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ASYMMETRIC SHORT-RUN AND LONG-RUN IMPACT OF ECONOMIC GLOBALIZATION ON CROP PRODUCTION IN TURKIYE

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ABSTRACT

This study explores short-run and long-run relationship between economic globalization and crop production in Turkiye by utilizing linear and nonlinear ARDL models for two distinct indicators of crop production. Based on linear and nonlinear ARDL bound tests, the relevant variables are co-integrated and hence they move together in the long run. Economic globalization and crop production possess statistically significant positive association in the long run in linear ARDL models. On the other hand, short-run and long-run symmetry test results disclose that the relationship of economic globalization and crop production in the short-run and long-run is asymmetric. According to the estimation findings, positive and negative changes in economic globalization augment crop production. Meanwhile several tests were conducted to check the statistical validity and robustness of our findings. The results of those diagnostic tests show that neither linear ARDL models nor nonlinear ARDL models incorporate problems in the sense of non-normality, autocorrelation, heteroskedasticity, model misspecification, and parameter instability.

Keywords: economic globalization, crop production, ARDL, NARDL, asymmetric co-integration.

INTRODUCTION

According to the Food and Agriculture Organization (FAO, 2022), the value of agricultural production in Turkiye increased from 12.6 billion USD in 1961 to 51.2 USD in 2020. More specifically, rice production in Turkiye increased from 233,300 tons in 1961 to 980,000 tons in 2020. Although developmentalist policies were used in Turkiye from 1950-1980, unplanned agricultural policies were implemented in the 1980s in order to integrate the country into the global economy (Aydın, 2010). In addition, the government began to support a process of a structural transformation of the economy. Although the Turkish economy has experienced a constitutional transformation of the economy from the agriculture sector to industry through various reform programs, the high population density in the agricultural sector is still a primary difficulty for the transformation of the economy (Günçavdi et al., 2013).

Agriculture may be an important strategic sector to solve problems in the economy in terms of economic slowdown, inflation, and unemployment, because it may cause an increasing in the agricultural machine and rural worker demand through food production, economic growth, employment, and export to developing countries. Therefore, activities in the agriculture sector have an essential role in increasing economic activities and providing economic stability. In this sense, larger economic growth levels may be observed when agricultural activities increase and markets in the agriculture sector are great. The empirical literature usually investigates whether economic growth is affected by the agricultural sector. Thus, previous papers have found a positive relationship between the agriculture sector and economic growth (Yao, 2000; Chebbi,

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2010; Islam et al., 2020), while the statistical results of several papers have indicated that economic growth does not benefit from agricultural output (Gylfason, 1999). In addition to evidence for the direct effect of agriculture on economic growth, Kaya et al. (2012) examined the associations between foreign aid indicators, such as agricultural aid, social infrastructural aid, investment aid, and non-investment aid and economic growth. The findings of this paper concluded that an increase in foreign aid to the agricultural sector of the developing countries create a positive and significant impact on economic growth in the short run. Within this framework, earlier papers also examined possible causal linkages between agriculture and economic growth (Katircioglu, 2006; Jatuporn et al., 2011; Awokuse and Xie, 2015). In the literature, there are also some papers that have explored the inflationary role of agriculture (Aisen and Veiga, 2006; Narayan et al., 2011; Bhattacharya and Sen Gupta, 2018; Ismaya and Anugrah, 2018; De Camargo Barros et al., 2022). Another way of expressing the contribution of agriculture is to assess its effects on the employment level. A large body of empirical literature has presented that agriculture has a positive contribution in decreasing unemployment (Chaudhuri and Banerjee, 2010; Baah-Boateng, 2013; Bein and Çiftçioğlu, 2017; Enilolobo et al., 2019; Fawole and Ozkan, 2019; Olowu et al., 2019). With respect to the impact of advances in the agriculture sector on employment, there are also many papers in the literature (Bayramoğlu, 2014; Oloni et al., 2017; Wang et al., 2017; Garrone et al., 2019; Edeme et al., 2020; Gyapong, 2020). As a result, economic performance may tend to rise with increasing developments in the agricultural sector in developing countries. Thus, these results indicate the importance for analyses of the determinants of agriculture.

In the literature on the determinants of agriculture, numerous factors have been highlighted (Kostov and Lingard, 2004; Adekunle et al., 2016; Looga et al., 2018; Sun and Xian-de, 2018; Diaz et al., 2021; Ma et al., 2021; Chi, 2022). It is believed that globalization is one of the determinants of agriculture. It can be seen that globalization as a reality in today's world also contributes many economic factors in the empirical literature, despite debates over who will control the globalization process now and in the future. For example, a number of empirical papers have examined the effects of globalization on female labor participation (Meyer, 2003; Rees and Riezman, 2012; Okşak and Koyuncu, 2017; Sangha and Riegler, 2020), interest rates (Argy and Hodjera, 1973; Yilmaz and Koyuncu, 2019), banking crises (Joyce, 2011; Ghosh, 2016; Koyuncu and Varsak, 2019), poverty (Bergh and Nilsson, 2014; Özen and Koyuncu, 2020), and taxes (Dreher, 2006a; Neumann et al., 2009; Unver and Koyuncu, 2021).

Furthermore, it is probable that globalization process may be a substantial determinant of the agriculture sector. In this regard, the increased globalization process seems to have been accompanied by significant transformations in the world food system since the 1980s. The basic transformations in the agricultural system are identified by four channels. First, innovation, together with the private sector and civil society, has shown advances in agricultural research and development through globalization. Second, small farmers have increasingly become more integrated at the domestic and global level in commercialized agri-food industries. Third, markets and retail industries associated with the globalization process are actively dominant in the formation and distribution of a global agri-food chain. Four, consumers in both developed and developing economies have a powerful impact on global food systems, much more than on their domestic markets (Von Braun and Diaz-Bonilla, 2008).

According to Dreher (2006b), economic globalization implies dimensions characterized by goods, capital, and service flows, including trade, foreign direct investment, and portfolio investment between countries. In the literature, empirical papers offer various explanations as to why trade liberalization might serve the agriculture sectors of economies. Hong et al. (2010) assessed the impact of trade openness on agriculture total factor productivity. The study used a two-stage estimation procedure model and time series data for 1978-2008. They concluded that trade liberalization resulted in an increase in the growth of China's agriculture. On the other hand, Erokhin et al. (2014) investigated the impact of trade liberalization on agricultural trade policies in developing countries in 2000-2010. They concluded that, if low import tariffs, which mean the involvement into the international trade integration, hamper the effective protection of domestic farmers, this leads to an easier entry into host markets for foreign agricultural producers, and thus indicates that trade liberalization can impede agricultural domestic production. In addition, many papers that examined the impact of foreign direct investment on agriculture found evidence of a link between globalization and agriculture. Edeh et al. (2020) reported a positive and significant relationship between foreign direct investment and agricultural sector output for Nigeria from 1981 to 2017. Slimane et al. (2016), in a study of 55 developing countries from 1995 to 2009, concluded that foreign direct investment in the agriculture sector had a statistically significant and positive influence on agriculture production and food security. Santangelo (2018) examined the impact of foreign direct investment in land in agriculture on food security from 2000 to 2011. They distinguished foreign direct investments between developed and developing country investors who entered 65 host developing countries. According to their results, the interaction between the variables yielded the opposite impact. Namely, FDI in land by developed country investors increased food security by expanding cropland, while FDI in land by developing country investors decreased food security by reducing land used for crop production.

The body of literature on the direct effect of economic globalization on agriculture is scarce. For example, Nugroho and Lakner (2022) reported a descriptive paper in which an increase in economic globalization provided both beneficial and harmful effects on the agriculture sector. They suggested that its positive impacts are an increase in agriculture production, supply chain, and food security, while the negative impact may be a decrease in food quality. Brunelle et al. (2014), studying the role of the diet convergence on the impacts of globalization on food and agriculture, found that globalization has an uncertainty associated with food and agriculture. Moreover, Nugroho et al. (2021) found that foreign direct investment inflows and agriculture export values, as the indicators of economic globalization, enhanced the agricultural value-added in 17 developing countries during 2006-2018.

This study contributes to this empirical literature with some different perspectives. The impact of economic globalization on the crop production in Turkiye was investigated. Also concentrated on was the short-run and long-run relationship between the variables by employing linear and nonlinear autoregressive distributed lag models. This paper examined the long-run linkage between the variables with data spanning from 1970 to 2008. It was argued that economic globalization may be linked to crop production in different ways. For example, economic globalization may be expected to increase crop production through the use of new technologies by attracting FDI from abroad, whereas an increase in economic globalization could lead to a reduction in crop production by substituting domestic crops with imported ones. Agricultural machinery, which reflects the technology and investment level in the agricultural sector, is expected to have a positive effect on the crop production. Also included herein was arable land, which is one of the main production factors in the agriculture sector and could increase the probability of crop production. Thus, it is to be expected that arable land and crop production are positively associated. Finally, inflation was used in the analyses herein to reflect economic uncertainty and instability due to economics, because uncertainty and instability become worse during periods of high inflation. Thus, a negative effect on the coefficient of inflation rate is assumed. The analysis results in this study confirmed these theorical expectations.

This paper is expected to make a contribution to the recent literature in three ways. First, to the best of our knowledge, there are no papers examining the association between economic globalization and crop production, while there are many papers showing that economic globalization affects the agriculture sector. Thus, the originality of this paper is the consideration of the impact of economic globalization on the crop production. Second, this paper used two distinct indicators of crop production, including the crop gross production value and crop gross production index, to test the robustness of the results. Three, there has been no research conducted in Turkiye on the interaction of economic globalization and crop production, even though this has become a trending topic among contemporary researchers worldwide. Thus, this paper's empirical results could provide important policy suggestions for other developing economies.

In this projection, the paper is organized as follows: Section 2 describes the data and the methods that were employed. The results and related discussions are reported in Section 3, and Section 4 presents the conclusion.

MATERIAL AND METHODS

In this study we employed annual data of Turkiye spanning the years of 1970-2008 in order to examine the long-run association between economic globalization and crop production by employing linear and nonlinear autoregressive distributed lag models (i.e., ARDL and NARDL models) and by using two distinct indicators of crop production. The data set contains observations on economic globalization, crop gross production value (constant 2014-2016, thousand US$), crop gross production index (2014-2016 = 100), agricultural machinery (tractors per 100 sq. km of arable land), arable land (% of land area), and Inflation (GDP deflator, annual %). The data on economic globalization (ECGLOB) were gathered from Gygli et al. (2019). Series of crop gross production value (CROPVAL) and crop gross production index (CROPINDX) were extracted from the FAO while series of agricultural machinery (AGRMACH), arable land (ARABLELND), and Inflation (INF) were collected from World Development Indicators of the World Bank. The sample period cannot go beyond the year of 2008 owing to the fact that data on agricultural machinery are unavailable for the years beyond 2008.

Economic globalization may increase domestic crop production via the use of new technologies brought by incoming FDI whereas it may decrease domestic crop production as a result of substituting domestic crops with imported ones. Therefore, the impact of economic globalization on crop production is ambiguous. Agricultural machinery by representing technology and investment level in the agricultural sector may promote crop production and hence a positive relationship between agricultural machinery and crop production is anticipated. Since one of the main production factors in the agricultural sector is land, we expect to have a positive coefficient for ARABLELND variable. We use inflation in our analyses to reflect economic uncertainty and instability by reason of economic uncertainty and instability get worse in the periods of high inflation. Thus, a negative sign for the coefficient of INF variable is presumed.

Table 1 below provides brief descriptive statistics for ARABLELND, AGRMACH, ECGLOB, INF, CROPINDX, and CROPVAL variables.

Table 1. Descriptive statistics

Summary Statistics Measures	ARABLELND	AGRMACH	ECGLOB	INF	CROPINDX	CROPVAL
Mean	31.75698	263.4163	41.82705	45.85329	64.91000	29236060
Maximum	33.49402	488.5061	56.48025	143.6397	89.75000	39801785
Minimum	28.00696	42.20546	28.01392	6.199758	37.36000	16700982
Std. Dev.	1.139740	128.9977	9.985692	31.35633	15.54823	6850720.
Skewness	-1.423471	-0.131587	-0.132582	0.877224	-0.138783	-0.255175
Kurtosis	5.566722	1.966683	1.466695	3.674769	1.876702	1.909296
Jarque-Bera	23.87635	1.847633	3.934673	5.741772	2.175616	2.356403
Probability	0.000007	0.397001	0.139829	0.056649	0.336954	0.307832
Observations	39	39	39	39	39	39

The starting point in a time-series analysis is to ascertain the integration order of each series utilized in the analysis. Thence we firstly employed Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test to find out the stationarity level of each series. Secondly co-integration analyses were conducted via the ARDL bound test approach. Lastly we constructed and estimated ARDL and NARDL models to perform long-run and short-run analyses.

ARDL bound test introduced by Pesaran et al. (2001) is one of the most favored co-integration tests in the literature as it lets series to be integrated order zero, integrated order one or mixed, dissimilar to the conventional co-integration tests requiring series with integrated order one. ARDL models adapted to our study are given below:

$$\Delta \text{CROPVAL}_t = \mu + \delta_1 \text{CROPVAL}_{t-1} + \delta_2 \text{ECGLOB}_{t-1} + \delta_3 \text{AGRMACH}_{t-1} + \delta_4 \text{ARABLELND}_{t-1} + \delta_5 \text{INF}_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta \text{CROPVAL}_{t-i} + \sum_{i=0}^{q-1} \alpha_i \Delta \text{ECGLOB}_{t-i} + \sum_{i=0}^{s-1} \phi_i \Delta \text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1} \theta_i \Delta \text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1} \gamma_i \Delta \text{INF}_{t-i} + \varepsilon_t \quad (1)$$

$$\Delta \text{CROPINDX}_t = \mu + \delta_1 \text{CROPINDX}_{t-1} + \delta_2 \text{ECGLOB}_{t-1} + \delta_3 \text{AGRMACH}_{t-1} + \delta_4 \text{ARABLELND}_{t-1} + \delta_5 \text{INF}_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta \text{CROPINDX}_{t-i} + \sum_{i=0}^{q-1} \alpha_i \Delta \text{ECGLOB}_{t-i} + \sum_{i=0}^{s-1} \phi_i \Delta \text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1} \theta_i \Delta \text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1} \gamma_i \Delta \text{INF}_{t-i} + \varepsilon_t \quad (2).$$

The symbols of $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5$ in Equation 1 and 2 above stand for long-run coefficients; β_i, α_i, ϕ_i, θ_i, γ_i notations depict short-run coefficients; Δ notation is first difference operator; μ is intercept term, and ε_t is white noise error term of the regression models.

The null hypothesis of ARDL bound co-integration test for the models given in Equation 1 and 2 is given by H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$. F-statistic value exceeding the upper bound critical value (i.e., I_{upper}) is evidence for the co-integrating association among the variables.

The ARDL models given in Equation 1 and 2 reflect the symmetric short-run and long-run interaction between economic globalization and crop production. On the other hand, if the relationship between economic globalization and crop production is asymmetric then we will be committing a model misspecification error. In this regard, we need a model considering asymmetric association between economic globalization and crop production and thus eliminating the potential model misspecification error aforementioned.

Non-linear autoregressive distributed lag (NARDL) model introduced by Shin et al. (2014) accounts for asymmetric nexus between economic globalization and crop production. NARDL method employs the decomposition of ECGLOB variable into its positive and negative partial sums of increases and decreases as follows:

$$\text{ECGLOB}_t^+ = \sum_{j=1}^{t} \Delta\text{ECGLOB}_j^+ = \sum_{j=1}^{t} \max(\Delta\text{ECGLOB}_j, 0) \quad and \quad \text{ECGLOB}_t^- = \sum_{j=1}^{t} \Delta\text{ECGLOB}_j^- = \sum_{j=1}^{t} \min(\Delta\text{ECGLOB}_j, 0) \qquad (3).$$

The NARDL model can be constructed by adding short-run and long-run asymmetries into the linear ARDL models given in Equation 1 and 2 as below:

$$\Delta\text{CROPVAL}_t = \mu + \delta_1\text{CROPVAL}_{t-1} + \delta_2^+\text{ECGLOB}_{t-1}^+ + \delta_2^-\text{ECGLOB}_{t-1}^- + \delta_3\text{AGRMACH}_{t-1} + \delta_4\text{ARABLELND}_{t-1} + \delta_5\text{INF}_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\text{CROPVAL}_{t-i} + \sum_{i=0}^{q-1}(\alpha_i^+\Delta\text{ECGLOB}_{t-i}^+ + \alpha_i^-\Delta\text{ECGLOB}_{t-i}^-) + \sum_{i=0}^{s-1}\phi_i\Delta\text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1}\theta_i\Delta\text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1}\gamma_i\Delta\text{INF}_{t-i} + \varepsilon_t \qquad (4)$$

$$\Delta\text{CROPINDX}_t = \mu + \delta_1\text{CROPINDX}_{t-1} + \delta_2^+\text{ECGLOB}_{t-1}^+ + \delta_2^-\text{ECGLOB}_{t-1}^- + \delta_3\text{AGRMACH}_{t-1} + \delta_4\text{ARABLELND}_{t-1} + \delta_5\text{INF}_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\text{CROPINDX}_{t-i} + \sum_{i=0}^{q-1}(\alpha_i^+\Delta\text{ECGLOB}_{t-i}^+ + \alpha_i^-\Delta\text{ECGLOB}_{t-i}^-) + \sum_{i=0}^{s-1}\phi_i\Delta\text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1}\theta_i\Delta\text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1}\gamma_i\Delta\text{INF}_{t-i} + \varepsilon_t \qquad (5).$$

The superscripts (+) and (–) in Equation 4 and 5 show the positive and negative partial sums decomposition of ECGLOB variable as explained before.

In the context of ARDL bound test of Pesaran et al. (2001), the null hypothesis for co-integration test of the models given in Equation 4 and 5 is depicted by H_0: $\delta_1 = \delta_2^+ = \delta_2^- = \delta_3 = \delta_4 = \delta_5 = 0$. If F-statistic value higher than the upper bound critical value (i.e., I_{upper}) then it is concluded that the variables are co-integrated and hence they move together in the long-run. F-statistic value smaller than the lower bound critical value (i.e., I_{lower}) implies that the variables are not co-integrated while we are indecisive for F-statistic value falling in two bounds' critical values.

Long-run symmetry between economic globalization and crop production can be tested by using Wald test for the null hypothesis of H_0: $\delta_2^+ = \delta_2^-$. Failing to reject null hypothesis points out a symmetric long-run association between economic globalization and crop production whereas rejecting the null hypothesis indicates an asymmetric long-run relationship between economic globalization and crop production. Similarly we can test the short-run symmetry by utilizing Wald test of the null hypothesis that $\alpha_i^+ = \alpha_i^-$ for all *i = 0,...,q-1* and rejection of the null hypothesis means the existence of the short-run asymmetry.

Equation 4 and 5 are reduced to Equation 1 and 2 respectively when the both null hypotheses of short-run and long-run symmetry are accepted. Accepting the null hypothesis of either the long-run symmetry test or the short-run symmetry test will lead to the NARDL models with just short-run asymmetries as in Equation 6 and 7 and to the NARDL models with just long-run asymmetry as in Equation 8 and 9, respectively:

$$\Delta\text{CROPVAL}_t = \mu + \delta_1\text{CROPVAL}_{t-1} + \delta_2\text{ECGLOB}_{t-1} + \delta_3\text{AGRMACH}_{t-1} + \delta_4\text{ARABLELND}_{t-1} + \delta_5\text{INF}_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\text{CROPVAL}_{t-i} + \sum_{i=0}^{q-1}(\alpha_i^+\Delta\text{ECGLOB}_{t-i}^+ + \alpha_i^-\Delta\text{ECGLOB}_{t-i}^-) + \sum_{i=0}^{s-1}\phi_i\Delta\text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1}\theta_i\Delta\text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1}\gamma_i\Delta\text{INF}_{t-i} + \varepsilon_t \qquad (6)$$

$$\Delta\text{CROPINDX}_t = \mu + \delta_1\text{CROPINDX}_{t-1} + \delta_2\text{ECGLOB}_{t-1} + \delta_3\text{AGRMACH}_{t-1} + \delta_4\text{ARABLELND}_{t-1} + \delta_5\text{INF}_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\text{CROPINDX}_{t-i} + \sum_{i=0}^{q-1}(\alpha_i^+\Delta\text{ECGLOB}_{t-i}^+ + \alpha_i^-\Delta\text{ECGLOB}_{t-i}^-) + \sum_{i=0}^{s-1}\phi_i\Delta\text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1}\theta_i\Delta\text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1}\gamma_i\Delta\text{INF}_{t-i} + \varepsilon_t \qquad (7)$$

$$\Delta\text{CROPVAL}_t = \mu + \delta_1\text{CROPVAL}_{t-1} + \delta_2^+\text{ECGLOB}_{t-1}^+ + \delta_2^-\text{ECGLOB}_{t-1}^- + \delta_3\text{AGRMACH}_{t-1} + \delta_4\text{ARABLELND}_{t-1} + \delta_5\text{INF}_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\text{CROPVAL}_{t-i} + \sum_{i=0}^{q-1}\alpha\,\Delta\text{ECGLOB}_{t-i} + \sum_{i=0}^{s-1}\phi_i\Delta\text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1}\theta_i\Delta\text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1}\gamma_i\Delta\text{INF}_{t-i} + \varepsilon_t \qquad (8)$$

$$\Delta\text{CROPINDX}_t = \mu + \delta_1\text{CROPINDX}_{t-1} + \delta_2^+\text{ECGLOB}_{t-1}^+ + \delta_2^-\text{ECGLOB}_{t-1}^- + \delta_3\text{AGRMACH}_{t-1} + \delta_4\text{ARABLELND}_{t-1} + \delta_5\text{INF}_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\text{CROPINDX}_{t-i} + \sum_{i=0}^{q-1}\alpha_i\,\Delta\text{ECGLOB}_{t-i} + \sum_{i=0}^{s-1}\phi_i\Delta\text{AGRMACH}_{t-i} + \sum_{i=0}^{r-1}\theta_i\Delta\text{ARABLELND}_{t-i} + \sum_{i=0}^{w-1}\gamma_i\Delta\text{INF}_{t-i} + \varepsilon_t \qquad (9)$$

Meantime Akaike information criterion was used to identify the optimal lag lengths of linear ARDL models in Equation 1 and 2 and nonlinear ARDL models in Equation 4 and 5. All analyses were implemented by using logarithmic values of ARABLELND, AGRMACH, ECGLOB, INF, CROPINDX, and CROPVAL variables, therefore the results provided in the next section were gathered by employing logarithmic values of the variables.

RESULTS AND DISCUSSION

As both ARDL and NARDL models are not suitable for the variables integrated order two or more, we firstly implemented ADF and PP unit root tests to disclose integration level of each variable. As revealed by ADF and PP unit test results in (Table 2), ARABLELND, AGRMACH, ECGLOB, INF, and CROPVAL variables are integrated order one and CROPINDX variable is integrated order zero in PP test but integrated order one in ADF test. The findings satisfy the integration order requirement of ARDL and NARDL methods and hence we are able to implement short-run and long-run analyses for both linear ARDL and nonlinear ARDL models.

Table 2. ADF and PP unit root test results

Variables	ADF Test		PP Test	
	Level	1. Difference	Level	1. Difference
ECGLOB	-1.5542	-6.500358 ***	-1.546858	-6.501294 ***
CROPVAL	-1.109612	-6.788739 ***	-3.170903	-28.96926 ***
AGRMACH	-2.746136	-3.519568 *	-2.712439	-3.474276 *
CROPINDX	-1.916798	-6.513400 ***	-3.385568 *	-
ARABLELND	-1.079148	-6.687291 ***	-1.086546	-7.297953 ***
INF	-1.821038	-5.978302 ***	-1.704336	-11.08133 ***

*** and * represent significance level at 1% and 10%, respectively. The constant & trend terms were included.

After meeting the integration order requirement of ARDL and NARDL approaches, we can conduct co-integration tests by utilizing ARDL bound test of Pesaran et al. (2001). ARDL bounds test procedure provides upper and lower critical values to decide on if there is a co-integrated relationship between variables of both linear ARDL and nonlinear ARDL models. The results of co-integration tests are displayed in (Table 3). As can inferred from (Table 3), F-statistic values of 22.04461 and 33.87142 exceed the upper bound critical value of 5.06 at 1% significance level for linear ARDL models and F-statistic values of 12.90790 and 9.552787 surpass the upper bound critical value of 4.68 at 1% significance level for nonlinear ARDL models. These findings imply that ARABLELND, AGRMACH, ECGLOB, INF, CROPINDX, and CROPVAL variables are co-integrated and thus there is a co-movement among them in the long run.

Table 3. Co-integration Test Results for Linear ARDL and Non-linear ARDL Models

Methods	Dependent Variable: CROPVAL			Dependent Variable: CROPINDX		
	F-stat.	I_{lower} (at 1%)	I_{upper} (at 1%)	F-stat.	I_{lower} (at 1%)	I_{upper} (at 1%)
Linear ARDL	22.04461	3.74	5.06	33.87142	3.74	5.06
Selected Model	ARDL (3, 3, 3, 2, 3)			ARDL (3, 3, 3, 2, 3)		
Num. of models evaluated	768			768		
Model selection method	AIC			AIC		
Non-linear ARDL	12.90790	3.41	4.68	9.552787	3.41	4.68
Selected Model	ARDL (1, 3, 2, 3, 3, 3)			ARDL (3, 3, 2, 3, 2, 3)		
Num. of models evaluated	3072			3072		
Model selection method	AIC			AIC		

Short-run and long-run coefficient estimations of linear ARDL models are denoted in (Table 4). We have highly statistically significant long-run coefficient estimations, meeting our prior expectations, for all independent variables (i.e., ARABLELND, AGRMACH, ECGLOB, and INF) in both linear ARDL models. Long-run coefficients of ECGLOB variable indicate that economic globalization possesses a positive effect on crop production. In other words, a jump in economic globalization by 1% induces to an increase by 0.39% and by 0.41% in crop production for CROPVAL and CROPINDX models in Turkiye for the period of 1970-2008. Moreover, positive long-run coefficient estimations are obtained for ARABLELND and AGRMACH variables while we get negative long-run coefficient estimation for INF variable. (Table 4) also contains diagnostic test results for Jarque-Bera normality test, Breusch-Godfrey serial correlation LM test, heteroskedasticity test of Breusch-Pagan-Godfrey, and Ramsey RESET test. Since none of the test statistics of the diagnostic tests is statistically significant at conventional significance level, our two linear ARDL models are free of problems of non-normality, autocorrelation, heteroskedasticity, and model misspecification.

Table 4. Estimation results for linear ARDL models

Variables and Tests	Dependent Variable: CROPVAL	Dependent Variable: CROPINDX
	ARDL (3, 3, 3, 2, 3) Model	ARDL (3, 3, 3, 2, 3) Model
	Short-run Coefficients	**Short-run Coefficients**
D [CROPVAL (-1)]	-0.129914	-0.303558 **
D [CROPVAL (-2)]	-0.197972	-0.376231 ***
D [ECGLOB)	-0.281178 **	-0.29179 ***
D [ECGLOB (-1)]	-0.77824 ***	-0.709823 ***
D [ECGLOB (-2)]	-0.481429 **	-0.540005 ***
D (AGRMACH)	-0.538218	-0.423324
D [AGRMACH (-1)]	-0.217797	-0.266364
D [AGRMACH (-2)]	0.979027 ***	1.007548 ***
D (ARABLELND)	-0.348011	-0.455688
D [ARABLELND (-1)]	-2.390129 **	-2.246701 ***
D (INF)	0.016265	0.00702
D [INF (-1)]	0.047671 **	0.046795 ***
D [INF (-2)]	0.044963 ***	0.049269 ***
	Long-run Coefficients	**Long-run Coefficients**
ECGLOB	0.397664 ***	0.411707 ***
AGRMACH	0.379552 ***	0.391905 ***
ARABLELND	3.066487 ***	3.129731 ***
INF	-0.080349 ***	-0.090164 ***
	Diagnostic Tests	**Diagnostic Tests**
R-squared	0.935822	0.956841
Adj. R-squared	0.867869	0.911143
Jarque-Bera	0.93573	0.353873
BG LM Test	0.479237	0.564151
BGP Heteroske. Test	0.51795	0.98116
Ramsey RESET Test	0.745505	0.310335

*** and ** depict significance level at 1% and 5%, respectively.

In (Table 5), we report the short-run and long-run estimation findings for nonlinear ARDL (1, 3, 2, 3, 3, 3) and ARDL (3, 3, 2, 3, 2, 3) models. Wald test statistics of long-run symmetry tests (i.e., $Wald_{LR}$) are statistically significant at 10% for ARDL (1, 3, 2, 3, 3, 3) model and at 5% for ARDL (3, 3, 2, 3, 2, 3) model. Meantime Wald test statistics of short-run symmetry tests (i.e., $Wald_{SR}$) are statistically significant at 1% for ARDL (1, 3, 2, 3, 3, 3) and ARDL (3, 3, 2, 3, 2, 3) models. These results disclose that there is both short-run and long-run asymmetric relationship between economic globalization and crop production, and therefore the models given in Equation 4 and 5 are valid in this study. Put it differently, there is asymmetric response of crop production to negative and positive changes in economic globalization in both short-run and long-run. The long-run coefficient estimations of ARABLELND, AGRMACH, ECGLOB_POS, ECGLOB_NEG, and INF variables are statistically significant at least at 5% significance level and take the anticipated signs in both nonlinear models. Long-run coefficients of ECGLOB_POS and ECGLOB_NEG variables are positive and these finding hints that economic globalization and crop production move in the same direction in the cases of positive and negative changes in economic globalization. This means that positive changes (i.e., positive shocks) and negative changes (i.e., negative shocks) in economic globalization enlarge crop production, but at different magnitude rather than at same amount owing to the existing asymmetric relationship. According to the estimated parameters, both a 1% positive and a 1% negative shock of economic globalization cause to a jump in crop production by 0.46% and by 0.32%, respectively in ARDL (1, 3, 2, 3, 3, 3) model. Also, both a 1% positive and a 1% negative shock of economic globalization cause to a rise in crop production by 0.43% and by 0.22%, respectively in ARDL (3, 3, 2, 3, 2, 3) model. Having positive coefficient for positive changes in economic globalization may be explained by dominating effect of the usage of new technologies brought by incoming FDI as a result of economic globalization. Conversely, having positive coefficient for negative changes in economic globalization may be clarified by substituting crop imports with increased domestic crop production. In regard to other independent variables of the models, highly statistically significant positive long-run coefficient estimations are obtained for ARABLELND and AGRMACH variables whereas we have negative long-run coefficient estimation for INF variable in both nonlinear ARDL models.

According to the diagnostic test results shown in (Table 5), nonlinear ARDL (1, 3, 2, 3, 3, 3) and ARDL (3, 3, 2, 3, 2, 3) models do not contain problems in terms of non-normality, autocorrelation, heteroskedasticity, and model misspecification.

Table 5. Estimation results for nonlinear ARDL models

Variables and Tests	Dep. Variable: CROPVAL		Dep. Variable: CROPINDX
	ARDL (1, 3, 2, 3, 3, 3)		ARDL (3, 3, 2, 3, 2, 3)
	Short-run Coefficients		**Short-run Coefficients**
D (ECGLOB_POS)	-0.630242***	D [LOGX6(-1)]	-0.154241
D [ECGLOB_POS (-1)]	-1.151736***	D [LOGX6(-2)]	-0.182504
D [ECGLOB_POS (-2)]	-0.810107***	D (ECGLOB_POS)	-0.509558***
D (ECGLOB_NEG)	-0.027612	D [ECGLOB_POS (-1)]	-0.980678***
D [ECGLOB_NEG (-1)]	-0.72209**	D [ECGLOB_POS (-2)]	-0.679693***
D (AGRMACH)	-1.205421**	D (ECGLOB_NEG)	-0.064244
D [AGRMACH (-1)]	-0.310225	D [ECGLOB_NEG (-1)]	-0.465642*
D [AGRMACH (-2)]	0.743289***	D (AGRMACH)	-0.840707**
D (ARABLELND)	-0.972592*	D [AGRMACH (-1)]	-0.271874
D [ARABLELND (-1)]	-2.820858***	D [AGRMACH (-2)]	0.869271***
D [ARABLELND (-2)]	-0.539674	D (ARABLELND)	-0.813854*
D (INF)	0.031542**	D [ARABLELND (-1)]	-2.362964***
D [INF (-1)]	0.04824**	D (INF)	0.028143*
D [INF (-2)]	0.058937***	D [INF (-1)]	0.039549**
		D [INF (-2)]	0.052195***
	Long-run Coefficients		**Long-run Coefficients**
ECGLOB_POS	0.46243***	ECGLOB_POS	0.437781***
ECGLOB_NEG	0.324838***	ECGLOB_NEG	0.22043**
AGRMACH	0.271858***	AGRMACH	0.295663***
ARABLELND	2.91109***	ARABLELND	2.622221***
INF	-0.063213***	INF	-0.058171***
$Wald_{LR}$	3.706013*	$Wald_{LR}$	4.345841**
$Wald_{SR}$	10.28534***	$Wald_{SR}$	11.27409***
	Diagnostic Tests		**Diagnostic Tests**
R-squared	0.950291	R-squared	0.967092
Adj. R-squared	0.879278	Adj. R-squared	0.913934
Jarque-Bera	1.885404	Jarque-Bera	0.176667
BG LM Test	0.346451	BG LM Test	1.281725
BGP Heteroske. Test	1.371678	BGP Heteroske. Test	0.704414
Ramsey RESET Test	0.847727	Ramsey RESET Test	1.233082

***, **, and * depict significance level at 1%, 5%, and 10%, respectively.

Lastly, the log-run coefficient estimation of ARABLELND variable is the largest one among all independent variables; therefore, arable land has the highest explanatory power on crop production in both linear ARDL and nonlinear ARDL models.

On the other hand, the log-run coefficient estimation of INF variable is the smallest one and hence inflation has the lowest explanatory power on crop production in both linear ARDL and nonlinear ARDL models.

CONCLUSIONS

Agricultural sector is very important area in this century as it plays a main role in economic issues. Nowadays, concerned with economic issues originating from agriculture, governments have focused on the realization of key topics of Sustainable Development Goals (SDGs) from United Nations, such as poverty reduction, zero hunger, healthy eating and food safety. Thus, it can be stated that policies improving efficiency in agriculture sector will directly or indirectly contribute to economic development of the relevant country. More specifically, higher domestic crop production and thus higher agricultural production can be associated with; sustainable food supply, a drop in hunger and poverty, a jump in agricultural employment and as a result of those achieving higher social and economic development.

Meantime the dynamic process of the increasing attention to agricultural issues may be associated with an increased globalization process, especially with economic globalization. This study mainly aims to scrutinize short-run and long-run association between economic globalization and crop production in Turkiye by utilizing linear and nonlinear autoregressive distributed lag models. We employed two different indicators of crop production in order to be sure that the finding remains the same no matter which indicators of crop production are used. Significant long-run positive relation between economic globalization and crop production was identified.

It can be argued that the direction of interaction between economic globalization and domestic crop production is vague; and thus, there are two different standpoints on this issue. In this regard, the first viewpoint puts forward a simple process of why we should expect a positive impact of economic globalization on crop production. In the light of this first stance, if economic globalization is higher, one may expect increases in crop production because it provides the higher levels of new technology usage and FDI inflows from abroad for agriculture sector in a country, especially towards to developing ones. Conversely, the second perspective debates that the effect of economic globalization on crop production is negative. From this point of view, it is believed that higher economic globalization would lead to more crop import through trade openness and thus lower domestic crop production. Our findings confirm the validity of the first perspective between economic globalization and crop production in Turkiye. Thus, we disclosed the long-term mechanism through which economic globalization enhances crop production in Turkiye. Given the fact of positive significant long-term impact of economic globalization on crop production, our finding may indirectly contribute to the realization of SDG's goals of poverty reduction, zero hunger, healthy eating, and food safety not only in Turkiye but also in other developing countries with same implications.

The findings of this study also provide some evidences about the effect of usage of technology and investment in agriculture sector on the crop production. In this sense, we included agricultural machinery variable represented by number tractors as a proxy of technology and investment level in our analysis. According to the results, the increase in agricultural machinery usage will contribute to the increase in crop production by increasing efficiency in agriculture sector in Turkiye.

As a representative of factors of production, we also employed arable land variable. The results indicate that there is a positive relationship between arable land and crop production in Turkiye. This finding proposes that higher level of arable land induces to higher crop production. Finally, our paper seeks to examine the impact of inflation rate on crop production. Here inflation was taken as the indicator of economic uncertainty and instability. The results imply that inflation (i.e., economic uncertainty and instability) worsens crop production because, under uncertain and instable environment of Turkish economy, investors and producers are unable to see the future and hence they will hesitate to produce or invest more.

In overall, our findings imply that economic globalization may be one of the policy tools for policy maker to increase crop production in developing countries like Turkiye.

In addition to our analyses, it can be stated that there are more spaces and opportunities to be investigated on the same issue but from the different aspects. For example, it will be interesting to examine the role of globalization and its sub-components on other agricultural items (e.g., corn production, wheat production, grain production, livestock production, poultry products, fishery products etc.), especially for developing countries.

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