Demand for Imported Crude Oil in Pakistan: NARDL Framework

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Abstract

This research article analyzes the long run relationship between real GDP growth rate and demand for imported crude oil in Pakistan assuming asymmetries. Annual time series data for quantity of imported crude oil, real GDP growth rate and price of imported crude oil are used from 1970 to 2014. Using Nonlinear Autoregressive Distributed Lag (NARDL) Model, the variables are found to be cointegrated. As theory predicts, demand for imported crude oil is relatively in-elastic and negatively related to its price. There is no evidence of non-linear or asymmetrical relationship between real GDP growth rate and demand for imported crude oil in the long run. However, dis-aggregation shows that negative changes in real GDP growth rate lead to a rise in the demand for imported crude oil while positive changes have no significant effect. The results suggest that even though local crude oil production is increasing, there is still a growing dependence on imported crude oil and thus, it is important to invest in local and alternative energy resources to revive the crumbling energy sector in Pakistan.

Keywords: Energy demand, imported crude oil, Non-Linear Autoregressive Distributed Lags (NARDL), Pakistan economy

I. INTRODUCTION

In Pakistan, demand for energy has been steadily rising due to higher competition in the markets, growing population and expanding urban areas. Being an energy deficient country, it fulfills its energy related needs by importing crude oil. Based on the rationale that economic growth fluctuation has an impact on the import demand of crude oil, this study has been designed to analyze long run and short run relationship between demand for imported crude oil and economic growth in Pakistan using NARDL approach. On one hand, a non-linear relationship between the two variables is assumed because irrespective of the direction of economic growth rate, demand of imported crude oil should continuously increase or remain stable as it is a basic need. On the other hand, during economic booms, imports of crude oil are bound to increase whereas during economic downturns, demand for imported crude oil is expected to fall. Therefore, it is of interest to analyze the strength and magnitude of the impact of economic growth rate on the quantity of imported crude oil in Pakistan considering the possibility of asymmetrical relationship as explained above. Also, previous studies have focused on the issue of oil price shocks and their impacts on oil demand in Pakistan making this study the first of its kind. Section 2 is titled as literature review which is followed by the overview of Pakistan economy regarding demand for crude oil. Section 4 provides the data, model specification and empirical methodology. The last section discusses the results and findings with policy implications and further research suggestions.

II. LITERATURE REVIEW

Earlier empirical studies are related to price and income elasticity of energy demand that is due to changes in the price and income levels of various forms of energy. Bentzen and Engsted, (2001) [1]and Christopoulos (2000)[2], for example, worked on energy demand while Alves and Bueno (2003)[3] and Storchmann (2005)[4] examined the gasoline demand. Cooper (2003)[5]analysed on crude oil demand and oil price, found inelastic for both short run and long run. Ghouri (2001)also showed that for USA, Mexico and Canada, demand for oil is price inelastic in the long run.

Numerous researchers found the price and income elasticity of energy demand inelastic. Altinay (2007)[6]and Ghosh (2009)[7]provide evidences considering crude oil and natural gas in the world market. By using ARDL, Altinay (2007)[6]finds the short run and long run estimates of crude oil demand for Turkey. Demand for crude oil and other independent variables that were nominal price and income had cointegration. However, the model with real price as explanatory variable showed no significant relation in the long run. Estimates found demand for crude oil and natural gas as significantly income elastic. Ghosh (2009)[7]found using ARDL that in India, demand for oil is income elastic in the long run. Elasticity for imported crude oil demand

with respect to income was 1.9 and causality tests showed significant unidirectional causality from economic growth to oil import demand. In another study where the focus has been on demand for energy and oil prices, Gately and Huntington (2002)[8]estimated long run income elasticity and price elasticity assuming asymmetric effects for OECD and non-OECD countries. Price elasticity was found to be 0.64 and income elasticity was 0.56 for OECD countries while non-OECD countries had lower elasticity.

Another study used structural econometric model for the world oil market, in which Dees et al. (2007)[23]analysed the developments and risks of oil market. Supply and demand model are estimated with ordinary least squares (OLS) technique to get the long-run estimates and for short run dynamics they used error correction model (ECM). Income elasticities for some of the developed countries range from 0.17 to 0.98 whereas the short run estimates range from 0.001 to 0.82. Semboja (1994)[9]applied static computable general equilibrium model to examine the impact of oil prices in Kenya. The results indicated that output decreased due to an increase in oil prices. Panel study for Middle East by Narayan and Smyth (2007)[10]used cointegration technique and found that demand for oil is price inelastic and income elastic. While from time series cointegration analysis, Xiong and Wu (2009)[11]found demand for crude oil in China was income and price inelastic. Similarly, Ziramba (2010)[12]used multivariate methods for time series in South Africa and results showed demand for oil as price and income inelastic in long run.

From recent years, Tsirimokos (2011)[13]andStambuli (2013)[14]used Partial Adjustment Model (PAM) to estimate price and income elasticities of oil demand and found inelastic demand inshort-run for price and income. Long-run oil demand was income elastic and price inelastic thus implying oil demand more sensitive to income changes as compared to oil price changes. Study suggested adopting domestic production techniques like choice of bio-fuels and extraction of oil and gas from discovered fields to save more foreign currencies. In a more recent study, Yaprakliand Kaplan (2015)[24]verified with structural breaks the income and price response to crude oil demand and found both elasticities in the long-run as inelastic.

With respect to Pakistan, earlier disaggregate level studies were conducted by Siddiqui and Haq (1999)[15]and Aqeel and Butt (2001)[16]. They contributed to find the relationship between energy consumption, economic growth and price level. They found limited impact of changes in prices on economic growth which is an indication for the necessity of energy sources. Income increases had significant impact on gas consumption in Pakistan while unidirectional causality was found for petroleum consumption from economic growth. Later, Khan and Ahmad (2008)[17]. analysed similar relationship using dynamic modeling and found almost similar results. From the literature, it can be said that the price elasticity of demand for energy is low in long run as well as in short run whereas the income elasticity is inelastic in certain studies. However, long run coefficients were higher than the short-run. Most of the studies use panel data for estimation purpose whereas few studies used country specific time series. Pakistan imports oil for various purposes. But since there is electricity shortage, to run the economy, it is vital to import crude oil which acts as major input for electricity generation. Evans and Hunt (2009)[18]however state that:

'According to theory of dematerialization, with the improvement of an economy, intensity of economic activity declines, which cause less use of energy sources. So, it is the structure of the economy that influences the demand as well.'

Since economic growth rate and demand for crude oil imports can go in any direction, this study uses annual time series covering the period from 1970–2014 to find out that how strong or weak is the relationship between economic growth rate and demand for imported crude oil in Pakistan.

III. BACKGROUND

For smooth running of the economy, basic facility such as energy provision is vital. Pakistan is basically agro-based economy, and over time the structure of economy changed with more share of industry and services. Thus, the demand for crude oil increased with time to meet the requirements. Acute energy shortage, especially 2007 and onwards worsened the economy. Fluctuating economic growth patterns aggravated the conditions of the economy towards stagflation. These energy crises forced the industrialist to move their industries abroad due to disappointing situation in the country, causing increase in cost of production. Cheap supply of energy sources is thus necessary for development of the country.

Table 1. Production and Consumption of Petroleum

Year	Production (000 of metric tons)	Consumption (000 of metric tons)	Production as percentage of consumption
1949-50	99	817	12

1969-70	461	3820	12
1989-90	2619	9972	26
1999-2000	2744	17,768	15
2009-2010	2832	20,563	13
2010-2011	2950	22,386	13
2011-2012	3082	25,850	12
2012-2013	3365	28984	11

Source: G.O.P (various issues)

Oil is extracted in some parts of the country as the areas are covered with sedimentary rocks that are favourable for oil creation. Oil and Gas Development Corporation (OGDC) of Pakistan is working for the extraction and refining energy sources. Table 1 indicates the production of oil during the period of 1949-50 was 99 thousand metric tons and two decades later, it was 461 thousand metric tons. In 1989-90 it raised up to 2619 thousand metric tons. However, after that there was increase of 2744 thousand metric tons in 1999-2000, increasing at a slow pace till 2012-13. On the other hand, demand increased with the growth in population and despite production side improvements, the extra demand was met by imports. According to ministry of petroleum and gas of Pakistan, U.S $1.5 million annually are spent for import of crude oil.

Table 2: Sector wise share of crude oil in Pakistan (%)

Sector	Share
Transportation	51.9%
Power generation	39.18%
Industrial sector	5.92%
Government	1.72%
Household	0.67%
Agriculture	0.60%

According to economic survey of Pakistan (Government of Pakistan, 2013-14)[19], transport sector is the major demand source followed by power sector. Industrial sector ranks at third after which comes the government, household and agriculture sector. Almost 80% of the total demand for energy in Pakistan is fed with oil and gas resources but supply shortage of gas leads towards the increase in demand of crude oil. Over time the oil use for power generation has been increased due to severe electricity crises. Presently, total energy need is 34 million tons of oil equivalents (MTOE). Other sources of energy are also contributing such as hydroelectricity (13%) and coal (7%), (GOP, 2013-14)[19].

IV. DATA AND METHODOLOGY

This study uses the basic model of derived demand from Marshallian theory of demand. Crude oil import demand is a function of income and prices. Income is measured by real GDP growth rate to capture the effects of economic activity on imported crude oil demand. The second variable is the real value of crude oil prices in Pakistan. The basic model is specified below.

$$Q = f(p, y) \quad (1)$$

'Q' denotes the crude oil imported in thousand metric tons, 'Y' is the growth rate of real GDP and 'P' is the price of crude oil in Pakistani Rupees per metric ton (PKR/mt). Data for the years of 1970 to 2014 is taken from State Bank of Pakistan, various issues of Economic Survey of Pakistan and Finance division of Pakistan. The data for 'Q' and 'P' has been converted to natural logarithms. Since Pakistan economy has been divided into democratic and military dictatorship regimes, a dummy variable has been introduced to capture the effects of a particular government regime on the demand for crude oil imports. Years comprising of democratic regimes from 1970 to 2014 have been allocated the value of 1, 0 otherwise. Time trend has also been introduced in the equation.

Empirical model used is based on Nonlinear ARDL approach introduced by Shin et al. (2011)[20], which

captures the asymmetry of the long run relationship among the variables. It is the advancement of well-known cointegration technique of ARDL developed by Pesaran et al. (2001)[21] based on bound testing. If deviation or economic shocks take place, the variables may have different speeds of adjustment to reach the equilibrium point or the potential path. Hence, the empirical model of NARDL is used for this study:

$$Q_t = \alpha_0 + \varphi_0 D_t + \alpha_1 P_t + \alpha_2 gr_t^+ + \alpha_3 gr_t^- + e_t \quad (2)$$

In the above equation gr+ and gr- are positive and negative changes for real GDP growth rate respectively. According to Shin et al. (2011)[20] these partial sums are defined as:

$$gr_t^+ = \sum_{i=0}^{t} \Delta gr_t^+ = \sum_{i=0}^{t} max(\Delta gr_i, 0) \quad (3)$$

$$gr_t^- = \sum_{i=0}^{t} \Delta gr_t^- = \sum_{i=0}^{t} min(\Delta gr_i, 0) \quad (4)$$

α_0, φ_0, α_1, α_2 and α_3 are the coefficients to be estimated for long run equation and e_t is the random error term. In autoregressive model, it is assumed that change in oil consumption in current time period is the result of errors in previous time periods. The long run equation can be written in the form of ARDL based model as proposed by Shin et al. (2011)[20]:

$$\Delta Q_t = \vartheta_5 + \vartheta_0 D_t + \vartheta_1 Q_{t-1} + \vartheta_2 P_{t-1} + \vartheta_3 gr_{t-1}^+ + \vartheta_4 gr_{t-1}^- + \sum_{i=1}^{q} \beta_i \Delta Q_{t-i} + \sum_{i=0}^{q} \gamma_k \Delta P_{t-k} + i=0q(\theta i+\Delta grt-i++\theta i-\Delta grt-i-)+\beta 0t+\varepsilon t \quad (5)$$

In above formulation, q is the lag orders. Long run coefficients in Equation 1, α_2 and α_3 can be derived from Equation 5 as-ϑ_3/ θ_1 and -θ_4/ θ_1 respectively. Short run influences of economic growth rates are reflected in the coefficients (θ_i^+ and θ_i^-) of Δgr^+ and $\Delta gr^-$with zero to q lag levels.

Preliminary analysis for time series comprising of unit root tests has been done using Augmented Dickey fuller (ADF) test and Phillips-Perron (PP) test. For NARDL modeling, integration of the variables at I(0) and I(1) is acceptable. However, if any variable is of I(2), then computed F-statistics are rendered inaccurate. Following the unit root tests, Equation 5 is estimated using usual Ordinary Least square (OLS). Based on SIC, AIC and HQ criteria, the appropriate lags are chosen, and then insignificant lags truncated in the general to specific procedure. Then Wald test is applied with null hypothesis as H_0: $\vartheta_1 = \vartheta_2 = \vartheta_3 = \vartheta_4 = 0$. Rejection of H_0 indicates cointegration among the variables. Following that, the long run coefficients in Equation 1 are calculated. Lastly, the dynamic cumulative multipliers have also been calculated for positive and negative deviations in the real GDP growth rate. This shows asymmetric cumulative dynamic multiplier effects of a one percent change in gr_t^+ and gr_t^- , which are shown as:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial Q_{t+j}}{\partial gr_t^+} and m_h^- = \sum_{j=0}^{h} \frac{\partial Q_{t+j}}{\partial gr_t^-} and h = 0, 1, 2 \ldots \infty$$

$$h \to \infty, m_h^+ \to \alpha_2 and m_h^- \to \alpha_3$$

V. RESULTS AND DISCUSSIONS

Table 3 shows the unit root tests. The results show that all variables are integrated of order one I(1) or zero I(0). So NARDL model can be used to estimate long run and short run dynamics.

Table 3: Unit Root Tests.

Variable	ADF Unit Root Test		PP Unit Root Tests	
	Level	First Difference	Level	First Difference
Q	-2.218482 (0.4674)	-4.887327 (0.0016)***	-5.194774 (0.0006)***	-12.31907 (0.0000)***
P	3.794913 (0.0264)**	-7.596092 (0.0000)***	--5.257896 (0.0005)***	-7.591576 (0.0000)***
Y	-5.118902 (0.0007)	-8.832273 (0.0000)***	-5.075487 (0.0008)	-21.91177 (0.0000)***

Statistics are given with probabilities in parenthesis. *** indicates significant at ≤ 1%, ** indicates significant at ≤ 5%, * indicates significant at ≤ 10%

OLS estimation of Equation 5 is shown in Table 4. Based on SIC, AIC and HQ criteria, 3 lags are chosen. Then using general to specific procedure, final dynamic model was achieved and then bound testing was done to confirm presence of cointegration in Table 5.

Table 4: Non-Linear ARDL Results

Variable	Coefficient	Probability
Dependent Variable: DQ		
C	6.3680***	0.000
Q(-1)	-0.6805***	0.000
P(-1)	-0.1411***	0.009

gr^{+}(-1)	-0.0459**	0.015
gr^{-}(-1)	0.0218	0.206
DQ(-1)	0.1949*	0.079
DP	-0.3872***	0.000
DP(-1)	0.1774**	0.037
Dummy	-0.1688***	0.000
TREND	0.0939***	0.000
R-Squared	73.25%	
J-B	0.7068	0.702
LM(1)	0.1699	0.683
LM(2)	0.3515	0.706
ARCH (1)	0.1892	0.666
ARCH(2)	0.1628	0.850

****indicates significance at <1%**indicates significance at <5%; *indicates significance at <10%. D represents first difference of the variables while numbers in the parenthesis are lag orders. J-B, LM and ARCH are the residual tests for normality, serial correlation and heteroskedasticity respectively*

Table 5: Bounds Test for NARDL Cointegration

Bounds Test for Cointegration			
F-Statistic	**99% Lower Bound**	**99% Upper Bound**	**Result**
7.4433	4.763	6.200	Cointegration

The F statistics exceeds the upper bound value at 99% critical value, seen in Naryan (2005)[22]. Hence, long run relationship exists between the variables. Diagnostic tests satisfy all the conditions for final dynamic model whereby no problem of autocorrelation (LM test), Normality (J-B), heteroskedasticity (ARCH) and stability (CUSUM) are found (Figure 1). For autocorrelation and heteroskedasticity, LM test and ARCH test up to order 2 have been conducted and both tests satisfy the condition of non-existence of autocorrelation and heteroskedasticity. Jarque-Bera (J-B) normality test also shows that the error normality condition is held for this specified econometric model.

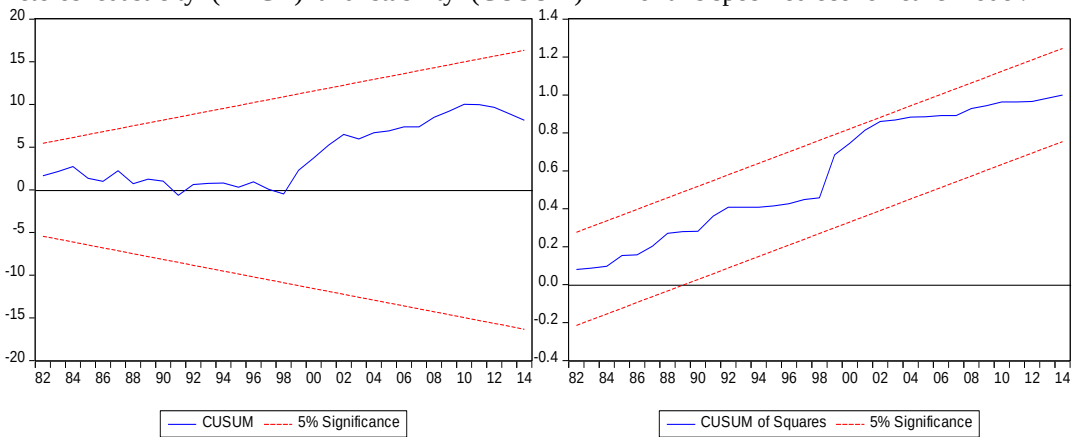

Figure 1: CUSUM and CUSUM of Squares for selected NARDL Model

From the estimated NARDL results found in Table 4, long run coefficients can be calculated as shown in Table 6.

$$Q_t = \alpha_0 + \varphi_0 D_t + \alpha_1 P_t + \alpha_2 gr_t^{+} + \alpha_3 gr_t^{-} + e_t$$

$$\alpha_0 = -{}^{\vartheta_5}/_{\vartheta_1}, \quad \alpha_1 = -{}^{\vartheta_2}/_{\vartheta_1}, \quad \alpha_2 = -{}^{\vartheta_3}/_{\vartheta_1}, \alpha_3 = -{}^{\vartheta_4}/_{\vartheta_1}, \varphi_0 = {}^{\vartheta_0}/_{\vartheta_1},$$

ϑ_1 is the error correction term equal to -0.6805. Thus, the long run model with respective coefficients is written as:

Table 6: Long run estimates.

Variables	Coefficients	P-value
D	-0.2060***	0.0100
Trend	0.1230***	0.0002
P	-0.2314**	0.0226
gr^+	-0.0316	0.2626
gr^-	0.0498**	0.0477

The price of crude oil is inversely related to the quantity of crude oil imports. 1% increase in price leads to a 0.23% reduction in crude oil imports reflecting an inelastic demand. Similar results found in previous studies (Ziramba, 2010[12]; Tsirimokos, 2011[13]; Stambuli, 2013[14]; Yaprakli and Kaplan, 2015)[24].

It is evident from the long run estimates that there is absence of non-linear relationship between real GDP growth rate and demand for crude oil imports. However, disaggregation between positive and negative changes in real GDP growth rate shows important results. A 1% increase in positive change in real GDP growth rate leads to 0.03% decrease in the demand for imported crude oil. Although this effect is insignificant, it has crucial implications. As explained above, Pakistan economy is dependent on oil as a major source of electricity production and transport. Hence, as GDP is increasing, demand of transport and electricity is also increasing but more of the crude oil production is done locally and therefore, imports fall. The local production of crude oil in Pakistan is increasing as shown in Figure 2. Hence, the demand for imported crude oil falls by a small and insignificant amount as economic growth rate increases.

Figure 2: Production of Crude Oil in Pakistan (BBL/D/1K)

On the other hand, a 1% increase in negative changes of real GDP growth rate leads to a 0.05% increase in crude oil imports. This is because as the GDP growth rate falls in Pakistan, the ability and potential to produce crude oil locally also falls and hence, imports pick up as crude oil is a major input of the economy. In the face of the on-going energy crisis and stagnant GDP growth rate in Pakistan, demand for imported crude oil is therefore significantly increasing.

As far as short run results are concerned, it is again prominent that negative changes in real GDP growth rate have significant positive immediate impact on the demand for imported crude oil. Without any fluctuations, the demand for imported crude oil reaches its long run value of 0.03% in 4 years. As price increases, in the short run, the demand for imported crude oil falls immediately to approximately 0.4%. Since demand for imported crude oil is price-inelastic, it then increases to -0.15% in a year and then eventually reaches its long run value of 0.2% in 7 years. The short run changes in the imported crude oil demand because of positive changes in GDP growth rate have not been calculated due to insignificant results.

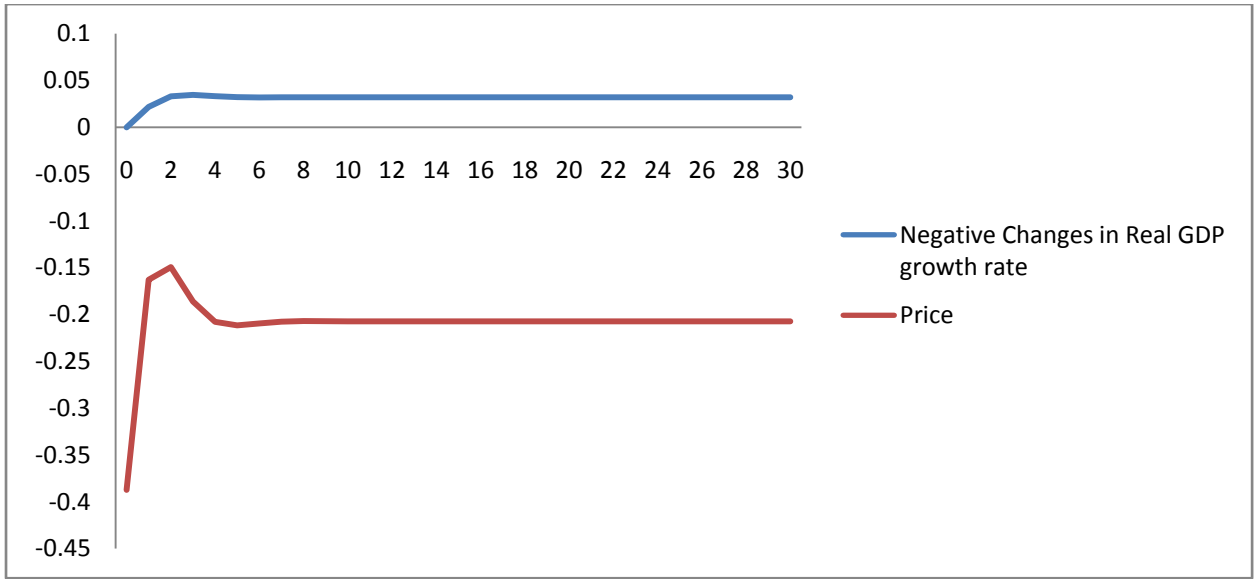

Figure 3: Short run and long run multipliers of growth rate decreases

VI. CONCLUSION

This study is conducted to analyse the demand function of imported crude oil in Pakistan which is influenced by the crude oil price in the international market and real GDP growth rate in Pakistan. Another motive is to explore if there is an asymmetric relationship between real GDP growth rate and demand for imported crude oil. Keeping in view the findings of the study, it can be concluded that although there is no asymmetry in the long run relationship between import demand for crude oil and GDP growth of Pakistan, the results do have important policy implications. Demand for imported crude oil is inversely related to price and is inelastic in nature. Positive changes in real GDP growth rate do not have a significant change in demand for imported crude oil although the import falls by small amount reflecting the rising local crude oil production.

In short to medium run, the demand for crude oil imports increases at a decreasing rate with an increase in negative changes in the GDP growth rate. It reaches the long run value in 4 years. With a stagnant GDP growth rate, the demand for crude oil imports increases as the capability to produce it locally falls. Since crude oil is a crucial input of the Pakistan economy, the demand of crude oil is fulfilled by importing it even if though GDP growth rate is falling. As a result, the import bill enhances contributing to a trade deficit which eventually puts a drain on local foreign reserves. As the imports increase, the local currency depreciates which further increases the price of imported oil and other imported inputs leading to an even higher import bill, trade deficit and energy induced inflation. Once the economy enters this vicious futile spiral, it is difficult to escape. Hence, the policy implications include increasing GDP growth rate so that more crude oil can be produced locally and dependence on crude oil import falls. This will also help in retrieving the falling value of Pakistani currency and restricting the import bill. Also, there is a need to continue the usage and exploration of alternative energy resources so that dependence on oil reduces. The government of Pakistan must continuously invest in latest fuel-efficient technologies and alternative resources like gas extraction measures and coal generated power plants to run the engine of economy. This could also form a basis for future research.

VII. DISCLOSURE STATEMENT

There is no potential conflict of interest to be reported.

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