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Mathematical Analysis of GST-Induced Changes in Livelihood and Employment Patterns in Rural and Urban India

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Abstract

The implementation of the Goods and Services Tax (GST) in India marked a significant reform in the country's indirect taxation system, aiming to unify the fragmented tax structure and promote economic efficiency. This study presents a mathematical and statistical analysis of the impact of GST on livelihood and employment patterns across rural and urban regions of India. The research focuses on understanding how GST has influenced labour market dynamics, income distribution, and sectoral employment trends. Using quantitative tools such as regression analysis, index numbers, and comparative statistical measures, the study evaluates pre- and post-GST scenarios. The analysis incorporates secondary data from government reports and economic surveys to assess variations in employment levels, particularly in agriculture, manufacturing, and service sectors. Special attention is given to the informal sector, which constitutes a significant portion of rural employment.

The findings indicate that GST has contributed to increased formalization of the economy, leading to improved transparency and long-term employment opportunities in urban areas. However, short-term disruptions were observed in rural livelihoods due to compliance challenges and lack of awareness among small-scale producers. Mathematical models reveal a gradual stabilization in employment trends over time, suggesting positive long-term outcomes. The study concludes that while GST has the potential to enhance economic integration and employment generation, targeted policy interventions are necessary to support vulnerable rural populations. This research highlights the importance of mathematical approaches in evaluating large-scale economic reforms.

Keywords, Mathematical Analysis, Employment Patterns, Rural Economy, Urban Economy, Livelihood, Statistical Modelling, India

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Introduction

The Goods and Services Tax (GST), implemented in India in 2017, replaced a complex system of indirect taxes with a unified taxation structure. The primary objective of GST was to eliminate cascading taxes, improve transparency, and create a single national market. This reform has had significant implications for production, consumption, and employment patterns across the country. India's economy is characterized by a dual structure consisting of rural and urban sectors. Rural areas depend largely on agriculture and informal employment, while urban areas are dominated by industrial and service sectors. The introduction of GST has affected these sectors differently, leading to variations in livelihood and employment outcomes.

This study focuses on analysing these changes using mathematical and statistical tools, providing a quantitative understanding of GST's impact.

OBJECTIVES

To analyse the impact of GST on employment patterns in rural and urban India
To comare livelihood changes before and after GST implementation
To apply mathematical and statistical tools for economic analysis
To examine the effect of GST on informal and formal sectors
To evaluate regional disparities in employment trends

LITERATURE REVIEW

Previous studies indicate that GST has contributed to economic formalization and improved tax compliance. However, several researchers have highlighted short-term challenges faced by small businesses and rural enterprises.

Studies using statistical models have shown mixed impacts:
Positive effects on organized sectors
Temporary disruptions in informal employment
Gradual stabilization over time

Despite these findings, there is limited research focusing on mathematical modelling of GST's employment impact, which this study aims to address.

METHODOLOGY

1. Data Collection Framework

The study is based on **secondary data** collected from:
Employment statistics (rural & urban)
Sector-wise labour data (agriculture, industry, services)
GST revenue and compliance data
Data is divided into:
Pre-GST period (before 2017)

Post-GST period (after 2017)

2. Percentage Change Analysis

Used to measure change in employment levels:

Percentage Change =

Where: = Employment after GST

= Employment before GST

3. Index Number Method

To compare employment trends over time:

Employment Index =

Where: = Employment in current year

= Employment in base year

4. Regression Analysis Model

To study relationship between GST and employment:

Where Y= Employment level x = GST-related variable (tax rate, compliance level)

a = Intercept b= Impact coefficient ε = Error term

5. Correlation Coefficient

To measure strength of relationship:

Where r ranges from **-1 to +1**

6. Mean and Standard Deviation

To measure average and variability:

Mean = **Standard Deviation =**

RESULTS AND DISCUSSION

Overall Employment Trends

The analysis of employment index data indicates that the introduction of GST in 2017 led to a short-term decline in employment, particularly visible in the dip from 97 (2016) to 90 (2017). This decline can be mathematically interpreted using the growth rate formula, which shows a negative growth of approximately **–7.22%** during the initial implementation phase.

However, post-2017 data reveals a steady recovery trend, with employment index rising to 102 by 2021. The time series trend graph clearly demonstrates a U-shaped recovery pattern, indicating that the economy gradually adjusted to the new tax regime

Rural Employment Analysis

The rural sector experienced greater volatility compared to urban areas. This is supported by:

Higher standard deviation in rural employment data

Larger fluctuations in index values

Key Observations:

Small and marginal farmers faced input cost uncertainties

Informal sector workers encountered compliance and registration challenges

Rural micro-enterprises showed initial contraction

Mathematically, the variability suggests:

Over time, the rural employment index improved due to:

Better integration of supply chains

Reduced tax cascading

Increased market accessibility

Urban Employment Analysis

Urban areas displayed a more stable and positive growth pattern:

Key Findings:

Growth in formal employment sectors

Expansion of service industries

Increased business registrations under GST

Regression analysis shows a positive slope ($b > 0$), indicating:

$$\text{GST Implementation} \uparrow \Rightarrow \text{Formal Employment}$$

Urban employment benefited from:

Digital tax systems

Easier compliance for large firms

Expansion of organized retail and logistics

SECTOR-WISE IMPACT Agriculture (Rural)

Moderate impact

Improved logistics and reduced tax burden on inputs

Gradual increase in employment

Manufacturing

Initial disruption due to tax restructuring

MSMEs affected due to compliance costs

Recovery observed after stabilization

Service Sector (Urban)

Significant growth

High GST compliance

Increased employment opportunities

Growth Rate Analysis

The growth rate table shows:

Negative growth in 2017 (**–7.22%**)

Positive growth in subsequent years
This reflects:
Short-term shock effect
Long-term economic stabilization
Mathematically $\text{Growth Rate}_{\text{post-GST}} > 0$
Correlation Analysis
The correlation between GST compliance and employment levels is moderately positive:
$r > 0$
This implies:
Higher compliance → Higher formal employment
Increased tax transparency → Business expansion

Inequality and Livelihood Patterns

The study suggests that GST contributed to:
Reduction in income inequality in urban areas
Temporary increase in rural disparities
Using inequality measures:
Urban areas show more balanced income distribution
Rural areas initially show higher inequality due to uneven adaptation

Comparative Rural–Urban Analysis

Factor	Rural	Urban
Initial Impact	Negative	Moderate
Recovery Speed	Slow	Fast
Employment Growth	Gradual	Strong
Variability	High	Low

This comparison highlights that:
Urban areas adapted faster due to better infrastructure
Rural areas required more time due to limited resources

Conclusion

The study concludes that GST has played a transformative role in reshaping India's economic structure. While urban areas benefited from increased formalization and employment opportunities, rural regions faced short-term challenges due to limited awareness and infrastructural constraints. Mathematical analysis confirms that the long-term effects of GST are positive, particularly in promoting transparency and economic stability. However, policy measures such as training, digital literacy, and simplified compliance procedures are essential to ensure inclusive growth. The integration of

mathematical tools in economic analysis provides a deeper understanding of reform impacts and supports evidence-based policymaking.

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