agriculture

MDPI

Article

Investigating the Impact of International Markets on Imported and Exported Non-Cereal Crops in Bangladesh

Arifa Jannat [1,2], Kentaka Aruga [3], Jun Furuya [4] and Miyuki Iiyama [5,*]

1 Graduate School of Life and Environmental Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba 305-8572, Japan; arifaecon_bau@yahoo.com
2 Institute of Agribusiness and Development Studies, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
3 Graduate School of Humanities and Social Sciences, Saitama University, 255 Shimo-Okubo, Sakura-ku, Saitama 338-8570, Japan; aruga@mail.saitama-u.ac.jp
4 Social Sciences Division, Japan International Research Center for Agricultural Sciences, 1-1 Owashi, Tsukuba 305-8686, Japan; furuya@affrc.go.jp
5 Information Program, Japan International Research Center for Agricultural Sciences, 1-1 Owashi, Tsukuba 305-8686, Japan
* Correspondence: miiyama@affrc.go.jp

Abstract: To maintain a sustainable market for major non-cereal crops in Bangladesh, the present study evaluated the asymmetric effect of the key macroeconomic variables on the imported and exported non-cereal crops. In this connection, this study evaluated the nonlinear interactions and co-movements between the international market indicators such as the world prices, total trade amount, and gross domestic product per capita (*GDPPC*) and the market prices of potato and rapeseed in Bangladesh. Using yearly data from 1988 to 2019, we used the nonlinear autoregressive distributed lag (NARDL) model to investigate both short- and long-term market dynamics concerning the positive and negative shocks in the macroeconomic variables on imported and exported non-cereal crops. First, the study identifies that during the period investigated, the world potato and rapeseed prices led to an increase in the Bangladesh potato and rapeseed prices when they are increasing. Second, we find that the changes in the trade volume only have an influence on the potato price, both in the long-run and short-run. Finally, our findings revealed that domestic rapeseed prices tend to decrease when the *GDPPC* increases. Our empirical findings imply that it is important for market participants of potato and rapeseed in Bangladesh to take into consideration the sensitivity of the above-mentioned variables when designing resource allocation decisions in the event of positive and negative effects.

Keywords: asymmetric price effect; potato; rapeseed; export; import; NARDL

check for updates

Citation: Jannat, A.; Aruga, K.; Furuya, J.; Iiyama, M. Investigating the Impact of International Markets on Imported and Exported Non-Cereal Crops in Bangladesh. *Agriculture* **2022**, *12*, 833. https://doi.org/10.3390/agriculture12060833

Academic Editor: Giuseppe Timpanaro

Received: 2 May 2022
Accepted: 8 June 2022
Published: 9 June 2022

1. Introduction

Agriculture has always been an important part of the Bangladeshi economy, since it is difficult to feed its population. Because of the economically developing country's location near the Himalayas and the Bay of Bengal, Bangladesh is one of the world's most climate-sensitive nations [1]. Bangladesh has developed and updated its national agriculture policy (NAP) to ensure food security and improve socioeconomic conditions through increased productivity and crop diversification, ensuring nutritious and safe food production and improving the marketing system [2,3]. In recent years, the agriculture sector has been improving steadily as a result of supportive policies [4]. Likewise, Bangladesh retains its top spot in terms of agriculture output, producing large quantities of rice, wheat, cotton, meat, poultry, eggs, and fish.

Since Bangladesh is a rice-eating nation, rice dominates agricultural research and is given a great deal of attention over other crops. Bangladesh has already attained food security status, although nutritional security remains questionable [5]. According to estimates, more than 20 million people in Bangladesh are adversely affected by chronic vitamin A, iron, and zinc deficiencies, which more strongly affect pregnant women and infants [6]. However, the changing climate is having an adverse effect on food and nutritional security in Bangladesh [7]. It has been predicted that by the end of the century, major crop production in Bangladesh might decline by 30% because of the negative consequences of climate change [8]. In most cases, proper attention and policy formulations for cereal production and its pricing structure have been taken into consideration [9,10]. However, the pricing policies of major non-cereals, considering international market dynamics, are always ignored. Furthermore, there are still many opportunities and ways to improve the pricing policies for major non-cereals through upgrading and modifying existing policies that will lead to achieving sustainable development goals (SDGs).

However, among major non-cereal crops, potato and rapeseed cover almost 3% of the total cultivated area of Bangladesh and have a great impact on food and nutritional security [11]. Potatoes constitute the second-largest crop in terms of cultivated area (after rice). It is a year-round crop and provides as many as 6% of the daily per-capita calories and protein consumed in rural areas because of its abundant supply. It is regarded as a partial substitute in many households in Bangladesh [12,13].

On the other hand, among other oilseeds, rapeseed is regarded as an energy-smart food crop, and its productivity and supply capability are mostly influenced by different market forces, though it is naturally adapted to more dry and humid climate conditions [14]. According to the United Nations Food and Agriculture Organization, potatoes are regarded as a vital food-security crop and a substitute for cereal crops due to their high yields and nutritional value, whereas rapeseed is regarded as an energy-smart food crop that has both human health and environmental benefits. In addition to its role as a biofuel, rapeseed oil also plays an important role as a renewable energy source. Between these two crops, the volume of potato production is much higher than rapeseed [15] due to the introduction of modern high-yielding varieties (HYV) of potatoes after 2001. Moreover, in terms of trade volume (both export and import), potato is an exported product, while rapeseed is a foreign and imported product. Therefore, the farm prices of potato and rapeseed might have been affected differently by the world markets.

The impact of macroeconomic variables on agricultural productivity and markets has been investigated in many previous kinds of literature [16–18]. There has never been a thorough investigation of market forces in the process of price variations from the global to the domestic markets in Bangladesh. Bangladesh is a small economy where domestic prices of imported goods closely follow world prices. According to recent experiences in the global market for some commodities, importers in Bangladesh usually increase the price with the changes in the global market, but they do not decrease the price as quickly when prices in the global market decline. As a result, there seems to be a perception in the country that traders are conspiring to take unfair advantage of the market. Therefore, we assume that world prices might influence the domestic prices of imported and exported commodities distinctly.

Moreover, developing countries, whose principal means of pricing strategies depend on the exports and imports (trade volume) of agricultural products, are plagued by unstable market prices, which create macroeconomic instabilities and complicate macroeconomic management. Therefore, major non-cereals (such as potato and rapeseed) net importing countries should be considered the traded volume for a sustainable pricing policy along with the international pricing of tradeable items. Hence, we hypothesize that the total trade amount of any particular commodity might have effects on farm prices. Finally, agricultural commodity prices in a market economy are also influenced by the trend of per capita income.

In this study, the potential international market indicators were investigated to test their effects on market prices for imported and exported non-cereal crops in Bangladesh. Through this study, we make a modest attempt to fill this gap in the literature by considering the potato and rapeseed oil market price fluctuations by integrating international market indicators for Bangladesh.

This paper is organized as follows: Section 2 includes the details of previous research and the research gap. Section 3 describes the materials and methods of the study. Section 4 shows the estimated results with different tests. Section 5 provides the discussion of the study. Section 6 presents the conclusions and policy implications.

2. Previous Research

Some prior studies have been conducted and found that significant decreases in the per capita income of residents have negative implications for the market prices of major commodities [19,20]. Besides, different functional relationships, including price linkage functions, import–export-oriented functions, etc., were examined through the supply and demand approach, which also highlights that world prices, trade, and GDP per capita (*GDPPC*) influence the equilibrium market prices of different crops [21–25].

However, due to the insufficient and inappropriate pricing policies for potatoes and rapeseed, there have been significant losses associated with the domestic production of potatoes and rapeseed [26,27]. So, an appropriate trading and pricing policy for the potato and rapeseed markets should be explored for identifying the price risks and managing sustainable market dynamics for a developing economy such as Bangladesh, where fluctuations in market prices of major non-cereals are the topmost concern [23].

To date, numerous studies have investigated the potato marketing systems [28], and the demand, supply, and price hikes of potatoes and rapeseed [29,30]. Some research highlights the economic impacts of rapeseed [31], the impact of trade liberalization, and world price changes in Bangladesh [32]. Besides, a few researchers focused on rice pricing and farm wage policies by using the ARDL model [33], analyzing the effects of increasing world food prices [34], price transmission between world food prices and different consumer food prices [35], and food price volatility and economic shocks [36–39].

However, up until today, no study had explored the effect of the international market indicators on the import and export of non-cereal crops in Bangladesh in particular and globally in general. Therefore, the motivation of this research was to test the effects of these international indicators on domestic market prices of imported and exported non-cereal crops.

3. Materials and Methods

To know the effects of the changes in world prices and associated variables linked to the market dynamics on the Bangladesh potato and rapeseed market prices, we applied the nonlinear autoregressive distributed lag (NARDL) technique based on autoregressive distributed lag models (ARDL). A method developed by Pesaran et al. (2001) enables us to test whether a long-term or level relationship exists [40]. Due to its better statistical properties, this method is better suited to small samples to determine the positive and negative shock variables. Additionally, using its asymmetric extension, proposed by Shin et al. (2014), we can test whether there is an asymmetry in either the short-run or long-run [41]. The only study by Delatte and López-Villavicencio (2011) that found asymmetric effects used ARDL models, but it focused on inflation rather than export- and import-oriented prices [42].

To use the ARDL model, the endogenous variables in the model must be either integrated to order zero or one. To test this, we initially performed stationarity tests on farm prices (USD/MT), trade-in metric tons (MT) of potato and rapeseed, and the GDP per capita (*GDPPC*) of Bangladesh that were transformed into constant international dollars (base 2015), followed by purchasing power parity (PPP) rates, and world prices (USD/MT) of potato (Netherlands) and rapeseed (Canada). The data for the included variables (average annual value) have been obtained from the Food and Agricultural Organization statistical database (FAOSTAT) online database for the period 1988 to 2019. Figure 1 illustrates the steps followed to perform the NARDL model for this study.

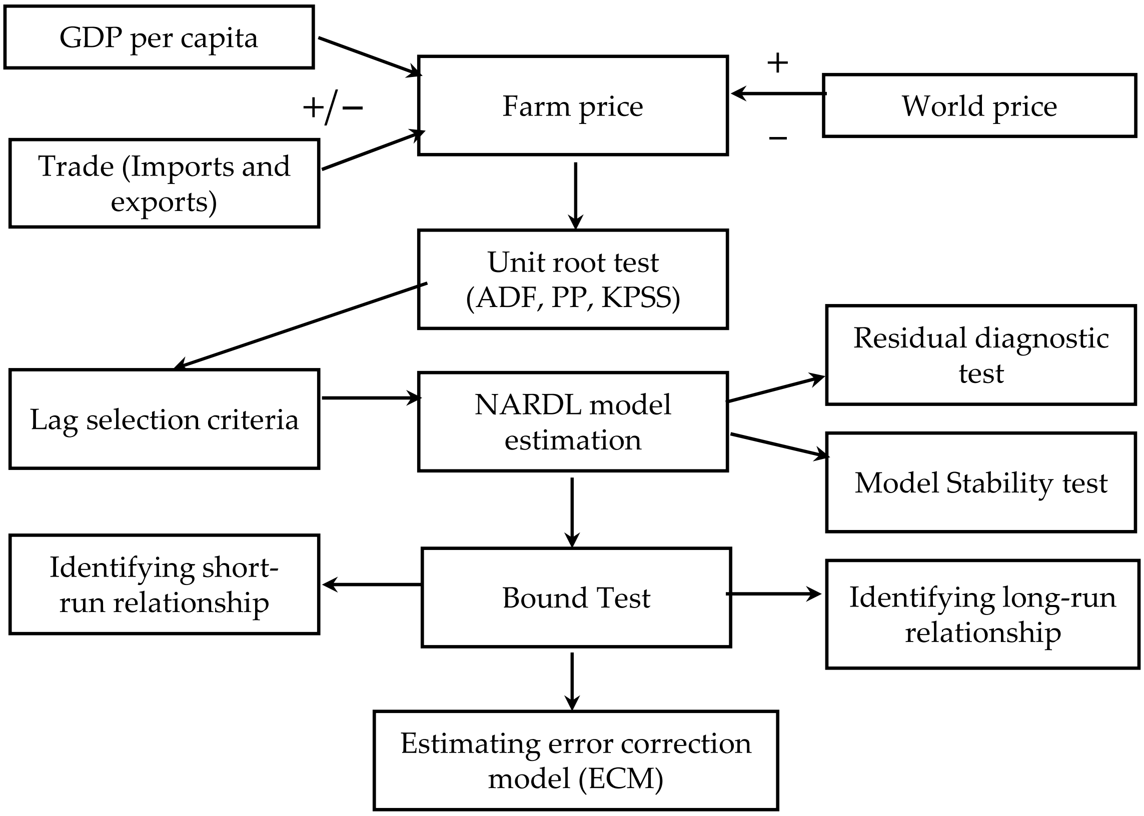


Figure 1. Overview of the steps of the NARDL model.

To identify the level of integration of the test variables, we performed the Augmented Dickey−Fuller (ADF), Phillips–Perron (PP), and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests [43–45]. The unit root tests suggest that the other variables are also either integrated of order zero or one, suggesting that all our test variables satisfy the precondition of the ARDL model. Table 1 illustrates the results of these tests.

Table 1. Unit root tests.

Variables	Levels			First Differences		
	ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
			Potato			
FP	−3.376 *	−3.245 *	0.111	−5.395 ***	−15.280 ***	0.500 ***
WP	−2.762	−4.149 **	0.129 **	−5.903 **	−4.370 ***	0.178 **
TRD	−3.850 **	−3.782 **	0.103	−4.906 ***	−16.847 ***	0.151 **
GDPPC	4.0829	4.083	0.198	−3.306 *	−3.265 *	0.182 **
			Rapeseed			
FP	−1.8020	−1.768	0.159 **	−5.162 ***	−5.148 ***	0.089
WP	−3.3837 *	−1.935	0.079	−4.544 ***	−5.428 ***	0.376 ***
TRD	−4.2221 **	−3.217 *	0.103	−4.809 ***	−7.243 ***	0.236 ***

Note: all the unit root tests include both a constant and a linear trend. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. Farm price = *FP*, world price = *WP*, GDP per capita = *GDPPC*, trade = *TRD*.

The basic model of this study was developed by Ogundipe et al. (2019), who analyzed the macroeconomic impact of agricultural commodity price volatility [46]. In this equation, the changes in variables (world price, trade, and *GDPPC*) are used as a variable to examine the effects of the domestic price of major non-cereals, while Ogundipe et al. (2019) used the macroeconomic variables (GDP, export, import, government expenditure, and inflation, etc.) to investigate the impact of agricultural commodity price volatility [46]. Moreover, in market dynamics mechanisms, previous studies showed that the equilibrium farm price of agricultural crops is influenced by the aforementioned variables [23,24].

To find the relation between farm prices of potato and rapeseed with a set of the most influential macro indicators, namely, world price, trade quantity, and *GDPPC*, the following ARDL model was constructed in the following form:

$$FP_t = \alpha_0 + \alpha_1 WP_t + \alpha_2 TRD_t + \alpha_3 GDPPC_t + \epsilon_t \tag{1}$$

where FP_t is indicating farm prices of potato and rapeseed in USD MT^{-1} within the time frame *t* (1988–2019). WP_t and TRD_t denote world price (USD/MT) and total trade (MT) of potato and rapeseed, respectively. $GDPPC_t$ indicates GDP_t per capita where the real GDP is divided by the total population of Bangladesh. $\alpha_0, \alpha_1, \alpha_2,$ and α_3 are the coefficients of variables.

The study used the Akaike information criterion (AIC) for choosing the lag length. After finding the long run association existing between variables, the study used the conditional error correction model (ECM) to find the short-run and long-run dynamics. The ECM general form of Equation (1) is formulated below in Equation (2):

$$\begin{gathered}\Delta FP_t = \alpha_0 + \alpha_1 FP_{(t-1)} + \alpha_2 WP_{(t-1)} + \alpha_3 TRD_{(t-1)} + \alpha_4 GDPPC_{t-1} + \\ \textstyle\sum_{i-1}^{n1} \alpha_5 \Delta FP_{(t-1)} + \sum_{i-0}^{n2} \alpha_6 \Delta WP_{(t-1)} + \sum_{i-0}^{n3} \alpha_7 \Delta TRD_{(t-1)} + \\ \textstyle\sum_{i-0}^{n4} \alpha_8 \Delta GDPPC_{t-1} + \lambda e_{t-1} + \epsilon_t\end{gathered} \tag{2}$$

where Δ is the first difference operator. If the empirical findings reported a cointegration relationship among the variables (*FP*, *WP*, *TRD*, and *GDPPC*), the short-run dynamic would be adjusted through error correction "λe_{t-1}" movement. Besides, the coefficient sign of λe_{t-1} is assumed to be negative and significant to achieve long-run equilibrium if devaluations exist in the model. Based on this equation, the ARDL cointegration test, which is also known as the bounds test, was conducted. For the two variables of our interest to be cointegrated, the F-test statistic computed from the equation must be higher than both the lower- and upper-bound critical values provided in Pesaran et al. (2001) [40]. EViews 12 was used to run the ARDL model.

Based on Equation (2), the NARDL model was applied to estimate the relationship presented in Equation (1). For applying the NARDL, we decomposed all explanatory variables into positive and negative shocks and the variations of $WP_{c,t}$, $TRD_{c,t}$, and $GDPPC_t$ into positive and negative partial sums, which are as follows:

$$WP_t^+ = \textstyle\sum_{i-1}^{t} \Delta WP_i^+ = \sum_{i-1}^{t} \max(\Delta WP_i, 0) \tag{3}$$

$$WP_t^- = \textstyle\sum_{i-1}^{t} \Delta WP_i^- = \sum_{i-1}^{t} \min(\Delta WP_i, 0) \tag{4}$$

$$TRD_t^+ = \textstyle\sum_{i-1}^{t} \Delta TRD_i^+ = \sum_{i-1}^{t} \max(\Delta TRD_i, 0) \tag{5}$$

$$TRD_t^- = \textstyle\sum_{i-1}^{t} \Delta TRD_i^- = \sum_{i-1}^{t} \min(\Delta TRD_i, 0) \tag{6}$$

$$GDPPC_t^+ = \textstyle\sum_{i-1}^{t} \Delta GDPPC_i^+ = \sum_{i-1}^{t} \max(\Delta GDPPC_i, 0) \tag{7}$$

$$GDPPC_t^- = \textstyle\sum_{i-1}^{t} \Delta GDPPC_i^- = \sum_{i-1}^{t} \min(\Delta GDPPC_i, 0) \tag{8}$$

The WP_t, TRD_t, and $GDPPC_t$ are decomposed into positive and negative shocks, for example, WP_i^+ and WP_i^-. This shows that a one-unit increase in the independent variables leads to an increase (positive shocks) and a decrease (negative shock) in the dependent variables. Granger (1983) suggests that if cointegration exists between two-time series variables (i.e., positive and negative), they are in the form of hidden cointegration and have a linear form of cointegration, which is a special case of hidden cointegration [47]. Thus, the linear cointegration is converted to nonlinear cointegration. We can use the bound test suggested by Pesaran et al. (2001) [40] to test the asymmetric relationship between the following equations:

$$\Delta FP_t = \alpha_0 + \alpha_1 FP_{(t-1)} + \alpha_2 WP^+_{(t-1)} + \alpha_3 WP^-_{(t-1)} + \alpha_4 TRD^+_{(t-1)} + \alpha_5 TRD^-_{(t-1)} + \alpha_6 GDPPC^+_{(t-1)} + \alpha_7 GDPPC^-_{(t-1)} + \sum_{i-1}^{n1} \alpha_8 \Delta FP_{(t-1)} + \sum_{i-0}^{n2} (\delta_i^+ \Delta WP^+_{(t-1)} + \delta_i^- \Delta WP^-_{(t-1)}) + \sum_{i-0}^{n3} (\gamma_i^+ \Delta TRD^+_{(t-1)} + \gamma_i^- \Delta TRD^-_{(t-1)}) + \sum_{i-0}^{n4} (\tau_i^+ \Delta GDPPC^+_{(t-1)} + \tau_i^- \Delta GDPPC^-_{(t-1)}) + \epsilon_t \quad (9)$$

4. Results

Market prices continually respond to multiple influences, especially for agricultural commodities. In addition, markets are dynamic and quickly adjust to new realities and competitiveness. According to price determination models, changes in supply and demand conditions in one market will impact trade and prices in other markets through spatial arbitrage [48–50]. We estimated the ARDL model to investigate if the world price changes, along with the total import quantity and GDP per capita of Bangladesh, have an impact on potato and rapeseed market prices. Table 2 illustrates the descriptive statistics of our modeled variables using yearly average data. Moreover, a graphical representation of our modeled variables is presented in Figure 2. Farm prices for both potato and rapeseed have increased over the study periods (1988–2019), while world prices have fluctuated in both cases. However, a very sharp increasing trend was observed for the GDP per capita of Bangladesh.

Table 2. Descriptive statistics.

Statistics	**Potato**			**Rapeseed**			
	FP **(USD/MT)**	***WP*** **USD/MT**	***TRD*** **(MT)**	***FP*** **(USD/MT)**	***WP*** **(USD/MT)**	***TRD*** **(MT)**	***GDPPC*** **(USD Per Capita)**
Mean	8298.03	169.53	2,851,031	25,772.22	369.38	47,393.84	643.70
Median	7000.00	150.00	2,210,500	18,470.00	367.00	44,811.00	395.96
Maximum	17,060.00	380.00	11,556,000	48,740.00	565.00	129,000.0	1846.42
Minimum	2280.00	72.00	126,000.0	11,090.00	220.00	259.00	252.73
Std. Dev.	4375.46	83.61	2,596,944	13,623.96	106.42	30,441.95	458.87
Skewness	0.59	1.12	1.18	0.54	0.24	0.77	1.27
Kurtosis	1.88	3.37	4.83	1.58	1.87	3.36	3.43
Jarque-Bera	3.22	7.00	44.74	4.26	2.00	3.35	8.89
Probability	0.19	0.03	0.00	0.12	0.37	0.19	0.01
Observations	32	32	32	32	32	32	32

To test for cointegration relationships among the selected variables, we conducted the ARDL bound test (Pesaran et al. 2001) [40]. The results shown in Table 3 portray that the F-statistics are larger than the upper bounds at the 5% significance level for both the potato and rapeseed models. Thus, the results indicate that our selected non-cereal crop price models have a cointegration relationship.

Next, we estimated the ARDL model to investigate the world prices and trade of potato and rapeseed with *GDPPC*, which has a long-run impact on the yearly domestic market prices of potato and rapeseed in Bangladesh. The results of the model estimations are presented in Table 4. It is apparent from Table 4 that the world prices of potato and rapeseed had a significant and negative relationship with domestic prices, while *GDPPC* had a positive and significant association with domestic potato prices only.

Finally, Table 5 displays the results of the short-run impacts.

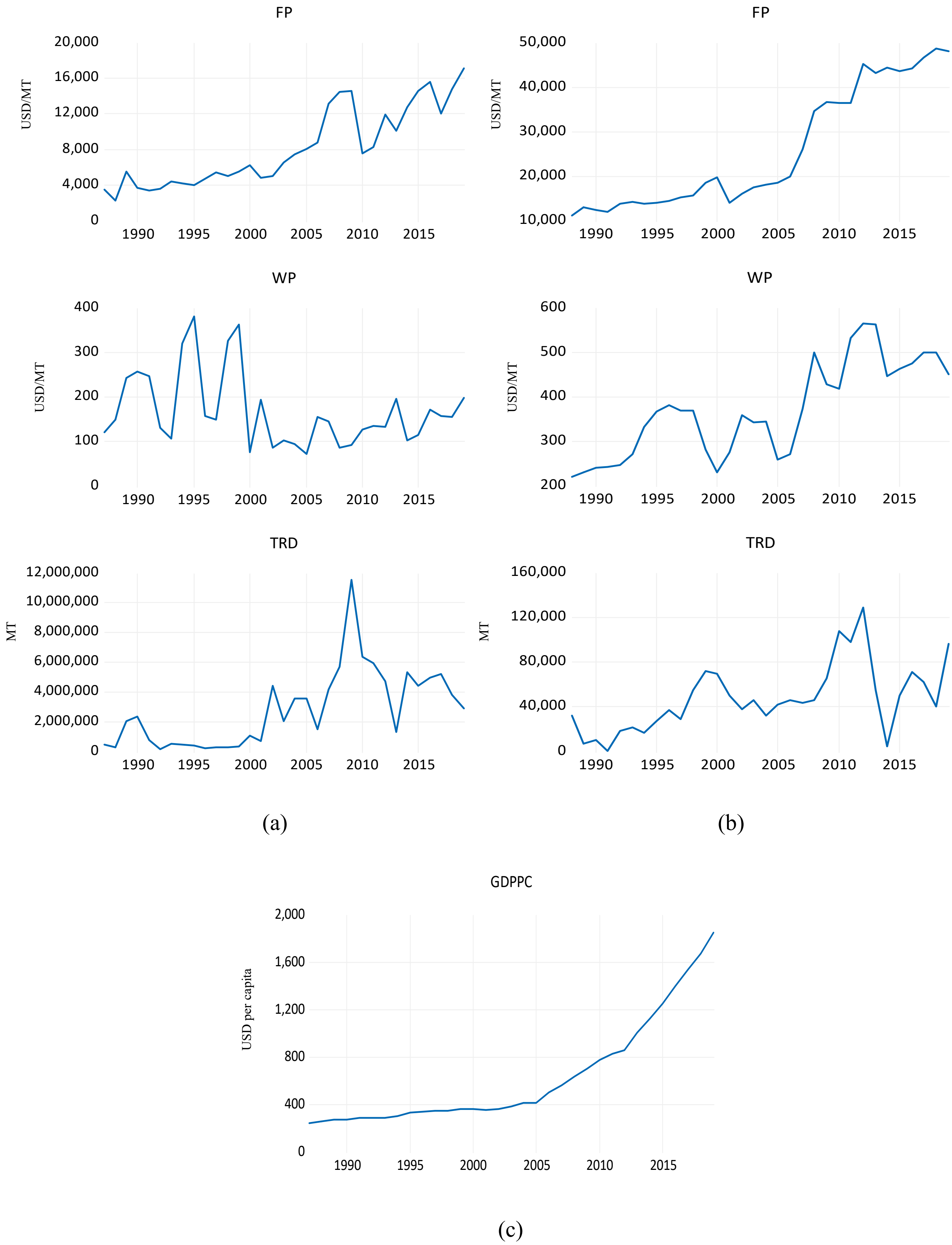


Figure 2. Trends in farm prices, world prices, and total trade of (**a**) potato and (**b**) rapeseed, as well as (**c**) Bangladesh GDP per capita from 1988 to 2019.

Table 3. ARDL Bound Test.

Test Statistic	Potato	Rapeseed
F-statistic	4.572 **	4.398 **
Critical value bounds (N = 32)		
Significance	I_0 bound	I_1 bound
10%	2.618	3.532
5%	3.164	4.194
1%	4.428	5.816

Note: ** denotes significance at the 5% level.

Table 4. ARDL long-run estimation.

Variables	Potato		Rapeseed	
	Coefficient	t-Stat.	Coefficient	t-Stat.
WP	−56.218 ***	−2.83	−59.328 ***	−2.31
TRD	−0.0008	−0.44	−164.701	−0.44
GDPPC	8.306 *	2.11	0.785	0.54
Constant	16,050.350	0.98	50,932.230	0.46

Note: *** and * denote significance at the 1% and 10% levels, respectively.

Table 5. Linear ARDL model estimation.

Variables	Potato		Variables	Rapeseed	
	Coefficient	t-Stat.		Coefficient	t-Stat.
Constant	6037.267 ***	3.482	Constant	6680.13 *	1.861
FP(−1)	−0.376	−0.950	*FP*(−1)	−0.131	−0.493
Δ*FP*(−1)	0.011	0.042	Δ*FP*(−1)	−0.334	−1.310
WP(−1)	−21.146 **	−2.754	*WP*(−1)	−7.781	−0.580
Δ*WP*	0.538	0.130	Δ*WP*	−8.008	−0.624
Δ*WP*(−1)	12.097 **	2.637	Δ*WP*(−1)	22.599 *	1.959
TRD (−1)	−0.0003	−0.797	*TRD* (−1)	0.102 **	2.487
Δ*TRD*	0.0005 **	2.398	Δ*TRD*	0.067 **	2.740
Δ*GDPPC*	3.124244	1.512	Δ*TRD* (−1)	−0.051 **	−2.082
			Δ*GDPPC*	60.519 **	2.358
			GDPPC (−1)	−21.601 **	−2.716
			Δ*GDPPC* (−1)	74.766 ***	3.124

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

It is seen from the Table 5 that the domestic price of potato received a positive and statistically significant impact from the trade based on the 5% significance level. The result suggests that a one unit increase in total trade will lead to an increase in the farm price of potato by 0.0005 units. On the other hand, rapeseed farm prices had positive and significant relationships with trade and *GDPPC* based on the 5% significance level. Positive and significant findings suggest that increasing the per capita income of residents will lead to a change in the consumption behavior of respondents. Since the price of rapeseed oil is much higher than other oilseed crops, increasing income will push us to consume more nutritious, high-valued, and environment-friendly oil crops instead of cheap substitute crops.

Table 6 shows the results of bounds test in the nonlinear specification. The findings show that the F-statistics value is greater than the upper bound value at a 5% significance level, confirming asymmetric cointegration for both the potato and rapeseed models.

Table 6. NARDL Bound Test.

Test Statistic	Potato	Rapeseed
F-statistic	4.637 **	12.174 ***
Critical value bounds (N = 32)		
Significance	I_0 bound	I_1 bound
10%	2.254	3.388
5%	2.685	3.96
1%	3.713	5.326

Note: *** and ** denote significance at the 1% and 5% levels, respectively.

Then, the long run coefficients of the NARDL model were estimated, and the result of this estimation is depicted in Table 7. The outcomes of long run NARDL estimation reveal the asymmetric effect that the positive shock to the world price increases the domestic price of potato by 12.64%, while both positive and negative shocks have significant coefficients for the rapeseed model, implying that the world price of rapeseed has a direct relationship with the domestic price.

Table 7. NARDL long-run coefficient estimation.

Variables	Potato		Rapeseed	
	Coefficient	t-Stat.	Coefficient	t-Stat.
Constant	3186.765 ***	5.556	15,245.81 ***	6.147
WP^+	12.645 **	2.308	34.147 ***	3.263
WP^-	7.621	1.536	−143.409 **	−2.912
TRD^+	0.0005 ***	4.050	0.047	0.967
TRD^-	0.0006 ***	4.089	0.046	1.322
$GDPPC^+$	1.419	0.840	−21.064	−1.563
$GDPPC^-$	70.925	0.569	303.537 ***	3.384

Note: ***, and ** denote significance at the 1%, and 5% levels, respectively.

Similarly, positive and negative shocks to total trade increase the domestic market price of potato by 0.0005 and 0.0006 USD/MT at the 1% significance level, respectively. This implies that total trade amount movements could significantly affect the Bangladesh potato market in the long-run, while there are no significant shocks found for the rapeseed model. This might be due to the nature of commodities. Potato is a highly produced domestic and exported product, while rapeseed is a foreign and imported product, since the descriptive statistics table reveals the smaller trade amount for rapeseed than potato (Table 2).

Besides, *GDPPC* also holds a direct relationship with the rapeseed market price, and positive shocks in *GDPPC* increase the market price by 303.54% at the 10% level of significance. This is a very positive and promising finding since the economy of Bangladesh is progressive and GDP per capita income has been increasing significantly over the last couple of years. So, increasing per capita income will lead to a change in the consumption status of rapeseed oil, irrespective of soybean and other oil crops in the future. That will bring a positive change to the environment, since rapeseed produces fewer CO_2 emissions and requires less tillage than other oil crops [51].

Finally, the results from NARDL of the short-run effects of the world price, trade, and GDP per capita on the domestic prices of potato and rapeseed are presented in Table 8. It is evident from the table that both the positive and negative shocks of trade increase the domestic price of potato significantly. Since the export of potato started in 2001, it has encouraged Bangladeshi farmers to adopt HYV that lead to higher farm prices and greater returns [15]. These findings are similar to prior studies [52–55]. On the other hand, the positive shocks in the world price positively impacted rapeseed market prices, while negative shocks had negative and statistically significant associations with the farm price of rapeseed. This result is perhaps because of the fluctuations in major exporting countries' market situations, international pricing policies and relations, and changes in tariff rates. Positive shocks ($GDPPC^{+}$) have a decreasing trend in rapeseed farm prices, while negative shocks ($GDPPC^{-}$) have an increasing and statistically significant (at the 1% level) relationship (Table 8).

Table 8. NARDL conditional error correction model estimation.

Variables	Potato		Variables	Rapeseed	
	Coefficient	**t-Stat.**		**Coefficient**	**t-Stat.**
Constant	5505.691 ***	3.999	Constant	8889.267 ***	6.098
$FP\ (-1)$	−1.728 ***	−5.510	$FP\ (-1)$	−0.583 ***	−4.496
$\Delta FP\ (-1)$	0.705 ***	3.502	$\Delta FP\ (-1)$	0.225 **	1.881
ΔWP^{+}	3.022	0.494	ΔWP^{+}	19.909 **	2.408
ΔWP^{-}	13.167	1.512	ΔWP^{-}	−22.924 **	−2.261
$WP^{+}\ (-1)$	21.846 **	2.216	$WP^{-}\ (-1)$	−83.616 ***	−4.384
$\Delta WP^{+}\ (-1)$	−23.141 **	−2.343	$\Delta WP^{-}\ (-1)$	56.692 ***	3.167
ΔTRD^{+}	0.0008 **	2.790	ΔTRD^{+}	0.005	0.196
ΔTRD^{-}	0.001 ***	2.959	ΔTRD^{-}	0.026	1.424
$\Delta GDPPC^{+}$	89.765 *	2.195	$TRD^{+}\ (-1)$	0.027	1.044
$\Delta GDPPC^{-}$	122.536	0.559	$\Delta GDPPC^{+}$	−12.282 **	−1.908
$GDPPC^{+}\ (-1)$	2.451	0.825	$\Delta GDPPC^{-}$	1769.327 ***	5.234

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The results of our analysis indicated that our assumptions for both imported and exported goods prevailed. This implies that even prices for exported goods, i.e., potato market prices, were much more influenced by trade volume. Imported goods, on the other hand, were influenced by world prices and the *GDPPC*.

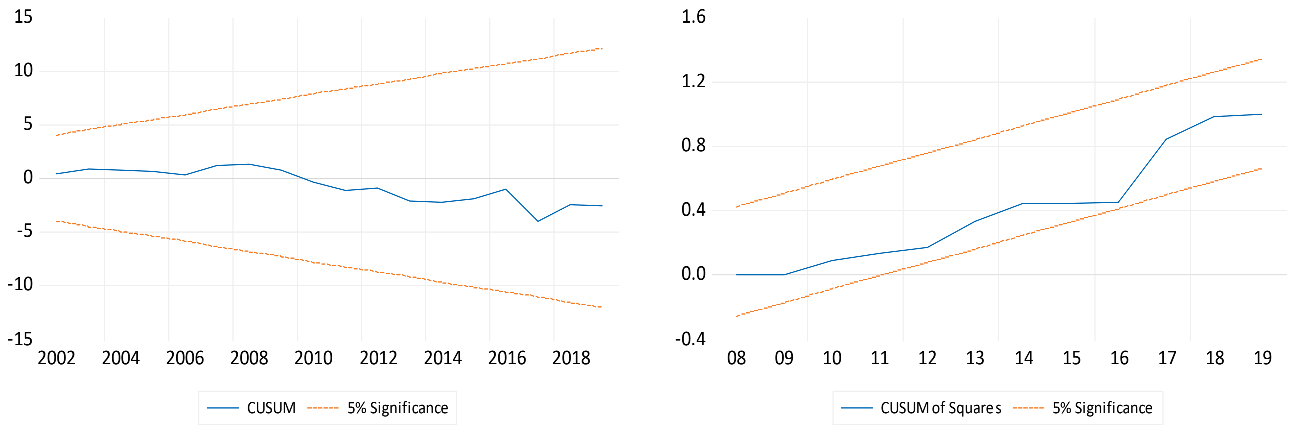
To determine the validity of our ARDL and NARDL results, we used a variety of diagnostic tests, including the Breusch–Godfrey serial correlation Lagrange multiplier (LM) test for serial correlation, the Breusch–Pagan–Godfrey test for heteroskedasticity, and CUSUM and CUSUMSQ for model stability.

The diagnostic test results are shown in Table 9, and we confirmed that the model is free of serious flaws. The problem of serial correlation does not exist in our model. Our model is stable and has no issues with heteroskedasticity. These diagnostic tests show that the model is correctly specified, that no major flaws exist, and that the results are trustworthy.

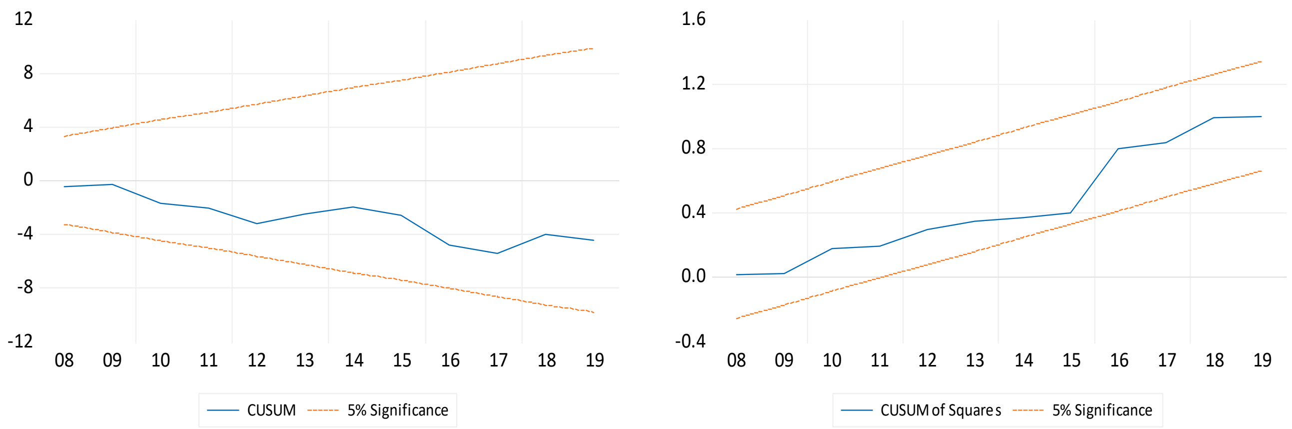
Table 9. Diagnostic tests.

Tests	Problem	Potato (*p*-Value)		Rapeseed (*p*-Value)		Decision
		ARDL	**NARDL**	**ARDL**	**NARDL**	
BG F-stat. (LM)	Serial correlation	0.470	0.423	0.884	0.138	No serial correlation exists
BPG F-stat.	Heteroscedasticity	0.116	0.778	0.764	0.778	No heteroscedasticity exists
CUSUM	Stability	–		–		Model is stable
CUSUMSQ	Stability	–		–		Model is stable

Figures 3 and 4 are the plots of the CUSUM and CUSUMSQ tests. For both ARDL and NARDL models for potato and rapeseed, CUSUM and CUSUMSQ statistics fell inside the 5% confidence intervals of parameter stability, suggesting that the coefficients in these models were stable.

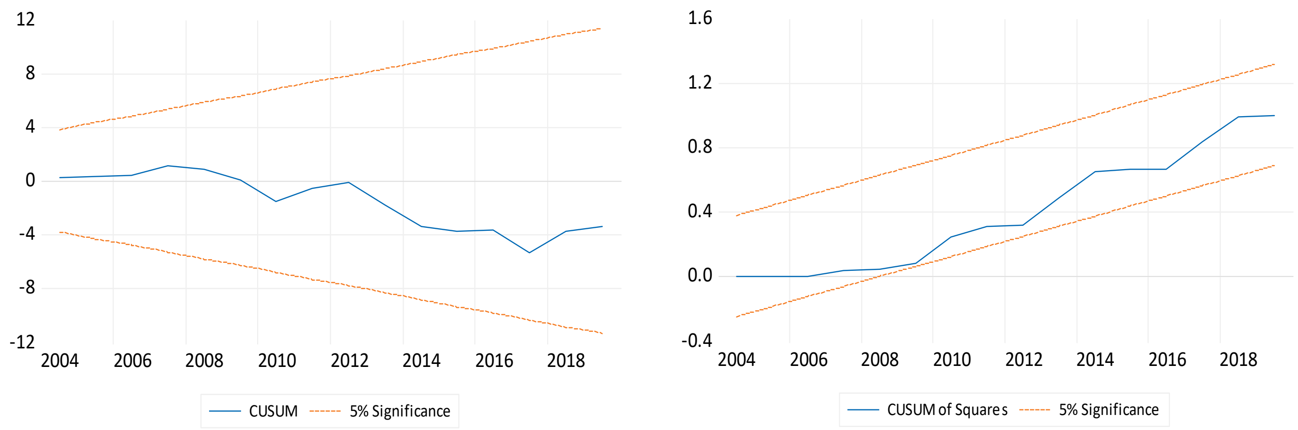


(a)



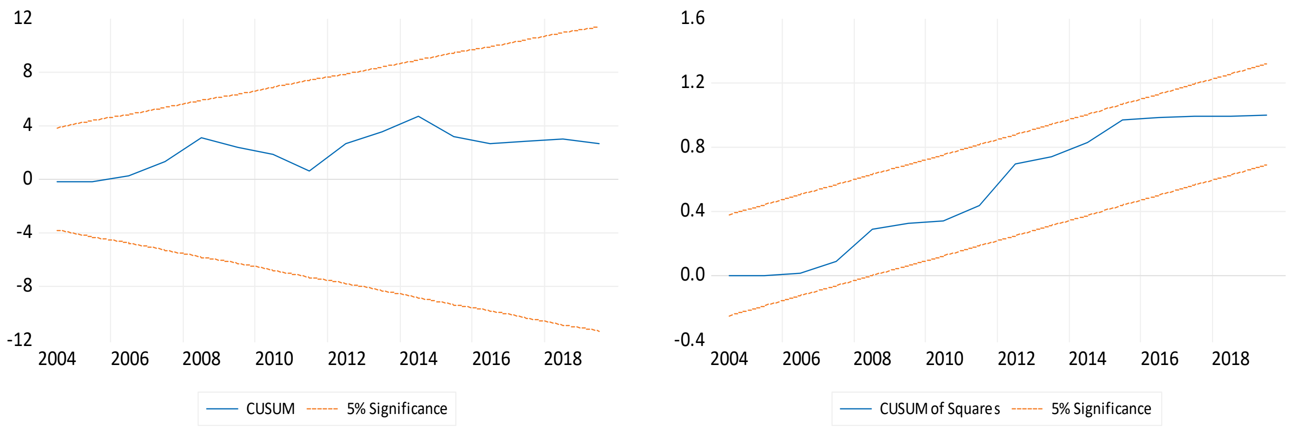
(b)

Figure 3. CUSUM and CUSUMSQ tests for the ARDL models. (**a**) Potato; (**b**) rapeseed.



(a)

Figure 4. *Cont.*



(b)

Figure 4. CUSUM and CUSUMSQ tests for the NARDL models. (**a**) Potato; (**b**) rapeseed.

5. Discussions

In recent years, global food prices went up abruptly, which prompted a rise in inflation rates, affecting mainly the poor developing nations who spend much of their income on food. The phenomenon of food prices fluctuating at national and regional levels is not new. The causes and potential solutions to soaring food prices have been the subject of many studies in the past few years [56]. A number of factors drive food prices to increase, including biofuel demand, speculation in commodity futures markets, countries' aggressive stockpiling policies, trade restrictions, and macroeconomic shocks to money supply and exchange rates. This study examined whether macroeconomic shocks affect food crops other than cereals, which must also be evaluated. It identified that in the long-run, the world potato and rapeseed prices led to an increase in the Bangladesh potato and rapeseed prices when they are increasing. Bangladesh's rapeseed price increased when the world rapeseed price decreased, while the domestic potato price decreased only slightly when the world potato price declined.

This happened due to the surplus in potato production over the last few decades. The tuber crop research center of the Bangladesh Agricultural Research Institute (BARI) has released 66 high-yielding varieties of potato [57], which has also contributed to the huge production of potatoes in Bangladesh. Presently, Bangladesh exports potatoes and items related to potatoes to different countries such as the United Arab Emirates (UAE), Belgium, Brunei, Bahrain, Canada, Netherlands, Russia, Singapore, and so forth [58]. This statement aligns with our findings that the changes in the trade volume affected the Bangladesh potato price in the long and short-term.

Based on the NARDL long-run result, it is also evident that domestic rapeseed prices decrease with an increase in GDP per capita. These findings are similar to Bhati and Kumar, 2020, who found that imports and exports of the crop affected the fluctuation in its prices as the international prices of rapeseed and mustard oils fluctuate more than the domestic prices, as India is the importer of these oilseeds [27]. However, due to the progressive economy, Bangladesh may import other oilseeds, resulting in a decrease in the domestic rapeseed price. This indicates that there is a strong substitution effect among vegetable oils. This substitution relationship also happens between crude oil and vegetable oils, as shown by Saghaian [59].

Since the study indicates that exporting and importing non-cereals have been influenced differently by the international indicators, it implies the importance of ensuring a sustainable marketing system for potatoes and rapeseed. The study has some limitations in that it only focused on the effects of macroeconomic indicators on the non-cereal markets, and hence, future research should also include other factors, such as market and production factors, irrigation techniques, and environmental conditions, which have an influence on the market prices of studied crops. Besides, some other non-cereal crops can also be checked in future research.

6. Conclusions and Policy Implications

The purpose of this empirical study was to enrich the extant literature by investigating the asymmetric effects of changes in world prices and the total trade of potato and rapeseed, along with GDP per capita, on the changes in the domestic price of potato and rapeseed in Bangladesh. We measured the nonlinear effect of world non-cereal prices, trade volumes, and GDP per capita on farm prices of potato and rapeseed using yearly data from 1988 to 2019. We adopted the NARDL model to capture the short- and long-run relationships of the variables.

The study identified that during the period investigated, the world potato and rapeseed prices led to an increase in the Bangladesh potato and rapeseed prices when they were increasing. However, when the world rapeseed price was declining, the Bangladesh rapeseed price tended to decrease accordingly, while the domestic potato price did not receive such an impact from the world potato price. This distinction is likely due to the difference in the characteristics of potato and rapeseed in Bangladesh: the potato is considered an exported crop while rapeseed is an imported product.

Second, we found that the changes in the trade volume only had an influence on the Bangladeshi potato price both in the long-run and short-run. We conjecture that the reason for the rapeseed not receiving impacts from the trade is that the volume of rapeseed trade is much smaller compared to potatoes in Bangladesh.

Finally, the NARDL long-run result suggested that domestic rapeseed prices tend to decrease when GDP per capita increases. As an effect of the progressive economy, the country may import other oilseeds, which in turn lowers the rapeseed price in the domestic market. Consequently, to reduce the import reliance on oilseeds from other countries and ensure the sustainable domestic production of rapeseed, the government needs to adopt a long-term strategy that includes subsidizing crops and promoting high-yielding varieties.

Our empirical findings imply that it is important for market participants of potato and rapeseed in Bangladesh to take into consideration the sensitivity of the above-mentioned variables when designing resource allocation decisions in the event of positive and negative effects on these non-cereal crop markets. To increase potato and rapeseed cultivation for increased production, the government can introduce a cooperative marketing system among rural farmers to maintain sustainable production. More research is needed to develop a more sufficient supply of potatoes and rapeseed in the market. Research institutes can take initiatives to develop the overall situation of non-cereal markets.

Author Contributions: A.J. and K.A. conceptualized the idea; A.J. and K.A. contributed regarding the use of software; A.J. conducted formal analysis; A.J. prepared the original draft; A.J., K.A., J.F. and M.I. reviewed and edited the document; and M.I. supervised the research. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We appreciate the data provided by the BBS, BARC, FAO, and WB. The authors are grateful to the University of Tsukuba in Japan for allowing them to conduct their research in their lab. We would also want to thank the More Jobs Better Lives (MJBL) Foundation in Japan for providing scholarships for us to conduct this research there.

Conflicts of Interest: The authors declare that they have no conflict of interest.

References

1. Rahman, M.M.; Hossain, M.A.; Ali, M.R.; Ahmed, Z.; Hedayutul Islam, A.H.M. Assessing vulnerability and adaptation strategy of the cyclone affected coastal area of Bangladesh. *Geoenviron. Disasters* **2022**, *9*, 6. [CrossRef]
2. Shahabuddin, Q.; Rahman, A. Agricultural and Food Policy Framework in Bangladesh: An Assessment. *Bangladesh Dev. Stud.* **2017**, *40*, 27–51. Available online: https://www.jstor.org/stable/26572743 (accessed on 22 February 2022).
3. Osmani, S.R. Pricing and Distribution Policies for Agricultural Development in Bangladesh. *Bangladesh Dev. Stud.* **1985**, *13*, 1–40. Available online: http://www.jstor.org/stable/40775789 (accessed on 3 March 2022).
4. WB. Overview of Bangladesh, Where We Work, World Bank Report. 2022. Available online: https://www.worldbank.org/en/country/bangladesh/overview#1 (accessed on 11 April 2022).
5. Talukder, R.K. Food Security, Self-Sufficiency and Nutrition Gap in Bangladesh. *Bangladesh Dev. Stud.* **2005**, *31*, 35–62. Available online: https://ideas.repec.org/a/ris/badest/0470.html (accessed on 22 June 2020).
6. FAO (Food and Agriculture Organization of the United Nations). *The State of Food and Agriculture*; FAO: Rome, Italy, 2015; Available online: http://bit.ly/KAn84P (accessed on 16 May 2020).
7. HIES. *Household Income and Expenditure Survey*; Preliminary Report on Household Income and Expenditure Survey; Bureau of Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh: Dhaka, Bangladesh, 2015.
8. FAO/WHO. Food and Agriculture Organization of the United Nations/World Health Organization. Bangladesh Country Nutrition Paper. In Proceedings of the International Conference on Nutrition 21 Years Later, Rome, Italy; Geneva, Swaziland, 19–21 November 2014.
9. Dameus, A. Impact of Government Pricing Policies on Cereal Grain Producers in Haiti. Master's Thesis, Iowa State University, Ames, IA, USA, 1988. Available online: https://lib.dr.iastate.edu/rtd/16585 (accessed on 14 February 2022).
10. Taylor, D.S.; Phillips, T.P. Food-Pricing Policy in Developing Countries: Further Evidence on Cereal Producer Prices. *Am. J. Agric. Econ.* **1991**, *73*, 1036–1043. [CrossRef]
11. BBS. Bangladesh Bureau of Statistics. *Yearbook of Agricultural Statistics of Bangladesh*; Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh: Dhaka, Bangladesh, 2019. Available online: http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/1b1eb817_9325_4354_a756_3d18412203e2/2020-10-06-09-58-453f7e0a42348e05f0999979870ec07b.pdf (accessed on 11 January 2022).
12. BBS. Bangladesh Bureau of Statistics. *Yearbook of Agricultural Statistics of Bangladesh*; Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh: Dhaka, Bangladesh, 2017. Available online: http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/1b1eb817_9325_4354_a756_3d18412203e2/Yearbook-2017-Final-05-05-2018.pdf (accessed on 21 February 2022).
13. Hossain, M.M.; Abdulla, F. Forecasting potato production in Bangladesh by ARIMA model. *J. Adv. Stat.* **2016**, *1*, 191–198. [CrossRef]
14. Jaime, R.; Alcántara, J.M.; Manzaneda, A.J.; Rey, P.J. Climate change decreases suitable areas for rapeseed cultivation in Europe but provides new opportunities for white mustard as an alternative oilseed for biofuel production. *PLoS ONE* **2018**, *13*, e0207124. [CrossRef]
15. FAOSTAT. FAOSTAT Data. 2021. Available online: www.faostat.fao.org (accessed on 16 November 2021).
16. Setshedi, C.; Mosikari, T.J. Empirical analysis of macroeconomic variables towards agricultural productivity in South Africa. *Ital. Rev. Agric. Econ.* **2019**, *74*, 3–15. [CrossRef]
17. Kadir, S.U.S.A.; Tunggal, N.Z. The impact of macroeconomic variables toward agricultural productivity in Malaysia. *South East Asia J. Contemp. Bus. Econ. Law* **2015**, *8*, 21–27.
18. Brownson, S.; Vincent, I.M.; Emmanuel, G.; Etim, D. Agricultural Productivity and Macro-economic Variable fluctuation in Nigeria. *Int. J. Econ. Financ.* **2012**, *4*, 114–125. [CrossRef]
19. Motamed, M.; Hungerford, A.; Rosch, S.; O'Donoghue, E.; MacLachlan, M.; Astill, G.; Cessna, J.; Cooper, J. *Federal Risk Management Tools for Agricultural Producers: An Overview*; The U.S. Department of Agriculture, Economic Research Service: Washington, DC, USA, 2018; ERR-250.
20. Frankel, J.; Rose, A.K. *Determinants of Agricultural and Mineral Commodity Prices*; HKS Faculty Research Working Paper Series 10-038; John, F., Ed.; Kennedy School of Government, Harvard University: Cambridge, MA, USA, 2010.
21. Jannat, A.; Ishikawa-Ishiwata, Y.; Furuya, J. Does Climate Change Affect Rapeseed Production in Exporting and Importing Countries? Evidence from Market Dynamics Syntheses. *Sustainability* **2022**, *14*, 6051. [CrossRef]
22. Kamaruddin, K.; Hazmi, Y.; Masbar, R.; Syahnur, S.; Majid, M.S.A. Asymmetric Impact of World Oil Prices on Marketing Margins: Application of NARDL Model for the Indonesian Coffee. *Int. J. Energy Econ.* **2021**, *11*, 212–220. Available online: https://econjournals.com/index.php/ijeep/article/view/11857 (accessed on 29 January 2022). [CrossRef]
23. Jannat, A.; Ishikawa-Ishiwata, Y.; Furuya, J. Assessing the Impacts of Climate Variations on the Potato Production in Bangladesh: A Supply and Demand Model Approach. *Sustainability* **2021**, *13*, 5011. [CrossRef]
24. Salam, M.A.; Furuya, J.; Kobayashi, S. Climate effect on supply and market price stability of rice in Bangladesh: Assessment of climate and socioeconomic scenarios. *Jpn. J. Agric. Econ.* **2017**, *19*, 60–65. [CrossRef]
25. Furuya, J.; Kobayashi, S.; Yamauchi, K. Impacts of climate change on rice market and production capacity in the Lower Mekong Basin. *Paddy Water Env.* **2014**, *12*, 255–274. [CrossRef]

26. Ahamed, M.S.; Moniruzzaman, M.; Tabassum, N. Can Cold Storage Reduce Seasonal Variation in Prices of Agricultural Commodities? A Case of Potato in Bangladesh. *Bangladesh J. Agric. Econ.* **2021**, *42*, 19–36. Available online: https://bjae.bau.edu.bd/index.php/home/article/view/100 (accessed on 12 December 2021).
27. Bhati, M.; Kumar, R. Price Volatility of Oilseeds under Trade Liberalization in India: Analysis of Rapeseed and Mustard. *Int. Econ. Stud.* **2020**, *50*, 61–74. [CrossRef]
28. Singha, U.; Maezawa, S. Production, Marketing System, Storage and Future Aspect of Potato in Bangladesh. *Rev. Agric. Sci.* **2019**, *7*, 29–40. [CrossRef]
29. Sabur, S.A.; Monayem Miah, M.A.; Begum, M.E.A.; Rahman, M.S.; Molla, M.M.U. Demand, supply and reasons for price hike of potato in Bangladesh. *Bangladesh J. Agric. Econ.* **2021**, *42*, 93–108.
30. Rahman, S.; Kazal, M.M.H.; Begum, I.A.; Alam, M.J. Competitiveness, Profitability, Input Demand and Output Supply of Maize Production in Bangladesh. *Agriculture* **2016**, *6*, 21. [CrossRef]
31. Miah, M.M.A.; Shiblee, S.M.A.; Rashid, M.A. Economic Impacts of Oilseed Research and Development in Bangladesh. *Bangladesh Dev. Stud.* **2015**, *38*, 1–31.
32. Alam, M.J.; Buysse, J.; Begum, I.A.; Nolte, S.; Wailes, E.J.; Van Huylenbroeck, G. Impact of trade liberalization and world price changes in Bangladesh: A computable general equilibrium analysis. *Agric. Econ.* **2015**, *4*, 1. [CrossRef]
33. Hassan, F.; Kornher, L. Farm wage and Rice Price dynamics in Bangladesh. *Food Sec.* **2022**, *14*, 127–146. [CrossRef]
34. Hossain, M. What implications does the world food price rise have for food security in Bangladesh. *Int. J. Food Agric. Econ.* **2014**, *2*, 51–63.
35. Barahona, J.F.; Chulaphan, W. Price transmission between world food prices and different consumer food price indices in Thailand. *Kasetsart J. Soc. Sci.* **2019**, *40*, 17–23. [CrossRef]
36. Ivanic, M.; Martin, W. *Short- and Long-Run Impacts of Food Price Changes on Poverty*; The World Bank: Washington, DC, USA, 2014. [CrossRef]
37. Jacoby, H.G. Food prices, wages, and welfare in rural India. *Econ. Inq.* **2016**, *54*, 159–176. [CrossRef]
38. Jayasuriya, S.; Mudbhary, P.; Broca, S.S. *Food Price Spikes, Increasing Volatility and Global Economic Shocks: Coping with Challenges to Food Security in Asia*; Food and Agriculture Organization of the United Nations: Bangkok, Thailand, 2012; Available online: http://www.fao.org/docrep/016/i3031e/i3031e00.htm (accessed on 2 November 2021).
39. Kalkuhl, M.; Von Braun, J.; Torero, M. Food Price Volatility and Its Implications for Food Security and Policy. 2016. MPRA Paper No. 72164. Available online: https://mpra.ub.uni-muenchen.de/72164/ (accessed on 23 June 2021).
40. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
41. Shin, Y.; Byungchul, Y.; Matthew, G.M. Modeling asymmetric cointegration and dynamic multipliers in an ARDL framework. In *Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications*; Horrace, W.C., Sickles, R.C., Eds.; Springer Science and Business Media: New York, NY, USA, 2014; pp. 281–314.
42. Delatte, A.L.; López-Villavicencio, A. Asymmetric Exchange Rate Pass-through: Evidence from Major Countries. *J. Macroecon.* **2012**, *34*, 833–844. [CrossRef]
43. Dickey, D.A.; Fuller, W.A. Distribution of the estimators for autoregressive time series with a unit root. *J. Am. Stat. Assoc.* **1979**, *74*, 427–431.
44. Phillips, P.C.; Perron, P. Testing for a unit root in time series regression. *Biometrika* **1988**, *75*, 335–346. [CrossRef]
45. Kwiatkowski, D.; Phillips, P.C.; Schmidt, P.; Shin, Y. Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *J. Econom.* **1992**, *54*, 159–178. [CrossRef]
46. Ogundipe, A.A.; Adu, O.; Ogundipe, O.M.; Asaleye, A.J. Macroeconomic Impact of Agricultural Commodity Price Volatility in Nigeria. *Open Agric. J.* **2019**, *13*, 162–174. [CrossRef]
47. Granger, C.W.J. *Cointegrated Variables and Error Correction Models*; Discussion Paper; University of California: San Diego, CA, USA, 1983.
48. Samuelson, P.A. Spatial Price Equilibrium and Linear Programming. *Am. Econ. Rev.* **1952**, *42*, 560–580.
49. Takayama, T.; Judge, G.G. *Spatial and Temporal Price Allocation Models*; North Holland: Amsterdam, The Netherlands, 1971.
50. Taslim, M.A.; Hossain, M.A. Asymmetric Transmission of International Price of Edible Oil in Bangladesh. *Bangladesh Dev. Stud.* **2015**, *38*, 33–54.
51. Canola Council. *Growing Canola*. 2021. Available online: https://www.canolacouncil.org/growing-canola/ (accessed on 10 December 2021).
52. Sarker, R. Trade Expansion, International Competitiveness and the Pursuit of Export Diversification in Bangladesh. *Bangladesh Dev. Stud.* **2018**, *41*, 1–25. Available online: https://www.jstor.org/stable/10.2307/27031073 (accessed on 10 January 2022).
53. Shahbaz, M. Does trade openness affect long run growth? Cointegration, causality and forecast error variance decomposition tests for Pakistan. *Econ. Model.* **2012**, *29*, 2325–2339. [CrossRef]
54. Latruffe, L. *Competitiveness, Productivity and Efficiency in the Agricultural and Agri-Food Sectors*; OECD Food, Agriculture and Fisheries Working Papers No. 30; OECD Publishing: Paris, France, 2010.
55. Raihan, S.; Khondker, B.H.; Uddin, H. *Price Monitoring of Selected Commodities in Dhaka City*; A Report Prepared for the Ministry of Commerce, Government of Bangladesh; Government of Bangladesh: Dhaka, Bangladesh, 2010.
56. Tadesse, G.; Algieri, B.; Kalkuhl, M.; von-Braun, J. Drivers and triggers of international food price spikes and volatility. *Food Policy* **2014**, *47*, 117–128. [CrossRef]

57. Roy, T.S.; Chakraborty, R.; Parvez, M.N.; Biswas, S.; Chakraborty, S. Development of sustainable gross national income from potato export in Bangladesh- a perspective review. *Univ. J. Agril. Res.* **2017**, *5*, 46–51. [CrossRef]
58. Bangladesh Export Promotion Bureau, BEPB (2016) Statistical Data for 2015–2016, Ministry of Industry, Government of People's Republic of Bangladesh. Available online: www.epb.gov.bd (accessed on 10 April 2022).
59. Saghaian, S.; Nemati, M.; Walters, C.; Chen, B. Asymmetric Price Volatility Transmission between U.S. Biofuel, Corn, and Oil Markets. *J. Agric. Resour. Econ.* **2018**, *43*, 46–60. Available online: http://www.jstor.org/stable/44840974 (accessed on 6 May 2022).