination of factors. Aside from the crude oil price itself, the US dollar exchange rate is also considered a very important factor (*Zhang et al.* [2008]). Hence, several studies have tried to determine how retail prices of premium gasoline, diesel, or petrol adjust to increases or decreases in World crude oil prices and the exchange rate effect. These studies have reached mixed conclusions. However, the perception is that oil marketing companies adjust retail fuel prices upwards faster than they adjust them downwards and some authors have found the difference to be statistically significant.

After experimenting with fuel subsidies, most countries have started liberalising their sectors, making the role of the US dollar exchange rate variable more pronounced. The liberalisation agenda is always a politically sensitive issue to implement in developing countries. This is because the populace does not trust the government to use savings from lower oil prices (if the country is a net importer of crude oil) or budget savings from higher oil prices (if the country is a net exporter of crude oil) to their benefit.

Most studies have focused on countries that have deregulated their petroleum sub-sector to allow oil marketing companies (OMCs) to set their own prices without government interference. They mostly test asymmetry between the retail and the international crude oil prices, eliminating the exchange rate effect in this regard. However, asymmetry can also be tested in situations where governments play a major role in setting retail prices of petroleum products and also based on the movement of the US dollar exchange rate.

The present study resolves this problem by using a non-linear autoregressive distributed lag (NARDL) model which in this case measures the effect of positive and negative changes in the exchange rate and international Brent crude oil prices on the ex-pump price of premium gasoline in Ghana, Kenya and Colombia. The rest of the study is structured into five sections. Section 1 provides a review of the relevant literature, a description of the study area is introduced in Section 2, Section 3 delves into the data and the methodology used for this research, the results and analysis are presented in Section 4 and conclusions and recommendations are proposed in Section 5.

1. Literature review

Changes in oil prices are the result of a confluence of many factors. In international crude oil trading, the US dollar is mainly used as the invoicing currency. Therefore, fluctuations in the US dollar exchange rate are believed to underline volatilities of crude oil prices around the World. Its relative depreciation played a key role, for example, in soaring oil prices between 2002 and 2007 (*Zhang et al.* [2008]).

Among many sources of real disturbances, such as oil prices, fiscal policy, and productivity shocks, real exchange rate movements can be mainly explained by oil price changes. Exchange rate fluctuations can be attributed primarily to non-monetary shocks. *Clarida–Gali* [1994] and *Lastrapes* [1992] found that real shocks can account for more than 50% of the variance of real exchange rate changes over all time horizons (*Chen–Chen* [2007]).

1.1. Effect of exchange rate shocks on oil prices

Using monthly panel data of G7 countries, *Chen–Chen* [2007] suggested that real oil prices may have been a dominant source of real exchange rate movements and that there is a link between real oil prices and real exchange rates. They used different measures of oil prices, UAE (United Arab Emirates) price of oil (Dubai), British price of oil (Brent), and the US West Texas Intermediate price of oil compared to other studies that have used only one.

On the other hand, *Backus–Crucini* [2000] found that oil accounts for much of the variations in the terms of trade over the last 25 years and its qualitative role varies significantly over time. The results of their dynamic general equilibrium model suggested that the economy responds differently to oil supply shocks than to other shocks.

Crude oil exporting countries may lose from a weak US dollar while benefiting from a strong US dollar. Hence, when the prospects of the US dollar are not considered promising, a large amount of money will flow to the oil market, driving up oil prices (*Zhang et al.* [2008]). A depreciation of the US dollar reduces oil price to foreigners relative to the price of their commodities in foreign currencies and thus escalating their purchasing power and oil demand, consequently pushing up the US dollar price of crude oil (*Uddin et al.* [2013]).

Golub [1983] and *Krugman* [1983] note the role of oil prices in explaining exchange rate movements. Basically, a country exporting oil may face exchange rate appreciation when oil prices rise and depreciation when oil prices fall, whereas the case is the opposite for an oil-importing country. Oil is a homogenous and internationally traded commodity priced in US dollars.

1.2. Effect of crude oil prices on retail prices of gasoline

Most studies have sought to determine how retail prices of gasoline, diesel, or petrol adjust to increases or decreases in World crude oil prices. In testing the hypothesis put forward in the *Monopolies and Mergers Commission's* reports [1965], [1979], [1990] that the speed of adjustment of UK retail gasoline prices to cost changes is more rapid when costs rise than when they fall, *Bacon* [1991] found no evidence of faster and more concentrated response to cost increases between 1982 to 1989. *Reilly–Witt* [1998] extended the dataset to 1995 using monthly data and confirmed the conclusions of *Bacon* [1991]. They claim that the asymmetry response by petrol retailers to crude oil price rises and falls is rejected by data over the period examined, and the same occurs for the exchange rate variable. *Bettendorf–van der Geest–Varkevisser* [2003] also studied asymmetry in the Dutch consumer petrol market and like *Bacon* [1991], found that the effect of asymmetry on the Dutch consumer costs is negligible.

Liu–Margariti–Tourani–Rad [2010] drew a different conclusion when they studied the New Zealand market. Using an asymmetric error correction model (ECM), they examined how pre-tax petrol and diesel prices respond to changes in crude oil prices. They revealed that oil companies adjusted diesel prices upwards faster than they adjusted them downwards and the difference was statistically significant. However, the authors also determined a significant relationship for petrol suggesting that diesel prices may not be as competitive, backing the call for government actions and monitoring.

1.3. Dealing with irregularities in the retail sector of premium gasoline

Households are generally against domestic fuel price increases. This is because such increases generally (directly or indirectly) lead to higher prices for fuels consumed for cooking, heating, lighting, and private transport with final consequences on the cost of production and consumer prices. However, the degree of impact is dependent on the explanatory power of these factors across different income groups (*del Granado–Coady–Gillingham* [2012]).

Recent volatility in international fuel prices has highlighted the fiscal risk inherent in the current approach to fuel pricing in many developing and emerging countries (*Coady et al.* [2013]). In most of these countries, domestic fuel prices are administratively determined and increases in international fuel prices are often not fully passed through to domestic consumers. This has often been in the form of unpaid subsidies leading to huge fiscal costs over long periods. These and other

factors have increased the call for developing countries to implement a pricing formula that will ensure pass-through over the medium term and avoid sharp increases and decreases in domestic prices (Coady *et al.* [2013], Coady *et al.* [2017]).

The foregoing solution is always a politically sensitive issue to implement in developing countries. This is because there is a lack of trust in the government to use savings from lower oil prices (if the country is a net importer of crude oil) or budget savings from higher oil prices (if the country is a net exporter of crude oil) for the benefit of the populace. Furthermore, high income groups arguably benefit the most from fuel subsidies and consequently poverty among lower income groups increases. Unless reform policies are able to deal with these problems in developing economies, subsidy reforms are less likely to succeed (*del Granado–Coady–Gillingham* [2012]). The problem is also compounded by the irregular nature of retail fuel prices in developing countries due mainly to the political aspect. Prices are not often adjusted downwards when there is a significant appreciation and/or a reduction in international crude oil prices. However, any slight depreciation and/or an increase in international crude oil prices is sufficient justification for the government and its agents to increase domestic retail fuel prices (Kojima [2009]).

It is clear from the cited literature that the level of fuel price asymmetry is market specific. It is heavily dependent on effective monitoring and implementation of a good pricing mechanism. In countries that have this in place, retail prices of petrol or gasoline adjust to price increases or decreases at the same rate. Most studies have focused on countries that have deregulated their petroleum sub-sector to allow OMCs to set their own prices devoid of government interference. They mostly test asymmetry between the retail fuel prices and the international crude oil prices, eliminating the exchange rate effect in this regard. However, asymmetry can also be tested in situations where governments play a major role in setting retail prices of petroleum products and also based on the movement of the US dollar exchange rate. This can test whether petroleum prices adjust more quickly to cost increases than to cost decreases. The current study examines the case of Ghana, Kenya, and Colombia, taking into consideration the fact that Ghana and Kenya import more crude oil than they export.

2. Study area

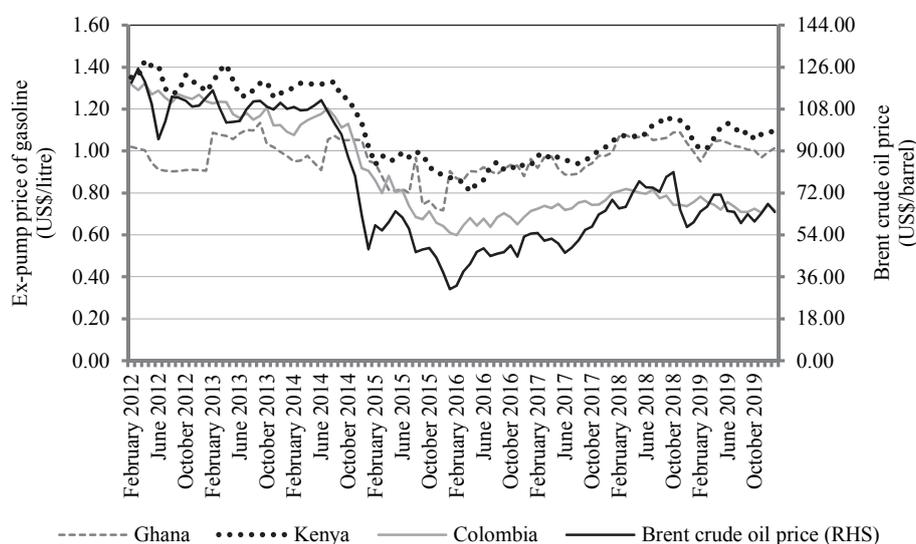
The study focuses on Ghana and Kenya with a similar study on Colombia to serve as a control experiment. The former two countries are all lower middle-income countries in Sub-Saharan Africa. As mentioned previously, both import more crude

oil than they export, especially in terms of their share of crude oil receipts. As a result, these countries are expected to benefit/lose significantly when the price of crude oil falls/increases. On the other hand, Colombia is a middle-income country but also an oil producer with similar regulatory problems to Ghana and Kenya. The policy situations in the study countries in terms of how they have managed the retail crude oil/gasoline sub-sector are discussed below.

The governments of Kenya and Ghana, and to some extent Colombia, used to set the wholesale and retail prices of fuel with the main objective of ensuring low consumer pricing (subsidies). The tariff structure adopted by these countries aimed at the maximisation of government revenue and the subsidisation of kerosene. The argument was that low-income consumers had to be protected but the implementation of this tariff structure proved to be ineffective as it had no effect on the incomes of poor households. For these households, low incomes meant that there was no motivation to use more efficient fuels.

Between 1994 and 2005, Kenya deregulated its petroleum sub-sector. Oil marketers had the authority to import oil in crude or refined form. They adopted a pricing system that allowed them to set their own margins and consumer prices. The market was open to competition, which saw the entry of many small players but the government could not effectively monitor and control their operations on the ground due to lack of efficient licensing systems. As a result, there were increased cases of dumping, tax evasion, product adulteration, and substandard retail outlets. In a bid to manage this situation, the Kenyan Government introduced price regulation in the petroleum sector through the enactment of laws to tighten its control of the sector in 2006 (*Mutero [2017]*).

Prior to 2015, Ghana had also attempted to implement an automatic adjustment formula – to help deregulate the pricing of fuel or gasoline. However, this was not successful, mainly due to lack of political will to ensure pass-through when there were increases in the Brent crude oil prices. At the same time, the Government of Ghana signed a memorandum of understanding with OMCs and other distributors to import finished petroleum products through competitive tendering to supplement supply from the country's refinery (Tema Oil Refinery). The price at which these bulk distribution companies (BDCs) supplied the economy with fuel was mostly different from the price at which the Government or the National Petroleum Authority (NPA) directed them to sell to the market. This led to price under- and over-recoveries – an under-recovery means that fuel consumers are paying too little for the product, whilst in an over-recovery situation, consumers are paying too much for that. Thus, the NPA set prices that were lower than the supply contract price as per the NPA's supply contract formula. With under-recoveries, the government were indebted to the BDCs and vice versa if there were over-recoveries (*IMF [2015]*).

Ex-pump price of premium gasoline and Brent crude oil price, February 2012–January 2020

Source: NPA, Kenya National Bureau of Statistics, globalpetrolprices.com

An attempt by the Ghanaian Government to manage its Forex reserve also led to a new form of under-recovery known as foreign exchange (FX) loss under-recovery. This occurs when the FX rate used by the NPA or government in determining the ex-refinery price of retail fuel or gasoline is lower than the FX rate at which the NPA or government provides US dollars to the BDCs through the Bank of Ghana to pay for the imported or procured products. These and many factors brought about a huge debt in the sector that banks held as non-performing loans on their books. During these periods, compared to Kenya and Colombia, Ghana's ex-pump price of gasoline was the lowest. This was mainly due to low taxes and higher ex-refinery prices when Brent crude oil prices were falling in 2014 (see the figure and the Appendix).

With a sharp fall in crude oil prices in 2014, Ghana seized an opportunity to deregulate the oil sub-sector, which paved the way for a successful implementation of the automatic adjustment formula. The Ghanaian Government argued that the deregulation would free scarce FX resources and government revenue for other development projects. In other words, the deregulation of the petroleum downstream sector has meant removing the government from the control and regulation of petroleum downstream business.

In Colombia, gasoline and diesel have been explicitly or implicitly subsidised since 1983. Starting in 1998, the government had tried unsuccessfully to eliminate the fuel subsidy. In 2003, the government again attempted to gradually remove the subsidy. It based its decision on the fact that the subsidy was highly regressive and costly for the state. However, subsidies still exist, albeit at a lower level, and the last steps to eliminate them are proving difficult. Public opinion holds a very dim view of increases in fuel prices. Colombians do not understand why, despite its status as an oil producer and exporter, the country has the highest gasoline prices in Latin America behind Uruguay, Brazil, and Chile. Their obvious points of comparison are Venezuela and Ecuador, two countries with extremely low fuel prices and high government subsidies (*Romero–Etter* [2013]).

To avoid a re-occurrence of these situations (irregular implementation of subsidies and transparency fuel pricing), new formulas to calculate producer income regarding gasoline and diesel were implemented in Colombia in November 2011 and November 2012. While these formulas are also based on producers' opportunity costs, the way producers' income is set has become more transparent compared to the past (*Romero–Etter* [2013]).

An interesting characteristic of a deregularised petroleum market is that the products are similar and the supplier costs structures are alike under a cooperative distribution system and with prices and margins set on an industry-wide basis (*Liu–Margaritis–Tourani-Rad* [2010]).

As noted in the Appendix, taxes and levies make up a significant portion of retail fuel prices in Ghana and any changes in government taxes and levies can therefore have a significant impact on retail diesel and petrol prices (*Liu–Margaritis–Tourani-Rad* [2010]). Through the deregulation that the country has implemented, the Parliament of Ghana continues to determine petroleum taxes and levies by the issuance of an Act of Parliament. *Rietveld–van Woudenberg* [2005] refers to the differences in taxes as the reason why fuel prices differ from one country to the other.

3. Data and methodology

Data were sourced from the International Monetary Fund's international financial statistics, Kenya National Bureau of Statistics, and globalpetrolprices.com. They track retail prices of motor fuel, electricity, and natural gas in over 150 countries. Each data point is cross-checked using multiple sources and without automation. For instance, the ex-pump price of fuel in Ghana was determined using data from the NPA and OMCs (total and allied); the NPA has stopped providing data on

monthly fuel prices since the sector was deregulated in 2015. The data used for the analysis span from February 2012 to December 2019. Data availability was one of the limiting criteria in deciding on the sampled countries.

Various methods have been used to examine asymmetry in the petroleum sub-sector. *Bacon* [1991] proposed a quadratic quantity adjustment model to test this hypothesis. Most studies including *Reilly–Witt* [1998], *Bettendorf–van der Geest–Varkevisser* [2003], and *Liu et al.* [2010], applied the ECM for this purpose. *Radchenko* [2005] used both the partial adjustment model and the vector autoregressive model for the construction of the gasoline price impulse response and asymmetry measures. *Karantininis–Katrakylidis–Persson* [2011], *Greenwood–Nimmo–Shin* [2013], *Atil–Lahiani–Nguyen* [2014], *Alsamara et al.* [2017], and *Kisswani* [2019] among others, have recently adopted the NARDL model to measure price asymmetry especially in the oil sub-sector. The popularity of this model is based on the fact that it is one of the simplest forms of non-linear ECMs (*Greenwood–Nimmo–Shin* [2013]).

Before the adoption of the NARDL model, its predecessor, the autoregressive distributed lag (ARDL) model was also popularly used. The ARDL model like the one specified in Equation /1/, assumes a linear combination of y_t and x_t , which indicates a symmetric adjustment in the long and the short run (*Alsamara et al.* [2017]).

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta x_{t-1} + r\mathbf{w}_t + \sum_{i=0}^{p-1} \alpha_i \Delta y_{t-1} + \sum_{i=0}^{q-1} \delta_i \Delta x_{t-1} + \mu_t \quad /1/$$

where α is the intercept, while ρ , θ , r , α and δ are coefficients associated with a linear trend. p and q are the lag variables of the dependent and explanatory variables, respectively. \mathbf{w}_t is a vector of deterministic variables and μ_t is an *iid* (independent and identically distributed) stochastic process. The two variables y_t and x_t in Equation /1/ are not cointegrated if $\rho = \theta = 0$.

The relationship between these variables can also be non-linear, which makes the use of a linear model misleading. The ECM and NARDL models were proposed to deal with this problem. Since the ARDL is a cointegrated model, it was thus suggested that an ECM provides a more appropriate specification for testing asymmetric price transmission. Proponents of these models make tests for cointegration and the existence of a cointegrated relationship a must because if there is no cointegration, then there is no price transmission, which means there cannot be any asymmetric price transmission either, and the results will have no economic meaning since the two prices have no relationship (*Karantininis–Katrakylidis–Persson* [2011]). This strict application of the ARDL model has been relaxed by recent studies.

The reason was that a long-run relationship between two series will prevent them from drifting apart. This implies that the test for asymmetry can only be prudent in the short run with respect to the speed of adjustment. Analysis of the magnitude of the asymmetry is not possible. This is because such asymmetry suggests that there is a permanent divergence between positive and negative price changes, which in the long run means that the series cannot be cointegrated. Another disadvantage is that if there is asymmetry in the series, this may confuse the standard tests such as the Dickey-Fuller unit root test and the Johansen test for cointegration (*Karantininis–Katrakylidis–Persson* [2011]).

Due to these shortfalls in some of the models illustrated above, this study adopts the NARDL model used by *Alsamara et al.* [2017] because it can be applied irrespective of the order of integration of the regressors. This allows for statistical inferences on long-run estimates, which are not possible under alternative cointegration techniques. Based on the ARDL model in Equation /1/, the NARDL model is developed by first breaking the x_t variable into negative and positive partial sums as shown in Equation /2/:

$$x_t = x_0 + x_t^+ + x_t^- \quad /2/$$

$$\text{where } x_t^+ = \sum_{i=1}^t \Delta x_i^+ = \sum_{i=1}^t \max(\Delta x_i, 0) \text{ and } x_t^- = x_t^+ = \sum_{i=1}^t \Delta x_i^- = \sum_{i=1}^t \max(\Delta x_i, 0).$$

The non-linear asymmetric cointegration regression can be expressed as

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \mu_t \quad /3/$$

where β^+ is the long-run coefficient associated with the positive change in x_t and β^- is the long-run coefficient associated with the negative change in x_t . *Shin–Yu–Greenwood–Nimmo* [2014] revealed that by substituting Equation /3/ in the ARDL (p, q) model presented in Equation /1/, we obtain the following non-linear asymmetric conditional ARDL:

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + r\mathbf{w}_t + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{q-1} (\delta_i^+ x_{t-1}^+ + \delta_i^- x_{t-1}^-) + \mu_t \quad /4/$$

$$\text{where } \theta^+ = \frac{-\rho}{\beta^+} \text{ and } \theta^- = \frac{-\rho}{\beta^-}.$$

Equation /4/ is estimated using the standard ordinary least squares, checking for cointegration between the levels of the series, and testing the long- and short-run

symmetry using the Wald test. The equation is used to derive dynamic multipliers m_h^+ and m_h^- associated with changes in x_t^+ and x_t^- .

The dependent variable is the change in the natural log of the ex-pump price of premium gasoline (*DLNGAS*). The independent variables are the natural log of Brent crude oil prices (*LN_BRENT*), the benchmark used by Europe and the rest of the World, and the exchange market pressure (EMP) index. The EMP index used in this study is similar to that introduced by *Girton–Roper* [1977]. Before settling on this, different versions of the index were estimated and the one with the simple average of exchange rate changes and a foreign reserve depletion indicator to capture the reaction function of policy authorities was identified as the most responsive (*EMP_2*). The Eviews software was used for the estimation and also to automatically select the appropriate lags for the dependent and explanatory variables.

4. Results and analysis

The NARDL model presented in Table 1 breaks the independent variables into two parts. Thus, measuring both the positive and negative changes in Brent crude oil prices and the EMP index, the following is sought to be investigated: Whether the effect of increasing Brent crude oil prices is the same as that of decreasing Brent crude oil prices, and whether the effect of the increasing EMP index is the same as that of the decreasing EMP index. According to Table 1, in the short run, the previous second, fifth and ninth months all had a significant negative effect on fluctuations in the ex-pump price of premium gasoline in Ghana. In Kenya, changes in ex-pump premium gasoline prices had a significant negative relationship with previous ex-pump gasoline prices. This conclusion is not different from the control experiment that uses Colombia as the study country.

Increases in the Brent crude oil prices did not have any significant impact on the changes in the ex-pump price of premium gasoline in Ghana over the study period. However, in Kenya and Colombia, the third and sixth lags were positively and significantly correlated with the ex-pump price changes, respectively. The significance level was 10% for Kenya and 5% for Colombia. There was a strong association between the first lag of negative changes in the Brent crude oil prices and the changes in the ex-pump price of premium gasoline in Kenya. This is similar to the case in Colombia where a significant relationship between the third lag of the negative changes in Brent crude oil prices and the changes in the ex-pump price of premium gasoline was found, too. This was also true for the seventh, eighth and ninth lags in the case of Ghana.

Table 1

NARDL model for the changes in the log of premium gasoline prices

Variable	Ghana		Kenya		Colombia	
	Coefficient	<i>t</i> -statistic	Coefficient	<i>t</i> -statistic	Coefficient	<i>t</i> -statistic
<i>DLNGAS(-1)</i>	-0.162	-1.400	-0.343	-2.919*	-0.250	-4.241*
<i>DLNGAS(-2)</i>	-0.306	-2.522**	-0.423	-3.708*	-0.129	-3.400*
<i>DLNGAS(-3)</i>	-0.123	-0.955	-0.191	-1.775***		
<i>DLNGAS(-4)</i>	-0.074	-0.582	-0.373	-3.465*		
<i>DLNGAS(-5)</i>	-0.280	-2.290**				
<i>DLNGAS(-6)</i>	0.070	0.640				
<i>DLNGAS(-7)</i>	-0.058	-0.563				
<i>DLNGAS(-8)</i>	-0.102	-1.097				
<i>DLNGAS(-9)</i>	-0.190	-2.109**				
<i>LN BRENT POS</i>	0.090	0.500	0.077	0.885	0.008	0.201
<i>LN BRENT POS(-1)</i>	0.117	0.539	-0.054	-0.472	0.017	0.333
<i>LN BRENT POS(-2)</i>	0.154	0.682	0.109	1.003	0.030	0.587
<i>LN BRENT POS(-3)</i>	-0.272	-1.146	-0.144	-1.828***	-0.062	-1.358
<i>LN BRENT POS(-4)</i>	-0.371	-1.637			-0.028	-0.617
<i>LN BRENT POS(-5)</i>	0.290	1.296			0.064	1.414
<i>LN BRENT POS(-6)</i>	0.261	1.090			-0.074	-2.352**
<i>LN BRENT POS(-7)</i>	-0.293	-1.555				
<i>LN BRENT NEG</i>	0.004	0.034	-0.013	-0.213	0.011	0.350
<i>LN BRENT NEG(-1)</i>	0.127	0.649	0.280	2.974*	0.077	1.816***
<i>LN BRENT NEG(-2)</i>	-0.086	-0.442	-0.037	-0.380	0.024	0.575
<i>LN BRENT NEG(-3)</i>	0.230	1.154	0.052	0.535	-0.074	-2.491**
<i>LN BRENT NEG(-4)</i>	-0.023	-0.110	-0.134	-1.586		
<i>LN BRENT NEG(-5)</i>	-0.211	-1.063	-0.074	-0.911		
<i>LN BRENT NEG(-6)</i>	-0.165	-0.843	-0.085	-1.050		
<i>LN BRENT NEG(-7)</i>	0.478	2.332**	-0.061	-0.739		
<i>LN BRENT NEG(-8)</i>	-0.493	-2.616**	-0.028	-0.332		
<i>LN BRENT NEG(-9)</i>	0.237	1.885***	0.084	1.634		
<i>EMP 2 POS</i>	-0.489	-2.344**	-0.252	-1.667	-1.044	-19.755*
<i>EMP 2 POS(-1)</i>	-0.003	-0.011	0.055	0.314		
<i>EMP 2 POS(-2)</i>	-0.453	-1.720***	-0.020	-0.121		
<i>EMP 2 POS(-3)</i>	0.764	3.003*	0.303	1.818***		
<i>EMP 2 POS(-4)</i>	-0.520	-2.399**	-0.331	-1.998***		
<i>EMP 2 POS(-5)</i>			-0.001	-0.004		
<i>EMP 2 POS(-6)</i>			-0.257	-1.554		
<i>EMP 2 POS(-7)</i>			0.315	1.765***		
<i>EMP 2 POS(-8)</i>			0.394	2.324**		
<i>EMP 2 POS(-9)</i>			-0.343	-2.368**		
<i>EMP 2 NEG</i>	-0.494	-4.472*	-0.147	-1.089	-0.912	-15.617*
<i>EMP 2 NEG(-1)</i>	0.181	0.790			-0.253	-3.011*
<i>EMP 2 NEG(-2)</i>	-0.072	-0.279				
<i>EMP 2 NEG(-3)</i>	-0.815	-3.206*				
<i>EMP 2 NEG(-4)</i>	0.811	3.179*				
<i>EMP 2 NEG(-5)</i>	-0.641	-2.913*				
<i>EMP 2 NEG(-6)</i>	0.208	1.927***				
α	0.032	1.882***	0.008	0.519	0.026	6.933*
R^2	0.775		0.745		0.945	
Adjusted R^2	0.581		0.611		0.933	
Durbin-Watson statistic	1.917		2.116		2.156	

*** $p < 0.1$, ** $p < 0.05$, * $p < 0.01$.

Note. The appropriate lags for the dependent and explanatory variables were selected based on the information criteria, by using the Eviews software.

Both positive and negative lag movements of the EMP index had mostly significant impacts on fluctuations in the ex-pump price of premium gasoline for Ghana, Kenya, and Colombia. This highlights the importance of the exchange rate and the policy response in terms of retail gasoline prices in these three countries in the short run.

The long-run form of the estimated NARDL model (see Table 2) largely confirms the findings in the short-run form in Table 1. The results indicate that, except for Colombia, there was no significant relationship between positive/negative changes in Brent crude oil prices and fluctuations in the ex-pump price of premium gasoline over the study period. For Colombia, a unit increase in Brent crude oil prices led to a 0.033 fall in the ex-pump price of premium gasoline. In addition, a unit decrease in Brent crude oil prices resulted in a 0.028 fall in the ex-pump price of premium gasoline (because we are dealing with negative changes). This is expected as fuel prices in Colombia are still subsidised despite the reforms in 2012. It is further compounded by the fact that its neighbours sell fuel at far lower prices at the pumps (Romero–Etter [2013]).

Also in the long run, there were significant relationships between the positive/negative movements in the exchange rate (EMP_2) and the ex-pump price of premium gasoline in Ghana and Colombia, but not in Kenya. In Ghana and Colombia, a unit increase in the EMP index (appreciation pressure) brought about a 0.315 and 0.757 fall in the ex-pump price of gasoline, respectively. On the other hand, a unit fall in the EMP index (depreciation pressure) induced a 0.370 and 0.845 increase in the ex-pump gasoline prices, respectively.

The long-run results reveal that over the study period the exchange rate was very significant in determining the ex-pump price of gasoline in the countries except for Kenya. The situation in Kenya was probably due to the fact that the country is ‘moving back and forth’ in terms of the regulation of the retail fuel sub-sector: price regulation prior to 1994, price deregulation from 1994 to 2005, and then back to price regulation from 2006 onwards. A Wald test conducted on the positive and negative changes of the EMP index did not suggest that these effects were significantly different from each other for all countries. In Ghana, the study period corresponds mostly with the period since the price deregulation in 2015. This may have accounted for the significance of the EMP index and for the acceptance of the null hypothesis of the Wald test on the equal effects of positive and negative EMP index movements on the changes in the ex-pump premium gasoline prices.

The diagnostics tests have accepted the null hypothesis of no autocorrelation and no heteroscedasticity between the residuals of the models estimated. Furthermore, the null hypothesis of normality was accepted for all cases except for the model for Colombia.

Table 2

Long-run form of the NARDL model

Variable	Ghana		Kenya		Colombia	
	Coefficient	<i>t</i> -statistic	Coefficient	<i>t</i> -statistic	Coefficient	<i>t</i> -statistic
<i>LN_BRENT_POS</i>	-0.010	-0.485	-0.005	-0.685	-0.033	-3.653*
<i>LN_BRENT_NEG</i>	0.044	1.193	-0.007	-0.736	0.028	2.599*
<i>EMP_2_POS</i>	-0.315	-2.799*	-0.059	-0.806	-0.757	-14.362*
<i>EMP_2_NEG</i>	-0.370	-3.384*	-0.063	-1.091	-0.845	-17.023*
<i>C</i>	0.015	2.093**	0.004	0.523	0.019	6.959*

*** $p < 0.1$, ** $p < 0.05$, * $p < 0.01$.

5. Conclusion

This study has investigated the problem of price asymmetry in the petroleum sub-sector of Ghana, Kenya, and Colombia. This was driven by the fact that the retail price of petrol or gasoline is expected to be affected by the World price of Brent crude oil and the US dollar exchange rate. In this respect, the literature discussed herein confirms the determining effect of these two variables on the ex-pump price of petrol or gasoline. How retail prices respond to changes in these important variables has often been discussed. The general perception is that prices are likely to adjust faster upwards than downwards. To measure this phenomenon, the present study has adopted a relatively new method, NARDL, which is used to estimate the effect of positive and negative changes in various variables on a price variable. This model was chosen because it deals with the problem of non-linearity of the pricing variable and with both short- and long-run effects of the variables.

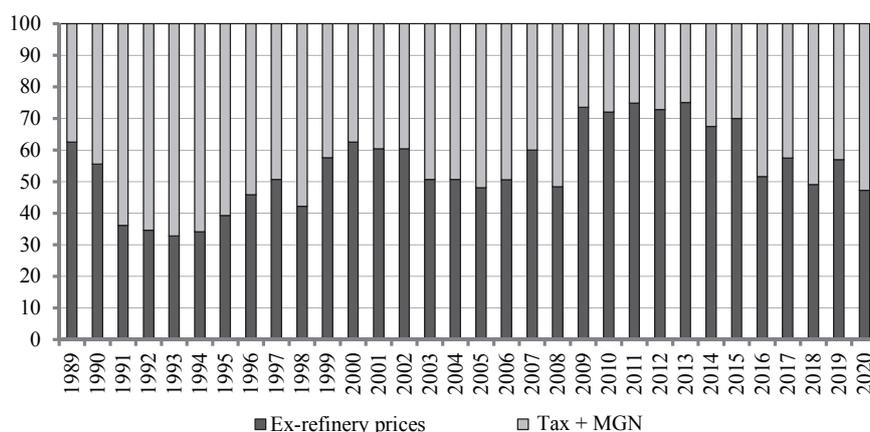
The results have revealed that the positive and negative movements in the US dollar exchange rate over the study period, measured by the EMP index, were significant in determining fluctuations in the ex-pump price of premium gasoline in the short run for Ghana, Kenya, and Colombia and in the long run for Ghana and Colombia. The null hypothesis of the equality of these effects was accepted. Increases and decreases in the international Brent crude oil prices all led to falls in the ex-pump price of petrol or gasoline in Colombia in the long run. This was due to the fact that Colombia's petroleum sub-sector is still regulated by the government even though its fuel price is low among its neighbours. Neither international Brent crude oil prices nor the EMP index was significant in determining changes in the ex-pump

price of petrol or premium gasoline for Kenya in the long run. This was caused by the shifts between regulation and deregulation in the country's petroleum sub-sector over the study period.

The study suggests that the exchange rate is likely to be an important variable in determining the ex-pump price of petrol or gasoline once the petroleum sub-sector moves towards deregulation, as is evident in the case of Ghana. The policy recommendation in this case would be to allow the exchange rate to freely float but, considering its effects, if there is excessive depreciation or appreciation pressure, accumulation of reserves is recommended as an immediate solution to prevent exchange rate shocks. However, this solution also comes with the opportunity cost of using these reserves for the much-needed investments in these countries. The effect of taxes cannot also be ignored once deregulation takes place – this is the case in Ghana.

Appendix

Components of the ex-pump price of premium petrol in Ghana



Note. MGN: processing or storage margins of premium gasoline producers.

Source: NPA and own estimates.

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