REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

OPEN ACCESS

Citation: Susanta Kumar Sethy, Phanindra Goyari (2023). Examining financial inclusion-agricultural productivity connection in south asian countries: evidence from FMOLS and DOLS approaches. *Italian Review of Agricultural Economics* 78(1): 33-48. DOI: 10.36253/rea-14079

Received: November 25, 2022

Revised: April 27, 2023

Accepted: May 02, 2023

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Corresponding Editor: Anna Irene De Luca

Research article

Examining financial inclusion-agricultural productivity connection in south asian countries: evidence from FMOLS and DOLS approaches

Susanta Kumar Sethy[1,*], Phanindra Goyari[2]

[1] *Department of Economics, Rajendra University, India*
[2] *School of Economics, University of Hyderabad, India*
*Corresponding author. E-mail: susanthu2010@gmail.com

Abstract. The main purpose of this paper is to examine the impact of financial inclusion on agricultural productivity in South Asian countries from 2004 to 2018. By following the Human Development Index method, we construct a multidimensional time-varying financial inclusion index to measure the level of financial inclusion. The long-run elasticity of financial inclusion on agricultural productivity is examined by using the FMOLS and DOLS approaches. The empirical results confirm that financial inclusion has a positive impact on agricultural productivity. Furthermore, the interaction term between financial inclusion and human capital is positively associated with agricultural productivity. These results suggest that South Asian countries can increase agricultural productivity by improving the coverage of financial inclusion in the long run.

Keywords: financial inclusion, financial inclusion index, agricultural productivity, FMOLS and DOLS.
JEL codes: O43, G21, Q14.

HIGHLIGHTS

- The study examines the impact of financial inclusion on agricultural productivity using a sample of seven South Asian countries during the period 2004-2018.
- A multidimensional Financial Inclusion Index (FII) was constructed to measure the level of financial inclusion.
- Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) methods were employed.
- Empirical results confirm that financial inclusion has a positive impact on agricultural productivity.

1. INTRODUCTION

Around the globe, the agricultural sector is and will remain a key component in the achievement of the Millennium Development Goals. Agricultural production must increase to 70% by 2050 to feed the world, despite population expansion, climate change and rapid urbanization putting pressure on available cultivable land (Food Agriculture Organization, 2009). Furthermore, according to the Global Agriculture and Food Support Program (GAFSP) and World Bank (2007a), agricultural growth is many times more effective than other sectors of the economy in reducing poverty. It also increases agricultural income and gives rural residents the buying power they need to purchase manufactured goods. Moreover, financial inclusion has also been one of the instruments in reducing poverty over time (Gurley, Shaw, 1955; Goldsmith, 1969; Cull *et al*., 2014; Park, Mercado, 2015; Omar, Inaba, 2020). The effect of financial inclusion on agriculture is also well acclaimed by some studies (Laha, Kuri, 2014; Fowowe, 2020; Atakli, Agbenyo, 2020). The availability of finance leads to increased agricultural productivity and higher incomes for farmers. As a result of this, hunger of the poor is reduced, and they are able to escape poverty traps (Nathan Associates, 2015).

Schultz (1980) states that «Most of the World's poor people earn their living from agriculture, so if we knew the economics of agriculture, we would know much of the economics of being poor». Agriculture is the backbone of many South Asian economies. It supplies food and jobs to the rapidly increasing population and still contributes significantly to overall economic growth. Despite increased focus on industrial growth, agriculture remains a substantial contributor to the country's Gross Domestic Product (GDP). The overall significance of the agricultural sector is also strong in South Asian countries, where it makes a major contribution to GDP and is a major source of jobs (SAARC, 2014). The agricultural sector contributes roughly 20% of GDP in India, Bangladesh, Pakistan and Bhutan, as well as 33.1% in Nepal. In India, Bangladesh and Pakistan, the agricultural sector hires roughly half of the total workforce (ILO, 2015), 31% in Sri Lanka (CBSL, 2015), and the highest (i.e., 65.6%) in Nepal. So, these statistical data indicate the significance of the agricultural sector in absorbing these countries' growing labour force. An increase in agricultural productivity will promote and facilitate industrial growth in a variety of ways. It allows the agricultural sector to supply labour to the non-agricultural sector while also meeting the non-agricultural sector's food demand. It allows the agricultural sector to provide low price food to industrial workers, thus increasing industries' profitability (Kuznet, 1961). Furthermore, the Food and Agriculture Organization (2022) has identified a number of factors that affect agriculture growth and productivity, including the environment, productive human capital, GDP, agricultural fertilizer, capital use, trade openness, industrialization, and agricultural terms of trade etc. Despite this, an inclusive financial system is one of the influencing factors for agricultural productivity. Financial inclusion allows farmers to invest in and adopt new innovations in the agricultural sector, which helps to increase productivity. It provides money to helpless farmers to purchase agricultural inputs such as fertilizers, pesticides and seeds, which increase agricultural productivity. Therefore, the affordable costs of formal financial services are important to increase agricultural productivity.

Many researchers believe in a positive linkage between banking products and productivity (Awunyo-Vitor *et al*., 2014). In addition, various researchers (Sial *et al*., 2011; Baffoe *et al*., 2014; Chandio *et al*., 2016a; Chandio *et al*., 2016b) studied the effect of agricultural finance on agricultural productivity in Pakistan and Ghana, and their studies showed that agricultural finance had a favorable effect on agricultural productivity.

Empirical research on the linkages between financial inclusion and agricultural productivity in South Asian economies is scarce and very limited. To the best of the authors' knowledge, there has been no study on the topic till now. Few pieces of research have been conducted in South Asian countries to find out the influence of agricultural credit on agricultural production/productivity (according to Table 1). However, most of these studies were conducted for specific individual countries. The pieces of research have not examined the influence of financial inclusion on agricultural productivity. With this motivation, the aim of this study is to examine the impact of financial inclusion on agricultural productivity in South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Pakistan and Sri Lanka).

The study contributes to the existing literature in the following ways. *First*, it has investigated the impact of financial inclusion on agricultural productivity in South Asian countries using Pedroni cointegration to check the long connection among study variables. *Second,* the Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) approaches have been adopted to show the long-run connection between financial inclusion and agricultural productivity for the period 2004 to 2018.

The rest of the article is organized as follows: Section 2 contains a review of the literature. Section 3 presents materials and methods (statistical and econometrics). Section 4 explains empirical results and discussion. Section 5 gives the conclusion, policy recommendations and limitations.

2. LITERATURE REVIEW

2.1. Nexus between agricultural finance, financial inclusion (FI) and agricultural productivity

It is impossible to underestimate the importance of credit in agricultural production. Feder *et al*. (1989) examined agricultural finance and farm performance in China based on farmers survey data. According to their findings, the availability of credit may have a positive impact on agricultural productivity because farmers who are short on money may use lower levels of agricultural inputs in their production activities.

Various researchers studied the effect of agricultural finance on agricultural productivity in different nations around the globe and their studies evidence that agricultural finance had a favorable effect on agricultural productivity (Table 1). As a result, agricultural productivity can be increased by ensuring that credit is available when it is required, thus allowing farmers to buy agricultural inputs such as fertilizers, pesticides, high-yield seeds and advanced agricultural equipment. In addition, increased agricultural productivity and income of farmers are linked to the availability or accessibility of finance. According to Nathan Associates[1] (2015), financial inclusion can have a two-fold effect on agriculture: *first*, it can *increase agricultural productivity*. Credit delivery makes it easier to buy agricultural inputs and hire workers and machinery, which can help to increase agricultural productivity. *Second*, available finance makes it easier for farmers to diversify their livelihoods and raise their profits.

A recent study was conducted by Magezi, Nakano (2020) which examined the effect of microcredit on agricultural productivity based on baseline survey data in Tanzania. They estimated the intention-to-effect and Local Average Treatment Effect (LATE) of microcredit. According to their findings, increasing banking products access alone may not be enough to boost small-scale farmers' agricultural productivity because other factors (i.e., total land holding, value of household assets, years of schooling of household head, and age of household head) are also responsible for agricultural productivity. Fowowe (2020) examined the association between FI and agricultural productivity for 2010-2011, 2011-2013, and 2015-2016 in Nigeria. He used simple panel data estimation and his empirical results reveal that FI has a positive influence on agricultural productivity. Atakli, Agbenyo (2020) used Ghana Living Statistical Survey data and multiple regression models. Their results confirm that FI has a positive association with agricultural productivity. Magazzino *et al*. (2021) investigated the relationship among credit access, output and productivity in the agricultural sector for a large set of countries from 2002 to 2012. They used an artificial network approach. Their empirical results show that credit access significantly affects agricultural production in developing countries and productivity in developed countries. Chandio *et al*. (2022) examined the impact of financial development on agricultural production in China from 1989 to 2016. They used an autoregressive distributed lag (ARDL) approach and their empirical results confirm that financial development has a positive impact on agricultural production in both the long- and short-run.

2.2. Nexus between financial inclusion and agricultural productivity: Theoretical argument

In recent times, financial inclusion has been playing an important role in agricultural productivity (Nathan Associates, 2015). Furthermore, greater access to formal financial services has a positive influence on agricultural productivity (Laha, Kuri, 2014; Nakano, Magezi, 2020; Fowowe, 2020). A theoretical connection between financial inclusion and agricultural productivity is explained in Figure 1.

Figure 1 indicates that financial inclusion can help to boost agricultural productivity through access to an affordable cost of credit and access to attractive deposit and insurance products. The following is how the logic works. Access to affordable and low-cost credit facilitates the purchase of agricultural inputs (such as equipment, fertilizer and quality seeds) and employing labour, which in turn can increase farmers' efficiency and increase agricultural productivity.

3. MATERIALS AND METHODS

3.1. Construction of Financial Inclusion Index (FII)

For the present study, a multidimensional FII is constructed based on the FII previously proposed by Sarma (2015). With the rising interest in financial inclusion among policymakers, a multiplicity of financial inclu-

[1] Nathan is a private multinational economic and analytics consulting company that provides realistic solutions and long run results to government and commercial clients around the world.

Table 1. Survey of existing literature between formal agricultural credit and agricultural production/productivity.

Authors	Study Country	Methodology	Findings
Binswanger *et al.* (1993)	India	Theoretical Analysis	+ve
Navin (1988)	Bangladesh	Theoretical Analysis	+ve
Iqbal *et al.* (2003)	Pakistan	Ordinary Least Square estimates	+ve
Petrick (2004)	Poland	Microeconomic farm household model	+ve
Blancard *et al.* (2006)	France	Credit constraint profit maximization model	+ve
Sindhu *et al.* (2008)	India	Simultaneous (four) equation model	+ve
Guirkinger, Boucher (2008)	Peru	Switching regression model	+ve
Hussein (2009)	Bhutan	Theoretical Analysis	+ve
Das *et al.* (2009)	India	Arellano-Bond Regression	+ve
Pathak (2010)	Bhutan	Theoretical Analysis	+ve
Kumar *et al.* (2010)	India	Tobit model	+ve
Rahman *et al.* (2011)	Bangladesh	Linear and exponential equations, Pearson Correlation equation	+ve
Sial *et a*l. (2011)	Pakistan	ADF test, Phillips Perron Unit root test, Granger causality test	+ve
Gyeltshen (2012)	Bhutan	Bivariate PROBIT Model	+ve
Dong *et al.* (2012)	China	Switching regression model	+ve
Ciain (2012)	European countries	Matching estimation	+ve
Laha, Kuri (2013)	India	Financial Inclusion Index	+ve
Alauddin, Biswas (2014)	Bangladesh	Empirical study	+ve
Awunyo-Vitor *et al.* (2014)	Ghana	ANOVA, Heckman's two stages regression model	+ve
Sarker *et al.*(2015)	Bangladesh	Simple linear regression model	+ve
Khandker, Koolwal (2015)	Bangladesh	Augmented household panel data model	+ve
Mishra *et al.* (2016)	India	State-level panel model	+ve
Narayan (2016)	India	Mediation analysis framework	+ve
Chavan, Sivamurugan (2017)	India	Logistic Model	+ve
Iftikhar *et al.* (2017)	Pakistan	Multiple linear regression models	+ve
Onoja (2017)	Developing countries	Fixed effect econometrics approach	+ve
Olaniyi (2017)	Nigeria	Autoregressive Lag Distributed (ARDL) approach	+ve
United States Agency for International Development (2018)	Afghanistan	Theoretical analysis and Ratio analysis	+ve
Chandio *et al.* (2018)	Pakistan	Instrumental variables (two-stage least squares) approach	+ve
Wang *et al.* (2019)	Bhutan	Logit regression model	+ve
Agbodji, Johnson (2019)	Togo	PSM and ESR methods	+ve
Moahid, Maharajan (2020)	Afghanistan	Probit model, and Double-hurdle model	+ve

sion indicators has been developed (Sarma, 2008; Sethy, 2016; Sethy, Goyari, 2018; Sethi, Sethy, 2019; Sethy, Goyari, 2022; Sethy *et al.* 2023). The following steps calculate the multidimensional FII.

Step 1: This study initially calculates a dimension index for each dimension of financial inclusion in order to develop an index. We first define as in equation (i):

$$d_i = w_i * \frac{A_i - m_i}{M_i - m_i} \quad \text{(i)}$$

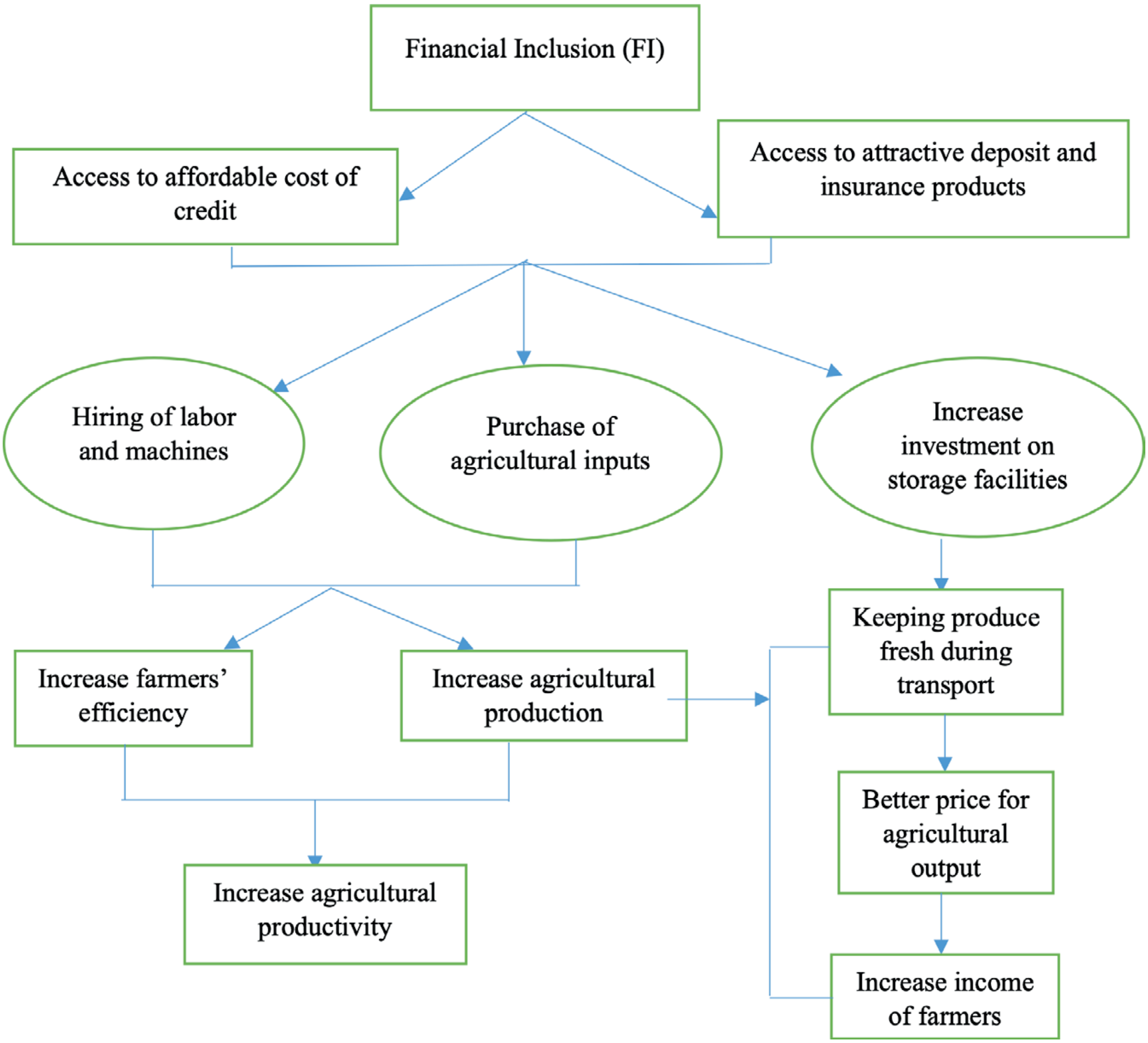
where,
w_i = Weight attached to the dimension i, $0 \le w_i \le 1$, A_i = Actual value of dimension i, m_i = Minimum value of dimension i, M_i = Maximum value of dimension i, d_i = Dimensions of financial inclusion i.

Equation (i) confirms that $0 \le w_i \le 1$ and here, n dimensions of financial inclusion are represented by a point X = (1, 2, 3…). Point 0 = (0, 0, 0…0) represents the worst situation and Point W = (1, 2, 3 …) represents an ideal situation. Here we take W =1 (equal weighting approach).

*Step 2***:** We calculate X_1 based on d_i and W_i as in equation (ii):

$$X_1 = \frac{\sqrt{d_1^2 + d_2^2 + d_3^2 + \dots\dots\dots + d_n^2}}{\sqrt{w_1^2 + w_2^2 + w_3^2 + \dots\dots\dots + w_n^2}} \quad \text{(ii)}$$

Figure 1. Linkages between financial inclusion and agricultural productivity.



Step 3: In the third step, we calculate X_2 based on d_i and W_i as in equation (iii):

$$X_2 = 1 - \frac{\sqrt{(w_1-d_1)^2+(w_2-d_2)^2+(w_3-d_3)^2+ \dots\dots\dots +(w_n-d_n)^2}}{\sqrt{w_1^2+w_2^2+w_3^2+ \dots\dots\dots +w_n^2}} \quad \text{(iii)}$$

Step 4: We calculate the FII based on X_1 and X_2 as in equation (iv):

$$FII = ½ (X_1 + X_2) \quad \text{(iv)}$$

In equation (ii), for financial inclusion index (FII), X_1 indicates the average of the Euclidian distance between X and 0. In equation (iii), for FII, X_2 indicates inverse Euclidian distance between X and W. Equation (iv)[2] is the simple average of X_1 and X_2 which is the multidimensional Financial Inclusion Index used in the present study.

3.2. Panel cointegration tests

First, to determine whether stationarity exists in the data series, the panel unit root test is used. The

[2] The FII presented in Sarma (2015), Sarma and Pais (2011), Sethy (2016), Goel and Sharma (2017), Sethy and Goyari (2018), Sethy (2023) was based on the distance from the ideal only.

study used the Im, Peseran, Shin (IPS) panel unit root test. The second step of empirical research is to use the panel cointegration test to investigate the long-term relationship between the variables. For panel data research, Pedroni (1999 and 2014) cointegration is the best method for estimating co-integration among variables. The Pedroni (1999) cointegration test is then used to determine whether there is a long-run relationship between all study variables.

Pedroni (2004) considers the following type of regression in equation (v):

$$z_{i,t} = a_i' + \ddot{a}_\iota t + \widehat{a_{1\iota}} y_{1i,t} + \widehat{a_{2\iota}} y_{2i,t} + \ldots\ldots\ldots\ldots + \widehat{a_{M\iota}} y_{Mi,t} + e_{it} \quad \text{(v)}$$

for t = 1,2,3……,T; i =1,2,3……N; m =1,2,3…..M.

For the panel data analysis, Pedroni (1997) suggests seven statistics to check the null hypothesis of no cointegration. There are two types of tests in this. First is the panel cointegration test (within dimension) and second, the panel cointegration test (between dimensions).

3.3. FMOLS and DOLS approach

The possibility of heterogeneity cannot be overlooked because this study is based on panel data from seven South Asian countries. With this in mind, we used Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) approaches, which are capable of dealing with heterogeneity and serial correlation in the data (Danish *et al*. 2019). In addition, FMOLS and DOLS methods were employed to solve the endogeneity problem and remove the serial correlation present in Ordinary Least Square (OLS). We examined the long-run effects of financial inclusion on agricultural productivity in South Asian countries employing the FMOLS and DOLS approaches.

The FMOLS method is proposed by Philips, Moon (1999) and the FMOLS cointegrating equation is:

$$\hat{\beta}_{FMOLS} = \frac{1}{N}\left[\{\sum_{t=1}^{T}(y_{it} - \bar{y_i})^2\}^{-1} \{\sum_{t=1}^{T}(y_{it} - \bar{y_i})\, z_{it}^* - T\hat{y_i}\right] \quad \text{(vi)}$$

where $z_{it}^* = y_{it} - \bar{y_i} - \left(\hat{\Omega}_{21i} / \hat{\Omega}_{22i}\right)\Delta y_{it}$ and

$$\hat{y_i} = \hat{\Gamma}_{21i} + \hat{\Omega}^0_{21i} - (\hat{\Omega}_{21i} / \hat{\Omega}_{22i})(\hat{\Gamma}_{21i} + \hat{\Omega}^0_{21i}).$$

The DOLS method is proposed by Stock and Watson (1993) and the DOLS cointegrating equation is:

$$b_{DOLS} = N^{-1}\sum_{i=0}^{n}(\sum_{t=1}^{T}\forall_{it}\forall'_{it})^{-1}(\sum_{t=1}^{T}\forall_{it}(z_{it} - \bar{z_i})) \quad \text{(vii)}$$

where $\forall_{it}$ represents 2(K+1)×1 vector of explanatory variables including (y_{it} - $\bar{y_i}$,..,,,$\Delta y_{i,j}$).

3.4. Econometric model specification

Generally, the traditional *Cobb-Douglas (CD)* production function consists of two inputs – capital and labour. But, according to Echevarria (1998), a production function can include more factors of production.

The functional form of CD production function is as given below in equation (viii):

$$Y_{i,t} = AK_{i,t}^{\alpha}L_{i,t}^{\beta}e^{\mu_{i,t}} \quad \text{(viii)}$$

where, agricultural productivity is denoted by *Y*, Capital is denoted by *K*, and Labour is denoted by *L*. The parameters α and β are the partial elasticity of Y with respect to capital and labor respectively. Here, *i……n*, *t…..T*, and the error term is represented by μ.

This study proceeds to investigate *the impact of FI on agricultural productivity*. So when FI is included in the model, equation (viii) becomes (ix):

$$Y_{i,t} = \mathrm{A}K_{i,t}^{\alpha}L_{i,t}^{\beta}FI_{i,t}^{\rho}e^{\mu_{i,t}} \quad \text{(ix)}$$

where, *FI* is represents financial inclusion that is measured by the multidimensional financial inclusion index (FII), the parameter ρ must be in the range between 0 and 1 and it indicates the marginal influence of FI on agricultural productivity. After taking the logarithm, the above equation (ix) becomes equation (x):

$$ln\ Y_{i,t} = \alpha_0 + \alpha(lnK)_{i,t} + \beta(lnL)_{i,t} + \rho(lnFII)_{i,t} + \mu_{i,t} \quad \text{(x)}$$

Besides financial inclusion, agricultural productivity is influenced by a number of other economic variables such as trade openness, lending interest rate and emission.

Then, the above equation (x) can be re-written as in equation (xi):

$$ln(Agripro)_{i,t} = \alpha_0 + \beta_1(lnK)_{i,t} + \beta_2(lnL)_{i,t} + \beta_3(lnFII)_{i,t} + \beta_4(lnTrade)_{i,t} + \beta_5(lnInterest)_{i,t} + \beta_8(lnCO_2)_{i,t} + \alpha_i + \mu_{i,t} \quad \text{(xi)}$$

where, *Agripro* is agricultural productivity defined as agriculture, forestry and fishing, value added per worker (constant 2010 US$), *lnAgripro* = log of agriculture productivity and independent variables are *lnK* = log of physical capital; lnL = log of labour (human capital); lnFII = log of multidimensional financial inclusion index; $lnTrade$ = log of trade openness; $lnInterest$ = log of lending interest rate; $lnCO_2$ = log of carbon emissions; α_i = unseen effects and $\mu_{i,t}$ = error term, t = 1, 2, 3,…….15 years (from 2004 to 2018) and i = 1, 2, 3…7 (Afghanistan, Bangladesh, Bhutan, India, Maldives, Pakistan and Sri Lanka).

Here, financial inclusion (FI) is expected to increase agricultural productivity or is positively associated with it because easy access to affordable formal financial services and micro credit increase agricultural investment. As a result, it increases agricultural productivity and incomes of farmers.

The following regression equation (xii) is used to examine *the conditional effect of FI on agricultural productivity* in South Asian countries.

$$ln(Agripro)_{i,t} = \alpha_0 + \beta_1(lnFII)_{i,t} + \beta_2(lnK)_{i,t} + \beta_3(lnL)_{i,t} + \beta_4(lnFII{*}lnX)_{i,t} + \alpha_i + \mu_{i,t} \qquad \text{(xii)}$$

where, the interaction of a multidimensional FII with other particular control variables (i.e., lnX) that can impact the result of FII in terms of increasing agricultural productivity is denoted by ($FII * lnX$). The other specifications are the same as the above equation (xi). A brief theoretical explanation on measurement of some independent variables is given below:

Physical capital: Physical capital plays an important role in the agricultural sector. In this study, physical capital is measured by the gross fixed capital formation (% of GDP).

Labour: Human capital is represented by labour force, which is determined by many factors such as education levels of various categories, skills, training, physical health, population size etc. In this study, we measure labour by the secondary school enrolment rate (similar to Barro, Lee, 2010). Others could not be considered due to lack of consistent data for all countries.

Financial inclusion (FI): Inclusive finance is measured by the financial inclusion index (Sarma, 2008; Sethy, 2016; Sethy, Goyari, 2022).

3.5. Variables and data sources

The study is based on 15 years of annual panel data from 2004 to 2018. By excluding Nepal (because of the non-availability of consistent comparable and uniform data of formal financial services and other study variables), the rest of the seven South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Pakistan and Sri Lanka) are taken for the analysis. The dataset is collected from the Financial Access Survey (FAS) database of the International Monetary Fund (IMF) and World Development Indicator (WDI). Tables 2 and 3 give a detailed explanation of the variables and sources.

4. EMPIRICAL RESULTS AND DISCUSSIONS

4.1. Descriptive statistics

Table 4 presents descriptive statistics of the study variables used in the regression analysis for the sample of 89 observations over the period 2004-2018 for seven South Asian countries.

Table 4 shows that agricultural productivity has a mean (median) value of 7.17 (7.14) and a standard deviation (SD) of 0.34. It varies from 6.30 (min) to 7.94 (max). Similarly, physical capital (K) has a mean (median) value of 3.27 (3.26) and an SD of 0.41. Labour (L) has a mean (median) value of 4.04 (4.01) and an SD of 0.38. One of the important explanatory variables, *i.e.* financial inclusion, has a mean (median) value of 0.67 (0.72) and SD of 1.03. The coefficients of financial inclusion range from -6.008 (min) to 0.001 (max). Trade openness has a mean (median) value of 3.38 (3.73) and SD of 1.12. The interest rate has a mean (median) value of 2.50 (2.56) and SD of 0.21. Among the variables, agricultural productivity has the highest average (in log form) of 7.17, and a standard deviation of 0.34, and CO_2 emission has the lowest average (in log form) of 0.40 with a standard deviation of 0.75.

4.2. Correlation matrix

Table 5 presents the Pearson correlation matrix, to determine the nature and strength of the correlation among explanatory variables.

Table 5 shows that there is a significant correlation among a few explanatory variables. Two important observations can be found from correlation coefficients in Table 5. First, a positive correlation is present between agricultural productivity with carbon dioxide (0.57), labour (0.29), and financial inclusion (0.46). Particularly, the positive relationship between financial inclusion and agricultural productivity (also observed in other studies like Laha, Kuri 2014; Fowowe 2020; Atakli, Agbenyo, 2020) indicates that access to banking services leads to an increase in agricultural productivity in South Asian countries. Second, other explanatory variables like trade openness, physical capital and interest rate are negatively correlated with agricultural productivity. Such correla-

Table 2. List of variables for constructing the Financial Inclusion Index (FII).

Availability Indicators	Accessibility Indicators	Usage Indicators
Demographic Branch Penetration:	*Geographic ATM Penetration*:	*Credit Penetration*:
(1) Number of bank branches per 1 lakh adults (2) Branches of Commercial Bank	(5) Number of ATMs per 1000 km^2	(7) Outstanding loans with Commercial Banks (8) Outstanding loans with Commercial Banks (% of GDP)
Demographic ATM Penetration:	*Geographic Branch Penetration*:	*Deposit Penetration*:
(3) ATMs per 1 lakh Adults (4) Number of ATMs	(6) Branches of Commercial Bank per 1000 km^2	(9) Outstanding deposits with Commercial Banks (10) Outstanding deposits with Commercial Banks (% of GDP)

Source: Financial Access Survey (FAS), IMF.

Table 3. Variables, unit and data sources.

Variables	Unit	Source
Agricultural productivity (*Agripro*)	Constant 2010 US$	WDI, World Bank
Capital (*K*)	(% of GDP)	WDI, World Bank
Labour (*L*)	(% gross)	WDI, World Bank
Financial inclusion (*FII*)	Index	Financial Access Survey (FAS), IMF
Trade openness (*Tradeopen*)	Trade percentage of GDP	WDI, World Bank
Lending interest rate (*Interest*)	(%)	WDI, World Bank
Carbon emission (CO_2)	Metric tons per capita	WDI, World Bank

Table 4. Descriptive statistics.

	lnAgripro	lnK	lnL	lnFII	lnTradeopen	lnInterest	ln
Mean	7.175	3.275	4.041	0.671	3.386	2.507	0.404
Median	7.149	3.268	4.011	0.724	3.739	2.56	0.298
SD	0.345	0.417	0.381	1.032	1.127	0.213	0.754
Min	6.302	2.527	2.924	-6.008	0.758	1.939	-2.961
Max	7.941	4.248	4.608	0.001	4.758	2.938	0.722
Observation	89	89	89	89	89	89	89

Source: Authors' estimations based on data compiled from the IMF and WDI.

tions have important policy implications. Interpretations of these results are given in the next section along with estimated regression results.

4.3. Empirical results on the conditional impacts of financial inclusion (FI) on agricultural productivity

It is important to examine the conditional impact between financial inclusion and other micro and macroeconomic variables on agricultural productivity. From Table 6, in specification 1 of the time fixed effect model, estimated coefficient of financial inclusion and agricultural productivity coefficients is positive. Furthermore, estimated results also confirm that there is a positive relationship between FI and agricultural productivity in other specifications (see columns 2, 4, 5, and 6 of Table 6) except column 3. This shows that an inclusive financial system can create more efficient investment in the agricultural sector which can lead to higher productivity. Similarly, the coefficients of carbon emissions indi-

Table 5. Correlation matrix.

	lnAgripro	lnK	lnL	lnFII	lnTradeopen	lnInterest	lnCO_2
lnAgripro	1						
lnK	-0.109	1					
lnL	0.293	0.492	1				
lnFII	0.461	-0.139	0.309	1			
lnTrade	-0.608	0.548	-0.085	-0.159	1		
lnInterest	-0.319	0.136	-0.153	-0.083	0.531	1	
lnCO_2	0.572	0.285	0.448	0.228	-0.26	-0.482	1

Source: Authors' estimations based on data compiled from the IMF and WDI.

Table 6. Conditional effects of financial inclusion on agricultural productivity (fixed effect estimation).

Variables	(1) lnAgripro	(2) lnAgripro	(3) lnAgripro	(4) lnAgripro	(5) lnAgripro	(6) lnAgripro
lnFII	0.150 *** (0.001)	0.889*** (0.002)	- 1.014*** (0.019)	0.147*** (0.002)	1.584*** (0.000)	0.846*** (0.000)
lnK	0.033 (0.755)	- 0.204 (0.134)	- 0.080 (0.464)	0.039 (0.723)	- 0.153 (0.170)	- 0.252*** (0.022)
lnL	0.333 (0.725)	2.640 (0.999)	0.334*** (0.041)	0.036 (0.703)	0.104 (0.274)	0.147* (0.101)
lnCO_2	0.230*** (0.000)	0.235*** (0.000)	0.258*** (0.000)	0.221*** (0.000)	0.267*** (0.000)	0.292*** (0.000)
lnInterest	0.468*** (0.004)	0.449*** (0.004)	0.445*** (0.005)	0.466*** (0.005)	- 0.021 (0.913)	0.049*** (0.000)
lnTradeopen	- 0.179*** (0.000)	- 0.174*** (0.000)	- 0.155*** (0.000)	- 0.180*** (0.000)	- 0.138*** (0.000)	- 0.248*** (0.000)
lnFII*lnK		- 0.216*** (0.008)				
lnFII*lnL			0.295*** (0.007)			
lnFII*lnCO_2				- 0.007 (0.834)		
lnFII*lnInterest					- 0.590*** (0.000)	
lnFII*lnTradeopen						- 0.176*** (0.000)
Constant	6.889*** (0.000)	7.586*** (0.000)	5.760*** (0.000)	6.890*** (0.000)	7.989*** (0.000)	7.362*** (0.000)
Observations	89	89	89	89	89	89
R^2	0.690	0.720	0.722	0.690	0.741	0.774
Number of Id	6	6	6	6	6	6

Note: *** and * indicate significance at 1 and 10% level, respectively.
Source: Authors' estimations based on data compiled from the IMF and WDI.

cate that there is a positive relation between emission, and agricultural productivity. This finding is similar to other studies like NASA (2016), Mujtaba *et al*. (2022) and Chandio *et al*. (2022).

The conditional impact of FI on agricultural productivity in South Asian nations is also presented in Table 6. To assess the independent impact of a particular variable on agricultural productivity, this Table examines control variables and their links with financial inclusion independently. The Table indicates that the interaction term of FI with physical capital, human capital (i.e., *labour*), interest rate and trade openness are significant. However, the interaction term of FI with emissions is not statistically significant for agricultural productivity.

Financial inclusion and physical capital have an adverse effect on agricultural productivity when they are combined, implying that higher physical capital increases the marginal effect of FI in reducing agricultural productivity. This empirical finding is consistent, in the sense that increased fixed capital (i.e., spending on machinery and large equipment purchases, etc.) may create less demand for labour, may decrease real wages and lower the standard of living of many people, particularly in rural areas. This can lead to an inefficient inclusive banking system, which may reduce agricultural investment and then further reduce agricultural productivity. In a study, Zepeda (2001) found that an increase in physical capital had an adverse impact on agricultural production and profits.

Financial inclusion and *human capital* (i.e., proxied by secondary school enrolment) have a positive impact on agricultural productivity when they are combined. This implies that when the number of students enrolled in secondary school rises, the marginal effects of financial inclusion on growing agricultural productivity increases. This empirical evidence is valid in the sense that a higher education level in poor families increases general workforce skills and farmers become better "managers" by enhancing their decision-making skills, which subsequently increases the financial literacy rate and in turn helps to use digital banking. Such positive relations between financial inclusion and human capital were observed in many studies, also leading to higher agricultural productivity (Asadullah, Rahman, 2009, Nguyen, 1979; Kawagoe *et al*. 1985; Fulginiti, Perrin, 1993; Reimers, Klasen, 2013).

In addition, the interaction term between *FI* and *carbon emission* has a negative impact on agricultural productivity when they are combined. This result can be interpreted like this – an inclusive financial system can improve the accessibility of banking products, which in turn can increase investment and can also increase energy-consuming machines like tractors, power tillers and combine harvesters etc. Finally, it can increase CO_2 emissions that may indirectly reduce agricultural productivity. A similar finding was observed in Kwakwa *et al*. (2022).

Financial inclusion and *interest rate* have a negative impact on agricultural productivity when they are combined. This result can be interpreted in the sense that a higher interest rate charged by the formal financial institutions largely can restrict farmers from seeking credit from these institutions and may create less investment in the agricultural sector. Finally, it may lead to a decrease in agricultural productivity. Some studies (Danladi *et al*. 2021; lliyasu, 2022) had such findings.

The interaction effect between *financial inclusion* and *trade openness* is negatively related to agricultural productivity. This result may be interpreted as sometimes openness to trade has a negative effect on technical efficiency in the agricultural sector (as evidenced in Hart *et al*. 2015) and economic growth (as found in Kim, 2011; Rigobon, Rodrik, 2005; Vamvakids, 2002; Ulasan, 2015; Fenira, 2015). These may create less demand for labour, and will reduce real wages, thus can decrease the standard of living. In this way, negative cycles of opportunities may be generated. This can lead to an inefficient inclusive banking system that reduces agricultural investment and ultimately decreases agricultural productivity. Table 7 reports (results from random effect model) similar results to those in Table 6 (results of fixed effect model estimation).

4.4. Panel unit root results

In general, the panel data model needs to test stationarity of the data before regression estimation (Wang *et al*. 2015). In this section, the order of integration of variables is tested through unit root tests before checking for panel cointegration. In order to ensure the effectiveness and stability of the data, the Im-Pesaran-Shin (IPS) test (Im *et al*. 2003) is employed since it emphasizes parameter heterogeneity in panel models.

Table 7. Conditional effects of financial inclusion on agricultural productivity (random effect estimation).

Variables	(1) lnAgripro	(2) lnAgripro	(3) lnAgripro	(4) lnAgripro	(5) lnAgripro	(6) lnAgripro
lnFII	0.103 *** (0.000)	0.803*** (0.003)	- 0.933*** (0.017)	0.102*** (0.000)	1.142*** (0.002)	0.487*** (0.000)
lnK	0.060 (0.558)	- 0.165 (0.209)	- 0.040 (0.698)	0.062 (0.563)	- 0.079 (0.457)	- 0.100*** (0.312)
lnL	0.056 (0.532)	0.030 (0.725)	0.256* (0.041)	0.057 (0.533)	0.050 (0.577)	0.035 (0.667)
lnCO_2	0.212*** (0.000)	0.216*** (0.000)	0.239*** (0.000)	0.209*** (0.001)	0.238*** (0.000)	0.240*** (0.000)
lnInterest	0.378*** (0.009)	0.371*** (0.008)	0.410*** (0.003)	0.377*** (0.010)	- 0.018 (0.920)	0.372*** (0.003)
lnTradeopen	- 0.186*** (0.000)	- 0.183*** (0.008)	– 0.168*** (0.000)	– 0.186*** (0.000)	– 0.155*** (0.000)	– 0.237*** (0.000)
lnFII*lnK		- 0.207*** (0.015)				
lnFII*lnL			0.258*** (0.008)			
lnFII* lnCO_2				- 0.002 (0.944)		
lnFII*lnInterest					- 0.433*** (0.004)	
lnFII*lnTradeopen						- 0.110*** (0.000)
Constant	7.084*** (0.000)	7.736*** (0.000)	5.997*** (0.000)	7.085*** (0.000)	7.952*** (0.000)	7.432*** (0.000)
Observations	89	89	89	89	89	89
R^2	0.673	0.701	0.703	0.673	0.705	0.717
Number of Id	6	6	6	6	6	6

Note: *** indicates significance at 1% level.
Source: Authors' estimations based on data compiled from the IMF and WDI.

Table 8. IPS panel unit root test.

Variables	lnAgripro	lnK	lnL	lnFII	lnCO_2	lnInterest	lnTradeopen
Level	1.400 (0.919)	0.120 (0.547)	-2.113 (0.017)	- 0.660 (0.254)	2.043 (0.979)	- 1.360 (0.086)	0.612 (0.729)
First differences	- 3.527*** (0.000)	- 2.734*** (0.003)	-2.641*** (0.004)	-2.770*** (0.002)	-1.989*** (0.023)	-3.455*** (0.000)	- 3.118*** (0.000)

Note: *** indicates significance at 1% level.
Source: Authors' estimations based on data compiled from the IMF and WDI.

Table 8 reveals the unit root test. The Im-Pesaran-Shin (IPS) unit root test result indicates that the variables are stationary at first difference but non-stationary at level. In South Asian countries, all the study variables such as lnAgripro, lnK, lnL, lnFII, lnCO_2, lnInter and lnTrade are found to be stationary at their first difference, rejecting the null hypothesis of non-stationary at 1% significance level. This result confirms the use of panel cointegration that requires the same order of integration.

4.5. Cointegration result

The above unit root test confirms that the variables follow the first order of the integration (I(1)) process. This indicates that these two key variables of lnFII and lnAgripro may be cointegrated after controlling the effect of lnK, lnL, lnCO_2, lnInter and lnTrade. To find the cointegration, the Pedroni (1999, 2004) test is employed in a balanced panel because this cointegration test allows heterogeneity among the countries.

Seven test statistics of Pedroni cointegration are reported in Table 9. This result confirms the cointegration between lnFII and lnAgripro across the panel countries. Out of seven, four Pedroni test statistics reject the null hypothesis of non-cointegration at 1% level of significance. It means that financial inclusion and agricultural productivity have a long-run relationship. Furthermore, this implies that if financial inclusion is prioritized now, it would help South Asian countries in the long-run.

Table 9. Pedroni panel cointegration estimation.

	Statistics	P-value
With Dimensions		
Panel v-Statistics	-3.037	0.996
Panel ρ Statistics	3.512	0.999
Panel Phillips-Perron t	-12.654***	0.000
Panel Augmented Dickey Fuller t	-4.187***	0.000
Between Dimensions		
Group ρ Statistics	4.140	1.000
Group Phillips-Perron t	-7.512***	0.000
Group Augmented Dickey-Fuller t	-4.108***	0.000

Note: *** indicates significance at 1% level.
Source: Authors' estimations based on data compiled from the IMF and WDI.

4.6. Panel FMOLS and DOLS estimations

As the Ordinary Least Square (OLS) estimator is biased and gives inconsistent results in the panel data analysis, the study uses Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) approaches that control the endogeneity and serial correlation problems.

Table 10 shows the FMOLS and DOLS estimation results. The FMOLS results indicate that financial inclusion (i.e., lnFII) and agricultural productivity (i.e., lnAgripro) are cointegrated. The coefficient is positive and statistically significant at 1% level and has the expected sign. This positive sign indicates that 1% increase in access and usage of banking services like savings, microfinance, deposits and loans across the selected nations would increase agricultural productivity by 0.13%. Similarly, the DOLS results confirm that financial inclusion and agricultural productivity have a long-run connection. The long run coefficient is positive, which confirms that a 1% increase in financial inclusion will result in 0.10% increase in agricultural productivity. This result is consistent with findings of some studies like Binswanger *et al.* (1993), Magri (2002), Akudugu *et al.* (2009), Olaniyi (2017), Awunyo-Vitor *et al.* (2014), Fowowe (2020), Atakli, Agbenyo (2020). They found that availability and usage of formal financial services (such as loans, savings and deposits) at an affordable cost leading to an increase in credit that ultimately leads to increased agricultural productivity through efficient investments in inputs like fertilizer, pesticides, quality seeds and irrigation etc. Therefore, financial inclusion can help poor farmers to have more suitable livelihoods.

A strong association between human capital and agricultural productivity is also observed in some studies

Table 10. Panel FMOLS and Panel DOLS estimations.

Dependent Variables: LnAgripro	FMOLS			DOLS		
	Coefficients	t-Statistics	P-Value	Coefficients	t-Statistics	P-Value
lnFII	0.137***	4.270	0.000	0.106***	5.148	0.000
lnK	0.014	0.126	0.899	0.044	0.350	0.720
lnL	0.506***	2.863	0.005	0.343**	2.122	0.037
ln	0.250***	3.279	0.001	0.240***	2.894	0.004
lnInterest	– 0.168*	– 1.668	0.099	– 0.086	-0.828	0.410
lnTradeopen	– 0.086**	– 1.983	0.051	– 0.087*	-1.838	0.069
R^2		0.940			0.932	
Adj. R^2		0.930			0.922	

Notes: ***, **, and * indicate significance at 1%, 5%, and 10 % level, respectively.
Source: Authors' estimations based on data compiled from the IMF and WDI.

(Asadullah, Rahman, 2009; Nguyen, 1979; Kawagoe *et al.* 1985; Fulginiti, Perrin, 1993; Reimers, Klasen, 2013).

The long-run estimated coefficients indicate that a 1% increase in L (i.e., *human capital*) would lead to a 0.50% (FMOLS) and 0.34% (DOLS) increase in agricultural productivity in our panel countries. Similarly, the estimated result has also indicated that there is a positive association between CO_2 emissions and agricultural productivity. The long-run coefficients indicate that a 1% increase in CO_2 emissions would lead to a 0.25% (FMOLS) and 0.24% (DOLS) increase in agricultural productivity. A similar finding was observed in some studies (Mujtaba *et al.*, 2022; Chandio *et al.*, 2022). But only two study variables (interest rate and trade openness) are found to be negatively cointegrated with agricultural productivity (as seen in Table 10). This indicates that proper policies on interest rates and trade openness have to be formulated and implemented so that agricultural productivity does not decline in the long run.

5. CONCLUSION

Based on annual data, this study has examined the effect of financial inclusion on agricultural productivity for a group of seven South Asian countries from 2004 to 2018. The study has some important findings as follows. *First,* results of the study confirm that the interaction term of financial inclusion with physical capital, interest rates, trade openness and carbon emissions are negatively linked with agricultural productivity. But the interaction term of financial inclusion with human capital is positively linked with agricultural productivity. *Second*, the Pedroni cointegration test result confirms that a long-run relationship exists among study variables. *Third*, FMOLS and DOLS results confirm that financial inclusion has a positive impact on agricultural productivity in the long run. The findings of this study support the evidence from other studies like Laha, Kuri (2014), Fowowe (2020), Atakli, Agbenyo (2020). This result suggests that expanding formal financial services such as savings, loans, deposits, microfinance, etc., can increase agricultural productivity in the long run in South Asian economies.

The findings have important policy implications for the study countries. South Asian countries can increase agricultural productivity by increasing the coverage of financial inclusion services. South Asian governments and policymakers need to resolve the issues surrounding access to banking services. To bridge the gap in financial services in South Asian countries, the government and other stakeholders in South Asia need to have good quality and quantity financial institutions that are inclusive in nature. This will help in meeting the requirements of farmers, especially in rural communities. Furthermore, to increase agricultural productivity, the government needs to invest more in human capital so that skilled labour with better infrastructure facilities can contribute towards agricultural productivity. Proper policies need to be formulated on physical capital creations, interest rates, trade openness and carbon emissions in ways that will increase agricultural productivity.

Like many other studies, the present study also suffers from some limitations, the non-availability of required data for all countries for important study variables being the major one. The study shows results for the aggregate of all seven South Asian countries. Along with aggregate results, it would be interesting to examine individual countries either with the same method or alternative methods using regional data.

ACKNOWLEDGMENT

We thank the editor-in-chief, co-editor in chief and anonymous reviewers for their useful suggestions and comments, which helped us to improve the quality of the manuscript.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analysed during the study are available in the Financial Access Survey (IMF) and World Development Indicator (2019).

REFERENCES

Agbodji A.E., Johnson A.A. (2019). Agricultural credit and its impact on the productivity of certain cereals in Togo. *Emerging Markets Finance and Trade*, 57(12): 3320-3336. DOI: https://doi.org/10.1080/1540496X.2019.1602038

Alam A., Casero P.A, Khan F., Udomsaph C. (2008). Productivity growth in Eastern Europe and the former Soviet Union. Unleashing Prosperity, The International Bank for Reconstruction and Development and The World Bank, Washington, DC.

Alauddin M., Biswas J. (2014). Agricultural Credit in Bangladesh: Trends, Patterns, Problems and Growth Impacts. *The Jahangirnagar Economic Review*, 25: 126-138.

Asadullah M.M., Rahman S. (2009). Farm productivity and efficiency in rural Bangladesh: the role of education revisited. *Applied Economics*, 41(1): 17-33. DOI: https://doi.org/10.1080/00036840601019125

Atakli B.A., Agbenyo W. (2020). Nexus between Financial Inclusion, Gender and Agriculture Productivity in Ghana. *Theoretical Economics Letters*, 10(3): 545-562. DOI: 10.4236/tel.2020.103035

Awunyo-Vitor D., Al-Hassan R.M., Sarpong D.B., Egyir I. (2014). Agricultural credit rationing in Ghana: what do formal lenders look for?. *Agricultural Finance Review*, 74(3): 364-378. DOI: https://doi.org/10.1108/AFR-01-2013-0004

Baffoe G., Matsuda H., Masafumi N., Akiyama T. (2014). The Dynamics of Rural Credit and Its Impacts on Agricultural Productivity: An Empirical Study in Rural Ghana. *OIDA International Journal of Sustainable Development,* 7(5): 19-34.

Barro R.J., Lee J.W. (2010). *A New Data Set of Educational Attainment in the World, 1950-2010*. NBER Working Paper 15902.

Bashir M.K., Mehmood Y., Hassan S. (2010). Impact of Agricultural Credit on Productivity of Wheat Crop: Evidence from Lahore, Punjab, Pakistan. *Pakistan Journal of Agricultural Sciences*, 47(4): 403-407.

Binswanger H.P., Khandker S.R., Rosenzweig M.R. (1993). How Infrastructure and Financial Institutions Affect Agricultural Output and Investment in India. *Journal of Development Economics*, 41(2): 337-366. DOI: https://doi.org/10.1016/0304-3878(93)90062-R

Blancard S., Boussemart J.P., Briec W., Kerstens K. (2006). Short- and Long Run Credit Constraints in French Agriculture: A Directional Distance Function Framework Using Expenditure-Constrained Profit Functions. *American Journal of Agricultural Economics*, 88(2): 351-364. DOI: https://doi.org/10.1111/j.1467-8276.2006.00863.x

CBSL (2015). Central Bureau of Statistics of the Central Bank of Sri Lanka. Economic and Social Statistics of Sri Lanka 2014; Statistics Department: Colombo, Sri Lanka.

Chandio A.A., Jiang Y., Joyo M.A., Rehman A. (2016a). Impact of area under cultivation, water availability, credit disbursement, and fertilizer off-take on wheat production in Pakistan. *Journal of Applied Environment and Biological Science*, 6(10): 10-18.

Chandio A.A., Yuansheng J., Sahito J.G.M., Larik S.A. (2016b). Impact of formal credit on agricultural output: evidence from Pakistan. *African Journal of Business Management*, 10(8): 162-168. DOI: https://doi.org/5897/AJBM2015.8042

Chandio A.A., Jiang Y., Wei F., Guangshun X. (2018). Effects of agricultural credit on wheat productivity of small farms in Sindh, Pakistan: Are short-term loans better?. *Agricultural Financial Review*, 78(5): 592-610. DOI: https://doi.org/10.1108/AFR-02-2017-0010

Chandio A.A., Jiang Y., Abbas Q., Amin A., Mohsin M. (2022). Does financial development enhance agricultural production in the long-run? Evidence from China. *Journal of Public Affairs,* 22(2): 2342. DOI: https://doi.org/10.1002/pa.2342

Chavan P., Sivamurugan T. (2017). Formal Credit and Small Farmers in India. In book: How to Small Farmers Fare? Chapter: Formal Credit and Small Farmers in India, Publisher: Tulika Books, Edited by Madhura Swaminathan and Sandipan Baksi.

Ciaian P., Falkowski J., Kancs D. (2012). Productivity and credit constraints: A firm-level propensity score evidence for agricultural farms in central and east European countries. *Acta Oeconomica*, 62(4): 459-487. DOI: 101556/AOecon.62.2012.4.3

Cull R., Ehrbeck T., Holle N. (2014). Financial inclusion and development: recent impact evidence. *The Consultative Group to Assist the Poor*, (92): 1-12.

Danish Zhang J., Hassan S.T., Iqbal K. (2019).Toward achieving environmental sustainability target in Organization for Economic Cooperation and Development countries: The role of real income, research and development, and transport infrastructure. *Sustainable Development*, 28(1): 83-90. DOI: https://doi.org/10.1002/sd.1973

Das A., Senapati M., John J. (2009). Impact of Agricultural Credit on Agriculture Production: An Empirical Analysis in India. *Reserve Bank of India Occasional Papers*, 30(2): 75-107.

Djomo J.M.N., Sikod F. (2012). The Effects of Human Capital on Agricultural Productivity and Farmer's Income in Cameroon. *International Business Research*, 5(4): 149-159. DOI:10.5539/ibr.v5n4p149

Danladi J.D., Falaye M.H., Ochinke N.A. (2021). The effect of agricultural financing on agricultural productivity in Nigeria.

Dong F., Lu J., Featherstone A.M. (2012). Effects of credit constraints on household productivity in rural China. *Agricultural Financial Review*, 72(3): 402-415. DOI: https://doi.org/10.1108/00021461211277259

Echevarria P.C. (1998). A Three-Factor Agricultural Production Function: The Case of Canada. *International Economic Journal*, 12(3): 63-75. DOI: https://www.tandfonline.com/doi/abs/10.1080/10168739800000029

Feder G., Lau L.J., Lin J.Y., Luo X. (1989). Agricultural credit and farm performance in China. *Journal of Comparative Economics,* 13(4): 508-526. DOI: https://doi.org/10.1016/0147-5967(89)90024-3

Fowowe B. (2020). The effects of financial inclusion on agricultural productivity in Nigeria. *Journal of Economics and Development*, 22(1): 61-79. DOI: 10.1108/JED-11-2019-0059

Food and Agriculture Organization (FAO) (2022). The future of food and agriculture – Drivers and triggers for transformation. *The Future of Food and Agriculture*, No. 3. Rome.

Fulginiti L., Perrin R. (1993). Prices and Productivity in Agriculture.*The Review of Economics and Statistics*, 75(3): 471-82. DOI: https://doi.org/10.2307/2109461

Guirkinger C., Boucher S.R. (2008). Credit Constraints and Productivity in Peruvian Agriculture. *Agricultural Economics*, 39(3): 295-308. DOI: https://doi.org/10.1111/j.1574-0862.2008.00334.x

Gurley J.G., Shaw E.S. (1955). Financial aspects of economic development. *American Economic Review*, 45(4): 515-538.

Goel S., Sharma R. (2017). Developing a Financial Inclusion Index for India. *Procedia Computer Science*, 122: 949-956. DOI: https://doi.org/10.1016/j.procs.2017.11.459

Goldsmith R.W. (1969). Financial Structure and Development. New Haven Yale University Press, New Haven, CT.

Gyeltshen T. (2012). Formal and Informal Credit Markets in Rural Bhutan. MSc. Thesis in Development Economics Group, Wageningen University, The Netherlands.

Hart J., Milijkovic D., Shaik S. (2015). The impact of trade openness on technical efficiency in the agricultural sector of the European Union. *Applied Economics*, 47(12): 1230-1247. DOI: https://doi.org/10.1080/00036846.2014.993134

Hussein M.H. (2009). State of Microfinance in Bhutan. Prepared for Institute of Microfinance (InM), As part of the project on *State of Microfinance in SAARC Countries*.

Iftikhar S., Mahmood H.Z. (2017). Ranking and relationship of agricultural credit with food security: A district level analysis. *Cogent Food and Agriculture*, 3(1): 1-16. DOI: https://doi.org/10.1080/23311932.2017.1333242

ILO (2015). International Labour Organization. Key Indicators of the Labour Market Database; International Labour Organization: Rome, Italy.

Im S.K., Pesaran M., Shin Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1): 53-74. DOI: https://doi.org/10.1016/S0304-4076(03)00092-7

Iqbal M., Ahmad M., Abbas K. (2003). The Impact of Institutional Credit on Agricultural Production in Pakistan. *The Pakistan Development Review*, 42(4): 469-485. DOI: 10.30541/v42i4IIpp.469-485

Kawagoe T., Hayami Y., Ruttan V.W. (1985). The Inter-country Agricultural Production Function and Productivity Differences among Countries. *Journal of Development Economics*, 19(1): 113-32. DOI: https://doi.org/10.1016/0304-3878(85)90041-0

Khandker S.R., Koolwal G.B. (2015). How has microcredit supported agriculture? Evidence using panel data from Bangladesh. *Agricultural Economics*, 47(2): 157-168. DOI: https://doi.org/10.1111/agec.12185

Kim D.H. (2011). Trade, growth and income. *The Journal of International Trade and Economic Development*, 20: 677-709. DOI: https://doi.org/10.1080/09638199.2011.538966

Kumar A., Singh K., Sinha S. (2010). Institutional credit to agriculture sector in India: Status, performance and determinants. *Agricultural economics Research Review*, 23(2): 253-64. DOI: 10.22004/ag.econ.96935

Kuznets S. (1961). Economic Growth and the Contribution of Agriculture: Notes on Measurement. *Inter-*

national Journal of Agrarian Affairs, 3(2): 20. DOI: 10.22004/ag.econ.229152

Kwakwa P.A., Alhassan H., Adzawla W. (2022). Environmental degradation effect on agricultural development: an aggregate and a sectoral evidence of carbon dioxide emissions from Ghana. *Journal of Business and Socio-economic Development*, 2(1): 82-96. DOI: https://doi.org/10.1108/JBSED-10-2021-0136

Laha A., Kuri P.K. (2013). Financial Inclusion and Agricultural Productivity: Evidence from Rural West Bengal, India. *Journal of Economic Policy and Research*, 8(2).

Lliyasu A.S. (2019). An empirical analysis of the impact of interest rate on agriculture in Nigeria. *Journal of Economics and Sustainable Development*, 10(22): 106-112. DOI: 10.7176/JESD/10-22-19

Lockheed M.E., Jamison D.T., Lau L.J. (1980). Farmer's education and farms efficiency: A survey. *Economic Development and Cultural Change*, 29(1): 37-76. DOI: http://dx.doi.org/10.1086/451231

Looney R.E. (1994). The impact of infrastructure on Pakistan's agricultural sector. *The Journal of Developing Areas*, 28(4): 469-486.

Magazzino C., Mele M., Santeramo F.G. (2021). Using an Artificial Neural Networks Experiment to Assess the Links among Financial Development and Growth in Agriculture. *Sustainability*, 13(5): 2828. DOI: https://doi.org/10.3390/su13052828

Misra R., Chavan P., Verma R. (2016). Agricultural Credit in India in the 2000s: Growth, Distribution and Linkages with Productivity". *Margin-The Journal of Applied Economic Research*, 10(2): 169-197. DOI: https://doi.org/10.1177/0973801015625

Moahid M., Maharjan K.L. (2020). Factors Affecting Farmers' Access to Formal and Informal Credit: Evidence from Rural Afghanistan. *Sustainability*, 12(3): 12-68. DOI: https://doi.org/10.3390/su12031268

Mohapatra R., Sen B. (2013). Technical, allocative in sugarcane production: a nonparametric approach. *International Journal of Advanced Research*, 1(6): 366-374.

Mujtaba A., Pawar S., Joshi D.P.P., Gopinathan R. (2022). Examining asymmetric impact of climatic factors on crop yields in India, *Applied Economics Letters*, 30(11): 1488-1495. DOI: 10.1080/13504851.2022.2064416.

Nakano Y., Magezi E.F. (2020). The impact of microcredit on agricultural technology adoption and productivity: Evidence from randomized control trial in Tanzania. *World Development*, 133(C). DOI: https://doi.org/10.1016/j.worlddev.2020.104997

Narayanan S. (2016). The productivity of agricultural credit in India. *Agricultural Economics*, 47(4): 399-409. DOI: https://doi.org/10.1111/agec.12239

NASA (2016). Rising Carbon Dioxide Levels Will Help and Hurt Crops.

Nathan Associates (2015). The intersection of agricultural and financial markets.

Navin R.E. (1988). Institutional Credit in Bangladesh Agriculture. Columbus, OH: The Ohio State University, *Economics and Sociology Occasional Paper No. 1527*, November 3, p.49.

Nguyen D. (1979). On Agricultural Productivity Differences among Countries. *American Journal of Agricultural Economics*, 61(3): 565-570.

Olaniyi E. (2017). Back to the land: The impact of financial inclusion on Agriculture in Nigeria. *Iranian Economic Review*, 21(4): 885-903. DOI: 10.22059/ier.2017.64086

Omar M.A., Inaba K. (2020). Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. *Journal of Economic Structures*, 9(37). DOI: https://doi.org/10.1186/s40008-020-00214-4

Onoja J.J. (2017). Financial Sector Development and Agricultural Productivity. Master's Thesis. The University of San Francisco.

Park C.Y., Mercado R.V. (2015). Financial Inclusion, Poverty, and Income Inequality in Developing Asia. *ADB Economics Working Paper Series*, No.426.

Pathak B.P. (2010). Review for improving Microfinance services in Bhutan. Microfinance/Agriculture Credit Consultant Kyingkhor Consultancy Services, Thimphu, Bhutan.

Pedroni P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics*, 61(1): 653-670. DOI: https://doi.org/10.1111/1468-0084.0610s1653

Pedroni P. (2001a). Fully modified OLS for heterogeneous cointegrated panels. Nonstationary Panels, Panel Cointegration, and Dynamic Panels. *Emerald Publishing, Bingley*, 93-130. DOI: https://doi.org/10.1016/S0731-9053(00)15004-2

Petrick M. (2004b). A Microeconometric Analysis of Credit Rationing in the Polish Farm Sector. *European Review of Agricultural Economics*, 31(1): 77-101. DOI: https://doi.org/10.1093/erae/31.1.77

Phillips P.C.B.M., Moon H.R. (1999). Linear regression limit theory for nonstationary panel data. *Econometrica*, 67(5): 1057-1111. DOI: https://doi.org/10.1111/1468-0262.00070

Rahman M.W., Luo J., Cheng E. (2011). Policies and performances of agricultural/rural credit in Bangladesh: What is the influence on agricultural production?". *African Journal of Agricultural Research*. 6(31): 6440-6452. DOI: 10.5897/AJAR11.1575

Reimers M., Klasen S. (2013). Revisiting the role of education for agricultural productivity. *American Journal of Agricultural Economics*, 95(1): 131-152. DOI: https://doi.org/10.1093/ajae/aas118

Rigobon R., Rodrik D. (2005). Rule of law, democracy, openness, and income: Estimating the interrelationships. *The Economics of Transition*, 13(3): 533-564. DOI: https://doi.org/10.1111/j.1468-0351.2005.00226.x

SAARC Secretariat (2014). *Best Practices in Poverty Alleviation and SDGs in South Asia: A Compendium*; SAARC Secretariat: Kathmandu, Nepal, 2014.

Saiti B., Afghan M., Noordin N.H. (2018). Financing agricultural activities in Afghanistan: a proposed salam-based crowd funding structure. *ISRA International Journal of Islamic Finance*, 10(1): 52-61. DOI: https://doi.org/10.1108/IJIF-09-2017-0029

Sarker S., Gosh S.K., Palit M. (2015). Role of Banking-Sector to Inclusive Growth through Inclusive Finance in Bangladesh. *Studies in Business and Economics*, 10(2): 145-159. DOI: https://doi.org/10.1515/sbe-2015-0026

Sarma M. (2008). Index of financial inclusion. *ICRIER Working Pape*r No. 215, New Delhi.

Sarma M. (2015). Measuring Financial Inclusion. *Economics Bulletin,* 35(1): 604-611.

Schumpeter J.A. (1934). *The Theory of Economic Development,* Cambridge Harvard University Press.

Sethi D., Sethy S.K. (2019). Financial inclusion matters for economic growth in India: some evidence from cointegration analysis. *International journal of social economics*, 46(1): 132-151. DOI: https://doi.org/10.1108/IJSE-10-2017-0444

Sethy S.K. (2016). Developing a financial inclusion index and inclusive growth in India. *Theoretical and Applied Economic*, 2(607): 187-206.

Sethy S.K., Goyari P. (2018). Measuring financial inclusion of Indian states: An empirical study. *Indian Journal of Economics and Development*, 14(1): 111-118. DOI: 10.5958/2322-0430.2018.00012.4

Sethy S.K., Goyari P. (2022). Financial inclusion and financial stability nexus revisited in South Asian countries: evidence from a new multidimensional financial inclusion index. *Journal of Financial Economic Policy*, 14(5): 674-693. DOI: https://doi.org/10.1108/JFEP-07-2021-0195

Sethy S.K., Goyari P. (2022). Measuring financial inclusion and its present status in South Asian countries. Evidence from a multidimensional Financial Inclusion Index. *Theoretical and Applied Economics*, 3(632): 131-150.

Sethy S.K., Mir T.A., Gopinathan R., Joshi D.P.P. (2023). Exploring the socio-economic attributes of financial inclusion in India: a decomposition analysis. *International Journal of Social Economics*, 50(7): 941-955.. DOI: https://doi.org/10.1108/IJSE-08-2021-0451.

Sethy S.K. (2023). Measuring Financial Inclusion and Its Purpose: A Cross-Country Impact Assessment. *Asian Economics Letters*, 4(Early View). DOI: https://doi.org/10.46557/001c.70299

Sial M.H., Awan M.S., Waqas M. (2011). Role of institutional credit on agricultural production: a time series analysis of Pakistan. *International Journal of Economics and Finance*, 3(2): 126-132.

Shahbaz M., Shabbir M.S., Butt M.S. (2013). Effect of financial development on agricultural growth in Pakistan new extensions from bounds test to level relationships and Granger causality tests. *International Journal of Social Economics*, 40(8): 707-728. DOI: https://doi.org/10.1108/IJSE-01-2012-0002

Schultz T.W. (1980). Schultz, T. W. (1980). Nobel Lecture: The Economics of Being Poor. *Journal of Political Economy*, 88(4): 639-651. DOI: http://dx.doi.org/10.1086/260895

Sidhu R.S., Vatta K., Kaur A. (2008). Dynamics of institutional agricultural credit and growth in Punjab: contribution and demand-supply gap. *Agricultural Economics Research Review*, 21: 407-414. DOI: 10.22004/ag.econ.47891

Stock J.H., Watson M.W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica*, 61(4): 783-820. DOI: https://doi.org/10.2307/2951763

Ulasan B. (2015). Trade openness and economic growth: panel evidence. *Applied Economics Letters*, 22(2): 163-167. DOI: https://doi.org/10.1080/13504851.2014.931914

USAID (2018). Agricultural credit in Afghanistan. Under USAID BPA Call AID-306-BC-15-00005 Agricultural Credit Enhancement II Project, Implemented by the Business Department of American University of Afghanistan.

Vamvakids A. (2002). How Robust Is the Growth-Openness Connection? Historical Evidence. *Journal of Economic Growth*, 7(1): 57-80. DOI: https://doi.org/10.1023/A:1013418610712

Wang S.W., Manjur B., Kim J.G., Lee W.K. (2019). Assessing Socio-Economic Impacts of Agricultural Subsidies: A Case Study from Bhutan. *Sustainability*, 11(12): 1-12. DOI: https://doi.org/10.3390/su11123266

Wang Y., Zhang X., Kubota J., Zhu X., Lu G. (2015). A semi-parametric panel data analysis on the urbanization-carbon emissions nexus for OECD countries. *Renewable and Sustainable Energy Reviews*, (48): 704-709. DOI: https://doi.org/10.1016/j.rser.2015.04.046

World Bank (2007). World Development Report 2008: Agriculture for Development. Washington, DC.

Zakaria M., Jun W., Khan M.F. (2019). Impact of financial development on agricultural productivity in South Asia. *Agricultural Economics – Czech,* 65(5): 232-239. DOI: 10.17221/199/2018-AGRICECON

Zepeda L. (2001). Agricultural investment and productivity in developing countries. *FAO Economic and Social Development paper No.148.*