The non-linear impacts of crude oil prices and trade openness on the foreign income of Bangladesh

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Abstract

The asymmetric effects of crude oil prices, inflation, and trade openness on Bangladesh's foreign income are investigated in this study from 1995 to 2020.To evaluate the non-linear impacts of our research variables on foreign income; we used the non-linear autoregressive distributed lag model. Long-run co-integration is evident among the study variables, according to the NARDL method's bound test results. The empirical findings of this study demonstrate that higher oil prices have a considerable negative impact on foreign income in the long run, but a positive and significant impact in the short run. In contrast, lower oil prices have a negative and considerable impact on foreign income in both the short and long term. The adjustment asymmetry in the dynamic multiplier graphs shows that the response of foreign income to a negative change in oil prices is stronger than the response to a positive change. Accession or reductions in inflation and trade openness, on the other hand, have a major impact on foreign income both in the long run and in the short run. The Wald test indicates that there are asymmetries among variables. The ramifications of this study are critical for Bangladeshi politicians and investors.

1. Introduction

Bangladesh's economy is classified as being in the early stages of development. In nominal terms, it is the 37th largest country, while in purchasing power parity, it is the 31st largest. It is categorized as a frontier market and one of the Next Eleven developing market middle-income economies. Bangladesh's economy grew at an annual pace of 8.3% in the first quarter of 2019, making it the world's seventh fastest-expanding economy. Overall goods foreign income growth for the first ten months of the current fiscal year (FY) 2020-21 was $32.07 billion, up 8.74 percent from the previous fiscal year. Bangladesh exported $46.4 billion in 2019, while importing $64.9 billion, resulting in an $18.5 billion trade deficit. There is no other option for reducing the trade imbalance than to increase foreign income. As a result, it's time to figure out what are the influencing factors Bangladesh's foreign income.

Consumer goods accounted for 89.78 percent of overall exports in Bangladesh in 2011. Readymade garments, as well as shrimp, jute, leather goods, and tea, are among Bangladesh's most popular exports. In fiscal year 2018-19, the RMG, one of Bangladesh's most important export items, generated more than 10% of GDP and accounted for 84 percent of the country's foreign exchange earnings (World Bank, 2019; BGMEA, 2019). Export income from Bangladesh's RMG sector totaled 29 billion US dollars which registered 6.5 percent of the global market. As a result, Bangladesh remained the world's second-largest apparel exporter in 2017.The United States and the European Union is the two most important export destinations. From China, India, the European Union, and Kuwait, Bangladesh imports mostly fuel, capital goods, and food. According to economic theory, one of the most important predictors of economic growth is foreign income growth. It asserts that an economy's total growth rate can be accelerated by increasing foreign income, and that foreign income can thus act as a "growth engine."

The major goal of this study is to look at the asymmetric effects of oil prices, inflation, and trade openness on Bangladesh's foreign income. To examine the nonlinear effects of oil prices, inflation, and trade openness on foreign income, we used Shin *et al.* (2014)'s nonlinear autoregressive distributed lag (NARDL) model. The error correction term, as well as long-term and short-period

nonlinearity, can be calculated using the NARDL model. We've conducted extensive studies around the world to better understand how oil prices, inflation, and trade openness affect a country's economy. We believe that a country's foreign income reflects its development. As a result, determining whether microeconomic variables like oil prices, inflation, and trade openness have an impact on foreign income is critical. There has been no research on this topic anywhere in the world, as far as we are aware. As a result, we decided to make this the focus of our study.

2. Literature review

Because of its great reliance on oil products, oil is a major source of energy in the economy and is frequently used as a gauge of economic stability. Changes in oil prices have been highlighted in several studies (Amin *et al.,* 2021; Alamgir and Amin, 2021; Sarwar *et al.,* 2017; Brini *et al.,* 2017) as an important source of economic volatility (both theoretically and empirically) and as a prototype of a global shock, likely to affect multiple economies at the same time. Higher oil prices raise production costs and restrict the availability of the principal productive input, slowing the pace of activity development and productivity. Oil prices may have a demand-side impact on the economy, decreasing household purchasing power and postponing consumer spending.

Increasing demand for a country's products may result in increased export growth, which will be reflected in economic growth. Increased exports provide more foreign exchange, which makes it easier to buy productive intermediate items. Exports are critical to modern economies because they provide people and businesses with access to a wider range of markets. One of the most important functions of diplomacy and foreign policy between governments is to promote economic commerce by stimulating exports and imports to the mutual advantage of all parties involved.

Oil price fluctuations have been identified as a primary source of economic growth. However, the literature on the impact of oil prices on economic growth is mixed. Numerous studies on the effects of oil prices on economic growth in Asia, the Arab world, and several Western countries have been conducted (Berument *et al.,* 2010; Du *et al.,* 2010; Cunado and Gracia, 2005). Whether a country is an oil importer or exporter determines the impact of abrupt variations in oil prices. Because oil is used as a raw material in the manufacturing process, an increase in its price increases the production costs of an oil importer. Cost-push inflation and weaker economic development are the results. Bangladesh imports petroleum products on a net basis. Oil-importing countries' balance of payments and terms of trade improve as oil prices decline. The oil price, crude oil output, and gross capital creation, according to Javed and Husain (2020), have a substantial impact on economic performance, whereas total revenue and oil revenue have a minor impact. The negative impact of exports on economic growth is significant.

Those countries whose economies are heavily reliant on oil have seen their income shrink as crude oil prices have been raised. Nusair and Olson (2021), who discovered that the variables are co-integrated, investigated the linear and nonlinear effects of crude oil prices on Asian economies using a nonlinear ARDL model. Rising oil prices have a significant impact on domestic output, whereas falling oil prices have only a tiny impact. In the long run, there is a strong asymmetric nexus between the variables. Inflationary pressures result from higher oil prices, which lower consumer income (Kisswani *et al.,* 2020). Furthermore, rising oil prices raise the cost of elements, limiting output, creating unemployment, and causing inflation (Katircioglu *et al.,* 2018). According to Anoruo and Elike (2009), an increase in oil prices has a negative influence on economic growth because of supply and demand.

Oil price volatility, according to economists and experts, affects economic growth at the same time (Hamilton, 1983; Hamilton, 1996; Mork and Hall, 1980; Guo and Kliesen, 2005; Rafiq *et al.,* 2009). Erdoan *et al.* (2021) discovered that negative real oil price changes had a bigger influence on real stock returns in the long run than positive changes, despite the fact that positive oil price changes have a negative impact on the full-sale market in the short term. In comparison to the pre-slump period, negative oil price changes had a bigger impact on stock prices in oil exporting countries,

whereas positive oil price changes had a greater impact on oil importers, according to Siddiqui *et al.* (2020).

Trade openness, on the other hand, is considered as vital to economic success not only in emerging but also in developed nations. Udeagha and Ngepah (2021) suggested that trade openness had asymmetric positive effects on economic growth in the short and long run. Openness to international goods markets encourages openness to new ideas and innovations. It makes it possible to fully use a country's comparative advantage due to the abundance of unskilled labor in developing countries. This result in high returns on capital, as well as simplifying the importation of intermediate and investment items to enhance manufacturing in these countries. Trade openness fosters improved innovation and entrepreneurship by increasing competition and increasing market access. It leads to longer-term expansion at constant returns rather than diminishing returns due to increased market access. Increased trade openness is thought to boost productivity, which in turn boosts employment and real income, thanks to increased investments.

Many experts have come to the opinion that countries that are internationally involved are more productive. As a result, they develop more quickly than their rivals who just produce for local use. A growing number of researchers have discovered that trade openness has a positive impact on economic growth (Malefane, 2018; Keho 2017; Vedia-Jerez and Chasco 2016; Ulaşan, 2015; Huchet-Bourdon *et al.,* 2018; Zarra-Nezhad *et al.* 2014; Kabuga and Ismail 2018). Trade openness, on the other hand, has been shown in a few empirical investigations to stifle economic progress (Lawal *et al.,* 2016; Zahonogo, 2016; Udeagha and Ngepah, 2021; Eris and Ulasan, 2013; Hye and Lau 2015).

The relationship between these variables is assumed to be nonlinear. Meanwhile, nonlinearity and asymmetric behavior have been identified in numerous studies in behavioral finance and economics. Both theories are frequently employed in the social sciences and are vital to human well-being, meaning that they are critical to human well-being. Inflation and trade openness are influenced by economic policies, business cycles, and structural changes in the same way that oil prices are. Because they presuppose linearity and systematic changes among the variables, traditional time series models cannot provide enough information about the nonlinear connection. This illustrates that the assumption of linearity is unnecessarily restrictive in a wide range of economic phenomena, particularly when it comes to the trade–growth link. The asymmetric influence of oil prices, inflation, and trade openness on foreign income is highlighted in this article. As a result, the NARDL model, which was established relatively recently, is widely employed in empirical research.

3. Methodology
3.1. Data Management

The asymmetric effects of crude oil prices, inflation, and trade openness on foreign income in Bangladesh are studied using the NARDL model from 1995 to 2020.The independent factors in this study were crude oil prices, inflation rate, and trade openness, while the dependent variable was foreign income. The yearly secondary time series data for empirical analysis was gathered from the years 1995 to 2020. Fig. 1 depicts the contribution of each variable. Table 1 lists the variable descriptions as well as their data sources.

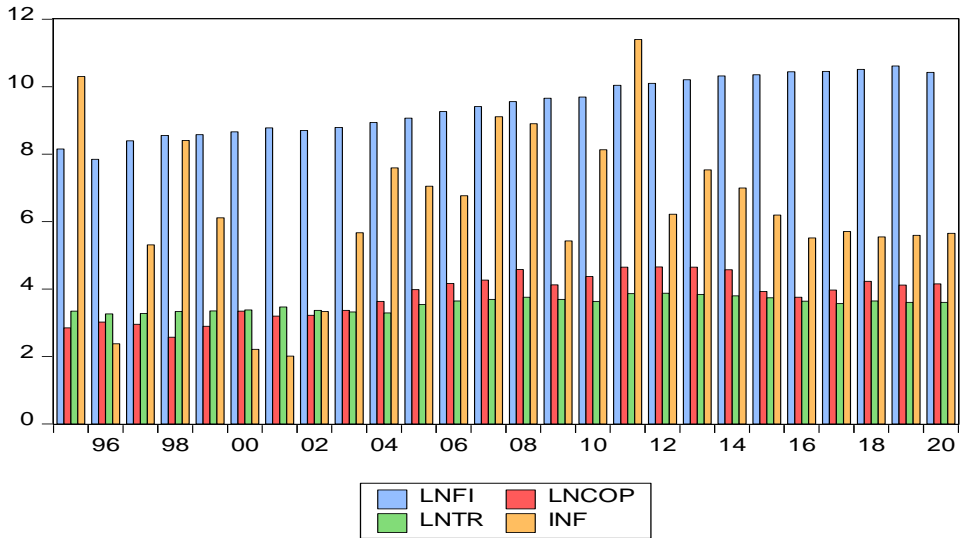**The non-linear impacts of crude oil prices and trade openness on the foreign income**

Fig. 1: Study variables contribution

Table 1: Sources and Description of the variable

Variables	Indicator	Description	Sources
Inflation Rate	INF	(Percentage of the total)"	World Development Indicators (WDI)
Crude Oil Price	COP	Oil Price (Dollar per barrel)	Statistical Review of World Energy 2020
Foreign income	FI	"Log of Foreign income (Million USD)"	Bangladesh Export Promotion Bureau (EPB)
Trade openness	TR	Trade openness: exports plus imports as percent of GDP	The Global Economy.com

Note: Foreign income, oil prices, and trade openness are all expressed as logarithms

3.2. Econometric modeling

The nonlinear links between oil prices, inflation, trade openness, and foreign income in the short and long run were investigated using a NARDL model. Pesaran and Shin (1997) developed a model to account for asymmetric variable connections in the short and long run, which was further refined by Pesaran and Shin (2001). The following linear equation was proposed to investigate the influence of crude oil prices, inflation, and trade openness on foreign income in Bangladesh:

$$LNFI_t = \alpha_0 + \alpha_1 LNCOP_t + \alpha_2 INF_t + \alpha_3 LNTR_t + + u_t \qquad (1)$$

Whereas, *FI*, *COP*, *INF*, and *TR* represent foreign income, crude oil prices, inflation, and trade openness respectively. Foreign income, oil prices, and trade openness are all expressed as logarithms. We conducted the current investigation in nonlinear settings due to nonlinearities in time series. This could be due to (a) concealed co-integration and (b) the co-integration of series components causes structural fractures and asymmetries. The nonlinear ARDL methodology employs positive and

negative changes or partial sum decompositions to determine the asymmetric effects in the long and short run time periods. This approach produces superior results with small samples, according to Romilley *et al.* (2001) & Pesaran *et al.* (2001). The following is the model's asymmetric functional form, which is used to examine the impact of crude oil prices, inflation, and trade openness on foreign income:

$$LNFI = f(LNCOP^+, LNCOP^-, INF^+, INF^-, TR^+, TR^-) \tag{2}$$

Based on the previous work of Long *et al.* (2018); Ibrahim (2015); Lacheheb and Sirag (2019), considering the asymmetric relationship between crude oil prices, inflation, and trade openness on foreign income, our model will be as follows:

$$LNFI_t = \beta_0 + \beta_1 LNCOP_t^+ + \beta_2 LNCOP_t^- + \beta_3 INF_t^+ + \beta_4 INF_t^- + \beta_5 LNTR_t^+ + \beta_6 LNTR_t^- + e_t$$
(3)

Where, the long-run parameters are connected with β_i. Positive changes COP^+, INF^+, and TR^+ as well as negative changes COP^-, INF^-, and TR^- respectively, account for the nonlinear influence of our research variables. Positive and negative changes in their partial sums in oil prices, inflation, and trade openness are represented by the following equations (4–9):

$$COP_t^+ = \sum_{i=1}^t \Delta COP_t^+ = \sum_{i=1}^t max(\Delta COP_i, 0) \tag{4}$$

$$COP_t^- = \sum_{i=1}^t \Delta COP_t^- = \sum_{i=1}^t min(\Delta COP_i, 0) \tag{5}$$

$$INF_t^+ = \sum_{i=1}^t \Delta INF_t^+ = \sum_{i=1}^t max(\Delta INF_i, 0) \tag{6}$$

$$INF_t^- = \sum_{i=1}^t \Delta INF_t^- = \sum_{i=1}^t min(\Delta INF_i, 0) \tag{7}$$

$$TR_t^+ = \sum_{i=1}^t \Delta TR_t^+ = \sum_{i=1}^t max(\Delta TR_i, 0) \tag{8}$$

$$TR_t^- = \sum_{i=1}^t \Delta TR_t^- = \sum_{i=1}^t min(\Delta TR_i, 0) \tag{9}$$

Under an unrestricted error correction representation, Equation 3 can be included into the following NARDL equation:

$$\Delta LNFI_t = \beta + \sum_{i=1}^q \mu_i \Delta LNFI_{t-i} + \sum_{i=1}^p \gamma_1 \Delta COP^+_{t-i} + \sum_{i=1}^p \gamma_2 \Delta COP^-_{t-i} + \sum_{i=1}^p \gamma_3 \Delta INF^+_{t-i} + \sum_{i=1}^p \gamma_4 \Delta INF^-_{t-i} + \sum_{i=1}^p \gamma_5 \Delta TR^+_{t-i} + \sum_{i=1}^p \gamma_6 \Delta TR^-_{t-i} + \theta_1 LNFI_{t-1} + \theta_2 COP_{t-1}^+ + \theta_3 COP_{t-1}^- + \theta_4 INF_{t-1}^+ + \theta_5 INF_{t-1}^- + \theta_6 TR_{t-1}^+ + \theta_7 TR_{t-1}^- + \varepsilon_t$$
(10)

Where q and p indicate the lag order and $\beta_1 = \theta_2/\theta_1$, $\beta_2 = \theta_3/\theta_1$, $\beta_3 = \theta_4/\theta_1$ and $\beta_4 = \theta_5/\theta_1$, $\beta_5 = \theta_6/\theta_1$, $\beta_6 = \theta_7/\theta_1$ are long-run asymmetric effects of crude oil prices, inflation, and trade openness on foreign income. Accordingly, $\sum_{i=1}^8 \gamma_i's$ are measure the short run asymmetric effects of crude oil prices, inflation, and trade openness on foreign income.

When using the NARDL model, there are several steps. To begin, we perform a unit root test to ensure that none of the series are I (2); nonetheless, any integration order, such as I (0) or I (1), is permitted. To begin, we used the well-known Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) tests to investigate the sequence in which our research variables were integrated. Secondly, we

estimate equation (10) using Katrakilidis and Trachanas (2012)'s typical ordinary least square (OLS) approach. Thirdly, we used a bound testing methodology developed by Pesaran *et al.,* (2001) & Shin and Greenwood-Nimmo (2014) to evaluate a long-term link exists between factors in a co-integration test. Using F-test, we check the null hypothesis of $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 = 0$ jointly. Fourth, using the Wald test, we establish both long run and short-run asymmetry relationships among the variables. Finally, we show how a 1% change in the positive and negative lagged value of independent variables can have asymmetric cumulative dynamic multiplier (CDM) effects.

We can evaluate the asymmetric effect by obtaining the cumulative dynamic multiplier of a unit change in COP_{t-1}^+, COP_{t-1}^-, INF_{t-1}^+, INF_{t-1}^-, TR_{t-1}^+, and TR_{t-1}^- respectively on *LNEX*:

$$m_h^+ = \sum_{j=0}^h \frac{\partial LNEX_{t+j}}{\partial COP_{t-1}^+}, m_h^- = \sum_{j=0}^h \frac{\partial LNEX_{t+j}}{\partial COP_{t-1}^-}, \text{ h=1, 2, 3,……..} \tag{11}$$

$$m_h^+ = \sum_{j=0}^h \frac{\partial LNEX_{t+j}}{\partial INF_{t-1}^+}, m_h^- = \sum_{j=0}^h \frac{\partial LNEX_{t+j}}{\partial INF_{t-1}^-}, \text{ h=1, 2, 3,……..} \tag{12}$$

$$m_h^+ = \sum_{j=0}^h \frac{\partial LNEX_{t+j}}{\partial TR_{t-1}^+}, m_h^- = \sum_{j=0}^h \frac{\partial LNEX_{t+j}}{\partial TR_{t-1}^-}, \text{ h=1, 2, 3,……..} \tag{13}$$

Note that as $h \to \infty$, $m_h^+ \to \beta_1$, β_3, β_5 and $m_h^- \to \beta_2$, β_4, β_6

4. Findings and discussion
4.1. Unit root test

The ARDL technique was utilized by Pesaran, *et al.* (2001) to evaluate series that are entirely stationary at purely I (0) or I (1), or a combination of I (0) and I (1). The need for all variables to be stationary in the same order was, however, a fundamental constraint for classic co-integration approaches (Engle and Granger, 1987). Furthermore, many academics believe that stationary verification for the ARDL model is unnecessary (Ibrahim, 2015). The ARDL approach, however, has one limitation: in the scenario where any series in the model is stationary at second difference I (2), in the presence of second difference variables, the co-integration F-statistics value becomes invalid, making the ARDL technique useless. (Ibrahim, 2015; Ilyas *et al.,* 2010).

The unit root test, also known as the stationary test, is the most important condition for time series data when looking at the order of integration of variables. The Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) tests were used to conduct our empirical research. Table 2 summarizes the results of the study. For the best lag structure, involving intercept and linear time trend at level but eliminating time trend from the first difference, the Schwarz information criteria (SIC) was used. The inflation rates are stationary at level, showing that they are I (0) according to both tests, whereas all study variables are stationary at first difference, according to both tests, showing that variables are I (1). In the absence of I (2) variables, we can utilize the bound testing methodology to approximate the equation (10).

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Table 2: Unit root test results

Variables	Level		First Difference	
	ADF	PP	ADF	PP
LNFI	-2.341	-2.343	-8.223**	-7.768**
LNCOP	-1.357	-1.391	-4.387**	-4.412**
INF	-4.047**	-4.106**	-6.343**	-18.541**
LNTR	-1.325	-1.325	-4.415**	-4.489**

Note: ** refer significant at 5% levels. For optimal lag, order SIC is used, and intercept and time trend are included in level and in first difference both.

4.2. Brock, Dechert and Scheinkmakn (BDS) test

It is necessary to determine whether variables are linearly or nonlinearly connected before using the ARDL or NARDL model. As a result, we used the Brock, Dechert, and Scheinkmakn (BDS) test to see if the variables had any asymmetric relationships (Brook *et al.,* 1996). As shown in Table 3, the null hypothesis, that the residual terms in the variable follow a six-dimensional independent and identical distribution, is rejected. These findings strongly suggest that the variables are nonlinear; indicating that a nonlinear ARDL (NARDL) model rather than a linear ARDL model should be adopted.

Table 3: BDS Non-Linearity Test Results

BDS Statistics Embedding Dimension=m				
Series	m=2	m=3	m=4	m=5	m=6
Foreign income	0.251222**	0.114213**	0.283211**	0.201221**	0.215092**
Oil price	0.245871**	0.126344**	0.301247**	0.210235**	0.215261**
Inflation	0.251471**	0.133623**	0.287412**	0.284471**	0.222122**
Trade openness	0.235682**	0.112412**	0.287412**	0.214587**	0.232379**

Note: Superscript ** indicates the acceptance of the residual alternative hypothesis at 5%

4.3. Linear and nonlinear co integration tests

The long-run relationship, according to Bahmani-Oskooee and Bohl (2000), is affected by the model's optimal lag selection. The most important information from the model isn't captured by using fewer lags, while using more lags "over-fits" the model, according to Stock and Watson (2012). As a result, we used the conventional VAR model to choose the best lag, and we chose 1 as the best lag based on AIC, SIC, LR, FPE, and HQ criteria, as shown in Table 4**.**

Table 4: Standard VAR model for optimal lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-13.13362	NA	0.326590	1.713362	1.912509	1.752238
1	31.62898	5.534022*	0.005144*	-2.462898*	-2.114392*	-2.394866*

2	27.37204	2.547291	0.007041	-2.137204	-1.838485	-2.078891
3	25.55255	58.02926	0.007580	-2.055255	-1.806322	-2.006661
4	31.63510	0.007340	0.005776	-2.363510	-1.965217	-2.285759
5	32.65596	1.122942	0.005893	-2.365596	-1.917516	-2.278126
6	33.53092	0.874967	0.006144	-2.353092	-1.855226	-2.255904

* Indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Model estimation results for symmetric and asymmetric co-integration are shown in Table 5. Because the F-statistic result of 2.137555 is smaller than the necessary lower limit of 3.23 at 5%, the bound test confirms that there is no co-integration in a linear fashion. The F-statistic value of 8.976915, however, exceeds the upper critical constraint of 3.61 at 5%, indicating co-integration for non-linear specification.

Table 5: Bounds test results for co-integration

Model specification	Statistic	values	95% lower bound	95% upper bound	Conclusion
	F-Statistic	2.137555	3.23	4.35	No co-integration
Linear	t-Statistic	- 2.724566	-2.93	- 3.81	
	F-Statistic	8.976915	2.45	3.61	Co-integration
Non-linear	t-Statistic	- 8.994125	-2.78	- 4.98	

Note: The critical values are from the Narayan (2005) and standard VAR model are used for optimal lag following SIC criterion.

4.4. Diagnostic test

Oil prices, inflation, and trade openness all have a non-linear impact on foreign income, as seen in Table 6. Some diagnostic tests were also undertaken to support the NARDL model's dependability. The Jarque-Bera (J-B) test, the Ramsey RESET test, the Autocorrelation Conditional Heteroskedasticity (ARCH) up to order 2 for heteroskedasticity, and the serial autocorrelation LM test up to level 2 for serial autocorrelation were all used to assess error normality. The NARDL model passes all diagnostic tests, implying that it is reliable. The Breuch-Godfrey serial correlation LM test, for example, reveals that serial correlation is not an issue in the model since the calculated F-value is sufficiently low to reject the null hypothesis of no correlation. The ARCH test shows that the model is homoskedastic. The residual term is normally distributed, according to the Jarque-Bera test. Finally, there's Ramsey's Reset test for functional misspecification. The speed of adjustment (SOA) is a metric that measures how quickly companies close the difference between their prior year's leverage and their current period's desired leverage. The adjustment speed, according to our data, is 1.0029, indicating a 100 percent increase in significance in the prior period to reach equilibrium.

4.5. Short run estimates

Table 7 summarizes the results of short-run dynamics. At a 5% level of significance, we found that an increase in international oil prices is positively associated with foreign income in the long run. The

drop in global oil prices, on the other hand, has a considerable negative influence on export profits. According to the results, a 1% increase in crude oil prices increases foreign income by 0.053 percent, whereas a 1% decline in crude oil prices decreases foreign income by 0.39 percent. As a result, a higher oil price means more foreign income for Bangladesh, which would help the country's GDP grow. Furthermore, oil prices have a favorable impact on living costs. We can identify two bottom line points for this outcome. For starters, rising oil prices raise transportation expenses, making every commodity more expensive. Several studies have found this similar result, such as Ibrahim and Chancharoenchai, (2014): Widarjono and Hakim, (2019). Secondly, an increase in the international oil price will increase international commodity prices, thus positively affecting the foreign income.

Table 6: Non-linear ARDL diagnostics test results

CointEq (-1)*	-1.0029**
R^2	0.995
J-B [prob]	0.7234
R-R [prob]	0.1927
LM (1) [prob]	0.3666
LM (2) [prob]	0.1841
ARCH (1) [prob]	0.3699
ARCH (2) [prob]	0.6853

Note: ** And *** refers significant at 5% and 10% levels of significance respectively.

In terms of inflation, rising prices have a substantial impact on foreign income. Our findings show that, in the near run, lowering the inflation rate has no substantial impact on foreign income. A 10% increase in inflation corresponds to a 0.261 percent increase in foreign income, according to the predicted short-run coefficient of 0.0261. The findings imply that a depreciation in the home currency may encourage foreign buyers to purchase more goods, boosting foreign income. Furthermore, as input costs like raw materials and labor rise, greater inflation has a direct influence on international earnings.

The impact of greater trade openness on foreign income is enormous. Our findings show that trade openness reduction has no immediate impact on foreign income in the short run. A 1% increase in trade openness leads to a 0.983 percent rise in foreign income, according to the predicted short-run coefficient of 0.983. Foreign income, economic growth, job creation, and poverty reduction are all aided by trade openness. Through competition, trade offers domestic enterprises additional market opportunities, higher productivity, and innovation.

3.6. Long run estimates

Table 7 shows the outcome of the long-term relationship estimation. Crude oil price changes have a long-term negative and considerable impact on foreign income. According to our findings, a 1% increase in oil prices would lower 0.1725 percent of foreign income in the long run, whereas a 1% fall in oil prices would reduce 0.247 percent of foreign income. The oil price coefficient is negative and significant, showing that changes in oil prices have a negative impact on Bangladesh's foreign income. This implies that as oil prices rise, so do input costs, reducing profit margins, and discouraging investors from investing more. This will have a secondary detrimental impact on the country's foreign income as well as its economic growth. Bangladesh buys oil from other countries. Import costs rise in tandem with the price of crude oil. After all, logistics have an impact on every aspect. Then traders won't be able to export as much, and purchasers will be more expensive, so they won't invest. As a

result, foreign income is lower. This is an accurate representation of our outcome. Furthermore, because the volume of oil imported and consumed by low-income nations like Bangladesh may be minor, the impact of oil prices on foreign income can shift over time. In the near run, economies of scale and labor intensiveness may propel these economies forward.

Table 7: Non-linear ARDL long run and short-run estimates

Long-run relationship				Short-run relationship			
Variable	Coefficient	Std. Error	t-statistic	$\Delta LNCOP^+$	0.053993***	0.113326	0.476437
$LNCOP^+$	-0.172535**	0.085434	-2.019513	$\Delta LNCOP^-$	-0.387985**	0.098236	-3.949533
$LNCOP^-$	-0.247070***	0.138425	-1.784867	ΔINF^+	0.026087**	0.011701	2.229476
INF^+	0.026398**	0.007775	3.395409	ΔINF^-	-0.004426	0.010155	-0.435864
INF^-	-0.012436***	0.006922	-1.796643	ΔTR^+	0.983472**	0.240305	4.092598
TR^+	1.603882**	0.229546	6.987199	ΔTR^-	0.692966	0.443411	1.562807
TR^-	-0.017525	0.393189	-0.044572	$\Delta LNCOP^+$	0.053993***	0.113326	0.476437

Note: **, *** refers significant at 5% and 10% levels of significance respectively.

The effect of inflation on foreign income is significant. According to our long-run relationship estimates, a 1% increase in inflation might raise 0.0264 percent of foreign income, while a 1% drop in oil prices may severely lower 0.0125 percent of foreign income. Lower unemployment rates result from increased production, which fuels demand even more. As people spend more freely, higher salaries lead to higher demand. As a result, paired with inflation, more foreign income is generated. The following are some of the ways inflation benefits the economy: Producers can sell at greater prices, resulting in increased profits. Investors and businesses are rewarded for investing in productive activities, which leads to higher investment returns. Production has increased. Strong foreign income is usually the source of rising inflation. We can expect a greater inflation rate if aggregate demand (AD) in an economy grows faster than aggregate supply. If demand outpaces supply, economic growth is quicker than the long-run sustainable rate.

Variable trade openness has a significant impact on foreign income, according to the findings of the final study. According to our long-term relationship calculations, a 1% increase in trade openness might boost foreign income by 1.64 percent. Increased trade openness, on the other hand, has little long-term impact on foreign income. Increased foreign direct investment and multinational corporations functioning in the country may have a direct impact on the country's positive trade openness–foreign income. As a result of the discovery and commercial production of crude oil, oil-related foreign direct investment may have boosted output growth, resulting in higher export income.

The positive association between trade openness and foreign income could explain why trade policies have shifted from restrictive and import-led substitution policies to export-led policies. The erratic trend in export profits that occurred during the Economic Recovery and Structural Adjustment Programs has lessened because of the move to a trade policy that focuses on exports. The government's enforcement of import controls and an import substitution program, which had a negative impact on the balance of payments, had produced this. Nonetheless, multinational corporations operating in the country could link the negative correlation between financial openness and foreign income to capital flight and profit repatriation.

3.7. Dynamic multipliers

Using Shin *et al.* (2014)'s dynamic multipliers, we compute dynamic asymmetric adjustments for OP, INF, and TR. Fig. 2 uses the cumulative dynamic asymmetric multiplier results to depict the foreign

income response to positive and negative shocks in OP, INF, and TR over a period of up to 15 years. As OP, INF, and TR change in positive (negative) directions, the solid (dashed) black lines depict how foreign income adapts. In contrast, the asymmetric line is a light dashed red line that lies between the bottom and higher bands of the 95 percent confidence range. Figure 2 indicates that all study variables have positive and negative shocks within 95% confidence lines, demonstrating that our NARDL model is stable.

The difference between positive and negative components is depicted by an asymmetric curve, which denotes the dynamic multiplier linked to changes in OP, INF, and TR. Over a particular forecasting horizon, the positive change curve will show asymmetric adjustments in foreign income owing to positive changes in oil prices, while the negative change curve will show negative adjustments in foreign income due to negative changes in oil prices. INF, TR, and INF all have the same explanation. According to all of the dynamic multiplier's figures, negative OP shocks, positive INF shocks, and negative TR shocks had the biggest influence on foreign income.

3.8. The Wald test and model stability test

The Wald test was used to confirm the nonlinearities between the variables under investigation. Table 8 shows the results, which demonstrate the occurrence of asymmetries between variables at a 5% level of significance. The robustness of every statistical study must be checked for parameter stability. After estimating the short-term and long-term coefficients, *Brown et al.* (1975) suggested using the stability test for CUSUM and CUSUMSQ parameters devised by Brown *et al.* (1975). Thus, we also used the CUSUM and CUSUM Square tests to ensure that the model was stable. Fig. 3 shows the results of these tests and shows that the model is quite stable.

Table 8: Testing the presence of asymmetric relationship (Wald test)

Variables	$Chi-square, X^2 - statistic[Prob]$	Asymmetric relationship
COP	23.02 [0.0000]	Nonlinear relationship exists between oil prices and foreign income
INF	39.54 [0.0000]	Nonlinear relationship exists between inflation and foreign income
TR	19.21 [0.0001]	Nonlinear relationship exists between Trade openness and foreign income

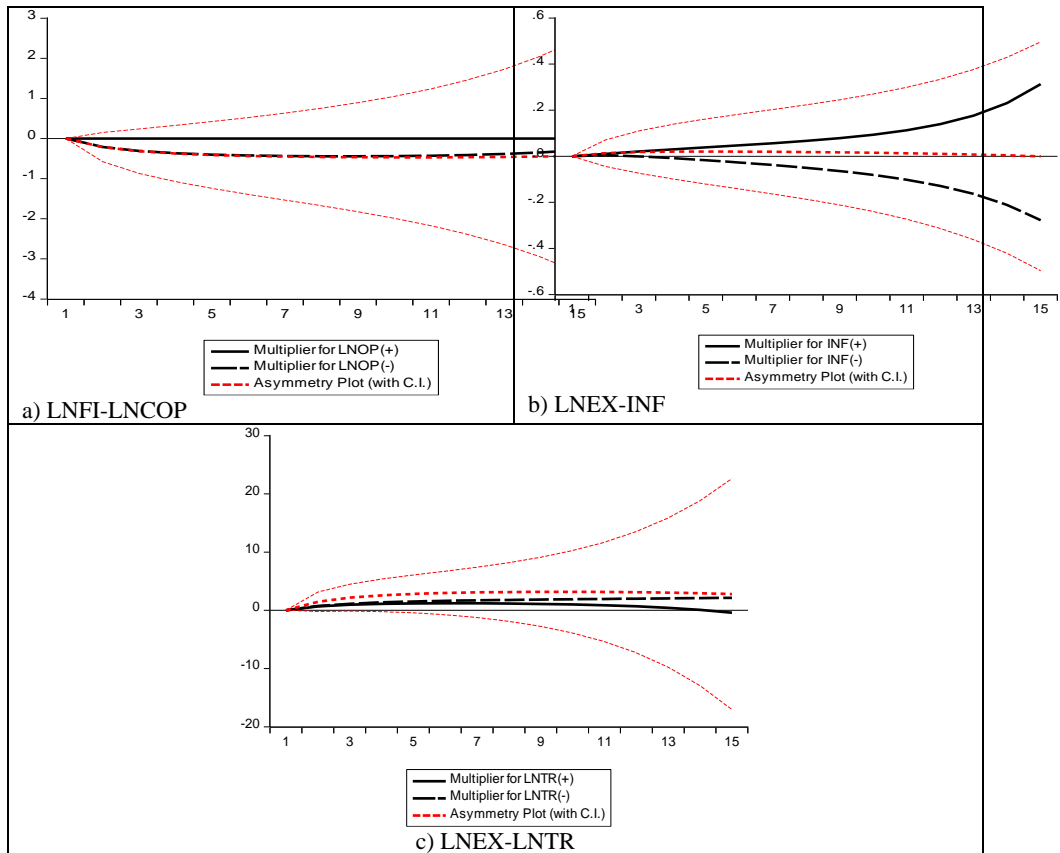**The non-linear impacts of crude oil prices and trade openness on the foreign income**

a) LNFI-LNCOP

b) LNEX-INF

c) LNEX-LNTR

Fig. 2: Cumulative dynamic multipliers (CDM)
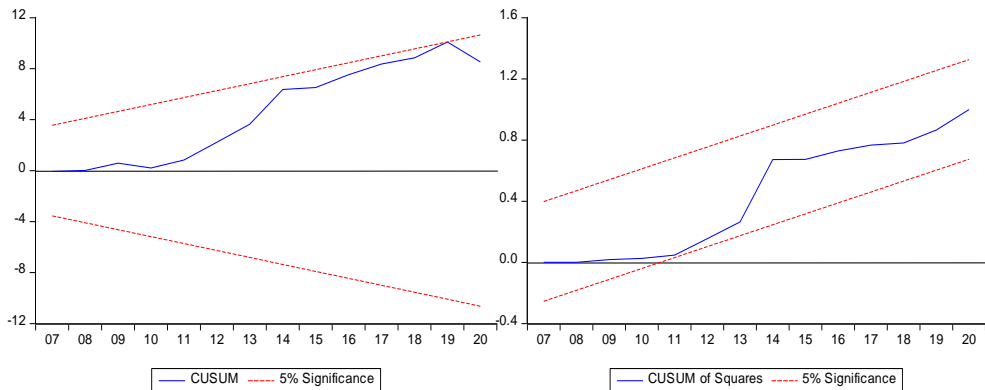
Fig. 3: Model stability check using the Cumulative Sum (CUSUM) and Cumulative Sum (CUSUM) square test

4. Conclusion and policy recommendations

Using annual data from 1995 through 2020, this research examines the relationship between crude oil prices, inflation, trade openness, and Bangladesh's foreign income. We looked at asymmetric impacts in the long and short run using a non-linear ARDL technique. The results of this study show that asymmetric effects exist among the factors studied in both the long and short runs. Higher oil prices have a substantial and negative influence on foreign income in the long run, but a positive and significant impact in the short run, according to the empirical findings of this study. Lower oil prices, on the other hand, have a negative and significant influence on foreign income in the short and long run. The adjustment asymmetry in the dynamic multiplier graphs reveals that foreign income responds more strongly to a negative change in oil prices than to a positive change.

Inflationary pressures, on the other hand, tend to improve foreign income in the long and short run. In the long term, inflation depreciation has a positive and significant impact on foreign income; but, in the short run, it has a negative and insignificant impact. Our other determinant, trade openness, has a significant impact on foreign income. Our findings show that increasing trade openness increased foreign income in the short and long term, whereas decreasing trade openness had no effect in either case.

The result has policy implications in that the government should keep an eye on rising oil prices and not allow them to continue to climb. Even a dramatic decline in worldwide prices due to indirect taxation in recent years, the government has not permitted the price of petroleum commodities to fall proportionally in the domestic market, despite the fact that the government has deregulated fuel prices. The rate of growth may have slowed as a result. If the price of petroleum products had been lowering in relation to world prices, the growth rate of output and employment would have been much faster. On the other hand, to promote Bangladesh's trade openness policy, it is important to encourage specialization in the production of certain goods. Particularly essential are tax incentives and capacity-building programs that result in increased export volumes and risk diversification. We also advise policymakers to give the service sector more weight and priority by broadening their technical knowledge base. We recommend policymakers adopt measures that improve financial openness while limiting capital outflows. Finally, we recommend that the country lower tariff barriers in order to boost commerce. Removing these barriers to trade can help reduce friction and boost exports.

Each research effort has its own set of limitations, and the current study is limited to Bangladesh, thus it cannot be generalized to other countries. In the future, other variables that may affect foreign income will be incorporated. Extending this research to other economies to see if the compensatory principle remains true would be exciting.

Declaration of interest statements

*"*We hereby confirm that the manuscript has no actual or potential conflict of interest with any parties, including any financial, personal, or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence or be perceived to influence. We confirm that the paper has not been published previously, it is not under consideration for publication elsewhere, and the manuscript is not being simultaneously submitted elsewhere."

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