Heliyon 10 (2024) e33522

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Moving towards food security in South Asian region: Assessing the role of agricultural trade openness, production and employment

Lihong Fan [a], Nazhat Nury Aspy [b], Dilruba Yesmin Smrity [b], Md. Farid Dewan [b,c], Md. Golam Kibria [b,*], Mohammad Haseeb [d], Mustafa Kamal [e,**], Md. Saidur Rahman [c]

[a] School of Finance and Economics, Hainan Vocational University of Science and Technology, Haikou, China
[b] Department of Economics, Noakhali Science and Technology University, Noakhali, 3814, Bangladesh
[c] Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, 2202, Bangladesh
[d] Department of Management Studies, Graphic Era Deemed to be University, Dehradun, Uttarakhand, 248002, India
[e] Department of Basic Sciences, College of Science and Theoretical Studies, Saudi Electronic University, Dammam, 32256, Saudi Arabia

ARTICLE INFO

Keywords:
Agricultural trade openness
Production
Employment
Food security
South Asia

ABSTRACT

Despite several accomplishments in addressing malnutrition, the issue of food scarcity remains a persistent concern all over the globe, particularly in the South Asian region. One recommended solution to address this situation involves advocating for further liberalization of global food trading and opening employment opportunities. In this context, using panel data spanning 2000–2019, this study makes a novel attempt to quantify the impact of agricultural trade openness and agricultural employment on food security in countries belonging to the South Asian region while controlling the tariff and agricultural production. Using "Fully Modified Ordinary Least Square (FMOLS)" and "Dynamic Ordinary Least Square (DOLS)" modeling, this article concludes that increased agricultural trade openness hinders food security in this region. Because, the member countries of South Asia are heavily reliant on food imports to meet their domestic needs, implying that the expenses of food imports exceed the potential benefits of increasing exports. Moreover, tariffs have a detrimental impact on food security in this region. However, production and employment in the agricultural industry augment earnings, strengthen the capacity to buy food, and ensure adequate nutrition intake over the long term. The study's findings suggest that these nations should prioritize food self-sufficiency to expand agricultural exports and lessen their reliance on imported food. More than that, economies should provide rewards to broaden their agricultural production locally, which aids in reducing hunger and uplifting food security.

1. Introduction

Despite the significant progress in technology witnessed in the 21st century, the persistence and exacerbation of food insecurity in emerging nations remains a confounding phenomenon [1]. Despite enormous gains in agricultural efficiency and financial success over

* Corresponding author.
** Corresponding author.
E-mail addresses: kibria.econ@nstu.edu.bd (Md.G. Kibria), kamal19252003@gmail.com (M. Kamal).

https://doi.org/10.1016/j.heliyon.2024.e33522
Received 31 May 2023; Received in revised form 24 May 2024; Accepted 23 June 2024
Available online 24 June 2024

the recent decades, food insecurity exists in South Asian nations as developing countries owing to factors such as climatic changes, rising food prices, and the ongoing conflict between Russia and Ukraine. Even though South Asian regions are home to only about 21 % of the worldwide population, they are also home to an estimated 20 % of the entire world's seriously starving folks [2]. However, closer interdependence, such as that facilitated by the South Asian economies, which leads to comprehensive trading among member nations, may ease the food insecurity dilemma [3].

The World Bank claims that South Asian economies' food vulnerability rose from 13.3 % to 18.7 % approximately within the 2016 to 2019 period. Furthermore, the COVID-19 pandemic increased this number by 2 % and hit 21 % in 2021 [2]. The COVID-19 outbreak, and inflation entirely caused by the Russia-Ukraine conflict are also major factors behind it, directly or indirectly affecting household purchasing power [4]. However, one of the critical factors of food consumption levels is availability [5], which is less satisfactory in South Asian nations than in other parts of the world due to inadequate production to meet the fundamental regional needs.

As outlined by the Food and Agricultural Organization [6], food security arises when everyone can access nutritious meals, they need to attain an acceptable quality of life. The FAO cites four aspects, availability, accessibility, stability, and nutritional status, jointly comprising the standard definition of food security [7]. Hence, a set of metrics pertaining to each aspect should be highlighted to get a better knowledge of food security [8]. At the World Food Summit in 1996, global heads of state committed to halving the prevalence of undernourishment by 2015 as a part of the eight Millennium Development Goals (MDGs) [9]. Furthermore, in 2015, seventeen Sustainable Development Goals (SDGs) were formed to develop a more novel global method for creating a practical dietary and nutritional framework by 2030, particularly, SDGs-2 emphasized ending hunger and protecting food security [10].

In the last few decades, local food poverty has been lowered due to trade liberalization actions of the world's socially and economically interdependent regions [11,12]. As a result, many countries today realize the benefits of trade openness in guaranteeing their citizens enjoy sufficient food access [13]. However, potential net gains are often used to identify the strengths of agricultural trade openness. Increasing agricultural trade opens markets and cuts food prices, helping people receive sufficient nutrition [14]. An empirical study suggested that food security status tends to improve after a certain level of trade openness [8]. Likely, Kang [15] assessed the intensity of global trading on food security that falls in the first phases of trade liberalization but increases once that barrier is crossed. However, Bezuneh and Yeheyis [16] asserted that trade openness's impact on achieving food availability needs to be clarified because it may reduce food shortages through increased imports while also turning developing countries more reliant on imports. Addressing this point, Chikhuri [17] analyzed several food security indicators and claimed that the consequences of various trade liberalizing initiatives on significant food security indices in the Sub-Saharan region are uncertain. Besides, tariffs, a specialized levy on imported and exported things, are vital to such trade reformation schemes. If regional or bilateral dialogues lead to lower tariffs on agricultural commodities, there could be an opportunity to boost food imports and cut food prices, thus bolstering food security [17].

A key indicator of overall food production is agricultural labor or the volume of the workforce who are engaged in agriculture [8]. In general, men in developing countries are more interested in industrial jobs or migrating, putting agriculture on women [18]. By providing their labor entirely, women may not be able to ensure that food production volumes remain sufficient to assure the nation's safety from hunger. Food insecurity is caused by many other factors, including lower agricultural production, and distribution issues accompanied by both available and constrained access to food [19]. Improvements in dietary consumption and increased or decreased food prices are also associated with food security [20,21]. On the supply side, more outstanding agricultural production frequently leads to higher food production and thus supply efficiency, which increases the income of poor agrarian labor in developing countries [22]; as well as food security condition is boosted by improving availability, accessibility, and stability [23].

However, the South Asian region is an agriculture-oriented nation, and its growing population has made significant success in raising domestic food production. Still, food security is threatened by several geopolitical, environmental, and socioeconomic issues besides food inflation, such as a lack of institutional support for progressive farming, inadequate infrastructure, and the availability of modern technology used in agricultural production [24]. Moreover, improper management, ineffective transportation systems, inadequate financial support, unfair prices, and insufficient research are also responsible for food insecurity [25,26]. Such factors are mainly behind limited agricultural productivity that cannot fully meet domestic demand as land, production, and employment in agriculture are decreasing.

Most of the prior research used development or poverty indicators such as social welfare [27,28], poverty and inequality [14], economic growth [29], and trade-related consequences [30,31] rather than food security indicators [1,8,13]. To be more explicit, the existing literature discloses that most attempts target general trade openness instead of agricultural trade openness for its link to food security. To bridge this knowledge gap, this study is the first to look at tariffs, agricultural employment, and agricultural production alongside trade policies to assess their impact on food security in the South Asian region. This paper adopts the methods of Zhao and Liu [32], who figured out agricultural trade openness by aggregating agricultural export and import trade openness. As a contribution, this article endeavors to answer the following questions and make proposals for policy for tackling food insecurity in South Asian economies.

(a) Does agriculture trade openness assist in lessening food insecurity challenges or not?
(b) How significant is agricultural employment in enhancing food security?
(c) Is there any connection between tariffs and food security status in South Asian nations?
(d) Does agriculture production affect food security or not?

To figure out the answers, this article conducts the FMOLS and DOLS procedures for the availability indicator of food security, employing panel data from 2000 to 2019 in the context of South Asian countries. The models are used because they strengthen ordinary least squares (OLS) by fixing their shortcomings regarding endogeneity bias and serial correlation [33,34]. To further elucidate the link between food security, agricultural trade openness, production, employment, and tariff [35], this study additionally incorporates Dumitrescu Hurlin's causality tests.

2. Past literature and hypothesis development

2.1. Trade openness, tariffs, and food security

It has always been a persistent problem for the global community to ensure food security. In case to eliminate this problem, recent developments in global food trading have emerged as a vital cog in the wheel of global food provisioning [36]. In many cases, experts discovered that trade openness led to more excellent food security. Still, some literature asserted the opposite scenario; agricultural trade openness or trade openness negatively affects food security by increasing food price inflation. However, the costs to farm households in poor countries are often disproportionate to the advantages, as was discovered by Wise [37]. Moreover, the phenomenon of international trade leads to an increased reliance on food imports in China, negatively impacting food security. In their study, Yu Zhu [38] demonstrated the negative interaction by employing an "autoregressive distributed lag (ARDL)" model. Nevertheless, it is important to note that many developing nations have challenges in terms of their ability to effectively engage in free trade and reap the benefits of liberalized agricultural commerce [39,40]. Fellmann [41] showed that temporary export controls can significantly exacerbate the detrimental impacts on food security. Furthermore, Mary [42] elaborated that if the food trade opened up by 10 %, malnourishment may spread by 6 % more widely. More precisely, emerging nations restrict food trade openness in reaction to rising famine and support protectionist policies. The openness of the food trade would be reduced by 0.9 % for every percentage increase in the frequency of undernourishment.

Pyakuryal [43] investigated that, with the lowest tariff rate within South Asian countries and other substantial policies, Nepal's aggregate food security indicator shows improvement. Additionally, Khalid [12] found that a higher exchange rate due to tariffs reduces the trade volume and claims the non-existence of a long-term correlation between regional trading and the level of food security.

2.2. Agriculture employment and food security

Employment in agriculture is one of the critical indicators of food production. With the flow of time, industrialization is grabbing the agricultural labor force. Migration of the labor force to the off-farm sector reduces agricultural employment. An attempt by Sunam and Adhikari [44] presented a complex and contradictory result from the perspective of temporary labor migration and food security in Nepal. It exhibited that labor migration from the agricultural sector, which is the reduction in agricultural employment, improves the food security condition in the short run by remittance. Still, at the same time, such erosion of agricultural jobs adversely influences food production. Low food production elevates food import dependency and impends the access of low-income groups to food. On the other hand, Gartaula [45] explored a positive nexus between off-farm labor migration and food security. This attempt found that increased male labor migration to off-farm jobs enhance food purchasing power and raises food security. Such a positive correlation of food security demonstrates an improved sufficiency and absorption of food for non-farm households. Mkwambisi [46] postulated a fact about urban agriculture, where a large portion of urban residents have access to rural agriculture through remittance or land ownership. Their investigation confirmed that such linkage between rural and urban agriculture and the participation of urban individuals in rural agriculture has a direct or indirect positive influence on food security by reducing poverty.

2.3. Agricultural production and food security

In developing nations, agricultural production can be crucial in alleviating poverty and food insecurity [47]. Higher agricultural production indicates higher food availability, making the food supply sustainable. According to the findings of Mozumdar [22], developing countries practice a positive correlation between agricultural production, poverty reduction, and food security. Identically, Darfour and Rosentrater [48] estimated that agricultural production is the principal element of reducing poverty as the earnings of individuals play a vital contribution in eliminating food insecurity. Mughal and Sers [49] detected a positive connection between cereal production and food security. Higher agricultural output as cereal production increases availability and ensures easy excess of poor individuals by reducing cereal prices. Similarly, Abdelhedi and Zouari [50] also depicted a favorable effect of agricultural production on food security. This paper outlines the following hypothesis based on prior research findings:

H1. A higher level of agriculture trade openness reduces the food security status.

H2. A higher tariff rate reduces the intensity of food security.

H3. Employment in agriculture positively affects food security.

H4. An increase in agricultural production increases the level of food security.

3. Conceptual framework of this study

Previous literature does not contain any formal theory that shows the linkage among agricultural trade openness, tariff, employment, and production in agriculture, all along with food security. This paper led to examining past thought as we wonder how other experts had addressed related issues of conceptual variety and attempted to establish a theoretical framework on this basis, as shown in Fig. 1.

Theoretically, agricultural trade openness is embodied in agricultural exports and agricultural imports. These two components illustrate two types of effects on food security. Basically, small-scale farmers in developing nations primarily account for a large portion of the world's hungry and malnourished people. Under this scenario, according to previous literature [51,52], importing agricultural products results in an excessive supply of food products in the domestic market, lowering the food price. Such a reduction in price causes a fall in the profit margin of domestic food producers or farmers who rely mainly on revenue from market surplus for nutrition intake. That is, agricultural import harms food security and is also supported by Mary [42]. On the other hand, agricultural exports show the opposite outcome because exporters enjoy their comparative advantage. Increased export of food products increases income and enhances the ability to buy food [42,53]. Correspondently, tariff raises imported food product prices and yields food price inflation that impedes the lower income group's nutrition attainment, and this negative hypothesis is supported by several authors [12,13,43,54].

However, a lower employment rate in the agricultural sector yields lower production and reduces the income level of mostly poor food producers. Such a relationship is shown by Suman and Adhikari [44] via agricultural labor migration toward off-farm jobs. Even if it increases the income level to have adequate dietary intake, in the long run, it hurts food security. Some other studies also support this complex conjecture of employment in agriculture and food security [55,56]. Several research pointed out that higher agricultural production increases the compatibility of food products and marks up the earning level of food producers to attain the required nutrition intake [22,48,49].

These conjectures from previous literature manifest the wholesome effect on food security that agricultural export and import show positive and negative impacts, respectively; tariff implies an adverse influence on food security, and agricultural employment and production exhibit a positive connection with food security.

4. Data

This study uses a panel data set of South Asian countries over the 2000–2019 period to prove the linkage between food security and agricultural trade openness, tariff, employment, and production in agriculture. Since there is a paucity of information on Maldives and Bhutan, this study focuses solely on six of the eight individual nations that make up South Asia. The six countries whose economies have been highlighted are Bangladesh, Afghanistan, India, Nepal, Pakistan, and Sri Lanka. Considering the four indicators of food security, including availability, access, stability, and utilization, this study employs dietary energy supply as the indicator of food security. Dietary energy supply is computed by comparing the minimum dietary energy intake with the probability of daily habitual dietary energy consumption, and data on this variable comes from FAOSTAT. However, the measurement of agricultural trade openness is built by following Zhao and Liu [32] by adding the agricultural export and import trade openness. The calculation procedure is as follows:

$$AGEX\ openness_t = \frac{nEX_{it}^2}{AGGDP_{it}\sum_{j=1}^{n} EX_{jt}}$$

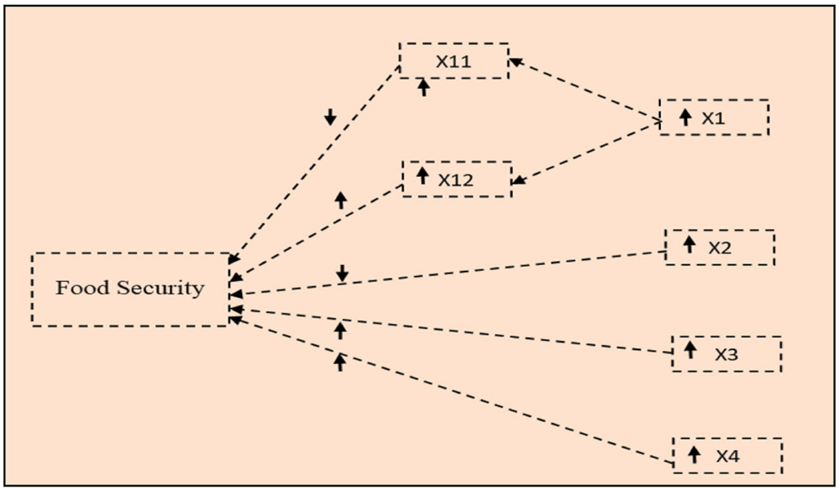

Fig. 1. Theoretical framework (Source: Genuine configuration of the author.). Note: X1 = agricultural trade openness; X11 = agricultural import; X12 = agricultural export; X2 = tariff; X3 = employment in agriculture; X4 = agricultural production.

$$AGIM\ openness_t = \frac{nIM_{it}^2}{AGGDP_{it}\sum_{j=1}^{n} IM_{jt}}$$

$$AG\ openness_t = \frac{EX_{it}}{EX_{it} + IM_{it}} AGEX\ openness_t + \frac{IM_{it}}{EX_{it} + IM_{it}} AGIM\ openness_t$$

Here, *AGEX openness*: agricultural export trade openness; *AGIM openness*: agricultural import trade openness; and *AG openness*: agricultural trade openness. *AGGDP*: agricultural value added (constant 2015 US$). The agricultural export and import data of all sorts of crops, along with livestock products and the agricultural value added (constant 2015 US$), are collected from FAOSTAT. The data of tariff is the import duty. The author used the ad-valorem tariff rate, and this data set has been collected from World Development Indicators (WDI). Table 1 presents the variables, unit, sources, and their effects.

Following Fig. 2, all the countries under investigation continue increasing trends for food security, where the food security level is relatively flatter for Bangladesh, India, and Pakistan. Nepal and Sri Lanka clearly show rapid improvement in attaining dietary energy. Among all of these, the food security status of Afghanistan is significantly lower, though it is improving rapidly. The panel of observing countries has positive trends for food security. Moreover, Tables 2 and 3 report the model's descriptive statistics and correlation matrix.

5. Methodology

To identify and answer the questions of this paper, firstly, cross-sectional dependency has been employed to decide whether first or second-generation panel unit root tests would be considered. The study performed a unit root test to verify the stationary in the second step. In the third step, a co-integration test is employed to check whether there is a correlation between the series. In the following phase, we used fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) to examine the effects of several factors on food security. The final step included the Causality test to investigate the causal connections among the variables.

5.1. Cross-sectional dependency test

Panel data sets tend to show significant cross-sectional reliance, which may develop when nations in the same region share similar shocks and unobserved components. So, controlling potential cross-sectional dependency across panel members is crucial. Pesaran [57] accentuated the significance of checking for cross-sectional reliance in a panel study. In addition, Pesaran [57] revealed that ignorance of cross-sectional dependency in estimations may result in significant bias and size distortions. Therefore, this study investigates the issue of cross-sectional dependency by utilizing frequently used tests of Breusch–Pagan [58] LM, Pesaran [57] scaled LM, bias-correlated scaled LM and Pesaran [59] CD tests. The null hypothesis CD test is that there is no cross-sectional dependency.

5.2. Panel unit root test

According to Kilic [60], the unit root test can be implemented after addressing the issue of cross-sectional dependency to identify the presence of unbiased estimations. Whether there exists a potential correlation between panel unit residuals or not, there are two generations of unit root tests [61]. The first-generation one does not take into account the issue of cross-sectional dependency, but the second-generation analyzes it. Among several unit root tests based on cross-sectional dependency assumption, this study considers second-generational panel unit root tests as the Cross-Sectional Augmented Dickey-Fuller (CADF) test.

5.3. Panel cointegration test

After performing the panel unit root test, the next stage is determining whether a long-term relationship exists between the variables. The Pedroni [64] cointegration method, a residual-based test that allows for significant heterogeneity, is used in this study to investigate the existence of a long-run link rather than several other likelihood-based and residual-based tests. The stationarity of residuals refers to the fact that there exists a long-term relationship between the variables. The null hypothesis served by Pedroni is the

Table 1
Descriptions of the variables.

Variables	Signifier	Unit	Sources
Dietary energy supply	LnFS	kcal/cap/day	FAOSTAT
Agricultural trade openness	AgTO	%	FAOSTAT
Tariff	TA	%	WDI
Employment in agriculture	EAg	%	WB
Agriculture production	AgP	Kg per hectare	WDI

"Note: FAOSTAT: Food and Agriculture Organization Corporate Statistical Database; WB: World Bank; WDI: World Development Indicators."

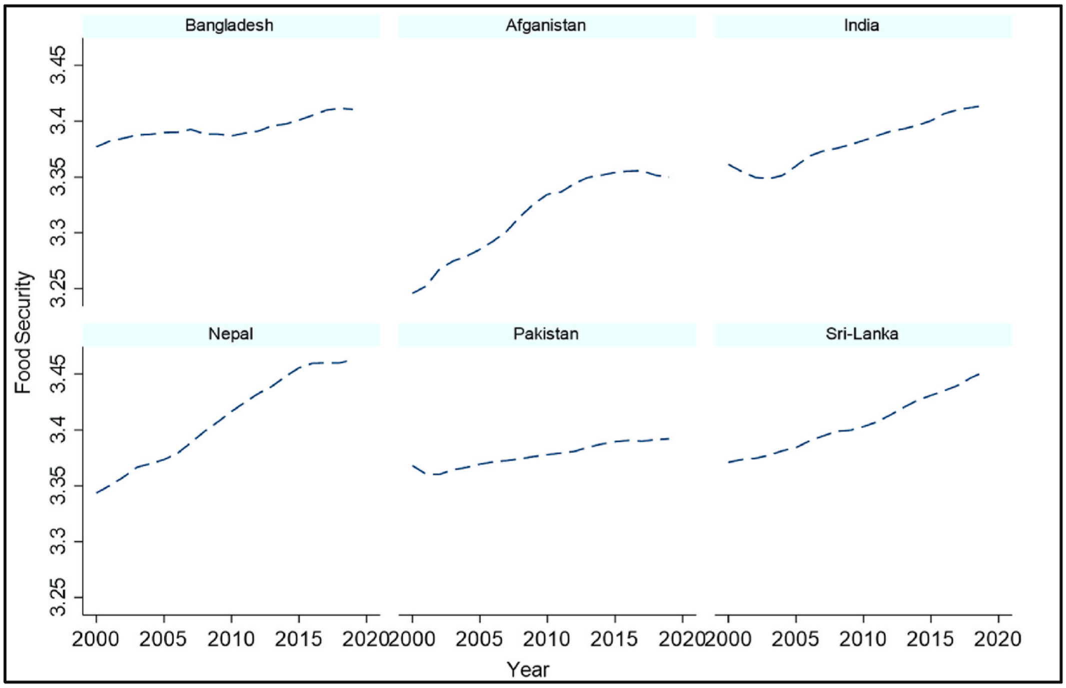

Fig. 2. Food security trends in the selected countries.

Table 2
Descriptive statistics.

Variables	Mean	Std. Dev.	Min	Max
LnFS	3.3805	0.0412	3.2457	3.4631
AgTO	0.0000108	0.0000103	2.20	0.0000506
TA	12.6385	5.4724	−0.74	33.4
EAg	49.4150	12.6084	25.3	73.2
AgP	2907.8630	857.0005	806.3	4810.8

Table 3
Correlation matrix.

Variables	LnFS	AgTO	TA	EAg	AgP
LnFS	1.0000				
AgTO	0.2006	1.0000			
TA	0.1567	−0.2209	1.0000		
EAg	−0.2572	−0.4394	0.2056	1.0000	
AgP	0.6050	0.4813	0.0909	−0.5592	1.0000

absence of cointegration. The variables are considered to be cointegrated if the panel rejects the null hypothesis. Pedroni uses the following regression equation (1):

$$y_{it} = \alpha_i + \delta_i + \beta_{1i}x_{1it} + \beta_{2i}x_{2it} + \ldots + \beta_{Mi}x_{Mit} + e_i \tag{1}$$

The residual cointegration test of Pedroni suggested seven distinct statistics with differing degrees of properties, which are split into two different groups: between-dimension and within-dimension. The first consists of panel v-statistic, panel ρ-statistic, panel PP-statistic, and panel ADF statistics named four tests and three tests from the second category group statistic, group PP, and group ADF. The cointegration test developed by Kao [62] is also used in this work to assess robustness. Ordinary Least Square (OLS) can be employed if the chosen variables are not cointegrated; however, when there is a cointegration relationship, OLS yields contradictory findings. Hence, DOLS and FMOLS are used in the analysis to get long-run estimations [63].

5.4. FMOLS and DOLS test

The affirmed cointegration evidence allows estimating the long-run coefficient of variables by utilizing fully modified OLS (FMOLS) and dynamic OLS (DOLS), as the long-run estimation of OLS in a cointegrated panel may yield inefficient and inconsistent parameters. The first approach used in this work is FMOLS, which was initially employed by Phillips and Hansen in 1990 to find the unbiased estimators of cointegrating regressions. Then, Pedroni designed an FMOLS regression model for long-run estimation [64]. FMOLS is a residual-based non-parametric test that produces efficient outcomes for cointegrated variables. This approach aims to upgrade ordinary least squares (OLS) by removing the endogeneity bias and serial correlation issues that the original OLS cannot solve [65,66]. The FMOLS estimation procedure is as follows in equation (2):

$$\widehat{\beta}^{*}_{NT} - \beta = \left(\sum_{i=1}^{N}\widehat{L}_{22i}^{-2}\sum_{t=1}^{T}(X_{it}-\overline{X}_i)^2\right)^{-1}\sum_{i=1}^{N}\widehat{L}_{11i}^{-1}\widehat{L}_{22i}^{-1}\left(\sum_{t=1}^{T}(X_{it}-\overline{X}_i)\mu^{*}_{it} - T_{\widehat{\gamma}i}\right) \tag{2}$$

Here, $\widehat{L}i$ is the lower triangular decomposition of a consistent estimator of the idiosyncratic asymptotic covariance matrix; $\widehat{\gamma}_i$ indicates the serial correlation adjustment parameter; the estimator $\widehat{\beta}^{*}_{NT}$ converges to the true value at a rate $\sqrt{\frac{T}{N}}$ and is distributed as $\sqrt{\frac{T}{N}}(\widehat{\beta}^{*}_{NT} - \beta)\rightarrow N(0,v)$, where v = 2 and 6 else if $\overline{x}_i = \overline{y}_i = 0$ under the null as T, N →∞.

Next, Dynamic OLS (DOLS), an alternative estimation approach, is used as the second analysis of this paper. A panel counterpart of single time series is called DOLS, a parametric method introduced by Saikkonen and later Stock and Watson [67,68]. The vital merit of the DOLS technique is that it additionally clarifies the existence of a combination that permits the integration of the relevant variables in the cointegrated structure [65]. The differentiable regressor leads and lags are used in DOLS to get rid of endogeneity and serial correlation issues. In addition, minor sample errors are also addressed by it [63]. Compared to FMOLS, DOLS yields superior results besides eliminating the potential consequence of endogeneity and the problem of serial correlation [69]. The DOLS estimation procedure is as follows in equation (3):

$$Y_t = \beta_0 + \overrightarrow{\beta}X + \sum_{j=-q}^{p}\overrightarrow{d}j\Delta X_{t-j} + \mu_t \tag{3}$$

Where X is the explanatory variable matrix; Y_t indicates dependent variable; $\overrightarrow{\beta}$ refers to the cointegrating vector, p is the length of lag; q refers to lead length.

5.5. Dumitrescu and Hurlin test

In the presence of cointegration among variables, the next step of this study is to detect the causality direction between the variables. The panel causality test was developed by Dumitrescu and Hurlin [35]. The two statistics used for this test are $\overline{Z}$-statistics and $\overline{W}$-statistics. While $\overline{W}$-statistics take into account the average statistic, the $\overline{Z}$-statistics show the normal distribution and the latter one is considered as the mean of test statistics. The bivariate application's two tests also show three potential outcomes such as unidirectional, bidirectional, or no causal relationship between the variables. The null hypothesis in this approach is that no cross-sectional evidence of causality exists between the variables.

6. Results and discussion

6.1. Cross-sectional dependence check

In the case of the exact regional panel estimation, one country's shock may have an impact on the other countries. Therefore, it is crucial to examine cross-sectional dependence (CSD) prior to the determination of whether the variables are stationary or not [70]. This study employs four different tests of Breusch–Pagan LM (BP-LM), Pesaran scaled LM (PS-LM), Bias-correlated scaled LM (BCS-LM), and Pesaran CD (P-CD) tests, and the outcomes are reported in Table 4. The findings confirm that the study's variables are cross-sectional dependent.

Table 4
Findings of CSD test.

CSD test	Variables				
	LnFS	AgTO	TA	EAg	AgP
BP-LM	2611.362***	113.191***	125.31***	229.023***	165.436***
PS-LM	44.979***	17.927***	20.141***	39.075***	27.466***
BCS-LM	44.821***	17.769***	19.983***	38.917***	27.308***
P-CD	16.138***	9.449***	0.847	15.005***	12.460***

Note: Null hypothesis of no cross-sectional dependency is rejected for all the variables at a 1 % (***) significance level.

6.2. Panel unit root test

However, it is required to operate a panel unit root test that considers CSD. On account of the existence of the CSD problem, the second generational panel unit root test has been applied in this study. This study applies the CADF test, and the findings are reported in Table 5. The findings suggest that all the variables reject the null hypothesis of no stationarity at the level and first difference.

6.3. Panel cointegration results

Now, long-run cointegration or cross-sectional dependencies among the variables have been tackled by means of the Pedroni residual-based cointegration test, and the outcomes are displayed in Table 6. First, concerning the within-dimension, we find that the four statistics falling under PP and ADF statistics refute the null hypothesis of no standard autoregressive coefficients at the 1 % significance level. To put it differently, four of the eight statistics highlight a cointegration link between the factors. In contrast, the group PP and ADF statistics in the between-dimension conclusions are statistically significant at the 1 % level and support the alternative hypothesis. In other words, 6 out of the 11 statistical assessments adopt the alternative hypothesis that long-run cointegration does exist among the variables and denies the null.

To cross-check the validity of the Pedroni residual cointegration test, this study employs the Kao residual cointegration test, shown in Table 7. It also accepts the alternative hypothesis and supports the existence of the long-run dependency of the variables. Thus, these tables clearly show that the Pedroni and Kao cointegration test results are consistent.

6.4. FMOLS and DOLS findings

As a result of the co-integration results, we can identify the long-run coefficients of the variables under investigation. After discovering the presence of a long-run correlation, the study applies the FMOLS and DOLS models to inquire into the connections between the explained and explanatory variables.

The results of FMOLS and DOLS are presented in Table 8. There is no inconsistency in the results, with the single exception of tariff. Table 8 points out that there is an opposite relationship between agricultural trade openness and food security. To be more specific, a rise in agricultural trade openness by 1 % may decrease food security by reducing the daily caloric intake of a person's diet by 7979 kcal. That is to say, the outbreak of undernourishment intensifies along with growing agricultural trade openness as all nations in the South Asian region are import-based, and as a result, imports weigh more than exports. This conclusion is in line with the results of other previous research findings [16,42,71,72] while contradicting previous studies [1,40,73,74]. The reverse relationship is noted in this study because people in investigated locations may not benefit significantly from the food trade, possibly due to a deficient communication network between cities and rural regions as well as other market weaknesses. Consequently, a considerable portion of the economic benefits derived from metropolitan trade become stagnant [42]. In addition, the growing reliance on traded goods to procure food would lead to a hike in the mean price of food and thereby make it harder for those with fewer options to safeguard their food security [51]. In a similar vein, it is plausible that the advantages of trade do not effectively trickle down to farmers and other producers in developing countries like South Asian nations, but instead, middlemen along the food supply chain disproportionately capture most of the margins [75].

In FMOLS estimation, the long-run effect of tariffs indicates a negative relationship with food security, and the coefficient is 0.253, which is also significant at 1 % and means that a 1 % rise in overall tariffs will reduce food security by 0.253 %, or that dietary energy intake may decrease by 0.253 kcal. Because of a connection between tariff protection and lower household consumption in developing nations due to higher food prices, tariffs threaten global food security. As most of these countries rely on importing food products, increasing tariff rates results in food price inflation. This negative impact of the tariff on food security is in track with the findings of Montolalu and Fusco [13,54]. However, the DOLS estimation of this study reveals a positive relation, which is significant at a 1 % level. It might be because South Asian nations are highly food import-reliant countries; they must import food products to maintain basic food needs even if the tariff rate is high. Moreover, the other consequence of higher tariffs is that it stimulates domestic food production and enriches the domestic food supply chain, improving food security.

Additionally, the long-run outcome of the FMOLS model exhibits that employment in agriculture and food security are positively correlated. A 1 % increase in agricultural employment can raise food security by providing 0.117 kcal daily. The DOLS estimation also shows a similar correlation. An increase in agricultural employment yields higher food production, which would be sufficient to attain

Table 5
Results of CADF unit root test.

Variable	Level	First difference	Stationary
LnFS	−1.244c*	−2.275 c***	I(0) & I(1)
AgTO	2.045c	1.749b***	I(1)
TA	1.737c	−1.432a**	I(1)
EAg	−1.268c*	−1.359b**	I(0) & I(1)
AgP	0.272c	−4.185b***	I(1)

Notes: 1 %, 5 % and 10 % levels of significance are alluded to ***, ** and * correspondingly. The chosen lag for a = 0, b = 1, and c = 2. I (0) and I (1) represent the level and first difference.

Table 6
Results of Pedroni residual cointegration test.

Null hypothesis: no common auto-regressive coefficients (within-dimension)				
	Statistics	Prob.	Weighted statistics	Prob.
Panel v-statistics	0.7521	0.2260	0.7585	0.2241
Panel rho-statistics	0.6463	0.7409	0.1906	0.5756
Panel PP-statistics	−1.9459***	0.0258	−2.3237***	0.0101
Panel ADF-statistics	−3.1124***	0.0009	−3.4173***	0.0003
Null hypothesis: no individual auto-regressive coefficients (between-dimension)				
	Statistics	P-value		
Group rho-statistics	1.1727	0.8795		
Group PP-statistics	0.646***	0.0075		
Group ADF-statistics	−1.946***	0.0003		

Notes: 1 %, 5 %, and 10 % levels of significance are displayed by ***, **, and *, correspondingly.

Table 7
Findings of the Kao residual cointegration test.

	t-statistic	P-value
ADF	−2.589***	0.0048
Residual variance	1.81E-05	
HAC variance	4.23E-05	

Notes: 1 %, 5 %, and 10 % levels of significance are displayed by ***, **, and *, correspondingly.

Table 8
Estimated results of FMOLS and DOLS testing.

Variable	FMOLS		DOLS	
	Coeff.	P-value	Coeff.	P-value
AgTO	−7978.97***	0.0128	−38734.15***	0.0000
TA	−0.253369***	0.0000	0.050272***	0.0000
EAg	0.116624***	0.0000	0.012747***	0.0000
AgP	0.000452***	0.0000	0.000726***	0.0000

Notes: 1 %, 5 %, and 10 % levels of significance are displayed by ***, **, and * respectively.

Table 9
Findings of Dumitrescu and Hurlin panel causality tests.

Null Hypothesis	Wbar-statistic	Zbar-statistic	P-value
AgTO → LnFS	3.535	3.215***	0.0013
LnFS → AgTO	4.029	3.881***	0.0001
EAg → LnFS	4.47633	4.519***	6.E−06
LnFS → EAg	7.325	8.381***	0.0000
EAg → AgTO	2.622	1.986***	0.0470
AgTO → EAg	3.174	2.728***	0.0064
AgP → LnFS	0.889	−0.343	0.731
LnFS → AgP	6.749	7.599***	3.E−14
TA → LnFS	11.202	13.636***	0.0000
LnFS → TA	2.049	1.228	0.2196
EAg → AgP	6.895	7.797***	6.E−15
AgP → EAg	0.804	−0.459	0.6464
TA → AgP	6.481	7.237***	5.E−13
AgP → TA	1.147	0.006	0.9951
TA → AgTO	1.607	0.619	0.5356
AgTO → TA	2.473	1.785**	0.0743
AgP → AgTO	2.279	1.523	0.1276
AgTO → AgP	2.009	1.161	0.2456
TA → EAg	1.972	1.123	0.2613
EAg → TA	2.026	1.197	0.2313

Notes: 1 %, 5 %, and 10 % levels of significance are displayed by ***, **, and *, respectively.

daily food requirements. Additionally, there is a robust connection between agricultural productivity and poverty reduction, which aids in regional food security [76]. As a result of greater economic security, better urban agriculture employment also ensures sufficient calorie intake [46].

The coefficient of the variable representing agricultural production shows a significant positive effect on food security; that is, it would eliminate the problem of food insecurity. This finding highlighted a 1 unit rise in agricultural production; per hectare, a 1 kg cereal yield increase may enhance food security by raising dietary energy consumption by 0.00045 kcal per day. It could happen as a result of the direct association between agricultural productivity and dietary consumption. More outstanding agricultural production frequently leads to higher food production and supply efficiency, which benefits household food supply by boosting availability, accessibility, and stability. In other words, higher agricultural production closes the yield gap and improves the level of food security. The DOLS estimation also supports such a positive correlation in this case. This positive interaction of agricultural production and food security in this study is supported by previous research [1,8,13,23].

6.5. Dumitrescu and Hurlin test

Additionally, for the identification of causal association among the investigating variables, the Dumitrescu and Hurlin panel causality test was applied, and it confirmed the presence of heterogeneity throughout all cross-sections. Results of the panel pairwise Dumitrescu Hurlin panel causality test using panel data are shown in Table 9. These results demonstrate that agricultural trade openness causes food security, and food security causes agricultural trade openness. This implies that a greater degree of agricultural trade openness would increase food security, which would increase the degree of agricultural trade openness. Thus, agricultural trade openness and food security exert bidirectional causality. Similarly, the causality between employment in agriculture and food security is bidirectional. Hence, both variables are caused by each other, as in the employment in agriculture and agricultural trade openness case.

Nevertheless, in the case of food security and agricultural production, the causality is unidirectional because agricultural production does not cause food security, but food security causes agricultural production. Furthermore, the causal association between tariffs and food security is unidirectional. Tariff causes food security but not the opposite way around, as the null hypothesis is accepted. Likewise, employment in agriculture and agricultural production and tariff, either with agricultural production or trade openness, implies unidirectional causality. On the contrary, there is no causal association between agricultural production and agricultural trade openness and tariff and employment in agriculture. In other words, agricultural production and trade openness do not share any impact on each other, and the tariff rate and employment in agriculture as well.

7. Conclusions and policy suggestions

In the developing world, especially in the South Asian states, food insecurity has become one of the major concerns in recent years. To abolish all types of malnutrition and starvation by 2030, the SDG goals have been adopted in 2015. International food trade openness has often been considered the pathway to end this issue. In this prospect, the present study examined the effect of agricultural trade openness on food security with a panel data set of 2000–2019 for South Asian countries, namely Bangladesh, Afghanistan, India, Nepal, Pakistan, and Sri Lanka. This study is the first quantitative study that estimates the impact of agricultural trade openness along with some other factors such as agricultural production and employment, and tariffs on the availability indicator of food security in the South Asian region via employing FMOLS and DOLS estimation to eliminate the potential endogeneity bias and serial correlation issues of explanatory variables.

To begin with, this statistical conclusion reveals a negative link between agricultural trade openness and food security. It implies that agricultural trade openness, on average, reduces the level of food security. As a result, this led to a decision that the negative effects of imports overshadow the beneficial outcomes of exports for the South Asian states owing to their heavy reliance on food imports. Second, food insecurity is exacerbated by tariff barriers due to domestic price inflation. After that, having a job in agriculture in South Asian countries boosts income and, consequently, the ability to afford food. Lastly, given that production is the single most crucial factor in determining a country's level of food security, an increase in agricultural production ensures adequate levels of nutrition intake by boosting the supply of food.

According to the empirical results of this estimation, the following policies can be developed to promote the food security status of investigated regions: South Asian countries might benefit by pursuing food self-subsistence policies and emphasizing the efficiency of local production even if such initiatives conflict with World Trade Organization (WTO) agenda. Taking comparative advantage into account, representative nations should enhance their agricultural exports more than they import. Furthermore, even though the tariff rate is much lower among South Asian countries after the establishment of SAFTA, they still cannot reach the zero-tariff policy implemented by SAFTA. Therefore, to smoothen agricultural trade, regional trade policies should be re-designed with a due focus on tariff rates. Besides, the free trade agreement should also be established with the other trading partner countries to uplift the free flow of goods between the South Asian countries and other global trading partners. Finally, each country's government should provide sufficient incentives to increase the employment rate in the agricultural sector to raise agricultural production. It should implement domestic agriculture-supportive policies, particularly when it comes to farm inputs, research, and development of new agricultural technologies.

Lastly, the article admits its limits and encourages more research using additional factors that may affect food security in South Asia. These additional elements include government proficiency, institutional effectiveness, regulatory quality, and natural disasters. Furthermore, the inclusion of all the South Asian nations in the analysis was constrained by the restricted availability of accessible data. In the near future, specialists may apply a variety of time series and dynamic panel statistical techniques, taking into account the most recent data, to evaluate the depth to which food security exists in South Asia.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Lihong Fan: Conceptualization. **Nazhat Nury Aspy:** Formal analysis. **Dilruba Yesmin Smrity:** Software. **Md. Farid Dewan:** Investigation. **Md. Golam Kibria:** Writing – original draft. **Mohammad Haseeb:** Writing – review & editing. **Mustafa Kamal:** Data curation, Visualization. **Md. Saidur Rahman:** Investigation, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] J. Dithmer, A. Abdulai, Does trade openness contribute to food security? A dynamic panel analysis, Food Pol. 69 (2017) 218–230.
[2] Statista, Prevalence of severe food insecurity in South Asia from 2014 to 2021, Heath, Pharma &Medtech (2023).
[3] P. Mkandawire, H. Nyantakyi-Frimpong, F. Armah, G. Arku, Regionalism, Food Security and Economic Development, 2014.
[4] World Food Programme. At a Glance: A Regular Lowdown on the Facts, Figures and Frontline Work of the World Food Programme.
[5] M.E.A. Begum, M.I. Hossain, L.D. Haese, Food security in Bangladesh: present status and trend, Progressive Agriculture 24 (1–2) (2013) 263–271.
[6] Food and Agriculture Organization of the United Nations, Declaration on World Food Security. World Food Summit, FAO, Rome, Italy, 1996.
[7] Food and Agriculture Organization of the United Nations, The State of Food Insecurity in the World 2001, Food and Agriculture Organization of the United Nations, Rome, Italy, 2001.
[8] Z. Sun, D. Zhang, Impact of trade openness on food security: evidence from panel data for central asian countries, Foods 10 (12) (2021) 3012.
[9] United Nations, United Nations Millennium Declaration, United Nations, New York, NY, USA, 2000.
[10] United Nations, Transforming Our World: the 2030 Agenda for Sustainable Development, United Nations, New York, NY, USA, 2015.
[11] S. McCorriston, D. Hemming, J.D. Lamontagne-Godwin, J. Osborn, M.J. Parr, P.D. Roberts, What Is the Evidence of the Impact of Agricultural Trade Liberalisation on Food Security in Developing Countries? EPPI-Centre, Social Service Research Unit, Institute of Education, University of London, 2013.
[12] M.W. Khalid, A.S. Kayani, J.M. Alotaibi, M. Muddassir, B.A. Alotaibi, H.S. Kassem, Regional trade and food security challenges: the case of South Asian countries, Agric. Econ. – Czech 66 (2020) 335–344.
[13] G. Fusco, B. Coluccia, F.D. Leo, Effect of trade openness on food security in the EU: a dynamic panel analysis, Int. J. Environ. Res. Publ. Health 17 (2020) 4311.
[14] C.N. Viet, The impact of trade facilitation on poverty and inequality: evidence from low- and middle-income countries, J. Int. Trade Econ. Dev.: An International and Comparative Review 24 (3) (2015) 315–340.
[15] H. Kang, A study on the relationship between international trade and food security: evidence from less developed countries (LDCs), Agric. Econ. 61 (2015) 475–483.
[16] M. Bezuneh, Z. Yeheyis, The effect of trade liberalization on food security: the experience of selected African countries, Journal of African Development 14 (2012) 13–26.
[17] K. Chikhuri, Impact of alternative agricultural trade liberalization strategies on food security in the Sub-Saharan Africa region, Int. J. Soc. Econ. 40 (2013) 188–206.
[18] M.N. Asadullah, U. Kambhampati, Feminization of farming, in: Food Security and Female Empowerment, 29, 2021 100532.
[19] M.P. Mosisi, Chiefdom Development Plan: Implications for Food Security in Swaziland (Doctoral Dissertation), 2015.
[20] C.P. Timmer, Agriculture and economic development, Handb. Agric. Econ. 2 (2002) 1487–1546.
[21] S. Self, R. Grabowski, Economic development and the role of agricultural technology, Agric. Econ. 36 (2007) 395–404.
[22] L. Mozumdar, Agricultural productivity and food security in the developing world. Bangladesh, J. Agric. Econ. 35 (454–2016-36350) (2012) 53–69.
[23] I. Bonuedi, K. Kamasa, E.E.O. Opoku, Enabling trade across borders and food security in Africa, Food Sec 12 (2020) 1121–1140.
[24] M.A. Karim, M.A. Qauyyum, S. Samsuzzaman, i H. Higuch, E. Nawata, Challenges and opportunities in crop production in different types of char lands of Bangladesh, Tropical Agriculture and Development 61 (2) (2017) 77–93.
[25] M.H. Mondal, Crop agriculture of Bangladesh: challenges and opportunities, Bangladesh J. Agric. Res. 35 (2) (2010) 235–245.
[26] B. Ghose, Fisheries and aquaculture in Bangladesh: challenges and opportunities, Annals of Aquaculture and Research 1 (1) (2014) 1–5.
[27] R.M. Desai, N. Rudra, Trade, poverty, and social protection in developing countries, Eur. J. Polit. Econ. xxx (2018) 1–11.
[28] M.A. Sheikh, M.A. Malik, R.Z. Masood, Assessing the effects of trade openness on sustainable development: evidence from India, Asian Journal of Sustainability and Social Responsibility 5 (1) (2020) 1–15.
[29] Y. Keho, The impact of trade openness on economic growth: the case of Cote d'Ivoire, Cogent Economics & Finance 5 (1) (2017) 1332820.
[30] B. Hoekman, B. Shepherd, Who profits from trade facilitation initiatives? Implications for African countries, Journal of African Trade 2 (1–2) (2015) 51–70.
[31] D. Sakyi, S.K. Afesorgbor, The effects of trade facilitation on trade performance in Africa, Journal of African Trade 6 (1/2) (2019) 1–15.
[32] D. Zhao, Z. Liu, Analysis of the agriculture trade openness impact on the rural household's food consumption in China, Agric. Econ. 61 (10) (2015) 461–474, https://doi.org/10.17221/188/2014-AGRICECON.
[33] P. Lustrilanang, Darusalam Suwarno, L.T. Rizki, N. Omar, J. Said, The role of control of corruption and quality of governance in ASEAN: evidence from DOLS and FMOLS test, Cogent Business & Management 10 (1) (2023) 2154060.
[34] M. Hamit-Haggar, Greenhouse gas emissions, energy consumption and economic growth: a panel cointegration analysis from Canadian industrial sector perspective, Energy Econ. 34 (1) (2012) 358–364.
[35] E.I. Dumitrescu, C. Hurlin, Testing for Granger non-causality in heterogeneous panels, Econ. Modell. 29 (4) (2012) 1450–1460.

[36] C. Zhang, Y. Yang, Z. Feng, C. Xiao, T. Lang, W. Du, Y. Liu, Risk of global external cereals supply under the background of the COVID-19 pandemic: based on the perspective of trade network, Foods 10 (6) (2021) 1168.
[37] T.A. Wise, The Limited Promise of Agricultural Trade Liberalization, Working Group on Development and Environment in the Americas, Disucssion Paper Number 19, 2008. July,.
[38] Yu Zhu, International trade and food security: conceptual discussion, WTO and the case of China, China Agric. Econ. Rev. 8 (3) (2016).
[39] J.-C. Bureau, R. Chakir, J. Gallezot, The utilisation of trade preferences for developing countriesin the agri-food sector, J. Agric. Econ. 58 (2) (2007) 175–198.
[40] S. Tokarick, Dispelling some misconceptions about agricultural trade liberalization, J. Econ. Perspect. 22 (1) (2008) 199–216.
[41] T. Fellmann, S. Hélaine, O. Nekhay, Harvest failures, temporary export restrictions, and global food security: the example of limited grain exports from Russia, Ukraine, and Kazakhstan, Food Secur. 6 (2014) 727–742.
[42] S. Mary, Hungry for free trade? Food trade and extreme hunger in developing countries, Food Sec 11 (2019) 461–477, https://doi.org/10.1007/s12571-019-00908-z.
[43] B. Pyakuryal, D. Roy, Y.B. Thapa, Trade liberalization and food security in Nepal, Food Pol. 35 (1) (2010) 20–31.
[44] R. Sunam, J. Adhikari, How does transnational labour migration shape food security and food sovereignty? Evidence from Nepal, in: Anthropological Forum, 26, Routledge, 2016, pp. 248–261, 3.
[45] H. Gartaula, K. Patel, D. Johnson, et al., From food security to food wellbeing: examining food security through the lens of food wellbeing in Nepal's rapidly changing agrarian landscape, Agric. Hum. Val. 34 (2017) 573–589, https://doi.org/10.1007/s10460-016-9740-1.
[46] D. D, D.G. Fraser, A.J. Dougill, Urban agriculture and poverty reduction: evaluating how food production in cities contributes to food security, employment and income in Malawi, Journal of International Development J. Int. Dev. 23 (2011) 181–203.
[47] J.J. Dethier, A. Effenberger, Agriculture and development: a brief review of the literature, World Bank policy research working paper (5553) (2011).
[48] B. Darfour, K.A. Rosentrater, Agriculture and Food Security in Ghana, American Society of Agricultural and Biological Engineers, 2016 162460507, https://doi.org/10.13031/aim.20162460507.
[49] M. Mughal, C. Sers, Cereal production and food security in South Asia, Working Papers hal-02089616, HAL archives (2019). Available at: https://hal.archivesouvertes.fr/hal02089616/document.
[50] I.T. Abdelhedi, S.Z. Zouari, Agriculture and food security in North Africa: a theoretical and empirical approach, J Knowl Econ 11 (2020) 193–210, https://doi.org/10.1007/s13132-018-0528-y.
[51] G. Otero, G. Pechlaner, E.C. Gürcan, The political economy of "food security" and trade: uneven and combined dependency, Rural Sociol. 78 (2013) 263–289.
[52] K.T. Sibhatu, M. Qaim, Rural food security, subsistence agriculture, and seasonality, PLoS One 12 (2017) e0186406.
[53] K.O. Adenegan, O.A. Adewusi, Determinants of food security status of rural households living with HIV/AIDS in Southwestern Nigeria, Afr. J. Biomed. Res. 10 (1) (2007).
[54] M.H. Montolalu, M. Ekananda, T. Dartanto, D. Widyawati, M. Panennungi, The analysis of trade liberalization and nutrition intake for improving food security across districts in Indonesia, Sustainability 14 (2022) 3291, https://doi.org/10.3390/su14063291.
[55] K. Patel, H. Gartaula, D. Johnson, M. Karthikeyan, The interplay between household food security and wellbeing among small-scale farmers in the context of rapid agrarian change in India, Agric. Food Secur. 4 (1) (2015) 1–16.
[56] E. Brown, Shifting Landscapes: the Effects of Male Out-Migration on Food Security and Food Sovereignty in Rural Nepal, 2020.
[57] M.H. Pesaran, Estimation and inference in large heterogeneous panels with multifactor error structure, Econometrica 74 (2006) 967–1012.
[58] T.S. Breusch, A.R. Pagan, The Lagrange multiplier test and its applications to model specification in econometrics, Rev. Econ. Stud. 47 (1) (1980) 239–253, https://doi.org/10.2307/2297111.
[59] M.H. Pesaran, General Diagnostic Test for Cross Section Dependence in Panels (Working Paper), University of Cambridge & USC, 2004.
[60] C. Kilic, Effects of globalization on economic growth, Panel Data Analysis for Developing Countries IV (LXVII) (2015), 1.
[61] C. Hurlin, V. Mignon, Second Generation Panel Unit Root Tests, 2007.
[62] C. Kao, Spurious regression and residual based tests for cointegration in panel data, J. Econom. 90 (1) (1999) 1–44.
[63] S. Ullah, M.S. Awan, M. Hasan, Environmental Quality and Health Status: Dynamic Ordinary Least Square Estimation for Developing Asian Countries, 16, 2020, pp. 153–180. January–December) pp.
[64] P. Pedroni, Fully modified OLS for heterogeneous cointegrated panels, Adv. Econom. 15 (2000) 93–130.
[65] P. Lustrilanang, Darusalam Suwarno, L.T. Rizki, N. Omar, J. Said, The role of control of corruption and quality of governance in ASEAN: evidence from DOLS and FMOLS test, Cogent Business & Management 10 (1) (2023) 2154060.
[66] M. Hamit-Haggar, Greenhouse gas emissions, energy consumption and economic growth: a panel cointegration analysis from Canadian industrial sector perspective, Energy Econ. 34 (1) (2012) 358–364.
[67] P. Saikkonen, Asymptotically efficient estimation of cointegration regressions, Econom. Theor. 7 (1) (1991) 1–21.
[68] J.H. Stock, M.W. Watson, A simple estimator of cointegrating vectors in higher order integrated systems, Econometrica 61 (4) (1993) 783–820.
[69] C. Kao, M.H. Chiang, On the Estimation and Inference of a Cointegrated Regression in Panel Data, 1999.
[70] M.I. Shah, Current Account Deficit across South Asia: A Second Generation Methodological Adaptive Approach, 2020.
[71] U. Abdullateef, A.T. Ijaiya, Agricultural trade liberalization and food security in Nigeria, J. Econ. Int. Finance 2 (12) (2010) 299–307.
[72] C.L. Chen, R. Duncan, Achieving food security in China: implications of world trade organization accession. ACIAR technical reports 69, Australian Centre for International Agricultural Research, Canberra, 2008, p. 67.
[73] K. Anderson, Agricultural Trade, Policy Reforms, and Global Food Security, Palgrave Studies in Agricultural Economics and Food Policy, Palgrave MacMillan US, 2016. ISBN: 978-1-137-46925-0.
[74] K. Anderson, Finishing Global Farm Trade Reform, Implications for Developing Countries, University of Adelaide Press, 2017. ISBN: 978-1-925261-34-9.
[75] R.J. Sexton, I. Sheldon, S. McCorriston, H. Wang, Agricultural trade liberalization and economic development: the role of downstream market power, Agric. Econ. 36 (2007) 253–270.
[76] Asian Development Bank, ADB's Work in Agriculture and Food Security, 2022. (Accessed 21 January 2023).