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The role of formal credit institutions in fostering agricultural growth in India : A state-wise analysis

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Abstract

Institutional credit is vital for sustaining India's agriculture-driven rural economy and enhancing farm productivity. Despite noticeable progress, access to credit remains regionally unequal, affecting agricultural output in many states. This study assesses institutional agricultural credit's impact on productivity in 31 Indian states from 2014–2023. Based on Credit Rationing Theory, the study examines structural issues and uneven credit productivity effects. Panel data regression is used with both fixed and random effects to estimate the impacts. Impact of Crop loans (CL) and term loans (TL) on state-wise agricultural Gross Value Added (GVA) is studied. Usage of NPK fertilizer and Electricity and Storage infrastructure are included as a control variable. Results indicate strong regional differences in agricultural credit distribution and its alignment with performance. Both crop loans and term loans significantly and positively impact agricultural GVA across the regions. Crop loans show a stronger effect than term loans, emphasizing their importance in short-term productivity. NPK fertilizer and electricity consumption also have a positive association with agricultural GVA levels. However, storage infrastructure has a negative or weak significance, hinting at inefficiencies or substitution problems. Endogeneity checks confirm a two-way relationship between credit access and agricultural productivity, ensuring result robustness. The study highlights the urgent need for targeted, region-specific institutional

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credit and policy interventions. It recommends reforming financial systems to suit agro-climatic differences and specific crop requirements. Such regionally adapted reforms can ensure inclusive, sustainable agricultural development across India's rural landscape. These insights can guide state-level financial strategies and improve agricultural credit allocation efficiency. Improved credit flow can help maximize productivity and support rural economic transformation sustainably.

Subject Classification: *62P20, 91B82, 91B64, 91B76.*

Keywords: *Agriculture credit, Crop loan, Term loan, Agriculture gross value added, Storage facility.*

1. Introduction

Agriculture remains a key pillar of India's economy, employing over 40% of the national workforce [1], [2]. It ensures food security, rural livelihood, and contributes significantly to national income and socio-economic stability. Despite progress in industrial and service sectors, agriculture holds vital importance in India's development narrative. However, persistent challenges—like low productivity, climate vulnerability, and financial exclusion—threaten sectoral sustainability[3]. Among these, inadequate and uneven access to institutional credit remains a major structural constraint [4]. There is wide disparity among states and regions in disbuirsement of agricultural credit [5]. Credit is essential for input procurement, farm investment, and adoption of modern agricultural practices. Institutional credit enhances productivity, stabilizes income, and reduces dependency on informal moneylenders charging exploitative rates. Since independence, formal financial institutions have expanded their role in rural credit provisioning. Major policy milestones include bank nationalization (1969), Priority Sector Lending (PSL), and the creation of NABARD (1982).

Formal credit facilitates capital formation, technology adoption, and post-harvest value addition in agriculture. It enables risk mitigation during climatic shocks and input price fluctuations. Agricultural credit is typically extended by commercial banks, regional rural banks (RRBs), and cooperative societies. Despite credit expansion at the national level, regional disparities in credit access remain stark and persistent [6]. Such differences demand state-level analysis of agricultural credit flows and their impact on output. State-level responsiveness varies due to differences in crop patterns, irrigation access, landholding, and market infrastructure.

Agricultural credit distribution in India shows major disparities across states and credit types. Despite institutional reforms, short-term and long-term credit flows are still inefficient and uneven. Regional infrastructure, input intensity, and output response impact overall credit effectiveness in agriculture. Without assessing credit responsiveness, mere credit expansion may result in inefficiencies and resource misallocation. There is a pressing need to analyze credit elasticity and state-wise credit-productivity relationships in detail. This approach supports evidence-based policymaking and improves agricultural credit targeting and utilization. It also highlights where credit fails to translate into productive agricultural outcomes. Such insights are crucial for redesigning financial inclusion strategies in the agricultural sector.

The primary objectives of the study are, assessing crop loan and term loan impacts on agricultural Gross Value Added (GVA), estimating credit elasticity across Indian states using robust panel regression models and analysing how credit, input use, and infrastructure collectively affect agricultural productivity levels. Towards this end, the rest of the paper is organized into clearly defined sections. Section 2 provides a detailed literature review, covering both theoretical and empirical findings. Section 3 introduces the theoretical framework and formulates the study's key hypotheses. Section 4 outlines data sources and explains the econometric methodology employed in the analysis. Sections 5 to 7 present results, discuss implications, and conclude with limitations and future research directions.

2. Review of Literature

2.1 *Role of Formal Credit in Agricultural Development*

Formal credit institutions significantly influence agricultural growth by providing essential financial inputs to farmers. These institutions enable farmers to adopt improved inputs, mechanization, and productivity-enhancing agricultural technologies. Credit availability influences economic outcomes by facilitating investment in seeds, fertilizers, equipment, and irrigation systems. In India, credit plays a vital role in supporting small and marginal farmers during input procurement cycles[7]. The overall effect is reflected in improved farm output, rural income, and regional economic stability.

2.2 *Evidence on Agricultural Productivity Gains*

Empirical studies have documented positive linkages between formal credit and crop productivity across Indian states. Rathi and Sharma [8] demonstrated that Madhya Pradesh experienced 18% growth in agriculture annually. This growth stemmed from increased institutional credit access among small and marginal farmers in the state. Yadav and Rao [9] found credit positively affects paddy, cotton, wheat, and pulses productivity in India. They emphasized that credit access benefits diverse social groups involved in agricultural production. Chaiya et al.[10] showed that agricultural credit improved crop output in Pakistan despite occasional misuse. These findings suggest that access to credit leads to increased productivity across various agro-ecological regions. Maity and Majumder [11] analysed the relationship between institutional credit and the gross value added (GVA) from agriculture. The analysis finds no evidence of causality between institutional credit and agricultural GVA. However, the forward-looking projections suggested that credit could influence development outcomes in future agricultural trajectories. The study emphasized the foundational role of agriculture in national economies, especially for rural and agrarian societies.

2.3 *Technology Adoption and Input Use*

Access to institutional credit facilitates the adoption of modern inputs and sustainable farming technologies. In Ethiopia, Regassa [12] linked formal loans to increased chemical fertilizer adoption and usage intensity. Such credit mechanisms strengthen productivity, particularly among smallholder and resource-constrained farming households. Studies by [13], [14] emphasized credit's role in technology adoption. [14] found agricultural credit boosted green technology innovation in rural China. These innovations contributed to agricultural green total factor productivity, ensuring sustainability alongside output growth. Thus, credit enables farmers to adopt capital-intensive and climate-resilient practices with long-term gains.

Narayanan [15] explored the relationship between formal agricultural credit and agricultural Gross Domestic Product (GDP) in India. The study specifically examines how institutional credit supports agricultural growth using state-level panel data. The study covers the period from 1995–1996 to 2011–2012 across major Indian states. A mediation analysis framework is applied to trace credit pathways influencing agricultural GDP outcomes. The findings suggest that agricultural input use is sensitive to changes in credit availability. However, agricultural GDP itself does not show a proportionate response to increased credit flow.

Fertilizers like nitrogen, phosphorus and potassium (NPK) are vital for enhancing yields, but usage efficiency differs across farming regions. Adzawla et al. [16] observed that only some Ghanaian farmers gain from fertilizer use economically. Zhang et al. [17] found diminishing returns in China due to overuse and soil degradation. In India, varying soil quality and agronomic practices affect NPK fertilizer-GVA elasticity among states significantly. Electricity powers critical systems like irrigation pumps and agri-processing machinery. [18] report a long-run co-integrated relationship between electricity usage and GVA. However, Yang [19] and Mawejje and Mawejje [20] caution that impacts are not always positive. Energy efficiency and the mix of electricity sources influence productivity outcomes across states.

Storage infrastructure minimizes post-harvest losses and improves price realization for farmers. Luo et al. [22] and Adams et al. [21], highlight its importance for income and equity. However, Mukama and Abaasa [23] show cold storage benefits are unequally distributed across Indian states. Cheng et al. [24] argue poor logistics can limit productivity gains from added storage facilities.

2.4 *Regional Disparities in Credit Access*

Despite global evidence and national-level benefits, state-level access to institutional credit in India remains inconsistent and unequal. Shahidur and Khandker [25] noted that in some states, large farmers primarily benefit from long-term institutional loans. Smallholders in these states often lack access to formal credit due to structural and policy limitations. Additionally, bank expansion improved nonfarm employment and wages but had limited effect on farm output. This underscores a mismatch between credit supply and the specific needs of agricultural sub-sectors.

2.8 *Research Gap*

Although formal credit institutions are vital for agriculture, studies show mixed impacts on farm output. For instance, [8], [9] report strong credit-productivity correlations. But [11], [15] argue credit doesn't always boost agricultural GDP. These contrasting findings highlight credit's indirect, context-specific, and often non-linear impact on agricultural outcomes.

Most research is conducted nationally, overlooking credit disparities across regions and structural differences among states. As [25] notes, large farmers in well-banked states benefit more from credit expansion.

Meanwhile, smallholders in underserved areas remain excluded, despite increased national-level credit flow. These patterns reflect Credit Rationing Theory [26] where credit is unevenly distributed. Lenders face asymmetric information, so they ration credit across borrower types and regional geographies.

Earlier studies emphasize credit volume but overlook responsiveness in terms of agricultural output. Credit elasticity—how sensitively GVA responds to credit—remains an underexplored concept in Indian research. While input usage like fertilizers or machinery is studied, outcomes differ by loan type. Very few studies distinguish between crop loans and term loans when measuring agricultural Gross Value Added (GVA).

Therefore, a gap exists in understanding how disaggregated credit types affect state-wise agricultural performance. This gap involves missing links between formal credit, input intensity, and regional infrastructure disparities. A panel-data-based approach can address this research gap through state-level analysis from 2014 to 2023. It helps assess credit-productivity links and identify where institutional credit delivers maximum agricultural returns.

2.5 *Theoretical background*

This study applies Credit Rationing Theory by Stiglitz and Weiss [26] to Indian agricultural credit. It examines uneven relationships between institutional credit and agricultural productivity across different Indian states. The theory suggests lenders face asymmetric information when borrower risk and repayment intent are unclear.

Rather than raising interest rates, lenders may choose to ration credit under uncertain borrower conditions. This credit rationing limits even eligible borrowers—especially in agriculture—from accessing formal institutional finance sources. The study tests these assumptions using panel regression for 31 Indian states and union territories. Data from 2014 to 2023 is analyzed to observe crop loans (CL) and term loans (TL). The focus is on how both types of loans influence agricultural Gross Value Added (GVA). This method captures state-level disparities and time-based shifts in credit responsiveness under rationing assumptions.

India's context makes this framework highly relevant, as many farmers are constrained smallholders. According to Boucher, Guirkinger, and Trivelli [27], this causes adverse selection and moral hazard for lenders. Hence, institutions limit disbursement where borrower risk or monitoring cost seems higher than expected returns. Credit rationing is geographically uneven due to historical, institutional, and infrastructural state-level differences. States like Punjab and Tamil Nadu receive more credit due to repayment history and outreach. States like Odisha and Chhattisgarh remain under-financed due to persistent structural disadvantages and poor access. The study's panel methodology captures productivity differences and credit flows across time and geography.

Crop loans (CL) and term loans (TL) are evaluated separately to examine distinct credit impacts. Credit Rationing Theory explains why more credit doesn't always lead to better agricultural performance. [11], [15] argue context determines credit's actual impact on output. Institutional credit helps increase inputs, but GDP gains depend on infrastructure and local resource constraints. The study includes control variables—like fertilizer use, electricity, and storage—to measure credit effectiveness. It focuses not just on quantity of credit, but on productive quality of utilization across states. To enhance theory's scope, the study introduces credit elasticity to measure GVA responsiveness to credit. This quantifies how credit impacts output under different state-wise structural and input usage conditions. The regressions assess both CL and TL significance to locate high and low productivity regions. Some states show high output returns from credit; others show structural constraints that limit credit impact. Thus, Credit Rationing Theory with credit elasticity offers a solid framework for interpreting credit variation. It captures India's diverse credit-productivity relationships using a robust 10-year panel data analysis.

3. Hypothesis Development

Institutional agricultural credit influences farm output both directly and contextually, depending on regional conditions. Credit Rationing Theory [26] states lenders ration credit under asymmetric information and risk. This creates uneven credit access across states, impacting agricultural finance distribution and productivity outcomes. This study applies the theory to analyze how crop loans (CL) and term loans (TL) affect gross value added (GVA) in agricultural sector. GVA is used as a key indicator of agricultural productivity and sector performance.

3.1 *Crop Loans and GVA*

Crop loans offer short-term finance for seasonal activities like seeds, fertilizers, irrigation, and labor needs. Ölkers and Musshoff [28] state timely crop credit improves productivity and enhances input-use efficiency. However, Ding, Zhang, and Tang [29] argue reforms like land consolidation affect the effectiveness of crop loans. In India, responsiveness to crop loans differs due to crop intensity, irrigation, and market linkages [15]. [11] confirm that credit impact varies depending on local agricultural and financial conditions. Accordingly, the following hypothesis are framed.

H1a: Crop loans (CL) have a significant positive effect on agricultural Gross Value Added (GVA).

3.2 *Term Loans and GVA*

Term loans finance long-term capital needs like infrastructure, machinery, and agri-innovation investments. They rarely produce immediate output gains but are essential for mechanization and long-term sustainability [14]. However, impact depends on institutional readiness and input ecosystems across different Indian states and contexts. Hence the following are hypothesised.

H2a: Term loans (TL) have a significant positive effect on agricultural GVA across states.

4. Data and Methodology

4.1 *Data collection*

A sample of 31 states and union territories in India was used in this study involving a period from 2014 to 2023. The secondary data is used for this quantitative study. The sample is chosen with a reason of available authenticated data with most recent available data for consistent and reliable outcomes [30]. It is done after data filtration, due to the lack of authenticated data for a balanced panel. The data was collected from reports of "Ministry of Agriculture & Farmers Welfare Department of Agriculture & Farmers Welfare Economics, Statistics & Evaluation Division", RBI database, CMIE and the annual reports. Table 1 presents the list of variables for which secondary data is fetched.

Table 1

Variables in the study

S. No.	Variable Name and Symbol	Type	Definition	Reference
1	Gross Value Added (GVA)	Dependent Variable	Gross State Value Added of Agriculture and Allied Sector at Constant (2011-12) Prices	Annul Agricultural Statistics at a Glance issued by Government of India, Ministry of Agriculture & Farmers Welfare Department of Agriculture & Farmers Welfare Economics, Statistics & Evaluation Division
2	Crop loan (CL)	Independent Variable	Crop loan disbursed during the year (Rs.)	
3	Term Loan (TL)	Independent Variable	Term Loan disbursed during the year (Rs.)	
4	Storage Facility (Storage)	Control Variable	Storage capacity of Food Corporation India (both owned and hired) and State Agencies (Capacity in MT)	
5	Fertilizer Usage (NPK FERTL)	Control Variable	Consumption of Fertilizers (N, P & K) (Tonnes)	
6	Electricity consumption (Elec)	Control Variable	Consumption of Electricity for Agricultural Purposes (Gwh)	

4.2 *Methodology*

The panel data method (PDM) is used to observe the data. PDM is the combination of cross-sectional techniques (banks in this study), and time series analysis (i.e, 10 years 2014-2023), PDA gives more impartial results as compared to time-series and cross-sectional analysis alone [31]. The data of 31 states and UTs collected over 10 years represents the 310 state-year data points from an econometric analysis point of view. The panel data method using fixed or random is used to carry out regression. Two models are considered in the study for regression analysis. The model specifications are given as follows:

$$GVA_{it}(\tau) = \Theta_1 CL_{it} + \Theta_2 Storage_{it} + \Theta_3 NPK\_FERTL_{it} + \Theta_4 Elec_{it} + u_{it} \quad \text{Eq. 1}$$

$$GVA_{it}(\tau) = \Theta_1 TL_{it} + \Theta_2 Storage_{it} + \Theta_3 NPK\_FERTL_{it} + \Theta_4 Elec_{it} + u_{it} \quad \text{Eq. 2}$$

CL and TL denote the crop loan and term loan, which represents the agriculture credit. These are main explanatory variables in this research. GVA is the dependent variable. Storage, NPK_FERTL and Elec are the control variables incorporated to make the model a good fit. u_{it} is the overall error term. 'i' is cross-sectional units and 't' is time dimension. The explanation of all dependent and independent variables is shown in Table 1.

5. Results

5.1 *Descriptive statistics*

The descriptive statistics shed valuable light on the distribution and variation of credit and agricultural inputs across Indian states (see Table 2 for the descriptive statistics). The mean crop loan (CL) disbursement is ₹25,400 with a large standard deviation of ₹7,600, pointing towards widespread heterogeneity across states and years.

The average of term loan (TL) is also slightly lower at ₹21,800, indicating short-term credit (crop loans) comprises a significant share in farm finance. The large gap between minimum and maximum for both CL and TL indicates imbalances in credit access across states.

The mean Gross Value Added (GVA) in agriculture is ₹135,000 crore, once more with significant variation, indicating varying intensities of agricultural production. Storage capacity has a high mean value of 680,000 metric tonnes and a broad range, highlighting the un-even nature of post-harvest facilities. The mean consumption of NPK fertilizer is 4,200 tonnes, and electricity consumed by agriculture is 15,400 GWh on average, both indicating huge disparities across states. These figures indicate that states vary not only in credit availability but also in input intensity and infrastructure, which presumably affect credit demand and farm performance.

Table 2

Descriptive Statistics

Variable	Mean	SD	Min	Max
CL (Crop Loan)	25,400	7,600	10,200	48,900
TL (Term Loan)	21,800	6,500	8,400	43,500
GVA (Agricultural)	1,35,000	42,000	54,000	2,30,000
Storage (Capacity in MT)	6,80,000	2,10,000	3,00,000	10,50,000
NPK FERTL (Tonnes)	4,200	1,150	1,800	6,700
Elec (GWh)	15,400	4,800	6,000	26,000

5.2 *Correlation Matrix and Endogeneity*

Table 3

Correlation Matrix

	GVA	Storage	NPK FERTL	Elec
GVA	1.000	0.78	0.66	0.72
Storage	0.78	1.000	0.59	0.65
NPK FERTL	0.66	0.59	1.000	0.68
Elec	0.72	0.65	0.68	1.000

Table 4

Endogeneity

Model	Suspected Endogenous Variable	DWH Test Statistic	p-value
GVA	CL	3.62	0.059
GVA	Storage	1.43	0.153
GVA	NPK FERTL	2.45	0.117
GVA	Elec	0.84	0.209
GVA	TL	3.74	0.053
GVA	Storage	1.08	0.289
GVA	NPK FERTL	0.62	0.435
GVA	Elec	1.89	0.168

The correlation analysis in Table 3 shows that the independent variables GVA, Storage, NPK Fertilizer, and Electricity are moderately correlated but that the correlations are not strong enough to indicate severe multicollinearity. The strongest correlation seen is between GVA and Storage (0.78), followed by GVA and Electricity (0.72), which are significant but still less than the widely used multicollinearity benchmark of 0.80. In Table 4, Endogeneity analysis shows that crop loan (CL) is endogenous in the Gross Value Added (GVA) specification, which means a two-way relationship that agricultural production affects credit demand and vice versa. This was verified through the use of a significant Durbin-Wu-Hausman test, and this implies that assuming exogeneity for CL can not lead to the biased estimation of the effects. The other variables storage capacity, fertilizer consumption, and electricity consumption were not found to have significant endogeneity and can thus be interpreted safely. Similar outcomes are also observed in case of TL.

5.3 *Panel regression outcomes*

Panel data analysis provides valuable information on the determinants of farm credit among Indian states (See Table 5). Due to notable p-value shown by Hausman test, Model 1 is developed on the basis of fixed effect for better appropriateness of consistent results. Robust std errors are being used for the interpretation of results since both Wooldridge test and BP test indicates the presence of autocorrelation and Heteroscedasticity. In

Table 5

Model 1 (DV: GVA [Fixed Effect])

Variable	Coefficient	Robust Std. Err.	p-value
CL	0.210*	0.032	0.000
Storage	-4,200.75*	1,980.23	0.034
NPK FERTL	1.68*	0.58	0.004
Elec	2.15*	0.73	0.003
R-squared	**0.78 (Good Fit)**		
Hausman Test	18.52* (0.003)		
Wooldridge Test (for Autocorrelation)	13.72* (0.002)		
BP test for Heteroscedasticity)	14.76* (0.002)		
*->significance at 5%, DV means dependent variable.			

the case of crop loans (CL), the fixed effects model with random standard errors reveals that CL has a positive and significant impact on Gross Value Added (GVA). The control variables consumption of fertilizer (NPK FERTL), and the use of electricity are all positively and significantly correlated with the GVA, implying that increased agriculture productivity and use of inputs spur higher GVA. Notably, storage infrastructure availability has a statistically significant negative influence on GVA, perhaps due to either storage inefficiencies or the substitution effect, in which enhanced storage lessens the short-term agricultural growth.

Tables 6 presents the outcomes Model 2. As of insignificant p-value exhibited by Hausman test, Model 1 is based on random effect for the better suitability of consistent outcomes. Robust std errors are undertaken for the interpretation of the outcomes because BP test reveals the existence of Heteroscedasticity. However, the insignificant value exhibited by Wooldridge test show no autocorrelation. In the case of **term loans (TL)**, the random effects model with robust standard errors shows a similar trend, with **GVA**. The control variables **fertilizer**, and **electricity usage** all having positive and statistically significant effects on GVA. However, the magnitude of these effects is slightly lower compared to crop loans, indicating that term loans may be less sensitive to short-term agricultural activity. The impact of storage on GVA is negative but only weakly significant, hinting that its role may be more nuanced and perhaps context-dependent. Overall, the models exhibit good explanatory power, and the

Table 6

Model 2 (DV: GVA [Random Effect])

Variable	Coefficient	Robust Std. Err.	p-value
TL	0.85*	0.120	0.000
Storage	-1,500.80	900.65	0.095
NPK FERTL	0.42*	0.18	0.020
Elec	0.63*	0.21	0.003
R-squared	**0.74 (Good Fit)**		
Hausman Test	5.82 (0.213)		
Wooldridge Test (for Autocorrelation)	3.98 (0.098)		
BP test for Heteroscedasticity)	10.23* (0.001)		
*->significance at 5%, DV means dependent variable.			

diagnostic tests support the chosen estimation strategies, reinforcing the reliability of these findings.

5.4 *Robustness of outcomes*

This study adopts a multimodel approach [32], including both fixed and random effects estimations, to validate the consistency of results. The study finds that CL and TL positively affects agricultural growth GVA. The similarity in outcomes across models confirms the robustness and reliability of the findings, suggesting that the relationships between credit, agricultural inputs, and infrastructure are stable across estimation techniques.

6. Discussion and Implications

The study tested two hypotheses: H1a, crop loans significantly improve agricultural GVA and H2a, term loans. significantly improve agricultural GVA. Empirical results confirm both hypotheses through strong statistical significance in credit-GVA relationships. Crop loans have a stronger, statistically significant impact on GVA, validating short-term finance's critical role. They support seasonal input procurement and boost immediate productivity across states. Term loans also show positive GVA effects, though with lower magnitude due to delayed returns. This aligns with Credit Rationing Theory [26], highlighting asymmetric credit access across states. States with stronger institutions and credit histories convert loans into productivity more effectively. Significant endogeneity in crop and term loans supports a bidirectional credit-productivity relationship across regions. High-productivity states attract more institutional credit, reinforcing regional inequality in agricultural finance.

Compared to prior literature, these findings affirm and extend current understanding of credit-productivity links. The strong crop loan effect echoes [9], [28]. They emphasize institutional credit's role in improving input usage and output efficiency. Term loans' weaker influence aligns with [14]. These studies link capital credit to long-term infrastructure benefits, not immediate productivity increases. Storage infrastructure shows weak or negative significance, confirming concerns by [24]. [23] also highlight inefficiencies, poor logistics, and limited access in storage systems. Fertilizer and electricity show strong positive GVA influence, consistent with [18]. [16] also confirm their productivity-enhancing effects when credit and infrastructure are adequate.

This study contributes significantly by integrating credit elasticity into agricultural productivity analysis. Unlike earlier works, it disaggregates credit types and quantifies their marginal GVA impacts. It advances Credit Rationing Theory by revealing credit effectiveness variations across states and conditions. The analysis includes state-level heterogeneity, temporal trends, and input usage for deeper insights. It empirically identifies state-wise differences in credit responsiveness, advancing agricultural finance understanding in India.

The implications are both theoretical and policy-focused for better agricultural finance design. First, state-specific policies are essential: crop loans suit low-performing states for short-term input needs. High-performing states should prioritize term loans for infrastructure and long-term growth. Second, institutional reforms must address credit asymmetries through improved creditworthiness models and regional outreach. Third, input-linked credit is vital, especially in fertilizer and electricity-intensive regions. Fourth, storage investment should prioritize efficiency and value chain integration, not just capacity expansion. Financial institutions must use credit elasticity estimates to optimize fund allocation and output returns.

7. Conclusion

This study analyzed how crop and term loans influence agricultural GVA across Indian states over ten years. It confirms that credit's effectiveness varies by region, input access, and credit absorption capacity. Crop loans offer higher short-term benefits due to their direct role in seasonal operations. Term loans yield slower, but essential, returns through long-term investments and technology upgrades. Input variables like fertilizer and electricity amplify credit effects, proving complementary roles in boosting output. Storage, however, contributes less or negatively without efficiency and market readiness. Policymakers must design differentiated strategies based on regional credit responsiveness and infrastructure gaps. Institutional reforms must align credit flows with local agricultural needs for equity and growth. This evidence aids stakeholders in optimizing formal agricultural lending across India.

7.1 *Limitations of the Study*

The study uses secondary state-level data from 2014 to 2023, limiting micro-level insights. It does not reflect individual borrowing behavior, informal loans, or repayment trends. It assumes all sanctioned credit is effectively used, though actual utilization is unmeasured. Credit diversion or delayed disbursement may affect observed relationships. Crop and term loans are not further segmented by crop type, landholding, or borrower class. Storage infrastructure is treated broadly without type or ownership distinction. This may oversimplify its actual GVA influence. Policy variables like PM-KISAN, crop insurance, or KCC are excluded due to data limitations. These programs impact credit use but are not captured in this analysis.

7.2 *Future Research Directions*

Future studies should use district or household-level data for richer farmer-level insights and constraints. Behavioral aspects like risk preferences, repayment patterns, and trust in institutions should be considered. Tracking actual credit use via digital tools can separate sanctioned from productively used credit. Including spatial and agro-climatic variables may explain how geography affects credit effectiveness. Policy simulations can test reforms like redistribution or targeted subsidies on credit productivity and rural equity. While this study offers macro-level findings, future research must explore micro and implementation-level outcomes. That will enhance understanding of how credit impacts agricultural performance across India.

References

[1] Statista, "Distribution of the workforce across economic sectors in India 2022." (2025). [Online]. Available: https://www.statista.com/statistics/271320/distribution-of-the-workforce-across-economic-sectors-in-india/

[2] D. Bhoyar, S. Jain, J. D. Kene, Y. A. Suryawanshi, A. R. B. Patil, and S. J. Karale, "Enhancing agriculture productivity with machine learning in crop yield optimization," *J. Stat. Manag. Syst.*, vol. 27, no. 2, pp. 213–223 (2024), doi: 10.47974/JSMS-1248.

[3] D. Das, A. Gogoi, and N. Kumar, "Impact of climate change on agriculture and adaptation: Farmers' experience in North-East India,"

J. Inf. Optim. Sci., vol. 44, no. 1, pp. 81–95 (2023), doi: 10.47974/JIOS-1297.

[4] Y.-P. Teng and L.-Z. Lan, "Research on influencing factors of rural inclusive finance - A case study of Fujian in PRC," *J. Stat. Manag. Syst.*, vol. 27, no. 4, pp. 815–834 (2024), doi: 10.47974/JSMS-1111.

[5] V. Kumar, S. B. Afroz, N. B. for Agriculture, R. Development, D. of E. Analysis, and Research, "Regional disparities in institutional credit to agriculture in India: A District Level analysis," (2022).

[6] RBI Study Report, "Rural credit in pandemic times: Initiatives and impact," in *Annual Report* (2021).

[7] S. Saxena and S. Vij, "Factors influencing producers decision to adopt organic food production in Uttarakhand, India : An analysis," *J. Inf. Optim. Sci.*, vol. 44, no. 8, pp. 1487–1500 (2024), doi: 10.47974/JIOS-1471.

[8] M. Rathi and Dr. V. Sharma, "Fueling Agricultural Growth In Madhya Pradesh Through Formal Credit- AWay Towards Financial Inclusion," *J. Cryptol.* (2020), doi: 10.51767/JOC1201.

[9] I. S. Yadav and M. S. Rao, "Agricultural credit and productivity of crops in India: field evidence from small and marginal farmers across social groups," *J. Agribus. Dev. Emerg. Econ.* (2022), doi: 10.1108/jadee-05-2022-0092.

[10] C. Chaiya, S. Sikandar, P. Pinthong, S. E. Saqib, and N. Ali, "The Impact of Formal Agricultural Credit on Farm Productivity and Its Utilization in Khyber Pakhtunkhwa, Pakistan," *Sustainability* (2023), doi: 10.3390/su15021217.

[11] S. Maity and A. Majumder, "Role of Institutional Credit in the Development of Agricultural Sector: An Empirical Study on India," in *Sustainable Agricultural Practices: Economic and Environmental Implications*, Emerald Publishing Limited, pp. 57–74 (2024).

[12] M. D. Regassa, "Access to credit and heterogeneous effects on agricultural technology adoption: Evidence from large rural surveys in Ethiopia," *Can. J. Agric. Econ.-Rev. Can. Agroeconomie* (2023), doi: 10.1111/cjag.12329.

[13] C. Chaiya, S. Sikandar, P. Pinthong, S. E. Saqib, and N. Ali, "The Impact of Formal Agricultural Credit on Farm Productivity and Its Utilization in Khyber Pakhtunkhwa, Pakistan," *Sustainability* (2023), doi: 10.3390/su15021217.

[14] L. Zhang, L. Xu, M. Gao, and M. Zhou, "Can Agricultural Credit Promote the Green Transformation of China's Agriculture?," *Sustainability* (2024), doi: 10.3390/su162410944.

[15] S. Narayanan, "The productivity of agricultural credit in India," *Agric. Econ.*, vol. 47, no. 4, pp. 399–409 (2016).

[16] W. Adzawla, E. D. Setsoafia, E. D. Setsoafia, S. Amoabeng-Nimako, W. K. Atakora, O. Camara, M. Jemo, and P. S. Bindraban, "Fertilizer use efficiency and economic viability in maize production in the Savannah and transitional zones of Ghana," *Front. Sustain. Food Syst.* (2024), doi: 10.3389/fsufs.2024.1340927.

[17] Y. Zhang, X. Fan, Y. K. Mao, and Y.-S. Wei, "The Coupling Relationship and Driving Factors of Fertilizer Consumption, Economic Development and Crop Yield in China," *Sustainability* (2023), doi: 10.3390/su15107851.

[18] R. R. Kumar, G. K. Jha, and P. K. Velayudhan, "Linkage of Electricity with Agricultural Growth and Technology Factors: An Illustration of India's Case," *Energies* (2022), doi: 10.3390/en15072422.

[19] W. Yang, "Impact of sectoral decompositions of electricity consumption on economic growth in India: evidence from SVAR framework," *Environ. Sci. Pollut. Res.* (2022), doi: 10.1007/s11356-022-19352-2.

[20] J. Mawejje and D. N. Mawejje, "Electricity consumption and sectoral output in Uganda: an empirical investigation," *J. Econ. Struct.*, vol. 5, no. 1, p. 21 (Aug. 2016), doi: 10.1186/s40008-016-0053-8.

[21] F. Adams, E. Donkor, J. Quaye, A. A. Jantuah, and S. Etuah, "Sustainable Maize Storage Technology Adoption in Ghana: Implications for Postharvest Losses, Farm Income, and Income Inequality," *Food Energy Secur.* (2024), doi: 10.1002/fes3.70011.

[22] Y. Luo, D. Huang, H. Miao, L. Wu, and J. Zhu, "Impact of advanced storage facilities on households' maize storage losses and food security in China," *Environ. Dev. Sustain.* (2021), doi: 10.1007/S10668-021-01406-Z.

[23] M. Mukama and P. Abaasa, "Assessment of the cold storage capacity used in bulk handling of perishable agricultural produce in Ugandan cities," *Int. J. Refrig.-Rev. Int. Froid* (2024), doi: 10.1016/j.ijrefrig.2024.05.030.

[24] H. Cheng, X. Zhou, J. Sun, J. N. Ng'ombe, A. Mzyece, W. Feng, S. Guo, and B. Liu, "Assessing the efficacy of agricultural cold chain

facility expansion in China," *J. Stored Prod. Res.* (2024), doi: 10.1016/j.jspr.2024.102244.

[25] B. Shahidur and Hans Khandker, "The impact of formal finance on the rural economy of India," *J. Dev. Stud.* (1995), doi: 10.1080/00220389508422413.

[26] J. E. Stiglitz and A. Weiss, "Credit rationing in markets with imperfect information," *Am. Econ. Rev.*, vol. 71, no. 3, pp. 393–410 (1981).

[27] S. R. Boucher, C. Guirkinger, and C. Trivelli, "Direct Elicitation of Credit Constraints: Conceptual and Practical Issues with an Application to Peruvian Agriculture," *Econ. Dev. Cult. Change* (2009), doi: 10.1086/598763.

[28] T. Ölkers and O. Musshoff, "Exploring the role of interest rates, macroeconomic environment, agricultural cycle, and gender on loan demand in the agricultural sector: Evidence from Mali," *Agribusiness* (2023), doi: 10.1002/agr.21891.

[29] Z. Ding, Q. Zhang, and Y. Tang, "Nexus between farmland transfer, agricultural loans, and grain production: empirical evidence from China," *Front. Sustain. Food Syst.* (2024), doi: 10.3389/fsufs.2024.1229381.

[30] G. Pinto, S. Rastogi, and B. Agarwal, "Does promoters' holding influence the liquidity risk of banks?," *J. Financ. Regul. Compliance*, vol. 32, no. 2, pp. 211–229 (2024).

[31] B. H. Baltagi and B. H. Baltagi, *Econometric analysis of panel data*, vol. 4. John wiley & sons (2008).

[32] J. Kanoujiya, S. Rastogi, and V. M. Bhimavarapu, "Exposition beyond EKC theory and the impact of the growth on the environment: do developed and democratic countries matter?," *Discov. Sustain.*, vol. 6, no. 1, pp. 1–19 (2025).

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