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Salma Bibi (salma.bibi@iiu.edu.pk)
International Islamic University
Abdul Rashid Rashid
International Islamic University Islamabad
Mirajul Haq
International Islamic University Islamabad

Research

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Posted Date: November 20th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-110173/v1

Economic Activity Asymmetries to Oil Price Shocks for Oil Importing Economies

Salma Bibi[1, *], , and Abdul Rashid[2] Mirajul Haq[3]

1 International Institute of Islamic Economics, International Islamic University, Islamabad 44000, Pakistan
2 International Institute of Islamic Economics, International Islamic University, Islamabad 44000, Pakistan
3 International Institute of Islamic Economics, International Islamic University, Islamabad 44000, Pakistan
* Correspondence: salma.bibi@iiu.edu.pk

Abstract

To prospect the query of asymmetry the data of 40 oil importing economies for period of 1990-2019 used in the analysis. All of the oil importing economies divided into 3 categories consisting of low, medium and high oil importing economy. The oil price shocks can lead to cross section to be correlated specifically oil importing panels this suspicion was realized by results the CD test of H. Pesaran (2004). The technique of dynamic common correlated effects (DCCE) by Chudik*, et al.* (2015) used for analysis. The results provided evidence of asymmetries for highest and lowest oil importing economies in long run. However, absences of asymmetry in short run for all oil importing nations.

Key words: Asymmetry, CD test, DCCE, oil importing economies

Introduction

Fluctuation in prices of oil affects the macroeconomic indicators of the economies based on the fact whether economy is net oil importer or exporter of energy. The oil price increases are considered a benefit for oil producing economies. The increase in oil price increases the purchasing power, disposable income and the current account position of oil producing economy. The revenue by positive shocks further makes it possible to spend on social security and investment spending Moshiri*, et al.* (2012). However if boom persists the blessing can be turned into a curse by initializing Dutch Disease[1].

Economies dependent on imported oil bear adverse effects of rising oil prices, the oil imports increase with positive shocks to its price will reduces output and generates inflation and deficit; see Rasche*, et al.* (1977) ,Hamilton (1983) Burbidge*, et al.* (1984), Mork (1989),Lee*, et al.* (1995),Hamilton (1996) . The shape of the aggregate demand curve and nature of shocks (transitory or permanent) plays a significant role to determine the magnitude of individuals' response to oil price increases Berument*, et al.* (2010). If the shock is permanent, disposable income and consumption decline and oil is moderately replaced in production as the cost effect rules. The decrease in productivity of capital and labor lowers potential output accordingly.

[1] The deterioration in the external position of oil exporting economies due to appreciation of exchange rate , caused by positive shocks to oil price creating increase in revenues and investments of the country. This unfavorable consequence of positive oil price shocks is explicated by the Dutch Disease in the literature.

Heightened uncertainty is factor having a central role for expectation about oil price changes. This can increase precautionary saving and decrease the consumption in short run Bredin, *et al.* (2011). The inelasticity of demand in short run can create an intensive effect of positive oil price shocks to exchange rate. An increase in oil price increase domestic price and pass through to exchange rate causes depreciation and higher input cost Kamin, *et al.* (2000).

The positive and negative shocks to oil price affect the economies and this effect is more dependent on degree of dependence Asab (2017). Earlier literature on the relationship between oil prices and economic growth adopted symmetric models, e.g. Bernanke (1983), Hamilton (1988) and Bredin, *et al.* (2011). Later, the asymmetric effect were considered and inscribing the symmetry specification to be inappropriate. The pioneering studies to refer asymmetric specification were Loungani (1986), Davis (1987a) and Mork (1989).

Economic theory presents a number of justifications for price asymmetries. These are sector reallocation, precautionary saving, irreversibility of capital labor ratio, and heightened uncertainty to name a few. Mork (1989) suggested that negative shocks to be insignificant and did not stimulate economic growth of oil importing economies. Hamilton (1996),Hamilton (2003) also supported findings of the Mork (1989).

Considering the response of industrial production to oil shocks most studies have been done for the U.S. economy; however, more recently reported have been for oil-exporting countries, see Eltony, *et al.* (2001), El-Anashasy (2006), Berument, *et al.* (2010), Olomola, *et al.* (2006). Cuñado, *et al.* (2003), Huang, *et al.* (2005), Jiménez-Rodríguez*, *et al.* (2005), Tazhibayeva, *et al.* (2008), Ayadi (2005), Lescaroux, *et al.* (2008), Korhonen, *et al.* (2009), Mendoza, *et al.* (2010). However, our contribution to the literature on the asymmetric specifications of oil price shocks is particularly for the net oil-importing economies over the globe. The U.S. Energy Information Administration (2017) forewarns that between 2015 and 2040 world consumption of energy to expand by 28%. The foretold increase in worldwide consumption growth and increasing energy prices will position net-importing economies, in taut position Gershon, *et al.* (2019). The oil importing economies are more vulnerable to the oil price shocks and increasing the energy consumption in coming years with fluctuation in oil price can affect the economic activity in these economies.

The contribution of our analysis is on many grounds. First we have shifted the focus from the US data (e.g. ; Kilian, *et al.* (2011a) Kilian, *et al.* (2011b), Hamilton (2011); Herrera, *et al.* (2011) and OECD data Herrera, *et al.* (2015) to a large sample of oil importing nations over the globe. Second we have categorized the oil importing economies into three different categories which enable us to estimate the amplitude of asymmetry to particular oil imports magnitude (the degree of dependence on imported oil). Third we use the state of art technique considering the problem of correlation among cross sections and homogeneity to test the symmetry in the oil price response. Further using the industrial production index instead of gross domestic product in analysis will be more informative as it is main parameter of the economic activity. Industrial production index of any country provides information about the changes in production where gross domestic product provides the value of said production[2].

Our results provide evidence that in symmetric model oil price to be significant for first two groups that is low and medium oil importing economies and insignificant in long run. Considering the asymmetry both positive and negative shocks are significant in long run for lowest and highest oil importing economies. Further the result provide evidence both positive and negative shocks increasing economic activity in long run. The negative shocks appear insignificant in short run and positive only significant for lowest oil importing economies. There is symmetry in response of industrial production in short run. However our analysis suggests presence of asymmetry in long run for lowest and highest oil importing economies.

The remaining parts of the study are arranged as follows. Section two presents literature reviews on the subject. Third section deals with theoretical underpinnings, the econometric model, and econometric technique and presents data and variables under consideration. Forth section discusses the results of the regression analysis. The last section concludes the analysis.

Literature on Oil Price Asymmetric Behavior

The process where retail prices respond to increase in wholesale prices but not to the reduction in the wholesale prices is termed as asymmetric price impacts. Asymmetric impact is termed as *"Rocket and Feather Effect"* firstly used Bohi (1991) in the literature. The concept of price asymmetries is not just incarcerated to the gasoline market, but it has been broadened to agricultural goods and financial markets. Peltzman (2000) examined 242 diverse product markets and verify rockets and feathers effect to be a regular pricing phenomenon in more than two thirds of the markets.

The empirical analysis of response of industrial production toward oil price shocks, Mork (1989) conclude that increase and decreases does not have the same implication for growth in US gross domestic product. Other studies that have reported a confirmation for nonlinear forecasting equation perform better comprise Lee*, et al.* (1995), Balke*, et al.* (1998), and Hamilton (1996, 2003). Carlton (2010) and Ravazzolo*, et al.* (2013) both

[2] Industrial production index is published on a monthly basis by the Central Statistics Organization (CSO). It consists of eight core industries (Steel, Electricity, Cement, Petroleum, Coal, Crude oil, Natural Gas and Fertilizer). It gives details on the productivity, growth, slowdown, viability of these industries. GROSS DOMESTIC PRODUCT Growth provides information about goods and services that is produced within the territory of country in a fiscal year.

confirmed these analytical improvements using real-time data. Frederer (1996) and Elder*, et al.* (2010) confirmed that oil-price variation predicts slower GROSS DOMESTIC PRODUCT growth, implying that oil price decreases causes contractationary effects.Herrera*, et al.* (2011) discovered a robust nonlinear response industrial production to oil prices for U.S., with the sizeable effects for energy intensive industries. For a number of OECD countries a nonlinear relation between real GROSS DOMESTIC PRODUCT growth and oil prices has also been reported by Cuñado*, et al.* (2003), Jiménez-Rodríguez**, et al.* (2005), Kim (2012), and Engemann*, et al.* (2010).

In contrast to previous studies Kilian*, et al.* (2011a), Kilian*, et al.* (2011b) found a little evidence for presence of nonlinearity (evidence of asymmetry) in response of gross domestic product growth of US to oil price. The reason stated for such contrasting results is use of methodology for evaluation of presence of asymmetry between oil price and economic activity is based on modeling the oil price variable. Herrera*, et al.* (2015) using simultaneous equation modeling finding presence of asymmetry for the economies either large oil exporter or oil importer further testing the null of joint symmetry provides little evidence of asymmetry.

Overall the above literature encompasses the relationship and reaction of different macroeconomic variables to oil prices by analyzing the oil importing and exporting countries with help of various economic techniques. However asymmetries dealt using US data (see e.g. Hamilton (2011), Kilian*, et al.* (2011a, 2011b) , Herrera*, et al.* (2011) and OECD data Herrera*, et al.* (2015) only. The negative relation between oil price hike and gross domestic product has been an established fact. The asymmetric response of gross domestic price to change in price of oil is not clear from literature with specific focus on oil importing economies. The present study will analyze the behavior of industrial production to oil price shocks by using Dynamic common correlated estimates by Chudik*, et al.* (2015) for oil importing economies. However oil importing economies are being classified into low medium and high oil importing economies.

Theoretical Justification for Asymmetric Impacts of Oil Prices:

This section discusses the theoretical rationale on the response of economic activity to oil price movements. The fluctuation in price of imported oil has been the primary focus of theoretical models for channeling the oil price shocks. There takes a decrease in purchasing power of household of the economy due to an unanticipated rise in the price of imported oil. The stated effect is the direct effect in case increase takes place in price of imported oil and not domestically produced oil. Such effect is symmetric in both increase and decrease in real price of oil. The justification for asymmetric responses of real gross domestic product to oil price is linked to the existence of supplemental indirect effects of unanticipated changes in the real price of oil. The literature describes three main explanations for asymmetric responses. First, is suggested to be *sector reallocation* Davis (1987a, 1987b), Bresnahan*, et al.* (1993) and Davis*, et al.* (2001). According to this literature fluctuation in the price of oil will produce capital and labor reallocation in a way to minimize costs. So for oil importing economies costly reallocation can cause recessionary effects to be amplified in case of positive shocks (negative) and can diminish the expansionary effects of a negative (positive) shock. So sector reallocation will guide to asymmetric effect of both positive and negative shocks on aggregate economic activity.

Another justification for asymmetric impact is *precautionary saving* (see Edelstein*, et al.* (2009). Increase in price of oil in importing economies will raise concerns in consumer related to decrease in employment and real income in future, increasing the precautionary savings. Such increase in saving can lead to decrease in demand driven production. As reduction in oil price will not be related to future uncertainty so this channel asserts asymmetry. On the same lines argument can be discussed for oil exporting economy[3].

Another justification is based on asymmetric response of monetary policy to the fluctuation in price of oil. The asymmetry arises due the fact that Federal Reserve does not respond so actively to declines in price of oil as it responds to the positive shocks to the oil price Bernanke*, et al.* (1997). However, the empirical evidence related to role of monetary policy to magnify the recessionary impact due to oil price is weaker (see e.g. Hamilton*, et al.* (2004) , Herrera*, et al.* (2009) ,Kilian*, et al.* (2011a).

Recent studies have revealed that high levels of uncertainty can produce asymmetric effects under general equilibrium. Plante*, et al.* (2012) examined DSGE model in which output initially is reduced due to oil price fluctuation. So high uncertainty sharpens the negative effect of an increase in price of oil and lessens the impact of reduction in price of oil in short run. The models of general equilibrium that heightened the asymmetry but do not results asymmetry have been proposed by Rotemberg*, et al.* (1996) and Leduc*, et al.* (2004). Rotemberg*, et al.* (1996) proclaimed that elasticity of labor utilization in the presence of markup price amplifies the shock impact.

Summarizing the theoretical model of asymmetry, these can be categorized into two groups on the basis of empirical effects.

- Models implying symmetry concentrate on direct transmission channels, however these have the view that indirect transmission can be through change in utilization of capital and markup price. These model analyze the precautionary saving assuming that household take the price changes symmetrical.
- Models implying asymmetry highlight the significance of reallocation disturbance. These models again examine precautionary saving considering employment to be uncertain in future. In other words, these models examine the oil price changes in heightened uncertainty.

Methodology

Data and Preliminary analysis

[3] The composition of the economy will play a role to determine the magnitude of the effects the factors are energy intensity in consumption , assumption that uncertainty in future level of employment.

The statistical analysis for the variables used is provided here to illicit the statistical properties. The time period for this study is 1990-2019. The study uses industrial production index as dependent variable. The annual data on the variable has been taken from International Financial Statistics. The variable is used in logarithm form. The Brent oil price data in US $ per barrel and it has been taken from OECD Economic Outlook. It has been transformed in logarithm. The exchange rate data is taken from World Development indicator also used in logarithm form. The investment, population growth and export manufacturing as determinant of industrial production by Ozturk, *et al.* (2017) and Mohsen, *et al.* (2015).The data on investment as percent of gross domestic product, export manufacturing and population growth has been used from World Development Indicator. The oil price variable has been further divided in positive and negative shocks by using Shin, *et al.* (2014) are used as explanatory variables. Our analysis will comprise of the following countries and country groupings:

Oil Importers

i. Major oil importers[4]
ii. Medium oil importer
iii. Low oil importers

The table 1 below provides the descriptive statistics for preliminary analyses, thereafter we present homogeneity test (table 2) cross sectional Dependence test (table 3). This section is concluded by carrying out panel unit root tests given dimension of the data used in study (table 4). We have presented the mean standard deviation minimum and maximum value of the included variable of the analysis. The average value of Brent oil is 3.65 $ over the period of 1990-2019 with less variation of 0.67. The positive shock series has less volatility than negative shocks. The official exchange rate over the mentioned period has the highest average value for highest oil importing economies with the highest volatility for medium oil importing and least for lowest oil importing economies. The average value for industrial productivity is more or less same for all oil importing nations. The volatility of industrial productivity ranges from 0.27-0.38 . The observations for industrial productivity are least. The presence of this variable mattered for inclusion of the economy in the analysis as most of economies were dropped from analysis for not having the sufficient number of observation of this variable. The average value of investment as percent of gross domestic product is highest for low oil importing economies and least for medium oil importing nations. However the volatility is highest in highest oil importing economies. The average value of manufacturing exports is highest for medium oil importing economies and least for highest oil importing economies. The volatility of manufacturing exports is highest for highest oil importing economies. The reason can be high oil imports and oil being the basic ingredient of production

[4] Where, analysis will comprise of categorizing the world countries as 30%-20% (named as group C used interchangeably)of oil imports as their total imports as major importer, 20%-10% (B) as medium importer and 10%-5%(A) as low importer.

process. The average growth rate of population is highest for high oil importing nations with volatility also being highest.

Table 1 Descriptive Statistics								
A group(Lowest oil Importing Economies)								
	oil	oil^{+}	oil^{-}	oex	ipi	inv	exm	pop
Mean	3.6569	5.6513	-4.1467	1.5630	4.5191	23.8524	67.9796	0.8808
Std. Dev.	0.6752	8.02695	10.2944	1.6799	0.2965	4.7563	23.5633	0.6644
Min	2.5496	0	-46.5532	-0.6936	3.0569	14.49	13.2354	-0.3757
Max	4.714	31.7443	0	5.4920	5.0856	46.924	93.8858	2.8909
Obs.	360	360	360	355	330	353	338	360
B group (Medium oil Importing Economies)								
	oil	oil^{+}	oil^{-}	oex	ipi	inv	exm	pop
Mean	3.6569	5.6513	-4.1467	1.9074	4.4955	22.0542	72.5896	0.8184
Std. Dev.	0.6748	8.0221	10.2883	2.4691	0.27933	4.6771	21.4955	1.0690
Min	2.5496	0	-46.5532	-6.0998	3.1056	5.834	3.3906	-1.8537
Max	4.7147	31.7443	0	7.6792	5.3915	38.193	373.2282	5.6145
Obs.	630	630	630	629	616	630	609	630
C group(Highest oil Importing Economies)								
	oil	oil^{+}	oil^{-}	oex	ipi	inv	exm	pop
Mean	3.6569	5.6513	-4.1467	4.2078	4.3627	23.0670	60.0507	1.1358
Std. Dev.	0.6759	8.0349	10.3047	2.7922	0.38393	8.0041	26.1565	1.2827
Min	2.5496	0	-46.5532	-10.4291	3.1287	4.039	6.1007	-2.2584
Max	4.7147	31.7443	0	7.2452	5.0768	41.374	96.0328	3.6066
Obs.	210	210	210	202	201	205	200	210

Analytical Framework

The cross-sections are considered correlated in analysis of energy sector due to three factors (i) unexceptional shocks; (ii) Mutual institutes; and/or (iii) spillover effects either local or regional. The oil price shocks are a specific case of common shocks to oil importing economies. The cross sectional correlation among the errors of panel regressions can give the estimates of parameter which are inconsistent and results in incorrect inferences when standard estimation methods are used Kapetanios, *et al.* (2011).So the dependency among cross sections has been checked before checking order of integration of the variables. For this purpose cross section Dependency (CSD) tests by H. Pesaran (2004) has been used.

There is substantial degree of heterogeneity as the relationships will be different for each state. And if the coefficients are assumed homogeneous mistakenly (when the true parameter of a dynamic panel are not homogeneous in fact), then the estimates will be inconsistent M. H. Pesaran, *et al.* (1995). The slope heterogeneity test of M. H. Pesaran, *et al.* (2008) has been used by the study. This test has superiority to other heterogeneity test due to fact that standard tests do not consider the cross sectional dependency Atasoy (2017). Further M. H. Pesaran, *et al.* (2008) is suitable with small sample size(N) and large time period (T), i.e. ,T>N[5]. Since, both properties of cross sectional correlation and T>N is being present in all groups of the study at hand hence uses this slope heterogeneity tests. To consider slope heterogeneity tests equation are specified by

$$\tilde{\Delta}_{SH} = (N)^{\frac{1}{2}}(2k)^{-\frac{1}{2}}(\frac{1}{N}\tilde{S} - k) \qquad (1)$$

$$\tilde{\Delta}_{ASH} = (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1)}{T+1}\right)^{-\frac{1}{2}}(\frac{1}{N}\tilde{S} - k) \qquad (2)$$

$\tilde{\Delta}_{SH}$ and $\tilde{\Delta}_{ASH}$ express delta and adjusted delta tilde ,respectively. The $\tilde{\Delta}_{SH}$ is based on the assumption $(N, T) \xrightarrow{j} \infty$ such that $\sqrt{N}/_{T^2} \to 0$ however, if the panel regression model is first order autoregressive model then $(N, T) \xrightarrow{j} \infty$ and $N/_T \to k$ so mean variance bias adjusted $\tilde{\Delta}_{SH}$ is expressed as $\tilde{\Delta}_{ASH}$ above.

To analyze the order of integration of the variables of the study, Im, *et al.* (2003), Cross-Sectionally Augmented Dickey- Fuller (CADF) and Cross-Sectionally Augmented IPS (CIPS) have been used. Im, *et al.* (2003) and Cross-Sectionally Augmented Dickey- Fuller (CADF) are first-generation unit root tests while the CIPS is second generation unit root test. The salient feature of CIPS test used here is based on the fact that it supposes crosss sectional dependency when compared with other tests. The presence of cross-sectional dependency among cross sections can provide misleading results by using the conventional panel unit root tests. Now withstanding this, to circumvent the biased in the outcomes to any unit root test the study have used all indicated unit root tests in sequence. CIPS's equation is specified as:

$$\Delta W_{i,t} = \varphi_i + \varphi_i Z_{i,t-1} + \varphi_i \bar{W}_{t-1} + \sum_{i=0}^{p} \varphi_{il}\, \Delta\bar{W}_{t-1} + \sum_{i=1}^{p} \varphi_{il}\, \Delta\bar{W}_{i,t-1}\mu_{it} \qquad (3)$$

The $\bar{W}$ in above equation is the cross section means and is specified as below:

$$W^{i,t} = \varphi^1 \overline{lnlop}^{i,t} + \varphi^2 \overline{lnlex}^{i,t} + \varphi^3 \overline{lninv}^{i,t} + \varphi^4 \overline{lnexm}^{i,t} \qquad (4)$$

The test statistics of CIPS is specified as

$$\widehat{CIPS} = N^{-1} \sum_{i=1}^{n} CDF_i \qquad (5)$$

The CDF means cross sectionally augmented Dickey- Fuller (CADF).

Empirical Model

[5] Study sample contains 3 groups all having a case of T>N.

To explore the symmetric and asymmetric impact of oil prices on industrial productivity and exchange rate of oil importing economies the approach of dynamic common correlated estimators presented by Chudik, *et al.* (2015) will be used. The dynamic common correlated approach is delineated on the basis of pooled mean group (PMG) technique M. H. Pesaran, *et al.* (1997), Mean group (MG) estimation by M. H. Pesaran, *et al.* (1995)., and CCE estimation M. H. Pesaran, *et al.* (1995), and CCE estimation M. H. Pesaran (2006). This approach has an advantage over the other conventional methods. These consider the cross-sectional dependence and allow for heterogeneous slopes and dynamic common correlated effects.

Following Herrera, *et al.* (2015) the DCCE model specification for this analysis is specified as:

$\Delta ipi_{it} = \alpha_0 + \alpha_{1i} ipi_{i,t-1} + \alpha_{2i} oil_{i,t-1} + \alpha_{3i} oex_{i,t-1} + \alpha_{4i} inv_{i,t-1} + \alpha_{5i} exm_{i,t-1} + \sum_{j=1}^{N_1} \lambda_{ij}\, \Delta ipi_{i,t-j} + \sum_{j=0}^{N_2} \lambda\psi_{ij}\, \Delta oil_{i,t-j} + \sum_{j=0}^{N_3} \gamma_{ij}\, \Delta inv_{i,t-j} + \sum_{j=0}^{N_4} \delta_{ij}\, pop_{i,t-j} + \mu_i + \varepsilon_{it}$ …….(6)

where i=1,2,...,*N* is the number of countries; *t* =1,2,...,*T* is the number of periods μ_i is the group specific effect ; ipi_{it} is the industrial production index lop_{it} represent oil prices (Proxied by Brent) lex_{it} represents official exchange rate. inv_{it} is investment as percentage of gross domestic product, exm_{it} is export of manufacturing sector and pop_{it} stands for population growth. The log transformation of the series eases the computation of the elasticity coefficient for oil price output movements for oil importing economies.

For each cross section , the long run coefficient are computed as - $\frac{\alpha_2}{\alpha_1}$ and - $\frac{\alpha_3}{\alpha_1}$ respectively since in the long run it is assumed that $\Delta lop_{i,t-j} = 0$; $\Delta lex_{i,t-j} = 0$; $\Delta y_{i,t-j} = 0$. However for each cross section estimates are derived as ψ_j and $\gamma_j$for oil price and determinants of industrial productivity respectively in short run.

To include error correction term the equation (1) can be re specified as bellow

$$\Delta ipi_{it} = \delta_i v_{i,t-1} + \sum_{j=1}^{N_1} \lambda_{ij}\, \Delta ipi_{i,t-j} + \sum_{j=0}^{N_2} \psi_{ij}\, \Delta oil_{i,t-j} + \sum_{j=0}^{N_3} \gamma_{ij}\, \Delta oex_{i,t-j} + \sum_{j=0}^{N_4} \delta_{ij}\, inv_{i,t-j} + \sum_{j=0}^{N_5} \gamma_{ij}\, \Delta exm_{i,t-j} + \sum_{j=0}^{N_6} \gamma_{ij}\, \Delta pop_{i,t-j} + \mu_i + \varepsilon_{it} \quad (7)$$

Where $v_{i,t-1} = ipi_{i,t-1} - \phi_0 - \phi_{1i} oil_{i,t-1} - \phi_{2i} exm_{i,t-1} - \phi_{3i} pop_{i,t-1} - \phi_{4i} inv_{i,t-1} - \phi_{5i} oex_{i,t-1}$ is linear error correction term; the parameter δ_i is the error correction speed of adjustment term while the underlying long run coefficients have been explained earlier as $\phi_{1i} = -\frac{\alpha_{2i}}{\alpha_{1i}}$ and $\phi_{2i} = -\frac{\alpha_{3i}}{\alpha_{1i}}$.

Note that the oil price is not decomposed into positive and negative shocks in both of the above equation; so specified on the presumption of symmetric behavior of oil price on industrial productivity. The asymmetric form of the equation (1) is given below however the oil price is decomposed into positive and negative changes in accordance with Shin, *et al.* (2014):

$$\Delta ipi_{it} = \alpha_0 + \alpha_{1i} ipi_{i,t-1} + \alpha_{2i} oil^{+}_{i,t-1} + \alpha_{3i} oil^{-}_{i,t-1} \alpha_{4i} pop_{i,t-1} + \sum_{j=1}^{N_1} \lambda_{ij}\, \Delta ipi_{i,t-j} + \sum_{j=0}^{N_2} \gamma_{ij}\, \Delta inv_{i,t-j} + \sum_{j=0}^{N_3} \gamma_{ij}\, oex_{i,t-j} + \sum_{j=0}^{N_4} \left(\gamma^{+}_{ij} oil^{+}_{i,t-j} + \gamma^{-}_{ij} oil^{-}_{i,t-j}\right) + \mu_i + \varepsilon_{it} \quad (8)$$

The above equation (8) the oil price variable has now been broken down into oil^{+}_{it} and oil^{-}_{it} depicting the changes of oil price both positive and negative respectively. The decomposed prices are defined theoretically as below:

$$oil^{+}_{it} = \sum_{j=1}^{t} \Delta oil^{+}_{ij} = \sum_{j=1}^{t} \max(\Delta oil_{ij}, 0) \qquad (9)$$

$$oil^{-}_{it} = \sum_{j=1}^{t} \Delta oil^{-}_{ij} = \sum_{j=1}^{t} \min(\Delta oil_{ij}, 0) \qquad (10)$$

After including an error correction term in equation (8) it can be re- specified as below

$$\Delta ipi_{it} = \tau_i\, \xi_{i,t-1} + \sum_{j=1}^{N_1} \lambda_{ij}\, \Delta ipi_{i,t-j} + \sum_{j=0}^{N_2} \gamma_{ij}\, \Delta inv_{i,t-j} + \sum_{j=0}^{N_3} \gamma_{ij}\, oex_{i,t-j} + \sum_{j=0}^{N_4} \left(\gamma^{+}_{ij} oil^{+}_{i,t-j} + \gamma^{-}_{ij} oil^{-}_{i,t-j}\right) + \mu_i + \varepsilon_{it} \quad (11)$$

The above equation (11) $\xi_{i,t-1}$ is the error correction term that represent the long run equilibrium in the asymmetric ARDL however, parameter associated t it (τ_i) conveys the magnitude of adjustment that is in presence of shock how long it takes the structure to calibrate to its long run equilibrium.

Results and Discussion

The results of M. H. Pesaran, *et al.* (2008) slope heterogeneity test are presented in Table 2[6]. The results show that both models symmetric and asymmetric for all of the groups of oil importing economies points to the heterogeneity problem. For the models to be heterogeneous implies that conventional unit root test will give biased results. For all groups of oil importing economies the test statistics are significant in case of both models.

Table 2 Pesaran and Yamagata (P&Y, 2008) Slope Heterogeneity.

Models	Country Groups	Statistics	Values
Symmetric	A group	$\tilde{\Delta}$	12.723***
		$\tilde{\Delta}_{adusted}$	14.883***
	B Group	$\tilde{\Delta}$	22.212 ***
		$\tilde{\Delta}_{adusted}$	25.550 ***

[6] Slope heterogeneity tests are implemented by using command xthst in Stata14 .
The null hypothesis : slope coefficients are homogenous

	C group	$\tilde{\Delta}$	9.332 ***
		$\tilde{\Delta}_{adusted}$	10.581 ***
Asymmetric	A group	$\tilde{\Delta}$	8.641 ***
		$\tilde{\Delta}_{adusted}$	10.108 ***
	B Group	$\tilde{\Delta}$	14.242 ***
		$\tilde{\Delta}_{adusted}$	16.382 ***
	C group	$\tilde{\Delta}$	9.715***
		$\tilde{\Delta}_{adusted}$	10.690***
*** represents significance at 1% level. The null hypothesis is slope coefficients are homogenous. Note: the case of normally distributed errors the mean-variance bias adjusted $\tilde{\Delta}$ =$\tilde{\Delta}_{adusted}$			

The results of the cross sectional dependence (CSD) H. Pesaran (2004) test (below table 3) depicts that cross section are not independent, which is obvious from significance of the test statistics[7]. The null of cross sectional independence (at the 1% level) is rejected for each variable present in the model by test statistics. From the results it is evident cross sections are dependent .More ever the value for coefficients of absolute mean correlation ranged from 0.4–1.0 (last three columns of Table 3). High values for mean correlation coefficient confirms the presence of correlation between the cross sections of the panel.

Table 3 Cross section Dependence (Pesaran 2004) Test

Variable	CD Test			Correlation		
	A group	B Group	C group	A group	B Group	C Group
ipi	18.613 ***	31.01***	13.429***	0.54	0.56	0.60
oil	44.497 ***	79.37***	25.1***	1.00	1.000	1.00
ExΔ Rate	25.291 ***	31.71***	8.738***	0.60	0.44	0.44
oil^{+}	44.497 ***	79.37***	25.1***	1.00	1.00	1.00
oil^{-}	44.497 ***	79.37***	25.1***	1.00	1.00	1.00
inv	3.886***	11.649***	-1.218	0.39	0.33	0.42
exm	12.003***	14.036***	8.156***	0.49	0.39	0.34
pop	7.378***	2.001	13.619***	0.38	0.31	0.59
*** represents significance at 1% level. The null hypothesis is cross-sections are independent.						

The issue of non satationarity deserves attention when dealing with macro panel data. Hence as precondition for non Stationarity we subjected each series of our model to unit roots tests. The data being unbalanced unit root tests performed include Im*, et al.* (2003), cross sectionally Augmented Dickey Fuller (CADF) and Cross Sectionally Augmented IPS (CIPS).

The result in the table 4 suggets that variables are either stationary at level or at first difference.

Table 4 Panel Unit Root Test

Variables	**Country Groups**	**Level**		**First-difference**		**Order**
		Intercept	Intercept and trend	Intercept	Intercept and trend	

[7] CD test by command xtcdf code Stata-14 null hypothesis being cross section are independent

First Generation Tests						
Im, Pesaran and Shin (IPS, 2003)						
ipi	A Group	0.4462	0.1773	-6.5389***	-4.6024***	I(1)
oil		1.3701	1.3488	-10.7720***	-8.2295***	I(1)
ExΔ Rate		-2.3299***	-0.1002	-8.7286***	-6.4587***	I(1)
oil^{+}		-6.1765***	-4.2490***	--	--	I(0)
oil^{-}		-9.2038***	-8.6433***	--	--	I(0)
exm		-0.5971	0.6212	-7.0545***	-5.4529***	I(1)
inv		-3.4169***	-2.2224***	--	--	I(0)
pop		-2.6479***	-7.4925***	--	--	I(0)
ipi	B Group	0.5146	1.7438	-10.5654***	-9.3824***	I(1)
oil		1.6211	1.5959	-12.7456***	-9.7372***	I(1)
ExΔ Rate		-5.149***	-7.137***	--	--	I(0)
oil^{+}		-7.3081***	-5.0274***	--	--	I(0)
oil^{-}		-10.890***	-10.2269***	--	--	I(0)
exm		-2.8103***	-2.2816***	--	--	I(0)
inv		-3.3488***	-2.3465***	--	--	I(0)
pop		-7.9016***	-9.8396***	--	--	I(0)
ipi	C Group	-0.2136	1.9359	-6.2083***	-9.5165***	I(1)
oil		1.1187	1.1013	-8.7953***	-6.7193***	I(1)
ExΔ Rate		-5.4890***	-5.8348***	--	--	I(0)
oil^{+}		-5.0431***	-3.4693***	--	--	I(0)
oil^{-}		-7.5149***	-7.0573***	--	--	I(0)
exm		-1.2192	-1.3988*	-7.9422***	-6.3247***	I(1)
inv		-1.6596**	-0.7962	-8.5278***	-7.3276***	I(1)
pop		-3.2940***	-7.2919***	--	--	I(0)
Cross-Sectionally Augmented Dickey-Fuller (CADF)						
ipi	A Group	9.801	-3.357***	--	--	I(0)
oil		2.610***	1.700	--	--	I(0)
ExΔ Rate		-9.427***	-9.316***	--	--	I(0)
oil^{+}		17.488***	16.741	--	--	I(0)
oil^{-}		2.610***	1.700			I(0)
exm		-1.827**	-2.370***	--	--	I(0)
inv		-1.028	0.477	-7.628***	-6.193***	I(1)
pop		-2.765***	-3.033***	--	--	I(0)
ipi	B Group	-0.309	2.991	-5.772***	-4.530***	I(1)
oil		2.610***	1.700	--	--	I(0)
ExΔ Rate		0.553	5.374	-4.826***	-4.019***	I(1)
oil^{+}		2.610***	1.700	--	--	I(0)
oil^{-}		2.610***	1.700	--	--	I(0)
exm		-1.921	-2.272	-7.707***	-5.835***	I(1)
inv		-2.073*	-2.534	-3.788***	-3.876***	I(1)
pop		-2.499***	-3.365***	--	--	I(0)
ipi	C Group	1.098	2.851	-2.669***	-2.602***	I(1)
oil		2.610***	1.700	--	--	I(0)
ExΔ Rate		-3.222***	-2.664***	--	--	I(0)
oil^{+}		2.610***	1.700	--	--	I(0)

oil^{-}		2.610***	1.700	--	--	I(0)
exm		-1.900**	-1.330*	--	--	I(0)
inv		-0.627	1.180	-6.217***	-5.340***	I(1)
pop		-2.955***	-4.020***	--	--	I(0)
2nd Generation Tests						
Cross-Sectionally Augmented IPS (CIPS)						
ipi	A Group	-1.598	-1.779	-4.061***	-4.246***	I(1)
oil		2.610	1.700	2.610***	1.700***	I(1)
ExΔ Rate		-1.721	-2.322	-4.144***	-4.127***	I(1)
oil^{+}		2.610***	1.700	--	--	I(0)
oil^{-}		2.610***	1.700	--	--	I(0)
exm		-1.793	-2.667***	--	--	I(0)
inv		-2.155	-2.454***	--	--	I(0)
pop		-2.171*	-1.837	-3.519***	-3.536***	I(1)
ipi	B Group	-1.747	-2.064	-4.438***	-4.726***	I(1)
oil		2.610	1.700	2.610***	1.700***	I(1)
ExΔ Rate		-3.174***	-3.120***	--	--	I(0)
oil^{+}		2.610***	1.700	--	--	I(0)
oil^{-}		2.610***	1.700	--	--	I(0)
exm		-1.376	-2.125***	--	--	I(0)
inv		-1.875	-2.185	-4.583***	-4.587***	I(1)
pop		-2.007	-2.447	-3.518***	-3.600***	I(1)
ipi	C Group	-1.589	-1.314	-4.361***	-4.651***	I(1)
oil		2.610	1.700	2.610***	1.700***	I(1)
ExΔ Rate		-1.665	-2.052	-3.302***	-3.291***	I(1)
oil^{+}		2.610***	1.700	--	--	I(0)
oil^{-}		2.610***	1.700	--	--	I(0)
exm		-1.520	-2.128***	--	--	I(0)
inv		-1.604	-1.521***	--	--	I(0)
pop		-1.792	-1.180	-2.668***	-2.834***	I(1)

I(0): stationary; I(1): integrated order one, nonstationary; Statistical significance level of 0.1% denoted by ***
--where variable is I(0) no need for test stat at 1st difference

The results of Cross Sectionally Augmented IPS for heterogeneous panel are dominant based on the fact that it presumes dependency among cross sections produced by single common element. To control the problem of serial correlation, we have used lag of the variables. The results by including trend and drift have also been reported. The positive and negative shocks for all groups of oil importing economies are found to be I(0). The oil price and industrial production index is found to be I(1) for all of the oil importing economies. However exchange rate is I(1) for highest and lowest oil importing economies and I(0) for economies with medium oil imports.

Discussion of CS ARDL Results

After checking the integration properties of all series under examination, we begin to discover the dynamics of the oil price industrial productivity relation in long run and short run. The above equation (6) and (8) has been estimated using dynamic common correlated estimator (DCCE) by using Chudik, *et al.* (2015)[8]. The models are represented without asymmetry (equation 6) and with asymmetry (equation 8). The estimation results are summarized in table 5. The table has two parts first part results without asymmetry and second part when asymmetry is taken into account. First the symmetric model results are reported for group A B and C and then asymmetric for 3 groups respectively. Each column of the table reports regression results in the long run and short run with and without asymmetry respectively.

Discussion of results without asymmetry:

The observed estimates are considered under two main headings with model without asymmetry and with asymmetry for oil importing economies with A group having oil imports (5-10%) B group having oil imports (10-20%) and C group with (20-30%). Lastly we have conducted the robustness check by changing oil variable proxy using West Texas Intermediate oil price following Salisu, *et al.* (2017). The results discussion is made in table 5 and 6 for analysis and robustness respectively.

Table 5 : Panel Regression Results

	Without Asymmetry			**With Asymmetry**		
	A group b/se	B group b/se	C group b/se	A group b/se	B group b/se	C group b/se
Short-Run Estimates						
Δoil	0.054*** (0.021)	0.027*** (0.009)	-0.029 (0.040)			
Δoex	0.120** (0.050)	-0.114 (0.093)	-0.048 (0.113)	0.104** (0.043)	-0.104 (0.135)	-0.148** (0.061)
Δinv	0.015*** (0.003)	0.015*** (0.003)	0.005 (0.005)	0.015*** (0.004)	0.017*** (0.003)	0.010** (0.004)
Δexm	0.001 (0.001)	0.002* (0.001)	0.003 (0.005)			
$\Delta\ Oil^{+}$				0.001** (0.000)	0.000 (0.001)	-0.000 (0.000)
$\Delta\ Oil^{-}$				0.000 (0.000)	-0.000 (0.000)	0.001 (0.001)
$\boldsymbol{ECT}$	-0.135*** (0.050)	-0.202*** (0.041)	-0.244*** (0.092)	-0.028** (0.012)	-0.096*** (0.018)	-0.174*** (0.064)
Long-Run Estimates						
oil^{+}				-0.063***(0.014)	-0.016 (0.037)	0.011** (0.004)
oil^{-}				0.048*(0.025)	0.036 (0.036)	-0.032* (0.018)
inv	0.046 (0.032)	0.012 (0.010)	0.028 (0.024)			
oil	0.272 (0.240)	0.245 (0.151)	-0.036 (0.123)			
pop	-0.520 (0.392)	0.234 (0.235)	-0.758(0.505)	-0.078 (0.447)	-4.877 (4.792)	-0.495 (0.369)
$Constant$	3.081** (1.485)	3.258*** (0.714)	6.420*** (1.070)	6.404*** (1.099)	4.580*** (0.730)	5.687*** (0.958)
$CD\ Statistics[p\ val$	4.64 (0.00)	7.90 (0.00)	0.60 (0.5505)	6.41 (0.00)	7.98 (0.00)	0.45 (0.6503)
$No. of\ Obs.$	299.000	573.000	180.000	314.000	594.000	187.000

[8] Using command xtdcce2 in Stata -14 by Jan Ditzen (2018)

$No\ of\ periods$	30	30	30	30	30	30
$F(p\ value)$	4.567 (0.00)	4.416 (0.00)	3.667 (0.00)	4.845 (0.00)	3.652 (0.00)	3.265 (0.00)
$No\ of\ cross\ sectior$	12	21	7	12	21	7

Considering the short run results first the elasticity coefficient of oil price is positive and significant for first two groups being insignificant for highest oil importing economies and significant for groups with oil imports from 10-20%. The magnitude of elasticity is 0.054 and .027 for both the oil imports with (5-10%) and (10-20%) respectively. The effect of the oil price on industrial productivity is positive in the short run for economies with oil imports less than 20%. As the oil imports are higher from 20-30% its response insignificant. The reason advanced by Fukunaga et al (2011) is that demand shocks whether specific to oil or global do not act as supply rather acts as a positive demand shocks that increases industry level production and prices.

The elasticity of exchange rate to industrial production of oil importing economies is only significant for lowest oil importing economies in short run. For the economies with oil imports being 20-30% and higher the response is negative but insignificant. That is as oil imports are higher the exchange rate does not play a significant role in determination of industrial production in economy.

The parameter of investment as percent of gross domestic product is significant for lowest and medium oil importing economies with magnitude of 0.015. That is a unit increase investment in the economy will increase the industrial production by 1.5 %. However its parameter is insignificant for highest oil importing economy. The high level of oil imports might be the reason of insignificance role of investment for industrial productivity of the economies. For first two groups of the oil importing the results are in complete consensus with Ozturk*, et al.* (2017).

The parameter of manufacturing export is only significant for medium oil importing economies with magnitude of 0.002. That is a unit increase manufacturing export in the economy will increase the industrial production by 0.2 %. The results are in partial consensus with Mohsen*, et al.* (2015) who finds a significant positive impact of manufacturing export to industrial output for Syria. The reason might be in the diversity of our sample structure as it comprises different economies on basis of oil imports over the globe.

For the long run the oil price, investment as percent of gross domestic product and population growth has been used as independent variables. The parameter of none of the variables stands significant. In the long run none of the variable responds significantly to industrial production of the oil importing economies where these are significant in short run.

A5symmetric Model Discussion

Our discussion about asymmetric model will start with the result of positive and negative oil price shocks on industrial production in short run. The dependent variable is in logarithm whereas the independent variable is linear for interpretation of the linear transformation models by Benoit (2011) approach will be used.

When asymmetry is examined in the relation, the observed parameters convey interesting results. The coefficient of ΔOil^{+} positive oil price shocks for low oil importing economies is .0011 that is .11 percent increase in industrial productivity is caused by a unit increase in price of oil in short run. The positive shocks coefficient is significant at 1% level of confidence for low oil importing economies only and insignificant for rest in short run. However, the oil^{+} positive oil price shocks are significant for lowest and highest oil importing group of economies in long run. The magnitude of the coefficient is -0.063 and 0.011 for lowest and highest oil importing economies respectively. That is a unit increase in price of oil causes a decrease in industrial production by 6.3% and increase by 1.1% for lowest and highest oil importing economies in the long run respectively.

Now examining the negative shocks ΔOil^{-} stands insignificant in short run for all of the categories. However considering oil^{-} negative oil price shocks, are again significant for lowest and highest oil importing economy in the long run. The coefficient for lowest oil importing economy is 0.048 that is a unit decrease in price of oil increase the industrial productivity by 4.8%. The same negative shock stands insignificant for medium oil importing economies and having coefficient of -0.032 for highest oil importing economies. That is a unit decrease in price of oil causes an increase in industrial productivity by 3.2% for the nations having oil imports of 20-30%.

The analysis of positive and negative shocks suggests there is symmetry in short run in response of industrial production to oil price shocks. However there is asymmetry for lowest and highest oil importing economies in the long run. The results of the analysis are in partial consensus with Herrera*, et al.* (2015) who, analyzed the data of OECD countries and found little support that response are asymmetric.

The $\boldsymbol{ECT}$ error correction term is negative and significant for all three groups of economies providing evidence for model stability and long run relationship of the variables for both symmetric and asymmetric models. The magnitude of $\boldsymbol{ECT}$ term for symmetric model is -0.13 -0.20 and -0.24 for lowest medium and highest oil importing economies respectively. That is for every short run disequilibrium 13.5 20.2 and 24.4 % of adjustment is made each year. That is disequilibrium is corrected at 13.5% 20.2% and 24.4% each year by three groups. The magnitude of correction is higher as oil imports are higher along group. For asymmetric model for all three groups the rate of adjustment of the disequilibrium is 2.8%, 9.6% and 17.4% for lowest medium and highest oil importing economies respectively. Again a momentum is observed that is as oil imports are higher the rate of elimination of disequilibrium is higher.

Testing model for Short run and Long run Asymmetries

Following Frey*, et al.* (2007) testing null hypothesis $\alpha_0^{+} = \alpha_0^{-}$ gives information about contemporaneous impact of positive and negative shocks on industrial production. The rejection or non rejection will determine asymmetry or symmetry according to null hypothesis. The results for the tests are provided in the table below.

The table 7 depicts presence of asymmetry in long run for lowest and highest oil importing economies. However in short run there is no evidence of asymmetry for any of the group of oil importing economy. The table also reports the number of years required for disequilibrium to halve for three categories. The results are evident of the fact that number of years for disequilibrium to be halved decreases as the oil imports increase in case of symmetric model. However the number of years required halving the disequilibrium also decreases as oil imports increase when splitting the oil shocks into positive and negative counterpart.

Table 7 : Decision about Short run and Long run Asymmetries

	Test Stats.		**Decision**		**↓disequilibrium by 50%(# of years)**	
Oil Imports	Short Run	Long Run	Short Run	Long Run	Symmetric	Asymmetric
Lowest oil Importing(A)	1.89(0.1703)	10.31***(0.0015)	Symmetric	Asymmetric	4.5	22.8
Medium oil Importing (B)	.17(0.6837)	0.51(0.4737)	Symmetric	Symmetric	3.07	6.57
Highest oil Importing (C)	1.52(0.2201)	6.061***(0.0152)	Symmetric	Asymmetric	2.40	3.72

No of years has been calculated by expression $dissequilibrium\ after\ adjustment^{n} = .50$

Robustness Check

The check for robustness is carried out using sample as in the main analysis. Recall the main estimation considers oil price as measured using Brent (oil price). Following Salisu, *et al.* (2017) however we replaced the Brent oil price proxy with WTI oil price and re-estimated all the equations for all groups. The results are summarized in table 6. From the results it is evident that the estimated results are robust to different oil proxies. In other words, it can be established that using different oil proxies (particularly Brent and WTI) will provide the similar conclusion. However, in terms of measure of influence a few differences are noticeable.

Table 6 : Panel Regression Robustness Results

	Without Asymmetry			**With Asymmetry**		
	A group b/p	B group b/p	C group b/p	A group b/p	B group b/p	C group b/p
Short-Run Estimates						
Δoil	0.066*** (0.005)	0.029*** (0.003)	-0.026 (0.527)			
Δoex	0.130*** (0.009)	-0.110 (0.274)	-0.048 (0.652)	0.102*** (0.008)	-0.099 (0.457)	-0.130**(0.021)
Δinv	0.015*** (0.000)	0.015***(0.000)	0.005 (0.267)	0.014*** (0.000)	0.017*** (0.000)	0.009** (0.034)
Δexm	0.001 (0.342)	0.002* (0.094)	0.003 (0.609)			
$\Delta\ Oil^{+}$				0.002*** (0.007)	0.000 (0.850)	0.000 (0.610)
$\Delta\ Oil^{-}$				-0.000 (0.816)	-0.000 (0.667)	0.000 (0.466)

ECT	-0.118*** (0.006)	-0.195*** (0.000)	-0.239** (0.012)	-0.018 (0.197)	-0.099*** (0.000)	-0.177*** (0.007)
Long-Run Estimates						
oil	0.392 (0.236)	0.356 (0.813)	0.010 (0.945)			
inv	0.072 (0.102)	0.190 (0.369)	0.054 (0.166)			
pop	-0.690 (0.251)	-1.945 (0.250)	-2.320 (0.249)	-2.042 (0.319)	-7.542 (0.207)	-4.249 (0.300)
oil^{+}				0.092 (0.473)	0.138 (0.315)	-0.028 (0.548)
oil^{-}				0.059 (0.705)	-0.103 (0.337)	-0.121 (0.241)
$Constant$	2.140 (0.243)	-4.000 (0.769)	10.128** (0.033)	8.549* (0.075)	6.356*** (0.000)	15.883 (0.161)
$CD\ Statistics[p\ value]$	4.93 (0.00)	8.02 (0.00)	0.86 (0.3904)	5.66 (0.00)	7.84 (0.00)	0.25 (0.7991)
$No. of\ Obs.$	299.000	573.000	180.000	314.000	594.000	187.000
$No\ of\ periods$	30	30	30	30	30	30
$F(p\ value)$	4.672 (0.00)	4.388 (0.00)	3.667 (0.00)	5.225 (0.00)	3.742 (0.00)	3.705 (0.00)
$No\ of\ cross\ sections$	12	21	7	12	21	7

Conclusion

This paper examines the responses of industrial productivity of oil importing economies to oil price shocks. The study has used annual data for period of 1990-2019 by dividing the oil importing economies into low, medium and high oil importing economies. By following Chudik, *et al.* (2015) model gives interesting results. The oil price variable stands significant in short run for low and medium oil importing economies being insignificant for high oil importing economies and insignificant for all groups in long run. However, following Shin, *et al.* (2014) when oil price is disjoined into positive and negative integrant the negative shocks stand insignificant for all oil importing economies in short run providing evidence for short run symmetry. However a positive shock appears significant only for low oil importing economies.

In the long run oil price shocks both positive and negative stand significant for lowest and highest oil importing economies. For lowest oil importing economies positive shocks decreases and negative increases industrial productivity of the economies. For highest oil importing economies both positive and negative shocks increases the industrial productivity of the economies. The implication of the analysis is that there is no evidence of asymmetry for all categories in short run. In the long run there is asymmetry for lowest and highest oil importing economies. As in long run negative shocks of oil price causes a decrease in productivity for lowest oil importing and increases in highest oil importing economies that can be due adjustments of inputs in long run.

Declaration

Availability of Data and Materials

Data and all material will be provided on request by the author.

Competing Interest.

I declare that I have no significant competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

Funding Information

The current study has not been funded by any organization and no funding source for conduct of analysis at any stage.

Author Contributions: Conceptualization, S.B, M.H and A.R.; methodology, S.B, M.H and A.R.; software, S.B; validation, S.B, M.H and A.R.; formal analysis, S.B; investigation, S.B.; resources, S.B.; data curation, S.B. and A.R.; writing—original draft preparation, S.B, M.H and A.R.; writing—review and editing, S.B, M.H and A.R.; visualization, S.B, M.H and A.R.; supervision, M.H and A.R.

Acknowledgement

I want to thank my both co authors for their helpful comments, suggestions and support. I want to also thank an anonymous referee for guidance and support.

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

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