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THE CAUSAL RELATIONSHIP BETWEEN OIL PRICE AND INFLATION IN BANGLADESH: AN EMPIRICAL ANALYSIS

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ABSTRACT

Bangladesh is one of the fastest growing developing economies in the South Asian region with very little fossil fuel endowment. As a result, the country typically relies on imported energy sources. Existing media reports point out an increase in global energy prices in recent years. An increase in global oil price simultaneously increases the rate of inflation in the oil importing countries as well. Hence, the aim of this paper is to empirically analyze the short-run and long- run causal relationship between oil price in the international market and domestic inflation in Bangladesh. Using annual data ranging from 1980 to 2021, the paper conducts a Johansen's cointegration test to identify the variables' cointegrating relationship. Moreover, Granger Causality and VECM causality tests confirm a unidirectional causality runs from oil price in the international market to domestic inflation in Bangladesh, both in the short run and in the long run.

Keywords: Inflation, Oil price, Bangladesh, Granger Causality, VECM Causality

1. INTRODUCTION

Energy is considered to be a "universal" production input that is essential for driving industrial growth and economic productivity. Energy availability plays a fundamental role in facilitating urbanization, industrialization and job creation that, eventually, leads to economic development. Without steady energy supply, it would be impossible for enterprises and factories to keep functioning and cities will not be able to provide jobs for its dwellers. Due to technological advancement and recent innovations, all economic sectors i.e.; industry, agriculture and services are also heavily dependent on automated equipment and energy driven machineries. Therefore, it is of paramount importance that energy moves along freely throughout the country to ensure economic efficiency and sustainable development.

Bangladesh has emerged as one of the fastest growing developing countries in the South Asian region in the past few decades. At the same time, its demand for energy in both its production and residential sectors has registered unprecedented growth. On average, total energy consumption has increased by 4.5% annually since 2010 (World Bank, 2022). However, Bangladesh has very limited fossil fuel-based energy endowment in forms of natural gas and coal. As a result, the country needs to rely heavily on imported energy. According to Bangladesh Petroleum Corporation (BPC), Bangladesh imports approximately 6.5 million tons of crude and refined oil annually that fulfills 90% of country's total fossil fuel based primary energy requirements. The remaining 10% of the primary energy requirements are fulfilled by natural gas and coal that are mostly domestically extracted or imported from neighboring countries.

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Therefore, the Bangladesh economy is particularly susceptible to international energy price shocks, especially oil price shocks in the international market[*]. Oil price shocks can affect a number of macroeconomic variables such as exchange rate, inflation, food security, the terms of trade, stock market and eventually, the economic growth. (Amin & Marsiliani 2015). This paper aims to investigate the relationship between the global oil price shocks and domestic inflation as price hikes are a challenging phenomenon to deal with, especially in a developing economy like Bangladesh. Oil price can affect domestic inflation directly through the demand side which is also known as "imported inflation". Petroleum products are often used as intermediate inputs in transport and residential services and in the agricultural sector. Therefore, with rapid economic growth, the country's demand for petroleum and oil products also increases and as Bangladesh is predominantly an oil importing country, it simply has to import oil at a higher price giving rise to domestic inflation via energy commodities in the consumption basket (Zakaria et al. 2021).

A rise in the price of imported oil gives rise to "cost-push" inflation in the domestic market. As cost of production for both industrial and agricultural goods rises due an oil price hike, firms cannot sustain profit margins by charging the same price. Apart from core production cost, oil prices also have cost-multiplier effects on the economy-wide supply-chain through forward and backward linkages in the production process. As prices of intermediate and final goods start to rise in the market and real income falls, labors may also start to demand an increase in wages leading to further increase in cost of production and subsequent inflation. Even though the flow-on effects of a price hike of oil in the international market on domestic inflation seem easy to explain, in reality oil prices are highly subsidized by the government in a developing country. As the size of subsidy grows with oil price hikes, government's other expenditure pursuits are compromised which eventually hampers overall economic performance of the country. It is widely reported in existing literature that an increase in oil price is responsible for curbing economic growth, boosting inflation and impeding productive activity in most economic sectors.

A few studies have empirically investigated the macroeconomic effects of global oil price hikes in the context of Bangladesh. However, it is an issue of immense importance; and according to World Bank (2019), Bangladesh's imported energy dependency will escalate to 90% by 2030. Zakaria et al. (2021) analyzed the relation between the global oil price and domestic inflation using an Impulse Response Function and they revealed a one standard deviation shock in global oil price increases inflation rate in Bangladesh by 7.72% after 24 months. Adebayo (2020), Husaini et al. (2019) and Sultan et al. (2020) have conducted cointegration and causality analysis between oil price and inflation for Nigeria, Malaysia and India respectively.

However, to the best of our knowledge, there is no extensive empirical study that investigated the connection between oil price and inflation distinguished by short run and long run. The analysis in this paper does that by using a Vector Error Correction Model (VECM) for Bangladesh. This paper explores the complex causal connection between oil price and domestic inflation in Bangladesh using annual data for years 1981-2021. Bangladesh is a rapidly developing country that recently transitioned from a low income to lower middle-income country. It faces a lot of economic challenges to maintain its buoyant economic growth given the current eco-political reality. Proper energy related policies are therefore extremely vital for the country's economic management.

[*]*the global market, natural gas prices are closely linked to oil prices. Hence, this paper specifically focuses on oil price.*

The rest of the paper is organized as follows: Section 2 presents a detailed review of existing literature; Section 3 describes the data and methodology adopted for econometric estimations; Section 4 explains the results derived from econometric analysis; and, lastly, the paper concludes in Section 5.

2. LITERATURE REVIEW

The relationship between international oil price and domestic inflation has been extensively researched and a host of papers have conducted detailed empirical analysis on this topic, using country specific time-series data, regional cross-section data and panel data. Kilian (2014) emphasized the importance of transmission channel through which oil price affects inflation and other macroeconomic attributes of an economy. The "pass-through" mechanism can be mobilized via supply side or demand side and may demonstrate a steady dominant trend as well as seasonal fluctuations. In certain cases, there will be drastic changes in forms of structural break caused by policy interventions, global turmoil or natural disasters etc.

The literature on the nexus between oil price and inflation can be broadly categorized in two groups. The first group includes handful of papers that reported the effect of oil price on inflation to be negligent and transitory. Hooker (2002) analyzed annual data of global oil price and inflation for year 1960 -2000 and found that oil price had positive impact on inflation only during 1960-1980. Since 1980 onwards till year 2000, he did not find any inflationary impact of oil price shocks. Chen and Wen (2011) analyzed data for year 1985-2011 and reported oil price rise is not responsible for underlying trend inflation and only have temporary effect in CPI inflation. Salisu et al. (2017) reported oil price has positive and significant impact on domestic inflation in both net oil exporting and net oil importing countries in the long run. However, the effect of oil price hike on inflation is more severe in net oil importing countries. They also reported ambiguous results in short run analysis.

Nonetheless, majority of the paper have reported strong inflationary effect of oil price shock. For example, Sek et al. (2015) have employed Pooled Mean Group Auto Regressive Distributive Lag (PMG-ARDL) model to analyze the effect of oil price on 10 high oil dependent group of countries and 11 low oil dependent group of countries. Analyzing annual panel data of years 1980-2010, they revealed oil price affect domestic inflation via direct channel in low oil dependency countries. On the other hand, in high oil dependent countries, oil price affects domestic inflation indirectly via increased real exchanged rate and exporters' production cost. The magnitude of impact of oil price is almost three times in high oil dependent countries than of low oil dependent countries. Choi et al. (2018) analyzed panel data of 72 advanced and developing countries for years 1970-2015. They applied Impulse Response Function (IRF) methodology and reported 0.4% increase in domestic inflation due to 10% increase in oil price in the international market.

Chou and Tseng (2011) reported positive and significant pass- through effect of oil price on Consumer Price Index (CPI) in Taiwan in the long run but the effect was insignificant in the short run. Taghizadeh-Hesary and Yoshino (2015) analyzed monthly data of China, Japan and United State of America for year 2008-2013 using a Structural Vector Auto Regressive (SVAR) model including structural break. Their findings suggest oil price is a positive and significant determinant of inflation that impedes economic growth in the long-run. Zakaria et al. (2021) empirically investigated the relation between global oil price and domestic inflation in South Asia using monthly panel data for years 1980-2018. Using a Variance Decomposition Analysis, they revealed a global oil price shock increases inflation rate in the long run.

A number of country specific literatures also exist in this field of research. Adebayo (2020) have applied Wavelet Coherence technique on monthly data of Nigeria for time period January 2007 to March 2020 and found unidirectional causality running from oil price to domestic inflation. Sultan et al. (2020) analyzed time series data of India for year 1970-2017. Using a Johansen cointegration test, they found long run association between global oil price and domestic inflation in India. They also reported one way causality running between oil price and inflation using Granger causality test. Husaini et al. (2019) analyzed time series data of Malaysia for year 1981-2015 using ARDL regression technique. They reported oil price has a positive and significant impact on inflation and has a stronger effect on Producer Price Index (PPI) compared to Consumer Price Index (CPI).

Ahmed et al. (2018) used panel data of SAARC countries for year 1982-2014 and employing FEVD methodology, they identified 4-8% of forecast error variance in inflation in Bangladesh can be explained by oil price shocks. Zakaria et al. (2021) analyzed monthly data of four South Asian countries for year 1980-2018 and reported a global price hike leaves a permanent and asymmetric impact on inflation in South Asia using IRF analysis.

3. DATA AND METHODOLOGY

The annual data for international crude oil prices are collected from BP statistical review of World Energy for years 1980-2021. In order to measure inflation, GDP deflator data are collected from World Development Indicator, World Bank for years 1980 -2021.

3.1 Unit Root Test

Time series datasets are particularly susceptible to non-stationarity that can generate spurious correlation in empirical analysis. Therefore, first course of action is to verify the stationarity of dataset using Augmented Dickey Fuller (ADF) Unit Root test. If we find presence of Unit root in the data set, we will have to take first-difference of the data set and run the ADF test again to ensure stationarity of the dataset.

3.2 Cointegration Analysis

In the next step, we check for cointegration between our variables of interests i.e. oil price and inflation. In the presence of cointegrated association, non-stationary variables are related as such that they cannot deviate from equilibrium in the long term. Cointegration tests are conducted to identify possible linear combinations of variables which could be considered as stationary. We have chosen the Johansen cointegration test as it provides a unified framework for estimation and testing for co-integration relations in the context of Vector Autoregressive (VAR) error correction model. (Johansen, 2008)

In this context, we have to apply an Unrestricted Vector of Autocorrelation of the form:

$$\Delta x_t = \alpha + \theta_1 \Delta x_{t-1} + \theta_2 \Delta x_{t-2} + \theta_3 \Delta x_{t-3} + \cdots\cdots + \theta_{k-1} \Delta x_{t-k+1} + \theta_k \Delta x_{t-k} + u_t$$

Here Δ = difference operator

$x_t = (n \times 1)$ vector of non-stationary variables at level I (0)

$u_t = (n \times 1)$ vector of random errors

θ_k = coefficients of the variables { $\theta_k = 0$: No cointegration vector

Rank of θ_k , r = 1 : At least one cointegration vector exists

1>r> n , there are multiple cointegration vectors exists}

Johansen and Juselius (1990) have developed two separate tests for identifying long run cointegration in variables. The first test is Trace test that tests the null hypothesis of at most ***r*** cointegrating vectors and the second test is Eigen value test that tests the null hypothesis of exactly ***r*** cointegrating vectors.

3.3 Causality Tests

3.3.1 Granger Causality Test

Granger (1969) elaborated the causality framework based on linear regression modeling of stochastic processes. Suppose *x* and *y* represents two time series variables. If past values of *y* can explain changes in present value of *x*, given past values of *x* is accounted for in the system, then we can say *y* granger causes *x*. In the presence of cointegration among variables, at least one direction of causality always exists. We will estimate the following equations:

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \cdots\cdots + \alpha_l x_{t-l} + \beta_1 y_{t-1} + \cdots\cdots + \beta_l y_{t-l} + u_t$$

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \cdots\cdots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \cdots\cdots + \beta_l x_{t-l} + v_t$$

The Standard granger causality follows the F-test for the joint hypothesis $\beta_1 = \beta_2 = \beta_3 = \cdots\cdots = \beta_l = 0$ However, Granger (1988) emphasized the importance of including error correction term in the model or else the granger-causality framework may demonstrate invalid causal linkage, especially in case non-stationary variables at level. Another advantage of including the error correction term to the model would be the ability to test for short run and long run causality. Granger causality can only account for long run causality but in an Error Correction model the lagged changes in the independent variables represent the short run causal impact while significance of the error correction term gives the information on long run causality.

3.3.2 Vector-Error-Correction Model (VECM)

While Granger causality framework can only test for long run causality among variables of interest, Vector error correction model (VECM) is a stochastic multivariate Vector Autoregressive model that can test for causal relationships in both short run and long run time frame. Under the assumption of at least one co-integrational relationship among variables, the VECM generated error correction term can capture the short-run deviations of time series variable from their long-run equilibrium path (Narayan & Smyth, 2004). Therefore, error correction models of co-integration under the tri-variate system in this study can be represented using the following equations

$$\Delta Y = \alpha + \sum_{i=1}^{m} \beta i \Delta Y_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta X_{t-j} + \sum_{k=1}^{0} \delta \Delta M^s + \sum_{l=1}^{p} \zeta \Delta N + \theta Z_{t-1} + \varepsilon_t$$

$$\Delta X = a + \sum_{i=1}^{m} b_i \Delta Y + \sum_{j=1}^{n} c_j \Delta X_{t-j} + \sum_{k=1}^{0} d \Delta M^s + \sum_{l=1}^{p} e \Delta N + f Z_{t-1} + \xi_t$$

The VECM model captures the short run effects through individual coefficients of the differentiated terms. The null hypothesis of the model assumes X does not Granger causes Y. The null hypothesis is rejected if the coefficients on the lagged values of X is jointly significant. In addition, in cases where X is included in cointegrating relationship, we accept the null hypothesis if the coefficient of the lagged error-correction term is statistically significant. Changes in an independent variable may be interpreted as representing the short run causal impact while the error-correction term provides the speed of adjustment of X and Y toward their respective long run equilibrium. Thus, the VECM representation allows us to differentiate between the short- and long-run dynamic relationships. The Chi-Square test statistic is used to determine the short run causalities between pairs of variables in the model.

4. RESULT AND DISCUSSION

Time series data sets are more likely to be non-stationarity due to stochastic or deterministic trend inherent in data and can generate spurious results and problematic statistical inference if not accounted for in a proper way. We conduct an Augmented Dickey-Fuller (ADF) test to check for non-stationarity and order of integration of the variables. As unit root tests are based on skewed asymptotic distribution, presence of time trends, constants and other deterministic elements can reduce power of the test. Therefore, ADF tests are conducted including both constant and time trend. The test results are presented in Table 1 in level and first differenced form. The null hypothesis of ADF test assumes unit root is present and we accept the null hypothesis at level for both oil price and Inflation and conclude both our variables are non-stationary at level.

Table 1: Augmented Dickey-Fuller Unit Root Test

Panel 1: Level			
	ADF Statistics (Only constant)	ADF Statistics (Constant & trend)	Decision
Oil Price	-1.4298 (0.5584)	-2.3243 (0.4120)	Unit root present, Non-Stationary
Inflation	4.117 (1.00)	0.6264 (0.9993)	Unit root present, Non-Stationary

Panel 1: 1st Difference			
	ADF Statistics (Only constant)	ADF Statistics (Constant & trend)	Decision
Oil Price	-5.8732*** (0.0000)	-5.7941*** (0.0001)	No Unit root, Stationary
Inflation	-4.3173*** (0.0014)	-5.8273*** (0.0001)	No Unit root, Stationary

p-values are reported in parenthesis. ***,** and * represents statistical significance at 1%, 5% and 10% level respectively.

Therefore, we conduct the ADF test again at 1st difference where the first difference of a time series is the series of changes from one period to the next. At first difference, for both Oil price and Inflation we can reject the hull hypothesis at 1% level of significance and conclude the variables are stationary at 1st difference. It implies statistical properties of the 1st differenced dataset will not change over time and the overall behavior of the data should remain constant.

Table 2: Johansen Test for Cointegration (Maximum Eigen value test)

	Null Hypothesis Ho	Maximum Eigen value Test Statistics	Critical value at α=5%	Alternate Hypothesis	Maximum Eigen value Test Statistics	Critical value at α=5%
Oil price and Inflation	Ho: No cointegration	25.1887*** (0.0001)	11.2248	At most one cointegration	2.5603 (0.1295)	4.1299

p-values are reported in parenthesis. ***,** and * represents statistical significance at 1%, 5% and 10% level respectively.

Table 3: Johansen Test for Cointegration (Trace test)

	Null Hypothesis Ho	Maximum Eigen value Test Statistics	Critical value at α=5%	Alternate Hypothesis	Maximum Eigen value Test Statistics	Critical value at α=5%
Oil price and Inflation	Ho: No cointegration	27.7491*** (0.0001)	12.3209	At most one cointegration	2.5603 (0.1295)	4.1299

p-values are reported in parenthesis. ***,** and * represents statistical significance at 1%, 5% and 10% level respectively.

In the next step, we conduct Cointegration test to reveal long-term correlation between oil price and inflation. Existence of cointegration implies multiple non-stationary (at level) data series are interlinked through an error-correction model. They move together in a way that their linear combination results in a stationary time series and they don't deviate from equilibrium in the long run. We imply Johansen test for cointegration and the results are presented in table 2 and 3 respectively. Both Maximum Eigen value test and Trace test reject the null hypothesis of no cointegration at 5% level of significance. Therefore, we can confirm one cointegration relationship exists between oil price and inflation in the long run.

Table 4: Oil Price and Inflation Granger Causality Test

Null Hypothesis	F-statistics	P-value	Decision
Oil price does not Granger cause Inflation	7.4821***	0.0020	Unidirectional causality runs from Oil price to inflation
Inflation does not Granger cause Oil price	0.9365	0.4016	

Table 5: Oil Price and Inflation VECM Causality Test

Short Run Causality			
Null Hypothesis	Chi-Square-Statistics	P-value	Decision
Oil Price does not cause Inflation in short run	18.18***	0.00	Unidirectional short run causality runs from Oil price to inflation
Inflation does not cause Oil Price in short run	0.95	0.32	

Long-Run Causality			
Null Hypothesis	F-Statistics	P-value	Decision
Oil Price does not cause Inflation in long run	9.53***	0.001	Unidirectional short run causality runs from Oil price to inflation
Inflation does not cause Oil Price in long run	0.48	0.61	

Notes: VECM is ran at lag 1 by following Akaike Information Criterion (AIC) criteria. The inverse roots are inside the circle, indicating stability of the VECM system of equations.

Once we confirm the long run cointegration among the variables of interest, we then run the Granger causality test. Results of Granger causality test presented in Table 4 reveals that first null hypothesis can be rejected at 1% level of significance which means oil price granger causes inflation but not vice versa as we cannot reject the second null hypothesis even at 10% level of significance. Therefore, we can conclude that a one-way causal relationship exists between oil price and inflation where oil price in the international market is found to cause domestic inflation in the long run in Bangladesh.

VECM causality test has an advantage over Granger causality as it can check for both short run and long run causal association. The results of VECM test are presented in Table 5. We find oil price causes inflation in Bangladesh in both short run and long run. However, inflation in Bangladesh seems to have no causal impact on oil price in short or long run. Our findings are consistent with results reported by Adebayo (2020), Sultan et al. (2020) and Ahmed et al. (2018). Since, Bangladesh is a solely oil import dependent country, it is only reasonable that an increase of oil price increases production cost domestically and leads to cost push inflation. Also, Bangladesh has a net trade deficit and its import cost also increases due to oil price hike which results in "imported inflation".

Noticeably, that oil price also impacts inflation in the short run but oil price in the domestic market of Bangladesh is regulated by Bangladesh Energy Regulatory Commission (BERC). Therefore, an international oil price hike does not always immediately translate into an increase in oil price in Bangladesh. BERC often takes time to regulate its pricing policy based on government directives and suggestions by concerned stakeholders. Therefore it is understandable that an increase in oil price will have an impact on inflation in long run, However, our results show an impact on domestic inflation in short run as well because an international oil price hike can cause domestic inflation based on fear of expected inflation in near future (Istiak and Alam, 2019).

On the other hand, domestic inflation in Bangladesh has no causal impact on oil price in the international market because compared to global context, Bangladesh economy is a small open economy that is a net importer of oil. Inflation in major oil exporting countries like Saudi-Arabia, UAE and Russia can influence global oil price to some extent as the countries try to strengthen their exchange rate and global competitive edge by hiking up oil price given global political context (Choi et al. 2018; Lioudis, 2022). However, since Bangladesh is not an oil exporter or a member of OPEC, domestic inflation in Bangladesh does not have any impact on international oil prices.

5. CONCLUSIONS

The paper has examined the impact of oil price change in the international market on the domestic inflation in Bangladesh. We have used annual data for international crude oil price and the GDP deflator as measurement of inflation for years 1980-2021. After running various econometric methods, the paper confirms unidirectional causality running from oil price to domestic inflation,

which implies international oil price is one of the major reasons for inflation in Bangladesh. Our finding is robust as both Granger causality and VECM causality have generated the similar results.

The long-run causality can be explained via the "cost-push" channel and the short-run inflation can be explained through "imported inflation" and the expected inflation theory. It implies that Bangladesh Energy Regulatory Commission (BERC) needs to adopt faster and pro-active price-adjustment mechanism so that it can assist the Bangladesh Bank to maintain a targeted inflation rate, especially in the short run. In the long-run, "cost-reflective" pricing strategy can be adopted to restructure the internal oil market in Bangladesh. The government can gradually privatize the energy market or encourage public-private partnerships to make the market structure more competitive. This will also reduce administrative inefficiency and proper policy implementation. The monetary policy should be more dynamic in nature so that it can be effective in curbing inflationary pressure. Also, the key players i.e., economic think tanks, development organizations and policy makers must keep a close watch on the global prices while addressing domestic issues.

One possible avenue of extending the paper is to investigate the asymmetric causality of oil price for domestic inflation. Clearly, the way inflation soars when there is a price hike in the international oil market, domestic oil price or commodity price does not fall when the oil price decreases in the international market. Gradually, more and more complicated energy markets can be analyzed within the country. The study can also be further extended in the context of South Asia.

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