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World Crude Oil price, Domestic Fuel Pump prices and Food price Dynamics; Evidence of Asymmetric Pass through Effect in Kenya

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Abstract

Macroeconomic stability is one of the key policy targets pursued by economic policy makers. One of the important indicators of macroeconomic stability is Inflation measured using the consumer price index. Largely, inflation in Kenya is attributed to soaring food prices or external shocks reflected in world crude oil price. This study therefore sought to understand the dynamic relationship between crude oil prices, domestic fuel pump prices and inflation. The study employed linear and nonlinear Autoregressive Distributed Lag Model (ARDL) to unearth these dynamics. The results reveals existence of asymmetric and symmetric response in pump fuel prices and consumer food prices respectively to world crude oil prices.

Keywords: World crude oil, food prices, asymmetric pass-through effect

1. Introduction

Kenya is a net importer of mineral fuels, mineral oils and products of their distillation since independence. In the last five years, the value of oil and oil related imports amounting into 12 Billion USD contributing upto 15% of the total imports bill. More than 80% of the total oil imports for the last five years are predominantly sourced from United Arab Emirate (32%), India (24%) and Saudi Arabia (20%). Other sources are Bahrain (3%), Iran (3%), Oman (2%), Netherlands (2%) and South Africa (2%). The distribution of 80% of the value of oil and oil related imports into Kenya by source are presented in figure 1.

Locally, the oil market is structurally oligopolistic. Kenya has a total of 60 registered oil firms but more than 75% the market is controlled by five large firms. These large market players and their respective market shares are; Vivo Energy Kenya (28%), Total Kenya Limited (23%), Kenol Kobil (10%), National Oil Corporation of Kenya (7.4%) and Libya Oil Kenya (7.2%). A similar market structure is observed in

China by Long, & Liang, (2018). Consequently, when the global oil price rises, the importing costs of domestic petroleum importing entities also rise. Since a few firms control the market, they have the market power to raise refinery prices process to desirable profit levels. Given that refined oils are inputs of a variety of industrial products, consequently, production cost is passed to retail prices through the entire supply chain. Eventually the Consumer Price Index (CPI) might be affected to a large extend. Based on this perceived chain of causality, Kenya decided to regulate domestic oil prices.

Figure 1: Main source of crude oil in Kenya

Through an act of parliament, Kenya established Energy and Petroleum Regulatory Authority (EPRA) as the successor to the Energy Regulatory Commission (ERC) to regulate, importation, refining, exportation, transportation, storage and sale of petroleum and petroleum products with the exception of crude oil. The authority undertakes retail pricing of petroleum products (Diesel, Super Petrol and Kerosene) as stipulated in the Energy (Petroleum Pricing) Regulations, 2010. However, such regulations seldom shield consumers from world oil price shocks which are entirely external to the domestic economy. Similarly, the oligopolistic market structure seems to contribute to oil price rigidities.

As argued in Lacheheb, & Sirag, (2019), the effects of oil price fluctuations to the inflation rate is well established, both theoretically and empirically. Facing a high oil price level, firms may either select to cut down production or translate it to higher level of output to consumers. In the same way, oil price reduction would lower the production cost and as a result the price level. However, oil price decrease may not lower the price level of goods in a downward rigidity in nominal wages, or market suppliers that hold price levels up. Similarly, Long & Liang, (2018) argues that fluctuations of oil prices are exogenous shocks to the economy, and oil price changes are directly related to the production cost of the product, which affects the changing price levels. It is widely accepted that oil price shocks at least partially pass through into inflation (Chen, 2009).

In Kenya, the World Bank commodity outlook report for 2019 reveals that oil prices and inflation have a positive correlation. As noted in the World Bank report, the cause-effect relationship is two folds; directly through higher pump prices and production costs and indirectly through the effect of US dollar pricing given petroleum imports account for nearly 15% of the country's import bill.

Figure 2: World oil price index (USD per barrel), Consumer Price Index (CPI) and domestic fuel pump prices in Ksh (per Litre)

Historically, domestic pump prices closely but sluggishly mirror the world prices as illustrated in figure 2. World oil price dynamics are closely linked to supply side changes and narrowly tied to continued supply rebalancing by Organization of the Petroleum Exporting Countries (OPEC). Between 2000 and 2004, world oil prices rose gradually majorly due to the US invasion of Iraq in 2003 which created uncertainty about the future supply of oil. Also, there was a notable increase in demand for oil in Asia especially in China contributing to a rise from $28.38 in July 2000 to over $115.6 in July 2008 per barrel. Immediately, after 2008, crude oil price experienced a tumbling as a result of the global financial crisis, reaching $44 per barrel in 2009. Afterwards, price rises to $44 in the fourth quarter of 2012 owing to Arab Spring of 2011, which created substantial supply shortages. Subsequent hydraulic fracturing technological advancement in USA has reduced OPEC's influence and caused prices to fall from $106.8 per barrel in June 2014 to below $32 in 2016. Recently, the collusion between OPEC and Russia to implement production cuts up to 2022 have steadily driven the oil prices up.

Normally, an increase in world prices is mostly cited locally as the driver of local consumer prices. For instance, commodity markets outlook report in 2019 by the World Bank shows that sharp food price changes are expected stemming from energy price fluctuations. Increase in food prices has far reaching implications in a small open economy. At the macroeconomic level, food price increases raise inflation and contribute to terms of trade shocks. At the microeconomic level, for households that are net sellers of food products, rising food prices can increase real incomes.

However, on average, higher food prices raise poverty, reduce nutrition, and curtail the consumption of essential services such as education and health care (World Bank 2011). As noted in (World Bank 2009) net food-importing countries usually counter rising food prices by lowering or abolishing trade tariffs on food items. These policies are often complemented with social safety net programs such as cash transfers or school feeding programs. Kenya has occasionally used trade related policies to address scarcity of cereals especially in the year 2017, 2018 and 2019.

To appreciate effective policies dealing with local fuel and food prices, it is crucial we understand the dynamic relationship in food prices, crude oil prices and local fuel prices. This study used both linear and nonlinear Auto Regressive Distributed Lagged Model (ARDL) to unearth the dynamics.

2. Literature Review

Changes in crude oil price has been linked to major economic growth episodes in both developed and developing economies. Hamilton (1983) shows that rising oil prices are responsible for nine out of ten of the U.S. recessions since the Second World War, thus amplifying the negative implications of oil price changes on output growth. Although the link to economic growth is proven, a strand of literature alludes that the transmission process is not symmetric. Lardic and

Mignon, (2008) supports this argument but emphasizes that the links between oil price and economic growth, have become weaker in recent years.

A couple of research papers have sought to address the dynamic relation between crude oil prices and domestic price levels with a special focus to determine if the relation is symmetric or asymmetric. Atil, Lahiani, & Nguyen, (2014) used the recently developed nonlinear autoregressive distributed lags (NARDL) model to examine the pass-through of crude oil prices into gasoline and natural gas prices. NARDL approach allows for a simultaneously test of the short- and long-run nonlinearities through positive and negative partial sum decompositions of the predetermined explanatory variables. It also offers the possibility to quantify the respective responses of gasoline and natural gas prices to positive and negative oil price shocks from the asymmetric dynamic multipliers. The results obtained by Atil et . al , (2014) indicate that oil prices affect gasoline prices and natural gas prices in an asymmetric and nonlinear manner, but the price transmission mechanism is not the same.

A similar approach to Atil et. al, (2014) is applied by Bala, & Chin, (2018) where the later investigates the asymmetric impacts of oil price changes on inflation in Algeria, Angola, Libya, and Nigeria . This study partitioned the oil price into positive and negative changes to capture asymmetric impacts and found that both the positive and negative oil price changes positively influenced inflation. However, the impact was found to be more significant when the oil prices dropped. Likewise, based on an augmented Phillips curve framework, Long & Liang, (2018) employed both the autoregressive distribution lag (ARDL) and nonlinear and asymmetric autoregressive distribution lag (NARDL) model to investigate pass-through effects of crude oil price on China’s producer prices index (PPI) and consumer prices index (CPI). It was found that the impact of global oil price fluctuations to China’s PPI and CPI are asymmetrical in the long run, and the long-term impacts of the rise in global oil prices on PPI and CPI are greater than the global oil price decline on PPI and CPI. In addition, the symmetric ARDL model failed to diagnose the impact of oil price to China’s PPI and CPI.

NARDL model has also been applied on environmental issues especially on carbon dioxide (CO2) emission allowance prices. Hammoudeh, Lahiani, Nguyen, & Sousa, (2014) use NARDL model to examine the pass-through of changes in crude oil prices, natural gas prices, coal prices and electricity prices to the CO2 emission allowance prices. The paper is an improvement on previous work done by Kim and Koo (2010) using linear ARDL model to determine the effect of price of coal on carbon allowances trading in United States of America. Hammoudeh et al (2014) outline various reasons why NARDL approach is applicable in modelling CO2 . First, this approach yields better results than the typical univariate and multivariate linear econometric models prevailing in the economics literature. Second, using NARDL, reliable long-run inferences can be achieved by bounds tests regardless of the integration order of the variables in the system. This is also echoed in (Shin et al., 2014). Third, regarding CO2 emissions, NARDL approach also takes into account non-linearities due to the presence of new government regulations which generally affect trends in variables of interest. Hammoudeh et al (2014) concludes that crude oil prices have a long-run negative and asymmetric effect on the CO2 allowance prices while the effect of the natural gas prices and electricity prices on carbon prices is symmetric.

Concerning crude oil price shocks on food prices, Wang, Wu, & Yang (2014) employed structural VAR analysis to investigate the effect of oil price changes on agricultural commodity markets. The study finds that oil shocks can explain a minor friction of agricultural commodity price variations before the food crisis in 2006–2008, whereas in post-crisis period their explanatory abilities become much higher. Using a similar approach, (Melichar, & Atems, 2019) examines the relationship between shocks to the global crude oil market and commodity prices. The study finds asymmetric responses in commodity index prices to endogenous oil price shocks, with oil demand shocks leading to higher energy and non-energy commodity index prices for the full sample period and oil supply shocks producing less of an impact. This study used asymmetric ARDL model developed by Shin et al. (2014) to decompose independent variables into negative and positive partial sum that allow to identify the asymmetric effect in short term and long run. This method has additional advantage including that: works efficiently even in small sample size, stationary test is not mandatory and the model is equally efficient for the variables that are stationary at level I (0) or first difference I (1) or even fractionally integrated. Lastly, NARDL model provides graphs of cumulative dynamic multipliers used to trace out the adjustment patterns following the positive and negative shocks to explanatory variables.

3. Methodology

In this note, we seek to understand the dynamic transmission of world crude oil prices into domestic fuel pump prices and food prices. Specifically, we derive both positive and negative partial sum decomposition of world crude oil prices and test for asymmetric/ non-linear relationship between the latter and local pump prices of super petrol, kerosene, and diesel. We also test the same effect on food prices. We adopt asymmetric/Nonlinear autoregressive distributed lag (NARDL) model developed by Shin et al. (2014). The negative and positive partial sums decomposition of world crude oil price index per barrel (oil) are obtained following equations 1 & 2 below; and

Subsequently, the asymmetric co-integrating model (3) of fuel pump or food prices (fp) is specified as follows; where (α0, α1, α2) is a vector of long run parameters to be estimated and and are partial sums of positive and negative changes in world crude oil price index. If a1>a2, then we have asymmetric long run crude oil pass through effect to domestic pump prices. We recast equation 3 into asymmetric ARDL model of order (p, q) as shown in (3) below which combines both the short run and long run dynamics. Subscripts (+) and (-1) represent the positive and negative partial sum decomposition of lagged levels and differences of crude oil prices. The optimal lag lengths p & q can be determined using the conventional econometric criteria.

The coefficients and capture the short run adjustments of fuel pump or food prices to crude oil shocks. We contact a bounds –testing procedure (table 0-2) for co-integration between crude oil and pump fuel prices given the empirical verification that all the variables are I (1) process as presented in table (1). This validates the use of ARDL model which is not useful when any of the variables is a I (2) process.

Table 1 ADF and PPP unit root tests order 1

Table 2 Symmetric and Nonsymmetric ARDL estimation (Long run coefficients) of world oil price index pass-through effect on fuel pump prices Lns, lnoil,lnd & lnk denotes natural logarithms for prices of super petrol, world crude oil index, diesel, and kerosene, respectively. ***, **, * denotes 1%,5% and 10% significant levels, while Δ is a change operator. LWT and FBT, represent long run asymmetry and bound test cointegration F test statistics. Adj_R2 is the adjusted coefficient of determination while X2SC and X2HET are F test statistics for Breusch-Godfrey LM test for serial correlation and Breusch-Pegan heteroscedasticity tests respectively. Lnoil+ and lnoil- refer to positive and negative long run coefficients pass through of oil prices.

The LM test reveal presence of serial correlation and heteroscedasticity in the ARDL model in table 2 and 3. Normally, if the error term in the distributed lag model (4) is serially correlated, Heteroscedasticity- and autocorrelation-consistent (HAC) estimators of the variance-covariance matrix are used to circumvent this issue. The results in table 2 reveals weak asymmetric transmission of world oil price index to domestic fuel prices. This is supported by statistically significant Wald F statistic across all the NARDL models estimated. Notably, in all estimated models, a positive (lnoil +) increase raises domestic fuel prices more than the response of fuel prices due to decline in world price index (lnoil -). A 1% increase in crude oil prices per barrels results into increase in super petrol, diesel and Kerosene prices by 0.07%, 0.1% and 0.05% respectively. An equal percentage decline lowers the respective prices by 0.06%, 0.08% and 0.04% signaling asymmetric responses. Wald test shows significant differences between the positive negative shock responses.

This dynamic behavior supports the existence of speculative pricing in local pump prices even with regulations in the market. It also signals under adjustment fallowing world crude oil price fall and over adjustment after a rise in world crude price increase. The trace paths of the asymmetric effect portray negative effect to be significantly higher in the short run, in the long run the effect is reversed. In table 3 below the symmetric ARDL model shows that a 1% increase in world oil price per barrel leads to a 0.02% increase in food price index. However, there is weak asymmetry given that the coefficient of negative change is statistically insignificant.

Table 3 Symmetric and Nonsymmetric ARDL estimation (Long run coefficients) of world oil price index pass-through effect on food prices. In this step, the study derives the asymmetric cumulative dynamic multiplier effects of a one percent change in Lnoil+ and Lnoil- respectively on dependent variable y captured as. h=0,1,2…, ……………………………………………………..….4As where and are the asymmetric long run coefficients calculated as and respectively.

In figure 3 and 4 below, we trace the dynamic response of the pump fuel prices and food price to positive and negative changes in world oil prices. Black line shows the positive impact of the Figure 3 Dynamic multiplier Kerosene and super petrol prices Figure 4 Diesel and food priceindependent variable on the dependent variable while the black dotted line shows the negative impact. The red line shows the asymmetry in short term while the dotted red lines show the upper and the lower bounds of the asymmetry. From panel A and B in figure 3 and C in figure 4 emphasizes the presence of asymmetric response.

The response of Kerosene and super petrol prices to positive change in world crude oil prices is steady and gradual in the next 13 months. The positive effect is non convergent in the 14 months' period selected for analysis. This implies that even with domestic pump price regulation, the effect of positive oil price shock significantly exceeds a one-year period. However, a negative shock only last for 3 months and smoothens corresponding to equilibrium state; signaling asymmetric response.

The trace paths of the asymmetric effect portray negative effect to be significantly higher in the short run, in the long run the effect is reversed. Concerning diesel –figure 4 C, there seems to be some sort of temporal asymmetry in the short run but not statistically significant. Graph 4 D shows the dynamic effect of a shock in world oil prices on food prices. Unlike domestic fuel pump prices, which depict asymmetric response, food prices do not. A positive change in world oil prices significantly raises food prices. The effect is persistent and explosive in the long run. A negative shock doesn't revert food price trends. This implies that food prices are mostly rigid downwards especially in absence of price regulations.

4. Conclusions and policy implications

The study sought to understand the dynamic relationship between world crude oil price, domestic fuel pump prices and food prices measured by respective price indices. The analysis reveals asymmetric responses to crude oil prices for super – petrol, kerosene and diesel supported by NARDL model estimates and the dynamic multiplier graphs. However, the dynamic response path for diesel is not statistically significant over the entire analysis horizon. Food prices are only symmetric to crude oil prices suggesting existence of downward rigidity in food prices especially in a deregulated market.

These results have several insights in policy sphere. Firstly, presence of asymmetric response of domestic fuel prices to crude oil prices shocks implies inefficient price regulation mechanism (Apergis, & Vouzavalis, (2018). A consistent price control mechanism would imply a symmetric response. Secondly, asymmetry may signal a market capture by a few firms which should be a concern for the anticompetitive regulatory body in Kenya. Given that fuels are predominantly used as inputs in the production process in Kenya, the asymmetric pass through of world crude oil prices to domestic fuel pump prices should inform investment decisions of several private firms especially on hedge against cost of fuel related risks. Lastly, the results have far reaching implications on taxation of oil imports in Kenya. High tax rates on oil products results into punitive food and domestic fuel prices and therefore this information should be key in informing food related tax incentive policy. Similarly, asymmetric response implies that the elasticities used in forecasting oil related revenue are misleading since they are assumed to be static and symmetric. This amplifies forecasting errors.

These results amplify the need for government to reduce monopoly pricing power of the petroleum enterprises. In addition, the government should incentivize research and use of alternative sources of energy so as to reduce world oil prices impact on domestic fuel prices and food prices. To sum up, the revenue forecasting model should equally incorporate the aspect of asymmetry especially on tax heads that use value of oil imports as their tax base.

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Figure 0-1: Main source of crude oil in Kenya

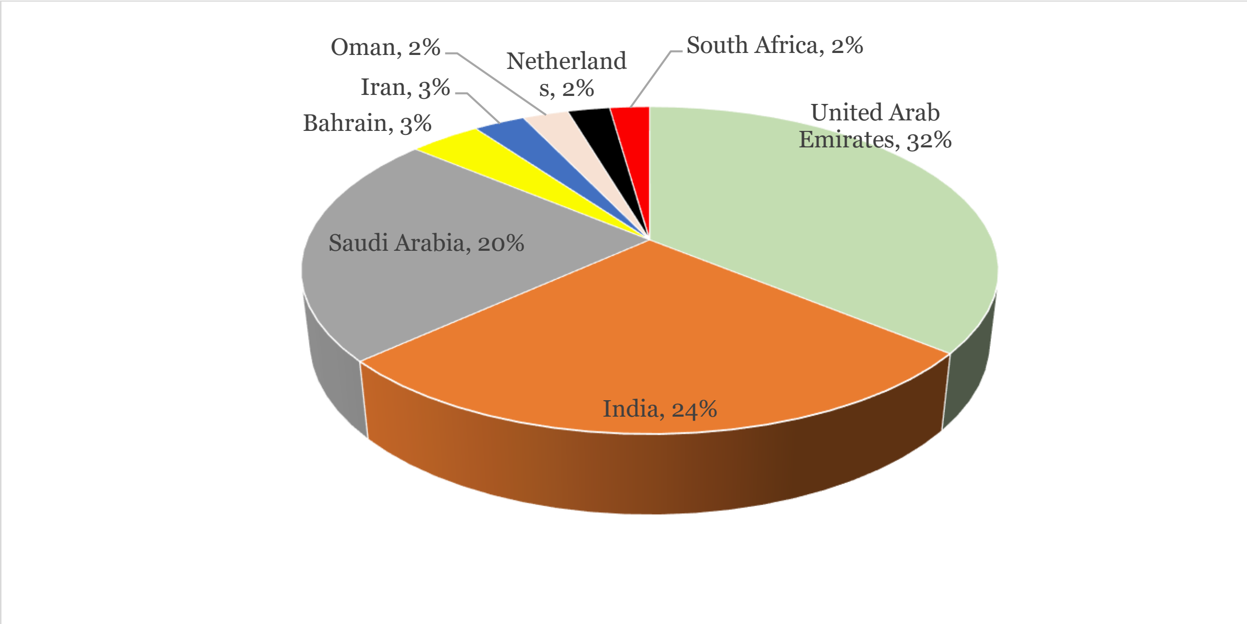


Figure 2: World oil price index (USD per barrel), Consumer Price Index (CPI) and domestic fuel pump prices in Ksh (per Litre)

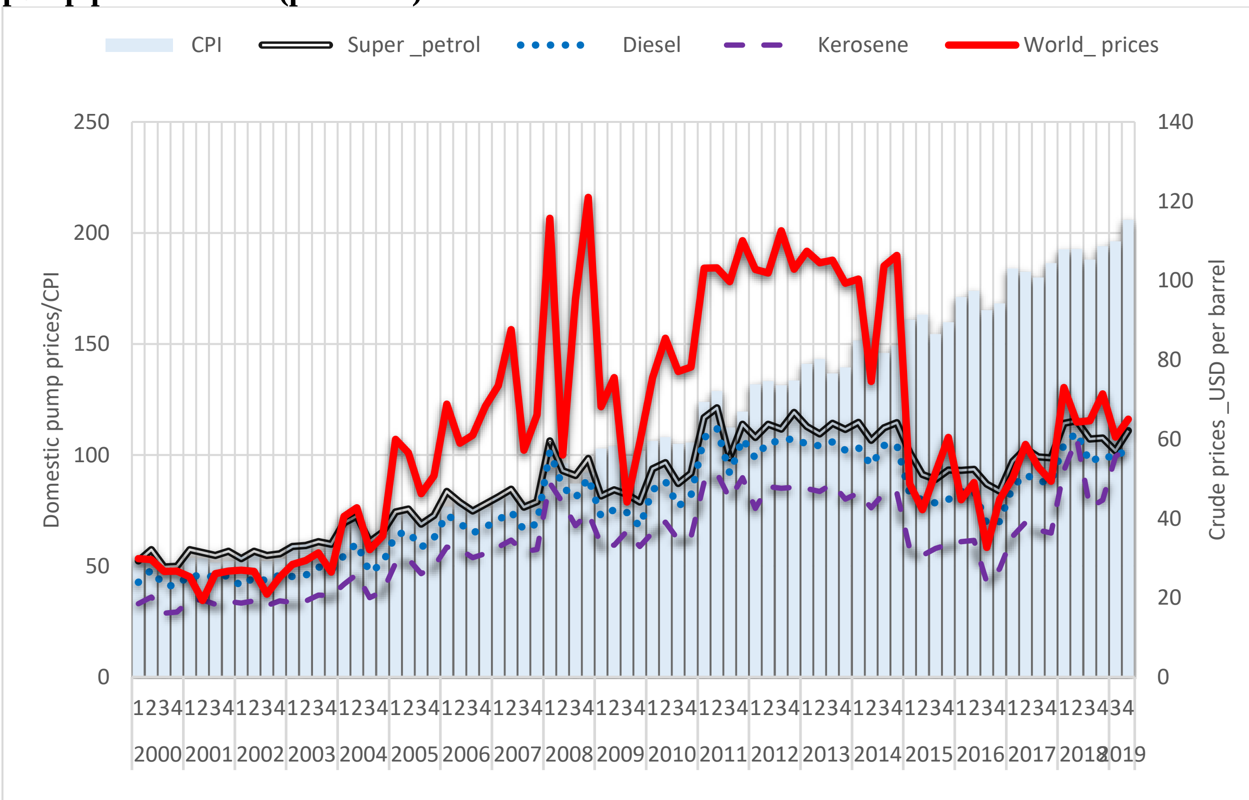


Table 1 ADF and PPP unit root tests

	Levels		First difference		Conclusion
Variables (Price)	ADF	PP	ADF	PP	
Ln_super petrol	-1.8359	-1.7015	-11.1732***	-11.1732***	I(1)
Ln_crude oil index	-2.0685	-1.9121	-11.2812***	-11.1227***	(1)
Ln_kerosene	-1.5311	-1.2671	-11.6176***	-11.4838***	(1)
Ln_diesel	-1.719	-1.4778	-11.0455***	-10.7544***	(1)
Ln_food price index	-0.3848	-0.6306	-3.9216***	-17.6536***	(1)

*** significant at 1%, Ln-natural logarithm, ADF –Augmented Dickey Fuller, PP-Philips-Perron, I(1)-Integrated of order 1

Table 2 Symmetric and Nonsymmetric ARDL estimation (Long run coefficients) of world oil price index pass-through effect on fuel pump prices

Ln_Super petrol(S)				**Ln_diesel(d)**				**Ln_kerosene (K)**			
Symmetric ARDL		NARDL		symmetric ARDL		NARDL		Symmetric		NARDL	
lnS(-1)	*0.213** *	*lnS(1)*	-	*Lnd(-*	*-0.18** *	*Lnd(-1)*	*-0.22** *	Lnk_{t-1}	*-0.03*	Ln_oil^{+}	*0.05*** *
lnoil(-	*0.066** *	*Lnoil+*	*0.07** *	*Lnoil(-*	*0.07** *	*Lnoil+*	*0.1*** *	$Lnoil_{t-1}$	*0.02*** *	$Lnoil^{-}$	*0.04**** *
@trend	*0.0004** *	*Lnoil-*	*0.06** *	*@trend*	*0.0003** *	*Lnoil-*	*0.08*** *	$\Delta lnoil_{t-}$	*0.21*** *	lnK_{t-1}	*-0.09*** *
c	*0.63*** *	*c*	*0.89** *	*c*	*0.43**** *	*c*	*0.8*** *	$\Delta lnoil_{t-}$	*0.12*	Δoil^{-}_{t-1}	*0.28*** *
$\Delta lnoil_{t-}$	*0.095*** *					$\Delta lnoil^{-}_{t-}$	*0.17** *	$\Delta ln(oil)$	*0.07*** *	Δoil^{+}_{t-2}	*0.17*** *
ΔlnS_{t-1}	*0.19*** *					Δlnd_{t-1}	*0.16*** *			Δoil_{t-1}^{+}	*0.13*
Lnoil	0.297***			Ln(oil)	0.41***	$\Delta lnoil^{+}_{t-}$	0.17***				
L_{WT}			37.7**				36.4***				5.7**
F_{BT}	20.04		8.76		12.7	16.2			4.2		2.7
Adj_R^2	0.41		0.42		0.45	0.45	0.44		0.33		0.33
X^2_{SC}	1.806		1.08		0.12	0.3	0.3		0.8		0.8
X^2_{HET}	3.6**		3.3**		3.8**	4.8***	4.8***		2.7***		1.9**

Table 3 Symmetric and Nonsymmetric ARDL estimation (Long run coefficients) of world oil price index pass-through effect on food prices

Ln_food_Price_Index			
Symmetric ARDL		**NARDL**	
lnoil(-1)	*0.0211***	*Lnoil+*	*0.0241****
Lnfood_price $_{t-1}$	*0.4851****	*Lnoil-*	*-0.008516*
Δlnfood_price $_{t-2}$	*0.2779***	*c*	*0.4808****
Δlnfood_price $_{t-3}$	*0.2648***	*Lnfood_price $_{t-1}$*	*0.7802****
c	*1.7896****	*Lnfood_price $_{t-2}$*	*0.1821**
@trend	*0.004****	*Lnfood_price $_{t-3}$*	*-0.0976*
F_{BT}	10.6		6.35
Adj_R^2	0.23		0.23
X^2_{SC}	0.42		0.3
X^2_{HET}	0.90		0.89

Figure 3 Dynamic multiplier Kerosene and super petrol prices

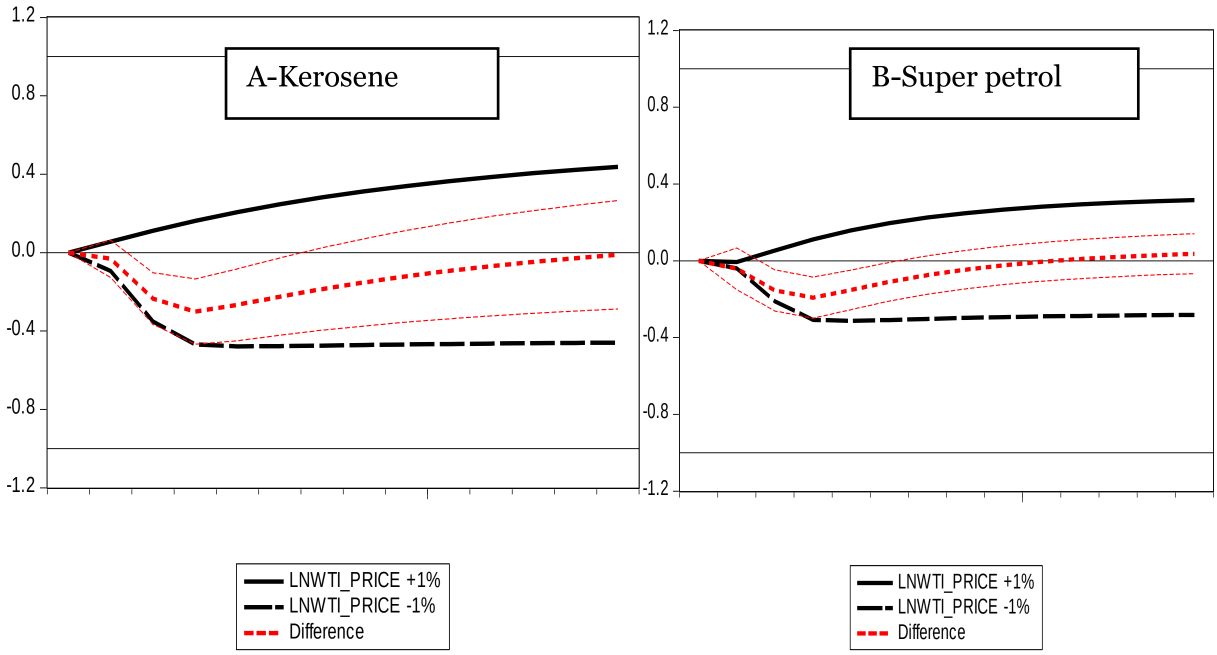
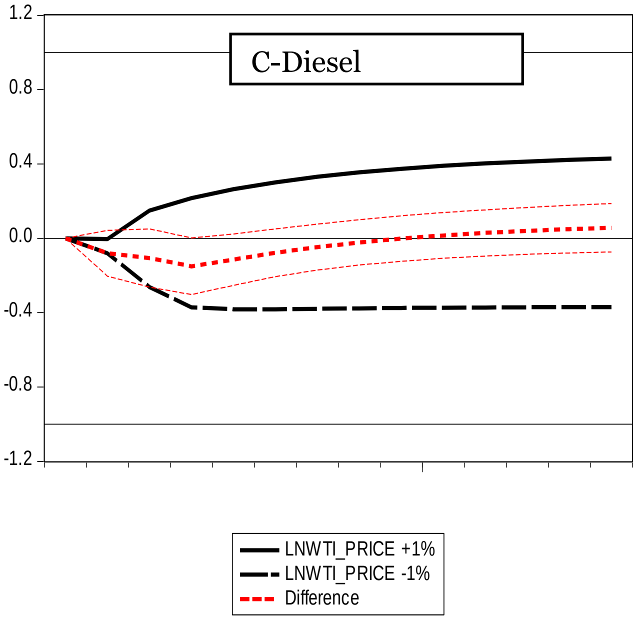
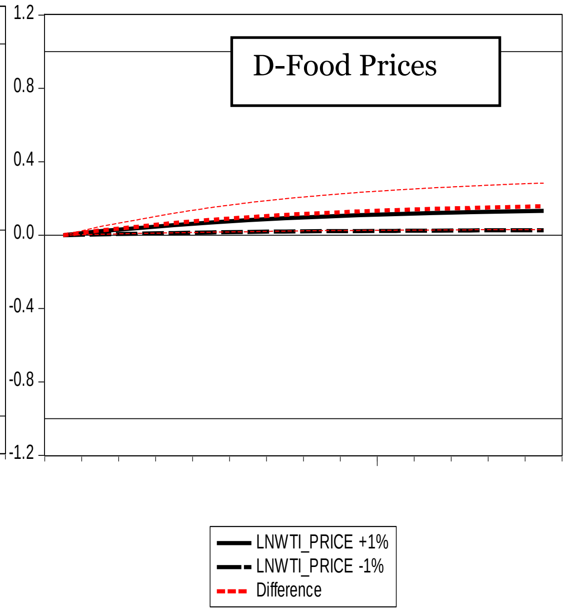


Figure 4 Diesel and food price


C-Diesel
1.2
0.8
0.4
0.0
-0.4
-0.8
-1.2
LNWTI_PRICE +1%
LNWTI_PRICE -1%
Difference


D-Food Prices
1.2
0.8
0.4
0.0
-0.4
-0.8
-1.2
LNWTI_PRICE +1%
LNWTI_PRICE -1%
Difference