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Beyond the Fields: Uncovering the Impact of Government Spending on Indian Agricultural Productivity

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Abstract

This study investigates the critical role of government expenditure in fostering agricultural productivity within India over the period 1990-91 to 2020-21. Utilizing data sourced from the national statistical account (GOI) and the World Bank, the analysis employs the Autoregressive Distributed Lag (ARDL) model to examine the dynamic relationship between these variables. Robustness checks are conducted using the Dynamic Ordinary Least Squares (DOLS) method. The empirical findings unequivocally demonstrate a statistically significant and positive association between government expenditure on agriculture and agricultural productivity in both the short and long run. Moreover, the study highlights the crucial contributions of agricultural labor force, gross cropped area, and economic growth in enhancing agricultural productivity. These results underscore the imperative for the Indian government to proactively implement targeted policies and strategies that significantly increase public investment in the agricultural sector. Such a commitment is crucial for ensuring food security, reducing import dependence, bolstering rural incomes, and creating sustainable employment opportunities within the agricultural domain. This research provides valuable insights for policymakers to formulate effective environmental and fiscal policies that maximize agricultural productivity and achieve desired economic outcomes.

Keywords: ARDL model; government expenditure; agricultural labour force; gross cropped area; economic growth and agricultural productivity.

JEL Classification: C87, C52, C32

Introduction

In most emerging nations, the agricultural sector is seen as the main engine of economic growth. As a result, the agricultural sector experiences size and structural changes to adapt to the evolving economic landscape over time (Anwar et al. 2015; Sertogluet al. 2017; Hongdouet al. 2018; Gokmenogluet al. 2018; Ullahet al. 2018; Bansal et al., 2021; Aman, 2023). Beginning around the turn of the 19th century, the size and composition of the Indian agricultural sector and agricultural output began to shift (Onder et al. 2011; Awokuse et al. 2015; Liuet al. 2017; Agboola et al. 2022). By its output capacity, the agriculture industry in India has been contributing significantly to economic growth over the years (Patra et al. 2017; Cagliarini et al. 2011; Mohammed et al. 2020; Baig et al. 2020).Agriculture has been a significant contributor to the Indian economy for centuries, providing livelihoods for millions of people and serving as the backbone of the country's food security (Ceesay et al. 2022). Agriculture is crucial in India's development and growth in the present scenario (Aman, et al. 2023).Agriculture continues to be a critical sector in India's economy, and its importance will likely remain. The government and policymakers need to prioritize the development of the agriculture sector to ensure its continued growth and sustainability.

Government expenditure plays a crucial role in enhancing agricultural productivity in India. Public investments in areas such as irrigation infrastructure, research and development (e.g., developing and disseminating improved seeds, fertilizers, and pest control methods), rural infrastructure (roads, electricity, and market access), and agricultural extension services are critical for boosting farm output and incomes. These investments not only directly improve agricultural productivity but also create an enabling environment for farmers to adopt new technologies, improve their farming practices, and increase their access to markets. Furthermore, government support for agricultural education and skill development empowers farmers with the knowledge and skills necessary to improve their farming practices and increase their productivity. By strategically allocating resources and effectively implementing policies,

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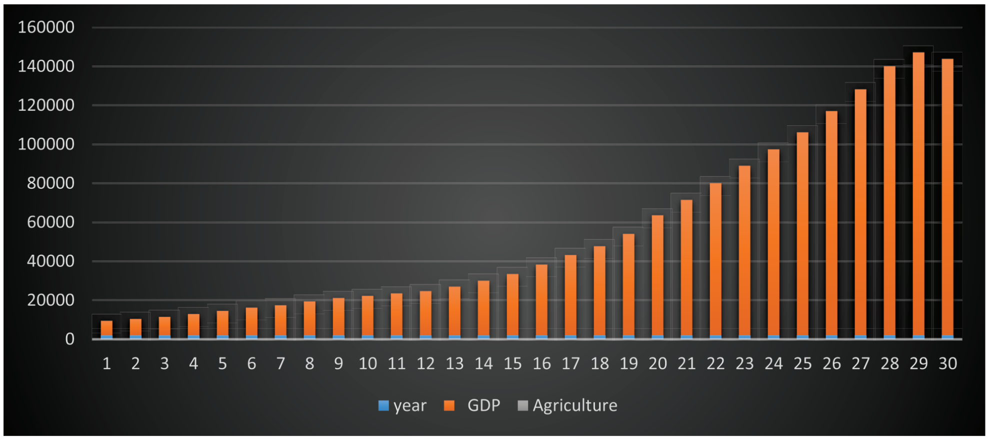

Figure 1: Agriculture Productivity and Economic Growth in India (1990-2020)

the government can significantly contribute to enhancing agricultural productivity and ensuring food security for a rapidly growing population in India.

The intricate interplay between government expenditure on agriculture, agricultural productivity, economic growth, environmental sustainability, and population growth is a critical factor in India's development trajectory. Public investment in agriculture, encompassing areas like irrigation, research and development, rural infrastructure, and agricultural extension services, plays a pivotal role in boosting productivity. Increased productivity leads to higher yields, improved incomes for farmers, and increased food availability, which directly impacts food security and reduces poverty. Enhanced agricultural productivity contributes significantly to overall economic growth by increasing agricultural output, stimulating related sectors like food processing and agro-industries, and generating employment opportunities in rural areas. Sustainable agricultural practices, promoted through government initiatives and investments, are crucial for preserving natural resources, mitigating climate change, and ensuring long-term food security. With a rapidly growing population, India faces the challenge of ensuring food security and meeting the increasing demand for food. Increased agricultural productivity is essential to feed a growing population while minimizing environmental impact.

This complex interplay necessitates a holistic approach to agricultural development that considers the interconnectedness of these factors. Government policies must prioritize sustainable agricultural practices, promote technological advancements, and ensure equitable access to resources and markets to achieve inclusive and sustainable agricultural growth in India.

Against this backdrop, this study delves into the intricate interplay between government expenditure on agriculture, agricultural productivity, economic growth, environmental sustainability, and population growth within the Indian context. The primary objective is to rigorously examine the symmetric impact of government investment in the agricultural sector on agricultural productivity. Recognizing the multifaceted nature of this complex relationship, the study incorporates a comprehensive set of control variables into the econometric framework to ensure robust and reliable findings.

Data Sources and Methodology

This section of the study provides information about the data sources, model-building process, and linear time series modeling. The data on agriculture productivity, government expenditure on agriculture, agricultural labour force and gross cultivated area were retrieved from several issues of National Statistical Accounts(GOI) and the Economic Survey of India from 1990-91 to 2020-21. The data on economic growth is collected from World Development Indicators (World Bank). Since the present study investigates the symmetric effects of government expenditure on agriculture on the agricultural productivity in India. However, we have acclimatized other control variables in the model to achieve efficacious results. The sources of relevant proxies, data and description of variables are presented in table 1. The study period is from 1990-91 to 2020-21 and we have used Eviews-12 software to analyze time series data.

Data, empirical model and methodological strategy

To empirically analyze the role of government expenditure in stimulating agriculture productivity in India. To do this, the present research uses time-series data that covers the period 1990-91 to 2020-21, we have resorted to a neo-classical model popularly known as the Cobb-Douglas production function model as:

$$AGRP_T = \beta 1 + \beta 2GAE_t + \beta 3GCA_t + \beta 4ALF_t + \beta 4EG_t + v_t \quad (1)$$

Where, $AGRP_t$ represents agricultural productivity. GAE_t, GCA_t, ALF_t, & EG_t represents government agriculture expenditure, gross cropped area, agriculture labour force, and economic growth respectively at time t.

Unit Root Test

The stationary test shows the agricultural productivity, government expenditure on agriculture, agriculture labour force, gross cropped area, and economic growth was integrated at I (1) first difference. We estimate Equations 2

Table 1: Description of Variables and data sources.

Name of variable	Variable description	Data source
Government Agriculture Expenditure(GAE)	It includes expenditure incurred by the government of India on agriculture out of the total government expenditure	National Statistical Accounts (Government of India), Economic Survey of India and various Budgetary Reports of government of India.
Gross Cropped Area (GCA)	It is also known as the total sown area, which includes the total area of India that is sown once or more than a year.	National Statistical Accounts (Government of India), Economic Survey of India and various Budgetary Reports of government of India.
Agricultural Productivity (AGRP)	It is calculated as the value addition from farming, hunting livestock production, forestry, and fishing	World Bank national accounts data, and OECD National Accounts data files.
Economic Growth (EG)	It is the total output growth of economy proxies by the GDP per capita.	World Bank national accounts data, and OECD National Accounts data files.
Agricultural Labour Force(ALF)	It is the sum of labour force engaged in agriculture-related activities out of the total working population of India.	National Statistical Accounts (Government of India), Economic Survey of India and various Budgetary Reports of government of India.

Source: *Compiled by authors.*

and 3 to test the integration series' stationary level by applying the augmented Dickey-Fuller (ADF) and the Philips and Perron (PP) tests. The ARDL method accomplishes the mixture of I(0) and I(1), but not I(2); there-fore, the authors pursue this method, and according to Ullah et al. (2021), the series structural breaks can weak and poor stationary performance (Wang et al. 2023). The stationarity test is the early test for testing the unit root issue of the series; ADF and PP are the essential tests of the stationarity, because these tests are applied at the level and first difference form of all variables. The ADF test's lag length is incorporated to tackle the problem of autocorrelation and robustness. The ADF equation is presented as follows:

$$\Delta T_t = \varphi_0 + \varphi T_t + \sum_{i=k}^{OP} w_i \ \Delta T_{t-1} + \varepsilon_t \tag{2}$$

Where Δ denotes the operator of the first difference, Tt shows the time dimension, Ψ0 explores the intercept term, OP illustrates the maximum lag length on the explained series, and the term ε shows the white noise random error term. The ADF unit root approach of the stationary provides the increasing the statistical distribution of ADF. Moreover, the PP test equation is presented in Equation 3 as follows:

$$\Delta T_t = \pi + S^{*} T_{t-1} + \varepsilon_t \tag{3}$$

The Philip and Perron unit root test is also the stationary approach linked with statistics by calculating the S∗ test statistics coefficient value.

Autoregressive Distributed Lag Model (ARDL) of Cointegration

While bridging the relationship between agriculture productivity, government agricultural expenditure, agricultural labour force, gross cropped area and economic growth, we have several time series econometric models at our disposal. However, we relied on Autoregressive Distributed Lag (ARDL) Model is an ordinary least square (OLS) regression which is developed in 1991 by Pesaran and Shin. This model is advantageous over the previous models because the model uses a combination of both endogenous and exogenous variables. It determines the short-run and long-run coefficients and does not demand the same integration order. The standard form of the auto-regressive distributive lag (ARDL) model is:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_1 y_{t-2} + \cdots \beta_p y_{t-p} + a_0 x_t + a_1 x_{t-1} + \cdots + a_q x_{t-q} + \varepsilon_t \tag{4}$$

Where ε_t is the white noise error term.

Equation (5) can be represented in ARDL form as:

$$\ln AGRP_t = \alpha_1 + \sum_{i=1}^{p} \alpha_2 \ln AGRP_{t-j} + \sum_{i=1}^{q} \alpha_3 \ln GAE_{t-i} + \sum_{i=1}^{r} \alpha_4 \ln GCA_{t-i} + \sum_{i=1}^{s} \alpha_5 \ln ALF_{t-i} + \sum_{i=1}^{u} \alpha_6 \ln EG_{t-i} + \rho_1 \ln AGRP_{t-1} + \rho_2 \ln GAE_{t-1} + \rho_3 \ln GCA_{t-1} + \rho_4 \ln ALF_{t-1} + \rho_5 \ln EG_{t-1} + v_{1t} \tag{5}$$

Where, p, q, r, s, and u are the suitable lag length, α_1, α_2, α_3, α_4, α_5&, $\alpha_6$are the short-run coefficients, while, ρ_1, ρ_2, ρ_3, ρ_4, and ρ_5 show the long-run coefficients of independent variables. The error term is represented by ν.

Dynamic Ordinary Least Square (DOLS) Model

The Dynamic Ordinary Least Squares (DOLS) method, pioneered by Stock and Watson (1993), is a robust single-equation approach specifically designed to address the challenges of endogeneity in cointegrated regressions. This technique mitigates the bias arising from correlated errors and the presence of serially correlated regressors by incorporating both leads and lags of the first differences of the endogenous regressors into the regression equation. By augmenting the standard regression model with these dynamic terms, DOLS effectively controls for short-run dynamics and improves the efficiency of the long-run parameter estimates. This approach offers a significant advantage over traditional Ordinary Least Squares (OLS) and Maximum Likelihood methods, particularly in situations where the assumption of strict exogenity of the regressors is violated.The standard form of a single-equation Dynamic Ordinary Least Squares (DOLS) model, as proposed by Stock and Watson (1993), can be expressed as:

$$y_t = \alpha_0 + \beta_1 X_t + \sum_{i=-p}^{p} \gamma_i \Delta X_{t=i} + \varepsilon_t (4)$$

Where, is the dependent variable at time t.is the endogenous regressor at time t.

represents the first differences of the regressor X at time t+i, where 'i' ranges from -p to p, capturing both leads and lags of the differenced regressor.α is the intercept term.β is the coefficient of interest, representing the long-run relationship between and . are the coefficients associated with the differenced regressors. is the error term.

This formulation effectively addresses endogeneity issues by including leads and lags of the differenced regressor, thereby controlling for potential feedback effects and improving the efficiency of the estimates.

Results and Discussion

ADF and PP unit root tests are employed to check the stationarity properties of variables of interest. However, all the selected variables are following the stationary property at the first integration order I(1). Moreover, the results are mentioned in Table 2.

The ARDL Cointegration bound test result is shown in Table 3. The F-test value of 7.87 is significant at a 1% level and confirmed the rejection of the null hypothesis of no Cointegration and is accepted as the alternative hypothesis which indicating the long-run association exists between the government expenditure on agriculture, agriculture productivity, agricultural labour force, gross cropped area, and economic growth in the case of India.

After the long-run relationship is established, all the independent variables' short-run and long-run coefficients are estimated, as displayed in table 4.The long-run standard ARDL results show a significantly positive relationship between agricultural productivity and government expenditure on agriculture in the Indian economy. It implies that the government spending on the agriculture sector in India improves the productivity of the said sector. The findings reveal that a unit increase in government spending on agriculture increases the agricultural productivity by 0.25 units. Our results are consistent with the study of Selvaraj(1993); Benin (2011); Lencucha et al. (2020), Ernawati et al. (2021). The control variables, including agriculture labour force, gross cropped area and economic growth, positively affect the agricultural productivity in India. One percent increase in the agriculture labour force, gross cropped area, and economic growth raise agricultural productivity by 0.47 percent, 0.53 percent, and 0.56 percent, respectively.

Table 2: Unit root test Results

Variables	ADF-Test		PP-Test		OI
	Level	First Difference	Level	First Difference	
AGRP	-0.6436	-7.3455***	-0.5432	-6.5757***	I(1)
GAE	-0.5777	-5.4857***	-1.1745	-6. 7675***	I(1)
ALF	-0.4654	-4.4523***	-1.4554	-4.4756***	I(1)
GCA	-0.7876	-6.7866***	-08675	-6.6867***	I(1)
EG	-1.5557	-1.3249***	-1.5244	-1.7876***	I(1)

Note: *OI: Order of integration; AGRP: Agricultural Productivity; GAE: Government Agriculture Expenditure; ALF: Agriculture Labour Force; GCA:Gross Cropped Area; EG: Economic Growth. However, *** denotes the significance level of 1 per cent.*

Table 3: Results of ARDL bound test.

	Lower bound	Upper bound	F-statistic value	Remark
Sig.	I(0)	I(1)		
10%	5.33	6.43	7.87***	Cointegration exists
5%	4.42	5.35		
2.5%	3.46	4.95		
1%	2.76	3.45		

*Source: compiled and calculated by authors; Note: *** denotes the significance level of 1%.*

Table 4: Results of ARDL Model (Long-run)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAE	0.2545	0.2655	0.9585	0.0000
ALF	0.4764	0.3216	1.4811	0.0063
GCA	0.5321	0.3865	1.3766	0.0012
EG	0.5674	0.2585	2.1947	0.0340
Constant	0.7454	1.5754	0.4731	0.0001

Source: *Compiled by authors.*

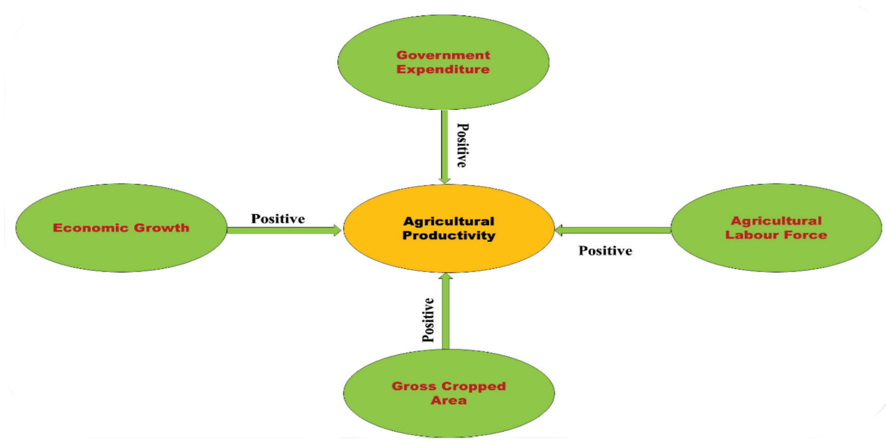

Figure 2.Graphical presentation of findings of long-run estimation.

Table 5 shows that the variables, including government expenditure on agriculture, agriculture labour force, and gross cropped area, stimulate agricultural productivity in India even in the short run. Although, the coefficient of economic growth is positive, but insignificant in the short run, as reported in Table 5. The error correction term (ECT) value is negative and significant with a coefficient of 0.55. It implies that 55 percent of the deviation is corrected within one year. Further, diagnostic tests were conducted to check the stability of the model. The results of diagnostic tests are mentioned in Table 6 and Figure 1 below.

The heteroscedasticity tests, serial correlation tests, and CUSUM tests confirm that our model is stable and reliable, and the inferences of the model can be used for policy formulation.

Robustness Checking

The DOLS model was used to test the robustness of the ARDL model. According to the DOLS model, all the variables show a significant positive relationship with economic growth in India.

Therefore, it is confirmed that the applied model ARDL in the study is fit to explain government spending on agriculture stimulates India's agricultural productivity. Further, it showed that the expenditure, agriculture labour force, gross cropped area and economic growth coefficient of received positively correlated with agricultural productivity in India. Thus, all the statistics results of the DOLS model show that the ARDL model is correctly specified and estimated the results.

Table 5: Results of ARDL (Short-run)

Variable	Coefficient	Std. Error	t-Statistic	p-value
D(GAE)	0.0210	0.0552	0.3804	0.0003
D(ALF)	0.1021	0.2213	0.4613	0.5646
D(GCA)	0.0102	0.2446	0.0417	0.0021
D(EG)	0.0211	0.4442	0.0475	0.8564
CointEq(-1)*	-0.5578	0.2217	-2.5160	0.0001

Source: Compiled by authors.

Table 6: Results of Diagnostic Tests.

Test	F-statistic	Prob.
Heteroscedasticity Test: Breusch-Pagan-Godfrey	0.5441	0.7597
Breusch-Godfrey Serial Correlation LM Test:	0.4964	0.8563

Source: *Computed and calculated by authors.*

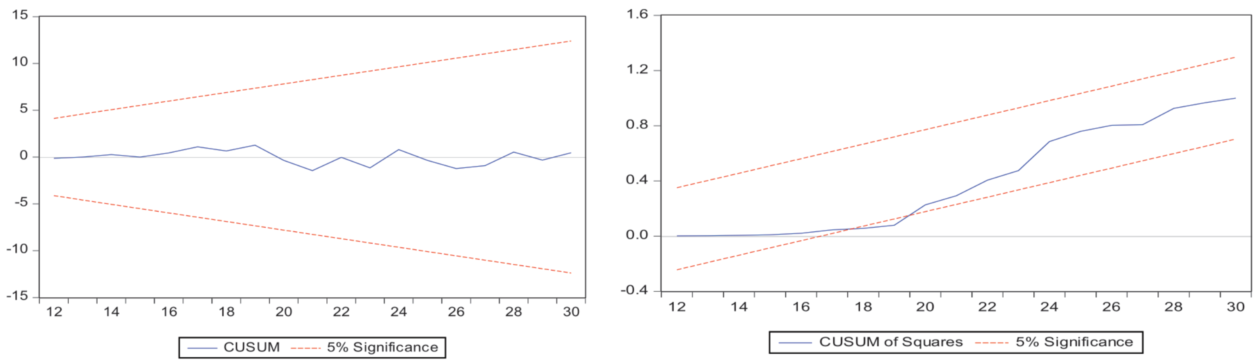

Figure 3. CUSUM and CUSUMSQ plots

Table 7: DOLS Model (for robustness checking)

Variable	Coefficient	Std. Error	t-Statistic	P-value
GAE	0.2545	0.1655	0.8585	0.0000
ALF	0.3764	0.1216	0.9815	0.0003
GCA	0.3421	0.1875	0.9986	0.0002
EG	0.4684	0.1587	1.1847	0.0040
Constant	0.7454	0.2754	0.9731	0.0001

Source*: computed by authors.*

Conclusion and Policy Implications

The present study investigates the effects of government spending on the agriculture sector on agriculture productivity in India in the post-reform period. The study has also incorporated several control variables, including agriculture labor force, gross cropped area, and economic growth, to get robust results. Since the study is based on the time series data of the Indian economy that spans from 1990-91 to 2020-21, we employed an advanced time series ARDL model. The ARDL bounds test validated the Cointegration relationship among the variables of interest. The empirical results of the model show a significantly positive relationship between agricultural productivity and agricultural spending in both the short and long run. The determinants of agricultural productivity, including agricultural labour force, gross cropped area, and economic growth, positively affect the long-run productivity of the agriculture sector in India. The study's findings devise several policy recommendations for the government of India. Since, India's agricultural sector's productivity is low compared to several developed and developing nations of the world. There exists a greater need for public spending in the agriculture sector. By investing in infrastructure, research and development, subsidies, credit facilities, and insurance schemes, the government can help farmers improve their productivity, increase their income, and contribute to the country's overall development. India must focus on strategies to promote agricultural productivity to meet the growing demand for food, reduce dependence on imports, increase rural incomes, and create employment opportunities in agriculture.

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