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ARTICLE

Strategic Investment and Inclusive Growth in India: Unpacking the Interlinkages between Capital Formation and Employment Generation

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ABSTRACT

Gross Fixed Capital Formation (GFCF) plays a vital role in economic development by enhancing productive capacity and stimulating growth. However, in India, a paradox persists: despite steady increases in GFCF and GDP, unemployment remains high, highlighting a disconnect between macroeconomic growth and labor market outcomes. This study examines the dynamic interrelationships among capital formation, economic growth, and employment in India during the post-reform period (1990–2024), marked by structural transformation, liberalization, and global shocks such as the COVID-19 pandemic. Using annual time-series data from official sources, the analysis employs the Johansen Cointegration Test and Vector Error Correction Model (VECM) to explore both long-run equilibrium and short-run dynamics. Findings confirm a statistically significant long-run cointegrating relationship among GFCF, GDP growth, and employment. Bidirectional causality is observed between growth and employment, while the causality from GFCF to growth is unidirectional and growth-induced. These results challenge conventional growth models that posit investment as the primary driver of output, instead suggesting that economic growth stimulates capital formation. The study also highlights persistent jobless growth, attributed to structural rigidities and capital-intensive production with

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low employment elasticity. It calls for a strategic reorientation of investment policy toward labor-intensive sectors such as agriculture, agro-processing, and rural infrastructure. Strengthening capital allocation in these areas is essential for enhancing the employment content of growth and achieving more inclusive and sustainable development. The study offers empirical insights to guide policymakers in designing growth strategies that align investment with employment generation in India's evolving economic context.

Keywords: Gross Fixed Capital Formation; Investment; Economic Growth; Employment; Granger Causality

1. Capital Formation and Development Dynamics: A Contemporary Review

The dynamic interplay between Gross Fixed Capital Formation (GFCF) and economic development remains a foundational pillar of macroeconomic policy and long-term growth strategy. GFCF, representing net investment in physical assets such as infrastructure, machinery, and equipment, is widely acknowledged as a principal engine driving productive capacity, income generation, and employment creation. In turn, sustained economic development—marked by rising income levels, improved living standards, and structural transformation—serves to reinforce investment cycles by fostering demand, expanding markets, and enhancing investor confidence. This reciprocal relationship forms a cyclical and self-reinforcing loop, where investment drives growth, and growth begets further investment.

Classical economic theories, including those derived from Harrod-Domar and Solow growth models, have long posited that increases in capital accumulation lead to output expansion and labor absorption. The empirical literature has supported this theoretical framework, particularly in the early works of Levine & Renelt (1992) [1], Mankiw, Romer & Weil (1992) [2], and De Long & Summers (1992) [3], which consistently identified a positive association between investment—especially in equipment—and economic growth. De Long and Summers notably emphasized the productivity-enhancing impact of equipment investment as a catalyst for long-run growth.

Further cross-country analyses, such as Summers and Heston (1991) [4], established that nations with consistently higher levels of GFCF experienced more robust and stable growth trajectories, particularly among developed OECD economies. However, subsequent studies introduced greater nuance into the understanding of causality within this relationship. Blomstrom, Lipsey & Zejan (1996) and Carroll & Weil (1994) [5,6] revealed that the direction of influence may be asymmetric, with economic growth often Granger-causing capital formation rather than being solely driven by it. These findings suggest that while investment is necessary, it may not be sufficient by itself; institutional quality, policy coherence, human capital, and macroeconomic stability play pivotal intermediary roles.

A growing strand of literature further interrogates the employment dimension of the investment–growth nexus, particularly in the context of technological change. While GFCF is conventionally associated with employment creation through multiplier effects, the emergence of automation, mechanization, and digital technologies has introduced a paradox: 'Jobless Growth'. First highlighted in seminal studies such as Coombs & Green (1981), later reinforced by Hodge (2009) and Frey & Osborne (2015) [7-9], this phenomenon denotes a scenario in which productivity and output increase, but employment stagnates or declines due to labor-displacing technologies. In this environment, capital-intensive investments may inadvertently reduce the labor share in output, intensifying unemployment and income inequality despite aggregate growth.

Moreover, evidence from emerging economies, including India, indicates that the composition of investment—whether directed towards labor-intensive sectors (e.g., agriculture, MSMEs, rural infrastructure) or capital-intensive industries (e.g., manufacturing automation, ICT)—is critical in determining their employment outcomes. A misalignment between the pattern of GFCF and the absorptive capacity of the labor force can amplify structural unemployment and deepen regional disparities.

Recent empirical analyses using time-series econometrics and panel data techniques have reinforced the existence of bidirectional causality between investment and economic growth, albeit with qualifications. For instance, capital formation responds to favorable macroeconomic

signals and policy incentives, thereby fostering long-term economic potential. However, the elasticity of employment for investment remains inconsistent, particularly in the digital age.

In summary, while GFCF retains its pivotal role in driving economic development, its impact on inclusive and sustainable growth is increasingly contingent upon the sectoral allocation of investment, the technological context, and the institutional environment. Policymakers must therefore go beyond the quantum of investment and focus on its quality, distributional effects, and employment generation capacity, especially in economies grappling with demographic pressures and uneven development. Striking a strategic balance between capital deepening and labor absorption is essential for achieving equitable development outcomes in the 21st century.

2. Investment, Growth, and Unemployment in India: Revisiting the Structural Linkages

Over the past three decades, the Indian economy has experienced notable structural transformation and consistent GDP growth, averaging over 6% annually, particularly following the 1991 economic liberalization reforms. These reforms aimed to attract private and foreign investment, enhance productivity, and stimulate long-term employment creation. However, despite this robust growth trajectory, India has witnessed a persistent and widening disconnect between economic expansion and employment generation—an economic paradox often referred to as "jobless growth."

Empirical evidence highlights a decoupling between investment-driven economic growth and employment expansion. Between 2012 and 2016, India experienced an alarming contraction in employment generation, culminating in an absolute decline in employment between 2013–14 and 2015–16, an unprecedented trend in post-reform India. Studies by Kannan and Raveendran (2019) [10], corroborated by international data from the ILO and UN [11-12], confirm this disturbing pattern, indicating a stagnant or falling labor force participation rate (LFPR) and a growing incidence of disguised unemployment, particularly in rural and informal sectors.

This phenomenon is attributed to the low employment elasticity of output growth in India. While GDP has risen due to capital-intensive investment strategies, employment generation has lagged, particularly in sectors adopting labor-displacing technologies. Sinha & Sinha (2022) [13], using log-linearized econometric models, observed a negative and statistically significant employment elasticity of GDP, suggesting that higher economic growth did not translate into proportional job creation. These results, supported by several related studies [14-22], lend credence to the hypothesis that India's growth model is structurally skewed towards sectors that generate low levels of employment per unit of investment, primarily financial services, automation-based manufacturing, and real estate.

Supporting studies such as Jagnathan (2018) [23], and Anyanwu & Kalu (2021) [24] similarly found a negative correlation between capital-intensive investment and employment levels, indicating that investment in productive capital alone is insufficient for inclusive development unless accompanied by labor-absorbing strategies. Furthermore, a substantial rise in informalization within the formal sector, characterized by temporary, low-paying, and precarious jobs, has exacerbated the problem. This shift, often overlooked in headline employment data, reflects a deeper malaise in the quality of jobs being generated.

From a structural perspective, India's unemployment crisis is compounded by a combination of factors:

a. Labor-capital substitution driven by technological adoption, reducing the need for human labor in manufacturing and services.
b. A supply-side demographic surge, with over 12 million individuals entering the labor force annually.
c. Insufficient public and private sector investment in labor-intensive sectors, such as agriculture, agro-processing, MSMEs, rural infrastructure, and social services.
d. Regional disparities in employment creation exist, with low-income states lagging significantly in attracting job-generating investments.

Notably, India's public investment has often fallen short of offsetting market failures, particularly in backwards and rural regions. The private sector, motivated by profit maximization, naturally gravitates toward capital

efficiency, leaving behind large segments of the population in underemployment or unemployment. This has created not just an economic imbalance but also a sociopolitical risk, as mass unemployment fuels poverty, social unrest, migration, and criminality.

The 1991 reforms were envisaged to create an open, investment-friendly environment capable of absorbing the growing workforce. However, while these reforms succeeded in liberalizing the economy and raising aggregate investment levels, they failed to address the employment intensity of growth. The Employment-Unemployment Surveys (EUS) and Periodic Labour Force Surveys (PLFS) consistently indicate a divergence between GDP growth and the employment rate, highlighting that economic reforms have disproportionately favored capital accumulation over labor absorption.

In this context, strategic reorientation is essential. A robust policy mix is required that prioritizes:

a. Labor-intensive public investment in physical and social infrastructure (roads, irrigation, education, health).
b. Targeted incentives for private investment in employment-generating sectors (e.g., textiles, construction, rural enterprises).
c. Re-skilling and upskilling initiatives to bridge the gap between labor supply and industry demand in an evolving technological landscape.
d. Institutional reforms that enhance labor market flexibility without compromising worker security.

The Government's role becomes paramount, not just in facilitating investments, but also in directing them strategically to sectors and regions where they can maximize employment returns. This entails recalibrating investment policy frameworks, enhancing the ease of doing business in labor-rich sectors, and ensuring that job creation becomes an explicit objective of macroeconomic planning.

The intricate nexus between investment, economic growth, and employment in India reveals a structural disjunction that threatens the sustainability and inclusiveness of its development model. While capital formation remains vital for expanding productive capacity, its employment outcomes are not automatic. Without a deliberate focus on employment-intensive investment, India risks perpetuating growth without jobs—a scenario that undermines poverty reduction, social cohesion, and long-term economic stability.

This study emphasizes the urgent need for empirical, policy-driven research into the sectoral and regional impacts of investment on employment, with an aim to redesign strategies that ensure both economic dynamism and job-rich growth. The challenge is not merely to grow, but to grow in a manner that uplifts livelihoods, narrows inequalities, and builds a more inclusive and resilient economy for future generations.

3. Investment, Growth, and Employment: A Structural Interdependence Analysis

The complex relationship among investment, economic growth, and employment continues to intrigue policymakers and scholars alike, as it lies at the heart of macroeconomic planning and development strategy. The theoretical frameworks that posit domestic investment as a catalyst for growth and job creation range from classical Keynesian interpretations—such as the Harrod-Domar model, which views savings and investment as the prime movers of economic expansion—to Solow's neoclassical growth model, where capital accumulation drives growth in the short run but diminishes over time due to diminishing returns. More recent endogenous growth theories, pioneered by Romer and Lucas, argue that investment in physical and human capital, particularly in innovation and R&D, can perpetuate growth by influencing productivity internally rather than exogenously.

These theoretical constructs have catalyzed extensive empirical exploration, albeit with divergent findings depending on the country context, sectoral composition, and temporal framework. Bond et al. (2007) [25]in a comprehensive cross-country study of 94 non-OECD nations, affirmed a positive long-term correlation between investment and economic growth. However, they found no consistent evidence of Granger causality from investment to growth, challenging the assertions of earlier works such as Jones (1995) [26] and Blomstrom et al. (1996) [8], who suggested a directional causality from growth to investment. The implication is that while investment plays a significant explanatory role in growth patterns, it may often be responding to,

rather than driving, growth trajectories.

Studies such as Girardi (2025) [27] added nuance by showing that expected returns on capital, rather than absolute investment levels, significantly condition the growth effects of investment. In countries with underdeveloped financial systems, like many developing economies, interest rates often do not function effectively as investment determinants. Attanasio et al. (2000) [28] and Bond et al. (2007) [25] reinforced that countries with high investment-to-GDP ratios generally enjoy superior output per worker, yet the relationship lacks uniformity.

The ambiguity is particularly stark in studies like Abdulle et al. (2025) [29], who revealed a surprising negative association between investment and economic growth in low-income countries, potentially due to capital misallocation, weak institutional environments, or corruption. This finding echoes the dual-edged nature of investment, which, if misdirected or inefficient, can impede growth or worsen inequality.

In the Latin American context, Hanson (2010) [30] revealed that in Mexico, real wage-driven consumption was a more potent driver of investment than monetary policy variables, highlighting a demand-led investment dynamic. Similarly, Mordecai and Ramirez (2014) [31] found in Uruguay that economic growth precedes and predicts both investment and employment, contradicting the classical supply-side view.

European studies, such as Donath et al. (2008) [32] and Damioli et al. (2019) [33], identified bi-directional causality between investment and growth, emphasizing feedback mechanisms operating in mature economies with well-functioning capital markets.

Investment–Growth–Employment Linkage: Indian and Global Perspectives

In the Indian context, research into this triadic relationship is gaining traction. Kanu and Ozurumba (2014) [34] and Dastidar (2015) [35] uncovered positive long-term relationships among exports, domestic investment, and growth, aligning with the export-led growth hypothesis. Abdouli & Hammam (2017) [36] similarly documented that in MENA countries, economic growth drives investment, particularly under open trade regimes. Bal, Dash & Subhasish (2016) [37] proposed bi-directional causality between capital formation and exports, emphasizing the synergy between trade and domestic resource mobilization.

In Eastern Europe, Tudorache (2024) [38] showed that net capital formation positively impacts employment in Romania, while in Malaysia, Karim et al. (2012) [39] affirmed that fixed investment drives short-run growth, albeit with limited spillovers to employment. South African studies, such as Odhiambo (2010) [40] and Meyer & Sanusi (2019) [41], reveal long-run relationships and causality from growth to both investment and employment, mirroring the Indian experience of growth not translating into proportionate job creation.

Recent Evidence and Emerging Consensus

Recent studies post-2020, especially in the wake of the COVID-19 pandemic, have further complicated the narrative. ILO (2021) and UNCTAD (2022) reports note that despite rebounds in GDP growth in 2021–2022, global and regional labor markets have not recovered proportionately, particularly in middle-income economies. Investment has tended to gravitate toward capital-intensive digital infrastructure and high-tech industries, where employment elasticity remains low.

In India, evidence from the Periodic Labour Force Survey (PLFS) and the CMIE database suggests that GFCF has increased in sectors with low employment absorption, such as real estate and telecommunications, while labor-intensive sectors like textiles, food processing, and MSMEs have faced chronic underinvestment.

Recent econometric studies, such as Sinha and Sinha (2024) [22], using a Vector Error Correction Model (VECM) framework for 1990–2021, affirm the presence of long-run cointegration among domestic investment, real GDP growth, and unemployment. However, short-run disequilibria persist, with shocks to capital formation or employment not immediately self-correcting, indicating structural rigidity in labor and investment markets.

The corpus of empirical and theoretical work underscores a lack of consensus on the direction and magnitude of causality among investment, economic growth, and employment. The relationship is neither linear nor unidirectional. It is mediated by institutional quality, sectoral structure, technological advancement, labor market dynamics, and policy frameworks.

While capital formation remains critical for long-term growth, its impact on employment is neither automatic nor

guaranteed. For economies like India, where demographic pressures and informal employment predominate, the policy imperative must shift towards employment-intensive investment strategies, particularly in infrastructure, agriculture, manufacturing, and care services. Moreover, augmenting human capital through education and skill development, improving financial intermediation, and ensuring efficient public investment allocation will be vital in transforming investment into inclusive growth.

The present study contributes to this ongoing discourse by quantitatively exploring the dynamic interactions among investment, growth, and employment in India, employing the VECM framework over the critical reform period from 1990 to 2024. The findings aim to inform evidence-based policies for a more equitable and employment-rich economic trajectory.

4. Data Foundation and Methodological Framework

At the core of this empirical inquiry lies a carefully structured framework of interrelated variables that collectively shape the complex dynamics of economic performance. The study is anchored on three key macroeconomic indicators: economic growth, proxied by real Gross Domestic Product (GDP); domestic investment, measured through Gross Fixed Capital Formation (GFCF); and employment, reflected in the absolute number of employed individuals. These variables serve as both conceptual and quantitative pillars for exploring the interplay between investment, growth, and labor market dynamics.

To ensure analytical robustness and empirical validity, the study utilizes a comprehensive dataset sourced exclusively from reputable and internationally recognized institutions. Secondary data have been systematically compiled from the World Development Indicators (WDI) database maintained by the World Bank, the International Financial Statistics (IFS) of the International Monetary Fund (IMF), and the Ministry of Statistics and Programme Implementation (MOSPI), Government of India, along with other relevant governmental departments. The reference period extends from 1990–91 to 2023–24, comprising a consistent time series of 34 annual observations.

To enhance the statistical reliability and interpretability of the results, all variables have been subjected to logarithmic transformation. This transformation not only stabilizes variance and linearizes exponential relationships but also facilitates elasticity-based interpretations. The transformed variables—log of real GDP (LRGDP), log of investment (LINV), and log of employment (LEMPLOY)—are succinctly presented in **Table 1** and form the empirical foundation of the analysis.

Table 1. Description of variables.

Acronym of a variable	Variable	Measurement of a variable
LINV	Investment	Gross Fixed Capital Formation
LRGDP	Real GDP	The GDP is at a constant price.
LEMPLOY	Employment	The number of people employed.

Source: Researchers' compilations (MOSPI & Related Government Departments).

In pursuit of methodological rigor, the study employs a suite of established econometric techniques specifically designed for time series data. These include tests for stationarity, co-integration, and causality, which are instrumental in discerning both short-run fluctuations and long-term equilibria. This rigorous approach ensures that the results are not only statistically sound but also economically meaningful, providing nuanced insights into the dynamic relationship among investment, economic growth, and employment in the Indian context.

5. VAR–VECM Framework for Capturing Dynamic Interlinkages

To unravel the complex interdependencies among economic growth, investment, and employment, this study employs a Vector Autoregressive (VAR) model integrated with a Vector Error Correction Model (VECM), providing a robust framework for distinguishing short-run dynamics from long-run equilibrium relationships.

All time series were logarithmically transformed to

stabilize variance and ensure proportional interpretation of elasticities. Stationarity was assessed using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests at levels and first differences. The unit root testing framework follows the general form:

$$\Omega x_t = \alpha + \beta x_{t-1} + \lambda_t + \sum \delta_s \Omega x_{t-s} + \gamma_t \quad (1)$$

where x_t denotes the variable under examination, and γ_t represents a white noise disturbance. The parameters α, β, and λ are estimated to determine the order of integration. The summation extends from *s* =1 to *n*, capturing the lagged effects of the differenced variable over n periods.

Cointegration analysis was conducted using Johansen's (1991)[42] methodology based on a p-dimensional VAR representation:

$$X_i = £ + \sum_{i=1 \text{ to } p} [\ _{t-i}] + ¥_t \quad (2)$$

where X_t is a vector of endogenous variables, $¥_t \sim N(0, \Sigma)$ is an i.i.d. Gaussian error term, and μ captures deterministic components. The Johansen approach tests the rank of the coefficient matrix π in the VECM representation:

$$\Delta Xt = £ + \sum_{i=1 \text{ to } p-1} [\Gamma_i \Delta X_{t-i}] + € X_{t-k} + ¥_t \quad (3)$$

The rank of € determines the number of cointegrating vectors, with trace and maximum eigenvalue statistics guiding inference. The presence of cointegration justifies the VECM specification, capturing both short-run adjustments and long-run equilibria.

Granger causality tests were subsequently embedded within the VECM framework to explore directional influences among the variables. This approach accounts for both lagged differences and the error correction term, enabling robust inference even when lagged differences are individually insignificant (Anoruo & Ahmad, 2001)[43].

This methodological architecture enables a nuanced exploration of dynamic causal linkages among capital formation, growth, and employment, transforming macroeconomic complexity into interpretable empirical insights.

6. Results and Discussion

6.1. Descriptive Statistics of the Key Variables

To unravel the intricate macroeconomic relationships that define the Indian economy in the post-reform era, we begin our empirical journey with a descriptive statistical analysis of the key variables—real GDP growth, gross fixed capital formation (investment), and employment. **Table 2** presents a detailed statistical profile of these variables over the period 1991–92 to 2023–24, offering valuable insights into their central tendencies and dispersion characteristics.

Table 2. Descriptive statistics of LRGDP, LEMPL, and LPIV.

Descriptive Statistics	LRGDP	LEMPL	LPINV
Mean	5.781	2.762	5.263
Median	6.595	2.654	5.303
Standard Deviation	3.223	0.304	0.456
Skewness	−2.884	3.566	3.123
Kurtosis	11.132	17.306	15.642

Source: Author's estimation.

The real GDP growth rate, representing the trajectory of economic performance, exhibits a mean value of 5.781 percent, signaling a moderate yet consistent pace of economic expansion during the post-liberalization phase. This clustering around the mean suggests that India has experienced relatively sustained economic momentum, driven by structural reforms, globalization, and sectoral diversification. The alignment of GDP growth around this central tendency reflects a significant departure from the volatile growth patterns of the pre-reform era, underscoring the macroeconomic stabilization and resilience that reforms have fostered.

Employment, a crucial social and economic indicator, records a mean growth rate of 2.762 percent. While this signifies a positive trend in job creation, the comparatively lower mean relative to GDP growth underscores a structural concern: the phenomenon of "jobless growth." Despite the commendable strides in economic output, employment

generation has not kept pace, indicating the presence of labor market rigidities, sectoral imbalances, and perhaps an overemphasis on capital-intensive growth strategies.

Investment, proxied by gross fixed capital formation, reveals a mean growth rate of 5.263 percent, closely mirroring the output growth. This indicates a strong investment-led growth mechanism, consistent with theoretical expectations from both Keynesian and neoclassical frameworks. The trajectory of investment is pivotal, as it not only reflects investor confidence but also underpins the productive capacity and potential future output of the economy.

In terms of variability, standard deviation values highlight the volatility embedded in each series. Economic growth exhibits the highest standard deviation, indicating greater susceptibility to macroeconomic shocks, policy changes, and global economic cycles. This contrasts with relatively more stable trends in investment and employment, though these too exhibit cyclical fluctuations influenced by exogenous and endogenous factors.

The skewness and kurtosis statistics further enhance our understanding of the data distribution. Positive skewness in GDP growth and investment suggests the presence of occasional spikes above the mean, likely corresponding to years of exceptional performance (e.g., post-2003 boom years). Employment, on the other hand, may exhibit a slightly flatter or platykurtic distribution, reflecting a more persistent yet subdued pattern over time. The deviations from normality, indicated by the kurtosis values, point to non-Gaussian characteristics, justifying the need for advanced econometric modeling in subsequent sections.

In summary, the descriptive statistics articulate a coherent narrative: the post-reform period in India has been characterized by robust economic and investment growth, but moderate employment expansion. The evidence points toward an imbalance between factor inputs and output outcomes, raising important policy questions regarding inclusive growth, labor market efficiency, and investment prioritization. These patterns underscore the need for deeper analysis of the causal mechanisms driving these dynamics.

6.2. Insights from Unit Root Tests

A rigorous time series analysis necessitates a foundational understanding of the stationarity properties of the variables under consideration. Stationarity ensures that the statistical properties of a series—such as its mean, variance, and autocorrelation—remain constant over time, thereby preventing spurious regressions in econometric modeling. To this end, we employ two widely accepted unit root tests: the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. The results are systematically presented in **Table 3**.

Table 3. Unit Root Results.

Variables	ADF test		PP test	
	T-stat	P-value	T-stat	P-value
LINV	−0.9610	0.7635	−1.2073	0.6683
LRGDP	−1.4723	0.5428	−1.3265	0.5921
LEMPL	−0.4682	0.8912	0.4587	0.8931
ΔLINV	−5.2084	0.0001*	−5.2081	0.0001*
ΔLRGDP	−4.6703	0.0002*	−4.5917	0.0003*
ΔLEMPL	−4.6762	0.0002*	−7.4850	0.0001*

Source: Author's estimation. Note: * implies the rejection of the null hypothesis at a 1% significance level.

In their levels (i.e., original untransformed forms), the log-transformed series—LRGDP, LINV, and LEMPLOY—fail to reject the null hypothesis of a unit root at conventional levels of significance, suggesting that the variables are non-stationary at level, or integrated of order zero, I(0). This implies that their statistical properties are time-dependent, with trends and potential structural breaks playing a prominent role.

However, upon first differencing, all three variables exhibit stationarity at the 5 percent level of significance,

as indicated by both the ADF and PP tests. This establishes that the variables are integrated of order one, I(1)—a necessary precondition for applying further time series techniques such as Johansen co-integration tests, Vector Error Correction Models (VECM), or Granger causality analysis.

The inclusion of both trend and intercept terms in the test specifications ensures a comprehensive treatment of deterministic components that may influence the time series structure. The presence of trend significance, particularly in GDP and investment, reinforces the idea that these variables evolve along a deterministic growth path, making differencing essential to achieve stationarity.

These findings are not merely statistical formalities—they are analytically significant. The non-stationary nature of the original series implies that shocks to GDP, investment, or employment have persistent long-term effects, thereby justifying the need for long-run equilibrium analysis through co-integration frameworks. Moreover, the transition to stationarity upon differencing validates the use of differential models that capture dynamic relationships while avoiding spurious regressions.

In conclusion, the results of the unit root tests provide critical empirical validation for the next stage of the analysis. With all variables confirmed as I(1), the study proceeds to investigate long-run equilibrium relationships and short-run dynamics among economic growth, investment, and employment—core themes central to understanding India's developmental trajectory in the post-reform era.

6.3. Long-Run Equilibrium Relationships: Insights from Johansen Cointegration

To examine the long-run interrelationships among economic growth, employment, and investment, the Johansen cointegration test was applied after establishing the stationarity properties of the variables through unit root testing. The empirical results derived from this procedure are systematically reported in **Table 4**.

Table 4. Johansen Cointegrating Results.

Trace Test				Maximum Eigen. Test			
H_0	H_1	Trace Stat.	P- value	H_0	H_1	Max. Eigen Stat.	P-value
r = 0	r > 0	64.9646	0.0040*	r = 0	r > 0	36.8904*	0.0035*
r < 1	r > 1	28.0741	0.2380	r < 1	r = 1	14.2594*	0.4385
r < 2	r > 2	13.8145	0.3924	r < 2	r = 2	10.5982	0.2829

Note: Both the Trace test and Maximum Eigen test results show cointegrating at the 5% significance level. Source: Author's estimation.

Recognizing the test's sensitivity to lag structure, an optimal lag length of two was selected based on consistent results from multiple information criteria.

The Johansen trace and maximum eigenvalue statistics indicate the presence of two cointegrating vectors at the 5% significance level, rejecting the null hypothesis of no cointegration. This confirms the existence of a stable long-run equilibrium among the variables and suggests at least one direction of causality within the system.

The estimated long-run equations are as follows:

$$\mathbf{LEMPLOY = 7.17 - 0.483\ LRGDP + 0.273\ LINV} \quad (4)$$

$$\mathbf{LRGDP = 14.58 + 0.587\ LINV - 0.285\ LEMPLOY} \quad (5)$$

Equation (4) reveals a positive long-run association between employment and investment, consistent with investment-driven job creation. However, the negative coefficient on economic growth suggests a decoupling of output expansion from labor absorption—a manifestation of jobless growth in the post-liberalization period.

Equation (5) further reinforces the positive link between investment and GDP growth, aligning with conventional growth theory. Yet, the inverse relationship between GDP and employment highlights persistent structural inefficiencies and labor market rigidities, potentially stemming from inadequate technological diffusion and a mismatch in skills and sectoral growth.

These findings underscore the complexity of India's growth-employment-investment nexus and suggest that long-run economic expansion has not translated proportionately into employment gains, necessitating targeted structural interventions.

6.4. Growth–Investment–Employment Interactions: A VECM-Based Causality Approach

Following the establishment of a long-run cointegrating relationship among economic growth, investment, and employment, the logical next phase in our empirical exploration involves disentangling the underlying causal dynamics. To this end, we adopt a dual-method approach: the Vector Error Correction Model (VECM), which captures both short-run dynamics and long-run causality through the inclusion of an error correction term (ECT), and the Pairwise Granger Causality test, which provides robustness checks and further delineates the directionality of inter-variable relationships. The empirical findings corresponding to these analyses are summarized in **Table 5, Table 6, Table 7 and Table 8.**

Table 5. VEC Granger Causality test results.

Dependent Variable	Independent variables			
	DLINV	DLRGDP	DLEMPL	All variables
DLINV	-	9.7778 (0.0028***)	0.5324 (0.7662)	10.1085 (0.9472)
DLRGDP	5.5584 (0.0621)	-	3.9626 (0.1379)	9.1119 (0.0850*)
DLEMPL	10.2536 (0.0059***)	1.0557 (0.5859)	-	12.2413 (0.0011***)

Note: * implies a 10% significance level; *** implies a 1% significance level; Source: Author's estimation

Table 6. Pairwise Granger Causality Test.

Null Hypothesis	P-value
LINV does not Granger-cause LRGDP	0.3516
LRGDP does not Granger-cause LINV	0.0005***
LEMPL does not Granger-cause LRGDP	0.0587*
LINV does not Granger cause LEMPL	0.0159**
LRGDP does not Granger-cause LEMPL	0.0002***
LEMPL does not Granger-cause LINV	0.0817*

Note: *** implies rejection of the Null Hypothesis at a 1% significance level; ** implies the rejection of the Null Hypothesis at a 5% significance level; and * implies the rejection of the Null Hypothesis at a 10% significance level.
Source: Author's estimation

Table 7. VECM estimation results.

Error Correction	D(LINV)	D(LRGDP)	D(LEMPL)
Cointegration Equation 1	0.0196 (0.0165) 1.1954	−0.0152 (0.0044) −3.5117	0.0153 (0061) 2.5158
D{LINV(−1)}	0.7742 (0.4673) 1,6568	−0.04613 (0.1232) 3.7397	0.3256 (0.1734) 1.8769
D{LINV(−2)}	1.2230 (0.4960) 2.2264	−0.1669 (0.1309) 1.3751	0.3314 (0.1840) 1.8610
D{LRGDP (−1)}	0.3712 (0.1154) 3.2148	−0.0134 (0.0304) −0.4392	−0.0036 (0.4285) −0.0854
D{LRGDP (−2)}	−0.1373 (0.1117) −1.2300	−0.0579 (0.0294) −1.9646	0.0404 (0.0414) 0.9768

Table 7. *Cont.*

Error Correction	D(LINV)	D(LRGDP)	D(LEMPL)
D{LEMPL(−1)}	0.1520	0.1314	0.0218
	(0.3138)	(0.0828)	(0.1164)
	0.4846	1.5868	0.1876
D{LEMPL(−2)}	−0.1574	−0.0200	0.1580
	(0.3942)	(0.0800)	(0.1128)
	−0.5127	1.2877	0.1406

Source: Author's estimation.

Table 8. Diagnostic Test Results.

Item	Applied Test	P-value	Decision
Serial Correlation	LM Test	0.4216	No serial correlation
Normality	Jacque-Bera Test	0.1971	Variables normal
Heterocedasticity	Breusch Pagan Godfrey Test	0.2697	No heterocedasticity

Source: Author's estimation.

Causal Structures Within the VECM Framework

The VECM specification, as represented in Equation (3), incorporates lagged first differences of the endogenous variables alongside the ECT derived from the cointegration equation, enabling the joint estimation of short-run fluctuations and long-run equilibrium reversion. **Table 5** presents the estimation results, revealing significant asymmetries in the causal transmission mechanisms.

A prominent result is the presence of unidirectional long-run causality flowing from real GDP to gross capital formation (investment). This suggests that output growth catalyzes investment, likely through enhanced business confidence, improved returns on capital, and greater policy credibility in the post-reform Indian context. Such evidence challenges the conventional investment-led growth paradigm, which presupposes capital accumulation as the primary driver of output—a notion increasingly contested in labor-abundant developing economies where endogenous factors like productivity and demand play a stronger role.

The causality from GDP to employment further reinforces this output-led dynamic. The statistically significant impact of GDP on employment levels indicates that economic expansion tends to be job-generating, though possibly with time lags or sectoral disparities. The absence of reciprocal causality from employment to GDP indicates that labor market improvements do not independently stimulate output growth, underscoring a "growth-led employment" trajectory characteristic of structural transformation.

Granger Causality Tests: Robustness and Bidirectional Linkages

Table 6 presents results from the Pairwise Granger Causality tests, which substantiate the directional linkages identified in the VECM model. The tests confirm that GDP Granger-causes both investment and employment, while neither variable significantly predicts GDP in return. This reinforces the proposition that economic growth is the prime mover in the Indian macroeconomic system during the post-liberalization era.

An additional insight emerging from the Granger framework is the existence of bidirectional causality between investment and employment. This reciprocal relationship highlights a feedback mechanism: increased investment spurs employment through physical capital accumulation and infrastructure development, while rising employment stimulates investment by enhancing aggregate demand and productivity. This finding aligns with previous empirical work, notably Rajni (2013) (31), thereby adding external validation to the model outcomes.

Short-Run Dynamics and Long-Run Adjustment Mechanisms

Short-Run Causality Analysis and Role of Lagged Variables: Table 7 presents the Vector Error Correction Model (VECM) estimation results, which help elucidate both the short-run dynamics and the mechanisms by which long-run equilibrium is restored after a shock. The coefficients of the error correction terms (ECTs) and the lagged

differenced variables provide critical insights into the adjustment processes of investment (LINV), real GDP (LRGDP), and employment (LEMPL).

Error Correction Terms (ECTs): Adjustment Toward Long-Run Equilibrium

The ECT in the GDP equation is negative and highly significant (–0.0152; t = –3.5117), indicating a robust and stable long-run relationship in which real GDP actively adjusts to correct deviations from the equilibrium path. This implies that GDP acts as the primary correcting force in the system, reflecting its responsive and integrative nature within the economic structure.

In contrast, the ECTs in the investment and employment equations are positive but statistically insignificant (0.0196 and 0.0153, respectively), with t-values below conventional thresholds. This suggests a weak or delayed correction mechanism for these variables, highlighting structural inertia or frictions that hinder their responsiveness to disequilibrium. These results point to an asymmetry in the adjustment process, where output (GDP) shoulders the burden of realignment, while investment and employment lag behind.

Short-Run Dynamics and Role of Lagged Variables

A detailed examination of the lagged differenced variables further clarifies the nature of short-run causality and dynamic interactions:

Investment Equation (D(LINV)):

i.) Both lagged values of investment—D(LINV(–1)) and D(LINV(–2))—are positive and statistically significant at the 10% and 5% levels, respectively (t = 1.6568 and 2.2264). This implies a strong degree of short-run persistence in investment behavior, where past investment positively influences current investment.

ii.) D(LRGDP(–1)) is also significant (t = 3.2148), suggesting that GDP growth has a positive and immediate short-run causal effect on investment, likely reflecting demand-driven investment behavior.

iii.) However, employment lags (D(LEMPL(–1), D(LEMPL(–2))) show no significant effect, indicating a weak transmission channel from labor market dynamics to investment decisions.

GDP Equation (D(LRGDP)):

i.) Interestingly, none of the lagged variables—including its lags and those of investment or employment—are statistically significant, except for D(LRGDP(–2)), which is marginally significant (t = –1.9646). This indicates limited short-run predictability from other macroeconomic variables, with GDP's correction process mainly operating through the long-run error correction term.

ii.) The relatively low responsiveness of GDP to short-term variations in employment or investment underscores its role as the system's anchor, responding to imbalances rather than driving them in the short run.

Employment Equation (D(LEMPL)):

i.) None of the lagged variables are statistically significant, although D(LINV(–1)) and D(LINV(–2)) approach significance (t ≈ 1.87). This suggests that while past investment may influence employment to some extent, the effect is not strong or immediate.

ii.) The lack of statistical significance in the error correction term and lagged variables highlights the inertial behavior of employment, possibly due to rigid labor laws, delayed hiring responses, or structural mismatch in labor demand and supply.

Synthesis of Causal Findings and Policy Relevance

The causality structure reflected in the VECM can be synthesized as follows:

a) Long-Run Causality:

i.) There is strong evidence of unidirectional long-run causality from GDP to investment and employment, signifying that sustained output growth is a prerequisite for broader economic transformation.

ii.) The bidirectional causality between investment and employment points to mutual reinforcement in the long term, consistent with a virtuous cycle of capital accumulation and job creation.

b) Short-Run Adjustment:

i.) The short-run correction is predominantly driven by GDP, as evident from the significant ECT in its equation.

ii.) Investment responds positively to past values of GDP and itself, indicating dynamic momentum but limited structural adaptability.

iii.) Employment remains the least responsive in the short term, revealing deep-rooted structural frictions and policy transmission lags.

Implications for Policy Design

These findings carry profound implications for macroeconomic policy in India:

a.) Growth-Led Strategy: Given the central role of GDP in driving both investment and employment, policies should prioritize sustained output expansion, particularly in productive and labor-intensive sectors.

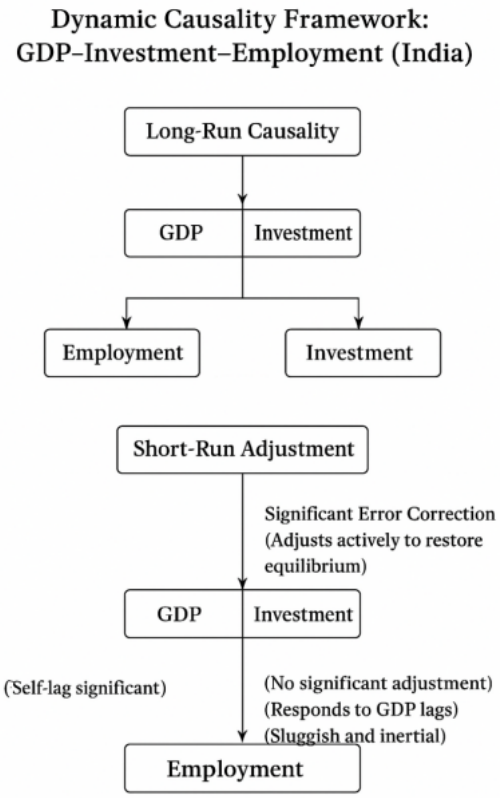
b.) Targeted Reforms: The sluggish responsiveness of investment and employment points to the need for structural reforms—streamlining regulatory processes, improving ease of doing business, and enhancing labor market flexibility.

c.) Investment Incentives: To accelerate capital formation, public investment should be used strategically to crowd in private investment, especially in infrastructure and manufacturing.

d.) Labor Market Revitalization: Employment generation demands a dual approach—promoting skill development and labor mobility on the supply side, and removing rigidities and hiring constraints on the demand side.

A **conceptual diagram** summarizing the dynamic linkages among GDP, Investment, and Employment based on the **VECM estimation** and **short-run/long-run causality findings**.

🔁 **Dynamic Causality Framework: GDP–Investment–Employment (India)**



🔍 **Interpretive Notes:**

- **Solid arrows (→)**: Significant long-run or short-run causal direction.
- **Bidirectional arrow (↔)**: Mutual causality (investment ↔ employment) in the long-run.
- **Dotted elements** (e.g., sluggish adjustment): Variables with **no significant ECT** or lag effects in the short run.
- **GDP**: Core driver and the only variable with **significant error correction**, indicating it restores equilibrium.
- **Investment**: Shows **short-run responsiveness** to its own and GDP's lags.
- **Employment**: Largely unresponsive in the short run;

requires structural reform to improve its dynamic linkages.

6.5. Ensuring Robustness: Diagnostic and Stability Tests

No empirical investigation attains credibility without ensuring the robustness and reliability of the estimated models. To this end, a series of diagnostic tests were conducted, with the results presented in **Table 8**.

Serial Correlation and Heteroscedasticity

The Breusch-Godfrey LM test for serial correlation and the White test for heteroscedasticity reveal that our VECM specification does not suffer from autocorrelation or non-constant error variance. The p-values for both tests exceed the 5% significance level, allowing us to retain the null hypotheses of no serial correlation and homoscedasticity. This ensures that the model's residuals are well-behaved, meeting classical assumptions and reinforcing the reliability of the estimated parameters.

Normality of Residuals

The Jarque-Bera test confirms that the residuals of the model are normally distributed, further validating the assumption of Gaussian errors that underpins the inference procedures in vector autoregressive models. The non-significance of the test statistics affirms that the model is free from specification errors or outlier-induced distortions.

CUSUM and CUSUMSQ Tests

Graphical analyses using the CUSUM and CUSUMSQ stability tests (not shown here for brevity) also indicate that the model remains structurally stable throughout the study period. There is no evidence of parameter instability or regime shifts, even across key macroeconomic events (e.g., global financial crisis, demonetization, COVID-19 shock), suggesting that the estimated relationships are robust and persistent.

Taken together, these tests establish the methodological soundness and stability of the model, thereby enhancing confidence in the empirical conclusions drawn from the analysis.

7. Investment, Growth, and Employment Dynamics: An Empirical and Policy Synthesis

The interlinkages among investment, employment, and economic growth lie at the core of development economics, particularly in labor-rich, capital-constrained economies such as India. The prevailing development hypothesis posits that investment is a fundamental driver of growth, which in turn acts as a catalyst for employment generation. However, the empirical realities are often more intricate and nonlinear.

This study, spanning the post-reform period from 1990–91 to 2023–24, provides critical insights into the evolution of this nexus using a robust time-series framework grounded in the Vector Error Correction Model (VECM). Our analysis yields several key findings:

a. A long-run equilibrium relationship exists among GDP, investment, and employment, confirming their macroeconomic interdependence.
b. Causality flows primarily from economic growth to investment and employment, challenging conventional wisdom that positions investment as the sole driver of growth.
c. Bi-directional causality between investment and employment highlights the mutual reinforcement between productive capacity and labor market dynamics.
d. Short-run adjustments occur predominantly in GDP, whereas employment and investment adjust sluggishly, revealing structural lags in transmission mechanisms.

These results carry profound implications. Most notably, the study affirms the existence of "jobless growth" in India—a condition where economic expansion has not been commensurate with employment creation. This points to the capital-intensive nature of post-reform growth, where productivity enhancements are driven more by technological and infrastructural improvements than by labor absorption.

8. Policy Implications

To address this imbalance, the following policy interventions are proposed:

a. Stimulate labor-intensive sectors, particularly agriculture, micro and small enterprises, and rural manufacturing, to increase the employment elasticity of growth.
b. Enhance infrastructural investment, especially in un-

derdeveloped regions, to crowd in private investment and generate local employment.

c. Facilitate skill development programs, aligning workforce capabilities with sectoral demands to reduce structural unemployment.
d. Promote inclusive investment policies, offering incentives for job creation in addition to capital accumulation.

In conclusion, this study not only deciphers the complex interplay among investment, employment, and economic growth in India but also charts a roadmap for sustainable and inclusive development. The findings serve as a clarion call for policymakers to recalibrate strategies toward fostering a growth model where economic expansion translates meaningfully into employment and human development.

9. Strategic Investment for Employment-Led and Sustainable Growth

Building upon the empirical insights derived from the exploration of the investment-employment-growth nexus, this section presents a set of strategic policy recommendations designed to recalibrate India's growth trajectory toward enhanced employment creation and sustainable economic vibrancy. These recommendations emerge not merely as normative aspirations but as actionable imperatives substantiated by robust econometric evidence and aligned with structural realities of the Indian economy.

9.1. Optimize Public Resource Allocation through Capital-Oriented Budgeting

A fundamental shift in fiscal architecture is warranted to amplify the impact of government expenditure on employment. The empirical findings of this study substantiate that capital expenditure exerts a more significant influence on employment generation than recurrent spending, particularly in the long run. Hence, a deliberate and systematic reallocation of budgetary resources away from non-developmental recurrent expenditures (e.g., administrative overheads, subsidies without production incentives) toward capital-intensive sectors (e.g., infrastructure, rural connectivity, and industrial clusters) is essential.

This strategy not only enhances productive capacity but also ensures multiplicative employment effects through forward and backwards linkages across sectors.

9.2. Foster a Competitive Investment Ecosystem through Structural Liberalization

The study underscores the pivotal role of economic growth in stimulating private investment, implying that a favorable investment climate is critical for sustaining this virtuous cycle. To this end, eliminating price distortions, streamlining regulatory bottlenecks, and liberalizing factor markets (especially land and labor) are vital to unleashing entrepreneurial dynamism.

Creating a competitive policy framework, underpinned by transparency, contract enforcement, and ease of doing business, will enable the private sector to emerge as a principal engine of job creation and innovation, particularly in urban and semi-urban industrial nodes.

9.3. Design and Deliver Sustainable, Production-Linked Subsidies

The indiscriminate application of consumption-oriented subsidies often results in fiscal inefficiencies and limited developmental gains. Our findings advocate a transition to performance-based, production-linked subsidies that directly incentivize investment in employment-intensive sectors.

This implies the redesign of subsidy regimes to align with measurable outcomes such as job creation, technology adoption, or export diversification. Moreover, subsidy rationalization must be accompanied by the establishment of transparent monitoring mechanisms, ensuring fiscal prudence while nurturing long-term private sector engagement.

9.4. Implement Sector-Specific Incentive Frameworks for Employment Multipliers

The evidence from this study reveals bi-directional causality between investment and employment, particularly in sectors characterized by low incremental capital-output ratios (ICORs). Sectors such as agriculture, manufacturing,

transportation, energy production, telecommunications, and mining exhibit strong employment elasticity and economic linkages.

The government should formulate tailored incentive packages—such as tax holidays, investment allowances, credit guarantees, and infrastructure support—targeted at these sectors. Prioritizing such sectors will facilitate broad-based employment creation while simultaneously accelerating structural transformation and inclusive growth.

9.5. Revitalize Agriculture and Allied Activities through Strategic Public Investment

Given that a significant share of India's workforce remains engaged in agriculture and allied sectors, the long-run solution to employment generation must include revamping the agrarian economy. Public investment in agricultural infrastructure (irrigation, storage, logistics), value chains, research and extension services, and agri-tech platforms is critical to enhancing productivity and value addition.

Special emphasis should be placed on promoting rural non-farm employment through the development of agro-processing, fisheries, horticulture, and animal husbandry. These interventions would not only uplift rural incomes and employment but also ensure food security and rural resilience in the face of climate and market shocks.

10. Conclusions

The policy recommendations articulated in this study are firmly anchored in its empirical findings and econometric diagnostics, reflecting a nuanced interpretation of India's evolving macroeconomic architecture. The interplay among economic growth, investment, and employment—analyzed through rigorous techniques such as Johansen cointegration, Vector Error Correction Models (VECM), and Granger causality—reveals both opportunities and structural constraints that must inform future macroeconomic strategy.

To transition toward a more inclusive and employment-intensive growth trajectory, India must recalibrate its policy architecture on three critical fronts:

a. Fiscal Realignment for Productive Capital Formation: Reallocating public expenditure toward capital outlays—particularly in infrastructure, rural development, and technology-driven sectors—can generate high employment multipliers while sustaining aggregate demand. This shift from consumption-led to investment-led fiscal policy is crucial for long-term productivity enhancement.
b. Cultivation of a Robust and Adaptive Investment Ecosystem: Removing structural bottlenecks, enhancing ease of doing business, and ensuring regulatory predictability are essential to crowd-in private investment. Special emphasis should be placed on sectors with high employment elasticity, including manufacturing, construction, and green industries.
c. Labor Market Activation and Skill-Responsive Industrial Policy: Addressing labor market rigidities, improving workforce employability, and fostering sectoral alignment between skills and demand can maximize the employment dividend. Policy interventions must integrate human capital development with industrial strategy, particularly in MSMEs and labor-intensive manufacturing.

As India advances toward its aspiration of becoming a $5 trillion economy, the reconciliation of robust economic growth with broad-based employment generation emerges as a critical dual objective. The analytical trajectories outlined herein provide not merely prescriptive interventions but a strategic framework for sustainable development, socio-economic inclusion, and structural transformation.

These recommendations must therefore be viewed not as optional enhancements but as strategic imperatives—essential for achieving macroeconomic resilience, distributive justice, and long-term competitiveness. In an era marked by global uncertainties and domestic challenges, aligning growth dynamics with employment outcomes is central to realizing the vision of an empowered, equitable, and employment-generating India.

10.1. 1Limitations of the Study

This study, while rigorous in its empirical approach and based on robust econometric techniques, is subject to several limitations that merit acknowledgment:

10.1.1. Dependence on Secondary Data

The analysis primarily utilizes secondary data obtained from official national and international statistical sources. While these datasets provide consistency, temporal coverage, and broad comparability, they are not without limitations. Issues such as underreporting, definitional inconsistencies, and incomplete representation—particularly for variables like labor force participation, informal employment, and underemployment—may affect data accuracy. Informal sector dynamics, which constitute a substantial share of the Indian labor market, are especially prone to mismeasurement due to methodological limitations of standard household or enterprise surveys. Consequently, the findings should be interpreted cautiously, recognizing that ground-level heterogeneity may not be fully captured.

10.1.2. Aggregation Bias and Lack of Regional/Sectoral Disaggregation

Due to limitations in data availability and consistency over the full sample period (1990–2024), the study models the Indian economy at an aggregate level. Sector-specific or state-level disaggregation was not feasible, as relevant time-series data for such dimensions were either unavailable, inconsistent, or incomplete. This aggregation constraint restricts the study's ability to examine sectoral (e.g., agriculture, manufacturing, services) or regional (e.g., interstate) heterogeneity. As a result, policy recommendations derived from the aggregate analysis may not fully reflect the structural diversity of India's economy and may require contextual adaptation at sub-national levels.

10.1.3. Absence of Structural Break and Stability Tests

Although the study covers a period marked by significant economic disruptions—such as the 1991 liberalization, the 2008 global financial crisis, and the COVID-19 pandemic—it does not explicitly test for structural breaks in the time series. This is primarily due to the methodological orientation of the study, which emphasizes long-run relationships and short-run adjustments within a cointegration and Vector Error Correction Model (VECM) framework. While the use of lag structures and the error correction mechanism implicitly accommodates some degree of temporal variability, the absence of formal structural break tests (e.g., Chow test, Bai-Perron test) may limit the precision of temporal inference, especially concerning regime changes. Future research could strengthen this dimension by incorporating formal stability diagnostics and breakpoint analysis.

10.1.4. Assumption of Linearity and Exclusion of Nonlinear Dynamics

The econometric modeling in this study is based on linear specifications of the VECM framework. Potential nonlinearities, threshold effects, or asymmetric causality patterns—which could be relevant in a complex, evolving economy like India—were not tested. The linear structure may oversimplify real-world economic behavior, particularly in periods of economic transition or crisis. Advanced models such as Threshold VECMs or Markov-switching models could uncover richer dynamics and are recommended for future exploration to capture possible nonlinear adjustments and regime shifts in macroeconomic relationships.

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Informed Consent Statement

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Data Availability Statement

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Conflicts of Interest

I declare no conflicts of interest regarding the publication of this article.

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