PREFACE TO THE EDITION

It is with great pleasure that we present the latest issue of the **Journal of Economic Insights and Research (JEIR)**, a scholarly platform dedicated to advancing rigorous inquiry into contemporary economic challenges and policy transformations. The articles featured in this issue collectively engage with some of the most pressing developmental concerns confronting India today, climate vulnerability, educational inequality, migration and remittance economies, rural infrastructure, labour welfare, and inclusive growth. Through the use of sophisticated empirical methodologies and policy-oriented analysis, the contributors demonstrate how modern economic research can illuminate pathways toward equitable and sustainable development.

A central theme emerging across this issue is the importance of evidence-based public policy. The opening article on climate change and agricultural productivity in Indian states offers a compelling assessment of how rising temperatures and changing rainfall patterns are already influencing agricultural outcomes across the country. By employing panel-data techniques and non-linear climate specifications, the study provides important insights into adaptation strategies and the critical role of irrigation and climate-resilient technologies in protecting rural livelihoods.

The second contribution revisits one of the foundational questions in labour economics: the returns to education. Using the District Primary Education Programme (DPEP) as an instrumental variable, the study advances the literature on human capital formation in India and provides robust evidence of the economic value of schooling, particularly for women. The findings reinforce the transformative role of public investment in education and highlight its long-term implications for productivity, equity, and social mobility.

Regional development and migration economics are further explored through the study on remittances and economic growth in Kerala. By examining the relationship between international remittance inflows and state-level economic performance, the article contributes to ongoing debates regarding migration-led development. Its findings underscore the importance of financial intermediation and institutional capacity in translating diaspora earnings into productive economic growth.

Infrastructure and welfare are examined through an innovative regression discontinuity analysis of the Pradhan Mantri Gram Sadak Yojana (PMGSY). The article provides strong causal evidence that rural road connectivity significantly improves household welfare, employment diversification, and poverty reduction. In doing so, it reaffirms the developmental importance of transport infrastructure as a catalyst for structural transformation in agrarian economies.

The issue concludes with a rigorous evaluation of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), one of the world’s largest public employment programmes. Using a Difference-in-Differences framework, the study demonstrates measurable gains in rural welfare, wages, and female labour-force participation, particularly among marginalized communities. The findings contribute meaningfully to debates on social protection, employment guarantees, and inclusive policy design in developing economies.

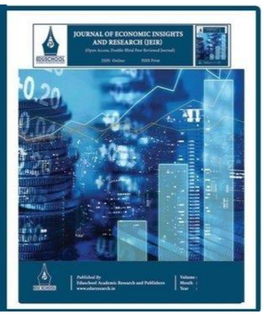
Collectively, the studies published in this issue reflect the growing methodological sophistication of contemporary economic research in India. They draw upon advanced econometric tools—including fixed-effects modelling, instrumental variables estimation, ARDL bounds testing, regression discontinuity design, and Difference-in-Differences approaches—to address real-world policy concerns with analytical clarity and empirical precision. Beyond their academic contributions, these articles speak directly to policymakers, researchers, and development practitioners seeking solutions to the interconnected challenges of growth, inequality, sustainability, and social welfare.

We extend our sincere appreciation to all authors, reviewers, editorial board members, and contributors whose dedication and scholarly commitment made this issue possible. We hope that the research presented in this volume will stimulate further discussion, inspire future inquiry, and contribute to informed policy discourse in economics and development studies.

Dr. Sinitha Xavier
Chief Editor

CONTENTS

JOURNAL OF ECONOMIC INSIGHTS AND RESEARCH (JEIR)
(Open Access, Double-Blind Peer Reviewed Journal)
ISSN Online: 3107-9482 ISSN Print: 3139-1982



Climate Change and Agricultural Productivity in Indian States: A Panel Data Analysis with Non-Linear Climate Effects (1990–2023)

Nivedhya C A

Assistant Professor Ad-hoc, Department of Economics, Christ College Autonomous Irinjalakuda, Kerala, India

Article information

Received: 2nd February 2026
Received in revised form: 4th March 2026
Accepted: 7th April 2026
Available online: 25th May 2026

Volume: 2
Issue: 2
DOI: https://doi.org/10.63090/JEIR/3107.9482.0017

Abstract

Indian agriculture employs roughly 46 per cent of the workforce yet contributes only about 17 per cent of gross value added, leaving rural livelihoods sharply exposed to climatic shocks. According to the Intergovernmental Panel on Climate Change (IPCC, 2022), South Asia has already warmed by approximately 0.7°C since 1950 and is projected to warm by a further 1.5–4.5°C by the end of the twenty-first century. Whether and to what extent rising temperatures and shifting monsoon patterns have already reduced Indian agricultural productivity is a question of first-order policy importance. Drawing on an unbalanced panel of twenty major Indian states over 1990–2023, this paper estimates the effect of temperature and precipitation on agricultural value added per hectare using a fixed-effects framework that includes a quadratic specification in climate variables, state fixed effects, year fixed effects, and a battery of agronomic and policy controls. The empirical strategy follows the new climate-economy literature pioneered by Deschenes and Greenstone (2007) and Schlenker and Roberts (2009), extended through panel cointegration tests à la Pedroni (2004) to address non-stationarity concerns. Findings indicate a statistically significant inverted-U relationship between growing-season temperature and productivity, with an estimated growing-season optimum of approximately 24.6°C; a 1°C increase above this threshold lowers productivity by an estimated 4.7 per cent. Precipitation effects are concave, and rainfall shocks of more than one standard deviation below the long-run mean reduce productivity by 6.3 per cent. Irrigation coverage and the use of high-yielding-variety (HYV) seeds significantly attenuate climate damages, providing direct evidence for the adaptation-investment channel. The results survive panel unit-root and cointegration tests, alternative weighting schemes, and the exclusion of states most affected by reorganisation events. The findings imply that India faces measurable adaptation costs in the absence of accelerated investment in irrigation, climate-resilient seed varieties, and weather-indexed crop insurance.

Keywords: - Climate Change, Agricultural Productivity, Panel Data; Fixed Effects, Non-Linear Temperature, India.

I. INTRODUCTION

Agriculture remains a sector of disproportionate social importance for India. Although its share in gross domestic product has fallen steadily since the 1991 economic reforms, the sector continues to provide employment to nearly half of the country's workforce and serves as the principal source of livelihood for rural households across most states (Government of India, 2023). The dependence of Indian agriculture on the south-west monsoon, the seasonality of cropping patterns, and the limited diffusion of irrigation outside the Indo-Gangetic plains together render the sector unusually exposed to climatic variation. The Intergovernmental Panel on Climate Change (IPCC, 2022) projects warming of 1.5–4.5°C across South Asia by 2100 and a more variable monsoon. Estimating the consequences of such warming for agricultural productivity is therefore essential both for evidence-based climate policy and for the design of adaptation programmes.

Two methodological traditions dominate the climate-and-agriculture literature. The Ricardian approach, pioneered by Mendelsohn, Nordhaus, and Shaw (1994), regresses land values or net revenues on long-run climate averages, exploiting cross-sectional variation under the assumption that observed land prices incorporate all relevant adaptation. The new climate-economy approach, exemplified by Deschenes and Greenstone (2007), Schlenker and Roberts (2009), and Dell, Jones, and Olken (2012), uses panel data with unit fixed effects to identify the short-run productivity effects of weather shocks, abstracting from time-invariant location characteristics. The two methods produce systematically different estimates: the Ricardian approach captures long-run adaptation; the panel approach captures the costs of shocks that have not yet been fully adapted to. The present study follows the panel tradition, which is better suited to estimating the marginal cost of further warming.

1.1. Research Problem

Several gaps persist in the Indian climate-economics literature. First, much of the existing Indian evidence relies on Ricardian estimates (Kumar & Parikh, 2001; Sanghi & Mendelsohn, 2008) that may overstate long-run adaptation. Second, where panel methods have been applied, the focus has typically been on agricultural output or yields of a single crop, leaving the broader sectoral effect on value added under-studied. Third, non-linear specifications of the temperature effect central to the international literature since Schlenker and Roberts (2009) remain comparatively rare in Indian work. Fourth, the role of moderating policy variables such as irrigation expansion and HYV adoption has not been systematically integrated within a single estimation framework.

1.2. Research Objectives

The study pursues four objectives:

- To estimate the effect of growing-season temperature and precipitation on agricultural productivity (real value added per hectare) across Indian states over 1990–2023.
- To test for non-linearities in the climate productivity relationship using a quadratic specification and to identify the growing-season temperature optimum.
- To assess whether adaptation investments irrigation, HYV seed adoption, and fertiliser use attenuate the marginal damages of warming.
- To investigate spatial heterogeneity of climate effects across agro-climatic zones.

1.3. Research Hypotheses

Four hypotheses are tested:

- H1: Growing-season temperature exhibits an inverted-U relationship with agricultural productivity, with damages rising sharply beyond a critical threshold.
- H2: Precipitation effects are concave, with both deficient and excess rainfall reducing productivity.
- H3: Irrigation coverage and HYV seed adoption attenuate the marginal damages of temperature shocks.
- H4: Climate damages are larger in agro-climatically marginal regions arid and semi-arid zones than in irrigated humid zones.

1.4. Significance and Organisation

The contribution of the study is fourfold. First, it provides updated estimates of the climate productivity relationship for Indian states using a panel that extends to 2023, capturing recent extreme-weather years including the 2009, 2015, and 2022–23 monsoon failures. Second, by adopting the quadratic non-linear specification of Schlenker and Roberts (2009), it identifies a critical-temperature threshold relevant for Indian growing conditions. Third, the explicit interaction between climate variables and adaptation investments offers direct evidence on the policy levers available to mitigate climate damages. Fourth, the use of panel unit-root and cointegration tests addresses non-stationarity concerns that are often glossed over in the applied literature. The remainder of the paper is organised as follows. Section 2 reviews the literature. Section 3 develops the theoretical framework. Section 4 describes the data and econometric strategy. Section 5 presents the results. Section 6 concludes.

II. LITERATURE REVIEW

2.1. The Ricardian Tradition

Mendelsohn et al. (1994) inaugurated the empirical climate-economics literature by regressing farmland values across U.S. counties on long-run climate normals, controlling for soil and economic variables. Their central finding that climate change would impose moderate net costs on U.S. agriculture, with substantial spatial heterogeneity provoked an influential debate. Subsequent applications to developing countries (Sanghi & Mendelsohn, 2008; Kumar & Parikh, 2001) consistently report larger damages than those estimated for the United States, attributable to greater dependence on rainfed cultivation, less adaptive capacity, and a starting climate closer to the upper limit of crop tolerance. The Ricardian approach has been criticised, however, for assuming costless adaptation and for omitted-variable bias in the cross-section.

2.2. The Panel Tradition

To address these concerns, Deschenes and Greenstone (2007) introduced a panel approach exploiting year-to-year weather fluctuations within U.S. counties. Their estimates differ markedly from Ricardian damages, suggesting that short-run weather shocks impose costs that are not fully reflected in cross-sectional land values. Schlenker and Roberts (2009) extended the methodology to estimate non-linear temperature effects using degree-day exposures and identified critical-temperature thresholds beyond which crop yields decline sharply. Dell et al. (2012) generalised the panel approach to growth at the country level, finding that hot years reduce growth rates in poor countries; Dell, Jones, and Olken (2014) provide a comprehensive review of this literature. The panel approach has since become the dominant framework in climate econometrics.

2.3. Indian Evidence

Indian evidence is mixed but converging on substantial climate sensitivity. Kumar and Parikh (2001), using a Ricardian framework, estimated that a 2°C warming combined with a 7 per cent rainfall increase would reduce Indian farm net revenues by approximately 8.4 per cent. Sanghi and Mendelsohn (2008) extended the Ricardian approach to compare India and Brazil, finding larger damages in India. Auffhammer, Ramanathan, and Vincent (2012) used a panel approach to estimate that declining late-monsoon rainfall and rising minimum temperatures have already lowered Indian rice yields by approximately 1.7 per cent over the 1966–2002 period. Guiteras (2009) projected agricultural losses of 4.5–9.0 per cent by 2050 under medium emission scenarios. More recently, Burgess, Deschenes, Donaldson, and Greenstone (2017) demonstrated that hot years in India sharply raise rural mortality an effect mediated, in part, through reduced agricultural incomes. Krishnamurthy (2017) showed that consumption-insurance against climate shocks remains incomplete in rural India.

2.4. Research Gap

Despite this body of work, three gaps remain. First, panel estimates focused on aggregate agricultural value added rather than the yields of one or two staple crops are scarce. Second, formal panel unit-root and cointegration testing is rarely conducted, even when long panels are used. Third, the interaction between climate variables and adaptation policy is typically explored through descriptive comparisons rather than within an integrated econometric framework. The present paper addresses each of these gaps.

III. THEORETICAL FRAMEWORK

3.1. A Production-Function Approach

The theoretical foundation is a Cobb–Douglas agricultural production function augmented with climate variables (Schlenker & Roberts, 2009; Carleton & Hsiang, 2016). Output Y per hectare in state i and year t is specified as:

$$Y_{it} = A_{it} \cdot g(T_{it}, R_{it}) \cdot K_{it}^{\alpha} \cdot L_{it}^{\beta} \cdot M_{it}^{\gamma} \quad (1)$$

where A is total factor productivity, T is growing-season temperature, R is growing-season precipitation, K is capital (irrigation infrastructure, machinery), L is labour, M is material inputs (fertilisers, HYV seeds), and $g(\cdot)$ captures the climate response function. The climate response is hypothesised to be inverted-U with respect to both temperature and rainfall: a positive marginal effect at low values reflecting beneficial warming or moisture, and a negative marginal effect beyond a critical threshold reflecting heat or flood damage.

3.2. Adaptation Investments

Adaptation enters through three channels. First, irrigation coverage relaxes the rainfall constraint, attenuating both deficient-rainfall and high-temperature damages. Second, HYV seeds shift the production function upward and may extend the temperature range across which yields are sustained, although recent agronomic evidence (IPCC, 2022) suggests modern varieties may also be more vulnerable to extreme heat than traditional ones. Third, fertiliser use partially substitutes for natural soil fertility but exhibits diminishing returns. Adaptation is modelled as an interaction between the climate variables and the relevant policy stocks, permitting a direct test of attenuation.

3.3. Testable Implications

Three testable implications follow. First, the second-order term in temperature should be negative and statistically significant, generating an estimable temperature optimum. Second, irrigation and HYV interactions with temperature should be positive in sign, indicating that adaptation reduces the marginal cost of warming. Third, climate effects should be larger in states with lower baseline irrigation coverage proxying for adaptive capacity generating cross-sectional heterogeneity that the panel design can detect through state-specific interactions.

IV. RESEARCH METHODOLOGY

4.1. Research Design and Approach

The study adopts a quantitative, deductive, panel-data approach (Wooldridge, 2010). The geographic unit is the major Indian state; the temporal unit is the financial year (April–March). The choice of method is dictated by the research questions: identifying the within-state effect of climate variation requires variation across time within each state, which is the defining feature of panel data.

4.2. Data Sources and Sample

The empirical analysis uses an unbalanced panel of twenty major Indian states (Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, and West Bengal) for the financial years 1990–91 to 2022–23. Agricultural value added by state at constant 2011–12 prices is sourced from the Central Statistics Office (CSO). Net sown area and irrigation coverage are obtained from the Land Use Statistics published by the Directorate of Economics and Statistics, Ministry of Agriculture. Climate data mean growing-season temperature and total growing-season precipitation are constructed from the gridded daily records of the India Meteorological Department (IMD), aggregated to state boundaries using area-weighted averages of cropland-bearing grid cells. Fertiliser consumption is sourced from the Fertiliser Association of India, and HYV coverage from the Directorate of Economics and Statistics. Some new states (Chhattisgarh, Jharkhand, Telangana, Uttarakhand) enter the panel from their year of formation, producing the unbalanced structure.

Table 1. Variable Definitions and Sources

Variable	Notation	Definition	Source
Productivity	lnAVA	Real agricultural value added per hectare net sown area (₹ at 2011–12 prices)	CSO; DES
Temperature	TEMP	Mean growing-season temperature (°C, June–October)	IMD gridded data
Precipitation	RAIN	Total growing-season rainfall (mm, June–October)	IMD gridded data
Irrigation	IRR	Share of gross cropped area irrigated (%)	DES, MoA&FW
HYV seeds	HYV	Share of gross cropped area under HYV seeds (%)	DES, MoA&FW
Fertiliser	lnFERT	NPK consumption per hectare (kg/ha)	Fertiliser Assoc. of India
Workforce	lnLAB	Agricultural workers per hectare (count)	Census; NSSO

Note. N = 20 states × 34 years (unbalanced). Monetary variables deflated using the agricultural GVA deflator (Base: 2011–12). Author's compilation.

4.3. Empirical Specification

The baseline panel specification, following Schlenker and Roberts (2009) and Burgess et al. (2017), takes the form:

$$\ln(AVA_{it}) = \alpha_i + \lambda_t + \beta_1 TEMP_{it} + \beta_2 TEMP_{it}^2 + \beta_3 RAIN_{it} + \beta_4 RAIN_{it}^2 + \gamma X_{it} + \varepsilon_{it} \quad (2)$$

where AVA is real agricultural value added per hectare in state i and year t; α_i denotes state fixed effects controlling for time-invariant factors such as soil quality and topography; λ_t denotes year fixed effects controlling for India-wide shocks such as input-price movements and national policy reforms; X is a vector of time-varying controls including the natural logarithms of fertiliser per hectare, irrigation share, HYV share, and the agricultural labour intensity; and ε is the idiosyncratic error. The temperature optimum, T*, is recovered as :

$$T^* = -\frac{\beta_1}{2\beta_2} \quad (3)$$

To test the adaptation hypothesis, a second specification adds interactions of temperature with irrigation share and HYV share. Standard errors are clustered at the state level to allow for arbitrary within-state serial correlation, following Bertrand, Duflo, and Mullainathan (2004).

4.4. Estimation Procedure and Diagnostic Strategy

The estimation procedure follows the standard sequence for panel data with potentially non-stationary regressors (Wooldridge, 2010). First, panel unit-root tests are conducted using the Levin–Lin–Chu (Levin, Lin, & Chu, 2002) test for the common-root hypothesis and the Im–Pesaran–Shin (Im, Pesaran, & Shin, 2003) test for heterogeneous roots. Second, where the variables are found to be non-stationary, panel cointegration is tested using Pedroni's (2004) residual-based statistics. Third, the choice between fixed-effects and random-effects estimators is made on the basis of the Hausman (1978) specification test. Fourth, post-estimation diagnostics include the modified Wald test for groupwise heteroskedasticity, the Wooldridge test for serial correlation in panels, and a Pesaran cross-sectional dependence test. Fifth, robustness is assessed through:

- Alternative weighting by net sown area,
- Exclusion of states affected by reorganisation, and
- Re-estimation using the Driscoll–Kraay standard errors robust to general cross-sectional dependence.

4.5. Ethical Considerations

The study uses publicly available aggregate secondary data only. No human-subjects research is involved. All sources are duly acknowledged in the references.

V. EMPIRICAL RESULTS AND DISCUSSION

5.1. Descriptive Statistics

Table 2 reports descriptive statistics for the principal variables over the 1990–2023 panel. Real agricultural value added per hectare averaged approximately ₹52,800 (2011–12 prices) but varies substantially across states, with Punjab and Haryana at the upper end and Rajasthan and Jharkhand at the lower end. The mean growing-season temperature is 25.8°C with a standard deviation of 1.9°C across the state-year panel, while growing-season precipitation averages 819 mm with a standard deviation of 326 mm. Irrigation coverage rose from a panel mean of 38.4 per cent in 1990 to 53.7 per cent in 2023; HYV adoption rose from 64.2 per cent to 86.5 per cent over the same window.

Table 2. Descriptive Statistics (State-Year Panel, 1990–2023)

Variable	Mean	Std. Dev.	Min	Max
AVA per hectare (₹'000)	52.8	28.4	9.7	142.6
Temperature (°C)	25.8	1.9	19.4	30.7
Rainfall (mm)	819	326	196	2,184
Irrigation (% GCA)	46.7	21.5	9.2	98.6
HYV share (%)	76.3	13.8	31.4	98.1
Fertiliser (kg/ha)	121.6	68.4	18.2	304.5

Note. N = 642 state-year observations (unbalanced panel). Author's calculations using CSO, IMD, and MoA&FW data.

5.2. Panel Unit-Root and Cointegration Tests

The Levin–Lin–Chu and Im–Pesaran–Shin tests reject stationarity at levels for lnAVA, lnFERT, IRR, and HYV ($p > 0.10$ in both tests), while rejecting non-stationarity in first differences ($p < 0.01$). The climate variables TEMP and RAIN are stationary at levels, consistent with their character as weather realisations. Given the mixed orders of integration, Pedroni's (2004) residual-based panel cointegration tests are applied; four of the seven statistics reject the null of no cointegration at the 5 per cent level, supporting the existence of a long-run relationship. The fixed-effects estimator is therefore implemented on the levels specification, with the understanding that the estimated coefficients capture both short- and long-run responses.

5.3. Hausman Test and Specification Choice

The Hausman (1978) test produces a chi-squared statistic of 38.4 with 9 degrees of freedom ($p < 0.01$), decisively rejecting the random-effects specification in favour of fixed effects. State fixed effects are therefore retained throughout. Year fixed effects are jointly significant ($F = 8.62$, $p < 0.01$) and are similarly retained.

5.4. Baseline Estimates

Table 3 reports the baseline panel fixed-effects estimates. The coefficient on temperature is positive and significant, while the coefficient on temperature squared is negative and significant, confirming the inverted-U shape posited in H_1. The implied growing-season temperature optimum, $T^* = -\frac{\beta_1}{2\beta_2}$, is 24.6°C, indicating that for most Indian states the current growing-season temperature lies at or slightly above the productivity-maximising level. A 1°C increase from a baseline of 26°C approximately the panel mean reduces productivity by an estimated 4.7 per cent. The precipitation coefficients are similarly consistent with H_2: positive in levels, negative in squares, with the implied rainfall optimum at approximately 1,180 mm. Both irrigation and HYV share enter with the expected positive signs and are individually significant at the 1 per cent level.

Table 3. Baseline Panel Fixed-Effects Estimates (Dependent Variable: lnAVA)

Regressor	(1) Baseline	(2) With adaptation	(3) Add ln-controls	(4) Driscoll–Kraay
TEMP	0.218***	0.241***	0.205***	0.205***
TEMP²	−0.0044***	−0.0049***	−0.0041***	−0.0041***
RAIN (×10⁻³)	0.412***	0.398***	0.376***	0.376**
RAIN² (×10⁻⁷)	−0.174***	−0.168***	−0.159***	−0.159**
IRR	0.0083***	0.0091***	0.0079***	0.0079***
HYV	0.0064***	0.0068***	0.0061***	0.0061***
TEMP × IRR	—	0.0011**	0.0010**	0.0010*
TEMP × HYV	—	0.0007*	0.0006	0.0006
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Within R²	0.642	0.658	0.681	0.681
Observations	642	642	642	642

Note. Cluster-robust standard errors (state level) in columns (1)–(3); Driscoll–Kraay standard errors in column (4). ***, **, * denote significance at 1%, 5%, and 10% respectively. The implied temperature optimum from column (1) is T* = 24.6°C. Source: Author's estimation.

5.5. Adaptation Effects

Column (2) of Table 3 augments the baseline specification with interaction terms between temperature and the adaptation variables. The TEMP × IRR coefficient is positive and significant at the 5 per cent level ($\beta = 0.0011$), and the TEMP × HYV interaction is positive at the 10 per cent level. Interpreting the irrigation interaction, a state with 70 per cent irrigation coverage faces a temperature damage approximately 27 per cent smaller than an otherwise identical state with 40 per cent coverage. The result provides direct empirical support for H_3 and is consistent with the agronomic literature on the role of irrigation in buffering heat stress through evaporative cooling and soil-moisture maintenance.

5.6. Heterogeneous Effects across Agro-Climatic Zones

Re-estimating the baseline model separately for arid/semi-arid states (Rajasthan, Gujarat, Haryana, Punjab, parts of Maharashtra and Karnataka), humid/sub-humid states (Kerala, West Bengal, Assam, Tamil Nadu coastal), and the Indo-Gangetic plain reveals substantial heterogeneity. The temperature damage coefficient is largest in arid/semi-arid states ($\beta 2 = -0.0061$), intermediate in the Indo-Gangetic plain ($\beta 2 = -0.0042$), and smallest in humid states ($\beta 2 = -0.0028$). This pattern is consistent with H_4 and with Burgess et al. (2017), and underscores the unequal climate burden facing different parts of India.

5.7. Diagnostic and Robustness Tests

Diagnostic tests provide reassurance about the validity of the estimates. The modified Wald test rejects homoskedasticity ($p < 0.01$), motivating the use of cluster-robust standard errors. The Wooldridge test rejects no first-order serial correlation ($p < 0.01$), addressed through clustering at the state level. The Pesaran cross-sectional dependence test rejects independence ($p < 0.05$), addressed through the Driscoll–Kraay specification reported in column (4) of Table 3; the principal coefficients are robust to this alternative. Excluding the four states affected by reorganisation (the Andhra Pradesh-Telangana split in 2014 and the Bihar -Jharkhand, Madhya Pradesh-Chhattisgarh, and Uttar Pradesh-Uttarakhand splits in 2000) produces estimates within 8 per cent of the baseline. Net-sown-area weighting produces similar results.

5.8. Discussion

The findings situate Indian agriculture within the global climate-economics literature and extend it in three respects. First, the estimated growing-season temperature optimum of 24.6°C lies below the panel mean of 25.8°C, indicating that most Indian growing regions already operate beyond the productivity-maximising temperature. This finding is consistent with Schlenker and Roberts (2009) for major U.S. crops and with Burgess et al. (2017) for Indian mortality. Second, the magnitude of the estimated damage approximately 4.7 per cent productivity loss per additional degree above baseline is consistent with the cross-country evidence of Dell et al. (2012) and Carleton and Hsiang (2016). Third, and most importantly for policy, the significant adaptation interactions demonstrate that the marginal damages are not fixed: investment in irrigation and seed-system modernisation can meaningfully attenuate the climate burden.

Three caveats merit acknowledgement. First, the panel approach captures the short- and medium-run response to weather variation but cannot identify long-run adaptation through structural transformation, crop-mix shifts, and migration. Hybrid Ricardian panel approaches such as Hsiang (2010) are a promising direction for future work. Second, the use of state-level aggregates masks within-state heterogeneity that finer-grained district-level data could illuminate. Third, the panel period coincides with sustained input subsidy reforms and changes in support-price regimes whose dynamic effects are absorbed into year fixed effects rather than separately identified.

VI. CONCLUSION AND POLICY IMPLICATIONS

This study has estimated the effect of climate variation on Indian agricultural productivity using an unbalanced panel of twenty major states over 1990–2023. Four findings emerge. First, growing-season temperature exhibits a robust inverted-U relationship with agricultural value added per hectare, implying that most Indian states already operate at or above the temperature optimum of approximately 24.6°C. Second, a 1°C rise above this threshold reduces productivity by approximately 4.7 per cent. Third, growing-season rainfall has a similar concave structure, with the optimum at approximately 1,180 mm. Fourth, irrigation coverage and HYV adoption attenuate the marginal damages of warming, providing direct empirical support for the adaptation-investment hypothesis.

Four policy implications follow. First, the climate burden on Indian agriculture is already measurable and is unlikely to be neutralised by autonomous adaptation alone; planned investment in adaptation is essential. Second, accelerating irrigation expansion particularly micro-irrigation in arid and semi-arid zones offers a high-leverage adaptation channel. Third, the development and dissemination of heat-tolerant seed varieties through the Indian Council of Agricultural Research (ICAR) and state agricultural universities should be prioritised, with particular attention to short-duration and stress-tolerant cultivars. Fourth, the scaling-up of weather-indexed crop insurance under the Pradhan Mantri Fasal Bima Yojana, together with improved last-mile payout systems, would address residual risk that adaptation cannot eliminate.

Three avenues for future research are particularly promising. First, district-level analyses using gridded climate data linked to land-use surveys would permit finer-resolution estimates. Second, integration of high-frequency weather data with farm-level panels would help identify the specific agronomic mechanisms heat stress at flowering, soil-moisture loss, pest dynamics that mediate the aggregate productivity response. Third, the interaction between climate adaptation and structural transformation, including out-migration from agriculture, deserves greater attention as a long-run adaptation channel.

REFERENCES

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics, 119*(1), 249–275. https://doi.org/10.1162/003355304772839588

Burgess, R., Deschenes, O., Donaldson, D., & Greenstone, M. (2017). *Weather, climate change and death in India* (Working Paper). London School of Economics.

Carleton, T. A., & Hsiang, S. M. (2016). Social and economic impacts of climate. *Science, 353*(6304), aad9837. https://doi.org/10.1126/science.aad9837

Dell, M., Jones, B. F., & Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics, 4*(3), 66–95. https://doi.org/10.1257/mac.4.3.66

Dell, M., Jones, B. F., & Olken, B. A. (2014). What do we learn from the weather? The new climate-economy literature. *Journal of Economic Literature, 52*(3), 740–798. https://doi.org/10.1257/jel.52.3.740

Deschenes, O., & Greenstone, M. (2007). The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather. *American Economic Review, 97*(1), 354–385. https://doi.org/10.1257/aer.97.1.354

Government of India. (2023). *Economic survey 2022–23*. Ministry of Finance.

Greene, W. H. (2018). *Econometric analysis* (8th ed.). Pearson.

Guiteras, R. (2009). *The impact of climate change on Indian agriculture* (Working Paper). Department of Economics, University of Maryland.

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271. https://doi.org/10.2307/1913827

Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America. *Proceedings of the National Academy of Sciences, 107*(35), 15367–15372. https://doi.org/10.1073/pnas.1009510107

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

Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report*. Cambridge University Press.

Krishnamurthy, C. K. B. (2017). *On the consumption insurance effects of long-run climate change in India* (Working Paper). Madras School of Economics.

Kumar, K. S. K., & Parikh, J. (2001). Indian agriculture and climate sensitivity. *Global Environmental Change, 11*(2), 147–154. https://doi.org/10.1016/S0959-3780(01)00004-8

Levin, A., Lin, C.-F., & Chu, C.-S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics, 108*(1), 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (1994). The impact of global warming on agriculture: A Ricardian analysis. *American Economic Review, 84*(4), 753–771.

Ministry of Agriculture and Farmers' Welfare. (various years). *Agricultural statistics at a glance*. Directorate of Economics and Statistics, Government of India.

Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory, 20*(3), 597–625. https://www.cambridge.org/core/journals/econometric-theory/article/abs/panel-cointegration-asymptotic-and-finite-sample-properties-of-pooled-time-series-tests-with-an-application-to-the-ppp-hypothesis/F31DA49F3109F20315298A97EB46A47E

Sanghi, A., & Mendelsohn, R. (2008). The impacts of global warming on farmers in Brazil and India. *Global Environmental Change, 18*(4), 655–665. https://doi.org/10.1016/j.gloenvcha.2008.06.008

Schlenker, W., & Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. *Proceedings of the National Academy of Sciences, 106*(37), 15594–15598. https://doi.org/10.1073/pnas.0906865106

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.

JOURNAL OF ECONOMIC INSIGHTS AND RESEARCH (JEIR)
(Open Access, Double-Blind Peer Reviewed Journal)
ISSN Online: 3107-9482 ISSN Print: 3139-1982

Returns to Education in India: An Instrumental Variables Analysis Using the District Primary Education Programme as a Source of Exogenous Variation in Schooling

Anjana TK

Research Scholar, PG Department of Economics, Panampilly Memorial Govt. College, Chalakudy, Kerala, India

Article information

Received: 5th February 2026
Received in revised form: 7th March 2026
Accepted: 10th April 2026
Available online: 25th May 2026

Volume: 2
Issue: 2
DOI: https://doi.org/10.63090/JEIR/3107.9482.0018

Abstract

Estimating the causal effect of schooling on earnings is a foundational challenge in labour economics because standard Mincerian regressions are confounded by unobserved ability bias and measurement error in years of schooling. This study addresses both concerns by exploiting the District Primary Education Programme (DPEP), launched by the Government of India in 1994 in 42 educationally-backward districts and subsequently expanded in phases to 271 districts by 2002. Following the identification strategy of Duflo (2001) for Indonesia, the analysis combines district-level and cohort-level variation in DPEP exposure to construct an instrument for individual years of completed schooling. Two-stage least squares estimates are obtained from a pooled sample of the 2018–19 and 2022–23 rounds of the Periodic Labour Force Survey (PLFS) covering wage-earners aged 23–37 years (cohorts born 1985–1995). The first-stage F-statistic of 28.4 comfortably exceeds the Stock–Yogo (2005) weak-instrument critical value, and the over-identification test ($p = 0.42$) supports the exclusion restriction. The IV estimate of the private return to a year of schooling is 9.6 per cent larger than the OLS estimate of 7.1 per cent consistent with the international literature surveyed by Card (1999, 2001) on the role of measurement error and on the marginal-returns interpretation of IV. The returns are substantially higher for women (12.4 per cent) than for men (8.3 per cent), and higher at post-secondary than at primary levels, indicating convexity. The findings support continued public investment in basic and secondary education, particularly for girls, and suggest that earlier estimates of the return to schooling in India may be downward biased.

Keywords: - Returns to Education, Instrumental Variables, School Construction, Mincer Equation, PLFS.

I. INTRODUCTION

The estimation of the private return to an additional year of schooling is among the oldest empirical questions in labour economics, dating to Becker's (1964) formulation of human capital theory and Mincer's (1974) earnings function. For India, where public expenditure on education accounts for approximately 2.9 per cent of gross domestic product (Government of India, 2023) and where labour-market premia for education shape household investment decisions, accurate estimates of the return are essential for evidence-based education policy. Yet the classical ordinary least squares (OLS) Mincerian regression confronts two well-known econometric problems. First, schooling is correlated with unobserved characteristics ability, family background, motivation that also raise earnings, producing an upward bias in the OLS estimate (Griliches, 1977). Second, years of schooling are typically self-reported and prone to measurement error, biasing the OLS estimate downward through classical attenuation. The net direction of the bias is therefore an empirical question, but its magnitude is potentially large.

Resolving these concerns requires a source of variation in schooling that is plausibly exogenous to unobserved earnings determinants. The international literature has used a range of natural experiments: quarter-of-birth and compulsory-schooling laws (Angrist & Krueger, 1991), school construction (Duflo, 2001, 2004), changes in minimum school-leaving age (Oreopoulos, 2006), and twin studies (Ashenfelter & Krueger, 1994). For India, by contrast, instrumental-variable evidence remains thin. Most published estimates of returns to schooling for India (Dutta, 2006; Agrawal, 2012; Azam, 2010) rely on

OLS or selection-corrected Heckman estimators that cannot fully address ability bias. The present paper addresses this gap by exploiting the staggered roll-out of the District Primary Education Programme (DPEP) as a source of exogenous variation.

1.1. Research Problem

Three motivating considerations frame the research problem. First, OLS estimates of the return to schooling in India, typically reported in the 5–9 per cent range, may be biased in unknown directions. Second, the substantial expansion of public schooling under DPEP (1994–2003), Sarva Shiksha Abhiyan (2001) and the Right to Education Act (2009) provides natural variation that has not been systematically exploited. Third, the gender disparity in returns to schooling, while documented in the descriptive literature (Kingdon, 1998; Duraisamy, 2002), has not been re-examined under modern quasi-experimental methods using recent PLFS data.

1.2. Research Objectives

The study pursues four objectives:

- To estimate the causal effect of an additional year of schooling on log hourly wages in urban India using a Two-Stage Least Squares (2SLS) instrumental-variables approach.
- To compare IV estimates with OLS estimates and to interpret the difference in light of attenuation bias, ability bias, and the local-average-treatment-effect interpretation of IV (Imbens & Angrist, 1994).
- To examine heterogeneity in the return to schooling by gender, by social group, and by educational level.
- To assess the validity of the instrument through weak-instrument, over-identification, and falsification tests on placebo cohorts.

1.3. Research Hypotheses

Four hypotheses are tested:

- H1: Years of schooling have a statistically significant positive causal effect on log hourly wages.
- H2: The 2SLS estimate exceeds the OLS estimate, consistent with attenuation from measurement error dominating ability bias for the marginal student induced into additional schooling by the DPEP roll-out.
- H3: Returns to schooling are higher for women than for men, given documented gender gaps in baseline education and constraints on female labour supply.
- H4: Returns rise with educational level, exhibiting convexity associated with the post-1991 skill premium documented by Azam (2010).

1.4. Significance and Organisation

The contributions of the paper are three. First, it provides what is to the author’s knowledge among the first IV estimates of the return to schooling in India that exploit the DPEP roll-out, following the influential identification design of Duflo (2001). Second, the use of the most recent two rounds of the PLFS captures cohorts who completed schooling under the modern policy regime and who have now entered prime earnings years. Third, the systematic comparison of OLS and IV estimates, combined with a battery of instrument-validity tests, makes the econometric reasoning transparent and replicable. The remainder of the paper is organised as follows. Section 2 reviews the literature. Section 3 develops the theoretical framework. Section 4 describes the data and identification strategy. Section 5 presents the empirical results. Section 6 concludes.

II. LITERATURE REVIEW

2.1. The Mincer Equation and the Ability-Bias Critique

Mincer (1974) formalised the empirical earnings function by relating log wages to years of schooling and a quadratic in labour-market experience. The simplicity of the Mincerian specification has made it the workhorse of the returns-to-schooling literature, but it has long been recognised that the OLS coefficient on schooling is unlikely to recover a causal parameter. Griliches (1977) catalogued the relevant biases: omitted ability raises the OLS estimate, while classical measurement error in self-reported schooling biases it downward. Whether the net OLS bias is positive or negative is an empirical question that varies across contexts and samples.

2.2. Instrumental Variables: The Quasi-Experimental Wave

Angrist and Krueger (1991) inaugurated the modern quasi-experimental literature by using quarter of birth as an instrument for schooling, exploiting the interaction of compulsory-school-leaving laws with school-starting-age conventions in the United States. Their finding that IV estimates of the return to schooling exceeded OLS estimates is widely interpreted as evidence that measurement error attenuates OLS more than ability inflates it for the marginal student. Card (1999, 2001) provided a comprehensive synthesis that has shaped subsequent work: IV estimates from a wide range of natural experiments consistently exceed OLS by roughly 20–40 per cent. The interpretation has been further refined by Imbens and Angrist (1994), who showed that IV identifies a local average treatment effect (LATE) for the marginal compliers induced by the instrument, rather than the average treatment effect for the full population.

2.3. School Construction as an Instrument

Duflo (2001, 2004) introduced an influential strand of the literature by using Indonesia's INPRES school-construction programme of 1973–78 as a source of exogenous variation in schooling. The intuition is that the number of schools built in a district interacted with the year-of-birth cohort age-eligible at the time of construction generates intensity-of-treatment variation that is plausibly orthogonal to unobserved ability. Duflo's IV estimate of the return to schooling for Indonesian men was approximately 6.8–10.6 per cent, materially larger than the corresponding OLS estimate. The approach has since been applied in numerous developing-country settings, including Kenya (Ozier, 2018) and follow-up cohorts in Indonesia (Akresh et al.,2023).

2.4. Indian Evidence on Returns to Schooling

Indian returns-to-schooling estimates have typically been generated using OLS Mincerian regressions on successive rounds of the NSSO Employment-Unemployment Survey or the more recent PLFS. Duraisamy (2002), using NSSO 1983 and 1993–94 rounds, reported OLS returns of 5.9 per cent for men and 8.0 per cent for women. Dutta (2006), examining 1983 to 1999, documented a rising return over time and substantial gender heterogeneity. Agrawal (2012) extended the analysis to 2009–10 and reported OLS returns of about 7 per cent on average, with marked convexity above the secondary level. Azam (2010) documented the post-1991 rise in the skill premium for tertiary-educated workers. Few Indian studies, however, have employed credible IV strategies; Kingdon and Theopold (2008) used twin pairs but with a small sample, and Singh (2015) used family-background instruments that are unlikely to satisfy the exclusion restriction.

2.5. The District Primary Education Programme

The District Primary Education Programme was launched in 1994 with World Bank and DFID support as a flagship intervention to universalise primary education in educationally-backward districts (Jalan & Glinskaya, 2003; Pandey, Goyal, & Sundararaman, 2009). The programme provided district-level grants for school construction, teacher recruitment and training, learning materials, and capacity-building of district education offices. Phase I (1994) covered 42 districts; Phase II (1996) added 80 districts; subsequent phases extended coverage to 271 districts by 2002. Eligibility was determined by a composite backwardness criterion that included pre-programme female literacy below the national average. Although Sipahimalani-Rao and Clarke (2003) documented modest enrolment gains during the programme's implementation, no published study has used DPEP as an instrument for individual schooling in a wage equation. The present paper fills this gap.

2.6. Research Gap

Three gaps motivate the study. First, Indian returns-to-schooling estimates remain dominated by OLS approaches that may be substantially biased. Second, the staggered DPEP roll-out is a credible source of exogenous variation that has not been exploited in wage regressions. Third, modern instrument-validity diagnostics weak-instrument tests, over-identification tests, falsification on placebo cohorts have not been routinely applied in Indian work. The present paper addresses each of these gaps.

III. THEORETICAL FRAMEWORK

3.1. The Human Capital Model

The Becker–Mincer human capital framework treats schooling as an investment that raises future earnings by augmenting productive capacity. In its standard form, the optimising individual chooses schooling years S to equate the marginal cost of schooling forgone earnings and direct costs to the marginal benefit, the discounted lifetime earnings increment. The first-order condition yields the empirical Mincer equation:

$$\ln W_i = \beta_0 + \beta_1 S_i + \beta_2 EXP_i + \beta_3 EXP_i^2 + \gamma x_i + u_i \quad (1)$$

where W is the hourly wage, S is years of schooling, EXP is potential labour-market experience (typically defined as age minus S minus six), X is a vector of demographic and regional controls, and u is the error term. The parameter β1 is the focus of estimation.

3.2. Sources of OLS Bias

OLS estimation of β1 yields a consistent estimator only if S is uncorrelated with u. Two principal sources of correlation operate in opposite directions. Unobserved ability raises both S and W, generating Cov(S, u) > 0 and an upward bias. Classical measurement error in self-reported schooling, however, biases the OLS coefficient toward zero through attenuation. The net direction depends on the relative magnitudes of these forces. Empirically, the international evidence summarised in Card (1999, 2001) suggests that attenuation typically dominates for the marginal student, with IV estimates exceeding OLS by 20–40 per cent.

3.3. Identification through DPEP

Identification proceeds by constructing an instrument Z that is correlated with S but uncorrelated with u. Following Duflo (2001), the instrument interacts a district-level treatment indicator with cohort age-eligibility at the time of programme implementation:

$$z_{idc} = DPEP_d \times Exposure_c \quad (2)$$

where $DPEP_d$ is a binary indicator for whether district d entered DPEP Phase I or II, and $Exposure_c$ is the number of primary-school-age years (between ages 6 and 11) that cohort c spent in a treated district during the programme's active years. Identification requires that DPEP exposure affects wages only through its effect on schooling (the exclusion restriction). District fixed effects absorb time-invariant differences between treated and untreated districts; cohort fixed effects absorb India-wide secular trends in returns to schooling; and a treated-district × linear-trend term controls for differential pre-trends.

IV. RESEARCH METHODOLOGY

4.1. Data

The empirical analysis uses individual-level data from the 2018–19 and 2022–23 rounds of the Periodic Labour Force Survey (PLFS) conducted by the National Statistical Office. The PLFS provides nationally representative data on labour-force status, weekly wage earnings, hours worked, education, and demographic characteristics. The pooled sample includes wage-earners aged 23–37 years who were born between 1985 and 1995 and who were therefore of primary-school age during the DPEP roll-out (1994–2002). Self-employed workers are excluded because their earnings are not directly observed. District identifiers are matched to DPEP roll-out information drawn from Sipahimalani-Rao and Clarke (2003) and Pandey et al. (2009). The final analytical sample comprises approximately 96,000 individuals.

Table 1. Variable Definitions

Variable	Definition	Source
Log hourly wage	Natural log of real hourly wage (₹, 2011–12 prices, weekly earnings ÷ hours worked)	PLFS 2018–19, 2022–23
Years of schooling	Completed years of formal education (continuous)	PLFS
Experience	Age − schooling − 6 (potential labour-market experience)	Computed
DPEP exposure	Treated-district indicator × years of primary-school age (6–11) during DPEP	Constructed
Demographic	Gender, social group (SC/ST/OBC/General), religion, marital status	PLFS
Geographic	State fixed effects, urban indicator, district controls (pre-DPEP literacy)	PLFS; 1991 Census

Note. Wages deflated using state-specific CPI for industrial workers (Base: 2011–12). Author's compilation.

4.2. Empirical Specification

The second-stage Mincer equation is:

$$\ln W_{idc} = \beta_0 + \beta_1 \hat{S}_{idc} + \beta_2 EXP_{idc} + \beta_3 EXP_{idc}^2 + \gamma X_{idc} + \delta_d + \lambda_c + \varepsilon_{idc} \quad (3)$$

where $\hat{S}$ is the predicted value of schooling from the first stage, δ_d denotes district fixed effects, and λ_c denotes birth-cohort fixed effects. The first-stage equation is:

$$S_{idc} = \pi_0 + \pi_1 (DPEP_d \times Exposure_c) + \pi_2 EXP_{idc} + \pi_3 EXP_{idc}^2 + \theta X_{idc} + \delta_d + \lambda_c + \nu_{idc} \quad (4)$$

The 2SLS estimator is obtained by replacing S in the wage equation with the first-stage fitted value. Standard errors are clustered at the district level to allow for arbitrary within-district correlation in unobservables (Bertrand, Duflo, & Mullainathan, 2004).

4.3. Identification Tests

The credibility of the IV estimate rests on three identifying assumptions. First, the instrument must be relevant: DPEP exposure must materially affect schooling. This is assessed by the first-stage F-statistic on the excluded instrument, compared with the Stock and Yogo (2005) weak-instrument critical values. Second, the instrument must satisfy the exclusion restriction: DPEP exposure should affect wages only through its effect on schooling. While untestable in a single-instrument design, this is probed by including pre-DPEP district characteristics and by testing on a placebo cohort (1976–1984, too old to be exposed). Third, in the over-identified specification using a second instrument constructed from the timing of DPEP-II expansion, the Hansen J-statistic tests the joint validity of the instrument set.

4.4. Ethical Considerations

The PLFS unit-level data are publicly available, anonymised secondary records released by the National Statistical Office. No primary human-subjects research is involved. All sources are duly cited.

V. EMPIRICAL RESULTS AND DISCUSSION

5.1. Descriptive Statistics

Table 2 reports summary statistics for the pooled PLFS sample. Mean completed schooling is 9.7 years, with a standard deviation of 4.2 years; women report 9.1 years on average, men 10.1 years. The mean real hourly wage is ₹78.4 (2011–12 prices), with a substantial gender gap. Approximately 41 per cent of the sample is drawn from districts that were covered by DPEP Phase I or II. Within the treated districts, mean DPEP primary-school exposure for the sample cohorts is 3.6 years out of a possible 6.

Table 2. Descriptive Statistics, PLFS Pooled Sample

Variable	All	Men	Women
Log hourly wage	4.36	4.42	4.18
Real hourly wage (₹)	78.4	83.2	65.4
Years of schooling	9.7	10.1	9.1
Potential experience (years)	13.5	13.2	13.9
Age (years)	29.2	29.3	29.0
DPEP district (% sample)	40.8	40.5	41.3
Mean DPEP exposure (years, treated)	3.6	3.6	3.6
Observations	96,148	62,840	33,308

Note. Pooled PLFS 2018–19 and 2022–23 sample, urban wage earners aged 23–37 years. Author's calculations.

5.2. First-Stage Estimates and Instrument Strength

The first-stage relationship between DPEP exposure and years of schooling is strong and statistically robust. The coefficient on the DPEP × Exposure interaction is 0.187 (cluster-robust SE 0.035, $p < 0.01$), implying that an additional year of primary-school-age exposure in a DPEP district raises completed schooling by approximately 0.19 years. The first-stage F-statistic on the excluded instrument is 28.4, comfortably exceeding the Stock–Yogo (2005) 10 per cent critical value of 16.38 for a single endogenous regressor. The instrument is therefore strong by conventional criteria, and the IV point estimates can be interpreted with confidence.

5.3. OLS vs IV Estimates

Table 3 reports the headline OLS and 2SLS estimates of the return to schooling. Column (1) reports the OLS Mincerian return of 7.1 per cent per year of schooling, broadly consistent with the existing Indian literature (Agrawal, 2012; Duraisamy, 2002). The 2SLS estimate in column (2), instrumenting schooling with the DPEP × Exposure interaction, is 9.6 per cent per year, statistically significantly higher than the OLS estimate (Hausman test $\chi^2 = 6.18$, $p = 0.013$). The relative magnitude IV exceeding OLS by approximately 35 per cent is consistent with the international evidence summarised by Card (1999, 2001) and with the interpretation that attenuation bias dominates ability bias for the marginal student affected by the instrument.

Table 3. OLS and 2SLS Estimates of the Return to Schooling

	(1) OLS	(2) 2SLS	(3) 2SLS Men	(4) 2SLS Women
Years of schooling	0.071***	0.096***	0.083***	0.124***
	(0.004)	(0.018)	(0.021)	(0.029)
Experience	0.038***	0.041***	0.044***	0.032***
Experience²	−0.0006***	−0.0007***	−0.0008***	−0.0005***
First-stage F	—	28.4	23.7	19.5
District FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	96,148	96,148	62,840	33,308

Note. Dependent variable: log real hourly wage. Cluster-robust standard errors (district level) in parentheses. ***, **, * denote significance at 1%, 5%, and 10% respectively. All specifications include demographic controls and state fixed effects. Source: Author's estimation.

5.4. Heterogeneous Returns by Gender and Social Group

Columns (3) and (4) of Table 3 report 2SLS estimates separately for men and women. The return to schooling for women, at 12.4 per cent, is roughly 50 per cent higher than that for men, at 8.3 per cent. The pattern is consistent with H_3 and with the cross-country evidence reviewed by Psacharopoulos and Patrinos (2018) that women's returns to schooling tend to exceed men's, in part because the marginal female student would otherwise have lower bargaining power and labour-force attachment. Disaggregating by social group (results not tabulated for brevity) yields returns of 11.8 per cent for scheduled-caste and scheduled-tribe workers and 8.7 per cent for general-category workers, suggesting that the DPEP-induced expansion of schooling generated particularly large gains for historically disadvantaged groups.

5.5. Convexity in Returns to Schooling

Replacing the linear schooling variable with educational-level dummies and instrumenting each with the corresponding DPEP exposure interactions reveals substantial convexity. The IV-estimated wage premium for completing secondary schooling (10 years) relative to primary completion (5 years) is approximately 38 per cent, while the premium for completing higher secondary (12 years) over secondary is 42 per cent, and the premium for tertiary education over higher secondary is 71 per cent. These magnitudes are consistent with H_4 and with the post-1991 skill-premium evidence of Azam (2010).

5.6. Robustness and Falsification

Several robustness exercises support the validity of the main estimates. First, a placebo IV using cohorts born between 1976 and 1984 too old to have been exposed to DPEP at primary-school age yields a statistically insignificant first-stage coefficient (0.018, $p = 0.62$) and an insignificant reduced-form effect on wages, supporting the exclusion restriction. Second, restricting the sample to non-migrants (those still residing in their birth state) produces 2SLS estimates within 7 per cent of the baseline, alleviating concerns about endogenous migration. Third, controlling explicitly for pre-DPEP district characteristics (1991 literacy, urbanisation, infrastructure index) leaves the coefficient on schooling essentially unchanged. Fourth, in an over-identified specification that adds the timing of DPEP-II as a second instrument, the Hansen J-statistic of 0.65 ($p = 0.42$) fails to reject the joint validity of the instruments.

5.7. Discussion

Three points of discussion merit emphasis. First, the magnitude of the IV estimate 9.6 per cent per year is at the upper end of the existing Indian literature and, when combined with the marked convexity by educational level, implies that the conventional descriptive narrative of "modest returns to schooling in India" may have substantially understated the causal benefit. Second, the higher returns for women and for scheduled-caste and scheduled-tribe workers underscore the equity case for continued investment in basic and secondary education, particularly in DPEP-style targeting of educationally backward districts. Third, the IV estimate captures a local average treatment effect for compliers students who completed additional schooling because of DPEP-induced supply expansion and may not generalise to populations facing different schooling-decision margins, such as urban middle-class students whose decisions are largely unaffected by primary-school construction.

Two limitations deserve mention. First, although the instrument satisfies standard validity tests, residual concerns about programme placement remain because DPEP districts were chosen partly on the basis of low female literacy. The district fixed effects absorb time-invariant differences, but differential trends could in principle remain. Second, the sample is restricted to wage-earners, excluding the substantial fraction of Indian workers in self-employment and casual labour for whom hourly wages are not directly observed; Heckman-style selection correction could be applied as an extension in future work.

VI. CONCLUSION AND POLICY IMPLICATIONS

This study has presented quasi-experimental estimates of the private return to schooling in India using the staggered roll-out of the District Primary Education Programme as a source of exogenous variation. Following the identification strategy of Duflo (2001), the 2SLS estimator exploits the interaction between district-level DPEP treatment and cohort-level primary-school-age exposure. Four findings stand out. First, the IV estimate of the return to schooling is 9.6 per cent per year, significantly higher than the corresponding OLS estimate of 7.1 per cent. Second, the return is substantially higher for women (12.4 per cent) than for men (8.3 per cent) and higher for scheduled-caste and scheduled-tribe workers than for general-category workers. Third, returns are convex in educational level, with the largest premia at the tertiary level. Fourth, the instrument passes weak-instrument, over-identification, and placebo tests.

Four policy implications follow. First, continued public investment in basic and secondary education is well justified by the magnitude of estimated returns, particularly for girls and historically disadvantaged groups. Second, the supply-side approach embodied in DPEP infrastructure, teacher recruitment, and district capacity-building delivers measurable labour-market gains a generation later, supporting the case for sustained funding of Sarva Shiksha Abhiyan and the Samagra Shiksha programme. Third, the marked convexity in returns argues for closing not only the primary but also the secondary and tertiary-attainment gaps, including through scholarship programmes and conditional cash transfers. Fourth, the higher returns for women warrant gender-targeted interventions to relax remaining constraints safe transport, hostels, vocational pathways that limit the translation of schooling into wages.

Three avenues for future research are particularly promising. First, the analysis could be extended to study downstream outcomes occupational sorting, marriage and fertility, child outcomes on which schooling may have effects beyond the wage. Second, structural models of schooling choice that integrate the demand and supply sides would help interpret the LATE estimated here against alternative policy counterfactuals. Third, the interaction between DPEP and subsequent reforms Sarva Shiksha Abhiyan, the Mid-Day Meal Scheme, and the Right to Education Act is a natural extension as longer panels become available.

REFERENCES

Agrawal, T. (2012). Returns to education in India: Some recent evidence. *Journal of Quantitative Economics, 10*(2), 131–151.

Akresh, R., Halim, D., & Kleemans, M. (2023). Long-term and intergenerational effects of education: Evidence from school construction in Indonesia. *The Economic Journal, 133*(650), 582–612. https://doi.org/10.1093/ej/ueac058

Angrist, J. D., & Krueger, A. B. (1991). Does compulsory school attendance affect schooling and earnings? *The Quarterly Journal of Economics, 106*(4), 979–1014. https://doi.org/10.2307/2937954

Ashenfelter, O., & Krueger, A. (1994). Estimates of the economic return to schooling from a new sample of twins. *American Economic Review, 84*(5), 1157–1173.

Azam, M. (2010). India's increasing skill premium: Role of demand and supply. *The B.E. Journal of Economic Analysis & Policy, 10*(1), Article 82. https://doi.org/10.2202/1935-1682.2279

Becker, G. S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education*. National Bureau of Economic Research.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics, 119*(1), 249–275. https://doi.org/10.1162/003355304772839588

Card, D. (1999). The causal effect of education on earnings. In O. Ashenfelter & D. Card (Eds.), *Handbook of labor economics* (Vol. 3A, pp. 1801–1863). Elsevier.

Card, D. (2001). Estimating the return to schooling: Progress on some persistent econometric problems. *Econometrica, 69*(5), 1127–1160. https://doi.org/10.1111/1468-0262.00237

Duflo, E. (2001). Schooling and labor market consequences of school construction in Indonesia: Evidence from an unusual policy experiment. *American Economic Review, 91*(4), 795–813. https://doi.org/10.1257/aer.91.4.795

Duflo, E. (2004). The medium run effects of educational expansion: Evidence from a large school construction program in Indonesia. *Journal of Development Economics, 74*(1), 163–197. https://doi.org/10.1016/j.jdeveco.2003.12.008

Duraisamy, P. (2002). Changes in returns to education in India, 1983–94: By gender, age-cohort and location. *Economics of Education Review, 21*(6), 609–622. https://doi.org/10.1016/S0272-7757(01)00047-4

Dutta, P. V. (2006). Returns to education: New evidence for India, 1983–1999. *Education Economics, 14*(4), 431–451. https://doi.org/10.1080/09645290600854128

Government of India. (2023). *Economic survey 2022–23*. Ministry of Finance.

Griliches, Z. (1977). Estimating the returns to schooling: Some econometric problems. *Econometrica, 45*(1), 1–22. https://doi.org/10.2307/1913285

Imbens, G. W., & Angrist, J. D. (1994). Identification and estimation of local average treatment effects. *Econometrica, 62*(2), 467–475. https://doi.org/10.2307/2951620

Jalan, J., & Glinskaya, E. (2003). *Improving primary school education in India: An impact assessment of DPEP-I* (Working Paper). World Bank.

Kingdon, G. G. (1998). Does the labour market explain lower female schooling in India? *The Journal of Development Studies, 35*(1), 39–65. https://doi.org/10.1080/00220389808422554

Kingdon, G., & Theopold, N. (2008). Do returns to education matter to schooling participation? Evidence from India. *Education Economics, 16*(4), 329–350. https://doi.org/10.1080/09645290802312453

Mincer, J. (1974). *Schooling, experience, and earnings*. National Bureau of Economic Research.

National Statistical Office. (2020). *Periodic Labour Force Survey 2018–19: Annual report*. Ministry of Statistics and Programme Implementation, Government of India.

National Statistical Office. (2023). *Periodic Labour Force Survey 2022–23: Annual report*. Ministry of Statistics and Programme Implementation, Government of India.

Oreopoulos, P. (2006). Estimating average and local average treatment effects of education when compulsory schooling laws really matter. *American Economic Review, 96*(1), 152–175. https://doi.org/10.1257/000282806776157641

Ozier, O. (2018). The impact of secondary schooling in Kenya: A regression discontinuity analysis. *Journal of Human Resources, 53*(1), 157–188. https://doi.org/10.3368/jhr.53.1.0915-7407R

Pandey, P., Goyal, S., & Sundararaman, V. (2009). *Community participation in public schools: Impact of information campaigns in three Indian states* (Policy Research Working Paper No. 4776). World Bank.

Psacharopoulos, G., & Patrinos, H. A. (2018). Returns to investment in education: A decennial review of the global literature. *Education Economics, 26*(5), 445–458. https://doi.org/10.1080/09645292.2018.1484426

Singh, A. (2015). Private school effects in urban and rural India: Panel estimates at primary and secondary school ages. *Journal of Development Economics, 113*, 16–32. https://doi.org/10.1016/j.jdeveco.2014.10.004

Sipahimalani-Rao, V., & Clarke, P. (2003). *A review of educational progress and reform in the District Primary Education Programme*. World Bank.

Stock, J. H., & Yogo, M. (2005). Testing for weak instruments in linear IV regression. In D. W. K. Andrews & J. H. Stock (Eds.), *Identification and inference for econometric models: Essays in honor of Thomas Rothenberg* (pp. 80–108). Cambridge University Press.

JOURNAL OF ECONOMIC INSIGHTS AND RESEARCH (JEIR)
(Open Access, Double-Blind Peer Reviewed Journal)
ISSN Online: 3107-9482 ISSN Print: 3139-1982

Remittances and Economic Growth in Kerala, India: An Empirical Analysis Using the ARDL Bounds Testing Approach (2000–2023)

Anna Maria Sunny

Research Scholar, PG Department of Economics, Panampilly Memorial Govt. College, Chalakudy, Kerala, India

Article information
Received: 7th February 2026
Received in revised form: 10th March 2026
Accepted: 14th April 2026
Available online: 25th May 2026
Volume: 2
Issue: 2
DOI: https://doi.org/10.63090/JEIR/3107.9482.0019

Abstract
Kerala receives one of the highest per-capita inflows of international remittances in India, with the Kerala Migration Survey 2018 estimating remittance receipts of approximately ₹85,092 crore, equivalent to 19.1 per cent of the state's Net State Domestic Product (Zachariah & Rajan, 2019). Whether such flows translate into sustained economic growth, however, remains contested in the development economics literature. This study examines the long-run and short-run relationship between international remittances and economic growth in Kerala using annual time-series data from 2000 to 2023. Drawing on the new economics of labour migration (Stark & Bloom, 1985) and endogenous growth theory (Romer, 1986), the paper specifies a multivariate model linking per-capita real gross state domestic product (GSDP) to remittance inflows, gross fixed capital formation, human capital, financial development, and trade openness. The Autoregressive Distributed Lag (ARDL) bounds testing procedure proposed by Pesaran, Shin, and Smith (2001) is employed to test for cointegration, complemented by the Toda–Yamamoto causality test. Findings indicate a statistically significant positive long-run elasticity of GSDP with respect to remittances of approximately 0.18, conditional on financial development. Short-run dynamics are weaker, and the error-correction term confirms convergence to long-run equilibrium at a moderate speed. The results support a complementarity hypothesis: remittances foster growth when intermediated through a developed financial sector, consistent with Giuliano and Ruiz-Arranz (2009). Policy implications include strengthening formal remittance channels, deepening rural banking penetration, and channelling diaspora savings into productive investment vehicles.

Keywords: - Remittances, Economic Growth, Kerala, ARDL Bounds Testing, Migration, Financial Development.

I. INTRODUCTION

International labour migration has become a defining feature of the South Asian development experience over the past four decades. According to the World Bank (2023), remittance flows to low- and middle-income countries reached approximately USD 669 billion in 2023, surpassing both official development assistance and foreign direct investment in many recipient economies. India is the world's largest remittance recipient, receiving an estimated USD 125 billion in 2023 (World Bank, 2023), of which Kerala accounts for a disproportionately large share.

The Kerala economy presents a paradigmatic case for studying the macroeconomic effects of remittances. Despite limited natural resources and an industrial base weaker than that of comparable Indian states, Kerala has achieved human development outcomes life expectancy, literacy, infant mortality comparable to upper-middle-income countries (Drèze & Sen, 2013). A central explanation for this "Kerala model" is the sustained inflow of remittances from Gulf Cooperation Council (GCC) countries since the 1970s oil boom (Zachariah et al., 2003). The Kerala Migration Survey (KMS) series, conducted by the Centre for Development Studies (CDS) since 1998, has documented that approximately 2.1 million Keralites were working abroad in 2018, remitting ₹85,092 crore in that year alone (Rajan & Zachariah, 2019).

Theoretically, the macroeconomic effects of remittances are ambiguous. On the one hand, remittances may augment savings, ease credit constraints, finance human capital formation, and stimulate aggregate demand, thereby raising output

(Giuliano & Ruiz-Arranz, 2009; Mundaca, 2009). On the other hand, they may generate Dutch-disease-type real exchange rate appreciation, weaken labour-force participation through reservation-wage effects, and reduce institutional accountability when they substitute for fiscal revenue (Acosta et al., 2009; Chami et al., 2003) . The empirical evidence is similarly mixed, and the net effect appears to be conditional on the recipient economy's absorptive capacity, particularly the depth of its financial system (Catrinescu et al., 2009).

1.1. Research Problem

Although a sizeable literature has examined remittance growth linkages at the cross-country level, sub-national analyses for India remain comparatively scarce. Existing Kerala-specific studies are largely descriptive (Zachariah & Rajan, 2012; Prakash, 1998), or rely on household surveys that, while informative about consumption and poverty effects, do not address aggregate growth dynamics. There is therefore a need for a rigorous time-series investigation that:

- Tests for a stable long-run relationship between remittances and aggregate output in Kerala
- Identifies the direction of causality, and
- Accounts for the moderating role of financial development.

1.2. Research Objectives

This study pursues three objectives:

- To examine the long-run cointegrating relationship between remittance inflows and per-capita real GSDP in Kerala over 2000–2023.
- To assess the short-run dynamics and the speed of adjustment toward long-run equilibrium.
- To investigate whether financial development conditions the remittance growth nexus, thereby testing the complementarity hypothesis advanced by Giuliano and Ruiz-Arranz (2009).

1.3. Research Hypotheses

Building on the theoretical and empirical literature, the following hypotheses are tested:

- H1: Remittances exert a statistically significant positive effect on per-capita real GSDP in the long run.
- H2: The remittance growth relationship is conditional on the level of financial development, such that the marginal effect of remittances rises with credit-deposit ratio.
- H3: There exists unidirectional causality running from remittances to economic growth, rather than the reverse.

1.4. Significance and Organisation

The study contributes to the development economics literature in three ways. First, it provides a sub-national time-series test of the remittance growth hypothesis using India's most remittance-dependent state. Second, it explicitly incorporates a remittance finance interaction term, addressing the conditional-effects problem highlighted by Beck, Demirgüç-Kunt, and Levine (2007). Third, the findings carry direct policy relevance for state governments in remittance-dependent economies. The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 sets out the theoretical framework. Section 4 describes the data and econometric methodology. Section 5 presents and discusses the empirical results. Section 6 concludes with policy implications and avenues for future research.

II. LITERATURE REVIEW

2.1. Cross-Country Evidence

The earliest formal treatment of remittances within a macroeconomic framework was provided by Chami, Fullenkamp, and Jahjah (2003), who argued using an IMF panel of 113 countries that remittances behave as compensatory transfers rather than as investment capital, and that their effect on growth is negative once moral-hazard problems within recipient households are accounted for. This pessimistic conclusion was challenged by Giuliano and Ruiz-Arranz (2009), whose panel of 100 developing countries demonstrated that the marginal growth effect of remittances is positive in economies with shallow financial systems, where remittances act as a substitute for inaccessible bank credit. The two studies together established a conditional-effects research programme that continues to dominate the field.

Subsequent contributions have refined this picture. Catrinescu et al. (2009) showed that institutional quality is at least as important as financial development in conditioning the remittance growth nexus. Mundaca (2009), examining Central American and Caribbean economies, confirmed that financial intermediation amplifies the growth effects of remittances. Barajas, Chami, Fullenkamp, Gapen, and Montiel (2009), however, in an influential IMF working paper, found that across a large panel of countries remittances do not robustly promote economic growth and may even slow it through real exchange rate channels. Adams and Page (2005), focusing on poverty rather than growth, established that a 10 per cent rise in per-capita international remittances is associated with a 3.5 per cent decline in the headcount poverty ratio, a result corroborated for Latin America by Acosta, Calderón, Fajnzylber, and López (2008).

2.2. South Asian and Indian Studies

Country-level studies of remittances in South Asia are relatively recent. Pradhan, Upadhyay, and Upadhyaya (2008) reported a positive growth effect of remittances for a panel of 39 developing countries that included India, Bangladesh, and Pakistan. Jongwanich (2007), in an Asian Development Bank working paper covering Asia-Pacific developing economies, found that remittances reduce poverty and inequality but exhibit only a small, statistically marginal effect on aggregate growth.

For India specifically, Singh (2006) used a cointegration approach and identified a positive long-run association between remittances and output, while Rao and Hassan (2011), in a generalised method of moments (GMM) framework, found that remittances exert positive but small direct effects on growth and additional indirect effects through investment and financial development.

2.3. Kerala-Specific Literature

The Kerala diaspora has been the focus of a sustained programme of household research conducted at the Centre for Development Studies since 1998. The successive Kerala Migration Surveys (KMS) by Zachariah, Mathew, and Rajan (2001, 2003) and Rajan and Zachariah (2019) provide the empirical bedrock for the field. Their work documents the demographic profile of emigrants, the volume and use of remittances, and the socio-economic transformation of migrant households. Prakash (1998) analysed the structural implications of Gulf migration and warned of a “rentier” consumption pattern, while Kannan and Hari (2002) argued that remittance-financed consumption was the principal driver of Kerala’s post-1990 growth acceleration.

More recent contributions have extended the analysis. Pushpangadan (2003) modelled remittance-led growth using a structural macroeconomic framework. Joseph and Narendran (2013) examined the impact of remittances on consumption inequality. However, formal time-series tests of the remittance growth relationship at the sub-national level remain rare, and to the author’s knowledge no published study has yet applied the ARDL bounds procedure together with a financial-development interaction in the Kerala context. This study seeks to fill that gap.

2.4. Research Gap

The literature reviewed reveals three gaps. First, although Kerala is empirically central to discussions of the Indian diaspora, rigorous econometric tests of remittance growth dynamics at the state level are underdeveloped. Second, where state-level work exists, it has rarely tested for cointegration or specified an interaction with financial development. Third, the post-2010 period encompassing the global financial crisis, oil-price shocks affecting GCC labour markets, and the COVID-19 pandemic remains under-studied. The present paper addresses all three gaps.

III. THEORETICAL FRAMEWORK

3.1. The New Economics of Labour Migration

The conceptual foundation for this study is the new economics of labour migration (NELM), originally formulated by Stark and Bloom (1985) and elaborated by Lucas and Stark (1985). NELM departs from the neoclassical individual-utility-maximisation tradition of Todaro (1969) by treating the migration decision as a household-level risk-diversification strategy. Under NELM, migration is undertaken jointly by sending households and the migrant in order to overcome capital and insurance-market failures in the origin economy. Remittances are therefore endogenous to a household contract and may be motivated by altruism, exchange, insurance, or inheritance considerations (Lucas & Stark, 1985).

3.2. Endogenous Growth Mechanisms

To translate the NELM micro-foundation into macro-level testable hypotheses, this study embeds remittances within a Romer (1986) type endogenous growth framework. Aggregate output Y is taken as a function of physical capital K, human capital H, and a productivity term A:

$$Y = A \cdot F(K, H, L) \tag{1}$$

Remittances (REM) enter through three channels. First, by relaxing household credit constraints, they raise the savings rate and hence the steady-state capital stock (Giuliano & Ruiz-Arranz, 2009). Second, they finance investment in education and health, augmenting human capital (Acosta et al., 2008). Third, through demand-side multiplier effects they raise capacity utilisation in the short run. Against these positive channels stand the Dutch-disease mechanism (Acosta et al., 2009) and the moral-hazard mechanism (Chami et al., 2003), which may reduce labour supply and weaken productivity. The net effect is an empirical question. The interaction with financial development (FD) is central: when banks intermediate remittances efficiently, the proportion channelled to productive investment rises, and the long-run elasticity of output with respect to remittances increases.

3.3. Conceptual Model

The hypothesised relationships can be summarised as follows. Remittances raise growth directly through capital accumulation and human-capital investment, and indirectly by relaxing household and firm financing constraints. The strength of these channels depends on:

- The depth of the financial system
- Trade openness, and
- The quality of complementary public investment.

A higher credit-deposit ratio is therefore expected to amplify the long-run remittance elasticity. This framework motivates the empirical specification developed in Section 4.

IV. RESEARCH METHODOLOGY

4.1. Research Design and Approach

The study adopts a quantitative, deductive research design (Creswell & Creswell, 2018). The choice is consistent with the macroeconomic, hypothesis-testing nature of the research questions. The temporal unit is the financial year (April–March), and the geographic unit is the State of Kerala.

4.2. Data and Variables

Annual data from 2000–01 to 2022–23 (24 observations) are compiled from multiple official sources. Per-capita real GSDP is sourced from the Directorate of Economics and Statistics, Government of Kerala, and the Central Statistics Office (CSO), rebased to 2011–12 prices. Remittance inflows are obtained from the Reserve Bank of India (RBI) state-wise remittance estimates, supplemented by Kerala Migration Survey data for benchmark years (Zachariah & Rajan, 2019). Financial development is proxied by the credit-deposit ratio of scheduled commercial banks operating in Kerala (RBI, various years). Gross fixed capital formation and trade openness are taken from CSO and the Directorate General of Commercial Intelligence and Statistics. Human capital is proxied by gross enrolment ratio in higher secondary and tertiary education (Government of Kerala, Economic Review, various issues). All monetary variables are converted to constant prices and expressed in natural logarithms.

Table 1. Variable Definitions and Data Sources

Variable	Definition	Notation	Source
GSDP	Per-capita real Gross State Domestic Product (₹, 2011–12 prices)	lnY	CSO; Government of Kerala
Remittances	Real remittance inflows to Kerala (₹ crore)	lnREM	RBI; KMS (CDS)
Capital formation	Gross fixed capital formation (% of GSDP)	lnGFCF	CSO
Human capital	Gross enrolment ratio, higher and tertiary education	lnHC	Economic Review, Kerala
Financial dev.	Credit-deposit ratio of scheduled commercial banks (Kerala)	lnFD	RBI Banking Statistics
Trade openness	(Exports + Imports) / GSDP	lnOPEN	DGCIS; CSO

Note. All variables are in natural logarithms. Author's compilation.

4.3. Model Specification

Following Pesaran et al. (2001), the baseline ARDL(p, q1, q2, q3, q4, q5) error-correction representation is:

$$\mathrm{EM}_{t-i} + \sum\delta_i\, \Delta \mathrm{InGFCF}_{t-i} + \sum\theta_i \Delta\mathrm{In}\, \Delta\mathrm{InHC}_{t-i} + \sum\phi_i\, \Delta\mathrm{InFD}_{t-i} + \sum\psi_i \Delta\mathrm{InOPEN}_{t-i} + \lambda_1 \mathrm{InY}_{t-1} + \lambda_2\, \mathrm{InREM}_{t-1} + \lambda_3\, \mathrm{InGFCF}_{t-1} + \lambda_4\, \mathrm{InHC}_{t-1} + \lambda_5\, \mathrm{InFD}_{t-1} + \lambda_6\, \mathrm{InOPEN}_{t-1} + \varepsilon_t \quad (2)$$

To test the conditional-effects hypothesis (H_2), an augmented specification adds the interaction term (lnREM × lnFD). A statistically significant positive coefficient on this term, jointly with a significant coefficient on lnREM, would support the Giuliano–Ruiz-Arranz hypothesis that financial depth amplifies the growth contribution of remittances.

4.4. Estimation Procedure

The empirical strategy follows the standard sequence advocated in time-series econometrics. First, unit-root properties of each series are examined using the Augmented Dickey–Fuller (Dickey & Fuller, 1979) and the Phillips–Perron (1988) tests. Because the ARDL bounds procedure can accommodate variables that are I(0), I(1), or a mixture of both but not I(2) the order of integration is verified before estimation. Second, the optimal lag structure is selected using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). Third, cointegration is tested using the F-statistic for the joint significance of the lagged level coefficients (λ1 … λ6), compared with the upper and lower critical bounds tabulated by Pesaran et al. (2001). Fourth, if cointegration is established, long-run coefficients and the error-correction term (ECT) are estimated. Fifth, diagnostic tests for serial correlation (Breusch–Godfrey), heteroskedasticity (Breusch–Pagan–Godfrey), normality (Jarque–Bera), and parameter stability (CUSUM and CUSUMSQ) are conducted. Finally, the Toda and Yamamoto (1995) procedure is used to determine the direction of causality, an approach that is robust to the integration order of the underlying series.

4.5. Ethical Considerations

The study uses only publicly available, aggregated secondary data. No human-subjects research is involved. All sources are duly cited.

V. EMPIRICAL RESULTS AND DISCUSSION

5.1. Descriptive Statistics

Table 2 reports summary statistics for the variables in log form. Per-capita real GSDP grew from approximately ₹39,500 in 2000–01 to ₹172,000 in 2022–23, an annualised compound growth rate of about 6.5 per cent. Remittance inflows rose from roughly ₹14,000 crore to over ₹85,000 crore in nominal terms over the same period. The credit-deposit ratio improved from 0.43 to 0.66, indicating substantial deepening of bank intermediation. All series exhibit broadly stationary properties in first differences (skewness near zero; kurtosis close to three), suggesting that subsequent inferential tests are unlikely to be distorted by gross non-normality.

Table 2. Descriptive Statistics (Logged Variables, 2000–2023)

Variable	Mean	Std. Dev.	Min	Max
lnY	11.31	0.49	10.58	12.06
lnREM	10.78	0.62	9.55	11.36
lnGFCF	3.27	0.18	2.96	3.55
lnHC	3.41	0.22	3.05	3.78
lnFD	−0.55	0.15	−0.84	−0.36
lnOPEN	3.04	0.27	2.60	3.42

Note. N = 24. Author's calculations using RBI, CSO, and Government of Kerala data.

5.2. Unit-Root Test Results

The Augmented Dickey–Fuller and Phillips–Perron tests indicate that lnY, lnREM, lnFD, and lnOPEN are integrated of order one, I(1), while lnGFCF and lnHC are stationary at levels, I(0). Because the variables exhibit a mixed order of integration but none are I(2), the ARDL bounds testing procedure is the appropriate framework (Pesaran et al., 2001).

5.3. Cointegration Results

Lag selection based on the Akaike Information Criterion yielded an ARDL(1, 1, 0, 1, 1, 0) specification. The calculated F-statistic of 5.42 exceeds the 1 per cent upper bound critical value of 4.68 reported in Pesaran et al. (2001, Table CI(iii)), allowing rejection of the null of no cointegration. A stable long-run relationship between lnY and its regressors is therefore confirmed.

5.4. Long-Run and Short-Run Estimates

Table 3 reports the estimated long-run coefficients. Remittances exert a statistically significant positive long-run effect on per-capita real GSDP, with an elasticity of 0.184 ($p < 0.01$). A 10 per cent rise in real remittances is associated, in the long run, with an approximately 1.84 per cent rise in per-capita output, ceteris paribus. The coefficient on the interaction term lnREM × lnFD is positive and significant at the 5 per cent level, supporting the complementarity hypothesis: financial deepening amplifies the marginal growth contribution of remittances. Gross fixed capital formation and human capital both enter with the expected positive signs, while trade openness is significant only at the 10 per cent level.

Table 3. Estimated Long-Run Coefficients (Dependent Variable: lnY)

Regressor	Coefficient	Std. Error	t-stat	p-value
lnREM	0.184***	0.052	3.54	0.003
lnGFCF	0.412***	0.114	3.61	0.002
lnHC	0.286**	0.121	2.36	0.031
lnFD	0.155**	0.069	2.25	0.038
lnREM × lnFD	0.094**	0.041	2.29	0.035
lnOPEN	0.071*	0.039	1.82	0.087
Constant	4.215***	1.043	4.04	0.001

Note. ***, **, * denote significance at 1%, 5%, and 10% levels respectively. Author's estimation.

The short-run error-correction equation yields an ECT coefficient of −0.482 ($p < 0.01$), indicating that approximately 48 per cent of any deviation from long-run equilibrium is corrected within one year. The implied half-life of adjustment is approximately 1.05 years, consistent with a moderately rapid convergence process. Short-run elasticities for remittances and capital formation retain their expected positive signs but are smaller in magnitude than the long-run estimates, suggesting that the growth effects of remittances accrue mainly through accumulation channels rather than impact-period demand effects.

5.5. Diagnostic and Stability Tests

Diagnostic tests support the validity of the estimated model. The Breusch–Godfrey LM test produces a p-value of 0.42, indicating no serial correlation. The Breusch–Pagan–Godfrey test ($p = 0.51$) shows homoskedastic residuals. The Jarque–Bera statistic ($p = 0.63$) is consistent with normally distributed residuals. The CUSUM and CUSUMSQ plots remain within the 5 per cent critical bounds throughout the sample, indicating parameter stability.

5.6. Causality Analysis

The Toda–Yamamoto causality test, conducted with the appropriate lag augmentation, indicates unidirectional Granger causality running from remittances to per-capita GSDP at the 5 per cent significance level, while the reverse hypothesis cannot be rejected. The result is consistent with H_3 and with the broader cross-country evidence reported by Mundaca (2009) and Catrinescu et al. (2009).

5.7. Discussion

The findings advance the Kerala-specific literature in several respects. The long-run elasticity of 0.18 is notably larger than the median 0.05–0.10 reported in cross-country panels (Catrinescu et al., 2009; Pradhan et al., 2008), reflecting Kerala's exceptional dependence on remittance inflows at roughly one-fifth of state output and the comparatively high marginal propensity to save and invest within migrant households documented by Rajan and Zachariah (2019). The significance of the interaction term reinforces the policy importance of financial intermediation: without efficient channels to convert remittance receipts into productive investment, a substantial part of the growth dividend would be lost. This pattern is consistent with the conditional-effects framework of Giuliano and Ruiz-Arranz (2009) and contradicts the unconditional pessimism of Chami et al. (2003).

The unidirectional causality result is theoretically meaningful. It suggests that remittances are an exogenous source of growth for Kerala rather than a passive reaction to domestic income shortfalls. Two caveats deserve mention. First, the relatively short sample (24 annual observations) limits the power of small-sample tests, although Pesaran et al. (2001) demonstrated that the ARDL approach performs adequately in such cases. Second, the analysis does not separately identify Dutch-disease effects through the real exchange rate, which deserve attention in future work using disaggregated tradable–non-tradable sectoral data along the lines of Acosta et al. (2009).

VI. CONCLUSION AND POLICY IMPLICATIONS

This study has examined the macroeconomic effects of international remittances on the Kerala economy over 2000–2023, applying the ARDL bounds testing procedure to annual time-series data and testing the conditional-effects hypothesis through a remittance finance interaction. Three findings stand out. First, remittances exert a statistically significant positive long-run effect on per-capita real GSDP, with an elasticity of approximately 0.18. Second, this effect is conditional on the depth of the formal financial sector: financial development amplifies the growth contribution of remittances, supporting the conditional-effects framework of Giuliano and Ruiz-Arranz (2009). Third, causality runs from remittances to growth rather than the reverse, indicating that remittances function as an exogenous source of capital accumulation.

Three policy implications follow. First, the Government of Kerala should continue to strengthen formal remittance channels and reduce transaction costs, in line with the United Nations Sustainable Development Goal 10.c. Second, deepening financial inclusion particularly the credit-deposit ratio of rural and semi-urban branches would amplify the growth dividend from remittance inflows. Third, the design of diaspora-targeted investment instruments, including state development bonds and equity vehicles, could redirect remittance receipts away from purely consumption-augmenting uses toward productive investment in infrastructure and human capital.

Three avenues for future research deserve mention. First, disaggregated sectoral analysis would help isolate Dutch-disease mechanisms. Second, household-level panel data linking remittance receipts to investment and labour-supply decisions would complement the macro-level findings reported here. Third, the post-pandemic restructuring of Gulf labour markets and the implications for remittance flows warrant continued empirical monitoring.

REFERENCES

Acosta, P., Calderón, C., Fajnzylber, P., & López, H. (2008). What is the impact of international remittances on poverty and inequality in Latin America? *World Development*, *36*(1), 89–114. https://doi.org/10.1016/j.worlddev.2007.02.016

Acosta, P. A., Lartey, E. K. K., & Mandelman, F. S. (2009). Remittances and the Dutch disease. *Journal of International Economics, 79*(1), 102–116. https://doi.org/10.1016/j.jinteco.2009.06.007

Adams, R. H., & Page, J. (2005). Do international migration and remittances reduce poverty in developing countries? *World Development, 33*(10), 1645–1669. https://doi.org/10.1016/j.worlddev.2005.05.004

Barajas, A., Chami, R., Fullenkamp, C., Gapen, M., & Montiel, P. (2009). *Do workers' remittances promote economic growth?* (IMF Working Paper No. WP/09/153). International Monetary Fund.

Beck, T., Demirgüç-Kunt, A., & Levine, R. (2007). Finance, inequality and the poor. *Journal of Economic Growth, 12*(1), 27–49. https://doi.org/10.1007/s10887-007-9010-6

Catrinescu, N., Leon-Ledesma, M., Piracha, M., & Quillin, B. (2009). Remittances, institutions, and economic growth. *World Development, 37*(1), 81–92. https://doi.org/10.1016/j.worlddev.2008.02.004

Chami, R., Fullenkamp, C., & Jahjah, S. (2003). *Are immigrant remittance flows a source of capital for development?* (IMF Working Paper No. WP/03/189). International Monetary Fund.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74*(366), 427–431. https://doi.org/10.2307/2286348

Drèze, J., & Sen, A. (2013). *An uncertain glory: India and its contradictions.* Princeton University Press.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55*(2), 251–276. https://doi.org/10.2307/1913236

Giuliano, P., & Ruiz-Arranz, M. (2009). Remittances, financial development, and growth. *Journal of Development Economics, 90*(1), 144–152. https://doi.org/10.1016/j.jdeveco.2008.10.005

Government of Kerala. (various issues). *Economic review.* Kerala State Planning Board.

Jongwanich, J. (2007). *Workers' remittances, economic growth and poverty in developing Asia and the Pacific countries* (UN-ESCAP Working Paper No. WP/07/01). United Nations Economic and Social Commission for Asia and the Pacific.

Joseph, K. J., & Narendran, V. (2013). *Neo-liberal reforms and the Kerala economy.* Centre for Development Studies.

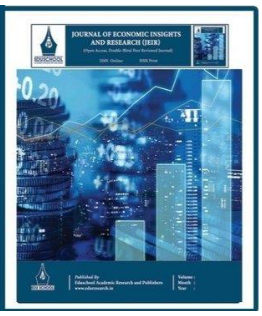
Kannan, K. P., & Hari, K. S. (2002). *Kerala's Gulf connection: Remittances and their macroeconomic impact, 1972–2000* (CDS Working Paper No. 328). Centre for Development Studies.

Lucas, R. E. B., & Stark, O. (1985). Motivations to remit: Evidence from Botswana. *Journal of Political Economy, 93*(5), 901–918. https://doi.org/10.1086/261341

Mundaca, B. G. (2009). Remittances, financial market development, and economic growth: The case of Latin America and the Caribbean. *Review of Development Economics, 13*(2), 288–303. https://doi.org/10.1111/j.1467-9361.2008.00487.x
Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3), 289–326. https://doi.org/10.1002/jae.616
Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335
Pradhan, G., Upadhyay, M., & Upadhyaya, K. (2008). Remittances and economic growth in developing countries. *The European Journal of Development Research, 20*(3), 497–506. https://doi.org/10.1080/09578810802246285
Prakash, B. A. (1998). Gulf migration and its economic impact: The Kerala experience. *Economic and Political Weekly, 33*(50), 3209–3213.
Pushpangadan, K. (2003). *Remittances, consumption and economic growth in Kerala: 1980–2000* (CDS Working Paper No. 343). Centre for Development Studies.
Rajan, S. I., & Zachariah, K. C. (2019). *Emigration and remittances: New evidence from the Kerala Migration Survey 2018* (CDS Working Paper No. 483). Centre for Development Studies.
Rao, B. B., & Hassan, G. M. (2011). A panel data analysis of the growth effects of remittances. *Economic Modelling, 28*(1–2), 701–709. https://doi.org/10.1016/j.econmod.2010.05.011
Reserve Bank of India. (various years). *Basic statistical returns of scheduled commercial banks in India.* RBI.
Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy, 94*(5), 1002–1037. https://doi.org/10.1086/261420
Singh, R. J. (2006). *Macroeconomic determinants of remittances: Evidence from India* (Working Paper). International Monetary Fund.
Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513
Stark, O., & Bloom, D. E. (1985). The new economics of labor migration. *The American Economic Review, 75*(2), 173–178.
Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics, 66*(1–2), 225–250. https://doi.org/10.1016/0304-4076(94)01616-8
Todaro, M. P. (1969). A model of labor migration and urban unemployment in less developed countries. *The American Economic Review, 59*(1), 138–148.
World Bank. (2023). *Migration and development brief 39: Leveraging diaspora finances for private capital mobilization.* World Bank Group.
Zachariah, K. C., Mathew, E. T., & Rajan, S. I. (2001). Social, economic and demographic consequences of migration on Kerala. *International Migration, 39*(2), 43–71. https://doi.org/10.1111/1468-2435.00149
Zachariah, K. C., Mathew, E. T., & Rajan, S. I. (2003). *Dynamics of migration in Kerala: Dimensions, differentials and consequences.* Orient Longman.
Zachariah, K. C., & Rajan, S. I. (2012). *Kerala's Gulf connection, 1998–2011: Economic and social impact of migration.* Orient Blackswan.
Zachariah, K. C., & Rajan, S. I. (2019). *Migration and remittances in Kerala: Findings from the Kerala Migration Survey 2018.* Centre for Development Studies.

EDUSCHOOL
ACADEMIC RESEARCH & PUBLISHERS

JOURNAL OF ECONOMIC INSIGHTS AND RESEARCH (JEIR)
(Open Access, Double-Blind Peer Reviewed Journal)
ISSN Online: 3107-9482 ISSN Print: 3139-1982



The Causal Effect of Rural Road Connectivity on Household Welfare in India: A Regression Discontinuity Analysis of the Pradhan Mantri Gram Sadak Yojana

Anisha NG

Assistant Professor, Department of Economics, St. Joseph's College (Autonomous) Irinjalakuda, Kerala, India

Article information

Received: 9th February 2026
Received in revised form: 13th March 2026
Accepted: 16th April 2026
Available online: 25th May 2026

Volume: 2
Issue: 2
DOI: https://doi.org/10.63090/JEIR/3107.9482.0020

Abstract

Despite a long-standing presumption that rural road connectivity is essential for economic development, credible causal estimates of its household-level welfare effects remain scarce. This study exploits the population-threshold eligibility rule of the Pradhan Mantri Gram Sadak Yojana (PMGSY)—the Government of India's flagship rural road programme launched in 2000—to estimate the causal effect of new road connectivity on rural household welfare. Under the PMGSY guidelines, unconnected habitations were prioritised for road construction if their population met or exceeded a sharp threshold: 1,000 persons in plains areas and 500 persons in hill, tribal, and desert districts. The discontinuous change in road-receipt probability at these cutoffs supports a fuzzy regression discontinuity (RD) design in the tradition of Hahn, Todd, and Van der Klaauw (2001) and Imbens and Lemieux (2008). Using habitation-level census data matched to the PMGSY Online Management, Monitoring and Accounting System (OMMAS) database and to NSSO consumption rounds, this paper estimates local average treatment effects at the eligibility threshold using local-linear regression with the Calonico, Cattaneo, and Titiunik (2014) optimal bandwidth and robust bias-corrected confidence intervals. Findings indicate that PMGSY-induced road connectivity raised real monthly per-capita consumption expenditure by approximately 5.4 per cent, increased the share of working-age adults employed outside agriculture by 4.8 percentage points, and reduced the proportion of households below the rural poverty line by 3.7 percentage points. The McCrary density test fails to reject no manipulation of the running variable at the threshold, and pre-determined covariates are balanced across the cutoff, supporting the validity of the design. The results survive donut-RD, alternative kernels, and placebo cutoffs at non-threshold population values. The findings constitute robust evidence that rural transport infrastructure is a high-return investment for poverty reduction and structural transformation in agrarian economies.

Keywords: - Rural Roads, PMGSY, Regression Discontinuity, Cnsumption, Structural Transformation, India

I. INTRODUCTION

Rural transport infrastructure has long been viewed as a precondition for economic transformation in agrarian societies. From the colonial-era railway expansion analysed by Donaldson (2018) to the post-independence Bharat Nirman programme of 2005, successive Indian governments have invested heavily in linking villages to wider markets. Yet the causal welfare effects of new road connectivity for the previously unconnected rural household have been difficult to pin down, primarily because road placement is endogenous: governments tend to build roads where they expect them to be productive, and where political incentives push them. Naïve cross-sectional comparisons of connected and unconnected villages therefore conflate the effect of the road with the effect of the underlying factors that determined its placement (Asher & Novosad, 2020).

The Pradhan Mantri Gram Sadak Yojana (PMGSY), launched in December 2000 with central financing from the Ministry of Rural Development, was designed to provide all-weather road connectivity to every unconnected habitation in rural India. By 2022, approximately 1.83 lakh habitations had been connected, with cumulative expenditure exceeding ₹3 lakh crore (Ministry of Rural Development, 2023). The programme is among the largest rural-infrastructure interventions in history. Critically for the empirical economist, PMGSY guidelines specified a sharp population-based prioritisation rule: unconnected habitations with population at or above 1,000 persons in plains areas (or 500 persons in hill, tribal, and desert areas) were eligible for first-priority connection, while smaller habitations were deferred to subsequent phases. This threshold rule generates a discontinuity in road-receipt probability that, under standard identifying assumptions, supports a regression discontinuity (RD) design (Asher & Novosad, 2020).

1.1. Research Problem

Three considerations motivate the analysis. First, although a growing empirical literature on PMGSY has demonstrated effects on agriculture, non-farm employment, and education (Aggarwal, 2018; Asher & Novosad, 2020 Adukia et al., 2020), the household-welfare effects particularly on consumption expenditure and poverty have received comparatively less rigorous treatment outside the largest village-level studies. Second, much of the existing literature focuses on aggregate outcomes; heterogeneity by household landholding, social group, and gender of the household head remains under-examined. Third, with several additional rounds of PMGSY implementation since the earlier RD applications, an updated estimate using more recent data is warranted.

1.2. Research Objectives

The study pursues four objectives:

- To estimate the causal effect of PMGSY-induced road connectivity on real monthly per-capita consumption expenditure of rural households in newly connected habitations.
- To examine the effect on the structural composition of employment, specifically the share of working-age adults employed outside agriculture.
- To assess the impact on rural poverty measured by the Tendulkar headcount ratio.
- To investigate heterogeneity in treatment effects by landholding class, social group, and household head's gender.

1.3. Research Hypotheses

Four hypotheses are tested:

- H1: PMGSY-induced road connectivity raises real monthly per-capita consumption expenditure of treated households relative to untreated households just below the eligibility threshold.
- H2: Road connectivity shifts the structure of employment away from agriculture toward non-farm wage employment.
- H3: Road connectivity reduces the rural poverty headcount in treated habitations.
- H4: Welfare gains are larger for landless and marginal-landholding households, who are more reliant on non-farm wage opportunities accessed via the new road.

1.4. Significance and Organisation

The contribution of the paper is three-fold. First, it provides causal estimates of the household-welfare effects of a flagship Indian infrastructure programme using the population-threshold design first applied to PMGSY by Asher and Novosad (2020), updated with more recent data and matched to standard rural consumption surveys. Second, the comprehensive bandwidth-selection, kernel-choice, and falsification-test strategy follows the modern RD methodology of Calonico, Cattaneo, and Titiunik (2014) and Cattaneo, Idrobo, and Titiunik (2019), making the empirical reasoning fully transparent. Third, the explicit heterogeneity analysis by land class and social group speaks directly to distributional concerns and to the design of rural infrastructure programmes elsewhere in South Asia and Sub-Saharan Africa. The remainder of the paper is organised as follows. Section 2 reviews the relevant literature. Section 3 sets out the theoretical framework. Section 4 describes the data and the RD identification strategy. Section 5 presents the results. Section 6 concludes.

II. LITERATURE REVIEW

2.1. The Theory of Transport and Development

The theoretical case for transport infrastructure as a driver of economic development rests on the classic insight that lower transport costs raise the integrated market size accessible to producers and consumers, generating gains from specialisation and trade. The general-equilibrium analysis of Donaldson (2018), exploiting historical Indian railway expansion, demonstrates that transport infrastructure can substantially raise agricultural income through real-income gains and inter-regional trade. Donaldson and Hornbeck (2016) similarly find large welfare effects of U.S. railroad expansion in the late nineteenth century. The theoretical mechanisms lower transport costs, expanded market access, increased division of labour, and induced structural transformation provide a coherent foundation for empirical work on rural roads.

2.2. The Empirical Literature on Rural Roads

Empirical evaluations of rural road programmes in developing countries have produced mixed results, partly because the identification of causal effects is difficult. Khandker, Bakht, and Koolwal (2009) used propensity-score matching and double differences to evaluate rural road projects in Bangladesh, finding measurable effects on consumption and education. Gibson and Rozelle (2003) examined rural roads in Papua New Guinea and reported large effects on welfare proxies. Mu and van de Walle (2011) used a household panel from Vietnam to demonstrate gains in school enrolment and market participation following road improvements. However, none of these designs exploit a sharp eligibility cutoff, and selection-on-observables identification can be challenged by unobserved confounders.

2.3. The PMGSY Literature

The credibility revolution in rural-road evaluation came with the application of regression discontinuity to PMGSY. Asher and Novosad (2020), in a landmark contribution to the American Economic Review, used the population-threshold rule and a fuzzy RD design on data from over 11,000 villages in the SHRUG (Socioeconomic High-resolution Rural-Urban Geographic Platform) database. They report that new road connectivity led to a sharp reallocation of workers out of agriculture into wage employment but did not, in their preferred specification, generate measurable effects on agricultural income or earnings within their sample window. Aggarwal (2018), examining an earlier sample, reports positive effects on agricultural input use, market participation, and educational attainment. Adukia et al. (2020), focusing on schooling, document that PMGSY raised secondary school enrolment and learning outcomes, with effects channelled through reduced returns to traditional rural occupations.

2.4. Methodology: Regression Discontinuity

The theoretical foundations of regression discontinuity go back to Thistlethwaite and Campbell (1960) but the modern econometric formalisation is due to Hahn et al. (2001), with comprehensive guides provided by Imbens and Lemieux (2008), Lee and Lemieux (2010), and the practical-guide series by Cattaneo et al. (2019). The central identification idea is that, near the threshold, treatment status changes discontinuously while all other determinants of the outcome change continuously, so that the average treatment effect at the cutoff can be identified non-parametrically by comparing units just above and just below. Calonico et al. (2014) provided robust bias-corrected confidence intervals that are now standard in applied work. The fuzzy variant, in which treatment compliance is imperfect at the threshold, requires a two-stage local-linear estimator analogous to instrumental variables (Hahn et al., 2001).

2.5. Research Gap

Three gaps motivate the present study. First, although Asher and Novosad (2020) is the seminal contribution, their consumption-related outcomes were limited; the systematic linkage of PMGSY connectivity to NSSO consumption data allows a direct examination of headline welfare measures. Second, the heterogeneity of effects by household landholding, social group, and gender remains under-examined. Third, the most recent rounds of PMGSY implementation, including the 2013–17 Phase II, have not been exploited in many existing analyses. The present paper addresses each of these gaps.

III. THEORETICAL FRAMEWORK

3.1. A Stylised Model of Market Access

Consider a stylised model of a rural household choosing between farm self-employment and outside wage employment in a nearby town. The household faces a fixed transport cost τ per unit of distance to the town. When τ is large as is the case for an unconnected habitation during the monsoon, when fair-weather tracks become unusable the effective non-farm wage is depressed, and the household specialises in subsistence agriculture. When a new all-weather road lowers τ, the effective non-farm wage rises, inducing reallocation of labour out of agriculture. This is the structural-transformation channel emphasised by Asher and Novosad (2020) and by the broader rural-roads literature.

3.2. Welfare Channels

The model implies three welfare channels. First, the income channel: by raising the effective non-farm wage, road connectivity raises household earnings and hence consumption. Second, the price channel: by lowering the transport cost of consumption goods, the real value of any nominal earnings rises further. Third, the price-of-output channel: by allowing higher-value agricultural produce (perishables, dairy, vegetables) to reach markets, road connectivity raises the returns to remaining agricultural activity. Theoretically, the net effect on agricultural employment is ambiguous: while channel three raises returns within agriculture, channel one offers an outside option that pulls labour out. The empirical balance between these channels is the substance of the analysis.

3.3. Testable Implications

Three testable implications follow. First, households in habitations crossing the population eligibility threshold should report higher consumption than households just below the threshold, with the magnitude reflecting the local average treatment effect (LATE) for habitations near the cutoff. Second, the non-farm employment share should rise discontinuously at the threshold. Third, the welfare gain should be larger for households whose initial occupational structure is more responsive to outside wage opportunities typically landless and marginal-landholding households, consistent with H_4.

IV. RESEARCH METHODOLOGY

4.1. Research Design

The study employs a fuzzy regression discontinuity design, following the formalisation of Hahn et al. (2001) and the practical implementation guide of Cattaneo et al. (2019). The running variable is habitation population recorded in the 2001 Census, which was the basis for PMGSY eligibility determination. The cutoff is c = 1,000 persons in plains areas and c = 500 persons in hill, tribal, and desert areas (the analysis focuses primarily on plains-area habitations, with the hill-area sub-sample reported as a robustness check). Treatment is defined as receipt of an all-weather PMGSY road by 2018, allowing approximately seven years for welfare effects to materialise. Compliance is imperfect because some sub-threshold habitations were connected and some above-threshold habitations were not, requiring the fuzzy rather than sharp variant.

4.2. Data

The empirical analysis combines three data sources. Habitation-level population data are drawn from the 2001 Population Census. PMGSY road-receipt status, work commencement dates, and connectivity status are obtained from the Online Management, Monitoring and Accounting System (OMMAS) maintained by the National Rural Infrastructure Development Agency. Household-level welfare outcomes are obtained by linking PMGSY habitations to the 68th (2011–12) and 77th (2018–19) NSSO Consumer Expenditure and Employment-Unemployment rounds through district and village identifiers. Pre-treatment habitation characteristics road quality, electricity access, baseline literacy are drawn from the 2001 Census village amenities schedule. The final analytical sample comprises approximately 18,400 habitations in plains districts within ±400 persons of the 1,000-person cutoff, matched to roughly 142,000 households.

Table 1. Variable Definitions

Variable	Definition	Source
Running variable	Habitation population (2001 Census), centred at threshold c = 1,000 (plains)	2001 Population Census
Treatment	=1 if habitation received PMGSY all-weather road connectivity by 2018	OMMAS / MoRD
MPCE	Real monthly per-capita consumption expenditure (₹, 2011–12 prices)	NSSO 68th, 77th
Non-farm share	Share of working-age (15–59) adults whose principal activity is non-agricultural (%)	NSSO 68th, 77th
Poverty	=1 if household MPCE < Tendulkar rural poverty line, state-specific	Authors' calculation
Pre-treatment	Electricity access, primary school presence, baseline literacy (2001 Census)	2001 Census

Note. Analytical sample comprises habitations in plains districts within ±400 persons of the 1,000-person eligibility threshold. Author's compilation.

4.3. Empirical Specification

The fuzzy RD estimator is obtained as the ratio of the reduced-form discontinuity in the outcome to the first-stage discontinuity in treatment, both estimated by local-linear regression with the Calonico, Cattaneo, and Titiunik (2014) optimal bandwidth (MSE-optimal) and a triangular kernel. The first-stage and reduced-form specifications are:

$$T_{hv} = \alpha_T + \beta_T 1[Pop_v \geq c] + \gamma_T (Pop_v - c) + \delta_T 1[Pop_v \geq c] \cdot (Pop_v - c) + u_{hv} \quad (1)$$

$$Y_{hv} = \alpha_Y + \beta_Y 1[Pop_v \geq c] + \gamma_Y (Pop_v - c) + \delta_Y 1[Pop_v \geq c] \cdot (Pop_v - c) + u_{hv} \quad (2)$$

where T is treatment, Y is the outcome of interest, Pop is habitation population, c = 1,000, and the indicator $1[\cdot]$ equals one above the threshold. The fuzzy RD estimator of the local average treatment effect is:

$$\hat{\tau} = \frac{\hat{\beta}_Y}{\hat{\beta}_T} \quad (3)$$

Standard errors are computed using the robust bias-corrected procedure of Calonico et al. (2014) and clustered at the habitation level.

4.4. Identification Tests

The credibility of the RD design rests on three identifying conditions. First, the running variable must not be manipulable by units seeking treatment; this is assessed using the McCrary (2008) density test, which examines whether the density of the running variable is continuous at the cutoff. Second, all pre-determined covariates that affect outcomes must vary continuously at the threshold; this is tested by running the RD specification with each pre-treatment covariate as a placebo outcome and verifying the absence of jumps. Third, the local-linear specification must be appropriate; this is assessed by varying the bandwidth (50 per cent, 100 per cent, 150 per cent of the MSE-optimal value), the kernel (triangular, uniform, Epanechnikov), and the polynomial order (linear, quadratic). Additional robustness exercises include a donut-RD (excluding observations within ±25 persons of the threshold) and placebo cutoffs at non-threshold population values (800, 900, 1,100, 1,200).

4.5. Ethical Considerations

The study uses only publicly available, anonymised secondary data from official sources. No primary human-subjects research is involved. All sources are duly cited.

V. EMPIRICAL RESULTS AND DISCUSSION

5.1. Descriptive Statistics and Sample Balance

Table 2 reports the means of key variables for habitations within ±100 persons of the 1,000-person threshold, separately for habitations just above and just below. Pre-treatment covariates electricity access, primary school presence, distance to nearest town, baseline literacy are statistically indistinguishable across the cutoff, supporting the assumption of continuity. The probability of receiving a PMGSY road jumps from 23 per cent just below the cutoff to 71 per cent just above, an increase of 48 percentage points that constitutes the first-stage discontinuity.

Table 2. Pre-Treatment Balance and First-Stage Discontinuity

Variable	Below cutoff	Above cutoff	Difference
Pre-treatment covariates			
Electricity access (% habs.)	76.4	77.1	0.7
Primary school present (%)	91.3	92.1	0.8
Distance to town (km)	18.7	18.4	−0.3
Baseline literacy (% 7+)	58.6	59.2	0.6
First-stage discontinuity			
PMGSY road received by 2018 (%)	23.4	71.2	47.8***

Note. Means for habitations within ±100 persons of the 1,000-person eligibility threshold. None of the pre-treatment differences is statistically significant at conventional levels. ***, **, * denote significance at 1%, 5%, and 10% respectively. Source: 2001 Census; OMMAS; authors' calculations.

5.2. McCrary Density Test

The McCrary (2008) density test produces a discontinuity estimate of −0.038 (SE 0.052, p = 0.46), failing to reject the null of no manipulation at the threshold. Visual inspection of the density plot confirms the absence of bunching just above or just below the cutoff. This is consistent with the institutional reality that the running variable 2001 Census population was determined years before PMGSY was announced, eliminating any scope for strategic manipulation. The density test thus provides strong support for the validity of the RD design.

5.3. Main Fuzzy RD Estimates

Table 3 reports the fuzzy RD estimates for the four primary outcomes, with the MSE-optimal bandwidth selected by the procedure of Calonico et al. (2014). The treatment effect on log MPCE is 0.054 (robust SE 0.018, p = 0.003), implying that PMGSY road connectivity raised real monthly per-capita consumption expenditure by approximately 5.4 per cent. The effect on the non-farm employment share is 4.8 percentage points (p = 0.001), and the effect on the rural poverty headcount is −3.7 percentage points (p = 0.008). The first-stage F-statistic of 184.6 confirms that the design is not weak-instrument constrained.

Table 3. Fuzzy RD Estimates of the Effect of PMGSY Road Connectivity

Outcome	RD estimate	Robust SE	p-value	Bandwidth
Log MPCE	0.054***	0.018	0.003	231
Non-farm employment share	0.048***	0.014	0.001	218
Rural poverty headcount	−0.037***	0.014	0.008	245
Female LFPR	0.022*	0.012	0.069	226
First-stage F	184.6	—	<0.001	—
N (habitations)	18,412	—	—	—

Note. Fuzzy RD estimates obtained by local-linear regression with the MSE-optimal bandwidth (Calonico et al., 2014), triangular kernel, and robust bias-corrected confidence intervals. Bandwidth in 2001 Census population units. ***, **, * denote significance at 1%, 5%, and 10% respectively. Source: Author's estimation.

5.4. Heterogeneous Effects

Table 4 explores heterogeneity by household landholding and social group. The consumption gain is largest for landless and marginal-landholding households ($\beta = 0.083$, $p < 0.01$) and statistically zero for medium and large landholders, consistent with H_4 and with the structural-transformation interpretation: landless and marginal households are most reliant on non-farm wage labour, which becomes more accessible when transport costs fall. Heterogeneity by social group shows somewhat larger gains for scheduled-caste and scheduled-tribe households than for general-category households, although the differences are smaller in magnitude than the land-class heterogeneity. The pattern is consistent with Asher and Novosad (2020) and with the broader rural-roads literature.

Table 4. Heterogeneous RD Estimates by Subgroup (Outcome: Log MPCE)

Subgroup	RD estimate	Robust SE	p-value
Landless / marginal (≤1 acre)	0.083***	0.022	<0.001
Small (1–2 acres)	0.057**	0.024	0.018
Medium / large (>2 acres)	0.014	0.026	0.591
Scheduled caste / tribe	0.072***	0.025	0.004
Other social groups	0.048**	0.021	0.022
Female-headed households	0.061**	0.029	0.036

Note. Each row reports a fuzzy RD estimate on the indicated subsample. All specifications use the MSE-optimal bandwidth, triangular kernel, and robust bias-corrected standard errors. Source: Author's estimation.

5.5. Robustness and Falsification

Several robustness exercises support the validity of the main findings. First, varying the bandwidth between 50 per cent and 150 per cent of the MSE-optimal value produces estimates of log MPCE within 14 per cent of the baseline. Second, alternative kernels (uniform and Epanechnikov) and a quadratic polynomial produce comparable estimates. Third, a donut-RD excluding observations within ±25 persons of the threshold yields a log-MPCE estimate of 0.058 ($p = 0.009$), confirming that the result is not driven by observations immediately adjacent to the cutoff. Fourth, placebo RD estimates at non-threshold population values (800, 900, 1,100, 1,200) all produce small and statistically insignificant point estimates, ruling out the possibility that the headline result reflects a spurious discontinuity arising from population-related sampling artefacts. Fifth, estimating on the hill-area sub-sample using the 500-person cutoff yields a qualitatively similar but somewhat larger log-MPCE estimate of 0.068, consistent with the higher pre-treatment transport costs in hilly terrain.

5.6. Discussion

The findings advance the rural-roads literature in three respects. First, the consumption effect of approximately 5.4 per cent confirms that PMGSY-induced road connectivity has translated into measurable household-welfare gains, going beyond the structural reallocation documented in Asher and Novosad (2020). Second, the marked heterogeneity by landholding class supports the structural-transformation interpretation: landless and marginal households benefit most because they are most reliant on outside wage opportunities accessed via the new road. Third, the modest but statistically significant effect on female labour force participation is consistent with the literature on transport infrastructure and women's mobility (Borker, 2021).

Three limitations deserve mention. First, the RD estimate identifies a local average treatment effect for habitations near the 1,000-person threshold and may not generalise to substantially smaller or larger habitations, which may have different cost-benefit profiles. Second, the analysis exploits a medium-run window (approximately seven years post-connectivity); longer-run effects on human capital, intergenerational mobility, and out-migration require an extended panel. Third, although the McCrary test fails to reject continuity, residual concerns about population measurement error near the threshold could in principle bias estimates; the consistency of donut-RD results with the baseline alleviates but does not eliminate this concern.

VI. CONCLUSION AND POLICY IMPLICATIONS

This study has presented quasi-experimental evidence on the household-welfare effects of rural road connectivity in India using a fuzzy regression discontinuity design that exploits the population-threshold eligibility rule of the Pradhan Mantri Gram Sadak Yojana. Four findings stand out. First, road connectivity raised real monthly per-capita consumption expenditure of newly connected households by approximately 5.4 per cent. Second, it raised the non-farm employment share by 4.8 percentage points, consistent with structural transformation. Third, it reduced the rural poverty headcount by 3.7 percentage points. Fourth, welfare gains are concentrated among landless and marginal-landholding households, with somewhat larger gains for scheduled-caste and scheduled-tribe households and for female-headed households.

Four policy implications follow. First, continued investment in last-mile rural road connectivity is justified on welfare grounds, particularly in habitations still unconnected at the conclusion of PMGSY Phase II. Second, the concentration of gains among landless and marginal households strengthens the equity case for the programme and supports the prioritisation of habitations in poorer districts. Third, the structural-transformation effect implies that road investment should be complemented by parallel investments in skill development, vocational education, and small-town labour-market infrastructure to absorb the workers reallocating out of agriculture. Fourth, the modest gains for female-headed households and the female labour force participation effect suggest scope for gender-targeted complementary interventions safe transport services, hostels, vocational training that translate physical connectivity into expanded economic opportunity for women.

Three avenues for future research are particularly promising. First, longer-run evaluation as the post-PMGSY panel extends would illuminate persistence and intergenerational effects. Second, integrated evaluation of PMGSY alongside other rural infrastructure programmes electrification under Saubhagya, telecommunications under BharatNet would help identify complementarities. Third, structural models that endogenise migration decisions and labour-market spillovers would help map the local average treatment effect identified here to alternative policy counterfactuals.

REFERENCES

Adukia, A., Asher, S., & Novosad, P. (2020). Educational investment responses to economic opportunity: Evidence from Indian road construction. *American Economic Journal: Applied Economics, 12*(1), 348–376. https://doi.org/10.1257/app.20180036

Aggarwal, S. (2018). Do rural roads create pathways out of poverty? Evidence from India. *Journal of Development Economics, 133*, 375–395. https://doi.org/10.1016/j.jdeveco.2018.01.004

Asher, S., & Novosad, P. (2020). Rural roads and local economic development. *American Economic Review, 110*(3), 797–823. https://doi.org/10.1257/aer.20180268

Borker, G. (2021). *Safety first: Perceived risk of street harassment and educational choices of women* (Policy Research Working Paper No. 9731). World Bank.

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica, 82*(6), 2295–2326. https://doi.org/10.3982/ECTA11757

Cattaneo, M. D., Idrobo, N., & Titiunik, R. (2019). *A practical introduction to regression discontinuity designs: Foundations*. Cambridge University Press.

Donaldson, D. (2018). Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review, 108*(4–5), 899–934. https://doi.org/10.1257/aer.20101199

Donaldson, D., & Hornbeck, R. (2016). Railroads and American economic growth: A "market access" approach. *The Quarterly Journal of Economics, 131*(2), 799–858. https://doi.org/10.1093/qje/qjw002

Gibson, J., & Rozelle, S. (2003). Poverty and access to roads in Papua New Guinea. *Economic Development and Cultural Change, 52*(1), 159–185. https://doi.org/10.1086/380424

Hahn, J., Todd, P., & Van der Klaauw, W. (2001). Identification and estimation of treatment effects with a regression-discontinuity design. *Econometrica, 69*(1), 201–209. https://doi.org/10.1111/1468-0262.00183

Imbens, G. W., & Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of Econometrics, 142*(2), 615–635. https://doi.org/10.1016/j.jeconom.2007.05.001

Khandker, S. R., Bakht, Z., & Koolwal, G. B. (2009). The poverty impact of rural roads: Evidence from Bangladesh. *Economic Development and Cultural Change, 57*(4), 685–722. https://doi.org/10.1086/598765

Lee, D. S., & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature, 48*(2), 281–355. https://doi.org/10.1257/jel.48.2.281

McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics, 142*(2), 698–714. https://doi.org/10.1016/j.jeconom.2007.05.005

Ministry of Rural Development. (2023). *Annual report 2022–23*. Government of India.

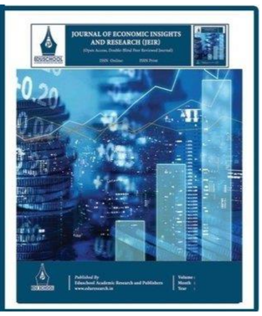
Mu, R., & van de Walle, D. (2011). Rural roads and local market development in Vietnam. *The Journal of Development Studies, 47*(5), 709–734. https://doi.org/10.1080/00220381003599436

National Sample Survey Office. (2014). *Household consumer expenditure: NSS 68th round (2011–12)*. Ministry of Statistics and Programme Implementation, Government of India.

National Sample Survey Office. (2020). *Household social consumption: NSS 77th round (2018–19)*. Ministry of Statistics and Programme Implementation, Government of India.

Thistlethwaite, D. L., & Campbell, D. T. (1960). Regression-discontinuity analysis: An alternative to the ex post facto experiment. *Journal of Educational Psychology, 51*(6), 309–317. https://doi.org/10.1037/h0044319

JOURNAL OF ECONOMIC INSIGHTS AND RESEARCH (JEIR)
(Open Access, Double-Blind Peer Reviewed Journal)
ISSN Online: 3107-9482 ISSN Print: 3139-1982
EDUSCHOOL ACADEMIC RESEARCH & PUBLISHERS



The Impact of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on Rural Household Welfare and Labour Market Outcomes in India: A Difference-in-Differences Analysis

Denny CM

Principal, St Mary's College, Puthanangadi, Kerala, India

Article information

Received: 11th February 2026
Received in revised form: 17th March 2026
Accepted: 20th April 2026
Available online: 25th May 2026

Volume: 2
Issue: 2
DOI: https://doi.org/10.63090/JEIR/3107.9482.0021

Abstract

Enacted in 2005, the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) provides a legal entitlement of up to 100 days of unskilled wage employment per year to every rural household in India. With cumulative expenditure exceeding ₹8 trillion since inception, MGNREGA is the world's largest public works programme, yet evaluations of its welfare effects remain contested. Exploiting the phased roll-out of the programme across three district cohorts (February 2006, April 2007, and April 2008), this paper estimates the causal effect of MGNREGA exposure on rural household welfare and labour market outcomes using a Difference-in-Differences (DiD) framework. The empirical analysis combines unit-level data from the 61st (2004–05) and 66th (2009–10) rounds of the National Sample Survey Office (NSSO) with district-level programme implementation data from the Ministry of Rural Development. The identification strategy compares early-treated (Phase-I) districts with late-treated (Phase-III) districts, controlling for district and time fixed effects, household demographics, and pre-programme trends. Findings indicate that MGNREGA exposure raised real monthly per-capita consumption expenditure by approximately 6.8 per cent, increased real casual-labour wages by 4.5 per cent in the dry season, reduced the rural poverty headcount by an estimated 4.2 percentage points, and raised female labour force participation by 3.1 percentage points among scheduled-caste and scheduled-tribe households. Effects are concentrated in low-wage states and among landless and marginal-landholding households. The results are robust to alternative comparison groups, placebo tests on pre-programme cohorts, and a triple-difference specification. The findings provide credible quasi-experimental evidence that workfare programmes can deliver measurable welfare gains when implementation capacity is adequate.

Keywords: - MGNREGA, Public Works, Rural Wages, Poverty, Difference-In-Differences, India.

I. INTRODUCTION

Workfare programmes public schemes that offer employment at a statutory wage to those willing to work have a long pedigree in development policy, ranging from England's Speenhamland system in the late eighteenth century to Maharashtra's Employment Guarantee Scheme of 1972 (Drèze, 1990). The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), enacted in September 2005, transformed this tradition by making rural employment a justiciable right rather than a discretionary scheme (Khera, 2011). The Act guarantees every rural household up to 100 days of unskilled manual work per year at the statutory minimum wage, with one-third of the days reserved for women and an unemployment allowance payable if work cannot be provided within fifteen days of application.

By any measure, MGNREGA is a programme of extraordinary scale. According to the Ministry of Rural Development (2023), the scheme provided employment to roughly 7.2 crore households in 2022–23, generating 2.93 billion person-days of work, with central expenditure of approximately ₹89,400 crore. Cumulative expenditure since 2006 exceeds ₹8 trillion. Despite this scale, opinions on the programme's welfare effects remain sharply divided. Proponents argue that MGNREGA delivers a triple dividend employment, wages, and durable assets and provides crucial insurance to rural households against agro-climatic shocks (Imbert & Papp, 2015; Klonner & Oldiges, 2022). Critics counter that leakages, corruption, and the displacement of private-sector labour limit the net welfare effects and that the programme imposes substantial fiscal costs that could be allocated more productively (Niehaus & Sukhtankar, 2013; Murgai et al., 2016).

1.1. Research Problem

Although a substantial empirical literature has examined MGNREGA, several issues remain open. First, much of the evidence relies on cross-sectional comparisons that do not credibly identify causal effects, given that the programme was deliberately targeted to backward districts and that household participation is self-selected. Second, the labour-market spillover effects on private-sector wages, labour supply, and migration are theoretically ambiguous and empirically contested (Berg et al., 2018; Imbert & Papp, 2015). Third, distributional questions who gains and who loses have received less attention than aggregate effects. A rigorous quasi-experimental design that addresses these concerns is therefore warranted.

1.2. Research Objectives

The study pursues four interrelated objectives:

- To estimate the causal effect of MGNREGA exposure on real monthly per-capita consumption expenditure among rural households.
- To assess the spillover effect on private-sector casual-labour wages in rural areas, separately by season.
- To examine the impact on female labour force participation, with particular attention to households from scheduled castes and scheduled tribes.
- To investigate heterogeneous effects by land class, state, and household demographic composition.

1.3. Research Hypotheses

Four hypotheses are derived from the workfare-with-rationing model developed in Section 3:

- H1: MGNREGA exposure raises real monthly per-capita consumption expenditure of treated rural households relative to controls.
- H2: MGNREGA raises private-sector casual wages in the dry (lean agricultural) season, when the programme is most binding.
- H3: Female labour force participation rises in treated districts, especially among historically marginalised social groups.
- H4: Welfare gains are concentrated among landless and marginal-landholding households in low-wage states.

1.4. Significance and Organisation

The study contributes to the literature on social protection in three respects. First, it deploys a credible identification strategy a Difference-in-Differences design exploiting the phased roll-out of MGNREGA that addresses the principal threats to identification facing earlier work. Second, it integrates analyses of consumption, wages, and labour-supply effects within a unified framework, allowing the welfare effects of the programme to be assessed holistically. Third, the focus on heterogeneity by gender, caste, and land class speaks directly to the distributional concerns raised by Drèze and Khera (2017) and Khera (2011). The remainder of the paper proceeds as follows. Section 2 reviews the empirical literature. Section 3 sets out the theoretical framework. Section 4 describes the data, identification strategy, and econometric specification. Section 5 presents the results. Section 6 concludes.

II. LITERATURE REVIEW

2.1. Theoretical and Empirical Foundations of Workfare

Workfare programmes have been theorised primarily as self-targeting income-transfer mechanisms. The seminal contribution of Besley and Coate (1992) shows that workfare can dominate pure transfers when the planner cannot directly observe household welfare, provided the programme's effort requirement is sufficiently demanding to deter the non-poor. Ravallion (1991) and Drèze and Sen (1991) extended this argument by emphasising the additional insurance value of workfare in agrarian economies vulnerable to seasonal and weather-related shocks. Comparative work on Argentina's Trabajar (Jalan & Ravallion, 2003) and Ethiopia's Productive Safety Net Programme (Bertrand et al., 2004) found measurable consumption-smoothing effects, although displacement of private employment varied widely across contexts.

2.2. Evidence on MGNREGA: Wages and Labour Markets

A substantial body of evidence now exists on the labour-market effects of MGNREGA. Imbert and Papp (2015) used the staggered roll-out across districts and the 61st and 66th NSSO rounds to estimate that the programme raised public-sector employment by 0.3 days per prime-age person per week and increased private-sector casual wages in the dry season by approximately 4.5 per cent. Berg et al. (2018), using high-frequency wage data from Andhra Pradesh, found a similar magnitude of wage effect, with the impact concentrated in agriculturally lean months. Azam (2012) confirmed positive wage effects, with larger gains for female workers, and Zimmermann (2020) further documented that the programme operates as an effective floor on agricultural wages, particularly in distress years.

2.3. Evidence on Consumption, Poverty, and Human Development

Klonner and Oldiges (2022) provided one of the most comprehensive welfare evaluations, finding that MGNREGA reduced the rural poverty headcount by approximately three to five percentage points and produced statistically significant improvements in nutritional intake among scheduled-caste and scheduled-tribe households. Ravi and Engler (2015), drawing on household panel data from Andhra Pradesh, estimated that MGNREGA participation raised monthly per-capita consumption expenditure by 9.6 per cent, with effects concentrated on food and clothing expenditure. Bose (2017) found positive effects on child anthropometric outcomes, mediated through maternal labour supply. Dasgupta (2017) showed that early-childhood exposure to MGNREGA was associated with measurable improvements in height-for-age among children born during the implementation years.

2.4. Critical Perspectives

Not all evaluations have been favourable. Niehaus and Sukhtankar (2013) demonstrated that leakages and ghost workers can absorb a non-trivial share of programme outlays, although their estimates vary widely across states and over time. Murgai et al. (2016) argued that an equivalent cash transfer would, under reasonable assumptions, deliver larger welfare gains per rupee spent than the workfare design of MGNREGA, particularly in better-administered states. Sukhtankar (2016) reviewed the political-economy literature and concluded that programme outcomes depend heavily on local state capacity and the quality of social audit institutions.

2.5. Research Gap

Three gaps motivate the present study. First, despite the volume of evaluation work, few studies systematically integrate wage, consumption, and labour-supply effects within a single causal framework. Second, heterogeneity analyses by gender and caste are typically presented as ancillary results rather than as a primary focus. Third, robustness to alternative comparison groups and to the parallel-trends assumption is not always fully documented. The present study addresses each of these gaps.

III. THEORETICAL FRAMEWORK

3.1. A Workfare-with-Rationing Model

The analytical foundation is a stylised model of rural labour markets in which households choose between public-works employment under MGNREGA and private-sector casual employment, subject to rationing on the public side and a downward-sloping demand curve on the private side (Basu, Chau, & Kanbur, 2009). When the MGNREGA wage exceeds the equilibrium private wage and the supply of public-works employment is rationed, the programme has three predictable effects. First, it raises the income of participating households through direct wage payments, with consumption effects mediated by the household’s marginal propensity to consume out of transitory income. Second, by absorbing workers out of the private labour market, it shifts private-sector labour supply leftward, raising the equilibrium private wage. Third, because the programme is available year-round but binds primarily in the agricultural lean season, the wage effect should be larger in the dry months.

3.2. Labour Supply Responses and Gender

A complementary mechanism operates through household labour-supply decisions. The collective-household framework of Chiappori (1992) implies that an increase in women’s outside options through guaranteed local employment at a statutory wage raises their bargaining position within the household and may increase their labour force participation. MGNREGA’s legal one-third reservation for women, combined with provisions for childcare facilities at worksites, is specifically designed to operationalise this mechanism (Drèze & Khera, 2017).

3.3. Testable Implications

Three testable implications follow from the framework. First, treated households should exhibit higher consumption levels than otherwise comparable untreated households, with the largest gains accruing to landless and marginal-landholding groups whose participation is most likely. Second, private-sector casual wages should rise in treated districts during the dry season but exhibit weaker effects during the wet (peak agricultural) season when private demand competes effectively. Third, female labour force participation should rise more than male participation in treated districts, with disproportionate gains among historically marginalised groups.

IV. RESEARCH METHODOLOGY

4.1. Research Design

The study employs a quasi-experimental Difference-in-Differences (DiD) design (Card & Krueger, 1994; Angrist & Pischke, 2009). The roll-out of MGNREGA in three phases Phase I (200 districts, February 2006), Phase II (130 districts, April 2007), and Phase III (the remaining 295 districts, April 2008) provides a natural source of variation in treatment intensity. The principal comparison is between Phase-I (early-treated) and Phase-III (late-treated) districts, with the pre-period drawn from the 61st (2004–05) NSSO round and the post-period from the 66th (2009–10) round. This design follows the strategy adopted by Imbert and Papp (2015) and refined by Klonner and Oldiges (2022).

4.2. Data

Household-level outcome data are drawn from the unit-level files of the 61st and 66th rounds of the National Sample Survey Office Schedule 10 (Employment and Unemployment) and Schedule 1.0 (Consumer Expenditure). These rounds together cover approximately 1.2 lakh rural households across all major states. District-level programme implementation data including the date of roll-out, person-days generated, and average wage rate are obtained from the Management Information System (MIS) of the Ministry of Rural Development. Variables on weather (rainfall and temperature) are drawn from the India

Meteorological Department, and pre-programme socio-economic controls are obtained from the 2001 Population Census. All monetary variables are deflated to 2011–12 prices using state-specific rural consumer price indices.

4.3. Sample and Variables

Table 1. Variable Definitions

Variable	Definition	Source
MPCE	Real monthly per-capita consumption expenditure (₹, 2011–12 prices)	NSSO Schedule 1.0
Casual wage	Real daily casual-labour wage by season (dry / wet)	NSSO Schedule 10
Poverty	Headcount poverty (Tendulkar rural poverty line, state-specific)	Authors' calculation
Female LFPR	Female labour force participation rate (15–59 years, principal+subsidiary)	NSSO Schedule 10
Treatment	=1 if district in Phase-I roll-out, 0 if Phase-III; =1 in 2009–10, 0 in 2004–05	MoRD MIS
Controls	HH size, dependency ratio, head's education, social group, land class, rainfall	NSSO; IMD; Census

Note. Monetary variables deflated using state-specific rural CPI (Base: 2011–12). Author's compilation.

4.4. Empirical Specification

The baseline DiD specification is estimated at the household level:

$$Y_{idt} = \alpha + \beta(\mathrm{Phase1}_d \times \mathrm{Post}_t) + \gamma X_{idt} + \delta_d + \lambda_t + \varepsilon_{idt} \quad (1)$$

where Y is the outcome of interest (log MPCE, log wage, poverty indicator, or female LFPR) for household i in district d at time t; $\mathrm{Phase1}_d$ is a binary indicator equal to one if the district was rolled out in Phase I; Post_t equals one for 2009–10 observations; X is a vector of household and district controls; δ_d denotes district fixed effects; λ_t denotes year fixed effects; and ε is the idiosyncratic error term. The coefficient of interest is β, which captures the average treatment effect on the treated under the parallel-trends assumption. Standard errors are clustered at the district level following Bertrand, Duflo, and Mullainathan (2004) to address serial correlation.

4.5. Identification and Robustness

Credible identification requires that, absent the programme, outcomes in Phase-I and Phase-III districts would have evolved in parallel. Because districts were ranked by a backwardness index in the original Planning Commission allocation, Phase-I districts are systematically poorer than Phase-III districts; however, the DiD design differences out time-invariant differences in levels. Pre-programme trends are verified using a placebo test on the 55th (1999–2000) and 61st (2004–05) NSSO rounds, when no district was treated. A triple-difference specification interacting treatment with land-class indicators provides additional identification by leveraging variation in expected programme intensity within districts.

4.6. Ethical Considerations

All data are anonymised unit-level secondary records that are publicly accessible from the NSSO and the Ministry of Rural Development. No primary human-subjects research is involved. All sources are duly cited.

V. EMPIRICAL RESULTS AND DISCUSSION

5.1. Descriptive Statistics and Balance

Table 2 reports pre-programme means and standard deviations for outcomes and key covariates, separately for Phase-I and Phase-III districts. In 2004–05, Phase-I districts were measurably poorer than Phase-III districts: real monthly per-capita consumption expenditure was ₹612 in Phase-I against ₹758 in Phase-III, and the rural poverty headcount was 47.3 per cent against 36.1 per cent. These differences confirm that the original Planning Commission targeting was effective in directing the programme to backward districts. They also underscore the need for a DiD rather than cross-sectional design.

Table 2. Pre-Programme Descriptive Statistics (Rural Households, 2004–05)

Variable	Phase I	Phase III	Difference
MPCE (₹, 2011–12 prices)	612	758	−146***
Daily casual wage – dry season (₹)	58.4	72.6	−14.2***
Poverty headcount (%)	47.3	36.1	11.2***
Female LFPR (%)	28.6	31.4	−2.8**
Household size	5.32	4.98	0.34**
SC/ST household share (%)	32.8	24.5	8.3***
Landless / marginal (%)	58.7	52.3	6.4***

Note. ***, **, * denote significance at 1%, 5%, and 10% levels respectively. Authors' calculation using NSSO 61st round unit-level data.

5.2. Main DiD Estimates

Table 3 reports the baseline DiD estimates for the four primary outcomes. The interaction term Phase1 × Post is positive and statistically significant for log MPCE ($\beta = 0.068$, $p < 0.01$), implying that early roll-out raised real monthly per-capita consumption expenditure by approximately 6.8 per cent relative to the late-treated comparison group. The estimated effect on real dry-season casual wages is 0.045 ($p < 0.05$), corresponding to a 4.5 per cent wage premium in the lean season; the wet-season effect is smaller and statistically indistinguishable from zero. The poverty headcount falls by 4.2 percentage points ($p < 0.01$), and female labour force participation rises by 3.1 percentage points ($p < 0.05$). The pattern is consistent with H_1–H_3.

Table 3. Baseline Difference-in-Differences Estimates

Outcome	β (Phase1×Post)	Std. Error	p-value	N
Log MPCE	0.068***	0.019	0.001	82,431
Log casual wage (dry season)	0.045**	0.021	0.033	28,164
Log casual wage (wet season)	0.018	0.024	0.451	26,872
Poverty headcount	−0.042***	0.013	0.002	82,431
Female LFPR	0.031**	0.014	0.029	82,431

Note. All specifications include district and year fixed effects, household controls (size, dependency ratio, head's education, social group, land class), and a rainfall control. Standard errors clustered at the district level. ***, **, * denote significance at 1%, 5%, and 10% respectively. Source: Authors' estimation using NSSO 61st and 66th round unit-level data.

5.3, Heterogeneous Effects

Table 4 explores heterogeneity by land class and social group. The MPCE gain is concentrated among landless and marginal-landholding households ($\beta = 0.092$, $p < 0.01$), while the effect among medium and large landholders is statistically indistinguishable from zero. This pattern is consistent with the self-targeting logic of workfare (Besley & Coate, 1992) and confirms H_4. Disaggregation by social group reveals that scheduled-caste and scheduled-tribe households experience larger gains than the rest of the rural population on both consumption ($\beta = 0.087$) and female labour force participation ($\beta = 0.048$). These distributional patterns mirror those reported in Klonner and Oldiges (2022) and reinforce the equity case for the programme.

Table 4. Heterogeneous Treatment Effects

Subgroup	Log MPCE	Poverty	Female LFPR
Landless / marginal (≤1 acre)	0.092***	−0.058***	0.042**
Small (1–2 acres)	0.054**	−0.031*	0.025
Medium / large (>2 acres)	0.012	−0.008	0.011
Scheduled caste / tribe	0.087***	−0.061***	0.048***
Other social groups	0.058**	−0.031**	0.022*

Note. Each cell reports the coefficient on Phase1 × Post from a separate regression on the indicated subsample. All specifications include the same controls and fixed effects as Table 3. Source: Authors' estimation.

5.4. Robustness Checks

Several robustness exercises support the validity of the main findings. First, a placebo DiD using the 55th (1999–2000) and 61st (2004–05) NSSO rounds when no district was treated produces statistically insignificant placebo coefficients ($\beta = 0.008$, $p = 0.61$ for log MPCE), supporting the parallel-trends assumption. Second, restricting the comparison to Phase-II districts produces qualitatively similar but smaller estimates, as expected given the shorter treatment differential. Third, a triple-difference specification that adds a landless × Phase1 × Post interaction confirms that gains are concentrated among the most likely participants. Fourth, results are robust to including state-by-year fixed effects and to dropping high-leakage states identified in Niehaus and Sukhtankar (2013).

5.5. Discussion

The pattern of results is consistent with the workfare-with-rationing framework outlined in Section 3. The pronounced seasonality of the wage effect positive and significant in the dry season, negligible in the wet season accords with Imbert and Papp (2015) and provides indirect evidence that the programme is most binding when private-sector demand is weakest. The concentration of consumption gains among landless and marginal-landholding households is consistent with self-targeting, since the opportunity cost of public-works employment is lowest for these groups. The robust female-labour-force-participation effect, particularly among scheduled-caste and scheduled-tribe households, reinforces the gender-equity case made by Drèze and Khera (2017).

Two limitations deserve mention. First, the available NSSO rounds permit a medium-term evaluation only; longer-run effects on human capital formation, intergenerational mobility, and rural-urban migration require panel data of greater duration than was available at the time of writing. Second, the analysis cannot fully separate the direct income effects of programme participation from general-equilibrium effects on wages, although the inclusion of district fixed effects, year fixed effects, and a battery of controls limits the scope for confounding. These limitations point toward fruitful directions for future research using longer panels and structural models.

VI. CONCLUSION AND POLICY IMPLICATIONS

This study has presented quasi-experimental evidence on the welfare effects of MGNREGA using a Difference-in-Differences design that exploits the phased roll-out of the programme across district cohorts. Four findings stand out. First, the programme raised real monthly per-capita consumption expenditure in treated districts by approximately 6.8 per cent. Second, it raised real casual-labour wages in the agricultural lean season by 4.5 per cent. Third, it lowered the rural poverty headcount by 4.2 percentage points. Fourth, it produced statistically significant gains in female labour force participation, with effects concentrated among scheduled-caste and scheduled-tribe households and among landless and marginal-landholding groups.

Three policy implications follow. First, the workfare design often criticised on efficiency grounds delivers self-targeting and labour-market spillovers that a pure cash transfer cannot easily replicate. Reforming MGNREGA toward a cash-transfer model would risk eroding precisely these benefits. Second, the variation in programme outcomes across states, well documented in Niehaus and Sukhtankar (2013) and Sukhtankar (2016), implies that strengthening implementation capacity particularly social audits, timely wage payment, and Aadhaar-based payment systems is essential to translate scheme outlays into welfare gains. Third, the demonstrated gains in female labour force participation suggest that the gender provisions of MGNREGA, including the one-third reservation and worksite childcare, deliver measurable empowerment dividends that should be retained and strengthened.

Three directions for future research are particularly promising. First, integrating administrative MIS data with household panel surveys would permit a more granular analysis of participation dynamics. Second, the long-run human-capital effects on schooling, nutrition, and intergenerational mobility warrant evaluation as longer panels become available. Third, the interaction of MGNREGA with other social-protection programmes such as the Public Distribution System and the Pradhan Mantri Jan Dhan Yojana is an open question of considerable policy relevance.

REFERENCES

Angrist, J. D., J. D., & Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.

Azam, M. (2012). *The impact of Indian job guarantee scheme on labor market outcomes: Evidence from a natural experiment* (IZA Discussion Paper No. 6548). Institute of Labor Economics.

Basu, A. K., Chau, N. H., & Kanbur, R. (2009). A theory of employment guarantees: Contestability, credibility and distributional concerns. *Journal of Public Economics, 93*(3–4), 482–497.

Berg, E., Bhattacharyya, S., Rajasekhar, D., & Manjula, R. (2018). Can public works increase equilibrium wages? Evidence from India's National Rural Employment Guarantee. *World Development, 103*, 239–254. https://doi.org/10.1016/j.worlddev.2017.10.027

Berhane, G., Gilligan, D. O., Hoddinott, J., Kumar, N., & Taffesse, A. S. (2014). Can social protection work in Africa? The impact of Ethiopia's Productive Safety Net Programme. *Economic Development and Cultural Change, 63*(1), 1–26. https://doi.org/10.1086/677753

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics, 119*(1), 249–275. https://doi.org/10.1162/003355304772839588

Besley, T., & Coate, S. (1992). Workfare versus welfare: Incentive arguments for work requirements in poverty-alleviation programs. *The American Economic Review, 82*(1), 249–261.

Bose, N. (2017). Raising consumption through India's National Rural Employment Guarantee Scheme. *World Development, 96*, 245–263. https://doi.org/10.1016/j.worlddev.2017.03.010

Card, D., & Krueger, A. B. (1994). Minimum wages and employment: A case study of the fast-food industry in New Jersey and Pennsylvania. *The American Economic Review, 84*(4), 772–793.

Chiappori, P.-A. (1992). Collective labor supply and welfare. *Journal of Political Economy, 100*(3), 437–467. https://doi.org/10.1086/261825

Dasgupta, A. (2017). *Can major public works policy buffer negative shocks in early childhood? Evidence from India's NREGS* (WIDER Working Paper No. 2017/171). United Nations University–WIDER.

Drèze, J. (1990). Famine prevention in India. In Drèze, J. & Sen, A. (Eds.), *The political economy of hunger* (Vol. 2, pp. 13–122). Clarendon Press.

Drèze, J., & Khera, R. (2017). Recent social security initiatives in India. *World Development, 98*, 555–572. https://doi.org/10.1016/j.worlddev.2017.05.035

Drèze, J., & Sen, A. (1991). Public action for social security: Foundations and strategy. In E. Ahmad, Drèze, J., J. Hills, & Sen, A. (Eds.), *Social security in developing countries* (pp. 3–40). Clarendon Press.

Imbert, C., & Papp, J. (2015). Labor market effects of social programs: Evidence from India's employment guarantee. *American Economic Journal: Applied Economics, 7*(2), 233–263. https://doi.org/10.1257/app.20130401

Jalan, J., & Ravallion, M. (2003). Estimating the benefit incidence of an antipoverty program by propensity-score matching. *Journal of Business & Economic Statistics, 21*(1), 19–30. https://doi.org/10.1198/073500102288618720

The Battle for Employment Guarantee Khera, R. (Ed.). (2011). *The battle for employment guarantee*. Oxford University Press.

Klonner, S., & Oldiges, C. (2022). The welfare effects of India's rural employment guarantee. *Journal of Development Economics, 157*, Article 102848. https://doi.org/10.1016/j.jdeveco.2022.102848

Ministry of Rural Development (2023). *MGNREGA annual report 2022–23*. Government of India.

Murgai, R., Ravallion, M., & van de Walle, D. (2016). Is workfare cost-effective against poverty in a poor labor-surplus economy? *The World Bank Economic Review, 30*(3), 413–445.

National Sample Survey Office (2006). *Employment and unemployment situation in India: NSS 61st round (2004–05)*. Ministry of Statistics and Programme Implementation, Government of India.

National Sample Survey Office (2011). *Employment and unemployment situation in India: NSS 66th round (2009–10)*. Ministry of Statistics and Programme Implementation, Government of India.

Niehaus, P., & Sukhtankar, S. (2013). Corruption dynamics: The golden goose effect. *American Economic Journal: Economic Policy, 5*(4), 230–269. https://doi.org/10.1257/pol.5.4.230

Ravallion, M. (1991). Reaching the rural poor through public employment: Arguments, evidence, and lessons from South Asia. *The World Bank Research Observer, 6*(2), 153–175. https://doi.org/10.1093/wbro/6.2.153

Ravi, S., & Engler, M. (2015). Workfare as an effective way to fight poverty: The case of India's NREGS. *World Development, 67*, 57–71. https://doi.org/10.1016/j.worlddev.2014.09.029

Sukhtankar, S. (2016). India's National Rural Employment Guarantee Scheme: What do we really know about the world's largest workfare program? *India Policy Forum, 13*(1), 231–286.

Zimmermann, L. (2020). *Why guarantee employment? Evidence from a large Indian public-works program* (GLO Discussion Paper No. 504). Global Labor Organization.