THE ECONOMICS SOCIETY
SHRI RAM COLLEGE OF COMMERCE

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EDITORS' NOTE

"The important thing is not to stop questioning. Curiosity has its own reason for existing." - Albert Einstein

Artha - The Shri Ram Economics Journal stands at the intersection of academic inquiry, thought-provoking ideas and opinions that matter. For years, it has carved a place for the academic research that it brings forward, spanning across domains that lie at the heart of Economics. In an era of constant change, Artha aims to present insightful work that enhances one's understanding of the multifaceted field.

The journal, over time, has transitioned into more than just a publication, but rather a window to academic discourse. Artha 2026 aims to carry forward the legacy of diverse voices, insights and economic realities. The journal is incomplete without the contributions that shape it; its strength lies in all the individuals who contributed to it. We extend our gratitude to all who contributed and trusted us to put forth their work and perspectives. Each submission that we went through had a mark of its own and would aid in fostering a commitment to meaningful inquiry and informed debate.

We are also deeply grateful to our principal, Professor Simrit Kaur, for her support towards such academic initiatives at SRCC. We also wish to express our sincere appreciation to Professor Abhishek Khadgawat for his guidance and mentorship throughout this journey. Their support has been invaluable in shaping this journal.

An appreciation is due to the Editorial Board without whose dedication, perseverance and collaboration this edition would not be what it is today. Their efforts have been instrumental in bringing this edition to fruition.

At last, to all our readers, we hope that Artha finds a space in your mind and heart as it did for us, and it serves more than just a collection of articles. We hope it becomes a space for reflection, dialogue, and inspiration, one that encourages you to question, engage, and explore the depth of economic theory.

Warmly,
Anvi Mansharamani and Vishnu Todi
Editors-in-Chief
The Economics Society, SRCC

FACULTY ADVISOR'S NOTE

For a hundred years, SRCC has defined education by exploring beyond the classroom. It has placed immense value on engaging with ideas that shape the world. In this tradition, The Economics Society offers a place where students push their own limits and learn that true understanding often starts outside familiar boundaries, and it is in these uncharted waters that the Society's legacy lives on.

This spirit shines its brightest through Artha 2026. The publication asks undergraduate students, working alongside scholars and thinkers, to engage with demanding intellectual work: to frame questions that matter, to gather and evaluate evidence with care, and to craft arguments that can stand on their own merit. Its scope covers economics and related fields, showing that knowledge grows when ideas are shared across boundaries, not kept apart. Each piece in this volume is included for its rigour, imagination, and reflection.

This publication is more than a set of academic pieces; it shows how serious inquiry can grow within a student community. Artha proves that when ideas are pursued with discipline and imagination, they can answer questions that matter beyond the classroom. As our institution celebrates its centenary year, the journal reminds us of the College's lasting commitment to intellectual excellence and the belief that dialogue can shape understanding.

As Faculty Advisor, I feel privileged to be a part of The Economics Society and this high-quality publication. I extend my warmest wishes to the team and the Society for the year ahead, confident that their work will continue to enrich both the college and the wider academic world.

Mr Abhishek Khadgawat
Teacher-in-Charge
The Economics Society, SRCC

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Structural Interlinkages Between Cryptocurrencies and Foreign Exchange: Evidence From Volatility and Returns Spillovers

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ABSTRACT

This paper studies the asymmetric and intertemporal nature of the magnitude and direction of returns and volatility spillovers between Bitcoin, Ethereum and six USD-based foreign exchange currency pairs. Employing EGARCH models to estimate conditional volatilities and Vector Autoregression frameworks, we apply the Diebold-Yilmaz FEVD methodology to measure cross-market spillovers for returns and volatility. While the USD-INR has the highest own variance share, other pairs like EUR-USD and USD-CHF show much higher vulnerability to external returns shocks. Volatility spillovers are substantially stronger in terms of cross-market transmission. Cryptocurrencies exhibit high internal volatility persistence and transmit volatility to currencies such as AUD-USD and GBP-USD, and have a much lesser impact on the currency returns. Our analysis shows that USD-INR displays asymmetric financial integration, absorbing external volatility from cryptocurrency and major forex markets, while transmitting minimal outward spillovers, suggesting structural vulnerability in emerging markets. The total spillover indices for returns and volatility reveal that volatility spillovers are almost two times stronger than return spillovers, and both spike during geopolitical and market uncertainty. Also, we propose a new indicator - Crypto-FX Spillover Vulnerability Index (CSVI), which is a risk indicator that is based on FEVD elements, EGARCH parameters, and a shock indicator to estimate the volatility exposure and can be beneficial for policymaking in emerging economies that are vulnerable to cryptocurrency shocks.

Keywords: cryptocurrencies, foreign exchange markets, volatility spillovers, returns spillovers, forecasting, financial connectedness, financial stability

JEL Classification: G15, G17, F31

1. Literature Review

The academic literature exploring the factors and drivers of spillovers between crypto and financial markets has expanded significantly after the widespread growth and adoption of decentralised finance (DeFi), including Bitcoin. There are several studies that empirically analysed the volatility spillovers among cryptocurrencies and the broader financial markets.

Vuković et al. (2025) adopted the Bayesian Vector Autoregression (BGVAR) model to study the shock transmission between cryptocurrency and financial markets and concluded that crypto shocks adversely affect stock markets, bond indices, exchange rates, and volatility indices, though they are generally short-term and heterogeneous in nature. Their paper dealt with structural shock forecasting using Generalised Impulse

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Response Functions (GIRF), and the results indicated that negative volatility spillovers had the most significant impact on the volatility indices. Bitcoin had the largest and statistically significant, but short-lived, impact, particularly on the VIX, whereas the impact of Ethereum was comparatively lower.

Li and Patel (2025) employed a VAR-X model and a bivariate GARCH-BEKK model on HFT 5-minute data (2022–2024), concluding that October 23, 2023, signifies a structural break associated with the approval of the Bitcoin ETF. There aren't as many studies on returns spillovers between crypto and financial markets as there are on volatility spillovers, which are more important for policy reasons. Iyer and Popescu (2023) utilised Diebold-Yilmaz connectedness indices and discovered that spillover magnitude increases during periods of uncertainty, particularly during COVID-19, indicating heightened interdependence.

Another important aspect to consider is how liquidity transmits between crypto and foreign exchange markets. Nekhili et al. (2023) constructed daily liquidity measures for five major cryptocurrencies and seven major fiat currencies and determined that liquidity connectedness is event-driven and time-varying. There is an increase in liquidity spillover at the peak of the COVID-19 pandemic, reflecting increased uncertainty and market instability. EUR-USD was the main transmitter of short-run liquidity shocks, and Ethereum was the main transmitter of long-run shocks.

As mentioned, studies concerning the returns spillovers between crypto and forex markets are fairly limited. This paper contributes to the existing literature by analysing the returns spillovers, which have not been studied in detail previously, as well as identifying the heterogeneous nature of volatility spillovers between safe-haven, developed, and emerging-market currencies. This has important implications for risk management, monetary policy formulation, and capital buffer requirements in an increasingly interconnected and globalised financial system.

2. Introduction

The global financial landscape has undergone a major transformation since the introduction of Bitcoin in 2009, evolving from initial scepticism toward decentralised finance (DeFi) to institutional adoption and integration. Cryptocurrencies have changed their position from niche digital assets to globally traded instruments with thousands of institutional miners, researchers, blockchain developers, and users. As of January 2026, the total market cap of all cryptocurrencies is at $3.18 T (TradingView). The two largest cryptocurrencies are Bitcoin (BTC) and Ethereum (ETH). Bitcoin has a global market cap of $1.74T, while Ethereum has a market cap of $352.61B as of December 2025 (Forbes, n.d.). Crypto adoption has significantly increased in South Asia, which recorded an 80% increase from 2024 and reached $300 B in trading volume (TRM Labs, 2025). India ranks top among the South Asian countries, likely due to the tech-savviness of the younger generation and advances in software development.

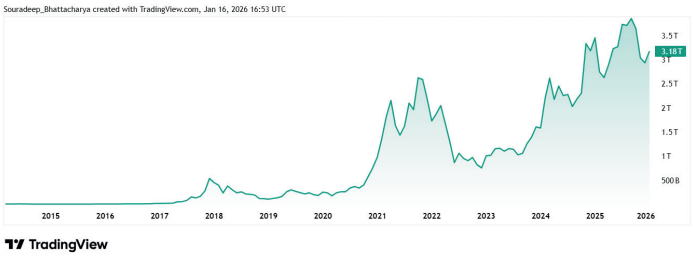


Figure 1: Total Market Capitalisation of Cryptocurrencies

Source: Tradingview

Their rising market capitalisation and widespread adoption have led to the rise of 'crypto millionaires', and this indicates that wealth endowments are becoming more unequal. Its integration with broader financial systems raises important questions regarding their interaction with established asset classes, particularly foreign exchange markets and the overall financial system. In the US, 80% of jurisdictions saw banks venturing into digital assets (TRM Labs, 2025), and this imposes systemic risk on the bank's balance sheets in the event of a crypto crash. Countries like Nigeria and Turkey hold cryptocurrencies as an inflation hedge (Agama, 2023), and this reliance undermines the ability of the central bank to implement effective monetary policy to address the core issues. Since both cryptocurrencies and exchange rates are sensitive to global risk sentiment, liquidity conditions and macroeconomic shocks can destabilise the system, and a study of these interlinkages is crucial.

This paper studies these interactions by analysing whether volatility and returns in cryptocurrency markets spill over into major foreign exchange markets, and conversely, whether currency market shocks influence cryptocurrency dynamics. The focus is on two leading crypto assets, Bitcoin and Ethereum, and six USD-denominated currency pairs, representing both advanced-economy and emerging-market currencies, to capture heterogeneous effects.

3. Research Methodology

The analysis is structured around three components: First, volatility characteristics are studied through EGARCH models to determine the characteristics of asymmetry, persistence and clustering. Secondly, a VAR(2) model is estimated to capture interdependencies among the log returns and a VAR(5) model is estimated to capture interdependencies among the estimated conditional volatilities. Lastly, the Diebold–Yilmaz generalised FEVD methodology is applied to quantify bilateral and aggregate spillovers, as well as draw inferences from the observations.

We use daily closing price data for BTC-USD, ETH-USD, EUR-USD, GBP-USD, AUD-USD, USD-CHF, USD-JPY and USD-INR from January 1, 2018, to January 1, 2025. The data was collected from Investing.com. The list of currencies includes both emerging and established markets with varying levels of financial integration to better capture the heterogeneity of spillovers. The data is cleaned, and log returns are calculated using the formula $rt = \log_e(Pt/Pt\text{-}1)$. Following this, an EGARCH (1,1) model is fitted to each currency pair, and the conditional volatilities are extracted. Both the log returns and estimated volatilities are tested for stationarity using the ADF test, and a VAR model is fitted separately to each based on optimal lag order determined by AIC. The residual correlation matrix is plotted, and a custom function is defined to predict cross-currency spillovers for H = 10 using the Diebold-Yilmaz framework.

The main goal is to identify whether these volatilities and returns spillovers are symmetric across crypto and FX markets, and which currencies act as key transmitters or recipients.

Augmented Dickey Fuller (ADF) Test

We check for stationarity in the returns series. Closing prices are non-stationary, but we would expect the daily

returns and GARCH-type volatility innovations to be generally stationary with a mean centred at zero. The Augmented Dickey-Fuller (ADF) test is a statistical test used to determine whether a time series is stationary or non-stationary. It tests for the presence of a unit root in the series, which is indicative of non-stationarity. The results of the ADF test are shown in the appendix.

Let the null hypothesis and alternative hypothesis be defined as:

H_0: A unit root is present in the time series
H_1: No unit root is present in the time series.

The values of the test statistic for all the assets are negative and strongly significant at the 5% level, except for the conditional volatility of USD-INR, which is weakly non-stationary. However, we avoid differencing it to avoid difficulties in interpretation. In general, we reject the null hypothesis and conclude that no unit root is present for all currencies in the series. Hence, all the series are stationary.

Conditional Volatility Estimation

In this section, the conditional volatility of Bitcoin and Ethereum is estimated to study the volatility clusters and asymmetric response to positive and negative shocks. The reason for not using realised volatility is that conditional volatility is based on the available information set and does not introduce any look-ahead bias, and GARCH-type volatility innovations are stationary, unlike realised volatility, and this enables us to fit the VAR model without specification errors.

We make an assumption that the variances of the log returns of risky assets are heteroscedastic. It is well documented that exchange rates and cryptocurrencies exhibit volatility clustering, i.e. periods of high and low volatility tend to occur in clusters (Borrego Roldán, 2024). Here, it is assumed that negative shocks have a larger impact on volatility than positive shocks, due to behavioural factors such as fear and panic. The model chosen is an Exponential Generalised Autoregressive Conditional Heteroscedastic Model (EGARCH) with parameters p = 1 and q = 1.

We broadly follow the methodology outlined in (Guirguis, 2018):

Let $y_t = \alpha + \varepsilon_t$
where y_t = log returns, α is a constant, and ε_t is an innovation (error) term. $\varepsilon_t = \sigma_t z_t$ where z_t is an independent and identically distributed series of standardised random variables with a Gaussian innovation distribution (MathWorks, n.d.).

The conditional variance becomes:
σ^2 = Var (ε_t, H_{t-1}), where H_{t-1} is the history that includes past variances and past innovations.

The conditional variance equation for EGARCH (p, q) becomes:

$$\ln(\sigma^2_t) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma^2_{t-j}) + \sum_{i=1}^{p} \alpha_i \left| \frac{\epsilon t-i}{\sigma t-i} - E\left(\frac{\epsilon t-i}{\sigma t-i}\right) \right| + \sum_{k=1}^{r} \gamma_k \frac{\epsilon t-k}{\sigma t-k}$$

where σ^2_t is the variance at time t, ω is a constant, ε_{t-i} is the lagged error term for i periods, σ^2_{t-k} is the k-period lagged variance (past conditional volatility). The α term shows the magnitude effects of volatility due to the past shocks, and the β term shows the persistence effects of the past shocks on volatility. The γ term captures leverage effects, i.e. if the volatility responds more strongly to negative shocks than positive shocks.

The variance is expressed in logarithmic form to ensure that it remains positive, without imposing parametric restrictions.

The currency pairs for which the leverage effect term was statistically significant were:
AUD-USD with a coefficient of -0.0319 (negative shock disproportionately impacts volatility) and USD-INR with a coefficient of 0.0324 (positive shock disproportionately impacts volatility)

The EGARCH (1,1) model is fitted to the daily log returns of BTC-USD and ETH-USD. The results are summarised, and the estimated conditional volatilities are plotted as follows:

Table 1: EGARCH model results for BTC-USD

Constant Mean - EGARCH Model Results

Dep. Variable:	BTC_USD	R-squared:	0.000
Mean Model:	Constant Mean	Adj. R-squared:	0.000
Vol Model:	EGARCH	Log-Likelihood:	-5097.99
Distribution:	Normal	AIC:	10206.0
Method:	Maximum Likelihood	BIC:	10233.5
		No. Observations:	1811
Date:	Sun, Dec 28 2025	Df Residuals:	1810
Time:	08:38:56	Df Model:	1

Mean Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
mu	0.0534	0.106	0.506	0.613	[-0.154, 0.260]

Volatility Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	0.4260	0.165	2.580	9.876e-03	[0.102, 0.750]
alpha[1]	0.2721	0.129	2.117	3.428e-02	[2.016e-02, 0.524]
gamma[1]	-0.0970	7.387e-02	-1.314	0.189	[-0.242,4.775e-02]
beta[1]	0.8593	5.101e-02	16.845	1.145e-63	[0.759, 0.959]

Covariance estimator: robust

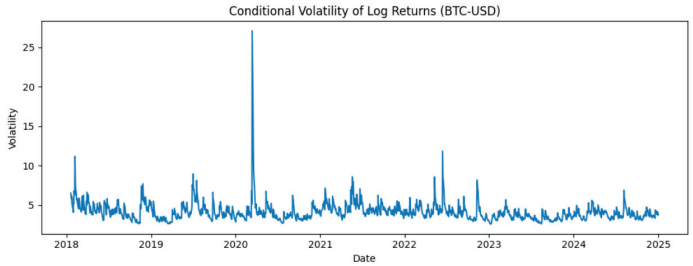


Figure 2: Estimated conditional volatilities for BTC-USD

It is seen that the value of α for BTC-USD is 0.2721 and is 0.8593 (Table 1). This implies that 27.21% of the past shocks influence future volatility, and 85.93% of the past volatility persists in the next period. Hence, volatility persistence decays slowly while the short-term volatility due to unexpected factors is low. Both parameter values are statistically significant as $p < 0.05$

The gamma term captures the leverage effect, and the value is -0.0970. However, it is not statistically significant at the 5% level.

Table 2: EGARCH model results for ETH-USD

Covariance estimator: robust

Constant Mean - EGARCH Model Results

Dep. Variable:	ETH_USD	R-squared:	0.000
Mean Model:	Constant Mean	Adj. R-squared:	0.000
Vol Model:	EGARCH	Log-Likelihood:	-5544.87
Distribution:	Normal	AIC:	11099.7
Method:	Maximum Likelihood	BIC:	11127.2
		No. Observations:	1811
Date:	Sun, Dec 28 2025	Df Residuals:	1810
Time:	08:38:56	Df Model:	1

Mean Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
mu	0.1059	0.108	0.980	0.327	[-0.106, 0.318]

Volatility Model

	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	0.1413	8.806e-02	1.604	0.109	[-3.132e-02, 0.314]
alpha[1]	0.1920	7.319e-02	2.623	8.725e-03	[4.851e-02, 0.335]
gamma[1]	-0.0326	3.930e-02	-0.829	0.407	[-0.110,4.444e-02]
beta[1]	0.9631	2.433e-02	39.588	0.000	[0.915, 1.011]

Covariance estimator: robust

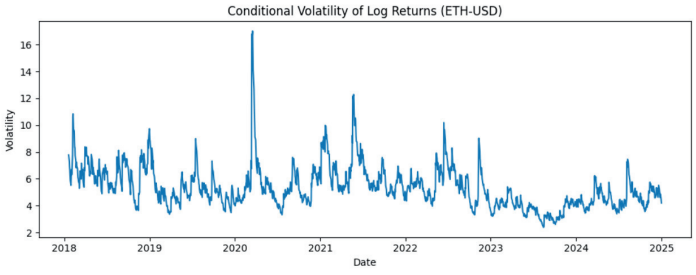


Figure 3: Estimated conditional volatilities for ETH-USD

It is seen that the value of α for ETH-USD is 0.1920 and β is 0.9631 (Table 2). This implies that 19.20% of the past shocks influence future volatility, and 96.31% of the past volatility persists in the next period. Hence, volatility persistence decays slowly while the short-term volatility due to unexpected factors is low. Both parameter values are statistically significant as $p < 0.05$. The leverage effect is -0.0326, which is not statistically significant at the 5% level.

There is noticeable volatility clustering as seen from the above plots, particularly around 2020, the COVID period. Ethereum demonstrated higher volatility than Bitcoin in general, except for 2020, when Bitcoin volatility spiked to a variance of over 25 log units. Bitcoin is much more volatile than Ethereum during periods of financial crisis.

Vector Autoregression (VAR) Estimation

In this section, the Vector Autoregression (VAR) framework is applied to the complete dataset of cryptocurrencies and foreign exchange currencies to capture the interdependencies between the currency pairs as well as potential transmission mechanisms. A vector autoregression (VAR) model is a multivariate time series model containing a system of n equations of n distinct, stationary response variables as linear functions of lagged responses and other terms. VAR models are also characterised by their degree p; each equation in a VAR(p) model contains p lags of all variables in the system (MathWorks, n.d.). The simple VAR model of order p (or lag p) for k equations is represented as:

$$y_t = c + \sum_{j=1}^{p} \Phi_j y_{t-j} + \epsilon_t$$

Where y_t is an n×1 vector of the endogenous variable, c is an nx1 vector of intercept terms, ϕ_j is an nxn coefficient matrix of lag j, and ε_t is an nx1 vector of error terms with zero mean and no autocorrelation.

Hence, the model states that the log returns of each currency depend on the log returns of itself and all other currencies. In this case, we consider n = 8, p = 2 for the log returns model, and n = 8, p = 5 for the volatility model. The estimated coefficients of the impact of the lagged currency pairs on each currency are shown in the appendix.

Log Returns VAR Model

We used a lag order of 2 to fit the VAR model for log returns. The optimal lag is selected using the Akaike Information Criterion (AIC). The statistically significant observed relationships are as follows:

- **Cryptocurrencies:** Both BTC-USD (- 0.505, L1) and ETH-USD (- 0.693, L1) returns are negatively affected by one-period lagged AUD-USD returns. ETH-USD is also negatively affected by two-period lagged USD-INR returns (- 1.193, L2), and this might be an indicator of increasing connectedness to emerging economies.

- **Major Currency Pairs:** AUD-USD has the broadest cross-market influence, positively affecting EUR-USD (0.057, L1) and GBP-USD (0.069, L1) returns with a one-period lag, while negatively impacting USD-CHF (-0.064, L1). EUR-USD displays mean-reversion in its own returns (-0.086, L1) and influences USD-CHF both positively at lag 1 (0.101, L1) and negatively at lag 2 (-0.097, L2), due to a short-run overshooting pattern. GBP-USD is also positively affected by two-period lagged USD-JPY returns (0.065, L2), and USD-JPY itself is driven by lagged USD-CHF (0.129, L1) and AUD-USD (0.058, L2).

- **Insulated Pairs:** AUD-USD and USD-INR show no statistically significant spillover effects from other currencies. While AUD-USD's insulation improves its safe-haven characteristics, USD-INR's insulation is mainly due to its regional nature and lower trading volume. But its statistically significant constant (0.000163) means that there is a positive drift.

The residual correlation matrix shows the correlation between the residuals after taking into account the lagged dynamics captured by the VAR(2) model. The matrix is plotted below.

We consider the residuals as shocks. Hence, the correlation values represent how shocks to each currency are linearly affected by shocks to others.

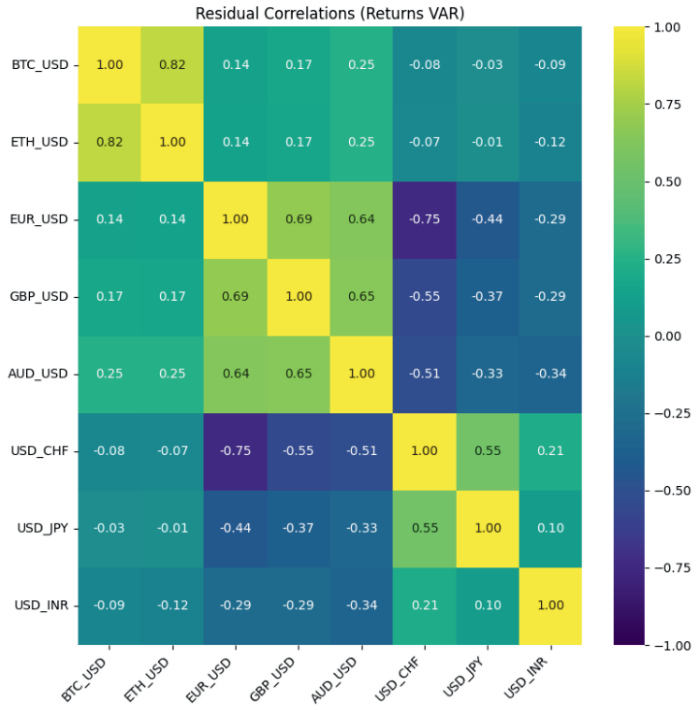


Figure 4: Correlation heatmap of returns VAR residuals

The correlation between the residuals of BTC-USD and ETH-USD is very high at 0.82. This indicates that unexplained returns of cryptocurrencies move strongly with each other, even after accounting for lagged effects. The European currency pairs, GBP-USD, EUR-USD and AUD-USD also have a strong correlation in their residuals at over 0.60. Both BTC-USD and ETH-USD residuals have a correlation of 0.25 with AUD-USD.

In general, USD-JPY and USD-CHF act as a hedge against these currencies, since they exhibit negative correlation with the crypto and European currency pairs. The correlation between the residuals of USD-JPY and USD-CHF is 0.55. USD-INR is also insulated from the crypto and European currencies since there is a weak negative correlation.

Hence, USD-JPY, USD-CHF and USD-INR can act as relatively safe-haven currencies.

Estimated Conditional Volatility VAR Model

We used a lag order of 5 to fit the VAR model for estimated conditional volatilities. The optimal lag is selected using the AIC criterion.

The statistically significant observed relationships are as follows:

- **Cryptocurrencies:** BTC-USD and ETH-USD volatility show strong own-persistence, with lagged coefficients of (0.635, L1) and (0.954, L1) respectively, and positive constants (0.720 and 0.270), indicating structurally high volatility. The two assets show bidirectional spillovers: lagged ETH-USD volatility positively affects BTC-USD (0.153, L1) but negatively at L2 (- 0.226, L2), while lagged BTC-USD positively influences ETH-USD (0.070, L2), implying short-run co-movement that partially reverses. Both cryptocurrencies are also sensitive to USD-JPY volatility, with positive effects at L2 (1.413 and 0.934) and negative effects at L4 (- 2.811 and - 1.305), and this again means delayed overshooting. BTC-USD also faces a negative impact from three-period lagged GBP-USD volatility (- 2.627, L3).

- **Major Currency Pairs:** All major forex pairs exhibit strong own-persistence at one period lag, (EUR-USD: 0.917, GBP-USD: 1.016, AUD-USD: 0.923, USD-CHF: 0.929, USD-JPY: 0.981, USD-INR: 1.003), and this is consistent with near-unit-root volatility. GBP-USD is a major transmitter and positively affects the volatilities of EUR-USD, AUD-USD, and USD-CHF at L1 (0.055, 0.052, 0.073), while its impact on USD-JPY oscillates across lags (- 0.128 at L2, +0.119 at L3). USD-INR exerts a recurring pattern on EUR-USD, AUD-USD, and USD-CHF, with positive effects at L4 and negative effects at L5, and this is implying that there is a shock pattern that mean-reverts within a week.

- **Crypto-to-Forex Spillovers:** Cryptocurrency volatility also transmits to forex markets. BTC-USD positively affects GBP-USD, AUD-USD, and USD-JPY at short lags, with partial reversals at L4 - L5, while ETH-USD has a weak positive effect on EUR-USD (0.005, L3) and GBP-USD (0.008, L3) with reversals at the next lag. BTC-USD also positively impacts USD-INR (0.002, L1), while ETH-USD exerts a small negative effect (- 0.003, L1) on the Indian rupee.

The residual correlation matrix shows the correlation between the residuals after taking into account the lagged dynamics captured by the VAR(5) model. The matrix is plotted below. The correlation between volatility residuals of BTC-USD and ETH-USD is high at 0.82. Besides cryptocurrencies, cross-asset volatility residual correlation is the highest for AUD-USD. The strongest cross-currency spillover is 0.56 between EUR-USD and USD-CHF.

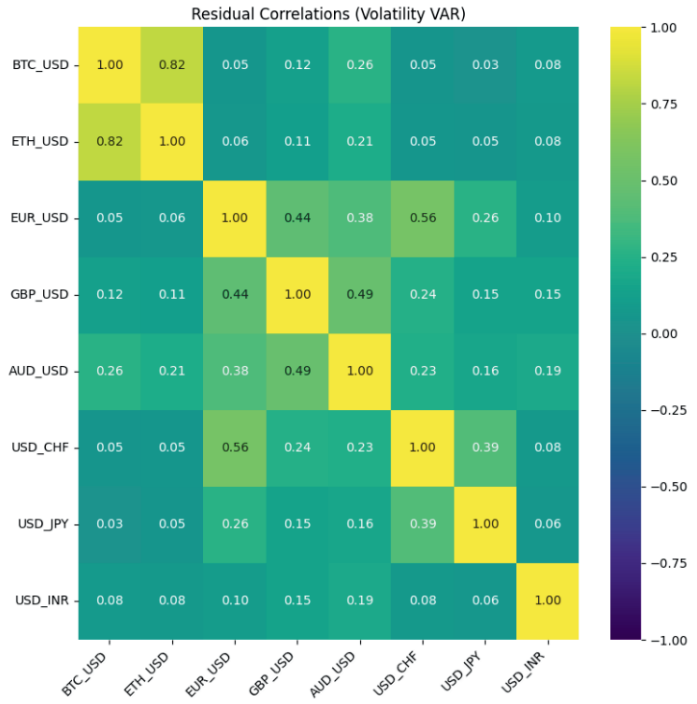


Figure 5: Correlation heatmap of volatility VAR residuals

This proves that contemporaneous correlations exist between the residuals, implying the presence of interactions not fully captured by the VAR(5) model and shock propagation from one market to another. Hence, we proceed with modelling the spillovers using Generalised FEVD following the Diebold–Yilmaz framework instead of the Orthogonalised FEVD.

Generalised FEVD Spillovers

In this section, the Diebold and Yilmaz framework is used to study the direction and magnitude of return and volatility spillovers. The forecast error variance is decomposed into shocks due to the currency pairs under study. The VAR(2) model is used to make forecasts for returns, and the VAR(5) model is used to make forecasts for volatility. If the forecast is made at time n, then it is assumed that no information beyond n is known for the 10-period forecast (Johnston & Dinardo, 1997). Diebold and Yilmaz (2009) postulated the method of generalised forecast error variance

decomposition (FEVD) to study the spillover dynamics. This method works even if the VAR residuals are non-orthogonal, which is the characteristic of this data. We follow the mathematical framework outlined in (Liu et al., 2023). Orthogonalised FEVD requires uncorrelated residuals from VAR estimation since it uses Cholesky decomposition.

We rewrite the VAR(p) model in the Moving Average (MA) form as:

$$y_t = \mu + \sum_{h=0}^{\infty} \psi_h \epsilon_{t-h}$$

where ψ_h is the impulse response coefficient matrix.

The framework uses Pesaran–Shin generalised FEVD, which avoids sensitivity due to variable ordering. The H-step-ahead contribution of shocks in currency j to the forecast error variance of currency i is:

$$\theta^{(H)}_{ij} = \sigma^{-1}_{jj} \sum_{h=0}^{H-1} (e'_i \psi_h \Sigma e_j)^2 / \sum_{h=0}^{H-1} (e'_i \psi_h \Sigma \psi_h' e_i)$$

and it is row-normalised as:

$$\tilde{\theta}^{(H)}_{ij} = \theta^{(H)}_{ij} / \sum_{j=1}^{N} \theta^{(H)}_{ij}$$

where e_i is the selection vector for the ith currency, and σ_{jj} is the innovation variance. In this section, the generalised forecast error variance decomposition (Generalised FEVD) is computed for 10 future steps (H = 10). The rows represent the currencies on which the shocks act, and the columns represent the currencies transmitting the returns shocks. Hence, each cell (i, j) of the matrix depicts the share of the forecast error variance of returns currency i that can be explained by the shocks to the returns of currency j at time horizon H = 10. The Generalised FEVD spillover matrix for the log returns of each currency following the VAR(2) model is denoted in the following table.

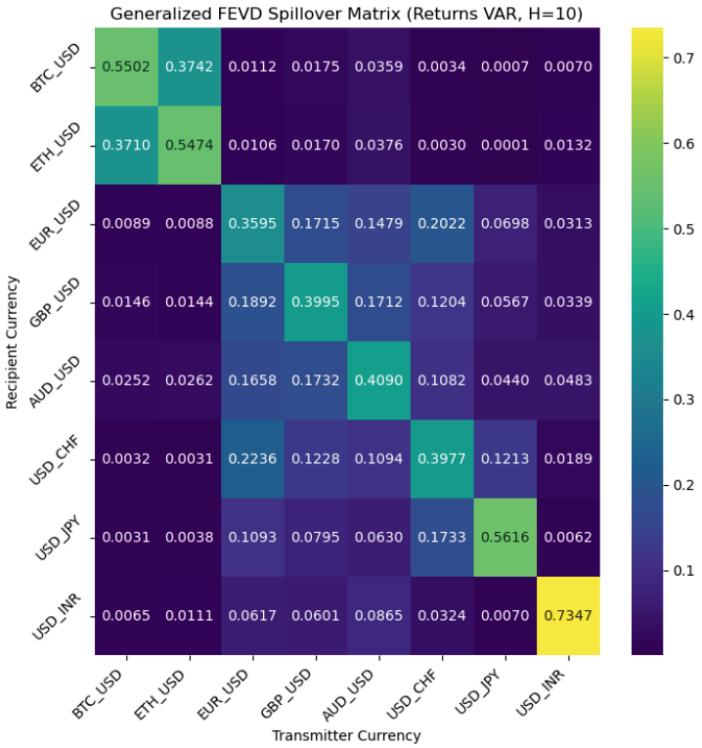


Figure 6: Generalised FEVD Spillover Matrix from Returns VAR (H = 10)

The diagonal elements range from 35.95% to 73.47%. This indicates that between 26% and 64% of the variance is driven by external spillovers. Within the cryptocurrency sector, BTC and ETH exhibit a high degree of mutual connectedness, with each explaining approximately 37% of the other's variance, yet they remain relatively disconnected from the foreign exchange market, where spillovers from crypto to forex stay below 3.8%.

In contrast, G10 currency pairs show deep integration. EUR-USD's own variance is only 35.95%, as it receives substantial shocks from USD-CHF (20.22%) and GBP-USD (17.15%). USD-INR is the most insulated pair with a 73.47% own-variance contribution.

The matrix shows that while crypto and forex markets are segmented from each other, the internal dynamics of the forex market are strongly interconnected.

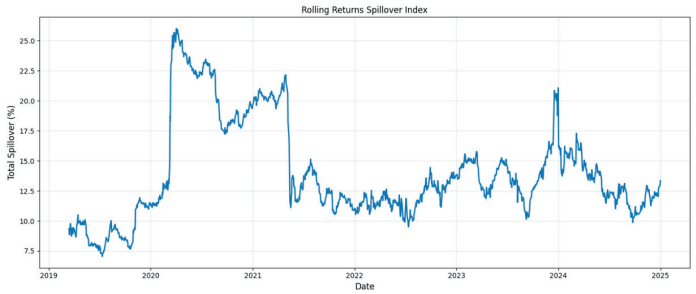


Figure 7: Time series plot of rolling FEVD spillover index of returns

We compute rolling sample estimates of the spillover measures with a window = 300 periods, and it is used to calculate the total spillover index. The Total Spillover Index measures the percentage of total forecast error variance that comes from cross-variable spillovers rather than own shocks (Allen et al., 2017). It is calculated as:

$$S^{g}(H) = \left(\sum_{i \neq j}^{N} \tilde{\theta}^{(H)}_{ij} \Big/ \sum_{i,j=1}^{N} \tilde{\theta}^{(H)}_{ij} \right) * 100\ \%$$

The time series plot of the total returns spillovers shows that return spillovers spiked from 12.5% to over 25% in mid 2020, due to the market instability and financial contagion as a result of the COVID-19 panic, and remained high until early 2021, after which it declined to around 12.5%. It again spiked in 2024, possibly due to the Japanese yen carry trade unwind. The Generalised FEVD spillover matrix for the estimated conditional volatilities of each currency following the VAR(5) model is denoted in the following table.

Volatility is more interconnected than returns. The diagonal elements range from 46.66% to 77.18%. This indicates that between 23% and 53% of a currency's volatility is driven by external shocks, and volatility spillovers are a stronger channel for cross-market interactions than returns spillovers. Notably, the cryptocurrency market acts as a significant transmitter of volatility to foreign exchange markets.

BTC-USD shocks contribute 8.18% to the variance of AUD-USD and 4.72% to GBP-USD, while ETH-USD contributes 6.11% to AUD-USD. Within the cryptocurrencies, BTC and ETH share a high degree of volatility interdependence, with each explaining approximately 36.7% of the other's variance. Meanwhile, major forex pairs exhibit strong internal linkages, such as the reciprocal volatility transmission between EUR-USD and USD-CHF (ranging from 16.39% to 19.45%). USD-INR remains the most insulated pair in the system with 77.18% own-variance, while it is somewhat vulnerable to volatility from major currencies like GBP-USD (6.06%) and AUD-USD (6.02%), its outward volatility transmission remains negligible, peaking at only 1.39% toward AUD-USD.

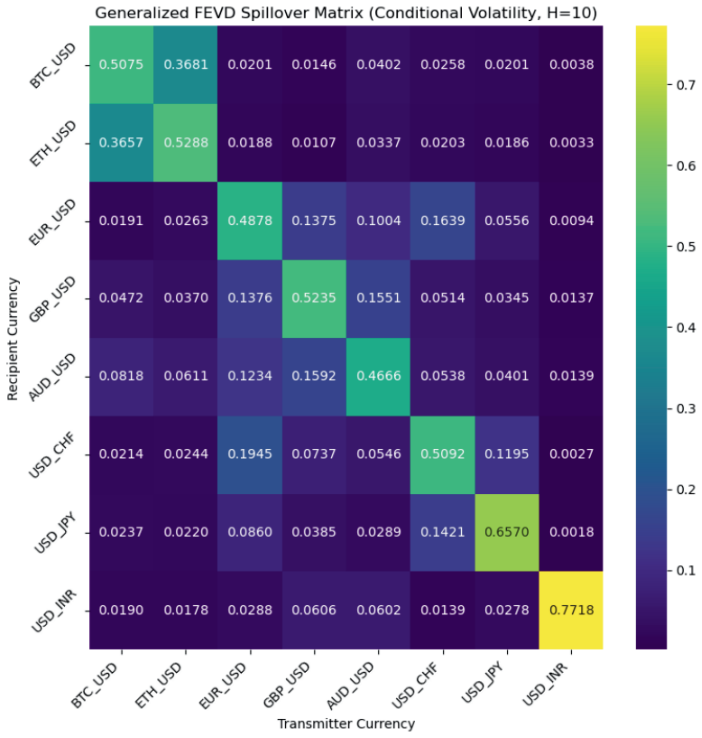


Figure 8: Generalised FEVD Spillover Matrix from Volatility VAR (H = 10)

currencies like GBP-USD (6.06%) and AUD-USD (6.02%), its outward volatility transmission remains negligible, peaking at only 1.39% toward AUD-USD.

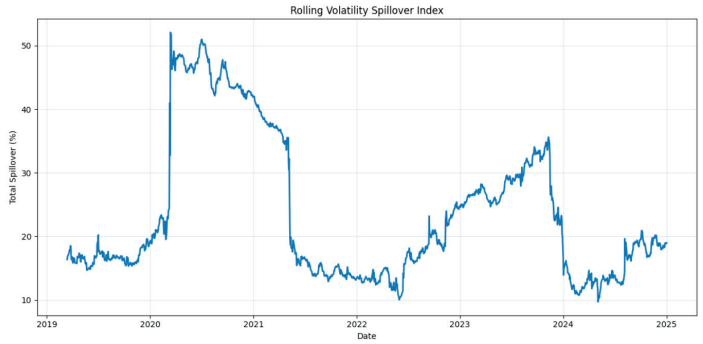


Figure 9: Time series plot of rolling FEVD spillover index of volatility

The total volatility spillover index spiked from around 25% to over 50% in early 2020 due to COVID-19-induced market volatility, after which it gradually decayed and dropped dramatically from 35% to below 20% in early 2021. It remained low at 15% from 2021 to mid 2022, after which it gradually increased to 35% in late 2023, possibly as a result of geopolitical crises and reduced USD confidence. It again declined to around 10% in 2024 and has since been increasing.

Crypto–FX Spillover Vulnerability Index (CSVI)

The FEVD matrix reveals that India is relatively insulated from volatility and returns transmissions from BTC-USD and ETH-USD; however, the magnitude of the reverse spillover is much limited. These spillovers are likely to increase once crypto becomes mainstream in India. In this context, we propose that India (and other emerging economies) should adopt a Crypto–FX Spillover Vulnerability Index (CSVI) that quantifies the degree to which USD-INR volatility is externally induced by cryptocurrency markets, based on risk regimes. It should combine FEVD-based volatility spillovers, EGARCH persistence, and asymmetric downside effects. We propose it as follows:

Let USD-INR be indexed by i, and the cryptocurrencies are $j \in C = \{\text{BTC-USD, ETH-USD}\}$. From the FEVD framework, the H-step ahead forecast error variance of USD-INR explained by crypto volatility shocks is:

$$S^{(H)}_{INR,\,C} = \sum_{j \varepsilon C} \tilde{\theta}^{(H)}_{INR,\,j},$$

Where $\tilde{\theta}^{(H)}_{i,\,j}$ is the row-normalised generalised FEVD element.

We define the persistence-adjusted spillover weight as:

$$P_{INR,\,C} = \sum_{j \varepsilon C} \beta_j \tilde{\theta}^{(H)}_{INR,\,j},$$

where β_j is the GARCH or EGARCH effect term capturing crypto volatility persistence.

Let $r_{j,\,t}$ denote the crypto return at time t. We define a downside shock indicator as: $I_{j,\,t} = 1$ if $r_{j,\,t} < 0$ and $r_{j,\,t} = 0$ if ≥ 0.

Now, let $A_t = \Sigma_j \in C\ |\gamma_j|\ .\ I_{j,\,t}\ .\ \theta^{(H)}_INR,\ j$ be an asymmetric penalty term that activates only when crypto returns are negative.

Hence, $V_t = S^{(H)}_{INR,\,C}[1 + P_{INR,\,C} + A_t]$ and H = 10
It can be normalised using min-max scaling as:
$CSVI_t = (V_t - \min(Vt)) / (\max(V_t) - \min(V_t)) \in [0, 1]$

A high CSVI would imply that INR volatility is being imported from crypto markets, and not being generated by domestic fundamentals. A low CSVI implies insulation, even if crypto markets are turbulent. This can guide policy decisions to ensure market stability.

4. Results and Discussion

- Return spillovers across cryptocurrencies and forex markets are small (below 3.8%), with own-variance shares ranging from 35.95% to 73.47% at a 10-day horizon. In contrast, volatility spillovers are stronger, and this shows the asymmetry in transmission channels where volatility, rather than returns, acts as the primary pipeline of cross-market interaction. BTC and ETH affect 0.65% and 1.11% of USD-INR returns, respectively. We have seen that the total returns reach a maximum of 25%, and total volatility spillovers exceeded 50% in crisis periods.

- BTC-USD and ETH-USD exert moderate influence on forex returns but are found to be statistically and economically significant transmitters of volatility. Bitcoin and Ethereum volatility mainly affect GBP-USD and AUD-USD, hence transmission patterns are asset-specific. BTC and ETH affect 1.9% and 1.8% of USD-INR volatility, respectively.

- EGARCH estimates show high volatility persistence and clustering, particularly during crisis periods such as COVID-19, with limited but asymmetric responses to negative shocks. This indicates that spillovers are state-dependent rather than structural, rising during periods of increased global uncertainty.

- Developed forex markets exhibit stronger intra-group volatility linkages, whereas USD-INR and USD-JPY display insulation from return and volatility shocks. USD-INR absorbs volatility from crypto and major forex markets, but the volatility that is transmitted outward is very little, reflecting asymmetric financial integration. AUD-USD is most affected due to spillovers from USD-INR of 4.83% (returns) and 1.39% (volatility). This may indicate the potential vulnerability faced by Indian markets due to crypto integration.

5. Policy Recommendations

On the basis of our analysis and the results outlined in this paper, some policy recommendations are provided to enhance market resilience, reduce systemic risk, and improve the effectiveness of policy responses to crypto-induced financial shocks. These are as follows:

- Automated Volatility Triggers: Central Banks and Policymakers can use rolling-window FEVD and GARCH-based models to identify regime shifts and reduce the inside lag in policy implementation. When crypto volatility persistence exceeds a threshold, they can temporarily widen forex bid-ask spreads or impose brief trading halts in vulnerable currency pairs.

- Spillover-Weighted Capital Buffers: Central banks should set up spillover-weighted capital buffers for banks and financial institutions whose balance sheets show significant exposure to foreign exchange instruments that are net volatility receivers from crypto markets. When the spillovers exceed a threshold, it will automatically impose higher capital buffers on banks exposed to currencies such as AUD-USD, EUR-USD, and GBP-USD.

- Asymmetric Intervention for Safe-Haven Currencies: Policymakers should formulate

detailed regulations for effective monitoring of relative safe-haven currencies to ensure stability. For currencies such as USD-JPY, USD-INR, central banks should adopt asymmetric intervention rules that allow appreciation driven by adverse crypto shocks but counter excessive depreciation, which may occur due to excessive downward volatility from negative shocks.

- Crypto–FX Spillover Vulnerability Index: All emerging markets exposed to cryptocurrencies at both the retail and institutional levels should formulate a Crypto-FX-Spillover Vulnerability Index (as proposed in this paper), and it should be regularly monitored to detect warning signs of asymmetric structural vulnerability. Thresholds can be calculated on a rolling basis depending on market regimes.

- Spillover Adjusted Trading: Traders should use spillover metrics as part of their risk management to control position sizing, leverage, and hedging strategies. When crypto volatility persistence or spillover intensity crosses a certain rolling threshold, trading systems should automatically reduce leverage, widen stop-loss bands, and increase hedge ratios using options.

6. Conclusion

Cryptocurrencies have achieved remarkable scale and adoption, and now exert considerable influence on foreign exchange market volatility despite limited impact on returns. The strengthening volatility spillover dynamics, according to our analysis, show that crypto markets have transitioned from speculative assets having apparently no ‘intrinsic value’ to getting closely integrated with traditional finance. The spikes in spillovers during market uncertainty emphasise the need for more effective risk management. Apart from the policy recommendations that we have outlined in this paper, the most important challenge that policymakers, researchers, and blockchain developers have to face is designing suitable regulations that are in tune with the continuous evolution of cryptocurrency markets. As digital assets continue reshaping global finance, the spillover dynamics that have been documented in this paper represent not endpoints but waypoints in a longer transformation whose trajectory will be determined by technological innovation, regulations, market forces, and the widespread adoption of DeFi as an alternative transactions mechanism.

We suggest that future research may extend our analysis by using higher-frequency data, other crypto assets such as stablecoins and altcoins, or models that jointly estimate conditional correlations. Such work can help us to gain a deeper understanding of the linkages between cryptocurrency and foreign exchange markets.

Appendix

Table 3: Descriptive Statistics of Daily Log Returns

	BTC_USD	ETH_USD	EUR_USD	GBP_USD	AUD_USD	USD_CHF	USD_JPY	USD_INR
count	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000
mean	0.001176	0.000674	-0.000092	-0.000058	-0.000141	-0.000031	0.000191	0.000162
std	0.042224	0.055325	0.004446	0.005571	0.006348	0.004514	0.005452	0.003153
min	-0.497278	-0.592454	-0.020646	-0.036939	-0.039319	-0.028053	-0.038578	-0.019648
25%	-0.016473	-0.022688	-0.002656	-0.003241	-0.003900	-0.002629	-0.002347	-0.001372
50%	0.000745	0.000535	0.000000	0.000000	0.000000	0.000108	0.000276	0.000084
75%	0.019641	0.025641	0.002553	0.003087	0.003589	0.002629	0.002943	0.001572
max	0.200785	0.358245	0.021207	0.030953	0.028668	0.020575	0.031642	0.023156

Table 4: Descriptive Statistics of Estimated Conditional Volatilities

	BTC_USD	ETH_USD	EUR_USD	GBP_USD	AUD_USD	USD_CHF	USD_JPY	USD_INR
count	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000	1811.000000
mean	4.154693	5.367193	0.433040	0.530374	0.616651	0.442871	0.512618	0.297754
std	1.215930	1.575260	0.094913	0.135434	0.141457	0.077827	0.172303	0.117342
min	2.607822	2.377151	0.263164	0.322535	0.374160	0.276884	0.251373	0.079666
25%	3.478800	4.280558	0.364446	0.446813	0.533580	0.388503	0.382793	0.217663
50%	3.937201	5.137291	0.424599	0.499271	0.588714	0.431463	0.454827	0.295967
75%	4.516338	6.188929	0.481002	0.572424	0.661626	0.480738	0.606310	0.374259
max	27.090080	17.010936	0.849492	1.272250	1.283877	0.908837	1.380613	0.661246

Table 5: ADF Test Results for Daily Log Returns

Currency	Test Statistic	p-value
BTC	-18.8989	0.0000
ETH	-28.9826	0.0000
EUR	-19.1251	0.0000
GBP	-17.7965	0.0000
AUD	-42.3654	0.0000
CHF	-40.6456	0.0000
JPY	-43.0354	0.0000
INR	-16.6188	0.0000

Table 6: ADF Test Results for Estimated Conditional Volatilities

Currency	Test Statistic	p-value
BTC	-11.9151	0.0000
ETH	-6.2170	0.0000
EUR	-3.8198	0.0027
GBP	-4.4300	0.0003
AUD	-3.7074	0.0040
CHF	-7.1075	0.0000
JPY	-4.8672	0.0000
INR	-2.5594	0.1017

Replication Package:

https://github.com/Souradeep-Bhattacharya-2005/Structural-Interlinkages-Between-Cryptocurrencies-and-Foreign-Exchange.git

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Globalisation, Institutions and Economic Prosperity: A Comparative Analysis of Japan, South Korea and India

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ABSTRACT

The effects of globalisation have varied considerably among the many countries that have adopted it. Various theories have tried to explain such divergence in results. In this paper, we draw upon the framework established by Acemoglu and Robinson in Why Nations Fail, and examine the intricate relationship between globalisation and institutional quality. Furthermore, we aim to illustrate that the institutional quality of a country remarkably influences the effects of globalisation on it. We also put forward the Institutional Saturation Theory, arguing that there are diminishing marginal returns to increasing institutional quality and that high levels of it can lead to rigidity and stagnation in the economy. For our research, we considered case studies of three countries with different levels of institutional quality: Japan, South Korea and India. While Japan suffers from institutional inertia with negligible gains from globalisation, South Korea occupies an adaptive 'sweet spot' with positive interaction effects. India, on the other hand, faces significant negative spillovers from globalisation due to weaker institutions. The paper concludes that the optimal institutional quality–globalisation combinations may vary by the countries' contexts. For example, Japan built its institutions over a long period, which allowed for minute fine-tuning but restricted its adaptability. We demonstrate that institutions can both enhance and constrain the benefits of globalisation, and optimised policies may help sustain economic prosperity in a globalised world.

Keywords: institutions, globalisation, economic prosperity, economic freedom, integration

JEL Classification: D02, E02, F15, F62, F63, O43

1. Introduction

Since the 1980s, globalisation has been considered an enabling force for developing countries to achieve economic growth and reach world standards. International organisations like the World Bank and International Monetary Fund (IMF) have been prioritising market-oriented reforms and opening up countries as a prerequisite for financial assistance. This approach, which emerged in the 1980s and was primarily influenced by neoliberal economic thinking, is known as the Washington Consensus. However, exposing various countries to globalisation has led to varying results, wherein some have grown substantially while others have faced significant economic degradation.

Most notably, the East Asian Tigers (Hong Kong, Singapore, South Korea, and Taiwan) experienced the largest growth from globalisation, with South Korea experiencing per capita income increases of over 600% (FRED). On the other hand, Latin American countries

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have not been able to reap the benefits of globalisation. Per Capita GDP in Latin American countries fell from 112% to 98% of the world average during the 1980s (Ocampo, J.A. (2014)).

This paper seeks to explain these differences in the effects of globalisation by utilising the framework of institutions as developed by James A. Robinson and Daron Acemoglu in their book Why Nations Fail (2012).

We demonstrate that the institutions within a country influence the effects of globalisation on it. A country with inclusive domestic institutions would be able to benefit from globalisation. On the other hand, a country with extractive domestic institutions would be hurt by globalisation, i.e. the negative effects of such institutions can be exacerbated on economic prosperity. We use three case studies of India, South Korea and Japan to show the varying effects of globalisation on growth.

Through our analysis, we are also able to demonstrate that returns accruing from increases in institutional quality are diminishing in nature; i.e., countries with mature institutions (such as Japan) experience institutional saturation effects.

It can help establish that optimal globalisation-institutional quality combinations exist and institutions create non-linear effects of globalisation on economic prosperity.

2. Literature Review

Institutions and Economic Development

The importance of effective institutions in encouraging economic progress has been recorded ever since the origin of Economics. The importance of well-developed Property Rights has often been seen as a prerequisite for the functioning of any modern economy (Smith, 1776), and such studies continue even now, focusing more on risk evaluation when it comes to investments varying based on effective property rights (Knack, Keefer, 1995).

Alongside the restraint in the power of government institutions to produce wider material and economic benefits through said institutions (Montesquieu, 1748), and the further importance of institutions, through the control of corruption, and greater overall effectiveness of said institutions (Mauro, 1995) in fostering greater economic development, has also been analysed keenly.

Theory has often focused on “social infrastructure” (Hall & Jones, 1999), focusing primarily on how effectively a government might prevent private actors from “distractions” such as thievery, corruption, organised crime and such, which reduce the productivity of an economy.

Further, in the debate between the importance of human capital versus that of effective government institutions, previous literature has pointed out the greater consistency of the role of institutions relative to human capital, when measuring the effect of institutions on the accumulation of human capital itself (Acemoglu et al, 2014). Alongside, empirical research conducted has also confirmed the significant role of economic institutions in guiding long-term economic growth (Acemoglu et al, 2004). The role of “inclusive institutions” (Acemoglu & Robinson, 2012) has also been stressed.

The effectiveness of government institutions, in particular, has been measured in multi-dimensional and significantly partitioned indexes, referred to as the "Worldwide Governance Indicators" (Kaufmann et al, 2011). This empirical data has been used reliably to analyse the role of institutions in fostering economic growth (Lopes et al, 2023), as well as for widespread, extensive research on the differences between countries and their levels of economic development (Azimi, 2022).

The diminishing marginal returns as investment into institutions grows have also been observed, particularly for financial institutions (Sahay et al, 2015), which have often acted as a deterrent to economic development at a point of over-maturity.

Globalisation and Economic Development

Differences in the permeation of such benefits have been observed by previous literature (Were, 2015), with a particular emphasis on Least Developed Countries (LDCs) often seeing a reduced benefit of globalisation, compared to countries at the middle level of development. However, research and theory still indicate the heavy impact Globalisation has had on economic progress and development overall across the globe (Lang & Tavares, 2023).

Literature thus points to the continued importance of Globalisation as an important step towards greater economic growth.

Institutions, Globalisation, and Economic Development

The role of institutions in moderating and enhancing the effects of globalisation on economic growth and development has received scant attention from researchers.

Research has often pointed out the relationship between financial institutions and their robustness, and the effects of globalisation on economic growth (Moshirian, 2008), but institutions as a moderating force on globalisation have received little interest as a concept. It has been noted, however, that the effectiveness of globalisation in improving economic growth has been higher in those countries with a higher level of effective governance (Hammudeh et al, 2020).

This points out the greater need for empirical research on this topic, to further and deeply analyse the role of effective governance in the furthering of the benefits of globalisation.

3. Theoretical Framework

Institutions

In the book 'Why Nations Fail' (Acemoglu & Robinson, 2012), institutions are defined as "official and unofficial rules that govern society, influencing individuals to comply with these rules".

Douglass North defines institutions as rules of the game in a society, i.e. formal rules, informal constraints, and their enforcement mechanisms, that shape human interaction and determine incentives. (North, D. C. (1990)).

In 'Why Nations Fail', the authors refer to strong or "inclusive" economic institutions that safeguard the property rights of various sections of society (not just the elite), do not permit arbitrary confiscation or non-consensual alienation of property, and allow everyone to actively participate in economic relations

(Acemoglu & Robinson, 2012). For example, through patents for innovations, everyone is provided an equal ground to partake in economic relations.

On the other hand, "extractive institutions" (Acemoglu & Robinson, 2012) prevent much of the populace from sharing the distribution of income resulting from their own activities. These institutions create barriers to entry, which allows political elites to collect rents while discouraging/restricting broad-based participation. The elite are allowed to isolate and confiscate the properties of the non-elite. For example, the system of slavery permeated society in the southern United States before the Civil War.

Inclusive institutions align the private returns of an individual with the social returns. Extractive institutions sever this link, making rent-seeking or expropriation more profitable than actual production. Furthermore, Acemoglu and Robinson emphasise that long-term prosperity is encouraged by inclusive political institutions that permit most of society to participate in the country's governance and make decisions that benefit the majority.

These institutions are the foundation of modern democratic governments, and it is important to note that these institutions can exist even if democracy itself does not.

Extractive institutions endure only in the presence of oppressive political institutions that empower a narrow stratum of society and forbid the majority of the population from participating in the governance of the country. Examples are absolute monarchies and authoritarian regimes.

It is also important to note that extractive institutions can exist even in the presence of democracies with constitutions and elections. This can be explored when we look at corruption and bribery, which act as a "tax on capital accumulation", whether physical, financial or human (Shleifer & Vishny, 1993; Mauro, 1995).

However, extractive institutions can also lead to rapid, albeit temporary growth, provided there is high political centralisation. This can be achieved by explicitly allocating resources from low-productivity sectors (e.g. agriculture) to high-productivity sectors (e.g. manufacturing). The USSR adopted a similar approach. But in these economies, the growth is soon curtailed due to a lack of creative destruction.

Globalisation

Globalisation can be defined as the increasing interdependence and integration among the economies, markets, societies, and cultures of different countries worldwide, accelerated by the reduction of barriers to international trade, liberalisation of capital movements, development of transportation, and the advancement of information and communication technologies.

It facilitates the interconnectedness of national economies, easing the movement of goods, services, capital, people, and ideas across borders, which creates opportunities for new avenues and greater competition.

As discussed in prior literature, Globalisation plays a very important role in promoting economic growth for countries. Increased volume of trade, greater possibilities of comparative advantages, and effective integration into global supply chains all these factors provide a great boost to any economy.

Thus, Globalisation is a key factor in promoting economic growth and development. However, by itself, it may not be enough to create and sustain economic growth or prosperity, and the domestic institutions of a country may influence its impacts.

Institutions X Globalisation

As mentioned earlier, inclusive institutions (both political and economic) lead to the creation of secure property rights, broad-based participation, optimal centralisation, and effective governance. Robust contract enforcement and impartial dispute resolution mechanisms significantly reduce risk premiums, thereby accelerating Foreign Direct Investment (FDI) inflows. An effective government can promote national industries to create a viable export sector and foster a robust environment for foreign investors to park capital in the country.

These factors can not only help assure investors and foreign Multi-National Companies to invest in the domestic country, but also facilitate positive macroeconomic spillovers, generating a multiplier effect that stimulates aggregate demand and domestic capital formation. An increased consumption can encourage other entities to invest in the country, and the process continues. This positive feedback loop helps capture the major benefits presented by globalisation.

Cohen and Levinthal (1989, 1990) define absorptive capacity as a firm's ability to leverage external knowledge. However, on a nationwide scale, it can indicate a country's ability to recognise, assimilate, and effectively utilise external knowledge, technology, and innovations to drive economic growth and development. In the presence of inclusive institutions, a country's firms can have higher absorptive capacity, enabling them to effectively assimilate and innovate on foreign knowledge through globalisation, resulting in economic growth and development.

On the contrary, extractive institutions lead to insecure property rights, narrow participation, and excessive or inadequate political centralisation. Insecure property rights can scare away investors and foreign companies from investing in the country. The presence of extractive institutions may lead to excessive elite capture and rent-seeking behaviour. In countries with a weaker rule of law, FDI flows concentrate in extractive industries (like mining or oil) rather than manufacturing. It creates an enclave economy, where foreign entities and local elites extract wealth without creating positive spillovers (like infrastructure or jobs) for the broader domestic economy.

It can stifle innovation and lead to a higher concentration of wealth among the elite, further reducing economic and political rights. To protest against such economic and political conditions, people may choose violent protests. Such conditions can further enhance capital flight.

When elites extract wealth via globalisation in a weak institutional environment, they rarely reinvest it domestically due to the lack of secure property rights. In most cases, extractive institutions condemn a country to the lowest, least profitable rungs of the global supply chain (e.g., raw material exporting), making them highly vulnerable to global commodity price shocks. Such shocks amplify negative spillovers for the broader economy, and the cycle continues.

Thus, the quality of institutions can significantly influence the effect of globalisation on a country.

Institutional Saturation Theory

Previous literature has already observed a diminishing return to investment in financial institutions with respect to economic growth.

We seek to establish that the returns to globalisation from an increase in institutional quality are diminishing in nature, i.e., the benefits of globalisation from better institutions are non-linear.

The Law of Diminishing Marginal Returns is a widely accepted theorem in Economics, according to which, as the quantity of any input is increased in any activity of production, holding the level of all other inputs as given, the marginal benefits gained from that input's greater usage will eventually begin to decline.
In this case, we shall see a situation where

MPI $= \partial Y/\partial I > 0$, but $\partial^2 Y/\partial I^2 < 0$ is observed.

In his 1982 book, 'The Rise and Fall of Nations', Mancur Olson explored this idea through the concept of institutional sclerosis. He stated that due to long-term political stability and continued improvement of institutions, these societies gradually accumulate dense networks of regulations and special interest groups such as trade unions, industry associations and other lobbying blocs that form to protect their economic rents. This accumulation reduces a society's ability to adapt to technological and economic changes, stifles innovation, and slows growth.

Transaction costs (The nature of the firm (1937)) can help us understand the various institutional development stages that countries undergo. These costs refer to the coordination costs, i.e. every exchange, decision, or collaboration requires effort, including finding information, negotiating terms, monitoring performance, and enforcing agreements. However, Coase defined these for the operation of a firm.

Douglass North extended this idea to include all political, economic, and social interactions, asserting that institutions exist to manage these costs (North, D. C., 1990). In this context, transaction costs arise primarily from specifying, enforcing, and trading property rights, i.e. costs from imperfect and asymmetric information.

Based on this, we can create a model:

$$E(I) = P - T(I) - G(I)$$

where E is efficiency, P is baseline production, T(I) represents societal transaction costs (which fall as institutions I improve), and G(I) represents governance/bureaucratic costs (which rise as institutions expand)

This model gives us three situations:

1. **Institutional Deficit**: High market failure costs, low governance costs. In this phase, the marginal reduction in transaction costs drastically outweighs the marginal cost of governance ($-T'(I) >> G'(I)$)
2. **Optimal institutions**: Minimised total costs (market failures + governance). This is the equilibrium point where the marginal benefit of reduced market friction perfectly equals the marginal cost of maintaining the bureaucracy ($-T'(I) = G'(I)$)
3. **Hyper Maturity**: Low market failure costs, high governance costs. Here, the governance costs (red tape, compliance, regulatory capture) outweigh any minor improvements in market efficiency ($-T'(I) < G'(I)$)

4. Methodology

We are using the following pooled regression model of our creation:

$$\log_e(GDP_Per_Capita_PPP) = \alpha + \beta_1^{(1)}K + \beta_1^{(2)}D1{:}\ K + \beta_1^{(3)}D2{:}\ K + \beta_2^{(1)}Ins_Q + \beta_2^{(2)}\ D1{:}\ Ins_Q + \beta_2^{(3)}D2{:}\ Ins_Q + \beta_3^{(1)}K{:}\ Ins_Q + \beta_3^{(2)}D1{:}\ K{:}\ Ins_Q + \beta_3^{(3)}\ D2{:}\ K{:}\ Ins_Q + Year$$

Here, $\log_e$(GDP_Per_Capita_PPP) is the dependent variable. We have considered GDP per capita, PPP (constant 2021 international $), as provided by the World Bank for the years 2009-2022. This measure has been taken to reflect the living standards of individual persons across countries. This measure also helps us mitigate against inflation-led growth in GDP Per Capita.

Taking log helps us adjust for the absolute differences in GDP Per Capita across the three countries, so that data from countries with high GDP Per Capita do not unduly influence the coefficients. Furthermore, using a log transformation, we attempt to mitigate heteroscedasticity.

K represents the numerical value of the KOF Globalisation Index (de facto), as provided by the KOF Swiss Economic Institute, ETH Zurich, which serves as a measure of globalisation across countries. This index includes measurements of trade globalisation (de facto) and financial globalisation (de facto) through variables such as Trade in Goods, Trade in Services, Foreign direct investment, and international income payments.

Ins_Q represents a composite Institutional Index that has been constructed by utilising five World Bank Worldwide Governance Indicators (WGIs):

- Control of Corruption: Estimate
- Government Effectiveness: Estimate
- Political Stability and Absence of Violence/Terrorism: Estimate
- Regulatory Quality: Estimate
- Rule of Law: Estimate

The index is given as:

0.30*(Rule of Law) + 0.25*(Government Effectiveness) + 0.20*(Control of Corruption) + 0.15*(Political Stability) + 0.10*(Regulatory Quality)

Rule of Law has been given the highest weightage because, without an established and effective respect for the rules and policies of the government, all other values provide little direct benefit. It also incorporates significant parameters advocated by Acemoglu and Robinson for evaluating an institution.

Government Effectiveness has been provided the second-highest weightage because not only does it measure the independence of civil services from political pressures, but also the quality of implementation of policies. This is important because centralisation is a key prerequisite for good institutions.

This is followed by control of corruption. Corruption can be considered a medium through which the state can be "captured" by elites and private interests, eroding the institutions of a country. This index is vital. Since good institutions ensure that the centralised figure (for example, the Prime Minister of India) has limited authority at his disposal, it is less likely that people will undertake violent measures to assume his/her position, as contenders have less to gain. Thus, we have included the index of political stability as well.

Regulatory Quality measures the government's ability to permit and promote private sector development. Private Sector (through creative destruction) serves to replace/modify the people in power, and thus may act as a balancing factor.

The index considers the numerical value of the WGIs and not annual changes in value.

To test the robustness of the findings to the construction of the Institutional Quality index, the model was rerun using an equi-weighted index. The coefficients from the primary model were found to be within the 95% confidence interval of the new model, suggesting that the results are not overly sensitive to the initial weighting scheme.

K: Ins_Q represents the interaction between globalisation (KOF Index) and institutional quality (index) of a country. This term reveals how the impact of global integration is modulated by institutional quality.

D1 and D2 are the two dummy variables that we have used for this pooled regression model. They can take the values of 1 and 0.

Since we aim to compute the coefficients for three countries, we have assumed three different conditions for India (D1 = 0, D2 = 0), South Korea (D1 = 0, D2 = 1), and Japan (D1 = 1, D2 = 0). Thus, India (with the worst institutions) has been considered the baseline for the model, with Japan and South Korea showing additional effects above those of India.

For example, the coefficient for India's interaction effect (K: Ins_Q) is given by β3(1) (D1 = 0, D2 = 0).

The coefficient for Japan's interaction effect, however, is given by β3(1) + β3(2). This is because the additional effects applicable for Japan are captured by β3(2), i.e. the coefficient of D1: K: Ins_Q (which is considered only when D1 = 1).

Similarly, the coefficient for South Korea's interaction effect is given by β3(1) + β3(3), where the additional effects for South Korea are captured by β3(3), i.e. the coefficient of D2: K: Ins_Q (which is considered only when D2 = 1). The total coefficients for Japan and South Korea are also calculated as detailed above.

Thus,

β_1: Effect of Globalisation holding Institutions and all other factors constant (ceteris paribus)

β_2: Effect of Institutions holding Globalisation and all other factors constant (ceteris paribus)

β_3: Rate at which institutional quality modifies globalisation benefits (interaction effect)

(The superscript would indicate the country)

The variable Year is a control variable meant to account for the increases in GDP Per Capita PPP over time.

```
Call:
lm(formula = log(GDP_Per_Capita) ~ K + D1:K + D2:K + Ins_Q + 
    D1:Ins_Q + D2:Ins_Q + K:Ins_Q + D1:K:Ins_Q + D2:K:Ins_Q + 
    Year, data = Data_0)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.087180 -0.008473 -0.000661  0.019360  0.041554 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -15.311558   4.342773  -3.526  0.00134 ** 
K            -0.040574   0.016859  -2.407  0.02225 *  
Ins_Q        19.963443   3.523431   5.666 3.18e-06 ***
Year          0.013254   0.002156   6.147 8.07e-07 ***
K:D1          0.035839   0.004635   7.732 1.01e-08 ***
K:D2          0.030164   0.003725   8.098 3.82e-09 ***
D1:Ins_Q    -21.073985   4.162991  -5.062 1.80e-05 ***
D2:Ins_Q    -22.927364   4.592348  -4.993 2.19e-05 ***
K:Ins_Q      -0.328505   0.059870  -5.487 5.31e-06 ***
K:D1:Ins_Q    0.340422   0.069277   4.914 2.75e-05 ***
K:D2:Ins_Q    0.368831   0.073911   4.990 2.21e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02586 on 31 degrees of freedom
Multiple R-squared:  0.9994,    Adjusted R-squared:  0.9992 
F-statistic:  5046 on 10 and 31 DF,  p-value: < 2.2e-16
```

Figure 1: R Console Output for Pooled OLS Regression

5. Case Study Analysis

In this section, we explore how each of the three countries in our analysis, Japan, South Korea and India, embarked on their journey of institutional development and economic prosperity and where they are now.

Out of the three countries, Japan was the earliest to start institutional development and unleash its powerful growth potential. Japan can be considered a precursor and inspiration to the Asian Tigers, like South Korea.

South Korea grew rapidly in the late 1980s following a model similar to Japan's state-led industrialisation and improvement of institutions. Although South Korea's institutions may have been in a better initial position because of the USA's influence on its functional economy.

Unlike Japan and South Korea, India, however, failed to utilise the state-led industrialisation model and only experienced rapid economic growth after its liberalisation in 1991. Nevertheless, it has been unable to sustain such high growth, which may be due to its poor institutions.

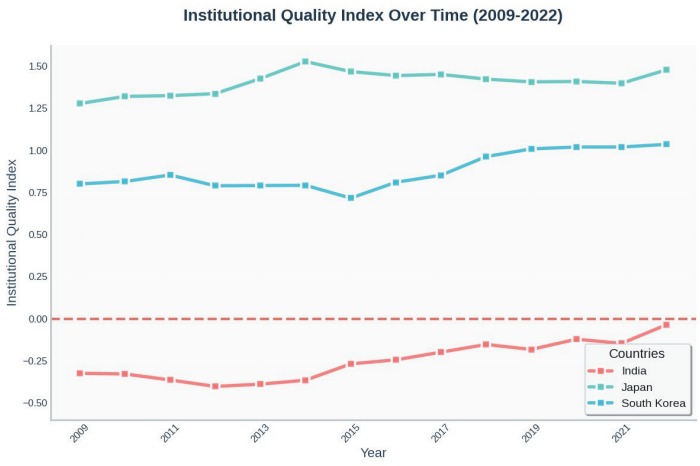


Figure 2: Institutional Quality Index for Japan, South Korea, and India for 2009-22

Source: World Bank Worldwide Governance Indicators

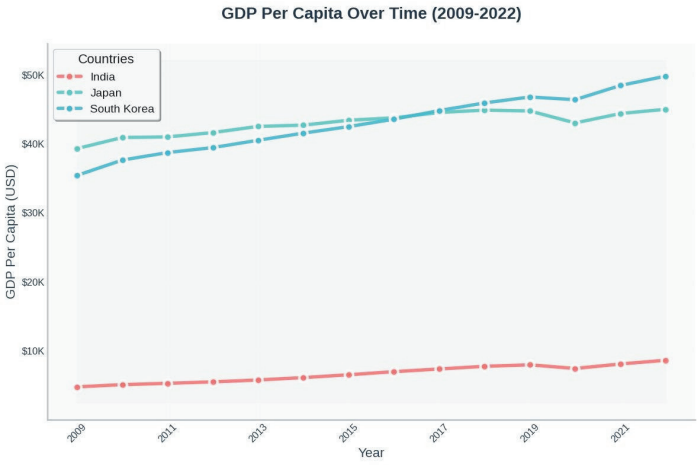


Figure 3: Real GDP Per Capita PPP for Japan, South Korea, and India

Source: World Bank

Japan: Gradual Optimisation Leading to Contemporary Rigidity

1. Historical Institutional Development (1960s-2009)

Japan's path of institutional development commenced in the 1960s with the formulation of elaborate industrial policies and the establishment of mechanisms of economic planning. The establishment of highly powerful bureaucratic institutions such as MITI (Ministry of International Trade and Industry) enabled government-business sector collaboration, resulting in Japan's 'miraculous' economic growth during the 1980s. Key changes in the government of Japan include administrative reforms undertaken during the 1990s, resulting in the amalgamation of ministries and the establishment of independent regulatory bodies. Japan succeeded in developing highly refined institutions that were optimised for manufacturing excellence and consensus-based decision-making. However, the optimisation process that led to Japan's high growth may have inadvertently restricted the flexibility of institutions to respond to a dynamic global environment.

2. Economic Performance and Institutional Constraints (2009-2022)

The economic model chosen by Japan during this period is an ideal example of the problems of institutional maturity. Japan has demonstrated an impressive ability to cope with the cumulative effects of the 2008 financial crisis, the 2011 earthquake, tsunami, and the COVID-19 pandemic.

The institutional framework of Japan, which provides stability, has also impeded the process of digitalisation and innovation in new sectors. The process of optimisation of traditional models has made it difficult for the country to adapt to the platform economies, as evidenced by the low productivity growth in the service sector.

South Korea: Rapid Institutional Development and Adaptive Capacity

1. Institutional Transformation Journey (1980s-2009)

The development of institutions in South Korea took a dramatic leap in the 1980s as the country moved from a military regime to a democratic government and adopted open market policies. The country gradually developed its domestic institutions and industries before moving towards open markets.

The Asian Financial Crisis of 1997 marked a turning point in the development of institutions in South Korea. The country undertook radical structural adjustments in its corporate governance, financial sector reforms, labour market flexibility, and regulatory systems. The country introduced new and independent regulatory systems and strengthened transparency and competition policies.

2. Economic Transformation (2009-2022)

In the wake of the 2008 global recession, South Korea has accelerated its institutional adaptation through green growth strategies, innovation-based policies, and digital government transformation.

The economic history of South Korea represents a case where compressed institutional development has offered opportunities as well as challenges. South Korea has demonstrated impressive potential for economic recovery from the 2008 global financial crisis through its export-based manufacturing, innovation, and rapid globalisation.

The rapidity with which South Korea has developed its institutions has resulted in flexibility, along with overlapping roles, complex regulations, and coordination challenges. The rapidly developed institutions and flexibility have helped South Korea respond rapidly to global challenges and capitalise on globalisation.

India: Foundation Building Since Economic Liberalisation

1. Institutional Evolution Since 1991

The institutional development process in India started its most relevant phase in 1991, when the economic liberalisation process began. This signified the transition from the license-permit raj, which had prevailed in the country since its independence. The removal of licensing, trade restrictions, and the opening up of sectors of the economy to private participation indicate the institutional improvements in the Indian economy.

The significant institutional changes in the Indian economy since 1991 are: the creation of independent regulatory bodies like SEBI (Securities Exchange Board of India) for capital markets, TRAI (Telecom Regulatory Authority of India) for telecommunications, etc.

2. Growth Trajectory and Structural Challenges (2009-2022)

The latest institutional strengthening measures include the Insolvency and Bankruptcy Code (2016), which introduced time-bound resolution mechanisms for corporate debt restructuring; Digital India, which focuses on e-governance; and the JAM Trinity (Jan Dhan-Aadhaar-Mobile), which provides digital infrastructure support. Labour laws and agricultural markets are examples of ongoing institutional modernisation.

While India has experienced a phenomenal improvement in its per capita income during this period, its institutional weaknesses have constrained its potential. The institutional weaknesses in governance effectiveness, regulatory standards, rule of law, and infrastructure development are large bottlenecks.

Some sectors that have stronger institutional foundations, such as information technology, pharmaceuticals, and manufacturing, are now globally competitive. In contrast, sectors that require complex regulatory clearances and high government interactions are challenged.

This institutional divide has resulted in a dual economy where creative destruction is low in India.

The econometric coefficients for each of the countries are now compared:

Table 1: Summary of Econometric Coefficients by Country

Country	K (KOF Globalisation Index)	Ins_Q (Institutional Quality)	K × Ins_Q (Interaction Variable)
Japan	-0.004735	-1.110542	0.011917
South Korea	-0.01041	-2.963921	0.040326
India	-0.040574	19.963443	-0.328505

Note on Model Fit: The pooled OLS regression yields an exceptionally high R2 of 0.9994. While this indicates a strong mathematical fit, it may also suggest potential overfitting. This is likely driven by the inclusion of multiple interaction terms and country-specific dummy variables relative to the sample size.

Japan and South Korea:

The interaction coefficient for Japan is 0.011917. This represents a 1.1% increase in GDP Per Capita PPP due to an increase in the interaction term. This may suggest that Japan's institutions have not been adapted well enough to adequately incorporate the positive effects of globalisation. It may also indicate that Japan's institutions have reached a point where simply increasing institutional quality may not amplify the positive effects of globalisation. Further, this rigidity and saturation in Japan's institutions may be why Japan fell behind South Korea's Per Capita GDP PPP, even though Japan had an earlier start.

South Korea, on the other hand, shows significant positive effects of the interaction term, wherein a one unit increase in its interaction term would result in a 4.03% increase in GDP Per Capita PPP. We may infer that South Korea's institutions may be better tuned to take advantage of globalisation, and thus have a high interaction effect. Their better utilisation of

technological advantages (digitalisation) may help explain why it overtook Japan's Per Capita GDP PPP.

India:

The interaction term for India is negative at -0.328505. This indicates a severe negative effect of the interaction term, wherein a one-unit increase in the interaction term would actually decrease GDP Per Capita PPP by almost 28%. This is consistent with our theory that India's bad institutions may have exacerbated the negative spillovers from globalisation.

This result is in line with our conjecture that India can tremendously benefit from increases in institutional quality (A 1 unit increase in our index would imply India has better institutions than South Korea, which is an immense increase in the quality of institutions).

6. Conclusion

The varying paths taken by India, South Korea and Japan show that not all institutions are created equal. Diminishing Marginal Institutional Returns have also been shown through the cases of both Japan and South Korea, which have attained a level of saturation with respect to their institutional capability. India, meanwhile, demonstrates the case of a developing economy that still needs to invest heavily into its own institutions to truly reap the benefits of its increased participation in the global economic field.

Thus, it is evident that policies need to be readjusted when it comes to organising and building institutions in any country, based on its position in the world economy, its current state of institutions, and its historic path of development. India must prioritise foundational domestic reforms, such as contract and property rights enforcement, before pursuing aggressive global integration.

We further show that the relationship between globalisation and institutional quality is strictly non-linear. Thus, Japan should pivot towards deregulation. Dismantling hyper-mature, rigid networks may help it build economic resilience against highly unpredictable, low-probability global shocks.

Ultimately, this paper establishes that globalisation is only a multiplier of existing domestic frameworks. Policymakers must recognise that for globalisation to ensure prosperity, optimal institutional design is necessary. It requires constant calibration rather than blind expansion. Only through such careful considerations may economics truly be an effective force for improving lives worldwide.

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The Impact of Shadow Economy on Economic Development: Analysing Sub-Saharan Africa

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ABSTRACT

The shadow economy has been referred to as the "key piece" of tax gaps that poses a threat to the economy in the long run (EY, 2025). In an economy, the public expects development and welfare initiatives from the government. To provide the economy with such provisions, the government requires funds that it collects from the taxpayers. But when the entities operating in the economy attempt to hide their incomes from the government or untraceable activities are carried out in the economy for one's own benefit, it leads to long-term consequences that come at the cost of development and detrimental effects. This paper aims to establish a relationship between economic development and the informal economy using a Composite Development Score, which establishes that a moderately negative relationship exists between the variables.

The methodology followed is primarily analytical and empirical in nature. The paper follows a mixed approach of analysis, relying on published reports, articles and papers for qualitative analysis of the topic, complemented by the quantitative analysis backed by data from various sources, including the World Bank, International Monetary Fund, etc. The comparative aspect of research has also been incorporated by comparing the economic data of several SSA countries, in parallel to the global analysis conducted using the same mechanism.

Keywords: shadow economy, tax gaps, composite development score, informality

JEL Classification: O17, O11, E26

1. Introduction

According to Schneider (2005), the shadow economy refers to all legal economic activities that are intentionally hidden from government authorities to avoid taxes, social security payments, or regulatory compliance. The shadow economy covers activities such as hidden operations of registered or unregistered (covering legal as well as illegal) businesses, silent or unreported activities from unregistered firms and enterprises, such as the production of legal or illicit goods which are not accounted for. Apart from these, it also covers activities such as household production and self-consumption or sale of goods, both legal and illegal.

Sub-Saharan Africa is the region of the African Continent located south of the Sahara Desert. Unlike North Africa, which is economically integrated with Europe and the Middle East, SSA encompasses lower and lower-middle-income economies and faces distinct developmental challenges. The integration into Mediterranean and European trade networks, along with tourism, has helped Northern Africa get out of its

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destitute state post-independence. Northern Africa is often coupled with the Middle East (MENA) for statistical purposes since several global datasets publish combined reports for both regions. SSA, on the other hand, remained in its agrarian state. The countries under the SSA relied heavily on subsistence farming and small informal trade, which significantly slowed down the economic progress.

The MENA countries engaged in global trade deals, aggressively expanding their trade outreach, while SSA, owing to its weak trade infrastructure, geographical disadvantages and inefficient economic practices, suffered a heavy impact.

Table 1: The Demographics of Sub-Saharan Africa

Demographics of SSA	
Number of Countries	45
Population	~1.1 billion (Median Age- 19)
Urbanization Rate	~45%
GDP (Current USD)	~1.9 trillion
GDP Growth Rate	3.4%
Sectoral Contribution to GDP (% of GDP)	Agriculture: 15-20%
	Industry: 25-30%
	Services: 45-50%

Source: World Bank (2025), UN Population Division (2022)

Various economic estimates are used to determine the scale of the informal economy in any particular region. The Shadow Economy Size (% of GDP) is the standard indicator for measuring the informal economy size of a particular region. It expresses the estimates of the shadow economy of a particular economy as a percentage of its Gross Domestic Product (GDP). Its simplicity and comparability make it a popular choice amongst economists to determine the scale of the informal economy of a region.

Table 2: % of Informal Economic Output in the State's GDPs (average of last 10 Yrs), calculated using the DGE Model and MIMIC Model.

	Economy	Code	Informal Economy (DGE) (% of GDP)	Informal Economy (MIMIC) (% of GDP)
MIDDLE EAST NORTHERN AFRICA	Tunisia	TUN	33.42	36.83
	Egypt, Arab Rep.	EGY	30.38	33.45
	Lebanon	LBN	30.24	31.56
	Morocco	MAR	29.46	33.64
	Algeria	DZA	29.16	31.52
	Malta	MLT	25.31	25.52
	Yemen, Rep.	YEM	24.47	29.48
	United Arab Emirates	ARE	23.14	29.34
	Israel	ISR	20	20.12
	Syrian Arab Republic	SYR	17.35	19.99
	Iran, Islamic Rep.	IRN	16.21	17.68
	Oman	OMN	16.19	19.97
	Jordan	JOR	15.85	18.22
	Kuwait	KWT	15.55	20.47
	Bahrain	BHR	15.48	19.69
	Saudi Arabia	SAU	15.12	17.29
	Qatar	QAT	15	18.31
	Average of MENA		**21.90**	**24.89**
	Economy	**Code**	**Informal Economy (DGE) (% of GDP)**	**Informal Economy (MIMIC) (% of GDP)**
Sub-Saharan Africa (SSA)	Zimbabwe	ZWE	61.3	60.67
	Nigeria	NGA	55.0	55.04
	Gabon	GAB	46.4	49.21
	Tanzania	TZA	45.4	53.32
	Benin	BEN	45.1	47.63
	Central African Republic	CAF	44.7	43.23
	Congo, Dem. Rep.	COD	43.4	44.85
	Guinea-Bissau	GNB	43.2	38.71
	Cote d'Ivoire	CIV	42.1	41.05
	Zambia	ZMB	41.5	46.62
	Comoros	COM	40.8	37.2
	Liberia	LBR	40.7	45.89
	Gambia	GMB	40.6	47.38
	Angola	AGO	40.1	44.25
	Malawi	MWI	39.6	37.59
	Eswatini	SWZ	39.5	38.63
	Congo, Rep.	COG	39.5	46.88
	Senegal	SEN	38.9	43.44
	Burundi	BDI	37.7	39.61
	Sierra Leone	SLE	37.6	43.16
	Chad	TCD	37.0	43.16
	Niger	NER	36.8	38.12
	Ghana	GHA	36.4	38.84
	Madagascar	MDG	36.3	42.72
	Uganda	UGA	34.7	40.05
	Mali	MLI	34.4	39.96
	Burkina Faso	BFA	33.7	38.53
	Guinea	GIN	32.3	37.82
	Togo	TGO	32.3	34.31
	Mauritania	MRT	30.6	32.25
	Mozambique	MOZ	30.1	37.71
	Cabo Verde	CPV	30.0	34.68
	Rwanda	RWA	29.7	36.67
	Cameroon	CMR	29.4	30.79
	Sudan	SDN	28.3	-
	Botswana	BWA	27.7	30.23
	Ethiopia	ETH	27.1	35.32
	Kenya	KEN	27.0	31.43
	Lesotho	LSO	26.2	29.29
	Namibia	NAM	25.5	29.5
	Equatorial Guinea	GNQ	24.6	32.66
	South Africa	ZAF	23.6	27.29
	Mauritius	MUS	20.1	21.54
	Average of SSA		**36.08**	**38.77**

Note: Data unavailability of the following countries led to their exclusion from the table: Eritrea, Seychelles, Somalia, South Sudan, Sudan (MIMIC), Djibouti, Iraq, Libya, the West Bank and Gaza

Table 1.2 contains the ten-year average of the % of the

shadow economy in the respective countries calculated using the **Dynamic General Equilibrium Model**. The DGE model functions like a simulation of the whole economy where the labour, capital and goods markets interact with each other continuously. The three markets work simultaneously and keep adjusting before reaching an equilibrium. DGE analysis requires constant revision and monitoring of how markets shift and balance over a period of time, hence the term 'dynamic' in its name.

One other model, the **MIMIC (Multiple Indicators and Multiple Causes) Model,** is also used by various researchers to estimate the percentage of informal economic output. This model implements a cause-and-effect approach towards estimating the scale of informality in the economy with the help of causes (high tax burden, corruption) and indicators (low tax revenue). The model treats the shadow economy as an unobservable variable and tries to infer the scale of informality from observed symptoms.

Despite extensive global research on the shadow economy, much of the literature has focused on advanced economies or broad cross-country analyses. Sub-Saharan Africa, however, faces distinct structural and institutional challenges that make informality particularly significant. Limited fiscal capacity, dependence on agriculture, and weaker enforcement mechanisms have left the region highly vulnerable to the adverse effects of the shadow economy. This paper contributes to covering this geographical gap by providing a region-specific analysis.

As mentioned in the table, the average composition of the informal economy in the Gross Domestic Product of Sub-Saharan Africa (average of all 43 countries under SSA) is around 36.08%. With a GDP of $1.96T, around 20% of which is supported by agriculture, SSA has an annual GDP growth rate of 3.4%. The primary objective of this paper is to analyse the level of impact of unrecorded, untracked, or unaccounted economic activity on a country's development.

Unlike existing studies that focus on single outcomes such as growth, debt, or sustainability, this paper contributes by constructing a multidimensional development index and empirically evaluating its relationship with informality in Sub-Saharan Africa using cross-country panel data.

The Null Hypothesis (H_0) assumes that there is no relationship between the informal economy and the overall development of Sub-Saharan African economies. On the contract, the alternate hypothesis (H_1) proposes that a negative relationship exists between both variables, supporting the argument that a negative association exists between the informal economy and economic development.

2. Literature Review

The informal economy has been discussed and researched by many researchers. Schneider and Enste (2000), in their review paper, discussed the main causes of the shadow economy. They found the major causes of the informal economy to be the rising burden of taxation and social security contributions, increased regulation of the economy, forced reduction of weekly working hours, unemployment and a declining civic virtue. The paper mentions how heavy taxation leads to underground transactions, escaping the radar of the authorities. Using the neo-classical leisure-income model presented by Peter de Gijsel (1984), Volker

Riebel (1983, 1984), Schneider pointed out that individuals who receive welfare payments from the government would prefer working in the underground economy since working in the official economy would raise their marginal tax rates often by 100 per cent.

Schneider (2005) contributed further to the topic by analysing the data of 110 OECD countries and concluded that economies with large-scale informality observe a decline in official GDP growth. The paper provided global quantitative estimates and helped gain an understanding of the shadow economies on a global scale. However, the data used by him for analysis is not reliable due to the lack of reliable estimates of corruption, which provided skewed results.

In his study, Schneider (2012) focuses on the assertion that punitive actions are not sufficient to control informal economic activities. The government should actually focus on the factors that lead to the creation of an informal environment in the economy in the first place. He suggested that reducing the heavy tax burden, simplifying regulations and improving institutional trust would help in reducing informality in the economy. Under this study, Schneider converged the MIMIC approach and Currency demand calibration to realistically analyse the informal economy of several OECD countries.

Ernest Aryeetey's study, "*The Informal Economy, Economic Growth and Poverty in Sub-Saharan Africa*", sheds light on contrasting aspects of the shadow economy's presence in SSA. Although Aryeetey acknowledges the negative effects of the shadow economy on the long-term growth of an economy, he also highlights the informal economy's role in employing a major portion of the economy. "According to the International Labour Organisation, approximately 85 per cent of all new employment opportunities around the world are created in the informal economy" (Aryeetey, 2015). The author labels the shadow economy "a long-term phenomenon", rejecting the passing phenomenon view. Aryeetey suggests that the concept of the informal economy be viewed with positivity since it provides large-scale employment in underdeveloped and developing countries, especially during instabilities and economic crises. He puts forth an alternative strategy, which includes massive "institutional changes", which, according to the author, would remove the negative attributes of the shadow economy.

Published under the International Monetary Fund, the working paper on Shadow Economy by Medina et al. (2017) modified the classical MIMIC indicator. The main purpose behind the modification was to avoid endogeneity. Under the traditional MIMIC model, GDP acts as both an indicator and a cause, due to which the results are often skewed and incomparable. To tackle this endogeneity, Medina replaced the standard GDP indicator with satellite data of night-time light intensity, as the latter is an independently captured economic activity. Their modified version of the MIMIC model produced robust and statistically significant results. They concluded that though SSA's informal economy is large, it is slowly declining. They also found that the Rule of Law, trade openness and moderate fiscal regulation result in lower informality.

Nkengfack et al. (2020) studied the link between the informal economy and environmental quality. Their study led to the conclusion that the shadow economy leads to lower CO_2 emissions in the long run. The paper challenges the conventional assumption that the

shadow economy worsens the environment. The paper, however, focuses on only one variable of environmental quality estimation, i.e. the CO_2 level in the environment. The other determinants of environmental quality, such as the level of Particulate Matter (PM), CO, NO_x, PB, and SO_2, are not taken into consideration while analysing and comparing the data for the various states of Sub-Saharan Africa.

The effect of financial development on the shadow economy of SSA has been well explained by Njangang et al. (2020). The authors utilised the data of 41 SSA countries to empirically measure the effect of financial development on the informal economy. A U-shaped (non-linear) relationship was identified in the study. Due to the development of the financial system, economic entities will have easy access to credit and banking facilities, thereby leading individuals and firms towards formality. However, after a certain point, unregulated, excessive financial expansion, income inequality, decreased efficiency, and credit concentration hamper economic growth. This U-shaped relationship between financial development and economic growth in an economy has been discussed at length by Law et al. (2018). Trade liberalisation also affects the level of informality in an economy. Nkemgha (2023) established an inverse relationship between trade liberalisation and the informal economy. When trade increases, the firms find it profitable to formalise to benefit from the global markets, hence trade liberalisation leads to reduced shadow economic activities.

Nantwi's study on the impact of the shadow economy and corruption on public debt in Africa establishes a positive relationship between corruption and public debt. He also empirically proved the positive relationship between the informal economy and public debt. Both variables were found to be in a direct relationship with public debt. Leakage of money from the flow of income resulting from corruption and informal activities induces the government to borrow funds from the public to cover the resultant deficit. The Granger test proved the causality to be unidirectional, implying that debt did not influence the level of corruption of the informal economy.

The links of the shadow economy to sustainable development have been explored by Ajide et al. (2024). Their study concluded that the shadow economy had a statistically significant effect on the sustainable development of an economy. Sustainable development and the informal economy are inversely related. With high informality in the economy, the economy observes a reduced focus on sustainable development practices. To achieve sustainability, a government requires funds to invest in education, health and the development of sustainable infrastructure. Since the shadow economy involves high-scale informality leading to decreased collection of tax revenue, there is less scope for sustainable development practices. Another reason that supports the negative relationship between the two variables is that informal activities aren't regulated by the government due to an obvious lack of knowledge. Hence, informal activities that might not support sustainability (fishing in restricted areas, illegal mining, etcetera) lead to decreased sustainability.

The literature has revealed the main causes of the shadow economy and answered how these causes impact the labour markets, economic development, financial markets, and the environment. However, the shadow economy's impact on the economy's overall development, particularly in the context of Sub-Saharan

Africa, has not been explored enough to establish any sort of relationship between the two. Therefore, a comprehensive study on the matter is required to find out whether informality is strongly linked to the economy's overall development.

3. Research Methodology

3.1 Research Design

The paper uses a quantitative approach to analyse the development state of countries and ascertain the degree and direction of the relationship between the overall performance of an economy and the level of informality that exists in that economy. To achieve this, Composite Development Scores of all the countries were calculated.

The paper has constructed a panel of SSA countries using secondary data for the time range of 2015-2019, the dependent variable being five proxies of economic development.

3.2 Population and Sample

The paper includes an analysis of:
a) All countries (124)
b) All SSA countries (32)

The inclusion of countries for the analysis is subject to cross-proxy data availability. The intersection of countries across datasets of all proxies was included for empirically analysing the data. Countries with incomplete data on any variable were excluded from the analysis.

3.3 Data Sources

The data files used for empirical analysis were obtained from the World Bank Open Data portal.

3.4 Variable and Measurement

Table 3: Classification and Measurement of Variables

Type	Variable
Dependent	Cumulative Score (0–5)
Independent	Informal Economy (% of GDP)
Control	Tax Revenue (% of GDP) GDP per Capita Vulnerable Employment (%) Control of Corruption Basic Sanitation Services Available (% of population)

3.5 Construction of Composite Development Score

To find the relationship between the economic development and the informal economy of a country, a Composite Development Score (CDS) was constructed. Five broad categories were identified for the assessment of the development of an economy, including fiscal, macroeconomic, institutional, labour, and socio-environmental performance.

Each category was assigned a proxy variable for the measurement of performance. The variables chosen were as follows:

Table 4: Components of the Composite Development Score (CDS) and Corresponding Proxy Variables

Category	Proxy Variable	Score Denotation	Direction
Fiscal	Tax Revenue (% of GDP)	α	Positive
Macroeconomic	GDP per capita (current US$)	β	Positive
Institutional	Control of Corruption: Estimate	γ	Positive
Labour	Vulnerable employment (% of total employment)	δ	Negative
Socio-Environmental	Basic Sanitation Services used (% of population)	ε	Positive

The time period for the analysis of each variable is 2015-2019.

The analysis was first conducted for 124 global countries and thereafter for 32 SSA countries. The

Composite Development Score (Z), being a positive score, had to be calculated using variables of all positive nature; hence, the Vulnerable employment variable was corrected for its negative direction by reducing the normalised score from 1.

The score of each category was calculated after normalising the average of 5 years (2015-2019) of the proxy variable, using the minimum-maximum normalisation method.

Composite Development Score (Z) = $\alpha + \beta + \gamma + \delta + \varepsilon$

Table 5: Composite Development Score Table (Unweighted, Normalised) of 124 Countries

S.No	Country	Tax Revenue	GDP per Capita	Vulnerable Employment	Control of Corruption	Access to Sanitation	Cumulative Score (5)	Informal Economy
1	Albania	0.5347	0.0407	0.4288	0.2820	0.9836	2.2698	33.0247
2	Angola	0.2903	0.0200	0.3677	0.0699	0.4528	1.2005	43.8820
3	Argentina	0.3253	0.1115	0.7759	0.3464	0.9415	2.5006	24.0047
4	Armenia	0.6281	0.0336	0.3344	0.2855	0.9286	2.2103	42.8323
5	Australia	0.6684	0.4928	0.9156	0.8934	1.0000	3.9702	13.6634
6	Austria	0.7728	0.4284	0.8953	0.8212	0.9997	3.9174	9.5828
7	Azerbaijan	0.4148	0.0397	0.4166	0.1863	0.9579	2.0153	53.5966
8	Bahamas	0.4268	0.2873	0.8492	0.7119	0.9449	3.2200	29.1291
9	Bahrain	0.0330	0.2263	0.9974	0.4031	1.0000	2.6598	19.3646
10	Bangladesh	0.2214	0.0138	0.4026	0.1799	0.4759	1.2936	34.2206
11	Belarus	0.4055	0.0523	0.9695	0.3711	0.9823	2.7807	42.9083
12	Belgium	0.6962	0.3989	0.8861	0.8068	0.9944	3.7824	21.4645
13	Belize	0.6082	0.0534	0.6977	0.3617	0.8673	2.5883	43.6787
14	Bhutan	0.3890	0.0278	0.2302	0.7792	0.7034	2.1297	26.7420
15	Bosnia and Herzegovina	0.5875	0.0470	0.8028	0.2766	0.9494	2.6634	31.4010
16	Botswana	0.6794	0.0606	0.6976	0.6200	0.7527	2.8103	29.9004
17	Brazil	0.4035	0.0817	0.7178	0.2956	0.8659	2.3646	38.8301
18	Bulgaria	0.5999	0.0778	0.9256	0.3582	0.8478	2.8092	32.2681
19	Burkina Faso	0.4334	0.0043	0.2312	0.3695	0.1491	1.1875	38.0851
20	Burundi	0.4149	0.0000	0.0876	0.0567	0.4107	0.9700	39.9983
21	Cabo Verde	0.5244	0.0334	0.6230	0.6418	0.7238	2.5465	34.4846
22	Cambodia	0.3591	0.0147	0.4282	0.0783	0.5697	1.4500	44.4824
23	Cameroon	0.3520	0.0115	0.2336	0.1085	0.3682	1.0738	30.2457
24	Canada	0.3717	0.4043	0.8945	0.9077	0.9883	3.5664	15.0800
25	Central African Republic	0.2101	0.0016	0.0000	0.0864	0.0780	0.3762	44.1785
26	Chile	0.5233	0.1287	0.7768	0.6931	0.9979	3.1198	18.3388
27	China	0.2598	0.0810	0.5387	0.3430	0.8699	2.0925	11.7393
28	Colombia	0.4390	0.0559	0.4980	0.3254	0.8958	2.2141	34.5561
29	Congo, Dem. Rep.	0.2162	0.0023	0.1240	0.0388	0.0979	0.4792	43.6483
30	Congo, Rep.	0.2882	0.0195	0.2002	0.0662	0.1285	0.7025	47.7174
31	Costa Rica	0.3909	0.1096	0.7379	0.5755	0.9725	2.7863	24.9681
32	Cote d'Ivoire	0.3383	0.0158	0.2291	0.2794	0.2727	1.1354	39.5089
33	Croatia	0.6457	0.1249	0.8955	0.4477	0.9578	3.0717	30.4396
34	Cyprus	0.7008	0.2414	0.8808	0.6173	0.9937	3.4341	28.1076
35	Czech Republic	0.4324	0.1891	0.8584	0.5601	0.9906	3.0306	17.0070
36	Denmark	1.0000	0.5166	0.9456	0.9961	0.9956	4.4539	17.1830
37	Dominican Republic	0.3863	0.0658	0.5766	0.2008	0.8498	2.0792	29.3334
38	Ecuador	0.4256	0.0534	0.5144	0.2551	0.8697	2.1182	31.7124
39	El Salvador	0.5199	0.0345	0.6257	0.2792	0.8498	2.3092	42.7643
40	Equatorial Guinea	0.2280	0.0691	0.1863	0.0000	0.6329	1.1163	33.2145
41	Estonia	0.6273	0.1882	0.9412	0.7747	0.9899	3.5212	29.5504
42	Eswatini	0.7500	0.0312	0.6476	0.3633	0.5945	2.3866	38.3628
43	Ethiopia	0.2216	0.0045	0.0766	0.2910	0.0000	0.5936	34.9324
44	Fiji	0.7104	0.0493	0.6433	0.5657	0.9265	2.8951	31.0413
45	Finland	0.6165	0.4155	0.9014	0.9956	0.9940	3.9230	17.7224
46	France	0.7062	0.3504	0.9271	0.7560	0.9853	3.7250	14.6589
47	Gabon	0.3344	0.0627	0.6729	0.2046	0.4476	1.7222	48.9329
48	Georgia	0.6712	0.0381	0.4715	0.6120	0.8560	2.6489	62.5805
49	Germany	0.3500	0.4096	0.9484	0.9038	0.9916	3.6034	14.8706
50	Ghana	0.3434	0.0160	0.2563	0.3734	0.1592	1.1483	38.2945
51	Greece	0.7841	0.1680	0.7236	0.3987	0.9889	3.0634	29.6812
52	Guatemala	0.3065	0.0362	0.6181	0.2031	0.6481	1.8121	48.9011
53	Guinea-Bissau	0.2613	0.0046	0.1874	0.0095	0.1552	0.6181	38.2131
54	Hungary	0.6736	0.1328	0.9292	0.4399	0.9782	3.1536	23.0038
55	Iceland	0.7657	0.5965	0.8797	0.9014	0.9868	4.1300	15.1224
56	India	0.3304	0.0146	0.1986	0.3372	0.6060	1.4869	20.2846
57	Ireland	0.5276	0.6571	0.8842	0.8364	0.8848	3.7901	14.8307
58	Israel	0.6828	0.3638	0.9212	0.6522	0.9995	3.6194	19.8403
59	Italy	0.7321	0.2948	0.8293	0.4592	0.9988	3.3142	28.3092
60	Jamaica	0.7786	0.0460	0.6224	0.3641	0.8507	2.6617	34.3803
61	Jordan	0.4370	0.0349	0.9067	0.4695	0.9716	2.8198	18.2847
62	Kazakhstan	0.3134	0.0805	0.7377	0.2442	0.9764	2.3523	37.9545
63	Kenya	0.4376	0.0133	0.3511	0.1770	0.2876	1.2667	30.7287
64	Korea, Rep.	0.4260	0.2791	0.7998	0.5520	0.9987	3.0556	25.8631
65	Kyrgyz Republic	0.5001	0.0090	0.6378	0.1402	0.9729	2.2601	36.7260
66	Lao PDR	0.3632	0.0196	0.1555	0.1568	0.7203	1.4153	28.3382
67	Latvia	0.4908	0.1373	0.9122	0.5322	0.9145	2.9870	27.0618
68	Lebanon	0.4302	0.0750	0.7808	0.1435	0.9624	2.3918	31.9722
69	Lesotho	0.9529	0.0077	0.6504	0.4019	0.3971	2.4101	28.9506
70	Lithuania	0.5163	0.1519	0.8921	0.5747	0.9210	3.0559	29.4049
71	Luxembourg	0.7432	1.0000	0.9350	0.9593	0.9739	4.6115	9.8477
72	Madagascar	0.2863	0.0022	0.0888	0.1572	0.0444	0.5789	42.1346
73	Malawi	0.3370	0.0026	0.3491	0.2180	0.3306	1.2374	37.1156
74	Malaysia	0.3789	0.0901	0.7420	0.4594	0.9530	2.6234	29.5249
75	Maldives	0.5937	0.0945	0.7993	0.2717	0.9579	2.7171	28.7824
76	Mali	0.3525	0.0062	0.1343	0.2367	0.3617	1.0914	39.8761
77	Malta	0.7535	0.2667	0.8870	0.5799	0.9996	3.4867	24.6447
78	Mauritius	0.4843	0.0947	0.8302	0.4672	0.9507	2.8271	21.1837
79	Mexico	0.3738	0.0872	0.7165	0.1787	0.8861	2.2423	29.4951
80	Moldova	0.5082	0.0298	0.3585	0.1987	0.8001	1.8953	40.6302
81	Mongolia	0.4138	0.0333	0.5053	0.2927	0.6223	1.8674	16.7355
82	Morocco	0.5891	0.0280	0.6122	0.3514	0.8311	2.4119	33.3140
83	Mozambique	0.6516	0.0025	0.1075	0.1966	0.2450	1.2032	37.5423
84	Myanmar	0.1607	0.0094	0.3293	0.2431	0.6978	1.4403	48.5133
85	Namibia	0.9129	0.0420	0.6990	0.4963	0.2868	2.4369	29.3651
86	Nepal	0.5178	0.0072	0.1466	0.2302	0.6265	1.5284	35.3278
87	Netherlands	0.6735	0.4509	0.8699	0.9078	0.9751	3.8773	13.0998
88	New Zealand	0.8161	0.3749	0.8610	1.0000	1.0000	4.0521	11.9500

Table 6: Composite Development Score Table (Unweighted, Normalised) of 32 SSA Countries

S.No	Country	Tax Revenue	GDP per Capita	Vulnerable Employment	Control of Corruption	Access to Sanitation	Cumulative Score (5)	Informal Economy
1	Angola	0.1079	0.2108	0.4083	0.1089	0.4763	1.3122	43.8820
2	Botswana	0.6318	0.6399	0.7747	0.9660	0.7918	3.8042	29.9004
3	Burkina Faso	0.3006	0.0452	0.2567	0.5758	0.1569	1.3352	38.0851
4	Burundi	0.2758	0.0000	0.0973	0.0883	0.4321	0.8935	39.9983
5	Cabo Verde	0.4232	0.3528	0.6919	1.0000	0.7614	3.2292	34.4846
6	Cameroon	0.1911	0.1213	0.2594	0.1691	0.3873	1.1282	30.2457
7	Central African Republic	0.0000	0.0173	0.0000	0.1347	0.0821	0.2340	44.1785
8	Congo, Dem. Rep.	0.0082	0.0238	0.1377	0.0605	0.1030	0.3333	43.6483
9	Congo, Rep.	0.1052	0.2058	0.2223	0.1032	0.1351	0.7716	47.7174
10	Cote d'Ivoire	0.1726	0.1673	0.2545	0.4354	0.2869	1.3166	39.5089
11	Equatorial Guinea	0.0242	0.7293	0.2069	0.0000	0.6658	1.6262	33.2145
12	Eswatini	0.7268	0.3299	0.7192	0.5660	0.6253	2.9672	38.3628
13	Ethiopia	0.0155	0.0470	0.0850	0.4534	0.0000	0.6009	34.9324
14	Gabon	0.1674	0.6617	0.7473	0.3187	0.4708	2.3660	48.9329
15	Ghana	0.1794	0.1695	0.2847	0.5817	0.1674	1.3827	38.2945
16	Guinea-Bissau	0.0690	0.0486	0.2082	0.0148	0.1633	0.5038	38.2131
17	Kenya	0.3063	0.1403	0.3900	0.2759	0.3025	1.4149	30.7287
18	Lesotho	1.0000	0.0814	0.7224	0.6262	0.4177	2.8477	28.9506
19	Madagascar	0.1026	0.0231	0.0986	0.2450	0.0467	0.5160	42.1346
20	Malawi	0.1709	0.0271	0.3878	0.3397	0.3478	1.2732	37.1156
21	Mali	0.1918	0.0655	0.1491	0.3688	0.3805	1.1556	39.8761
22	Mauritius	0.3691	1.0000	0.9220	0.7279	1.0000	4.0191	21.1837
23	Mozambique	0.5944	0.0263	0.1194	0.3063	0.2577	1.3040	37.5423
24	Namibia	0.9461	0.4440	0.7763	0.7732	0.3017	3.2412	29.3651
25	Rwanda	0.2717	0.0501	0.6110	0.8929	0.6917	2.5173	35.9430
26	Senegal	0.3751	0.1061	0.3183	0.6419	0.5364	1.9778	42.3611
27	South Africa	0.7099	0.5873	1.0000	0.6261	0.7525	3.6757	27.3346
28	Tanzania	0.1622	0.0724	0.1141	0.4381	0.2143	1.0012	52.6430
29	Togo	0.2485	0.0538	0.1196	0.3498	0.1048	0.8764	33.8678
30	Uganda	0.1704	0.0538	0.2112	0.2037	0.1367	0.7758	39.8637
31	Zambia	0.3215	0.1064	0.2398	0.4307	0.2964	1.3948	46.8218
32	Zimbabwe	0.1689	0.1727	0.2682	0.1212	0.3306	1.0616	60.3120

4. Analysis and Results

4.1 Global Relationship

The analysis of the 124 countries worldwide reveals a significantly negative relationship between the level of informality in the economy and the economic performance of that country. Running a simple correlational analysis between the proxy variables and the shadow economy (as % of GDP) shows an inverse association between the shadow economy and individual variables.

The correlation between CDS and the shadow economy (r = -0.673) suggests that economies with a higher share of unrecorded or informal activity tend to have weaker overall development outcomes.

Table 7: Correlation Between Composite Development Score Components and the Shadow Economy: Global Sample

Correlation (Global) (Proxy Variable and Informal Economy)	
Composite Development Score (CDS)	-0.67373
Tax Revenue (% of GDP)	-0.28769
GDP per Capital	-0.69157
Vulnerable Employment (Corrected)	-0.57223
Control of Corruption	-0.69705
Access to Basic Sanitation	-0.46561

Table 8: Regression Results for the Effect of the Shadow Economy on Composite Development Score: Global Sample

Statistic	Value
Observations (n)	124
R Square	0.454
Adjusted R Square	0.449
Coefficient (Informal Economy % of GDP)	−0.0569
Standard Error (Coefficient)	0.00565
t-Statistic	−10.07
p-Value	9.96×10^{-18}
95% Confidence Interval	[−0.0680, −0.0457]

The R-squared value is 0.454, implying that 45.4% of the variation in Composite Development Scores across countries can be explained by the level of informality. A negative 0.0569 coefficient implies that a rise in 1% informality level drops the CDS by 0.0569. The extremely low p-Value (9.96×10^{-18}) confirms that the analysis is statistically reliable and not just a byproduct of mere chance. A t-Statistic value of -10.07 here signifies reliability and indicates that a statistically significant relationship exists between the variables.

Countries like Zimbabwe and Nigeria, with highly informal economies, also exhibit significantly lower CDS values. In contrast to that, advanced economies like Denmark, Switzerland and Luxembourg with relatively less shadow economy show higher development scores. A global scatter plot illustrates this downward-sloping trend, capturing how development declines as informal economic participation rises.

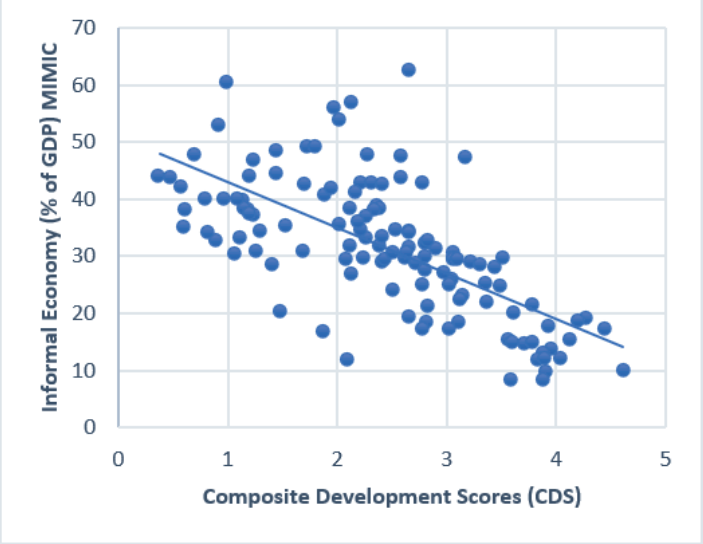


Figure 1: Relationship Between the Shadow Economy and Composite Development Score: Global Sample

4.2 SSA Analysis

The analysis of 32 SSA countries yields similar results to the global economy. A negative relationship was found between the Composite Development Score and the shadow economy.

However, the effect is notably weaker than the global sample, reflecting the region's unique structural and institutional context.

Table 9: Correlation Between the Shadow Economy and Composite Development Score Components: Sub-Saharan Africa Sample

Correlation (Global) (Proxy Variable and Informal Economy)	
Composite Development Score (CDS)	-0.67373
Tax Revenue (% of GDP)	-0.28769
GDP per Capital	-0.69157
Vulnerable Employment (Corrected)	-0.57223
Control of Corruption	-0.69705
Access to Basic Sanitation	-0.46561

Table 10: Regression Results for the Effect of the Shadow Economy on Composite Development Score: Sub-Saharan Africa Sample

Statistic	Value
Observations (n)	124
R Square	0.454
Adjusted R Square	0.449
Coefficient (Informal Economy % of GDP)	−0.0569
Standard Error (Coefficient)	0.00565
t-Statistic	−10.07
p-Value	9.96×10^{-18}
95% Confidence Interval	[−0.0680, −0.0457]

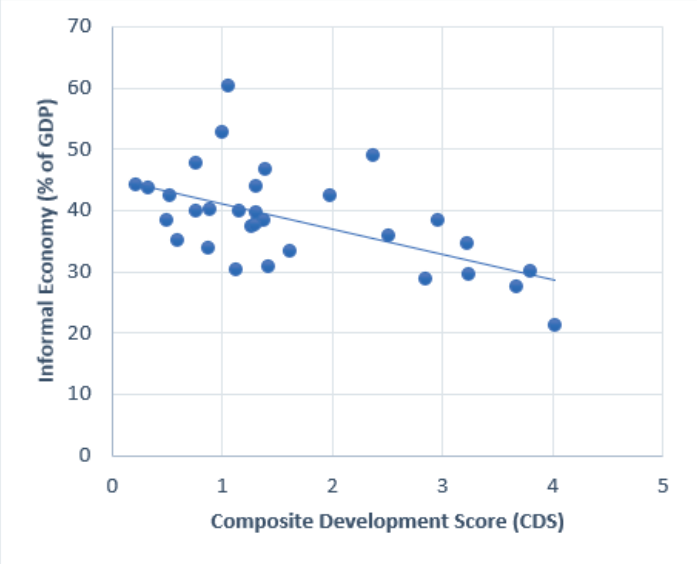


Figure 2: Relationship Between the Shadow Economy and Composite Development Score: Sub-Saharan Africa Sample

The analysis depicts a moderately negative relationship between economic development and the % of the informal economy in a country. Individual correlations between proxy variables and the informal economy suggest a negative relationship between the two. Here again, we notice that the statistical figures, though not as strong as the global analysis, imply that the analysis conducted is fairly reliable. Around 31.7% variation in scores across SSA economies is explained by the level of informality. A negative t-Statistic value and a p-Value of 0.000792 suggest that the data is reliable and robust.

The correlation value (-0.56) rejects the null hypothesis H_0 and supports the alternative hypothesis H_1, establishing the fact that negative associativity exists between development and the informal economy.

The negative trend in SSA can be visualised with a scatter plot, where countries like Zimbabwe, Tanzania and Zambia, with informal economy sizes above 45% of GDP, record some of the lowest scores. In contrast to that, more formalised economies like South Africa, Namibia and Mauritius demonstrate stronger development outcomes.

4.3 Results

Key interpretation of the findings:

a) Higher informality is consistently associated with weaker development.

b) Institutional weakness and low fiscal capacity are closely linked to shadow economic growth.

Thus, while the informal economy absorbs labour and sustains livelihoods in SSA, it also:

- Reduces tax collection
- Weakens governance and regulatory enforcement
- Limits investment in health, education and infrastructure
- Slows sustainable development momentum

One must notice the relatively weak correlation between Labour Performance and the Informal economy. A correlation of -0.504, though moderately

negative, is still weaker than what one would expect, given that labour and informality are strongly related components and that the labour score should reflect a strong relation with informality, which it does not. It may be so because in many developing countries, the informal economy includes family enterprises, small-scale businesses and skilled self-employment. These activities can protect households from unemployment and may not always lead to labour vulnerability.

One can also argue that Vulnerable Employment is a narrow proxy, since it focuses on workers without formal contracts, but ignores other aspects such as job skill level and productivity. It must also be noted that the correlational analysis conducted here only proves the association of variables and is not a measure of causation.

5. Discussion

The results of the analysis give a clear picture of the economic development and how informal practises affect the growth and development of an economy. The analysis highlights the negative relationship between the shadow economy and economic development. The global correlation between Composite Development Score (CDS) and the informal economy is strong (r = -0.673), and the SSA's relationship, though weaker, is still negative (r = -0.563). The regression outputs likewise show a larger explained variance in the global sample than in the SSA sample, indicating that informality accounts for more of the variation in development scores worldwide than it does within SSA.

The findings are consistent with the broad conclusion from the literature that informality is generally associated with weaker development outcomes.

The weaker SSA correlation requires careful interpretation. Two explanations can be derived from the paper's methodology, literature review and prior studies:

1) Different Composition and Role of Informality in SSA

Several LR contributions (specifically Aryeetey) emphasised that informality in developing regions frequently includes subsistence agriculture, household enterprises and small-scale self-employment that act as livelihood buffers. The labour proxy (vulnerable employment- corrected for positive score) shows a relatively weaker association with informality than it should, suggesting that informal activity in SSA may often provide employment, leading to a consumption boost. This might explain the moderate relationship between the two variables. The shadow economy has a dual role- it may reduce tax revenues and weaken governance, but simultaneously absorbs labour and mitigates unemployment.

2) Measurement Errors, Heterogeneity and Institutional Factors

The LR (Medina et al.) warns that measurement approach and governance variables help in the estimation of informality. SSA is somewhat heterogeneous in nature, meaning that countries differ in structure, institutional capacity and social protocols. These omitted or imperfectly measured dimensions weaken the relationship between CDS and informality. The reduced explanatory power in the SSA regressions is likely a result of measurement error and omitted variables, paired with the unavailability of data for many countries, thereby skewing the results.

5.1 Interpretation and Plausible Mechanisms

a) Zimbabwe (Informality = 60.3% of GDP; CDS=1.06)

Zimbabwe is one of the most extreme cases, depicting very high informality and one of the lowest development scores. This aligns well with the classical negative view of informality and its effect on the development of the country.

b) Tanzania (Informality = 52.6%; CDS = 1.00)

Tanzania's high-informality / low-CDS cases again represent the same result. In such cases, though informality may cure short-run labour absorption problems, it does more damage to the long-run economic development by constraining public investment (tax loss). This is consistent with the explanation provided by Ajide et al. and Nantwi.

c) Mauritius (Informality = 21.2%; CDS = 4.01) and South Africa (Informality = 27.3%; CDS = 3.67)

These are examples of low informality economies alongside high CDS. These help illustrate the other pole of the theory, i.e. stronger institutions, higher tax collection and more formalised labour markets co-exist with better development outcomes. LR's findings that the rule of law, trade openness and fiscal capacity help reduce formality are visible in these cases (Medina et al.; Schneider).

d) Gabon / Equatorial Guinea / Angola (High Informality; Middling CDS)

Resource-rich states with large formal extractive sectors may record higher GDP per capita but still show high formality in non-oil sectors. Such cases explain why high-income SSA countries still display significant informality. This interpretation echoes well with Law et al.'s discussion of distortions caused by financial and institutional sectors and how they may produce non-linear relationships.

The negative relationship between CDS and the informal economy mirrors Schneider (2005, 2012), establishing that higher informality correlates with lower development outcomes. The relationship of labour performance measured by the Vulnerable Employment (corrected-for-direction) proxy with the informal economy supports Aryeetey's argument that informality cannot be viewed purely negatively. It is a major source of employment and supports a large fraction of the working class in underdeveloped countries.

5.2 Policy Implications

1) Focus on gradual and measured reforms

Since the informal economy has a dual effect on the economy, in the sense that although informality harms government revenue, it also provides employment to a major fraction of the workforce of SSA countries, the government should focus on thoroughly considered, gradual measures to curb informality, ensuring that workers aren't affected abruptly. This would help the government build trust and reduce the overall cost of shifting towards economic formality. Abrupt, large-scale changes in employment structure and related policies would lead to instability and economic imbalance.

2) Primary focus on institutional development

The primary objective of the governments of SSA countries must be to focus on working primarily towards better governance, stronger and robust tax systems, establishing an equal and unbiased legal

system and reducing corruption. When the people have trust in the government and faith in the system laid out by it, they are more likely to comply with formal regulations and accept and move towards a formal economy.

5.3 Limitations and directions for future research

1) The analysis is correlational. Granger/panel causal methods are needed to establish causal relationships.

2) Proxies for the five dimensions (fiscal, macroeconomic, labour, institutional, and socio-environmental) of development have been chosen by considering relevance and alignment. This study uses these proxies unweighted to avoid judgment as to which dimension matters more. One may adjust the weights depending on one's objective.

3) Several SSA countries were excluded from the analysis due to data unavailability. The study would have been more accurate with the inclusion of these excluded countries.

4) Future studies can explore the concept of informality in SSA and its effect on economic development by studying the informality separately by sector (agriculture vs services) and region (urban vs rural) to explore different effects and mechanisms.

6. Conclusion

This study aimed towards examining whether the size of the shadow economy is associated with the level of economic development in Sub-Saharan African (SSA) economies. A Composite Development Score (CDS) constructed using fiscal, macroeconomic, institutional, labour and socio-environmental indicators was used for this purpose. The analysis using the Composite Development Score and Informal Economy (as a % of GDP using the MIMIC approach) of 32 SSA countries revealed a negative relationship between informality and performance.

However, the effect in SSA was observed to be moderately weaker compared to the global sample. This reflects the dual nature of informality in the region. While shadow economic activities adversely affect the development of the state, they remain an important safety net for a large number of workers. Limited formal employment opportunities, weaker industrial structures and institutional factors push workers towards unemployment. The shadow economy plays the role of a stabiliser by providing livelihood to such workers and acts as a cushion against unemployment and poverty.

The findings highlight the importance of institutional quality, regulatory efficiency, financial development and governance improvements in reducing informality and maximising development and economic growth. Policies aimed at formalisation must be gradual and incentive-driven, ensuring that informal workers aren’t left vulnerable and pushed into unemployment and poverty.

While this study provides clear empirical evidence of the association of economic development with informality, causality remains unaddressed. Future research can help strengthen the understanding of the topic by sector-wise decomposition, causality tests using panel econometrics and exploring deeper dimensions of economic development, providing profound practical insights for policy reforms in SSA

economies.

While SSA faces developmental challenges, it must be ensured that developmental policies are framed in such a way that growth is achieved using sustainable measures and stability is maintained throughout the pivotal process of economic growth and development.

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Utilisation of Digital Payments in India: Impact of Digital Payment Systems on Tax Revenue Growth Post-Demonetisation (2016)

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ABSTRACT

This paper looks at how digital payment systems have helped improve tax revenue generation between states in India since demonetisation. There are notable differences in how states adopt digital payments and the digital skills of their populations. These factors affect how businesses formalise and comply with tax laws. States that are more digitally ready tend to generate more tax revenue due to better tracking of transactions, improved compliance, lower compliance costs, and a friendlier business environment. The study suggests that increasing the use of digital increasing the use of digital payments boosts tax revenue growth by enhancing transaction traceability and encouraging adherence to tax regulations. To test this idea, the study uses a quasi-experimental Difference-in-Differences (DiD) approach along with simple linear regression analysis. It analyses state-level panel data from major Indian states from 2014 to 2023. The main variables include digital payment transaction volume, tax revenue indicators, state GDP, and other factors related to the economy and demographics. Data comes from official government sources, including the Reserve Bank of India and the Ministry of Finance. The results show a strong positive effect of digital payment adoption on tax revenue growth, especially in states with higher digital literacy and better infrastructure. States that saw rapid growth in digital transactions performed better in terms of tax revenue compared to those that are less digitally advanced. These findings indicate that digital payments play a key role in improving transaction traceability and advancing the formalisation of economic activities, with important implications for strengthening tax compliance. This paper adds to current research by offering state-level evidence on the financial effects of digital payments in India. It emphasises digital inclusion as a tool for improving tax capacity and encouraging balanced economic growth.

Keywords: digital payment adoption, tax revenue growth, Demonetisation (2016), formalisation of economy

JEL Classification: O33,H26,E58

1. Introduction

Demonetisation is when the government takes away the legal tender status of certain currency notes, which makes them no longer acceptable for transactions. India has done this three times, in 1946, 1978, and 2016. On the night of November 8, 2016, at 8:15 pm, India's television that from midnight onwards, currency notes of 500 and 1000 rupees would no longer be legal tender. The main reason for this decision was to stop money laundering, fight terrorism funding, get rid of fake currency, reduce illegal money in the economy,

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and push towards a cashless and digital India by increasing electronic transactions.

After demonetisation, the use of cashless payments grew quickly. Moving from cash to digital transactions had a positive impact on transparency, tax compliance, and made the economy more formal. One major result of this shift was how it helped increase Goods and Services Tax (GST) revenues. GST started in 2017, with the goal of combining different indirect taxes and making compliance easier by using a clear, tech-based system.

Digital payments were important in helping achieve this. They created clear records of financial activity, helped reduce tax evasion, and made reporting more accurate. Also, the spread of UPI and other electronic payment tools made things easier for businesses and people. This change in technology lowered transaction costs, made payments faster, and gave more people access to formal financial systems. So, the link between using more digital payments and growing tax revenues is a key area to study, as it shows how moving to digital finance affects tax outcomes.

2. Hypothesis

High digital payment adoption areas have seen more growth in Tax revenues since demonetisation, because of higher traceability and formalisation in the economy of India.

3. Objectives

1. To look at how much digital payment systems were used and how they grew in India after demonetisation in 2016.
2. To study the effect of digital transactions on GST revenue with implications for tax compliance.
3. To check if higher use of digital payments is linked to more traceability in tax collection.
4. To see how moving towards a cashless economy affected the overall growth of Tax revenues after demonetisation.

4. Review of Literature

An ever-expanding body of research investigates how the increase in digital payments has reshaped India's economy post-demonetisation.

Sampath et al. (2025) in the conference paper "An Analysis of Growth of Digital Payments in India" report that due to the affordable and convenient digital transactions, the shift to a cashless economy has led to the enhancement of the annual growth rate of the country, driving sustained macroeconomic growth.

Baheti et al. (2024), in their article, identify UPI as a critical catalyst of the transition to digital payments after demonetisation, shifting the consumers and merchants from the informal cash economy to the formal digital system. The study highlights how this rapid adoption not only increased the efficiency in transactions but also improved financial transparency and digital inclusion. Additionally, it has enabled small businesses to better access formal banking channels and improve their earnings.

Joseph and Ramalingam (2023) use the Error Correction Model to obtain the relationship between the variables GST revenue and Digital payments, including the transactions made using UPI, Debit card, and Credit Card. The finding is that the variables are indeed

positively related, suggesting that adoption of digital payment technology contributes to higher GST Revenues. This could be, partially because digital transactions leave digital footprints, which makes them more transparent plus tough to evade taxes.

Najib et al. (2025), in this study, demonstrate that digital payments lead to an increase in the revenues of small and medium enterprises. This study at the micro level proves to be of great importance in the case of India, as MSMEs form the backbone of the Indian economy and are a major driver of the National Income.

A study on MSMEs in Andhra Pradesh by Subba Reddy et al. (2025) reinforces the notion that digital adoption creates new ways to expand both rural and urban businesses by expanding their visibility and acceptance of payments digitally. This is because it allows businesses to overcome their geographical limitations and expand their market reach.

In a nutshell, the existing literature demonstrates that the transition towards digital payment systems like Unified Payments Interface, debit cards, credit cards, etc, not only brings about an expansion at the microeconomic level but also at a much larger national and global level too. Moreover, it also significantly shrinks the tax-evading tendencies, which ultimately increases the transparency and formalisation of the economy. However, the current literature treats digital payment adoption as a uniform national trend. The limited empirical evidence that compares the outcomes of the digitisation of payments across urban, semi-urban, and rural areas may vary based on differences in infrastructure, awareness, and the psyche of the residents. Therefore, this study aims to assess the variation in digital payment usage and its payoffs on the Tax revenue collections, while also examining their role in financial formalisation.

5. Methodology

The study employs a quantitative approach that utilises secondary data to gauge the impact of digital payment adoption on the revenues of various regions, with the 2016 demonetisation as the major catalyst. The methodology relies entirely on secondary data sourced from official government platforms, including the E-transactions dashboard, National Payments Corporation of India (NPCI), and Goods and Services Tax Network (GSTN) portal. Microsoft Excel software is used for data compilation. State-wise annual data is compiled to form a panel dataset, allowing the study to observe variations both across states and within states over time. Monthly data on the digital payments, largely UPI (Unified Payments Interface) transactions, are sourced from the National Payments Corporation of India (NPCI). The data on the revenues is proxied by the GST collections. Supplementary data on the macroeconomic indicators and the global insights are made available from the RBI Handbook of Statistics and the World Bank reports. The paper utilises two quantitative models: Difference-in-differences (DiD) and Simple Linear Regression Analysis.

5.1 Difference-in-differences

The difference-in-differences (DID) framework is employed to analyse the causal relationship between the Tax-reported revenues, digital payments adoption and other control factors across regions over time. This approach examines the change in revenue with the adoption of digital payments of various types before

and after demonetisation. The model is adjusted for the time-invariant regional characteristics and other economic trends to isolate the effect of digitisation. The rationale for the model is that, since there is a clear catalyst, demonetisation, along with initiatives like the Digital India program by the Government of India, this period marks a revolution in the move toward a cashless economy. To capture the before-and-after effects of this change, which is affected by the digital transformation, the Difference-in-Differences (DiD) model has been employed.

The functional specification is given as

$$\mathbf{Y_{it} = \alpha + \beta(Post_t \times Treat_i) + \gamma X_{it} + \mu_i + \lambda_t + \epsilon_{it}}$$

Where,

Y_{it} - denotes the revenues as per the Taxes collected for the region i at time t

$Post_t$ - denotes the post-demonetisation dummy

$Treat_i$ - denotes the states with high digital adoption

X_{it} - denotes the control variables

μ_i - state fixed effects

λ_t - time fixed effects

ϵ_{it} - denotes the random error

β - coefficient of the impact of digital payments on the regional revenue

5.2 Simple Linear Regression Analysis

Regression analysis is used to estimate the magnitude of the relationship between the said variables. The variables chosen are the Goods and Services Taxes, which serve as a proxy for the revenue, such that the greater the income, the more GST is paid on the revenue. This works as the dependent variable. The independent variable is the monthly UPI transaction volumes from the NPCI, since most digital payments are carried out through the Unified Payments Interface. This variable represents the magnitude of digital payment adoption. The frequency of the data is quarterly, which was compiled manually with the available monthly data.

$\mathbf{Y_i = \alpha + \beta X_i + \epsilon_i}$ was then used to formulate the whole regression analysis.

Where:

Y_i = Dependent variable, quarterly tax revenues

X_i = Independent variable, quarterly UPI transaction volumes

α = Intercept

β = Slope (regression coefficient)

ϵ_i = Error term

6. Analysis

State-wise annual data is compiled to form a panel dataset, allowing the study to observe variations both across states and within states over time.

Before proceeding with the empirical analysis, it is crucial to examine the evolution of digital usage throughout the study period. As electronic transactions (e-transactions) serve as the key explanatory variable, understanding their growth patterns offers essential information.

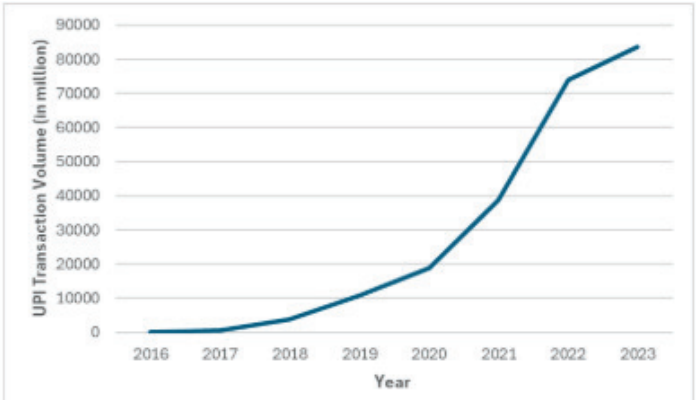


Figure 1: Trend in UPI Transaction Volume in India (2016–2023)

Note: Data compiled from NPCI annual reports

The graph illustrates a significant and rapid increase in UPI adoption since its launch in 2016. In 2016, the number of transactions was 2.65 million, and by 2023, this figure had surged to over 83,751 million. The rate of growth became particularly noticeable post-2020, fuelled by greater access to digital platforms, rising smartphone adoption, and shifts in payment behaviours.

This sustained rise in UPI adoption underscores the relevance of e-transactions as a significant factor in explaining variations in Tax revenue across different states. The expansion of digital payment systems reflects a broader trend towards more formalised and transparent economic activities, which could contribute to improved tax compliance.

6.1 Regression Analysis

A linear regression model is estimated to investigate the relation between the dependent variable and the independent variable. This model allows for the assessment of the extent to which the independent variable, that is, Digital Payments (UPI), affects the dependent variable and whether this relationship is statistically significant.

Table 1-Regression Summary Statistics

Regression Statistics	
Multiple R	0.973320254
R Square	0.947352316
Adjusted R-Square	0.945654004
Standard Error	20506.1997
Observations	33

Note. Author's compilation

The model demonstrates a very strong fit, with an Adjusted R-Square value of 0.9457.

Table 2: Regression Coefficients

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	204817.1326	5293.7653	38.69025561	8.3064E-28
Regression coefficient	0.033702989	0.001426992	23.61820969	2.21387E-21

Note: Authors' compilation

The regression coefficient (0.0337): This positive value indicates that a one rupee increase in the UPI volume transaction leads to a 0.0337 crores increase in the Tax revenues. The very low p-value (2.21×10^{-21}) confirms that the independent variable significantly influences the dependent variable. One should keep in mind that this reflects association and not causation. States with higher digital adoption tend to be more formalised, urban and have better administration.

Beyond statistical significance, the regression results have important economic implications. The strong positive relationship between e-transactions and tax revenue suggests that increased digital payment enhances transaction traceability and hence the formalisation of the economy. To verify the credibility

of the regression results, some diagnostic tests were carried out. The Durbin-Watson test statistic of 1.5, which points to mild positive autocorrelation. In other words, the residuals show a small pattern over time, but not one that would noticeably distort the regression outcomes. The Breusch–Pagan test also supports the model's stability. With a test statistic of 0.1645 and a p-value of 0.69, there is no indication of heteroscedasticity. This means that the spread of the residuals stays fairly even across observations, strengthening confidence in the estimated coefficients.

Taken together, these diagnostic results serve as a preliminary step before the Difference-in-Differences model, which provides a more credible causal interpretation.

Table 3: Differences-in-differences summary

Variable	Coefficient	SE	p-value
Interaction	33917	15988	0.0377

Note: Author's compilation

Table 4: Model Fit Statistics for the Differences-in-differences model

Model Fit	Value
R^2	0.0648
Adjusted R^2	−0.1942

Note: Author's Compilation

This study examines whether higher digital payments experienced stronger growth in Tax revenues. The study uses a Difference-in-Differences (DID) approach with annual data from 2013-2014 onward. States are divided into "high digital adoption" and "low digital adoption" groups based on trends from the e-transactions dashboard, where UPI makes up about 70% of the volume. The high digital adoption states are Maharashtra, Uttar Pradesh and Madhya Pradesh, while the states with low digital adoption are Bihar, Goa, Jharkhand, and Himachal Pradesh. Tax revenue is the dependent variable, and treatment status based on e-transactions serves as the main explanatory factor. This setup helps compare how Tax collection patterns changed in treated states after digital payments increased, compared to states that did not experience the same digital growth.

Table 5- DiD Results with Clustered Standard Errors by State

Variable	Coefficient	SE	p-value
Interaction	33,917	20,150	0.097

Note. Authors' compilation

The data is organised in a state-year panel. The analysis includes state fixed effects, which remove any long-term differences between states, such as economic structure, administrative capability, or tax infrastructure. Year fixed effects are also considered to neutralise nationwide shocks affecting all states at once. The estimate of DiD regression with clustered Standard Errors are 33917 with a p-value of 0.097, a positive but

statistically insignificant effect for the high digital adoption states in the period post-demonetisation. That is, after demonetisation, high digital adoption states experienced an increase of ₹33,917 crores in Tax revenues compared to the low adoption states. This indicates that higher taxes are collected in the high digital adoption states compared to the lower ones after the implementation of the policy.

The Wooldridge test was conducted to check whether the errors in each state are correlated over time. The Wooldridge tests report an F-statistic of 650.52 and a p-value of 2.2 × 10-16, which is close to zero, hence confirming that serial correlation does exist. The errors tell us about the unobserved factors that affect the Tax persist over time, such as administrative capacity, tax compliance, etc, which are not explained by the model. This violates the independence of errors, which can lead to the significance being overstated. Hence, we use clustered SEs as a correction measure.

To verify the assumption of parallel trends in the DiD model, the wild cluster bootstrap t-test is used to check if the pre-treatment years' coefficients are statistically different from zero, while accounting for the state-wise clusters.

The estimated coefficients are -31452 for 2013, -31347 for 2014 and -29501 for 2015 with the p-value 0.446, 0.442 and 0.459, respectively. None of the p-values is significant, so the null hypothesis cannot be rejected. It can be concluded that the treated and the control states were similar before the treatment.

The Placebo test was performed to observe whether the effects are purely due to demonetisation or are affected by the pre-existing differences in the control and treatment groups. To test this, it was assumed that the demonetisation occurred in 2015.

The placebo interaction term is positive and marginally significant, which suggests that the model does capture the pre-treatment dynamics. That is to say that the high digital adoption states were already pulling ahead even before demonetisation, such that demonetisation was not a catalyst but rather a phenomenon that amplified the effect of digital adoption on tax revenues. This means that states that experienced greater levels of digital adoption were already experiencing higher rates of growth prior to the occurrence of demonetisation.

Thus, demonetisation did not cause digital adoption to develop from a state of non-existence; instead, it acted to catalyse an increase in digital transaction activity that was already underway. Therefore, the interaction effect that has been estimated in this analysis should not be interpreted as a purely causal effect resulting from the policy shock, but rather as an acceleration or enhancement of existing digital adoption practices that ultimately resulted in increased Tax revenue.

In essence, higher digital adoption is associated with high tax revenues, but the serial correlation and the pre-existing trend differences state that the estimated values should be inferred with caution and as suggestive rather than a strict causal relationship.

7. Policy Recommendations

7.1 Strengthening Digital Infrastructure in Rural and Semi-Urban Areas

Building better digital infrastructure in rural and semi-urban areas is key to making digital payments widely used by everyone. Even though digital transactions are growing quickly, there are still big differences in access to reliable electricity, mobile networks, broadband internet, and digital devices. When the infrastructure is not good enough, it causes payment failures, delays in settling money, and makes both customers and businesses less likely to use digital payments. It is important to invest in public projects that expand broadband, set up more mobile towers, and ensure a stable power supply to close this gap. Working with private telecom companies and local governments can help bring better connectivity to the most remote areas. Strong infrastructure not only helps more people gain access to financial services but also supports economic growth and development in these regions.

7.2 Encouraging MSMEs to Adopt Digital Payment Systems

Getting small businesses to use digital payments is important for making the economy more formal and helping them run more efficiently. Many small businesses still rely on cash because they lack awareness of digital payments, find them too complicated, or worry about transaction costs. Digital payments help maintain better financial records, reduce the risk of cash loss, and improve transparency. This makes it easier for small businesses to access formal credit and government benefits. Policies such as simplifying onboarding processes, providing technical support, and linking digital payments with accounting and tax systems can significantly increase adoption. Wider use of digital payments by MSMEs can improve tax traceability, boost productivity, and support sustainable business growth.

7.3 Promoting digital payments for increased transaction traceability and transparency

Promoting digital payments is expected to boost economic transaction transparency and traceability through verifiable digital records.This is because, unlike traditional cash-based transactions that do not have verifiable records, digital transactions have verifiable and trackable records. This helps minimise cases of tax evasion. This is particularly vivid when there is trust and transparency within the tax system. In particular, post-demonetisation, there has been a push towards promoting digital payments. This means that with many people transitioning to digital alternatives from traditional modes of payment, there is greater efficiency and transparency within the tax system. This is because people are increasingly turning to digital payments. The tax revenues are expected to grow with digital payments as they are linked. Overall, promoting digital payments is expected to boost economic efficiency and thus improve tax revenues.

7.4 Reducing Transaction Costs for Digital Payment Usage

Reducing the cost of using digital payments is essential to encourage wider adoption, particularly among small businesses and low-income users. High merchant fees and hidden charges can discourage digital payment usage, especially for small and frequent transactions. Policies aimed at simplifying fee structures, offering concessional rates for small merchants, and promoting free or low-cost payment options can increase adoption. Lower transaction costs make it easier for businesses to

accept digital payments and motivate consumers to move away from cash. Over time, higher transaction volumes can offset lower fees and help create a sustainable and inclusive digital payment ecosystem.

7.5 Support digital adoption at the state level to address inter-state tax revenue disparities

It is also observed in India that there are disparities in the overall digital payment adoption and in the generation of tax revenues of various states in India. Residents of states with good digital payment adoption tend to generate higher amounts of tax revenue. By employing various strategies for the development of digital practices in low digital payment adoption states in India, disparities in the generation of taxes in these states of India can be reduced. This can be achieved by offering financial support to states with less favourable digital payment adoption. Once all states in India adopt digital payment systems for dealing with financial transactions in India, there will be even more growth in the overall economy of India. This creates an important condition in India which motivates people to adopt digital payments for business transactions through the informal sector. With the development of digital payment systems in less developed states of India, the disparities among states can be reduced.

7.6 Improvement of internet connectivity and payment systems

This is necessary to reduce the number of failed transactions and increase people's trust in digital payments. Learning how to use digital tools can improve people's understanding of these tools, reduce their anxiety about being scammed, and help them become more productive.

Online trust can only be built by ensuring that the data is secure and customers are not at risk. This is because improved trust, lower transaction costs, and greater awareness reduce uncertainty and risk, which are key factors limiting the adoption of digital payments. The promotion of new financial technologies through startups, testing areas with flexible rules, and collaborating with government institutions can enhance the functionality and ease of use of existing payment systems. The provision of these services to everyone, particularly women, those without formal employment, and rural residents, is crucial for achieving fair digital growth. These steps can collectively contribute to the growth of digital payment usage, which may result in more formal economic activity and better tax collection.

8. Conclusion

8.1 Summary of findings

In this study, the effect of digital payment adoption on Tax revenue growth in India after the demonetisation of 2016 was investigated based on the secondary data. The use of digital transactions, such as UPI, has been found to increase the growth of taxes in India.

The regression analysis reveals a strong and statistically significant relationship between digital payments and Tax revenues; the former explains a large proportion of the variation in the latter. The results of the DiD further suggest that the states with a greater adoption of digital payments grew more in the Tax revenues post the demonetisation era than the states with less adoption of the same. The DiD effect is marginally statistically significant, yet economically relevant and indicative of improved transaction visibility in the formal economy.

The evidence shows that the rise of digital payments has facilitated the formalisation of the economy, as it has encouraged the generation of transaction data, which is reflected in the improved tax base. It is important to state that the data and methodology are subject to certain limitations and require mindful interpretation. This research indicates that digital payments are crucial in improving the tax base and encouraging India to move towards a clean economy.

8.2 Limitations

The analysis faces some restrictions related to data availability and measurement. State-level data on UPI transactions were not available during the time of analysis, and thus, overall electronic transactions are considered as a proxy for digital payment. Even though it facilitates the empirical study, it may not indicate the level of engagement and nature of UPI transactions at the state level. Lack of sufficient pre-treatment data means that robustness testing of the parallel trends assumption is limited. It is an important requirement in identification through causal means. The original dataset has inconsistencies at different levels of sources and time. As a result, there has been extensive manual checking and matching. Although the accuracy of data is enhanced to some level of consistency, there may be a risk of manual errors. States that lacked complete data on e-transactions are excluded from the study. It further reduces the pool of data collected. Since only seven states are considered for the analysis, the results may reflect relatively sharp contrasts between leaders and followers in the technological adaptation process. Furthermore, population, economic activity, and the base of taxes of selected states may create uniform variations. Since there are no district and firm-level data on transactions within the states, there are limitations in indicating variations at various levels.

The paper is further faced with some methodological limitations in terms of modelling, identification, and inference. In its empirical specification, it considers only state and time fixed effects, omitting other control variables such as growth in income, urbanisation, intensity of enforcement, and sectoral structure, which can have their own separate influences on Tax receipts and usage of digital payments. Although it considers a Panel Data setting, which poses challenges of correlation within states across different observations in time. It uses cluster-robust standard errors to control for such problems, which may face challenges in terms of precision and reliability because of the limited number of cross-sectional entities. The pre-treatment differences in both treated and control states can have implications for macroeconomic and institutional factors in violating the assumption of difference in differences underlying the Difference-in-differences estimates. It is observed in placebo tests for treatment outcomes that some differences existed even before demonetisation, to some extent, implying that causal estimates may be inadequately separated in their observations to confine to the impact created through policy intervention. In addition, its inability to thoroughly test for alternative hypotheses in modelling specifications and treatment effect heterogeneity makes it limited in its pursuit of precise causal estimates.

Appendix- A

Table A1: Difference-in-Differences Analysis

Variable	Coefficient	SE	p-value
Interaction	33917	15988	0.0377

Note: Authors' compilation of two-way fixed effects. Standard errors are not clustered. Exact p-values are reported. Interaction = Treatment × Post.

Table A2 :Model Fit Statistics for the Differences-in-differences model

Model Fit	Value
R^2	0.0648
Adjusted R^2	−0.1942

Note: Authors' compilation Model fit statistics for the difference-in-differences (DID) model. R^2 represents the proportion of variance explained by the model.

Table A-3: DiD Results with Clustered Standard Errors by State

Variable	Coefficient	SE	p
Interaction	33,917	20,150	0.097

Note: Two-way fixed effects are included. Standard errors are clustered by state. Exact p-values are reported. Interaction = Treatment × Post.

Table A-4: Wooldridge Test for Serial Correlation in DID Model

Test	F	df1	df2	p
Serial Correlation	650.520	1	75	<.001

Note: The null hypothesis of no serial correlation is rejected.

Table A-5: Placebo Test

Variable	Coeff.	SE	p-value
Interaction	28450.0000	16330.0000	0.0862

Note: Two-way fixed effects are included. Standard errors are clustered by state. Exact p-values are reported. The placebo interaction assumes a fake treatment year before the actual policy implementation.

Table A-6: Pre-treatment Year Coefficients (Wild cluster Bootstrap)

Year	Coefficient (β)	SE	t(6)	p
2013	−31,452	38,570	−0.82	.446
2014	−31,347	38,099	−0.82	.442
2015	−29,501	37,306	−0.79	.459

Note: Pre-treatment coefficients indicate similar Tax revenue trends across states before demonetisation, supporting a balanced comparison for the analysis.

Table A-7: Regression Summary Statistics

Regression Statistics	
Multiple R	0.973320254
R Square	0.947352316
Adjusted R-Square	0.945654004
Standard Error	20506.1997
Observations	33

Note: The regression model shows a strong fit, with a high R^2 indicating substantial explanatory power based on 33 observations.

Table A-8: Regression Coefficients

	Coefficients	Standard Error	t Stat
Intercept	204817.1326	5293.7653	38.69025561
Regression coefficient	0.033702989	0.001426992	23.61820969

Note. The table reports estimated regression coefficients along with their corresponding standard errors and exact p-values.

Table A-9: Regression Diagnostic Test Results

Test	Statistic	p-value	Interpretation
Durbin-Watson (DW)	1.50	—	No autocorrelation
Breusch-Pagan (BP)	0.164	0.685	No heteroskedasticity

Note. DW = Durbin-Watson statistic; BP = Breusch-Pagan test for heteroskedasticity

Appendix- B

Table B-1: Data used in Simple Regression Analysis - Taxes and UPI Transactions by Year (2013–2025)

Year	Quarter	UPI	Taxes
2016-17	Q1	0	-
	Q2	36.11	-
	Q3	856.96	-
	Q4	6059.07	-
2017-18	Q1	8166.67	-
	Q2	12893.78	1,41,529
	Q3	29901.35	1,96,386
	Q4	58870	2,02,180
2018-19	Q1	101144.39	2,20,547
	Q2	165890.76	2,05,801
	Q3	259805.3	2,15,761
	Q4	350130.27	2,34,662

2019-20	Q1	441050.03	2,41,067
	Q2	462348.09	2,18,674
	Q3	583109.79	2,19,477
	Q4	645222.23	2,48,787
2020-21	Q1	631367.26	2,41,067
	Q2	1899749.9	2,59,000
	Q3	2366729.31	2,86,777
	Q4	2619417.77	3,03,785
2022-23	Q1	3039206.65	3,35,780
	Q2	3252222.54	3,12,722
	Q3	3684230.91	3,28,406
	Q4	3945016.25	3,48,077
2023-24	Q1	4380114.41	3,86,857
	Q2	4689206.18	3,58,215
	Q3	5278458.37	3,78,547

	Q4	5647306.55	3,99,631
2024-25	Q1	6016482.77	4,36,016
	Q2	6189022.69	3,86,871
	Q3	6829708.77	4,14,518
	Q4	7021740.42	4,38,291
2025-2026	Q1	7313153.57	4,78,494
	Q2	7483707.54	4,16,510

Note: UPI denotes Unified Payments Interface transaction value, measured in ₹ crore. Taxes represent total indirect tax revenue (GST and related taxes) in ₹ crore. Quarterly data are reported by financial year. A dash (–) indicates unavailability of tax data for the corresponding period. Data are compiled from official Government of India and NPCI sources.

Appendix- C

Table C-1: Data used in Difference-in-Differences Analysis: State-Level Taxes and E-Transactions by Year (2013–2024)

Year	State	E-transactions	Taxes	Treat	Post	Interaction
2013	Maharashtra	206609291	55269	1	0	0
2013	Madhya Pradesh	390182032	12283	1	0	0
2013	UP	100369535	27976	1	0	0
2013	Bihar	9036383	7671	0	0	0
2013	Goa	1004519	1546	0	0	0
2013	Himachal Pradesh	4478396	2403	0	0	0
2013	Jharkhand	9926647	5127	0	0	0
2014	Maharashtra	153961930	56652	1	0	0
2014	Madhya Pradesh	291163866	12997	1	0	0
2014	UP	261406283	28277	1	0	0
2014	Bihar	12787793	9496	0	0	0
2014	Goa	763777	1809	0	0	0

2014	Himachal Pradesh	7286288	2621	0	0	0
2014	Jharkhand	14293478	5598	0	0	0
2015	Maharashtra	63040438	59694	1	0	0
2015	Madhya Pradesh	349133899	14160	1	0	0
2015	UP	387676263	30822	1	0	0
2015	Bihar	12840853	9875	0	0	0
2015	Goa	573329	1915	0	0	0
2015	Himachal Pradesh	36235493	3086	0	0	0
2015	Jharkhand	11551636	6262	0	0	0
2016	Maharashtra	30829411	60505	1	0	0
2016	Madhya Pradesh	345862943	15329	1	0	0
2016	UP	437046453	33388	1	0	0
2016	Bihar	20033553	12621	0	0	0
2016	Goa	1616547	2181	0	0	0

2016	Himachal Pradesh	21160143	3634	0	0	0
2016	Jharkhand	15567182	6411	0	0	0
2017	Maharashtra	134392928	67459	1	1	1
2017	Madhya Pradesh	215043508	17374	1	1	1
2017	UP	325649123	36468	1	1	1
2017	Bihar	67664948	14574	0	1	0
2017	Goa	3809091	2398	0	1	0
2017	Himachal Pradesh	49239003	3559	0	1	0
2017	Jharkhand	22099188	8061	0	1	0
2018	Maharashtra	151010498	105186	1	1	1
2018	Madhya Pradesh	185523403	15544	1	1	1
2018	UP	346752301	36,858	1	1	1
2018	Bihar	135752844	5531	0	1	0
2018	Goa	4075650	2772	0	1	0

2018	Himachal Pradesh	53627685	5309	0	1	0
2018	Jharkhand	35810512	14162	0	1	0
2019	Maharashtra	259198102	170289	1	1	1
2019	Madhya Pradesh	198781121	25683	1	1	1
2019	UP	399095261	61,323	1	1	1
2019	Bihar	127515752	10755	0	1	0
2019	Goa	5943684	4103	0	1	0
2019	Himachal Pradesh	56845063	7593	0	1	0
2019	Jharkhand	45248812	23916	0	1	0
2020	Maharashtra	168113915	185917	1	1	1
2020	Madhya Pradesh	132522102	28354	1	1	1
2020	UP	384470516	65,281	1	1	1
2020	Bihar	106565556	12640	0	1	0
2020	Goa	3423620	4280	0	1	0

2020	Himachal Pradesh	27331657	7960	0	1	0
2020	Jharkhand	39431248	22847	0	1	0
2021	Maharashtra	418591938	12416	1	1	1
2021	Madhya Pradesh	232569264	1559	1	1	1
2021	UP	1090126013	4,210	1	1	1
2021	Bihar	392997934	279	0	1	0
2021	Goa	2734245	344	0	1	0
2021	Himachal Pradesh	43209486	510	0	1	0
2021	Jharkhand	93334771	225	0	1	0
2022	Maharashtra	412276432	20136	1	1	1
2022	Madhya Pradesh	857422994	1891	1	1	1
2022	UP	1381526373	5,271	1	1	1
2022	Bihar	271914498	280	0	1	0
2022	Goa	2894916	555	0	1	0

2022	Himachal Pradesh	92625964	800	0	1	0
2022	Jharkhand	291985066	387	0	1	0
2023	Maharashtra	799957730	270346	1	1	1
2023	Madhya Pradesh	1475542368	36232	1	1	1
2023	UP	2597498013	87,970	1	1	1
2023	Bihar	53262600	16548	0	1	0
2023	Goa	4557803	5520	0	1	0
2023	Himachal Pradesh	143485322	8778	0	1	0
2023	Jharkhand	591550996	32019	0	1	0
2024	Maharashtra	1243876563	320117	1	1	1
2024	Madhya Pradesh	3678257082	42174	1	1	1
2024	UP	2488933209	1,01,693	1	1	1
2024	Bihar	967235333	18021	0	1	0
2024	Goa	6627768	6475	0	1	0

2024	Himachal Pradesh	153854534	9956	0	1	0
2024	Jharkhand	945913672	34738	0	1	0

Note. E-Transactions = total digital transactions reported in crores; Taxes = total state-level taxes reported in crores; Treat = 1 for high digital adoption states (Maharashtra, Madhya Pradesh, UP), 0 for control states; Post = 1 for post-policy years, 0 otherwise; Interaction = Treat × Post.

Appendix- D

R software output D-1:

Difference-in-Differences Analysis

```
> summary(did_model)
Twoways effects Within Model

Call:
  plm(formula = taxes ~ treat + post + interaction, data = pdf,
      effect = "twoways", model = "within")

Balanced Panel: n = 7, T = 12, N = 84

Residuals:
  Min.  1st Qu.   Median  3rd Qu.     Max.
-82463.0 -12336.8    852.8  11454.2 151862.1

Coefficients:
  Estimate Std. Error t-value Pr(>|t|)
interaction    33917      15988  2.1214  0.03771 *
  ---
  Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    8.1216e+10
Residual Sum of Squares: 7.5957e+10
R-Squared:      0.064751
Adj. R-Squared: -0.19424
F-statistic: 4.5002 on 1 and 65 DF, p-value: 0.037709
```

R software output D-2:

Difference-in-Differences Analysis with Clustered Standard Errors

```
> # Clustered SE by state
> cluster_se <- vcovHC(did_model, type = "HC1", cluster = "group")  # group = state
>
> # Show coefficient table with clustered SE
> coeftest(did_model, vcov = cluster_se)

t test of coefficients:

            Estimate Std. Error t value Pr(>|t|)
interaction    33917      20150  1.6832  0.09712 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

R software output D-3:

Wooldridge’s Test for serial correlation

```
Wooldridges test for serial correlation in FE panels

data:  did_model
F = 650.52, df1 = 1, df2 = 75, p-value < 2.2e-16
alternative hypothesis: serial correlation
```

R software output D-4:

Wild cluster bootstrap test

```
===== Wild Cluster Bootstrap Results =====
  > print(WCB)
Alternative hypothesis: two-sided
Coef. Estimate    SE Null value t-stat d.f. (naive-t) p-val (naive-t) Sig.
lead2013   -31452 38570          0 -0.815              6           0.446
lead2014   -31347 38099          0 -0.823              6           0.442
lead2015   -29501 37306          0 -0.791              6           0.459
>
```

R software output D-5:

Placebo Test

```
> # 5. Output results
> coeftest(placebo_model, vcov = cluster_se)

t test of coefficients:

                     Estimate Std. Error t value Pr(>|t|)
interaction_placebo    28450      16330  1.7421  0.08622 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

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Digital Growth, Physical Cost: Assessing the Water Consumption of AI Infrastructure in Urban India

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ABSTRACT

Artificial Intelligence (AI) has significantly impacted modern economies, including the financial, healthcare, logistics, governmental, and communication sectors. Although sustainability issues related to AI have been extensively discussed in the context of carbon emissions and energy consumption, the water consumption of data centres has not been adequately addressed, especially in water-scarce nations. In such nations, the cooling needs of data centres in hot environments result in high water consumption, thereby raising concerns about the environmental compatibility of these data centres. Using a secondary, data-driven, quantitative research methodology, the study calculates the water consumption of data centres by multiplying the information technology capacity benchmarks by the global water usage effectiveness (WUE) figures. The study estimates that, with an operational capacity of 300 MW, the data centres would consume approximately 4.73 billion litres of water annually, equivalent to the domestic water consumption of nearly 24,000 urban households annually. Projecting the scenarios, the study finds that if the capacities double to 600 MW by 2030, the water consumption would rise to approximately 9.5 billion litres annually, even after accounting for improvements in efficiency. The study identifies a water-energy-AI nexus wherein efficiency gains in cooling infrastructure are systematically offset by the scale of hyperscale deployment. In water-stressed metropolitan contexts, this dynamic risks compounding existing inequalities in water access. To operationalise governance responses, the study proposes the AI Water Impact Index (AWII): a composite metric integrating water intensity, freshwater dependency, local water stress, and climate vulnerability as a tool for embedding water accountability into Environmental Impact Assessments and infrastructure licensing frameworks.

The study proposes the concept of an AI water impact index that takes into account water intensity, recycled water, and water stress to develop sustainable data centres. The study's intention is not to impede the development of AI but to ensure that it is sustainable, respecting the environmental realities of the region. By incorporating water as an important aspect in the discussion of AI sustainability, the study creates a framework that balances the need for technological development with the sustainability concerns in the metropolitan environment. The study reveals the presence of a high level of interconnection between water, energy, and AI, where improvements in efficiency can be offset by the scale of regional infrastructural development. In metropolitan environments facing water stress, uncontrolled hyperscale development is likely to exacerbate water inequality in the region.

Keywords: artificial intelligence (AI), data centres, water consumption, water usage effectiveness (WUE), urban water scarcity, digital infrastructure sustainability, AI Water Impact Index (AWII)

JEL Classification: Q25, Q55, Q56, L86

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1. Introduction

Artificial Intelligence (AI) is transforming today's tech landscape. From the latest advancements in language processing to predictive analytics, AI requires significant computational resources, most of which are supplied by hyperscale data centres. As the use of AI grows in various segments of the economy, the cloud resources that provide the foundation for AI will likely rise in parallel.

The environmental impact of AI is one of the major concerns in today's tech world, with most of the discussion revolving around the impact of carbon emissions and the consumption of energy. Estimates suggest that developing highly complex

AI requires the consumption of millions of kilowatt-hours of power, which sparks the concern of using fossil fuels and their impact on climate change. Another important aspect of the environmental impact of AI that has not been given due emphasis is its consumption of water, the second factor that needs to be considered.

Data centres require a lot of cooling systems because of the heat they produce. These cooling systems use a lot of water. The environmental impacts of AI and the use of water in cooling systems of hyperscale data centres are a major concern. Bengaluru, the technology capital of India, faces a water crisis.

The city is developing a strong technology industry and investing in cloud and AI technology. This study, therefore, asks: Can a water-scarce city like Bengaluru sustain the hyperscale data centre expansion demanded by AI growth without exacerbating its existing water crisis?

The current study focuses on the water consumption of hyperscale data centres in Bengaluru through a systematic estimation methodology.

Unlike other studies that discuss the environmental impacts of AI in a generalised manner, this study focuses on a local estimation of water consumption of hyperscale data centres in Bengaluru.

Within the broader framework of urban water governance, this research makes three contributions to the sustainability literature. It foregrounds water as a primary metric in the environmental analysis of AI technologies, following Mekonnen and Hoekstra (2012); it connects digital economy growth with urban resource governance in the Global South; and it offers a quantitative tool: the AI Water Impact Index, for policymakers engaged in sustainable urban infrastructure planning.

2. Literature Review

The current literature on the environmental impact of AI is primarily focused on energy consumption and carbon emissions (Strubell et al., 2019; International Energy Agency, 2023).

For instance, Strubell et al. (2019) measure the carbon footprint that is needed to train deep neural networks and also examine the effects of that footprint on the environment. Another example is that the International Energy Agency surveyed data centres around the world and found that data centres' electricity consumption is increasing (International Energy Agency, 2023).

On the other hand, water use is not given much attention in the literature. Mekonnen and Hoekstra (2012) highlight that indirect use of water is crucial in infrastructure networks by referring to industrial water consumption.

In recent literature, sustainability reports by Microsoft and Google address water use in data centres, especially in arid environments (Microsoft, 2023; Google, 2023). It is stated that data centres use millions of litres of water per year, depending on environmental conditions (Uptime Institute, 2023; Lawrence Berkeley Nation.

In addition, literature reviews of data centre cooling technologies are surveyed, including air-cooled data centre cooling, chilled water data centre cooling, and evaporative towers (The Green Grid, 2011; Lawrence Berkeley National Laboratory, 2020).

Although evaporative towers are efficient with regard to electricity consumption, they use more water in arid environments (Uptime Institute, 2023).

Regarding the Indian scenario, literature has mainly focused on Bengaluru's water scarcity and groundwater depletion (Central Ground Water Board, 2023; BWSSB, 2023). Previous studies have covered Bengaluru's dependency on pumping the Cauvery River and its tanker markets (Karnataka State Water Resources Department, 2023).

Yet, only a few studies connect industrial water usage with digital infrastructure and Bengaluru's urban water problems. Industry bodies, like NASSCOM and the Data Centre Association of India, offer projections for server capacity growth. (NASSCOM, 2023; Data -Centre Association of India, 2023). Yet, water sustainability is hardly ever the focus of these studies.

This indicates an apparent gap in the literature. While global studies do highlight the water usage of data centres (International Energy Agency, 2023; Uptime Institute, 2023), empirical studies are lacking for the water-scarce Indian urban scenario. The relationship between the growth of AI and urban water management has not been adequately explored.

This paper relies on global environmental impact studies while providing a geographically focused analysis.

3. Bengaluru's Water Crisis

Bengaluru has always been the technology hub of India, but the sudden spurt in growth has caused immense pressure on the water resources in the city (NASSCOM, 2023). Bengaluru was known for its lakes, but now these lakes are fenced off, polluted, or converted into real estate projects (Karnataka State Water Resources Department, 2023).

This has resulted in a huge gap between the demand for water and the supply of water that can be sustainably provided (BWSSB, 2023).

Currently, Bengaluru gets its water supply from the Cauvery River, which is about 100 kilometres away from the city (BWSSB, 2023). This requires lifting water through several hundred meters (BWSSB, 2023) In addition to this, Bengaluru also gets a substantial amount of its water supply from groundwater sources through borewells; Groundwater levels have shown a downward trend in Bengaluru in recent times (Central

Ground Water Board, 2023).

For instance, in the outer periphery, water tankers have become an additional water source by extracting water from bore wells in the surrounding rural areas (Karnataka State Water Resources Department, 2023). On the other hand, population growth and economic activities still place a strain on water resources despite the limited supply capacity (BWSSB, 2023). Besides, droughts and other climatic issues have also posed a problem (IPCC, 2021).

In this case, bore well water depletion and the increased use of water tankers during emergencies reflect the stress on water resources (Central Ground Water Board, 2023). Conservation and reuse of water have been highly recommended as methods to deal with these problems (Karnataka State Water Resources Department, 2023).

However, there are insufficient studies that estimate the amount of water needed to support the development of the digital economy, particularly with regard to data centres and cloud computing (International Energy Agency, 2023; NASSCOM, 2023). With the continued development of Bengaluru as a city known for its cloud computing and data centre capabilities driven by AI (JLL India, 2023; CBRE India, 2023), the increasing use of water-cooled systems presents a burden on Bengaluru's already strained water supply system (Uptime Institute, 2023).

A detailed understanding of Bengaluru's water crisis is necessary to understand the environmental impact of AI infrastructure. While data centres do not use a lot of water, it is necessary to consider whether this water usage would be sustainable to a metropolitan city that is already stressed for water (World Resources Institute, 2023).

4. AI Data Centres and Cooling Technologies

Artificial Intelligence computations require highly dense computational resources, mostly provided through GPUs and processors (International Energy Agency, 2023). These highly demanding hardware devices require heat management as a critical requirement for their reliable operation and longevity (Lawrence Berkeley National Laboratory, 2020). Data centres require continuous operation and thus pose a continuous requirement for heat management (International Energy Agency, 2023).

Data centre cooling systems require air conditioning systems, chilled water systems, and evaporative cooling towers for cooling purposes (The Green Grid, 2011; Lawrence Berkeley National Laboratory, 2020).

Conventional air conditioning systems require the circulation of cold air through the server racks for cooling purposes, thereby reducing water consumption and increasing electricity consumption due to the installation of air conditioning systems (Uptime Institute, 2023).

The chilled water systems require the circulation of cold water through heat exchangers for cooling purposes, thereby reducing server temperatures. The amount of water consumption depends upon the efficiency of the cooling system design (Lawrence Berkeley National Laboratory, 2020).

The evaporative cooling towers are widely adopted in data centres for cooling purposes because of the substantial amount of electricity savings achieved through this cooling technology (The Green Grid, 2011). This cooling technology requires water evaporation for cooling purposes.

Water evaporation changes its state of matter from liquid to vapour and absorbs heat during this process (Lawrence Berkeley National Laboratory, 2020). Water consumption proves to be a challenge in this technology because water evaporation increases in a warm environment, thereby increasing water consumption (Uptime Institute, 2023). Blowdown of the cooling towers requires periodic maintenance and increases water consumption (The Green Grid, 2011).

The Water Usage Effectiveness (WUE) of a data centre serves as a widely accepted benchmark for measuring the efficiency of water usage in a data centre (The Green Grid, 2011). WUE is defined as the ratio of annual water consumption and electricity consumption of information technology equipment (The Green Grid, 2011).

Even as organisations claim that water use efficiency (WUE) has improved with better design, water consumption is high in hyperscale data centres (Microsoft, 2023; Uptime Institute, 2023).

Environmental factors are one of the important factors that essentially influence the actual nature of cooling. In arid environments such as Bengaluru, the high ambient temperatures lead to a higher demand for evaporative cooling systems. This increases the water demand considerably for efficient cooling systems (Uptime Institute, 2023; IPCC, 2021). Some organisations are also exploring alternative cooling systems for their facilities. These alternative systems include liquid immersion cooling and wastewater cooling. These systems have not been widely adopted in the industry sector as of now (Microsoft, 2023; Google, 2023).

The increasing workload of artificial intelligence systems changes the systems in real time. The training of AI systems requires server farms running at full capacity (Strubell et al., 2019). The capacity for providing AI services increases in line with the demand for AI services. This requires the establishment of new facilities in the form of additional data centres. This increases the water demand for cooling purposes as well as the power demand for running the facilities (International Energy Agency, 2023; NASSCOM, 2023).

In Bengaluru, water forms a basic constraint for the environment. The selection of water-demanding cooling systems requires a critical analysis. The lack of transparency and regulatory frameworks could lead to a substantial increase in water demand for cooling purposes in the combined facilities of the industry sector. A critical analysis of cooling systems is required for an accurate estimation of water demand for AI and the development of appropriate policies.

5. Research Methodology

In this study, we use a quantitative approach and secondary data to estimate the WF of AI-enabled data centres located in Bengaluru. Since reliable data regarding facility-level water use is scarce in India, our study uses industry reports, academic literature, corporate sustainability reporting, and available

secondary data regarding infrastructure capacity.

Firstly, we estimate the total data centre operational capacity located in Bengaluru in terms of its megawatt (MW) capacity. Data regarding data centre capacity is available through industry publications and market reports, including those published by NASSCOM.

Secondly, we use the Water Usage Effectiveness (WUE) method to estimate data centre water consumption. Industry reports suggest that evaporative cooling technologies use, on average, 1.5 to 2.0 litres of water per kilowatt-hour (kWh) of electricity produced. To estimate data centre water consumption, we multiply data centre capacity (in kW) by the total number of operating hours per annum (8,760) and by the WUE value. Assumptions are made conservatively to ensure that our estimate is reliable and defensible.

Third, we contrast the approximate water usage in the industry with the domestic water demand in Bengaluru. Domestic water demand is calculated using standard urban per-capita water requirements and average household sizes. This helps to contextualise industrial water use in terms of household water use, which is helpful for policymakers.

Finally, scenario analysis forecasts water demand up to 2030, taking into account possible growth in installed capacity and possible efficiency gains. A sensitivity analysis is used to address possible uncertainties in cooling system efficiency and load factors.

The primary limitation of this approach lies in its reliance on aggregate capacity estimates and standardised efficiency benchmarks rather than

analysis is used to address possible uncertainties in cooling system efficiency and load factors.

The primary limitation of this approach lies in its reliance on aggregate capacity estimates and standardised efficiency benchmarks rather than facility-level disclosures. Heterogeneity in cooling technology mix, partial use of recycled water, and the absence of real-time public reporting introduce uncertainty into the estimates (Uptime Institute, 2023). Conservative parameter assumptions are applied throughout to ensure the model yields a reliable lower-bound approximation rather than an inflated projection.

6. Methodology and Estimation Model

This paper uses a secondary data-based quantitative approach to estimate the water consumption of AI-based data centres in Bengaluru. Since there is a lack of public access to data center facility-level water consumption data in India (Data Center Association of India, 2023), the approach combines data from industry market studies, data center cooling studies, company sustainability reports, and efficiency studies to create an estimation approach that is transparent and defensible rather than making assumptions based on data that may not be publicly available or accessible (International Energy Agency, 2023; Lawrence Berkeley National Laboratory, 2020).

Stage 1 of the approach will estimate the total installed IT processing capacity of existing data centres in Bengaluru. "Installed capacity in terms of megawatts (MW) acts as a standard measure of data centre processing capability and potential energy consumption" (International Energy Agency, 2023).

The determination of total installed capacity will be done by reviewing publicly available studies that report year-to-year increases in data centre capacity due to cloud services, artificial intelligence, and digitalisation of business processes (JLL India, 2023; CBRE India, 2023; NASSCOM, 2023).

Stage 2 of the proposed methodology will estimate annual energy consumption and associated water use. Annual energy consumption will be calculated by multiplying installed data centre capacity by total annual operating hours. Since data centres operate 24/7, annual operating hours will be 24 hours × 365 days/year, or 8,760 hours/year (International Energy Agency, 2023). To estimate data centre water use, the proposed approach will use Water Usage Effectiveness efficiency values based on technical studies published in the global technical literature (The Green Grid, 2011). Since evaporative cooling is commonly used in large data centres, it will be assumed that data centre cooling consumes 1.5 to 2.0 litres/kWh of IT energy use, depending on factors such as climate (Lawrence Berkeley National Laboratory, 2020; Uptime Institute, 2023).

Annual Water Use = IT Load (MW) × 8,760 hours × WUE Factor

In the following step, data centre water use will be contextualised by comparing data centre water use with urban domestic water demand in Bengaluru. Conventional urban per capita water supply values and assumptions regarding average household sizes (BWSSB, 2023) are used to estimate the number of households with annual water use equivalent to that of the data centre.

Although the process is based on certain assumptions, the variables are informed by industry standards and peer-reviewed articles (International Energy Agency, 2023; The Green Grid, 2011). The limitations of the methodology include the diversity in cooling technologies, the partial use of recycled water, and the unavailability of public data on real-time disclosure (Uptime Institute, 2023). Nonetheless, the process provides an easy estimate of the Water consumption of AI infrastructure in a water-scarce city (World Resources Institute, 2023).

7. Data Analysis and Comparative Assessment

Using the estimation framework, it has been estimated that the data centres in Bengaluru support an active capacity of 300 MW (JLL India, 2023; CBRE India, 2023; Knight Frank India, 2023). When these operate continuously at an average water usage effectiveness of 1.8 litres/kWh (The Green Grid, 2011; Uptime Institute, 2023), water consumption can be estimated.

300 MW equates to 300,000 kW. Operating continuously for 8,760 hours per annum (International Energy Agency, 2023), it can be calculated that 2.628 × 10^9 kilowatt-hours of electricity are used. Using 1.8 litres/kWh water usage effectiveness (Lawrence Berkeley National Laboratory, 2020), it can be calculated that 4.73 × 10^9 litres are used per annum.
Domestic water consumption can be used as a basis for comparison. Assuming that 135 litres per person per day (BWSSB, 2023) is used as an average water consumption per person, and assuming that there are 4 persons in a household, 540 litres are used per household per day. This equates to 197,100 litres used per household per annum. The water used by the data

centres (4.73 × 10^9 litres) divided by the water used per household per annum (1.971 × 10^5 litres) equates to 24,000 households that could be supplied with water for one year. While not a majority, it is a large proportion of water usage within a water-stressed system (World Resources Institute, 2023).

This estimate, however, does not take into account factors like future growth, indirect water usage in electricity production, or water usage during the construction phase (International Energy Agency, 2023). Local impacts are also not considered, as groundwater resources may affect the populations surrounding data centre clusters (Central Ground Water Board, 2023).

This, in essence, indicates that the usage of AI systems contributes to the total urban water usage, which needs to be considered as part of the broader urban water planning process (World Resources Institute, 2023). As digital growth continues to increase exponentially (NASSCOM, 2023), this may be more pronounced. Additionally, as the application of artificial intelligence technology continues to increase in sectors like finance, healthcare, government, and education, it is clear that the demand for computational resources will continue to grow exponentially (International Energy Agency, 2023). As the number of hyperscale data centres increases, along with edge data centres in urban environments (CBRE India, 2023), the cumulative effect of water usage may increase. As such, it is important to consider the adoption of more efficient cooling systems, like liquid immersion cooling systems, as well as recycled water systems (Microsoft, 2023; Google, 2023). As such, it is important for policymakers to encourage the disclosure of Water Usage Effectiveness, as well as the adoption of treated wastewater as opposed to fresh water (The Green Grid, 2011; Uptime Institute, 2023).

Table 1: Estimated Annual Electricity and Water Consumption of AI Data Centres in Bengaluru

Variable	**Value**	**Calculation**
Active Capacity	300 MW	Reported operational estimate
Converted Capacity	300,000 kW	1 MW = 1,000 kW
Annual Operating Hours	8,760 hours	24 × 365 (continuous operation)
Annual Electricity Consumption	2.628 billion kWh	300,000 × 8,760
Water Usage Effectiveness (WUE)	1.8 liters/kWh	Industry benchmark
Estimated Annual Water Usage	**4.73 billion liters**	2.628B × 1.8

- ***LL India:*** *Data Centre Update Reports (2023-2024)*
- ***CBRE*** *India Data Centre Market Reports*
- ***Knight Frank India:*** *Data CentreMarket Overview*
- ***NASSCOM*** *Data Centre Growth Reports*

These reports confirm Bengaluru's position as one of India's key data centre markets, with data centre capacities ranging from 250 to 350 MW.

Table 2: Comparative Domestic Water Consumption Equivalent

Variable	**Value**	**Calculation / Basis**
Per Capita Daily Usage	135 liters	Urban Indian benchmark
Household Size	4 members	Standard assumption
Household Daily Usage	540 liters	135 × 4
Annual Household Usage	197,100 liters	540 × 365
Equivalent Households Supported	≈ 24,000 households	4.73B ÷ 197,100

- Water Usage Effectiveness (WUE) was introduced by The Green Grid (2011).
- Uptime Institute Sustainability Reports
- Research by Lawrence Berkeley National Laboratory (LBNL) regarding data centre water use.
- Industry benchmark studies have shown that the industry average range for WUE is 1.5 to 2.0 L/kWh for evaporative cooling systems, and the measured value of 1.8 L/kWh is found to be within this range.

Table 3: Key Insights on Comparative Analysis

Total Annual Water Use	Household Equivalent	Policy Relevance
4.73 Billion Litres	≈ 24,000 households annually	Significant for water-stressed Bengaluru

9. Scenario Projection: 2030 Expansion Model

Industry projections show a significant increase in the data centre capacity in India. There is a possibility of the capacity in the country doubling or tripling by the year 2030 (JLL India, 2023; CBRE India, 2023; NASSCOM, 2023). The increase in data centres is fueled by the rapid adoption of artificial intelligence technologies, increased adoption of cloud computing services, digital governance policies in the country, and the digitisation of businesses (International Energy Agency, 2023; NASSCOM, 2023). Among the cities in the country, Bengaluru is expected to dominate in terms of data centre capacity (Knight Frank India, 2023). Therefore, it is important to assess the long-term implications of the increase in data centres on the water resources in the context of sustainable urban development in the country.

Based on the projections of a moderate increase in the data centre capacity in the country, the capacity in the

city of Bengaluru is expected to increase from 300 MW to 600 MW by the year 2030 (JLL India, 2023). Based on the assumption of constant operational behaviour and the application of the same Water Usage

Effectiveness (WUE) criterion (The Green Grid, 2011; Uptime Institute, 2023), the water consumption would increase proportionally with the capacity. In the base case scenario, the annual consumption of water is around 4.7 billion litres. At 600 MW, it will rise to around 9.5 billion litres. This is equivalent to the annual domestic water demand of around 48,000 households, based on BWSSB's supply standards (BWSSB, 2023). In a city that is already experiencing seasonal supply shortages and groundwater stress (Central Ground Water Board, 2023), an increase of this nature in industrial demand will have considerable policy implications. In the 600 MW scenario, water consumption is projected to fall to 7.5 billion litres annually, despite the 20 per cent improvement in cooling efficiency. However, it is also evident that water consumption is likely to increase with the rise in computing power, despite the improvement in cooling efficiency (The Green Grid, 2011).

In the high-growth scenario, projected annual water consumption exceeds 14 billion litres, even after accounting for efficiency improvements, despite improvements in cooling efficiency, in the event that the 900 MW scenario is achieved by the year 2030, considering the rise in hyperscale investments and artificial intelligence-driven digital transformation (CBRE India, 2023; NASSCOM, 2023). The overall water consumption associated with artificial intelligence is also likely to be influenced by the effects of climate change, such as the rise in temperatures in tropical cities, where the total rate of evaporation in cooling towers is also likely to rise (IPCC, 2021; Uptime Institute, 2023).

The geographic concentration of water consumption associated with artificial intelligence is also likely to be alarming, since the concentration of data centres in a particular geography is likely to raise the water consumption and extraction, despite the fact that water consumption in the city is likely to remain the same (Central Ground Water Board, 2023; World Resources Institute, 2023).

The prospect of uncontrolled AI-driven urban infrastructure development in the projected 2030 expansion scenario indicates that artificial intelligence is likely to influence the water demand in the city in the near future, and hence the need to integrate water sustainability with the region's technological development.

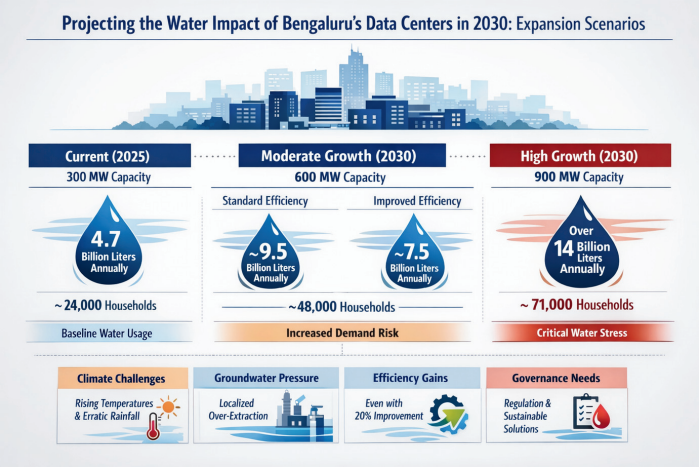


Figure 1: Comparative Domestic Water Consumption Equivalent

Note: The infographic itself was custom-designed using the above research inputs and projected calculations regarding Bengaluru's data-centre expansion and associated water consumption by 2030.

10. Policy Framework and AI Water Impact Index

In order to address the Water consumption associated with artificial intelligence, it is advisable to adopt a multilevel policy intervention. Firstly, it is recommended that data centres be required to report annual Water consumption data, including the total water withdrawn, water reused, and water discharged annually. This is now viewed as a necessity for the governance of sustainable infrastructure.

Secondly, it is recommended that data centres be incentivised to use non-potable water, such as recycled water, for cooling purposes. Local government bodies should mandate the use of a minimum level of recycled water for cooling purposes to reduce the consumption of potable water. Corporate sustainability reports indicate that the use of wastewater is increasing in data centre operations.

Thirdly, it is recommended that data centres be incentivised to adopt water-efficient technologies for cooling purposes. This could include water-neutral technologies, such as liquid immersion cooling, for data centres.

Another policy intervention that could be undertaken to address the Water consumption of artificial intelligence is the development of an AI Water Impact Index (AWII) that would rate data centres in the artificial intelligence industry based on Water consumption, recycled water, water usage effectiveness, and the water stress level of the region in which the data centre is located.

The inclusion of the AWII in all Environmental Impact Assessments would ensure that the development of data centres is aligned with sustainable development principles. In addition, the public release of the AWII would incentivise data centres to improve their sustainability ratings.

11. AI Water Impact Index (AWII): A Composite Assessment Framework

11.1. Rationale for a Composite Index Approach

Existing regulatory frameworks and corporate sustainability disclosures lack a composite metric that integrates water intensity with geographic and climatic context.

While Water Usage Effectiveness captures operational efficiency, it does not account for the water stress of the region in which a facility operates, the proportion of freshwater drawn from municipal supply, or the forward-looking risk imposed by climate change. The AWII is proposed to address this gap.

To address this problem, the AI Water Impact Index (AWII) is proposed in this paper. This is a composite index that quantifies the water stress impact of AI data centres.

The AWII combines four factors:

- Operational water intensity
- Freshwater use
- Baseline water stress
- Climate vulnerability amplification

11.2. Variable Definition

Let:

- **WU** = Water Usage Effectiveness (litres per kWh)
- **E** = Annual electricity consumption (kWh/year)
- **RW** = Proportion of recycled/non-potable water used (0–1 scale)
- **WS** = Local baseline water stress index (0–1 scale; e.g., WRI Aqueduct)
- **CV** = Climate vulnerability factor (0–1 scale)
- **W benchmark** = Global best-practice water consumption benchmark

11.3. Mathematical Formulation

Annual Direct Water Consumption

W = WUE × E

Where W represents total annual use (litres), derived from standard WUE methodology (The Green Grid, 2011).

11.4. Normalised Water Intensity

WI = W/ W benchmark

This type of normalisation allows us to make comparisons across the regions irrespective of the size of their infrastructure, as well as how far they are from the best-practice benchmarks (Lawrence Berkeley National Laboratory, 2020).

11.5. Composite AI Water Impact Index

AWII=WI×(1−RW)×WS×(1+CV)

This multiplicative form causes the efficiency, need for freshwater, geographic stress, and climate exposures to interact with each other, instead of looking at them individually (World Resources Institute, 2023).

11.6. Interpretation of Index Components

1. **Water Intensity (WI):** This component reflects the combined influence of infrastructure scale and cooling efficiency. Larger hyperscale deployments or legacy cooling systems increase WI (Uptime Institute, 2023).
2. **Freshwater Dependency (1 - RW):** This component penalises reliance on potable freshwater. Higher utilisation of treated wastewater or recycled sources reduces overall impact (Microsoft, 2023; Google, 2023).
3. **Local Water Stress (WS):** This variable integrates basin-level water risk into infrastructure assessment. Facilities located in highly stressed watersheds carry amplified sustainability risks (World Resources Institute, 2023).
4. **Climate Vulnerability (1 + CV):** This factor introduces a forward-looking risk adjustment reflecting increasing cooling loads under rising temperatures and extreme heat events (IPCC, 2021).

Table 4: Interpretation of AWII Values

AWII Value	Interpretation	Policy Implication
< 0.5	Low water impact	Eligible for standard approval
0.5 – 1.0	Moderate impact	Conditional approval + reporting
> 1.0	High impact	Mandatory mitigation + recycled water threshold
> 1.5	Critical stress zone	An infrastructure cap or offset is required

12. Governance Application

The AWII has four principal governance applications. In Environmental Impact Assessments, it provides a standardised water risk score that can condition development approvals. In urban water allocation planning, it enables municipal authorities to model cumulative industrial water demand from the digital sector. In sustainability disclosure frameworks, public release of AWII scores creates reputational incentives for operators to improve their ratings. Finally, in zonal infrastructure licensing, AWII thresholds can serve as binding constraints on data centre development in high water-stress areas, directing investment toward less water-vulnerable geographies.

The application of the ecological context to digital infrastructure planning enables proactive governance as opposed to reactive governance.

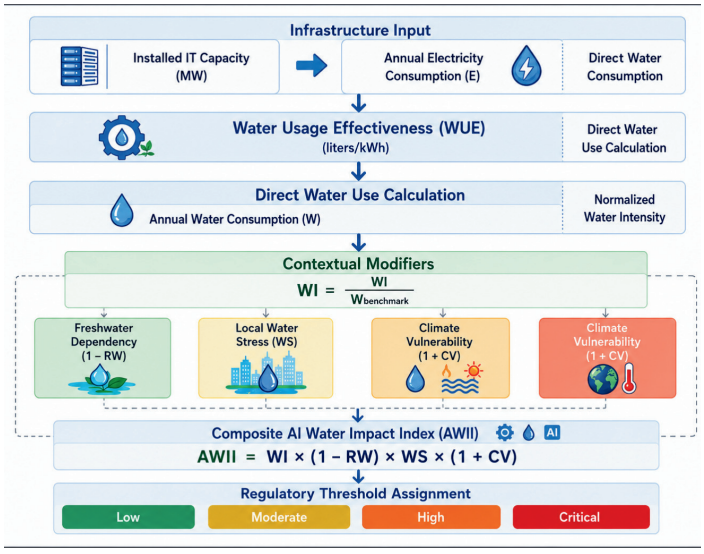


Figure 2: Structural Framework of the AI Water Impact Index (AWII)

13. Conclusion

Artificial Intelligence is often thought of as a mysterious digital entity behind emerging ideas and economic shifts. The present study demonstrates that AI is also linked to machines using water resources to function and impact the environment, particularly in cities with scarce water resources, such as Bengaluru (International Energy Agency, 2023; World Resources Institute, 2023). Using a simple calculation method based on Water Usage Effectiveness (WUE) standards (The Green Grid, 2011), it is evident from the study that AI-powered data centres use a large quantity of water resources for cooling high-performance computers (Uptime Institute, 2023). Currently, AI-powered data centres might not occupy a large portion of Bengaluru's overall water resources. Nevertheless, a predicted expansion in data centre capacity is expected to occur by 2030 (JLL India, 2023; CBRE India, 2023), which might lead to a large increase in water consumption for industrial purposes. Bengaluru already relies on water resources from distant rivers, groundwater resources, and water tankers (BWSSB, 2023; Central Ground Water Board, 2023). Expanding water resource-dependent infrastructure in these conditions might also raise sustainability issues. The study also proves a point that water consumption must be considered alongside carbon footprint while evaluating the environmental impacts of digital infrastructure (International Energy Agency, 2023). Water resource accountability is a must while permitting infrastructure to avoid unexpected environmental issues (World Resources Institute, 2023).

Finally, to conclude, the sustainability of AI is directly linked to the physical infrastructure supporting it. While cities are moving forward with AI-driven digital shifts, it is now a must to align technology growth with water resource management for a healthy ecosystem (IPCC, 2021).

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The Effectiveness of Zero Interest Rate Policy and Quantitative Monetary Easing

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ABSTRACT

The late 1990s saw economic stagnation and a decline in Japan after the bursting of the asset price bubble, one of the greatest macroeconomic phenomena in economic history. The bursting of the real estate and liquidity bubble is the cause of the deflation in Japan. To address this scenario, the Bank of Japan implemented a set of unconventional policies, including the Zero Interest Rate Policy, Quantitative Monetary Easing, the Negative Interest Rate Policy, and Yield Curve Control. The Bank of Japan temporarily implemented a zero interest rate policy and a 0.25 call rate on the overnights after indicating that the economy was recovering in 1999. This was, however, changed to a revised economic deterioration, causing the central bank to cut rates to 0.15% and the introduction of quantitative easing in 2001. In quantitative monetary policy, financial institutions are permitted to borrow with some collateral discounting, which makes the banking system liquid. This research paper will discuss how the unconventional monetary policies of Japan were effective in solving the deflation problem and boosting economic growth. This paper, using secondary macroeconomic data and qualitative analysis of the policy mechanisms, informs us of the connection between monetary expansion, inflation, GDP growth, and credit transmission. According to the research, unconventional policies helped to avoid a systemic financial breakdown and created a stable market; however, they did not lead to long-term inflation and economic recovery because of structural rigidities and poor credit demand. This experience demonstrates the weakness of monetary policies in the liquidity trap environment.

Keywords: Japan, unconventional monetary policy, deflation, quantitative easing, liquidity trap

JEL Classification: E52, E58, E31, E32, E44, E51, G21, O53

1. Introduction

The economy of Japan experienced extraordinary growth during the post-World War II period, emerging as one of the world's largest economies by the late 20th century. However, the late 1980s saw the formation of a massive asset price bubble, which is identified by rapidly rising stock and real estate prices. The collapse of this bubble in the early 1990s triggered an unusual period of economic stagnation often referred to as the "Lost Decade", although it lasted longer than 10 years.

One of the greatest stock indices, the Nikkei, which lost a substantial portion of its value, fell in the price of real estate. Several financial institutions accumulated large volumes of non-performing loans, which affected the banking sector. Investment slowed, consumption weakened, and inflation began to decline. By the late

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1990s, Japan was facing deflation, which affected the fall in prices.

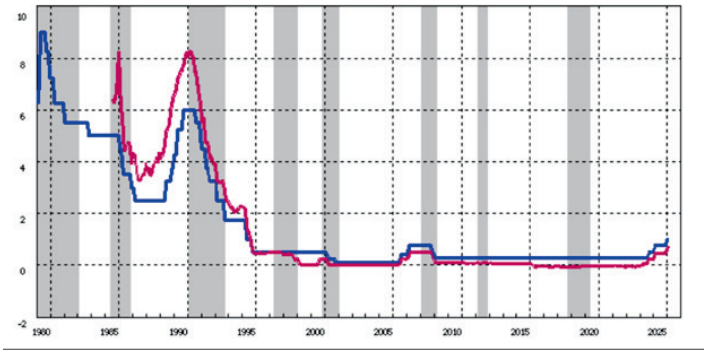


Figure 1: The graph represents the interest fluctuation of Japan from the 1990s to 2025.

Source: BOJ Time-Series Data Search

In response to these developments, the Bank of Japan has reduced short-term interest rates to zero. The adoption of a zero-interest rate policy aimed to enhance borrowing and lower the cost of credit. However, despite near-zero nominal interest rates, economic growth remained slow. Households and firms preferred to hold cash or repay debt instead of increasing spending. This concept is consistent with the liquidity trap, where monetary policy loses effectiveness because of an increase in the money supply and no chance of higher demand.

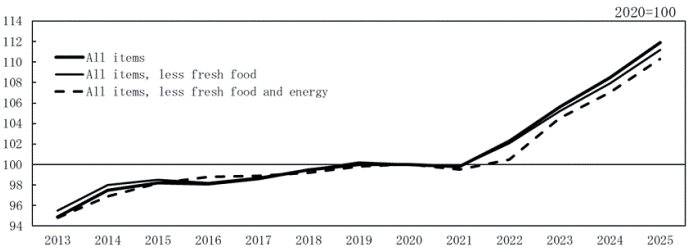


Figure 2: Index Price of Consumers' Goods

Source: Statistics Bureau of Japan

In the year 2000, observing tentative signs of economic improvement, the BOJ raised the overnight call rate to 0.25 per cent. The policy tightening proved premature, as economic conditions soon deteriorated. The central bank reversed its stance, reducing the rate to 0.15 per cent and eventually introducing quantitative monetary easing in 2001. This shift marked a transition from interest rate targeting to balance sheet expansion.

This research paper analyses Japan's unconventional monetary policy measures and evaluates their effectiveness in combating deflation and promoting growth. It seeks to answer the following research questions:

1. To what extent did the zero-interest-rate policy stimulate economic growth?
2. Was quantitative monetary easing really effective in boosting inflation and credit growth?
3. What were the structural reasons behind the failure of the monetary policy in Japan?

2. Literature review

2.1 Theoretical Background: Zero Lower Bound and Liquidity Trap

A key idea behind the analysis of ZLB monetary policy is the liquidity trap, which was originally attributed to Keynes and more recently formulated by Krugman (1998, 1999, as cited in Kimura et al., 2003). The liquidity trap develops when the monetary authority cannot make the real interest rate sufficiently low to exit its negative output gap because the nominal rate cannot go below zero, and deflation involves desires which maintain the real rate to remain high. As noted by Stawska (2017, p. 138), "The effectiveness of the monetary policy may be blunted by the liquidity trap, which arises when the monetary policy is no longer able to stimulate the demand, as there is no possibility to lower the interest rates any further."

Kimura et al. (2003) explain in more detail the theoretical transmission mechanisms by which monetary policy could still have an effect even at zero

interest rates – what they collectively refer to as the monetary base channel. These are (i) a relative asset supply effect, according to which open market operations change the composition of assets held by private agents, possibly affecting risk premia across a large class of financial and real assets (Meltzer, 2001; McCallum, 2000, as cited in Kimura et al., 2003); and (ii) a liquidity premium reduction effect, according to which abundant reserve provision causes a reduction in the liquidity premium on illiquid assets (Kimura et al., 2003, p. 286).

A critical theoretical difference involves whether money demand is satiated at a finite level of interest rates or at zero interest rates. If demand for real balances goes to infinity as rates go to 0 (log-log specification), then any expansion in the monetary base is passively absorbed, and therefore policy is powerless —the quintessential liquidity trap. If there is, however, a finite level of satiation (the semi-log or more general specification), then excess money balances may be converted into portfolio rebalancing and spending, and the monetary base channel may still play some role (Kimura et al., 2003, pp. 291-294).

3. Empirical Evidence on Macroeconomic Effects

3.1 Cross-Country Evidence: Inflation, GDP, and Public Finances

In the study, Stawska (2017) compares the Pearson correlation coefficients between the central bank base interest rates and the main macroeconomic indicators in the US, the Euro Area, Poland, and Japan between the years 2000 and 2015. Poland ($r = 0.74$, $p < 0.001$), the Euro Area ($r = 0.63$, $p < 0.01$), and the US ($r = 0.57$, $p < 0.05$) have a strong positive correlation between base rates and inflation that is consistent with inflation-targeting models in these economies. Remarkably, the correlation coefficient of Japan is insignificant and statistically nonsignificant ($r = 0.048$, $p = 0.855$), which is explained by Stawska (2017, p. 145) as the long run of deflation that broke the usual relationship between the policy rates and price dynamics.

Regarding output, the US and Euro Area are moderate when interest rates are correlated with GDP growth ($r = 0.43$ in each instance), but insignificant in the case of Poland and Japan. According to Stawska (2017, p. 146), this goes to indicate the lagged and indirect transmission mechanism of monetary transmission. The interest rate/general government deficit relationship is strong in the US ($r = 0.79$), medium-range in the Euro Area ($r = 0.57$) and Japan ($r = 0.59$), and strongly negative in most economies; that is, long-run periods of low rates have been accompanied by an increase in sovereign debt (Stawska, 2017, p. 146).

In terms of investment, Stawska (2017, p. 146) computes lagged correlations (rates at 1 vs investment at t), and only in the case of Japan ($r = 0.72$) and Poland ($r = 0.47$) are significant negative correlations obtained, with weak and non-significant coefficients in the US ($r = 0.31$) and in the Euro Area ($r = 0.15$). This implies that the relationship between monetary policy and capital formation is more indirect and situation-specific than the traditional theory would indicate, especially in more advanced economies, which are already at the ZLB.

3.2 Quantitative Easing: Monetary Base and Price Dynamics in Japan

Kimura et al. (2003) specifically concentrate on the

experience of the Japanese after the Bank of Japan took up QME in March 2001. They isolate the effect of monetary base expansions in the zero-rate period, not the effects estimated in normal-rate periods, using a methodological improvement of earlier fixed-parameter VAR analyses: a Bayesian VAR with time-varying coefficients. They find that the positive impact of an increase in the monetary base on inflation is statistically significant at 1985:Q2 (normal-rate regime), but it is non-existent at 2002:Q1 (ZLB regime). They conclude that the monetary transmission process occurred through the monetary base channel in the 1980s, but it does not occur at zero interest rates (Kimura et al., 2003, p. 291).

The given empirical observation falls in line with the current macroeconomic environment presented in their paper: although in early 2002, monetary base growth was higher than 20-30% per year, deflation was still ongoing in Japan, bank lending had declined, and M2 growth was restrained at about 3% per year (Kimura et al., 2003, pp. 284-285). Lack of relationship between the monetary base and broad money aggregates is a major characteristic of the ZLB setting, indicating that excess reserves were not intermediated into credit but instead accumulated by commercial banks.

Kimura et al. (2003) also estimate a money demand function to test whether a satiation level exists at zero interest rates. Their GMM estimation rejects the null hypothesis of no satiation ($\delta = 0$) at the 5% significance level ($p = 0.011$), supporting the view that money demand is bounded rather than infinite at zero rates. This is an important finding: it implies the liquidity trap need not be absolute in theory, and that there may remain some room for the monetary base channel to operate. However, the authors caution that this effect "is highly uncertain and very small" (Kimura et al., 2003, p. 296), with the output gap remaining unresponsive to monetary base expansions in their structural model estimations.

4. Interactions in Fiscal Policy and the Policy Mix

The two studies place extra emphasis on the increased significance of fiscal policy once the monetary policy is at the ZLB. Stawska (2017, p. 138) relies on the literature to state that zero-bound rates make fiscal increases more effective, especially with an accommodative monetary approach, since the cost of borrowing is diminished, and the government can maintain a large deficit at affordable debt service costs. She refers to Szymanska (2014) and Summers (2013) when she says that the fiscal tools can be quicker in driving up aggregate demand compared to monetary tools in recessions. Nonetheless, according to Stawska (2017, p. 138), the threat of fiscal-monetary interaction traps is also present. Based on Cizkowicz and Rzonca (2011, 2014), she observes that monetary growth at the zero bound may slow economic restructuring, lower total factor productivity, and maintain a low-growth environment that will keep the natural interest rate down—thereby postponing the ultimate normalisation of monetary policy.

The presented empirical data on Japan are especially shocking: the overall deficit of the government never dropped lower than 1.28% of GDP throughout the study period, with the highest level of 8.84% in 2009, and government debt increased between 133% of GDP in 1999 and 229% in 2015 (Stawska, 2017, Table 4 and Table 5, pp. 142-143). This concern is implicitly supported by Kimura et al. (2003), who observe that

the weak banking system in Japan, which was burdened by non-performing loans (NPLs), was a structural problem that meant monetary expansion did not materialise into credit creation and real activity. Banks strained by capital diverted excess reserves into government bonds instead of lending them to the market, and the effect of monetary base injection worked against transmission with or without the magnitude of monetary base injection (Kimura et al., 2003, p. 308).

4.1 Non-Conventional Monetary Policy: Strengths and Weaknesses

The two papers are useful contributions to the overall discussion on the benefits and drawbacks of quantitative easing as an unconventional instrument. According to Stawska (2017, p.139), quantitative easing might have assisted the US in escaping further recession, and analysts believe that without monetary easing, the US GDP would have decreased by around 30% instead of 4-5%. However, she, too, admits that the long-term effectiveness of QE as a stimulative measure for the US economy is not clear. Kimura et al. (2003) present a finer evaluation of the shortfalls of QME in a Japanese setup. They conclude that the prices of assets, equities, and the yen exchange rate did not adjust systematically to the amount of quantitative easing, and that the credit spreads on low-grade corporate bonds in fact rose after March 2001, not as a result of portfolio rebalancing as the proponents of QE would predict (Kimura et al., 2003, p. 284). Two structural explanations are provided: the effect of reserve injections is offset by highly volatile precautionary money demand, which is instigated by Y2K arrangements, the September 11 attacks, and uncertainty about the financial system; and banks were able to raise risky lending due to concern about capital adequacy even in the face of abundant liquidity.

The governance aspect of unconventional policy, brought out by Kimura et al. (2003, p. 309), is also related to large-scale acquisition of private assets: it is considered a way to take central banks into the fields of fiscal policy and resource distribution, which raises the issue of democratic accountability. This conflict between the imperative to have a bold policy response and the constraints on such policies as mandated by the constitution is an active question in the current monetary policy discussions. Synthesis, Limitations, and Research Gaps. When used together, Stawska (2017) and Kimura et al. (2003) provide a rather complementary view on ZLB monetary policy. Stawska offers descriptive breadth in her attempt to map the patterns of correlational rules on four different economies over almost twenty years; Kimura et al. present the depth of a methodological approach, in which time-varying econometrics and structural model estimation are used to isolate the ZLB-specific effects of monetary base expansion. Both papers come to the same conclusion about the ineffectiveness of conventional monetary policy at the ZLB, the tenuousness or absence of the relationship between base money and inflation, and the structural impediments, including deflation expectations, NPL problems, and weak banking intermediation, that can render even unconventional instruments of monetary policy ineffective.

5. Research Methodology

This study tells about a qualitative and descriptive analytical approach using secondary macroeconomic data. The analysis covers the period from 1990 to 2015

to capture the pre-crisis, crisis, and unconventional policy phases.

Data Variables Examined:

- Real GDP Growth Rate
- Consumer Price Index (Inflation Rate)
- Short-Term Policy Interest Rate
- Monetary Base
- Bank Lending Growth
- 10-Year Government Bond Yield

The methodology involves:

- Trend analysis of macroeconomic indicators.
- Policy timeline evaluation.
- Calculation of real interest rates.
- Comparative analysis of pre- and post-QE periods.
- The objective is not to perform advanced econometric modelling but to evaluate policy effectiveness using observable macroeconomic trends and theoretical interpretation.

6. Impact on Inflation and Economic Growth

Despite the aggressive and persistent monetary expansion, Japan was poor at achieving sustained inflation to its objective. The inflation was minimal, and the deflation was happening now and then. The increase in GDP indicated temporary gains that were not compelling or touching.

One of the reasons behind such an outcome could be referred to as the structural aspects of the Japanese economy. There was a decline in the increase of the labour force and a higher rate of savings due to an ageing population. The saving propensity of elderly households is also expected to be higher, and less spending will be a negative incentive to aggregate demand. In addition, the growth in wages was not excessive, and this limited the purchasing power and consumption-led growth.

Corporate behaviour also had a role to play. The majority of the Japanese firms became very competitive in exports and capital investments, compared to the internal growth of wages. This later constrained the monetary stimulus to the household income and consumption increase.

6.1 Policy Limitations and Structural Constraints

The long stagnation of Japan cannot be explained only by the failures of the monetary policy. The rigidity in structure played a big role in limiting the effectiveness of the policy. Demographic ageing augmented dependency ratios and put financial sustainability under strain. There were labour market rigidities that curtailed the growth in productivity, and safe corporate governance practices deterred risk-taking.

The experience of banking in non-performing loans also deteriorated credit transmission. Despite the excessive reserves, the banks developed conservative borrowing requirements because of the risk aversion. This action decreased the sensitivity of investment to low interest rates.

In addition, the self-reinforcing cycle was formed by the fact that persistent deflationary expectations reinforced each other. Consumers anticipate a decrease in prices, which causes them to postpone buying goods, and this lowers the demand, causing even greater deflation. To stop this cycle, monetary stimulus is not

enough; it should be accompanied by a plausible commitment and a complement to this fiscal stimulus.

7. Discussion

Japan's experience provides insight into the weaknesses and strengths of unconventional monetary policy. The move from ZIRP to quantitative easing, negative interest rates, and yield curve control makes sense of the ever-increasing number of instruments in the central bank toolkit in a crisis-ridden setting. This was helpful to prevent a financial meltdown and ensure that the banking system was well-liquidated.

However, the monetary policy did not suffice to generate sustainable inflation and sound growth. The conventional delivery system was susceptible to the liquidity trap situation, and demand was not as receptive as it could be because of structural issues. Deflation maintained the real interest rates at positive levels, and the power of the nominal interest rate cuts was diminished.

The Japanese example shows that macroeconomic policy must be coordinated. Policies that are complementary to monetary easing are fiscal expansion, structural reform, labour market flexibility and domestic consumption stimulation policies. Without such coordination, few effects can be produced even by a fierce money growth.

8. Theoretical Framework: Liquidity Trap and Monetary Transmission Breakdown

In order to give a complete analysis of the long stagnation experienced in Japan, the theoretical concepts of the liquidity trap and failure in the transmission process of the monetary concept must be examined. Monetary policy has various channels of operation in the normal macroeconomic environments, and these channels are the credit channel, the expectation channel, the interest rate channel, and the exchange rate channel. But in the case of Japan, these channels became much weaker.

The interest rate channel operates by reducing the cost of borrowing in order to increase investment and consumption. But as the nominal rates come close to zero, the central banks are faced with the zero lower bound constraint. Additional cutbacks in nominal rates are then impossible or ineffective at this point. In Japan, the aggregate demand was weak despite the policy rates going to zero, as the real interest rates remained positive as a result of deflation.

8.1 Balance Sheet Recession and Private Sector Deleveraging

The other characteristic of the stagnation in Japan was the tendency towards deleveraging of the private sector. After the failure of the asset's prices, collateral values experienced heavy losses on the part of the corporations. Most of the firms realised that they have liabilities higher than the market worth of their assets. When this occurs, the game changes from one of maximising profits to minimising debt.

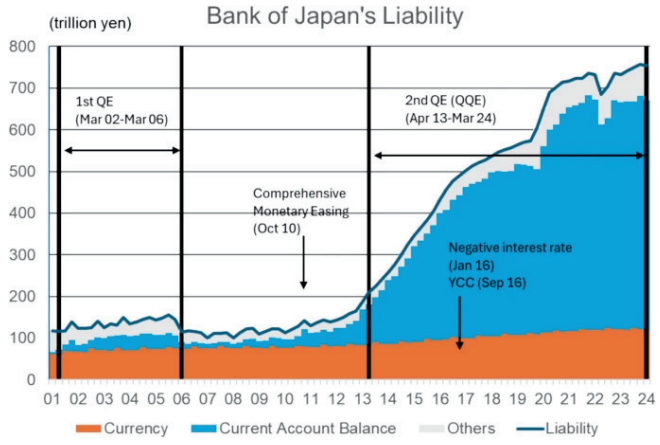


Figure 3: BOJ's Balance Sheet (liability side)

Source: Bank of Japan

This change is something that dramatically changes macroeconomics. Firms might not want to take loans even though banks might be willing to lend. Pessimistic expectations and weakened balance sheets become a limitation of investment decisions. It is no longer the case that a decline in interest rates will, in automatic terms, stimulate investment.

Precautionary saving was also employed by households. The fall in asset wealth took away confidence, and demographic ageing also strengthened saving habits. The consumption growth reduced with the age of the population, which restricted the multiplier impacts of monetary expansion.

The Japanese experience teaches that monetary policy in itself cannot be used to offset the macroeconomic impact of widespread repair of balance sheets.

8.2 Quantitative Easing: Portfolio Rebalancing and Asset Price Effects

Quantitative Monetary Easing was also meant to affect the asset prices via the portfolio rebalancing channel by increasing reserves as well. By a central bank buying government bonds and other assets, it decreases the amount of the same in the market. Investor,s in their turn,n redistribute money into riskier assets, i.e., stocks and corporate bonds, which may trigger investment.

Quantitative easing in Japan was linked to bringing stability to the financial markets. Government bonds yielded, and the asset markets slowly came back on track. But the flow of the higher asset prices to real economic activity was weak. The effects of wealth on consumption were relatively small. In addition, the correlation between the growth in the monetary base and broad money growth was not as strong as expected. The banking system had excess reserves accumulated without correspondingly translating into new loans.

8.3 Banking Sector Profitability and Financial Stability Concerns

Although unconventional monetary policy was intended to encourage lending, there were long-term structural issues for financial institutions caused by very low and negative interest rates. Traditionally, commercial banks utilise the difference between the deposit rates and the lending rates as a profit maker, which is the net interest margin. These margins become squeezed when interest rates are at or below zero over a long period of time.

Low profitability persisted in many Japanese banks due to low interest rates. Low profitability can deter risk-taking and undermine the motivation to increase credit. Besides, the pressure was especially on smaller regional banks, which could provoke the question of financial stability in the long run.

Negative interest rates, even though meant to punish excess holdings of reserves, did not always lead to aggressive lending increases. Rather, banks were increasingly discriminating in loans and giving preference to low-risk borrowers. This action further restricted the monetary stimulus flow to the small and medium-sized enterprises, which are usually the primary providers of employment and home demand.

8.4 Exchange Rate Dynamics and External Sector Influence

The exchange rate channel is another medium through which monetary easing can affect economic activity. The interest rates and quantitative easing have the propensity of weakening the domestic currency by decreasing the returns on the financial assets that are based on the domestic currency. A depreciated currency would enhance competitiveness in exports, which would increase foreign demand and lead to economic growth.

The monetary easing in the case of Japan could be related to the time when the yen was depreciated, which led to an advantage for export-driven sectors like automobiles and electronics. But dependence upon outside demand left the structure vulnerable. In situations where the global demand was low, especially in periods of global downturns, the growth of Japan was heavily hampered.

8.5 Inflation Expectations and the Credibility Problem

Modern monetary theory is chiefly influenced by inflation expectations. When households and firms anticipate inflation in the future, they will tend to spend and invest in the present. On the other hand, when deflation is anticipated to continue, economic agents put off their spending, which supports stagnation.

A change in ingrained deflationary expectations was one of the greatest challenges to the Japanese policymakers. The years of negative inflation made a psychological mark on consumers and businesses. Credibility was a problem even in situations where the central bank declared bold targets for inflation.

The efficacy of quantitative easing extends beyond the mechanical increase of the monetary base but also to the visualisation of the determination of the central bank to establish price stability. Unless there is a solid push in financial policy, expectations can’t be changed.

8.5 Interaction Between Monetary and Fiscal Policy

Monetary policy does not act alone. The fiscal policy decisions play a significant role in its effectiveness. During Japan's stagnation period, fiscal authorities implemented various stimulus packages to boost infrastructure investment and aggregate demand.

But fears of the increased national debt limited the amount and regularity of the fiscal stimulus. The government debt-to-GDP ratio in Japan has grown significantly over time, constraining fiscal options. The expansionary impact of monetary easing was reversed when fiscal consolidation measures were implemented too soon.

Liquidity traps involve the specific role of coordination between monetary and fiscal policy. The expansionary fiscal policy can boost aggregate demand directly; monetary policy keeps financing costs low. In the absence of this coordination, monetary stimulus will not work on its own in creating enough momentum.

9. Comparative Perspective: Some Lessons for Other Economies

The monetary experiment in Japan has had implications in the world. After the 2008 world financial crisis, other developed economies, such as the United States and Eurozone states, employed quantitative easing and near-zero interest rate policies. To prevent the

repeat of the long period of stagnation in Japan, policymakers researched the case of Japan.

One of the lessons is the necessity of taking action in the first place and promptly. Japanese banking sector issues were not identified early on, and this helped prolong the existence of non-performing loans. The recapitalisation and structural reform could have quickened recovery.

The other lesson is about the strategy of communication. It is important to have clear forward guidance and a believable commitment to inflation targets in order to shape expectations. The central banks need to assure the markets that they will continue to accommodate until the time recovery is realised.

9.1 The Long-term Effects of Long-term Monetary Accommodation

Long-termism of the unconventional monetary policy in Japan also comes with increased questions relating to the long-term implications. The low rates will never be constant and will cause excessive risk-taking in some regions, will cause distortions in the prices of assets, and will create reliance on monetary support.

At the same time, the untimely removal of accommodation will interfere with sensitive recovery. Policymakers must then be able to balance between long-term sustainability and short-term stabilisation.

The example of Japan reveals the complexity of the exit strategies. Once the central banks have lent out at very low rates and substantial balance sheets to the markets, then there is no simple way of normalising without creating financial volatility.

9.2 Improved Analytical Vision: The Reason Liquidity Was Not Adequate

The primary contradiction of the Japanese experience is that despite the poor growth of the economy, there was liquidity. The difference between liquidity and solvency can be used to expound on this paradox. Structural weaknesses and low asset value, which are the source of solvency problems, are not addressed by the release of temporary funding cuts.

The lack of money in Japan was not the only thing that resulted in a lack of investment opportunities. In the case of low expectations of returns on investment due to low demand and demographic trends, there may be no stimulated borrowing even with zero or negative interest rates.

10. Conclusion

The long history of experimentation with an unconventional monetary policy is an important lesson for the global policymakers in Japan. Although the financial markets were stable with the use of zero interest rates, quantitative easing, negative interest rates, and yield curve control, the strategies failed to achieve long-term economic growth and stable inflation.

The Japanese experience points to the shortcomings of monetary policy alone, especially in a liquidity trap of deflationary expectations and structural rigidities. Sustainable recovery needs an all-round program consisting of monetary stimulus, fiscal assistance, and structural reform.

Japan is a case in point in a world where most

developed economies have followed the same unusual course of action, which is a cautionary lesson and a wise lesson about the difficulties of macroeconomic management in the modern world.

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Trapped by Boilerplate: Incomplete Contracts, Ex-Post Inefficiencies, and the Case for a Statutory Force Majeure Doctrine

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ABSTRACT

The COVID-19 pandemic has highlighted the essential rigidities in the Indian contract law framework regarding the relationship between the Force Majeure (FM) clause and the statutory Doctrine of Frustration (DoF). Under the existing Indian legal framework, the presence of an FM clause automatically rules out the application of the DoF. Drawing on the theory of incomplete contracts and empirical economic evidence, this paper argues that the existing framework traps contracting parties in poorly drafted contracts when faced with unforeseen systemic shocks. This creates a significant ex post inefficiency, increasing transaction costs and deadweight losses by mandating a binary choice between strict performance and total discharge. To overcome this problem, this paper recommends statutory codification of the FM doctrine, drawing on comparative law from the PRC Civil Code. As a default rule for efficiency, a statutory FM doctrine would allow flexible remedies such as efficient suspension and renegotiation, thereby preserving commercial relationships and reducing the impact of future contingencies.

Keywords: force majeure, doctrine of frustration, Indian contract law, incomplete contract theory, ex-post inefficiency

JEL Classification: K12, D86, K41, D81, G33

1. Introduction

The COVID-19 pandemic, which involved stringent restrictions on the mobility of goods & people, unearthed an apparent economic shortcoming of the Indian Contract Law. Consequent lockdowns brought about radical changes in the functioning of the economic apparatus and created circumstances that made contractual performance impracticable and, in numerous instances, impossible (Twigg-Flesner, 2020). As a recourse, the businesses heavily relied on the two primary remedies stipulated by the Indian Contract Act, 1872, viz., the Doctrine of Frustration ["DoF"] and & Force Majeure ["FM"].

However, the Supreme Court's jurisprudence on the two doctrines indicates that the DoF is inapplicable where the parties' contract contains an FM clause. The economic inefficiencies that may arise from narrowly framed or poorly drafted FM clauses constitute the central premise of the present discussion.

The Supreme Court has also determined that while an act may not be literally impossible, it can become impracticable and ineffectual with respect to its intended purpose when its foundation is fundamentally compromised by an unforeseen event. The pandemic has become one such untoward event for which the world was largely unprepared.

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2. A Brief Overview of FM and DoF

In Indian law, the two doctrines operate on different planes. FM is essentially a contractual allocation of risks, a clause that specifically provides that unforeseeable and uncontrollable events will excuse or suspend performance under the contract. As such, it will depend on the contract and on a court's interpretation.

In cases where a contract includes a specific FM clause or a contingent-event clause, the courts will interpret and enforce it. The Indian Contract Act provides a statutory basis for a contract contingent on a future event under Section 32. In the absence of a clause on a contingent event, the statutory Doctrine of Frustration (DoF) will apply, and this will be governed by section 56 of the Indian Contract Act, which provides that a contract for the performance of an impossible act will be void.

In India, the common law tests for frustration, which have been adopted and developed in a line of authorities starting with Taylor v. Caldwell and Joseph Constantine, have been consistently followed, and Indian courts have specifically held that the event that causes frustration must be outside the control of the parties, unanticipated, and must go to the root of the contract.

In the economic literature, FM and frustration have been characterised as means to allocate and price the risks of large, unforeseeable events, and to address inefficiencies that arise when unexpected externalities render the expectations that existed before a contract obsolete.

From an economic perspective, express FM clauses can be viewed as cost-reducing, ex-ante bargaining devices that enable parties to internalise risk through definitions, suspensions or terminations, time extensions, and compensation. Without express FM clauses, the DoF can be viewed as an ex-post corrective mechanism. However, the social cost of the DoF, arising from the uncertain loss allocation and undermining of reliance interests, raises concern. Moreover, the empirical and theoretical literature, complemented by the COVID-19 literature surge, supports the inclusion of shock allocation within contracts or judicial doctrines grounded in rules, which equilibrate reliance interests with efficient risk allocation, minimising transaction costs and Inefficient party behaviour.

From an economic perspective, therefore, these legal constructs can be viewed as risk allocation and attenuation of transactional uncertainty. The economic view of these legal constructs is that they are not mere legal excuses; rather, gap-filling rules for incomplete contracts that the parties could not reasonably have contemplated or cheaply insured against.

Economically, FM can be viewed as an ex-ante risk allocation mechanism between the parties, who voluntarily assign the risk of specific events to one party or share it, usually to minimise future renegotiation or litigation costs. The DoF, on the other hand, can be viewed as a default rule set by the state that addresses ex post inefficiencies arising from contracts that fail to account for a “black swan” event. From an economic efficiency perspective, risk allocation is best placed with the party that can best bear the risk or the cheapest cost avoider.

3. Legal Lacuna Concerning the Doctrines in India - The Status Quo Problem

The doctrinal interplay between FM stipulations and the statutory framework of Section 56 of the Indian Contract Act poses a unique challenge in the Indian legal-economic jurisprudence. In its seminal judgement in Satyabrata Ghose v. Mugneeram Bangur, the Supreme Court held that an FM clause within a contract is a complete code in itself and, as such, the applicability of the legislative DoF is excluded, thereby restricting the remedy to the contract itself. Thus, DOF (Section 56) cannot be relied on by the parties in the event of a supervening event that falls within their risk allocation. This has been reiterated by the Supreme Court in its ruling in Energy Watchdog v. CERC, wherein the court observed,

"When a contract contains a force majeure clause which, on construction by the Court, is held attracted to the facts of the case, Section 56 can have no application."

Hence, the status quo problem is that, when the contract stipulates an FM clause that the court believes is pertinent to the situation that has arisen, Section 56 is inapplicable to the particular issue at hand. However, where the contract does not contain an FM provision, the parties remain free to rely on the DoF set out in Section 56.

This is particularly problematic, both in terms of equity and economic efficiency. The situation, as it persists, may prove hostile to the parties' interests and result in unmitigated damage when the specific verbiage of the FM clause fails to encompass certain important, radical changes within its ambit, is too narrow, or is generally badly drafted, thus restricting the room for relief. The status quo, which sustains and thus prolongs the current circumstances, requires an expeditious response and requisite amendment.

Economically, standard contract law is predisposed towards an "efficient breach" approach, i.e., you breach and pay damages if it is more valuable to breach than to perform. However, during systemic crises such as a pandemic, liquidity is scarce, and determining damages is an exceptionally complex exercise. Under Section 56 of Indian law, there is a binary choice of total discharge (Frustration) or strict performance. The binary choice causes deadweight loss because it is likely to force viable long-term business relationships into insolvency or termination, thereby reducing "relational capital." The statutory FM approach, on the other hand, allows for an "efficient suspension," thereby reducing the deadweight loss of termination.

4. Business Practices Exacerbating the Situation and Incomplete Contract Theory

However, incorporating boilerplate FM clauses into contracts that are ineffective in providing the requisite relief to parties is a common business practice.

The specificities of the FM clause are overlooked and, as a result, not adjusted to cater to the parties' needs (McCormick, 2009). Moreover, attempts to list all events that might fit the description of contingencies result in overly broad FM clauses, leading to the failure to recognise more specific events. Adverse decisions in court that are antagonistic to the client's interests are the result, as generic clauses like these are usually left to the court's interpretation. FM clauses that are too narrow, on the other hand, restrict the room for

recourse available to suffering parties (Haack & Esplin, 2020).

Incomplete contract theory provides a structural account of why such deficiencies in FM clauses are not isolated drafting failures, but rather a predictable feature of contractual practice. Parties systematically underprice low-probability, high-impact contingencies such as geopolitical instability or systemic supply-chain disruptions (Tirole, 2007; Anderlini & Felli, 2004). Attempts to address uncertainty by exhaustively enumerating FM events often result in clauses that are either overly generic or unduly narrow (Bernheim & Whinston, 1998). In both cases, interpretive discretion is shifted to courts, raising *ex post* transaction costs and increasing the likelihood of inefficient outcomes.

The theory recognises that contracts are inherently incomplete because parties cannot foresee, describe, or verify every possible future contingency at the time of formation. Cognitive limitations, asymmetric information, and the costs of negotiating detailed, state-contingent provisions lead parties to rely on simplified or boilerplate clauses as proxies for a range of uncertain risks. Parties either adopt generic formulations to economise on drafting costs or attempt exhaustive enumerations that still fail to capture unforeseen events. In either scenario, the contract leaves gaps that must be filled through judicial interpretation or renegotiation once the contingency materialises.

This shift from *ex ante risk* allocation to *ex post* adjustment increases transaction costs, incentivises strategic behaviour, and may produce inefficient outcomes when courts apply rigid interpretive doctrines.

The problems arising from poorly drafted FM clauses are illustrated by *Publicker Industries v. Union Carbide Corp.*

In this case, Union Carbide Corporation had agreed to sell a specialised type of ethanol to the plaintiff for a fixed number of years. Around the same time, conflicts in the Middle East caused the production costs to spike to untenable levels, way beyond the costs specified in the contract. Union Carbide sought to invoke the FM clause present in the contract between the parties in search of relief. The clause read:

"Neither party shall be liable for its failure to perform hereunder if said performance is made impracticable due to any occurrence beyond its reasonable control, including acts of God, fires, floods, war, sabotage, accidents, labour disputes, all shortages, governmental laws, ordinances, rules and regulations."

Union Carbide hoped to rely on the clause under the line "any occurrence beyond the parties' reasonable control." The problem with the clause in question is that it narrows itself from "any occurrence" to a specific list of potential FM events (war, sabotage, etc.). This is an example of ejusdem generis (Perillo, 2009), where specific language that narrows the broad introductory language that precedes it. Due to the particular wording of the clause, the defendant could no longer claim protection against unlisted events, namely a price rise in this case, leading the Court to rule that Union Carbide could not avail itself of the said FM provision.

5. The Resulting Judicial Problem and Ex Post Inefficiencies

Thus, a poorly drafted FM clause causes grave financial losses by restricting the scope of available relief

(Murray, n.d.)

This problem is especially exacerbated in India, where the status quo regarding a contract's FM stipulation and Section 56 of the ICA leaves the parties stuck with the FM clauses they have drafted. The stakeholders are not able to take recourse under alternate resolution mechanisms like the DoF when the fact situations attract the application of FM provisions because if a FM clause finds reasonable contextual closeness to the facts of the case, and it is imperfectly constructed, then that clause will be applied to the facts by the court to the exclusion of other doctrines, like the DoF, Impossibility or Frustration of Purpose as vested in Section 56, which might provide relief to the parties.
From an economic perspective, the consequences of poorly drafted FM clauses can be understood as a failure in both *ex-ante* risk allocation and *ex post* efficiency.

Contract theory assumes that parties use contractual provisions to allocate foreseeable risks in a cost-effective manner at the time of contracting (Cooter & Ulen, 2016). However, when FM clauses are drafted in a generic or overly narrow fashion, they fail to allocate risks in accordance with the parties' actual preferences or the underlying commercial realities, as discussed above. The implication is *ex post* inefficiencies, as courts are compelled to enforce imperfect clauses that either deny relief where it would have been mutually beneficial or provide relief in ways that distort the parties' original risk-sharing expectations.

This also results in increased litigation costs, strategic behaviour, and potential deadweight losses, particularly where performance continues despite severe hardship or where efficient termination is prevented by rigid contractual language. In jurisdictions like India, where the contractual presence of an FM clause may preclude recourse to broader doctrines such as frustration as set out in Section 56 of the Indian Contract Act, the cost of such drafting failures is magnified. Parties are locked into inefficient contractual outcomes, even when a more flexible legal doctrine could have produced a welfare-enhancing reallocation of risks. Consequently, the existing approach undermines the economic function of contract law, which is to facilitate efficient *ex ante* risk distribution and minimise welfare losses when unforeseen contingencies arise *ex post.*

It is in context and situations like these that it becomes important to resolve the unique problem created by the status quo in India. Such resolution becomes especially imperative when dealing with contract law doctrines whose entire purpose is to assist and mitigate losses suffered by parties due to complications arising from the no-fault or negligence of others.

6. Empirical Economic Evidence: Incompleteness in Contracts, Shock Transmissions, and Costs of Transaction

A more focused economic analysis of systemic shocks during 2020-2022 supports the hypothesis offered within this paper. The evidence supports the claim that incomplete allocation of contractual risks, combined with inflexible fallback rules, drives higher transaction costs, increased dispute resolution, and welfare losses. The macroeconomic evidence supports that the magnitude and surprise of the pandemic-induced shocks were as anticipated. The World Trade Organisation noted that global trade volumes fell by 5-8% during 2020. Moreover, trade in services fell by

more than 20% for certain categories, especially transport and travel. The magnitude of this event is a tail risk event outside normal cyclical variance. Empirical work on trade networks (Kiyota et al., 2021) supports the finding that systemic shocks were asymmetrically transmitted through global value chains. Supplier nodes that were highly concentrated triggered cascading effects. From an incomplete-contractual-economics perspective, this supports the view that contracts systematically misprice tail risks. The language of pandemic-related risks was only included in a minority of supply contracts before 2020.

Dispute incidence data serve as a proxy for ex post transaction cost escalation. In 2020, the International Chamber of Commerce (ICC) registered one of the highest numbers of arbitration cases on record, with a significant percentage involving non-performance and FM-related claims. The rise in arbitration and litigation during the period of systemic disruption is a symptom of bargaining failure. As per the theory of law and economics, when the scope of the contingency in a contract is ambiguous, and the default rules specify binary remedies (i.e., strict enforcement or complete discharge), the likelihood of a failure to renegotiate increases. In other words, the empirical evidence of the rising trend in dispute incidence during the pandemic supports the inference that the adaptability of private contracts to efficiently internalise unforeseen risks was significantly constrained.

In a similar context, financial data on firms reveal the impact of rigid contract enforcement. During the pandemic, firms worldwide entered a “hibernation phase,” during which liquidity shortages, reduced revenue, and reduced access to credit became prominent. Firms with low margins were especially affected by short-term disruptions in performance. In India, official data from the Insolvency and Bankruptcy Board of India for 2020-2021 reveal a significant level of corporate distress and a rising trend in insolvency resolution processes, prompting the government to temporarily suspend some IBC filings (IBBI, 2020). From an economic point of view, the data reveal a spillover effect: the rigid nature of the contract's payment obligations during the period of revenue collapse leads to liquidity shortages and increases the probability of default, resulting in deadweight losses. Research on the empirical design of contracts also supports the argument of efficiency. For instance, in European manufacturing firms, those operating under more relational or adaptive contracts were more likely to renegotiate privately and maintain continuity of supply during disruptions.

Related studies also indicate that firms engage in strategic incomplete contracting, suggesting that default legal regimes significantly affect contracts. For example, studies on the construction and public-private partnership industries during the COVID-19 pandemic indicate that contracts with renegotiation or hardship clauses were more likely to result in renegotiation than those involving litigation. This supports the idea that flexible default rules can minimise dispute costs and maximise surplus.

Taken together, these datasets suggest a coherent economic story: systemic shocks reveal systemic contractual incompleteness, rigid enforcement schemes amplify dispute and insolvency risk, and adaptive legal or contractual frameworks correlate to lower transaction costs and greater preservation of relational

value. The datasets substantiate the central argument of this paper: a structured statutory FM framework, serving as an efficiency-enhancing default rule, would address ex post inefficiencies by allowing for calibrated suspension, renegotiation, or adjustment rather than forcing parties to choose between welfare-reducing binaries of strict performance and discharge.

7. An Alternative Model

The problem of parties being restricted from seeking redress due to the current situation can be mitigated by statutorily recognising the FM doctrine as a statutory rule or law, as observed in some civil law regimes (Trenor & Lim, 2020).

This would involve granting the doctrine of FM statutory recognition, setting out its definition conspicuously, in the manner the DoF manifests itself as Section 56 of the Indian Contract Act. Doing so will set FM out as a principle of law parallel to the DoF, rendering it as a principle that would allow for temporary suspension of performance but also total termination of contractual obligations if the circumstances demand it and the contract allows it, keeping in line with the spirit of the principle of FM (Norton Rose Fulbright, 2020). This will also allow courts to be more liberal and justiciable in their response to parties when contemplating the application of the FM doctrine in relevant cases. Such equity will be a step beyond the law of frustration in India, as codified under Section 56 of the Indian Contract Act, which limits available relief to the full discharge of the parties' contractual obligations.

In such a system, parties would retain the freedom to tailor their own FM clauses to their industry-specific needs, ranging from the usual suspension or termination provisions to compensation or the initiation of negotiation mechanisms upon a contingency. These stipulated clauses shall be valid as long as the clause set out in the contract does not derogate from or directly contradict the definition of the doctrine provided in the statute and does not take away from the spirit of the doctrine.

Parties are allowed to set out for just immediate termination or suspension individually as relief, as also immediate termination or suspension as alternatives to be chosen from; suspension followed by possible termination of obligations may also be stipulated in FM clauses, along with initiation of negotiation mechanisms, or amendment of contract terms upon mutual agreement (Crowell & Moring, 2020). Flexibility in freedom to decide formats and alternative forms of relief shall continue as a discretion of the parties under the proposed regime, but the general principles outlining the nature of events that will be recognised as FM events shall be defined in a codified doctrine allowing for better relief mechanisms, as well as consistency in decision-making and dispute resolution. Hence, the scope of relief for parties will be expanded beyond the mere discharge of contractual obligations under Section 56 of the Indian Contract Act, thereby providing a further impetus to recognise FM as a statutory doctrine.

8. Advantages to the Proposed Regime

8.1 Statutory Force Majeure as an Efficiency-Enhancing Default Rule

While the parties shall retain the freedom to list in their contract those occurrences that would constitute FM events, the statute will save parties from lingering in disputatious and unaccommodating situations due to

restrictive or poorly drafted FM clauses, as discussed above. Such an arrangement becomes especially pertinent and necessary in India, given the status quo regarding FM and the DoF under Section 56 of the Indian Contract Act.

From the standpoint of incomplete contract theory, the proposed statutory recognition would function as an efficiency-enhancing default rule that fills the inevitable gaps left by private drafting.

Since parties cannot foresee or specify every possible contingency ex ante, the above discussion has demonstrated that contractual provisions frequently leave significant risks unallocated or poorly allocated, leading to costly ex post disputes and inefficient outcomes. Moreover, FM as a principle is more liberal and equitable in its approach than other doctrines of this nature, as it allows for relief to the parties according to their own needs, as parties reserve with the parties reserving the right to list and decide the consequences of the FM events, ranging from the usual suspension or termination of the contract to compensation or initiation of negotiation mechanisms. A codified FM doctrine would thus operate as a background rule that approximates the allocation of risks that rational parties would have agreed to under conditions of full information and negligible drafting costs.

By providing a structured set of responses (such as suspension, renegotiation, or termination), the statute would reduce the need for rigid judicial interpretation of defective clauses and instead facilitate welfare-maximising adjustments once contingencies arise.

Moreover, this would lower ex post transaction and litigation costs, discourage strategic behaviour, and promote efficient adaptation of contractual relationships to unforeseen shocks.

At the same time, preserving party autonomy to customise FM provisions ensures that ex ante risk allocation remains responsive to industry-specific needs, while the statutory doctrine serves as a safety net that corrects the inefficiencies produced by incomplete or poorly drafted contracts.

Such a legal regime will create a more accommodating environment for business and commerce and provide specific, efficient solutions tailored to industry-specific needs. Moreover, ambiguity surrounding what constitutes an FM event will be eliminated, with the overarching statutory definition serving as an objective standard. Hence, stakeholders can rely on the statute to obtain relief when they are affected by a deficient FM clause, while addressing the augmented ex post inefficiencies arising from the relevant legal regime's structural shortcomings in India.

8.2 An Example to be Emulated: PRC Civil Code, 2021

Under the PRC Civil Code, China has legislated FM as a statutory doctrine in Articles 180 and Article 590. The parties must establish causation between the FM event and the non-performance of the contract to meet the threshold for invoking the FM event. The invoking party is "*required to provide prompt notification to the counterparty and proof of the existence of the FM event and its impact*" (Baker McKenzie, n.d.).

In the absence of an FM clause in a contract governed by PRC law, the statutory definition of FM as per Article 180, which provides "objective circumstances

which are unforeseeable, unavoidable and insurmountable" applies to the contract. When there is an express FM clause, the contractual provisions apply, provided they do not conflict with or derogate from the general principles of PRC law (Tang et al., 2022).

Moreover, PRC Courts have been given discretion to apply the general principles of fairness and good faith in the absence of detailed legal stipulations and have the power to strike down unreasonable FM provisions. Parties also have the right to request a People's Court in China or an arbitration tribunal to amend or cancel a contract, which was unduly unfair at the time of conclusion (Glueck & Munzinger, n.d.).

Commentators note that the PRC Civil Code's codified FM and change-of-circumstances rules emphasise renegotiation, contract adjustment, and fairness-based judicial intervention, thereby reducing the need for breach litigation and preserving economically valuable transactions (Gilardino, 2022). By supplying a default statutory definition and remedial framework, the Civil Code reduces the need for parties to negotiate highly complex, contingency-specific clauses ex ante, thereby lowering transaction and drafting costs. At the same time, the availability of a uniform, legally recognised standard for unforeseeable and insurmountable events reduces uncertainty about judicial outcomes, which, in turn, lowers expected litigation costs and encourages settlement.

This improves allocative efficiency by allowing parties to adjust or terminate contracts in response to genuine supervening events, rather than being forced into economically wasteful performance or total discharge under rigid doctrines.

9. Conclusion

In this research paper, a comprehensive analysis of the intricacies and significance of the contract law concepts of FM and the DoF has been undertaken. Different aspects of the principles, ranging from their origins to their functioning in the field, have been evaluated. This has been done against the backdrop of the COVID-19 pandemic, which fundamentally hindered economic and commercial processes worldwide. Various case laws and the relevant statute, the Indian Contract Act, were referred to in this process. Through this examination, the nature of both principles was discerned, which was instrumental in recognising their relevance during the COVID-19 pandemic, which engulfed the globe. The doctrines of Frustration and FM became pertinent legal principles for navigating uncertain and unpredictable times, providing some order amid volatility. Furthermore, a legal vacuum in Indian contract law was identified, which, if addressed, could lead to more justiciable and efficient conditions in contract law. An alternative model to address this problem is mooted in this paper, which involves recognising FM as a statutory doctrine. The growing unpredictability in global affairs demands that the status quo on the relationship between FM and Section 56 be modified to address the increasing volatility in commercial transactions.

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Short-Run Credit-Output Relationship in the Mining Industry

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ABSTRACT

This paper fundamentally examines the short-run relationship between bank credit growth and industrial production growth in the mining and quarrying sector during the post-pandemic period (2021-2025). Using secondary data sourced from the Reserve Bank of India Handbook of Statistics on the Indian economy, the study employs simple statistical methods like trend analysis and Pearson's correlation coefficient to examine the credit-growth association. The correlation between the raw credit and production level indicated a strong positive relation (0.78); however, the correlation between the corresponding growth rates indicated a weak positive relation (0.19). This suggests that in the short run, industrial production may not be immediately dependent on bank credit but is largely based on monetary policy and sector-specific characteristics, along with reliance on alternative financing sources.

Keywords: credit growth, mining sector, short-run production, industrial production

JEL Classification: L72, E5, O16

1. Introduction

Industrial productivity plays an instrumental role in the overall economic growth of developing nations like India. The industrial sector contributes significantly to Gross Domestic Product (GDP), employment generation and productive resource mobilisation. Existing research and literature, such as Kaldor's growth laws and Verdoorn law, further reinforce the central role of industrialisation in development and its importance in the structural economic transformation. Thus, a sustained expansion of the industrial sector is crucial for the overall economic development, sustainability and structural growth.

Industrial growth acceleration relies heavily on the availability of adequate funds. For capital-intensive sectors like Manufacturing and Industries, there is a growing requirement for substantial investment in machinery, working capital, infrastructure and technology. Financial intermediaries play a vital role in facilitating the mobilisation and allocation of these necessary funds. Financial intermediation theory is a central concept within the sphere of this study. This theory broadly highlights the importance of financial intermediaries like banks, credit unions, investment and insurance firms. They facilitate the flow of funds by channelising surplus funds to the insufficient economic units in various sectors. Revisions in the availability of bank credits can deeply influence industrial production capacity, productivity, investment decisions and the overall growth and performance.

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This paper is fundamentally concerned with the mining sector specifically. sector specifically. The mining sector plays a crucial role in the overall industrialisation of a country as it provides the raw materials necessary for various industrial processes. This sector generates revenues from taxes, exports and raw material supply to other manufacturing industries. The mining industry also plays a crucial role in the energy sector.

This paper attempts to analyse the relationship between bank credits and the mining sector in the post-pandemic time period (2020-25) using data sources from the RBI Handbook of Indian Economy to interpret the bank-credit correlation in the short run.

2. Literature Review

Joseph Schumpeter (1911) emphasised the important roles played by financial intermediaries in accelerating economic growth. He acknowledged that effective banking and financial intermediation is the engine of innovation, which inevitably would lead to economic growth.

Goldsmith (1969) built on the principles of Schumpeter and argued that an efficient allocation of funds, as part of financial intermediary efficiency, into productive sectors, is a crucial step towards economic development and growth. For capital-intensive sectors like mining and quarrying, innovation is an indispensable factor necessary to overcome machinery and technological obsolescence. The importance of bank credits in the growth of industries is particularly emphasised by Arjune and Kumar (2022).

The relationship between economic growth and financial development can be illustrated by Hugh T. Patrick (1966) using the two–hypothesis framework: the supply-leading hypothesis and the demand-following hypothesis. This framework allows us to understand the direction of causality, whether financial intermediation stimulates economic growth or whether economic growth generates demand for financial intermediation. In simple words, this helps us answer the following question: Do bank credit act as a catalyst of growth or just respond to it?

Hausmann et al. (2007) went a step further and contributed to the development of the "stages of development" hypothesis, which emphasised the non-static relation between economic growth and financial development. He highlighted that the supply-leading hypothesis applies to the initial development stage of the economy, and demand-following is applicable as the economy matures. Paul and Otubu (2019) argued that a positive correlation can be computed between bank credits and manufacturing production.

The mining and quarrying industry is heavily capital-intensive in nature. This leads to greater dependence and demand for infrastructure investment, heavy machinery requirements, and technological advancement. (Khayal, 2022) expressed that given the involvement of a large capital and labour workforce, the majority of the mining industries are under large companies, which are mostly publicly listed.

3. Methodology

3.1 Research Objective and Design

Nature of study: The study adopts a quantitative research design with a focus on short-run trends of credit and production in the mining and quarrying sector. Given the limited sample size used (5-years), the study is fundamentally descriptive in nature.

The objective of the study is to interpret the following in a short-run period (2021-2025):

- To present the trends of :
  - Industrial production of the mining and quarrying sector and the corresponding growth rate.
  - Bank credits and the corresponding growth rate.
- To find the correlation between the Bank credit growth rate and the IIP growth rate.
- To find the correlation between Bank credit and production.

The research is conducted by adopting data analysis and interpretation of the found results in a simplified manner.

3.2 Data Source

The study uses secondary data sourced from "The Handbook of Statistics on Indian Economy", presented by the Reserve Bank of India.

3.2.1 Credit deployment to Industry

- Table 46: Industry-Wise Deployment of Gross Bank Credit
- Dated Aug 29, 2025
- Measured in ₹ Crore

3.2.2 Industrial production

- Table 27: Index Numbers of Industrial Production
- Date: Aug 29, 2025
- Base: 2011-12 = 100
- Source: National Statistics Office (NSO), Government of India.

3.3 Scope

- Sector: Mining and Quarrying
- Time period: 2021-2025 (post-COVID)
- Geographic area: India

3.4 Analytic Method

3.4.1 Trend

Line charts are an ideal analytical method to represent trends of a particular variable over a period of time. In this study, a trend is used to illustrate the movement of the following over the time span 2021-2025:

- Deployment of gross bank credit in the Mining and Quarrying industry
- Index number of industrial production
- Year-on-year growth rate of
  - Gross bank credit
  - Industrial Production

3.4.2 Pearson's Correlation coefficient

Correlation is the fundamental statistical tool used in this study. It is used to measure the relationship between the following two variables :

- Credit growth rate
- Production growth rate

4. Result

4.1 Trend in Industrial Production

The following data is used to interpret the trend in industrial production :

4.1.1 IIP (Index number of Industrial Production) Raw data:

Table 1 shows the index number of industrial production for the Mining and Quarrying sector in the assumed short run (2021-2025). In Figure 1, the trend

in the index number of industrial production of the mining and quarrying sector is plotted.

Index Number of Industrial Production - Mining and Quarrying sector					
Year	2020-21	2021-22	2022-23	2023-24	2024-25
Industrial Production	101.0	113.3	119.9	128.9	132.8

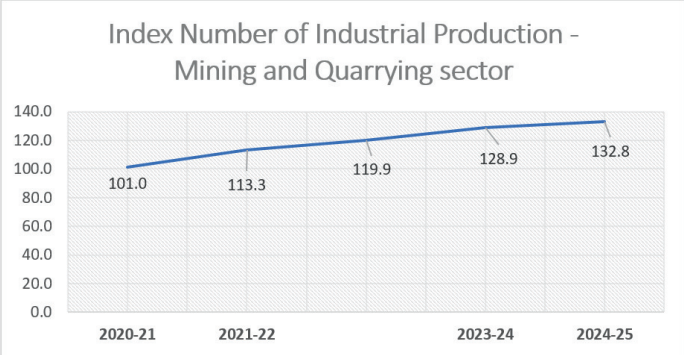


Table 1 and Figure 1: Index number of industrial production for the Mining and Quarrying sector in short run (2021-2025)

Source: India's Index of Industrial Production

4.1.2 IIP (Index number of Industrial Production) Growth Rate data:

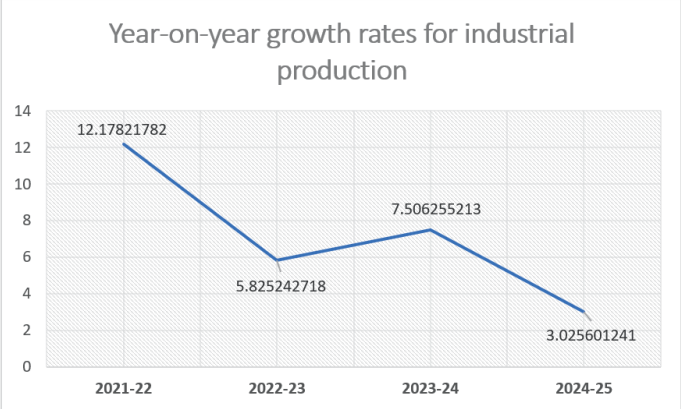


Figure 2: Growth rates for the Mining and Quarrying sector in the short run (2021-2025)

Source: India's Index of Industrial Production

4.1.3 Interpretation

The Mining and quarrying industry showed a consistent rise in industrial production over the time period of 2021-2025, with the highest production in 2024-25 reaching an index of 132.8. The Growth rate was observed to be highest in the year 2021-22 (12.1 %), reaching an index of 113. The year 2022-23 saw a diminished growth rate, reaching an index of 119 and a rate of ~6%. A significant increment in the growth rate was observed for the year 2023-24, reaching an index of 128.9. Subsequent decrease in the growth rate was observed, 2024-25(3.02%) being its lowest, with an index of 132.8.

4.2 Trend in Bank Credits

The following data is used to interpret the trend in bank credit :

4.2.1 Gross Bank Credit Raw Data

Deployment of Gross Bank Credits - Mining and Quarrying sector					
Year	2020-21	2021-22	2022-23	2023-24	2024-25
Bank Credit	43498	50353	60221	54166	56756

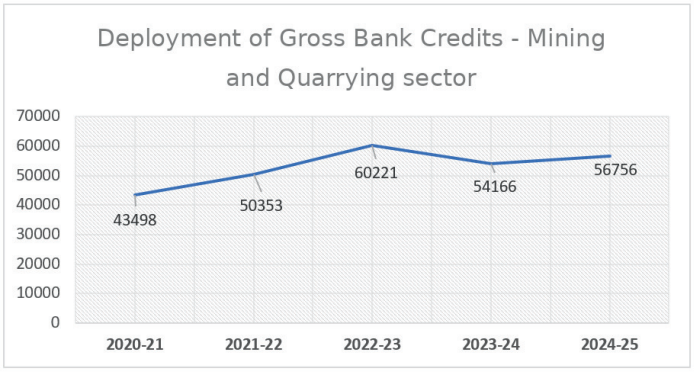


Table 2 and Figure 3: Index number of industrial production for the Mining and Quarrying sector in short run (2021-2025)

Source: India's Index of Industrial Production

4.2.2 Interpretation

The mining and quarrying sector showed a strong growth in 2021-22 (15.75%), followed by the highest credit growth rate of 19.59, reaching an index of 60221, for the year 2022-23.

The initial increase in the bank credit growth 2021-22 suggested an increase in demand for bank credits by the mining industry. In 2022-23, despite the highest bank credit growth, the lower industrial production suggests a probable lag effect or a push towards future

investments, causing immediate output to fall. The year 2023-24 saw a sudden fall in the growth of bank credits(-10.05%), reaching an index of 54166.

A modest recovery was observed for the subsequent year of 2024-25, reaching a growth rate of 4.78% and an index of 56756.

4.2.3 Gross Bank Credit Growth Rates

Year-on-year growth rates for gross bank credit				
Year	**2021-22**	**2022-23**	**2023-24**	**2024-25**
Credit Growth Rate	15.75935	19.59764	-10.05463	4.781597

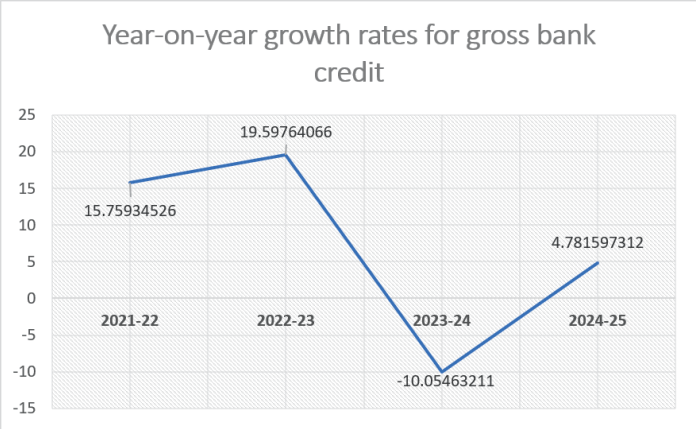


Table 3 and Figure 4: Gross bank Credit growth rates for the Mining and Quarrying sector in the short run (2021-2025)

Source: India Budget

4.3 Correlation

4.3.1 Bank Credit Growth and Production Growth

Table 5: Calculation of correlation between Gross bank Credit growth rates and production growth rates for the Mining and Quarrying sector in the short run (2021-2025)

Calculation of Correlation between Credit growth rate and Production growth rate of the mining sector		
Year	**Credit Growth Rate**	**Production Growth Rate**
2021-22	15.75934526	12.17821782
2022-23	19.59764066	5.825242718
2023-24	-10.05463211	7.506255213
2024-25	4.781597312	3.025601241
Correlation		0.199063808

Source: India Budget

4.3.2 Interpretation

The correlation computed between the bank credit growth rate and mining production growth rate is 0.199, suggesting the following:

- Strength of correlation: Weak
- Direction of correlation: Positive

5. Discussion

This section of the research attempts to elucidate the relationship between bank credit and industrial production by referring to the results of the analysis.

5.1 Yearly Analysis

5.1.1 2021-22

The initial year of study, that is, 2021-22, showed a consistent positive correlation between the rise in industrial production and credit growth. This alignment suggested the following :

- A post-pandemic acceleration in the banking sector that supported the growth of the industry (Supply-leading hypothesis).
- Or simply, a greater demand for financing from the mining sector, which led to the rise in credit deployment. (Demand-following hypothesis).

5.1.2 2022-23

Despite a significantly higher credit growth rate (19.5%) during 2022-23, the production growth rate fell drastically (to about 5.8%). This misalignment can indicate the following:

- Rise in production cost, disruption in supply chain and inflation may have led to a diminishing production in spite of high credit growth.

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- Credit lag effect: Lag effect is the delay in the implementation of the policy (monetary policy in this case) and the recognition and implementation) and the recognition and implementation of those policies in the economy. This suggests that credit dissemination does not necessarily translate to immediate production due to gestation lag (Kydland & Prescott, 1982). This also suggests that the 2022-23 bank credit deployment may result in a production rise for the following year.
- Probable investment of current funds into future projects.

5.1.3 2023-24

The year 2023-24 displayed a significant negative relationship between credit and production. Bank credit deployment to the mining sector strikingly fell to a -10% growth rate, a direct fall from 19% in 2022-23. The production, on the other hand, increased to 7.5%.

This suggests a case of short-term divergence, where two variables are moving in opposite directions or are decoupling from each other.

This can be understood with the following assumptions:

- Public sector dominance in the mining sector might have reduced the industry's dependence on loans or credit facility conditions. This is because the mining industry is a policy-heavy industry, with strong backing from the government and public sector enterprises. Firms, as a result, reduced their reliance on bank credit for investments during this period of time. This reduced demand for bank credit can be one reason for the negative credit growth rate.
- Firms increasingly relied on alternative funding sources and internal funding. This was also due to companies reducing their reliance on bank credit investments during this period of time, thus reducing the demand.
- The mining industry is heavily influenced by the price of commodity material. An increase in these prices also leads to greater mining activities, as highlighted by Arjune and Kumar (2022).

5.2 Correlation Interpretation

There was a difference in the correlation between the two variables depending on the data on which it was computed.

5.2.1 Raw Data Correlation

The computation of the correlation between bank credits as the independent variable and production as the dependent variable resulted in a value of 0.7845. This value indicates a strong positive correlation between the two variables. This value, however, cannot be an accurate measure of the correlation because of the strong trend-driven influence on the data. Both variables are seen to be in an uptrend for the computed period of time, and thus the correlation also translates the uptrend into its strong positive relationship. This is a classical spurious correlation problem in time series.

5.2.2 Growth Rate Correlation

The computation of the correlation between bank credit growth rates as the independent variable and production growth rates as the dependent variable resulted in a value of 0.19. This value implies a weak positive relationship between the two variables.

This correlation coefficient is considered the real economic signal. The weak positive correlation coefficient can be explained with the following reasoning :

- Credit deployment may not result in immediate production growth
- Less reliance on bank credit by firms
- Time lags
- The mining industry is more inclined and dependent on policy and government, global business environment, inflation and other monetary factors rather than just credit.

5.3 Limitations of the Study

The analysis of this study relied on a very small sample size (limited to 5 years, 2021-2025), forming one of the main limitations of the research. The small sample size was incorporated to support the core requirement of this study, which is based on a short-run dynamic with a focus on the post-COVID credit deployment and industrial production data. This, however, led to statistical and analytical restrictions as the correlation coefficient was sensitive to short-term fluctuations and had a drastic impact on the overall correlation between the two variables. The study couldn't capture the overall lag effect. This study was limited to simple but powerful statistical methods like trend and correlation. An attempt has been made to keep the research inclined towards descriptive analysis, and thus, findings are exploratory in nature rather than conclusive.

6. Conclusion

The study examined a short-run credit output relationship between the industrial production and bank credits for the mining and quarrying industry during the post-COVID period (2021-25).

The objective was to analyse the trends in production and bank credit along with their corresponding growth rates in order to study the nature of the relationship between the two variables. Trends suggested a fluctuation in the growth rates of the variables over the period of study, while a consistent rise in both production and bank credit was interpreted.

Despite the positive relationship raised as a result of computation, the strength of correlation was weak in nature. This suggested that industrial production, specifically of the mining and quarrying sector, did not necessarily depend solely on bank credits. The study concludes that industrial production of the mining industry is influenced by various factors beyond immediate bank credits, like government regulations and production targets, public sector dominance, policy and institutional factors, commodity price fluctuation and demand. The findings, however, remain explorative in nature due to the limited time frame. Future research with relatively larger data sources and advanced statistical methodologies may provide a comprehensive and deeper understanding of the complexity of the relationship between bank credits and industrial output.

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What is Seen, is Sold: Analysing the Impact of Digital Marketing on Consumers' Purchase Decisions of Cosmetic Products

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ABSTRACT

The Makeup, Cosmetics, and Wellness industry has become an important part of culture over the years, with each product serving as a unique medium of self-expression. Globalisation in the past three decades has expanded Indian consumers' options. Established international cosmetic brands enjoy wide popularity in India, while there is also a newer sense of awareness and trust for up-and-coming names. In this digital age, both Indian and international brands are constantly competing for attention through various marketing tactics, including advertisement campaigns, viral internet trends, and celebrity endorsements. This study aims to explore two interrelated questions: Do Indian consumers prefer Indian beauty brands? And, is this preference consistent with liking for the brand's digital marketing strategies? To reach conclusions about consumer behaviour in this market, this study employs a survey questionnaire crafted to assess our respondents' attitudes. As India targets self-reliance in its industries, understanding consumer preferences becomes invaluable for stakeholders in the Beauty market.

Keywords: cosmetics, beauty industry, wellness industry, digital marketing, consumer behaviour, brand perception

JEL Classification: M31, M37, D12, D91, L67, O33

1. Introduction

The Cosmetics Industry is, without a doubt, one of the biggest industries in the world today. According to recent market research, the industry was valued at approximately USD 14.9 billion in 2021 and is projected to reach USD 28.9 billion by 2026, reflecting a Compound Annual Growth Rate of 14.9% for the period of 2021-26. India is also observing a boom in the industry, supported by newer e-commerce platforms like Nykaa and Tira, which are increasingly connecting Indian consumers with foreign brands. At the same time, Indian origin brands like Indē Wild and Kama Ayurveda are finding their spotlight, especially as the focus now shifts to being "Vocal for Local".

With various innovations in technology, especially visible in the use of social media and overall digital space, brands today have the opportunity to set up a stage for themselves and show what they have to offer. From interesting marketing campaigns to intelligently priced products and culturally rooted origin stories, brands can do it all through digital marketing strategies.

Celebrities have long been at the centre of major marketing campaigns, but the introduction of influencers is completely changing the scene of digital marketing. They are bringing in relatability, transparency and honesty in the cosmetics market. Social media users and consumers now largely rely on these influencers to gain the information they need about a product. The average consumer today is just

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is just one click away from finding out all they need to know about the purchase they are making. Therefore, the game of positioning your brand and generating interest for your products becomes all the more difficult.

Thus, it is important to understand what is capturing the Indian consumer's attention. What marketing tools are reaching them and how they are reacting to them is crucial to understand for brands in order to position themselves in a way that is engaging to consumers. Certainly, it's not one, but many factors that a rational consumer is evaluating, and brands need to make sure that their target market gets exactly what they are looking for. This study focuses on analysing these very factors that command a consumer's interest and convert it into a purchasing decision. It also features comparative case studies between foreign and Indian cosmetic brands.

2. Literature Review

With the continuous development in digital technology and the increasing demand for digital content, it has been crucial for brands to maintain an online profile and cater for their target market with all the information they need and want to have, in order to initiate purchasing behaviour.

Maintaining a social media presence can also benefit companies in the sense that it can enable them to gain new customers, given the amount of growth these platforms have observed. SproutSocial, in their article for social media statistics, reports that in 2025, there are estimated to be 5.42 billion total social media users worldwide, with an average person using 6.83 different social networks per month. With people relying on social media for every bit of information, cosmetic brands can reap the benefits of increased influencer marketing and personalised ads.

Digital Marketing Sage, a leading digital marketing consultation agency, reports that after introducing digital marketing strategies like virtual try-on on their website, Sephora was able to reduce product returns. They were able to see a surge in online purchases and about 37% increase in conversion rate for featured products. Airbnb has also intelligently engaged in content marketing strategies. Instead of making ads, they shared local stories and experiences through their "Belong Anywhere" campaign. Over 50% bookings were influenced by content, and hosts reported more bookings. This shows that maintaining a personal connection with your target market can also increase sales; it shows that the brand cares about its customers and is willing to go the extra mile to cater to their needs.

In their research paper, "When is celebrity endorsement effective?", Mina Jun, Jeongsoo Han, Zhimin Zhou, and Andreas B. Eisingerich explore why celebrity marketing, too, is on the rise. Brands are increasingly engaging with the most popular celebrities to market their offering, but when does celebrity marketing effectively work? The main principle of celebrity marketing focuses on curated associations, aligning what people want to see, i.e. what their favourite celebrities are consuming, with what the brands sell. Often, brands associate with celebrities who have shown the same values as the brand itself. For example, as Glossier's brand ambassador, Olivia Rodrigo works on two levels- by catering to the market that they are targeting (girls and women in the age bracket of 18-25), and by aligning with their values of clean and natural beauty.

Shifting focus to the Indian context, Kay Beauty, launched by actress Katrina Kaif, revolutionised the cosmetic market in India. Her brand became the first Indian celebrity-owned makeup brand launched in 2019. It partnered with Nykaa for the purpose of distribution and proved to be one of the more successful partnerships. The brand's tagline, "It's Kay to be You", encapsulates the idea in which the brand is rooted - sustainability and inclusivity. The brand has since partnered with a diverse number of influencers. Its high-quality production, association with the right influencers and celebrity support have made it one of the most sought-after cosmetic products in the Indian Market today.

Conversely, the definition of celebrity is also changing with the advent of another social media trend of "influencers". Beauty and cosmetic influencers are now entering the cosmetics market and "bridging the gap between what is available in the market and what the market actually requires." This is Huda Kattan's philosophy, who, having tried a number of cosmetic brands, started her own. Huda Beauty's marketing mostly includes social media marketing, engaging the same community that she was once a part of– social media influencers.

Making intelligent use of influencer marketing, Indē Wild has emerged as one of the most successful brands in India today. Founded by influencer and entrepreneur Diipa Büller-Khosla, the brand is centred around making Ayurveda accessible. Indē Wild aims to break the age-old perception of Ayurveda being old-fashioned and uncool. They have organised major launch events in collaboration with influencers, which have enabled them to position their products in a more relatable and modern manner, rooted in their core values. This can be seen in the launch of their "Champi Hair Oil" or their Dewy Lip Treatments in the shades of "Masala Chai" and "Glazed Jalebi".

Forbes reports that today, more than 90% of people seek online reviews before making a purchase, but today, even celebrities alone can't move a consumer to buy as in the past. A recent survey in Europe showed this trend: 45% of European GenZers report they're more likely to buy fashion items they've seen on influencers than promoted by celebrities or even their peers. Influencers are steering the sales for many brands today that are heavily investing in influencer marketing. Projections show that the global affiliate marketing economy is expected to be worth $40 billion by 2030, and the overall creator economy is expected to be worth $480 billion by 2027 (as reported by Forbes in the aforementioned study).

Research by EY also shows that in India alone, the influencer marketing sector is projected to reach INR3,375 crore by 2026, with a compound annual growth rate (CAGR) of 18%. With celebrity marketing, celebrity-owned brands, the fame of the founders serves as the marketing for the brands. But for others, strategies like influencer marketing can promise increased sales and brand recognition as influencers become more and more synonymous with transparent reporting and relatability.

3. Research Gap and Reseach Objectives

A specific distinction of consumer preferences between Indian and Foreign brands has not been largely researched. Knowledge of the strategies that have worked for some of the most successful international brands, and what the average Indian consumer feels

about these brands (now that they can access these products), remains crucial information that Indian brands could potentially employ in their marketing strategies.

Our objective remains to gauge the central factors that affect the purchasing decisions of Indian consumers for cosmetic products, and what is essentially interesting to them. Our study can help Indian brands work on areas that foster better positioning in the long term as well as tailor their offerings more effectively for the Indian demographic.

4. Research Methodology

A Google form was circulated to collect primary data for the study. The study was conducted on 100 female college students in the age range of 18-24. For the scope of our study, the questionnaire was split into three parts, as further explained below.

Table 1: Questionnaire Structure

Section	Answer type	Questions
A	Scale (1 to 5)	The first section focused on various aspects of digital marketing. Respondents were asked to rate their preferences on a scale of 1 (little effect) to 5 (major effect). For example: **To what extent does influencer marketing affect your interest in a cosmetic product?** **To what extent does the social media aesthetic of the brand affect your interest in a product?**
B	Scale (1 to 5)	This section was related to other factors that affect a purchasing decision. Respondents were again asked to rank their preferences on a scale of 1 to 5. For example: **To what extent do your past experiences with a cosmetic brand/product affect your interest in a product?** **To what extent does the price of the product affect your interest in it?** **To what extent does the country of origin of the brand influence your interest in a product?**
C	Options (Indian product / International Product)	Respondents were shown a video containing 2 advertisements. Both were similar styles of ads for products in the same domain of cosmetics. One ad was by an Indian brand, and the other by an international brand. Following this, respondents were asked which product interested them more

		(solely based on the digital marketing content). Then, they were provided resources to research the two products themselves (a document containing prices, ingredients, and links to the official websites). Having gained the necessary information as conscious consumers, they were asked which product they were more likely to actually purchase. This process was done with 4 pairs of ads, comprising 8 brands in total.

The results of Section A were tabulated, highlighting the mean and modal scores of each parameter. The data from Sections A & B were visualised in Microsoft Excel to create a sentiment analysis chart of factors affecting interest in cosmetic products. The results of Section C were visualised using a 2 x 2 matrix for advertisement preference (Indian vs International product) and purchase likelihood (Indian vs International product). This allowed for correlational analysis to understand the consistency of consumer preferences.

5. Data Analysis

5.1 Section A and B

Table 2: Questionnaire Results

Type	Parameter	Mean Score (out of 5)	Mode (Out of 5)
Digital Marketing	Celebrity endorsement	2.14	1 (34%)
Digital Marketing	Interesting campaign	3.4	4 (46%)
Digital Marketing	Ingredients (makeup)	3	3 (38%)
Digital Marketing	Ingredients (skin)	3.8	5 (36%)
Digital Marketing	Ingredients (hair)	3.68	4 (36%)
Digital Marketing	Influencer marketing	2.32	2 (36%)
Digital Marketing	Packaging	3.22	4 (44%)
Digital Marketing	Social media aesthetic	2.88	3 (28%)
Digital Marketing	Overall	3.05	4
Others	Word of mouth	4.18	4 (52%)
Others	Past experiences	4.52	5 (58%)
Others	Price	4.08	5 (40%)
Others	Discounts	3.5	3 (32%)
Others	Substitutes	3.36	3 (40%)
Others	Personal conditions	4.24	5 (46%)
Others	Country Origin	3.04	4 (36%)
Others	Overall	3.84	5

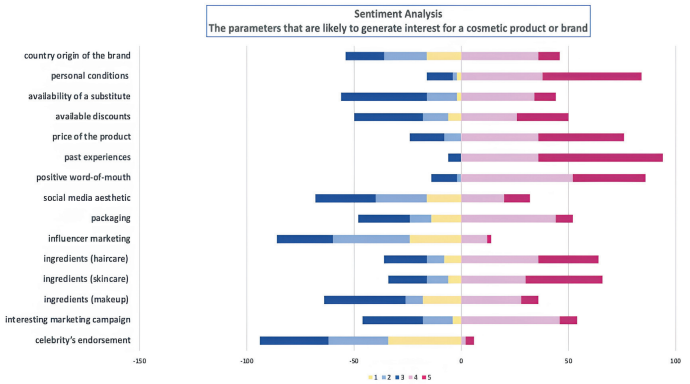


Figure 1: Sentiment Analysis on Factors Generating Brand Interest

Source: Author's research

Among digital marketing strategies, *'Celebrity Endorsement'* has the weakest influence on brand interest (Mean score = 2.14 and Mode = 1). 'Influencer Marketing' also shows a low score (Mean = 2.32, Mode = 2), as does 'Social Media Aesthetic' (Mean = 2.88, Mode = 3).

Similar modal scores of '3' for both *'Availability of Substitutes'* and *'Discounts'* indicate respondents' indifference towards these parameters. This neutrality in the data may suggest that the high availability of substitutes reduces the relative importance of discounts in this industry.

The digital marketing strategies with a clearer influence on consumer perception are *'Interesting Campaigns'* (Mode = 4, Mean = 3.4) and *'Product Packaging'* (Mode = 4, Mean = 3.22). Attention to ingredients varies based on product category. For instance, *'Reference to High-End Ingredients'* shows a mode and mean of 3 for 'makeup' products, but higher scores for 'skincare' and 'haircare' products. These results align with the findings regarding the influence of *'Personal Conditions'* (Mode = 5, Mean = 4.24).

'Product Price' (Mean = 4.08, Mode = 5) shows a major impact, but *'Past Experiences'* emerges as the factor with the strongest influence on consumer interest, with the highest mean (4.52) and mode (5) out of all parameters.

Most respondents were neutral on the '*Country of Origin'* of the brand (Mode = 4, Mean = 3.04). Overall, the mean and mode for digital marketing factors are 3.05 and 4, respectively, compared to 3.84 and 5 for the other factors.

In summary, these results suggest that the factors independent of digital marketing (such as past experience and personal needs) have a greater influence on the sample. However, this need not imply that interest in a product's digital marketing is completely unrelated to the purchase decision. The following section explores this idea in further detail.

5.2 Section C

The third section of the questionnaire aimed to explore the way consumer preferences play out in a real-world setting. After a pair of advertisements was displayed, consumers had to name the product which interested them more, solely based on the digital marketing. To further assess the consistency between digital marketing and purchase decision, consumers were then asked to name the product they were more likely to actually buy. This framing facilitates correlation analysis between advertisement preference and purchase likelihood between Indian and International brands.

5.2.1 CASE I:

In August 2023, American skincare brand Rhode, founded by model and socialite Hailey Bieber, released a lip balm in the scent "strawberry glaze." Its launch event was held at Krispy Kreme's Times Square

location, paying homage to the "strawberry glaze doughnut" that inspired the product. In May 2025, Indian beauty brand Indē Wild introduced a new addition to its "Dewy Lip Treatment" line – a balm inspired by desi masala chai. To celebrate, the founder hosted themed launch parties across multiple cities called "chai raves."

Both advertisements highlight the founders' presence at community-based launch events for their respective products. Each product belongs to the same cosmetics category and draws inspiration from a culturally specific food or beverage.

Some people might prefer the first advertisement because it strongly reflects personal branding as a celebrity-owned line. Its visual language emphasises the aspirational lifestyle of a New York-based influencer. In terms of purchasing decision, someone might prefer Rhode's product due to its established reputation and recognisability, as well as the perception that Indian equivalents are less premium or "cheap knockoffs."

On the other hand, others might be drawn to Indē Wild's advertisement for its emphasis on cultural familiarity and community spirit, rather than on individual celebrity glamour. Consumers may be more likely to buy the second product due to its lower price point and the belief that it is better suited to Indian skin tones and local beauty needs.

A phi correlation test was conducted to assess the nature of the relationship between liking for digital marketing content and the likelihood of product purchase.

	Prefer Indian Ad	Prefer International Ad
Would buy Indian product	42	24
Would buy International Product	0	34

Figure 2: Phi Coefficient Matrix: Rhode vs Indē Wild
Source: Author's own calculations

The test yielded a result of $\Phi = 0.610771$, suggesting a positive correlation between advertisement preference and purchase decision.

5.2.2 CASE II:

One of the bestselling products from the French haircare brand Kérastase is its anti-hair-loss serum under the Genesis line. A video on the brand's official YouTube channel features London-based creator Sasha Lillie, who demonstrates how to use the product and explains how it has become part of her self-care routine. In contrast, Indian haircare brand Fix My Curls released its "Leave-in Cream," designed to define curls and reduce frizziness. Creator Deepika Joshi appears on the brand's official YouTube channel in a tutorial video showing how to apply the product.

Both brands use influencer marketing and rely on tutorial-style videos to promote their products. This approach helps build trust by showing real people using the products, making them more relatable and encouraging viewers to try them.

Some viewers might prefer the Kérastase advertisement because it conveys the aspirational lifestyle of an English model and emphasises the concept of self-care as a ritual rather than simply promoting another beauty product. Likewise, someone might be drawn to Kérastase as it is a globally recognised brand under L'Oréal, with a long-standing reputation for quality. On the other hand, Fix My Curls' advertisement might

appeal more to those who relate to the daily personal challenges faced by Indians with curly or wavy hair. It also provides more detailed information about the ingredients, making it feel more transparent.

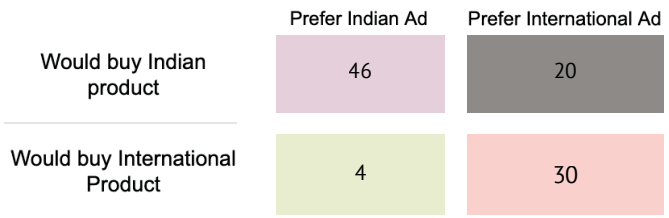


Figure 3: Phi Coefficient Matrix: Kérastase vs Fix My Curls

Source: Author's own calculations

Here, the test yielded a result of $\Phi = 0.548860$, again suggesting a positive correlation between ad preference and purchase decision.

5.2.3 CASE III:

Korean brand Beauty of Joseon is known for drawing inspiration from traditional hanbang (herbal) skincare. One of its signature products, Relief Sun, is a sunscreen formulated with ingredients such as rice extract. The brand's marketing presents it as a modern interpretation of skincare practices from the Joseon dynasty era. Similarly, Indian wellness brand Kama Ayurveda released its *Kumkumadi Day Cream*, which celebrates an ancient recipe featuring saffron, sandalwood, and lotus extracts. The brand's focus on traditionally prepared ingredients highlights its deep roots in Ayurvedic practices.

Both advertisements use rich cultural imagery and emphasise natural ingredients along with traditional methods of production. Some people might prefer the Beauty of Joseon advertisement because of its aesthetic that cultivates a sense of mystique and sophistication. It also aligns with the global surge of interest in Korean culture and lifestyle. As a purchase decision, it might appeal to consumers who trust the reputation of South Korean skincare. Conversely, others might be drawn to the Kama Ayurveda advertisement for its familiar setting and its focus on explaining the product's properties in a clear, informative way. The Kumkumadi Day Cream may be preferred by those who value traditional native ingredients and formulations, especially since it is well-suited to Indian skin types and local weather conditions.

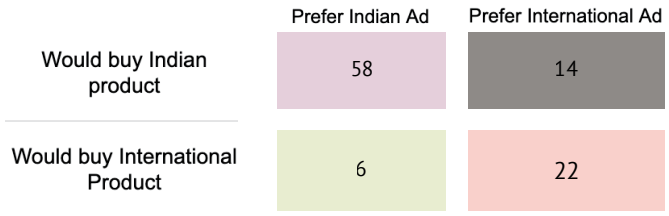


Figure 4: Phi Coefficient Matrix: Beauty of Joseon vs Kama Ayurveda

Source: Author's own calculations

Here, the test yielded a result of. Φ: 0.553082, suggesting a positive correlation.

5.2.4 CASE IV:

In October 2025, the French beauty brand L'Oréal released a Diwali-themed commercial titled "Mujh Mein Hai Diwali", starring actresses Alia Bhatt, Akansha Ranjan Kapoor, and Anushka Ranjan. The ad depicts the trio revisiting cherished childhood memories, partaking in festive celebrations, and embracing the idea of celebrating the light within. During the same festive season, Indian makeup brand Nykaa launched its "Tum Hi Ho Nykaa" campaign featuring actress Deepika Padukone. This commercial centres on the joy of "getting ready with nowhere to go," emphasising beauty as an act of self-love rather than something tied to external occasions.

Both advertisements rely on celebrity endorsements, featuring popular Indian actors, and both are set against the backdrop of Indian festivals, including L'Oréal's

international brand adapting to local cultural themes. Some viewers might prefer the L'Oréal ad for its sentimental storytelling and emotional appeal, as well as their fondness for the featured celebrities. The brand itself may also be preferred because of L'Oréal's global reputation, long-standing legacy, and association with luxury and trustworthiness in the beauty industry.

Others may be more drawn to Nykaa's advertisement for its relatable messaging, which redefines beauty as a personal and empowering experience rather than a social obligation. Nykaa, as a brand, might also appeal more to consumers because of its wide range of product prices, accessibility, and affordability within the Indian market.

	Prefer Indian Ad	Prefer International Ad
Would buy Indian product	44	8
Would buy International Product	6	42

Figure 5: Phi Coefficient Matrix: L'Oréal vs Nykaa
Source: Author's own calculations

Here, the test yielded a result of $\Phi = 0.720577$, again suggesting a positive correlation.

6. Discussion

This study aimed to determine whether Indian consumers prefer Indian cosmetic products. Based on responses in Section B, it can be inferred that the sample did not prioritise the country of origin of the brand. However, in Section C, the total votes for purchasing Indian products generally surpassed those for international products. The main observation in Section C was that responses were focused along the leading diagonals. This suggests that participants were more inclined to buy the product whose advertisement appealed to them most, regardless of its origin. The high Phi values from the correlation test further support the conclusion that digital marketing positively correlates with product sales.

However, the data in the table highlights that digital marketing alone is not the dominant factor influencing consumer interest. The overall mean score for digital marketing factors is considerably lower than that of other influences. Among all parameters, past experiences had the strongest impact, followed by personal conditions and word of mouth. These findings suggest that consumers are not passive recipients of marketing efforts but active decision-makers whose choices are shaped more by prior experiences and interpersonal influence than by online promotional tactics.

7. Conclusion

Today's entrepreneurs are moving beyond conventional business models and using technology to redefine how their brands generate, deliver, and enhance consumer value. The beauty industry is no stranger to this phenomenon. This paper examined consumer behaviour in India's cosmetics sector to understand how domestic brands can leverage digital technology to better connect with their audiences, strengthen brand loyalty, and enhance sales in an intensely competitive market.

The findings highlight that Indian beauty startups should focus on product efficiency and personalisation. The idea that a product is reliable, accessible, and 'made for them' is what makes consumers feel included in the brand's narrative. Building a strong sense of community around the brand, maintaining transparency in new releases, and actively listening to

consumer feedback are essential to fostering long-term trust. Even celebrity-led labels must position their founders as engaged, improvement-oriented entrepreneurs rather than distant brand faces.

At a policy level, there is a strong case for supporting innovation through initiatives such as "*Ayurpreneurship*". Such programs encourage the integration of traditional knowledge systems with modern entrepreneurship, focusing on the differentiating factor for Indian products. Policymakers can further strengthen this ecosystem by empowering startups to test, refine, and scale their products. It is also necessary to recognise the influence of digital creators in shaping consumer preferences. Government-backed incentives that promote "vocal for local" campaigns and awards celebrating responsible influencer marketing could enhance visibility for domestic brands. Additionally, integrating digital marketing and consumer psychology into business school curricula would better prepare future entrepreneurs for a rapidly evolving marketplace.

In the long run, India has the potential to become a global exporter of beauty products that are distinctly Indian in both formulation and branding. Future research in this field could explore the geographic and income-based variations in cosmetic consumption within India, as well as broader product categories, to gain a deeper understanding of this dynamic and evolving market.

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How Effectively Does Diversification Reduce Portfolio Risk in Indian Equity Markets?

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ABSTRACT

Portfolio risk management is a fundamental concern in financial economics, particularly for diversified equity investments. This study examines the risk and return characteristics of a portfolio composed of nine Indian large-cap equities using a combination of Monte Carlo simulation and regression analysis. Historical daily return data were used to estimate the statistical properties of asset returns, including the mean return vector and covariance matrix. These inputs were used to generate a distribution of simulated portfolio returns through a Monte Carlo framework that preserves the correlation structure among assets via Cholesky decomposition.

The simulation results indicate that the portfolio generates a mean daily return of approximately 0.117%, corresponding to an annualised expected return of about 29.5%. The estimated daily volatility of the portfolio is 0.179%, which translates to an annualised volatility of approximately 2.85%. Downside risk was evaluated using Value at Risk (VaR), with estimated values of −0.176% at the 95% confidence level and −0.301% at the 99% confidence level. Additionally, regression analysis against the NIFTY 50 index produced a beta coefficient of 0.79 and an R^2 value of 0.63, indicating moderate sensitivity to market movements.

Overall, the findings highlight the role of diversification in reducing portfolio risk and demonstrate the usefulness of Monte Carlo simulation as a practical tool for portfolio risk assessment in the Indian equity market.

Keywords: diversification benefits, Monte Carlo simulation, portfolio volatility, Indian stock market, large-cap equities

JEL Classification: C15, C63, G11, G17

1. Introduction

Risk management and portfolio diversification have been central concerns in financial economics for a long time since the development of modern portfolio theory by Harry Markowitz in 1952. Investors and researchers have sought many methods to balance risk and return. My diversification across assets with imperfect correlation can significantly reduce the volatility without reducing returns. But due to the increasing complexity of financial markets, traditional analytical approaches struggle to capture the full range of possible outcomes of the performance of a portfolio. In response to this, a simulation-based technique has become increasingly popular, known as the Monte Carlo simulation. It is widely used for modelling uncertainty in asset returns and estimating the distribution of possible portfolio outcomes. This is done by generating

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a large number of simulated return scenarios, which allow analysts to evaluate the risk associated with the portfolio and value at risk under realistic market conditions.

The Indian equity market provides an interesting context for studying this portfolio risk. Over the past two decades, India has emerged as one of the fastest-growing economies with rapid development and a capital market. Large capitalisation firms, listed on the Nifty 50 index, represent diverse sectors, including finance, energy, and consumer goods. Understanding how diversification works across sectors is important not only for academic research but also for practical investment decisions.

The study examines the risk characteristics of a diversified portfolio composed of nine large-cap Indian equities. Using historical data, this study applies a Monte Carlo simulation to generate a distribution of possible portfolio returns while taking into account the covariance through Koleski decomposition. In addition to this, regression is performed, keeping the Nifty fifty as the benchmark index to represent the market risk related to the portfolio.

The primary objective of the research paper is to evaluate how diversification influences portfolio risk and to assess the usefulness of a simulation-based technique for estimating risk measures such as VAR and volatility. The study aims to provide an understanding of portfolio risk-return characteristics in the context of the Indian equity market.

2. Literature Review

The study of portfolio risk and diversification has been an important topic in financial economics for several decades. Harry Markowitz has made a major contribution in the form of modern portfolio theory. He demonstrated that investors should evaluate portfolios not only based on returns but also in terms of variance or Volatility of returns. His work established that diversification across the sets with imperfect correlations can reduce portfolio risk without reducing the returns. The mean-variance framework developed by Markovits remains the foundation of modern portfolio management.

Based on this theory, Sharpe (1964) and Lintner(1965) developed the capital asset pricing model, which provides a relationship between expected return and systematic risk, which is measured by beta. According to this model, the expected return of an asset is determined by its sensitivity to humans and the overall market portfolio, which is represented by beta. The capital asset pricing model also introduced the idea that total risk can be categorised into systematic risk, which is related to market movements, and idiosyncratic risk, which is specific to individual assets and can be reduced through diversification.

Researchers and practitioners have also developed various quantitative measures to assess risk, like value at risk, which estimates the maximum potential loss and value of a portfolio over a specified time horizon at a given confidence level. It gained widespread adoption in financial institutions following the work of Jorion (2007), who described it as a standard for managing financial risk.

Among these, Monte Carlo Simulation has become an important tool because of its ability to model complex and uncertain systems. Unlike analytical models that rely on historical or simplified data, Monte Carlo

generates a large number of possible scenarios for asset returns by drawing random values from a probability distribution. These scenarios then allow the analysts to approximate the full distribution of returns and evaluate the likelihood of extreme outcomes. According to Hull (2018), simulation is particularly useful in risk management because it can incorporate correlations between a set and capture the combined effect of multiple sources of uncertainty.

So in this study, I have built upon his body of literature by applying Monte Carlo simulation and regression to a portfolio of Indian large gap equities. By combining theoretical insights from portfolio theory with empirical simulation methods, the research aims to contribute to understanding portfolio risk and diversification in terms of the Indian equity market.

3. Research Methodology

3.1 Data Sources and Sample Description

The study is based on historical price data for nine large gap companies listed on the Indian stock market. These firms represent a diversified set of industries, including finance services, information technology, consumer goods, energy, and pharma. Does diversity allow the portfolio to capture different sources of market risk and provide a suitable framework for analysing diversification benefits?

Daily stock prices for the selected stocks were taken from 2018 to 2025. Also, the values of the Nifty 50 index were collected to represent the overall market portfolio. The use of large-cap stocks ensures high liquidity, reliable price, information and broader sectoral representation.

3.2 Return Computation

To analyse the portfolio's performance, daily returns for each stock were calculated using simple percentage change between its closing price on two consecutive trading days.

Let P_t represent the closing price of a stock on day t, and P_{t-1} represent the closing price on the previous trading day. The daily return is calculated as:

$$R_t = (P_t - P_{t-1}) / P_{t-1}$$

This converts price data into returns, which are more appropriate for analysis because they are scale-independent and allow comparison across different assets.

The daily portfolio return was then calculated as the equal-weighted average of the returns of nine individual stocks. Since each asset receives the same weight in the portfolio, the portfolio return on day t can be expressed as:

$$R_p = (1/N) \Sigma_{i=1}^{N} R_i$$

where N represents the number of assets in the portfolio and R_i represents the return of the i-th asset.

3.3 Covariance Matrix and Descriptive Statistics

The next step in the analysis is calculating descriptive statistics for the return series, which includes the mean return and variance of each stock, and a covariance matrix is constructed using historical data.

The covariance matrix measures how returns of different Stocks move relative to one another. The diagonal elements of the matrix represent the variance of individual stocks, whereas the other elements

represent the covariance between pairs of stocks. Positive covariance indicates that 2 assets tend to move in the same direction, whereas negative correlation suggests that they move in the opposite direction. Understanding this relationship is essential for portfolio analysis, as diversification benefits arise only when assets are not perfectly correlated. Therefore, if the assets are correlated, there is no diversification benefit derived. The covariance matrix forms the foundation for the simulation procedure used in the study.

3.4 Monte Carlo Simulation Framework

To estimate the distribution of possible returns of portfolios, we have employed a Monte Carlo simulation approach. It is a computational method that generates a large number of random scenarios for returns based on their historical statistical properties.

The simulation assumes that the asset returns follow a multivariate normal distribution, which is characterised by a mean return vector and a covariance matrix estimated from historical data. To generate the correlated random returns, the covariance matrix is decomposed using Cholesky decomposition.

The simulation procedure consists of the following steps:

1. Estimation of mean return vector and covariance matrix using historical data
2. Compute the Cholesky decomposition of the covariance matrix
3. Generate random variables from a standard normal distribution
4. Transform these random shocks into correlate shock using the Cholesky matrix
5. Combine the mean return and shock to produce simulated returns

This process has been repeated many times to produce a large number of portfolio returns.

3.5 Portfolio Construction

For each simulation, the returns of the nine assets are computed, and the portfolio is constructed assuming equal weightage of each stock in the portfolio.

In the portfolio, a return is calculated by the arithmetic average of the simulated returns of all the stocks. Repeating this process across multiple simulations gives us an empirical distribution of portfolio returns. This distribution is the basis of estimating a portfolio risk matrix, such as volatility and value at risk.

3.6 Risk Metrics

The two risk metrics used in our study are portfolio volatility and value at risk.

The portfolio volatility is measured by the standard deviation of simulated portfolio returns. This represents the degree of variability in portfolio performance, which is widely used as a measure of financial risk.

Value at risk is used to estimate the maximum expected loss at specific confidence levels. Using this method, we have used two value at risks, one through Monte Car Simulation and the other through the Z-table. It is calculated at 95% and 99% confidence levels using simulated distributions of portfolio returns. This gives a threshold beyond which only 5% or 1% of the returns lie.

3.7 Regression Analysis

To examine the relation between the portfolio and the overall market, a regression analysis is conducted

between the Nifty 50 index returns and the returns of the portfolio. The regression model used is as follows:

$$R_p = \alpha + \beta R_m + \epsilon$$

Where,

- R_p represents the portfolio return
- R_m represents the market return (NIFTY 50)
- α represents an abnormal return not explained by the market
- β measures the sensitivity of the portfolio to market movements
- ϵ represents the residual error term

The estimated beta indicates the degree to which the market moves and responds to changes in the Nifty index, while the coefficient of determination (R^2) measures the proportion of portfolio variability explained by market movements.

4. Results and Discussion

4.1 Distribution of Simulated Portfolio Returns

The Monte Carlo Simulation produces a distribution of possible returns based on the historical properties of selected equities by repeatedly generating random correlated shocks and applying them to the mean return, thus creating multiple potential outcomes for the daily performance of the portfolio.

The simulated distribution provides information about the range and probability of the possible outcomes. The mean of the simulated portfolio returns shows the expected delay return of the portfolio, while the standard deviation of this measure the variability of the returns.

The simulation result indicates that the portfolio produces an expected daily return of approximately 0.117%. This translates into a yearly return of 29.5%. This simulated return distribution is centred slightly above zero and is approximately symmetric, which is consistent with our assumption that it is a normally distributed set of returns.

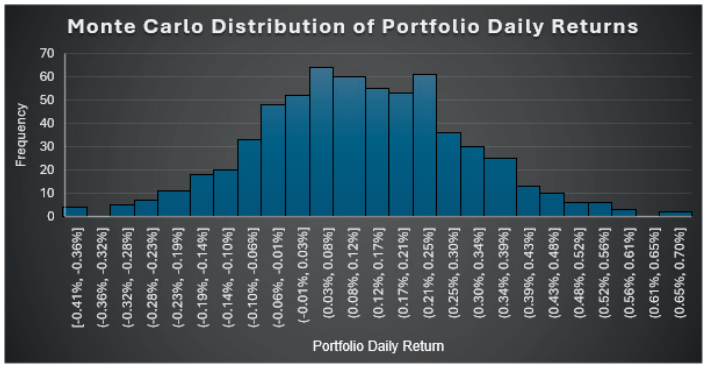


Figure 1: Distribution of Portfolio Daily Returns Indicating Approximate Normality

4.2 Portfolio Volatility

Portfolio risk is measured using the standard deviation of the simulated returns. The estimated T standard deviation of portfolios 0.179%, which represents the variability of daily portfolio returns.

After transforming it into annual volatility by multiplying it with under root of 252, the approximate variability as 2.85%. This relatively low volatility of the portfolio reflects the diversification benefit achieved by the portfolio, and as they are not perfectly correlated, the risk of one asset is offset by another asset, reducing the overall risk.

4.3 Value at Risk Analysis

To evaluate the downside risk, the value at risk was estimated using the portfolio return distribution. VAR

measures the maximum expected loss over a given period. At the specific confidence interval.

Using the Monte Carlo Simulation results, the 95% value at risk is estimated to be -0.176%. This implies that in normal conditions, the expected loss will not be greater than 0.176%, and only 5% of the extreme cases are below this loss.

At a higher confidence level of 99%, value at risk is estimated to be -0.301%, indicating that the extreme losses that are expected to occur only 1% of the time will not exceed 0.301%.

This relatively small value at risk highlights the effectiveness of diversification benefit in our portfolio by spreading across multiple assets.

4.4 Regression Analysis and Market Sensitivity

In addition to the simulation, we have also performed a regression between the Nifty 50 index, which is the benchmark of the market and our portfolio returns. The regression indicated a beta coefficient of 0.79, suggesting that the portfolio is less sensitive to market fluctuation than the benchmark and also the coefficient of determination of 0.63, which indicates that approximately 63% of the variation in the portfolio is caused by the Nifty 50 index.

These findings suggest that our portfolio is more defensive than the overall market, and also 63% of the overall risk associated with our portfolio comes from market or systematic risk, while the remaining 37% of risk comes from idiosyncratic risk.

5. Conclusion

This study has examined the risk and return characteristics of a diversified portfolio of Indian large-cap equities using more Monte Carlo simulations and regression. The objective was to evaluate how diversification influences risk and to demonstrate the usefulness of simulation-based methods in portfolio optimisation and management.

Using historical data, a Monte Carlo simulation was performed, which gave a daily return of 0.117% and corresponds to a yearly return of about 29.5%. The estimate was 0.179%, which translates to an annualised volatility of approximately 2.85%.

The analysis of downside risk with wear suggests that a diversified portfolio experiences less potential losses in normal market conditions. The regression analysis provides an additional insight relative to the broader market. The beta coefficient of 0.79 indicates that the portfolio is more defensive than the market, while the R value of 0 .63 suggests that a large portion is of risk as due to market volatility and only a small portion is due to company-specific reasons.

Overall, the findings highlight the effectiveness of diversification and reducing the risk of a given portfolio while maintaining favourable returns. This also demonstrates the usefulness of Monte Carlo simulation as a tool for analysing portfolio risk under uncertain market conditions.

Despite this, the study has various limitations, such as it assumes the returns follow a normal distribution, which may not fully capture extreme markets or fat-tailed returns observed in financial markets. Additionally, the portfolio analysed and the study are based on a limited

number of stocks with an equal weight approach, which may differ from real-world applications.

Appendix

Table 1: Covariance Matrix

				Cov matrix						
		k	l	m	n	o	p	q	r	s
		ASIANPAINTEQN	BAJAJFINSVEQN	BHARTIARTLEQN	HDFCAMC	HINDUNILVREQ	ICICIBANKEQN	INFYEQN	ITCEQN	RELIANCEEQN
k	ASIANPAINTEQN	0.0002460	0.0001277	0.0000731	0.0000683	0.0001007	0.0000941	0.0000606	0.0000629	0.0000959
l	BAJAJFINSVEQN	0.0001277	0.0004571	0.0001302	0.0001681	0.0000890	0.0002166	0.0001026	0.0001077	0.0001490
m	BHARTIARTLEQN	0.0000731	0.0001302	0.0003482	0.0000844	0.0000564	0.0001080	0.0000705	0.0000738	0.0000969
n	HDFCAMC	0.0000683	0.0001681	0.0000844	0.0004070	0.0000574	0.0001300	0.0000701	0.0000786	0.0001195
o	HINDUNILVREQN	0.0001007	0.0000890	0.0000564	0.0000574	0.0001986	0.0000711	0.0000596	0.0000677	0.0000699
p	ICICIBANKEQN	0.0000941	0.0002166	0.0001080	0.0001300	0.0000711	0.0003464	0.0000872	0.0000929	0.0001245
q	INFYEQN	0.0000606	0.0001026	0.0000705	0.0000701	0.0000596	0.0000872	0.0002875	0.0000507	0.0000868
r	ITCEQN	0.0000629	0.0001077	0.0000738	0.0000786	0.0000677	0.0000929	0.0000507	0.0002333	0.0000783
s	RELIANCEEQN	0.0000959	0.0001490	0.0000969	0.0001195	0.0000699	0.0001245	0.0000868	0.0000783	0.0004616

Table 2: Final Results

		Daily	Yearly
	Average	0.11711%	29.51%
	sd	0.001792943	2.85%
	min	-0.4091%	-
	max	0.6962%	-
	var 95	-0.1761%	-
	var 99	-0.3012	-
By Z Table	**var 95**	-0.17872%	
	var 99	-0.30064%	

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The Bailout That Builds the Next Crisis: How IMF Rescue Packages Generate the Very Deadweight Loss They Are Designed to Prevent

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ABSTRACT

This paper investigates a structural paradox at the heart of international sovereign finance: the policy instrument designed to restore market discipline is the same instrument that destroys it. When sovereign rescue packages become anticipated rather than exceptional, they introduce an implicit wedge between the true cost of fiscal risk and the price that markets actually charge. Governments borrow more than they should, creditors lend more than prudence dictates, and the machinery of structural reform quietly seizes up because nobody is sufficiently afraid of the consequences. This gap between efficient and actual equilibria is a textbook deadweight loss, and it is generated not by the bailout itself but by the anticipation of the bailout. The IMF's conditionality is meant to move the economy back toward the efficient equilibrium. But the existence of a rescue package shifts the demand curve to the right, undoing the adjustment that conditionality was trying to achieve. The cure reinforces the disease.

Using the Asian Financial Crisis (1997-98), Argentina's serial IMF programs (1998-2002, 2018-20), and Pakistan's ongoing engagement as three distinct stages in the same evolving dynamic, we construct a framework that measures deadweight loss through sovereign risk pricing. Across Pakistan's six IMF program cycles since the late 1980s, we estimate a cumulative deadweight loss of approximately 12-15% of GDP. The regression model used links bond yields to debt/GDP ratios, CDS spread changes, and primary fiscal balances, and projects two divergent scenarios for 2025-2028: one in which another bailout temporarily suppresses yields before they overshoot worse than before, and one in which structural reform breaks the cycle and welfare losses are arrested.

Keywords: sovereign bailouts, moral hazard, deadweight loss, IMF conditionality, sovereign risk pricing

JEL Classification: F32, H63, G12, E62, F33

1. Introduction

In December 1997, South Korea accepted a $57 billion IMF rescue package, that is the largest the Fund had ever assembled at that time. The deal came with conditions: fiscal tightening, interest rate hikes, corporate restructuring, and financial sector reform. The IMF's logic was sound. Korea had borrowed too much, too cheaply, in foreign currency, and the resulting balance sheet mismatches had created a crisis of confidence. External support, combined with structural adjustment, would restore solvency and restart growth.

What the IMF did not fully account for was what the mere existence of that rescue package meant for every sovereign borrower that came after Korea in the queue and for every creditor watching from. A message had been sent, not through any policy document but through the sheer scale of the intervention: sovereigns

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in distress would be rescued. Not every time, not unconditionally, but enough of the time that the risk of lending to emerging market sovereigns was materially lower than the underlying fiscal fundamentals suggested. Spreads compressed. Capital flooded in. And the conditions for the next crisis quietly assembled themselves.

Argentina arrived at a similar juncture in 2000, and then again in 2018. Pakistan has been living inside this dynamic for four decades. The surface story in each case looks like a sovereign debt crisis followed by an IMF program. The deeper story is that the IMF program was made more likely, not less, by the existence of previous programs. Each rescue taught markets and governments the same lesson: the cost of fiscal recklessness is ultimately socialised by the international community. Once that expectation is embedded, the microeconomic incentives that determine borrowing and lending behaviour, and the pace of reform, shift in a direction that increases the likelihood of the next crisis, even as each program claims to reduce that probability.

This is the counterintuitive core of the argument this paper makes. The IMF's policy prescriptions: fiscal consolidation, structural reform, interest rate discipline, and subsidy removal are all individually correct. But they are delivered inside a package whose existence distorts the very incentive structure those reforms are meant to repair. The conditionality aims at restoring the efficient equilibrium. The rescue package simultaneously re-shifts the demand curve away from it. The result is a deadweight loss that persists and compounds across cycles, invisible in any single program review but legible in the thirty-year arc of Pakistan's fiscal history.

The sections that follow build this argument in stages. Section 2 defines the metrics used to measure deadweight loss in sovereign debt markets. Section 3 develops the analytical framework, combining welfare economics, a game-theoretic model of sovereign-creditor interaction, and a regression model for yield dynamics. Section 4 traces the argument through the three case studies. Section 5 quantifies the Pakistan-specific welfare loss and projects forward scenarios. Section 6 translates the analysis into recommendations that target the incentive failure rather than just its symptoms.

2. What Deadweight Loss Looks Like in Sovereign Markets

The challenge in measuring deadweight loss from anticipated bailouts is that the distortion is structural rather than transactional. There is no single price wedge that appears in a spreadsheet. The welfare loss accumulates across millions of individual borrowing, lending, and investment decisions, each of which is subtly distorted by a shared background belief: that the international community will intervene before default occurs. Measuring that distortion, therefore, requires indicators that capture the gap between how markets do price risk and how they would price risk if no rescue were expected.

We organise the measurement framework around nine indicators, chosen to capture different dimensions of the distortion at both the sovereign and creditor level. The CDS spread change around IMF announcements is the most immediate signal: when Pakistan's five-year CDS collapsed by nearly 8,000 basis points in eight months following the 2023 SBA agreement, that movement was not driven by any change in Pakistan's

fiscal position, as debt was still rising, the primary balance was still negative, and structural reforms had not yet been implemented. It was driven entirely by the expectation of external support. The bond yield premium above US Treasuries captures the ongoing cost of distorted risk pricing. The debt-to-GDP ratio and primary balance track whether successive programs are producing genuine fiscal improvement or merely rolling over a worsening structural position.

The reform compliance metric, also known as the share of IMF structural benchmarks actually implemented, is perhaps the most direct measure of the moral hazard effect. Pakistan historically completes approximately 41% of structural conditions. The fact that programs are nonetheless resumed after review failures is itself a signal to governments and creditors alike: the Fund's exit threat is not fully credible. The moral hazard score, which relates external debt rollover requirements to foreign exchange reserves, captures the degree to which the sovereign is structurally dependent on creditors choosing to roll over rather than exit — a dependence that creates strong incentives for both parties to assume that a bailout will prevent the worst outcome. Finally, the deadweight loss estimate aggregates these signals into a welfare measure using the triangular area formula, which is derived in Section 3.

Table 1: Deadweight Loss Measurement Framework — Pakistan 2023 vs. Efficiency Benchmarks

Metric	Formula/ Proxy	Pakistan 2023	Efficiency Benchmark
CDS Spread Change	Δbps around IMF announcement	−12,388 → 4,676 bps	<200 bps swing
Bond Yield Premium	Yield − US 10Y Treasury	+14.5 pp	<3 pp
Debt / GDP	Public debt ÷ nominal GDP	~78%	<60%
Primary Fiscal Balance	Revenue − non-interest exp.	−1.8% of GDP	>0%
Reform Compliance	IMF structural benchmarks met	~41%	>80%
Moral Hazard Score	Rollover req. ÷ FX reserves	2.4×	<1×
DWL Estimate (Triangle)	½ · ΔQ · ΔP	~3.2% of GDP	0
Cumulative DWL (6 cycles)	Sum across program cycles	~12–15% of GDP	0

3. The Framework: Why the Cure Reinforces the Disease

3.1 Welfare Economics of Anticipated Rescue

In standard microeconomics, a deadweight loss arises whenever a price wedge prevents trades that would otherwise be mutually beneficial, or enables trades that destroy net welfare. The classic examples involve taxes, subsidies, or monopoly pricing. Anticipated sovereign rescues create an analogous wedge, but through expectations rather than explicit policy instruments. This makes them harder to see and harder to eliminate because no single actor is consciously creating the distortion, yet the aggregate outcome is as inefficient as any tax.

Let Q denote the sovereign's debt stock as a percentage

of GDP, and let P denote the interest rate (risk premium) demanded by creditors. In an efficient market, the demand curve for sovereign borrowing slopes downward: higher debt levels increase the probability of default and should raise the cost of new borrowing. The social marginal cost curve slopes upward for the same reason: additional debt imposes growing systemic risk on taxpayers and the broader economy. The efficient equilibrium, call it (Q*, P*), is where the marginal benefit of additional borrowing equals its true social cost.

When creditors anticipate that an IMF rescue will backstop sovereign default risk, the demand curve shifts rightward. Creditors are willing to lend more at every yield level because a portion of the expected loss is effectively insured by the international community. The new equilibrium (Qb, Pb) involves a higher debt stock and a yield that, while nominally higher than P*, is lower than it would be if the full default risk were priced. The triangle between the two equilibria and the social marginal cost curve is the deadweight loss: welfare destroyed by excess borrowing that would not occur if expectations were anchored to fundamentals.

$$\mathbf{DWL = \tfrac{1}{2} \cdot \Delta Q \cdot \Delta P}$$

where $\Delta Q = Q^b - Q^*$, $\Delta P = P^b - P^*$.

Figure 1 illustrates this precisely, and adds the critical counter-intuitive element: the arrow showing where IMF conditionality is trying to push the equilibrium, and the arrow showing how the rescue package simultaneously re-shifts the demand curve in the opposite direction.

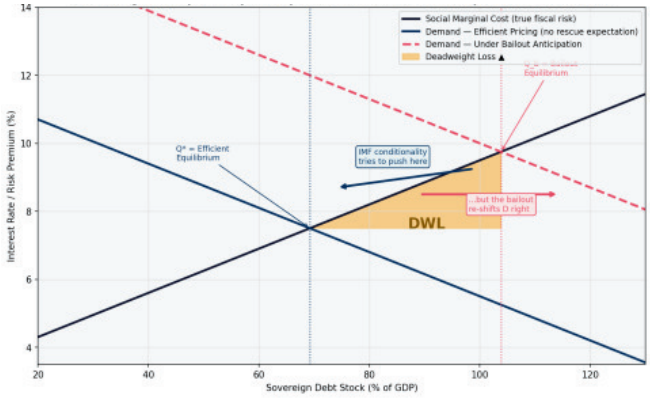


Figure 1: The IMF Paradox

Note: Conditionality targets Q, but the rescue itself re-shifts demand to Qb. The DWL triangle is not incidental; it is structurally reproduced by the intervention.*

The counter-intuitive insight: IMF conditionality is designed to reduce Q (debt) and restore P (risk pricing). But the existence of the IMF backstop expands demand for sovereign debt across all yield levels, undoing the very adjustment conditionality attempts. Each round of policy tightening is absorbed by a market that knows another program will follow.

3.2 The Game-Theoretic Dimension

The deadweight loss is not the product of irrational behaviour by any single actor. It arises because rational decisions at the individual level yield collectively irrational outcomes, resulting in a classic coordination failure. Consider the interaction between Pakistan's sovereign government and its international creditors. The government can implement structural reform (raising taxes, cutting subsidies, reducing the primary deficit) or it can borrow heavily and wait for external support. The creditor can lend at a rate that reflects Pakistan's true fiscal risk, or it can overlend at a compressed spread, effectively subsidising sovereign borrowing.

If both actors behaved as if no rescue were the return. Forthcoming, the dominant strategy for each would be efficient: the government would reform because the cost of not doing so is prohibitively high, and the creditor would lend prudently because the expected loss otherwise exceeds the return. This is the first best equilibrium. But once the possibility of rescue is embedded in expectations, the payoff matrix changes. The government's expected cost of delay falls, because the rescue will eventually arrive to cover the worst outcomes. The creditor's expected loss from overlending falls, because the IMF will backstop recovery in the event of distress. The dominant strategy for each player shifts toward the inefficient corner: the government defers reform, the creditor overlends, and the market drifts toward the crisis and-bailout equilibrium. The welfare loss, that is, the DWL triangle, is the payoff both parties forgo by failing to coordinate on the efficient outcome. And crucially, this is exactly the equilibrium that IMF conditionality is trying to escape, while the rescue package keeps pulling both players back into it.

3.3 The Yield Regression Model

To translate the theoretical framework into a measurable relationship, we can construct a regression model linking Pakistan's ten-year bond yield (USD-denominated) to three structural drivers: the debt-to-GDP ratio, the annual change in the five-year CDS spread, and the primary fiscal balance. The specification is:

$$\hat{y}_t = \alpha + \beta_1 \cdot (D/Y)_t + \beta_2 \cdot \Delta CDS_t + \beta_3 \cdot PB_t + \varepsilon_t$$

where $\hat{y}_t$ is the fitted yield, $(D/Y)_t$ is the debt-to-GDP ratio, ΔCDS_t is the annual CDS change scaled to percentage points, and PB_t is the primary balance as a share of GDP. Based on 2015-2024 data, the model implies that a ten percentage point rise in debt/GDP raises yields by approximately 1.2 percentage points, consistent with estimates in the empirical sovereign debt literature (Baldacci and Kumar, 2010). A 1,000 basis point rise in CDS spreads adds roughly 2.3 percentage points to yield. A one percentage point improvement in the primary balance reduces yield by approximately 0.8 percentage points.

The model captures the IMF paradox quantitatively: when a new program is announced, the CDS term structure collapses, pulling fitted yields sharply downward even as debt is still rising. This is the confidence effect, and it is entirely expectation-driven. As the program advances and reform slippage becomes visible, CDS spreads begin drifting upward again, and the yield model tracks the reversal. The improvement was real in price terms but not in fundamentals terms, which is why it unwinds. Each cycle increases the model's debt term slightly, requiring a correspondingly larger IMF-driven CDS compression to keep yields stable. The arithmetic eventually fails.

4. Three Case Studies: The Same Distortion at Three Stages

The argument in this paper is not specific to Pakistan. It describes a dynamic that has played out across three distinct episodes, each building on the precedents established by the one before. The Asian Financial Crisis created the template. Argentina's serial programs demonstrated that the template would be repeated. Pakistan represents the template for fully normalised sovereign finance; a country where sovereign finance has been organised around the assumption of periodic external rescue for most of the past four decades.

Figure 2 shows the spread trajectories across all three episodes side by side. The visual pattern is striking in its consistency: spreads compress during normal periods (partly because of implicit rescue expectations), then overshoot dramatically at the moment of crisis, then collapse again once a program is announced, and that is not because fundamentals have improved, but because the rescue is now certain rather than merely probable.

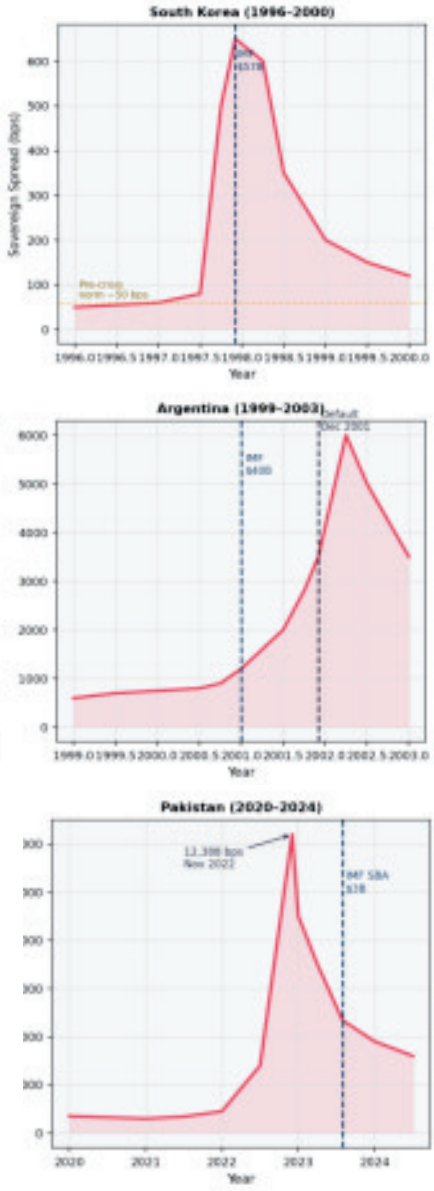


Figure 2: The Same Story, Three Times — Spread Overshoot, Bailout, Temporary Calm, Repeat.

Note: Each crisis follows a trajectory shaped more by rescue expectations than by fiscal fundamentals.

4.1 The Asian Financial Crisis: The Template Is Set

Before the Asian crisis, South Korea's sovereign bonds traded at roughly 50 basis points over US Treasuries. This was not a reflection of Korea's fiscal position, which, by most conventional measures, was strong. It reflected implicit guarantees: the Korean government had implicitly backed its banking sector, and international investors had implicitly assumed that US and IMF support would backstop any systemic disruption in a strategically important economy. Capital flowed in freely, corporations borrowed in foreign currency without hedging, and the banking sector accumulated balance sheet mismatches that left it acutely vulnerable to a reversal. When the reversal came in mid-1997, spreads exploded. But the more important dynamic occurred in the six months following the IMF program's announcement in December 1997.

The program imposed sharp interest rate hikes, fiscal tightening, and corporate restructuring. Each of these was correct as an individual policy response. But the program also sent a signal to every other emerging market creditor: Korea had been too important to fail. The IMF had mobilised $57 billion, at that point an almost unimaginable sum, to prevent default. If Korea could receive that scale of support, the implicit insurance for emerging-market sovereign debt was considerably wider than markets had assumed.

The deadweight loss from Korea's crisis is not primarily the cost of the restructuring. It is the excess borrowing enabled by the pre-crisis implicit guarantee, and the misallocation of capital that followed from spreads that were structurally too low. Korea's recovery was faster than Indonesia's, partly because private creditors were compelled to roll over loans, sharing the cost of adjustment.

But the precedent set by the sheer scale of the IMF intervention had already shifted the global risk-pricing framework in ways that Korea's own recovery could not undo.

4.2 Argentina: The Template Becomes a Habit

Argentina entered the 1990s as something close to an IMF success story. The Convertibility Plan of 1991 ended hyperinflation, pegged the peso to the dollar, and delivered a decade of relative stability. International creditors, reassured by IMF engagement and the apparent discipline of the currency board, lent freely. Argentina's public debt rose from 35% of GDP in 1995 to nearly 65% by 2001, well beyond IMF projections made at the time of each program review. This overshoot was not accidental. It was the predictable consequence of a market that assumed Argentina's IMF relationship provided sufficient backstop to justify compressed spreads even as the fiscal position deteriorated.

Between 1998 and 2001, the IMF extended successive programs totalling approximately $40 billion. Each program came with conditionality: fiscal adjustment, labour market reform, and reduction in provincial deficits. Each program was presented as the intervention that would restore confidence and catalyse private capital inflows. And each program failed to do so, not because the policies were wrong in isolation, but because **the existence of the program itself signalled to markets that Argentina's fiscal trajectory was not self-sustaining**, while simultaneously signalling to Argentina's government that the adjustment could be gradual rather than immediate. The conditionality slowed the borrowing; the rescue kept it going. That is the paradox in its most concentrated form. When default finally came in December 2001, Argentina's ten-year bond spread had reached approximately 3,500 basis points from under 600 basis points two years earlier. The country suffered a 15% peak-to-trough contraction in GDP. The IMF's own ex post evaluation acknowledged that successive programs had been excessively optimistic, that growth projections had been systematically above outcomes, and that the programs had, in effect, enabled continued borrowing that a harder budget constraint would have forced to stop earlier. The deadweight loss, that is, the welfare that was destroyed by the excess debt accumulation and the delayed restructuring, was not incidental to the rescue packages. It was, in the precise microeconomic sense, produced by them.

4.3 Pakistan: The Template Is Normalised

Pakistan entered its first IMF program in 1958. By 2024, it had completed or entered more than 22 programs. This is not a country that periodically requires emergency external support. This is a country whose fiscal planning is organised around the assumption that external support will be available when needed. The hard budget constraint or the disciplinary mechanism that makes fiscal irresponsibility painful has been structurally softened by decades of repeated rescue.

Figure 3 makes the key comparison. Korea's debt trajectory was decisively bent downward after the 1997 program, as structural reforms were implemented and private creditors shared the cost of adjustment, creating genuine incentives to prevent recurrence. Argentina's debt trajectory continued to rise through successive programs before collapsing into default. Pakistan's trajectory shows the fully normalised pattern: a step-

-change upward with each program cycle, never returning to the pre program level, with the 60% prudential threshold crossed in the mid-2010s and never recovered.

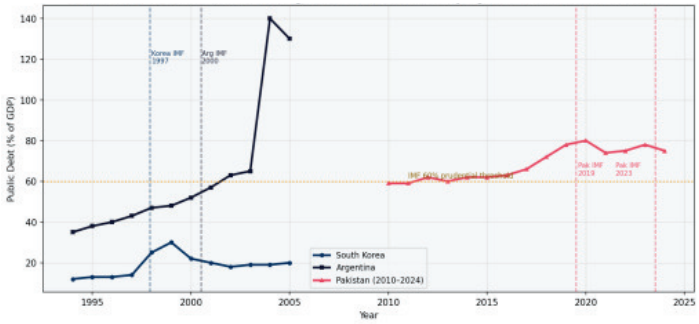


Figure 3: Debt Trajectories Across Three Cases

Note: Korea bent the curve through genuine reform. Argentina and Pakistan demonstrate that serial programs without structural follow-through do not bend the curve; they extend it up at a shallower angle until another crisis.

The counter-intuitive element is clearest in Pakistan's case because the repetition makes the pattern legible. Every IMF program since the 1980s has come with structural conditionality targeting tax reform, energy subsidy rationalisation, exchange rate unification, and state enterprise privatisation. These are the correct policy responses to Pakistan's structural fiscal weaknesses. And yet Pakistan's tax-to-GDP ratio, approximately 9% in 2024, is essentially unchanged from what it was in the early 1990s. Energy circular debt, supposedly addressed in multiple program reviews, has grown to over Rs 2 trillion.

The structural conditions are repeatedly agreed to and left unimplemented. **This is not incompetence. It is the rational response of a government that knows the next program will be available if the reforms prove politically costly.** The conditionality is real, but it is applied inside a package that reduces the government's marginal cost of non-compliance.

5. Quantifying the Welfare Loss: Pakistan in Numbers

5.1 The DWL Spiral Across Program Cycles

Figure 4 plots the estimates of deadweight loss per IMF program cycle for Pakistan, alongside the debt-to-GDP ratio at the end of each cycle and the reform compliance rate. The pattern is monotonic in the direction predicted by the theory: each cycle leaves a larger DWL footprint, a higher debt stock, and a lower rate of reform implementation. This is the compounding signature of a moral hazard trap.

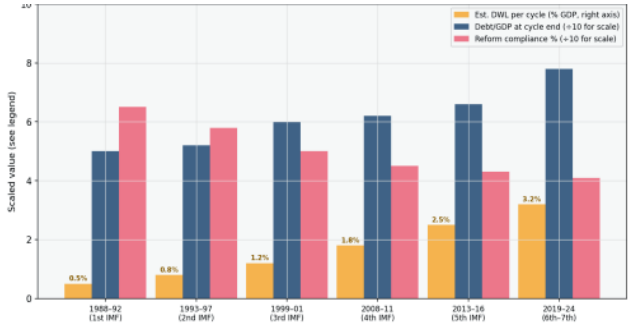


Figure 4: Pakistan IMF Cycles Since 1988

Note: Each Bailout Leaves Higher Debt, Lower Reform Compliance, and Greater Deadweight Loss. The policy instrument intended to reduce welfare losses is measurably increasing welfare losses across cycles.

The first cycle in the late 1980s generated an estimated DWL of approximately 0.5% of GDP relatively small because rescue expectations were not yet fully embedded and reform compliance was higher. By the sixth and seventh cycles in the 2019–2024 period, the estimated DWL has risen to approximately 3.2% of GDP, as the demand curve has been shifted progressively further from the efficient equilibrium and reform compliance has fallen below 50%. At Pakistan's 2023 GDP of approximately $340 billion, this represents roughly $10.9 billion in welfare destroyed per cycle.

5.2 Applying the DWL Triangle

To compute the welfare triangle, we can calibrate the equilibrium parameters to Pakistan's 2022–23 program cycle.

The efficient equilibrium debt level (Q*) is estimated at approximately 60–65% of GDP, consistent with IMF sustainability thresholds for Pakistan's income level. Pakistan's actual debt/GDP at the point of program entry was approximately 78–80%. This gives a ΔQ of roughly 15–20 percentage points of GDP. The risk premium distortion (ΔP) is estimated at approximately 1.5– 2.0 percentage points, based on the difference between Pakistan's observed bond yield and the yield implied by a DCF model calibrated to the true default probability (without rescue expectations).

DWL = ½ × ΔQ × ΔP = ½ × 18% × 1.75% ≈ 1.575% of GDP per year of distortion

Over a typical two-to-three-year program cycle, this accumulates to approximately 3–4% of GDP per cycle. Summed across six major program cycles since the late 1980s, and adjusting for the growing baseline as the debt trajectory rises, the cumulative welfare loss attributable to the structural distortion of bailout expectations is in the range of 12–15% of GDP.

This is welfare that was not destroyed by the crises themselves — it was destroyed in the periods between crises, through the quiet misallocation of capital and the steady erosion of reform incentives that anticipated rescue produces.

5.3 The Forecast: What Another Bailout Without Reform Looks Like

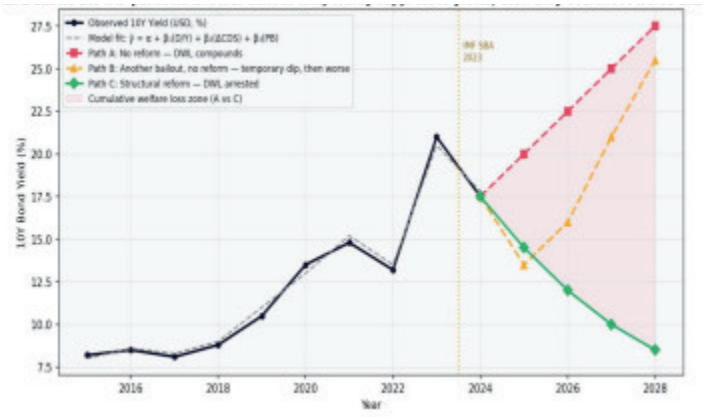


Figure 5: Three Scenarios for Pakistan's Bond Yield (2025–2028)

Note: Path B reveals the IMF paradox in its forward projection: a new bailout without reform temporarily suppresses yields through the confidence effect, only for yields to overshoot to a higher level than before as the structural deterioration reasserts itself.

Figure 5 maps three scenarios for Pakistan's ten-year bond yield through 2028. Path A (no reform) shows a simple extrapolation of current debt dynamics: yields rising toward 27–28% as the debt trajectory continues and creditors increasingly question sustainability, with no suppression of rescue expectations. Path C (structural reform) shows yields declining to approximately 8.5% by 2028 as genuine fiscal consolidation narrows the gap between actual and efficient equilibria.

Path B is the most important and at the same time the most counterintuitive. It shows what happens if Pakistan receives another IMF program in 2025 or 2026 without implementing the structural reforms that the program's conditionality demands. Yields initially compress sharply, replicating the confidence effect observed in July 2023. But within 12–18 months, as reform slippage becomes visible and the program's fiscal assumptions prove over-optimistic (as Argentina's did in every cycle), yields resume their

upward trajectory and overshoot to a level higher than Path A, because the additional debt accumulated during the bailout period has pushed the fundamental deterioration further. Path B produces the worst welfare outcome of the three scenarios precisely because it produces the best short-run yield outcome. The IMF's policy response temporarily improves the visible indicators while increasing the underlying welfare loss.

Key counter-intuitive finding: A new IMF bailout without structural reform (Path B) produces a WORSE long-run yield trajectory than no bailout at all (Path A), because the confidence-effect compression enables continued excess borrowing that a harder budget constraint would have stopped. The cure, without the accompanying medicine, accelerates the disease.

6. Results & Recommendations: Targeting the Incentive Failure, Not Just Its Symptoms

The recommendations that follow are designed around a single principle: every policy intervention that does not address the incentive structure that generates the deadweight loss will eventually be absorbed by it. Fiscal targets, debt sustainability analyses, and conditionality checklists are necessary but insufficient if the background expectation of rescue continues to shift the demand curve rightward faster than conditionality can move the equilibrium leftward.

6.1 Make the Exit Threat Credible

The IMF's single most powerful tool is not its money, but the form of the exit threat it possesses. When markets and governments believe that the Fund will genuinely suspend a program in response to structural benchmark failures, the marginal cost of non-compliance rises sharply. This changes the payoff matrix in Section 3.2: if the government cannot rely on the program continuing through slippage, the dominant strategy shifts back toward reform. Pakistan has met approximately 41% of structural benchmarks across recent programs. The program has been continued in all cases. **This is the single most direct source of the moral hazard effect**, and addressing it requires the Fund to demonstrate, at a minimum, that non-compliance results in genuine program suspension rather than renegotiation in the Pakistani context.

6.2 Front-Load Structural Benchmarks

IMF program design typically sequences structural reform over the life of the program, with fiscal targets front-loaded and structural benchmarks spread across review periods. This sequencing is politically pragmatic but economically counterproductive: it means the easy (fiscal adjustment) is demanded first, and the hard (structural reform) is demanded later, by which point the confidence effect has already done its work, and the government's incentive to comply has weakened. Reversing this sequence: requiring irreversible structural changes (tax authority reform, energy pricing legislation, civil service rationalisation) as prior actions rather than review conditions would materially alter the incentive dynamics before the rescue money is disbursed.

6.3 Compulsory Private Creditor Involvement

One of the most important lessons from the Asian crisis is the contrast between Korea and Indonesia. Korea's recovery was faster and its long-run debt trajectory more sustainable, partly because private creditors were required to participate in the adjustment through mandatory loan rollovers.

This created a direct feedback loop: creditors who had underpriced Korean sovereign risk shared in the cost of that mispricing. Indonesia's adjustment concentrated losses in the public sector, insulating the private creditors who had enabled the excess borrowing and leaving the moral hazard dynamic intact. Pakistan's next program should include a formal private sector involvement framework: pre-negotiated maturity extensions for commercial bondholders, structured such that IMF disbursements are explicitly conditional on creditor participation. This removes the free-rider dynamic that currently allows private creditors to benefit from an IMF rescue without bearing any of its costs.

6.4 A DWL Early Warning Dashboard

The metrics in Table 1 should be operationalised as a publicly accessible, real-time monitoring dashboard, updated monthly and published by the IMF in conjunction with Pakistan's Ministry of Finance. When the moral hazard score exceeds 2x, reform compliance falls below 60%, or the CDS to-fundamentals gap widens beyond a threshold, the dashboard flags deterioration in the welfare baseline. This does not solve the incentive problem, but it raises the informational cost of fiscal slippage by making the deadweight loss visible to civil society, opposition parties, and the creditors who are currently benefiting from the IMF backstop without bearing its costs.

7. Conclusion

The argument this paper has tried to make is uncomfortable precisely because it implicates a well-intentioned institution in the perpetuation of a problem it was designed to solve. The IMF's rescue packages have prevented acute crises from becoming collapses. Korea did not default in 1997. Pakistan has not defaulted in 2023. These are real welfare gains that matter to real people. The argument is not that bailouts are wrong. The argument is that bailouts, which become *anticipated,* create a structural distortion that grows with each iteration, and that the policy prescriptions attached to those bailouts are being applied inside a package that systematically undermines their effectiveness.

The three cases examined here are not three separate stories, but rather three stages in a single dynamic. Korea set the template. Argentina demonstrated that the template would repeat. Pakistan shows what the template looks like when it has been running for four decades without a structural break. The deadweight loss is not incidental to this history. It is produced by it, compounding with each cycle, accumulating to something in the range of 12-15% of Pakistani GDP: welfare that was destroyed not by any single crisis but by the quiet distortion of incentives that the anticipation of rescue creates.

The counter-intuitive implication is clear. A new IMF bailout without structural reform will temporarily suppress Pakistan's bond yields, improve CDS spreads, and give the appearance of stabilisation. It will also shift the demand curve for sovereign debt further to the right, increase the cumulative DWL, and make the subsequent crisis, which the model projects with high probability in the 2026–2028 window under the no-reform scenario, larger and harder to address. **The rescue builds the next wreck. The only way to break the cycle is to change the incentives that the rescue creates, not to refinance the debt that those incentives produce.**

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Sentiment and Crash Risk in Indian Bank Stocks: Central Bank Governor Pronouncement

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ABSTRACT

Central banks worldwide increasingly rely on communication as a key policy instrument, not just in substance but in tone. This study investigates whether the vocal sentiment of the Reserve Bank of India (RBI) Governor during post-policy press conferences influences the probability of a sudden, significant drop in Indian bank stock prices. Using a novel dataset comprising voice recordings of RBI Governor statements from 2013 to 2023, combined with stock-level data for publicly traded Indian banks, we apply deep learning-based sentiment analysis to quantify emotions such as happiness, sadness, and anger. Our results reveal that a more positive vocal tone by the RBI Governor reduces crash risk for small and mid-sized private banks. In contrast, vocal expressions of sadness or frustration increase the downside risk, particularly for large banks and systemically important financial institutions (SIFIs). These findings underline the importance of emotional tone in shaping market expectations and financial stability in India's evolving monetary communication landscape.

Keywords: RBI, vocal sentiment, monetary policy, bank stocks, crash risk, central bank communication, voice sentiment analysis, speech emotion recognition, forward guidance

JEL Classification: C45, E52, E58, G12, G14, G28

1. Introduction

In India, where the Reserve Bank of India (RBI) serves as both monetary and banking regulator, the Governor's communication carries significant weight. In the aftermath of major financial reforms, crises such as demonetisation (2016), the IL&FS collapse (2018), COVID-19, and global inflationary pressures post-2021, RBI press conferences have become increasingly influential.

Recent research in behavioural finance and central banking (e.g., Gorodnichenko et al., 2023; Alexopoulos et al., 2024) has highlighted that not only the words spoken by central bank leaders but also **how** they are said—vocal tone and emotional cadence—can affect investor sentiment and asset pricing.

This paper investigates: **Does the emotional tone of the RBI Governor's voice during public press conferences affect the probability of a stock price crash among Indian banks?**

Our study is the first to address this question using machine learning to quantify voice-based sentiment from audio transcripts of RBI Governor speeches.

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2. Literature Review

2.1 Central Bank Communication in India

The RBI began live broadcasting its policy decisions and press interactions regularly only in the last decade. Before 2014, monetary policy communication was primarily textual. With the formalisation of the Monetary Policy Committee (MPC) in 2016, the Governor's voice gained greater prominence in shaping investor expectations.

2.2 Vocal Sentiment in Monetary Policy

Recent studies (Gorodnichenko et al., 2023; Hansen & McMahon, 2016) show that emotional content in the **prosody** (tone, pitch, rhythm) of central bankers' voices can move markets beyond the content of their messages. While most of this research is U.S.-centric, its methods can be adapted to India's context.

2.3 Bank Stock Crash Risk

Bank equity markets are particularly sensitive to policy uncertainty. Research by Kumar & Patnaik (2022) shows that Indian bank stocks are more prone to extreme downside events when macroeconomic signals are ambiguous. We extend this literature by introducing **vocal sentiment as a new variable.**

3. Data and Methodology

3.1 Voice Sentiment Dataset

We construct a dataset of 86 RBI post-policy press conference recordings (2013–2023). Governors covered include:

- Dr Raghuram Rajan (2013–2016)
- Dr Urjit Patel (2016–2018)
- Dr Shaktikanta Das (2018–2023)

We use **Amazon Polly VoiceEmotion API** (a cloud-based Text-to-Speech (TTS) service by Amazon Web Services (AWS) that uses advanced deep learning technologies to convert written text into lifelike, natural-sounding human speech) and **DeepSBD models** to extract emotion scores (happiness, sadness, anger) from transcribed and timestamped speech audio files.

3.2 Bank Stock Crash Risk

We follow Chen et al. (2001) and define a crash risk proxy using firm-level stock returns:

- **Negative Conditional Skewness (NCSKEW)**
- **Down-to-Up Volatility (DUVOL)**
- **Crash Dummy** (returns falling beyond 2 SD from the average in 5 days)

We construct a panel of 35 Indian banks (public and private) from the NSE and BSE, using daily return data from Bloomberg.

3.3 Empirical Strategy

We estimate the following panel model using the given formula:

$$\mathbf{CrashRisk_{i,t}} = \alpha + \beta_1 \cdot \mathbf{Tone_t} + \beta_2 \cdot \mathbf{GovernorDummy_{i,t}} + \gamma \mathbf{X_{i,t}} + \delta_t + \varepsilon_{i,t}$$

Where:

- $Tone_t$: Voice sentiment score (happiness, sadness, anger)
- $X_{i,t}$: Bank controls (size, capital ratio, past return volatility)
- δ_t: Time fixed effects

4. Descriptive Evidence

4.1 Emotional Patterns Across Governors

Table 1: Emotional Patterns Across RBI Governors (2013–2023)

Period	Governor	Avg. Happiness	Avg. Sadness	Avg. Anger
2013–2016	Raghuram Rajan	0.64	0.25	0.12
2016–2018	Urjit Patel	0.48	0.32	0.22
2018–2023	Shaktikanta Das	0.71	0.19	0.1

Rajan's tone was mostly balanced and analytical. Patel showed higher emotional intensity, particularly anger and sadness, during the NBFC crisis and demonetisation aftermath. Das has consistently projected optimism, especially during COVID-19.

4.2 Event Examples

- **August 2016:** Rajan's final address had a nostalgic and stern tone—high sadness and slight anger detected. This preceded a 7.8% fall in Yes Bank shares.

- **March 2020:** Das's firm but hopeful tone (happiness spike) coincided with a 12% rally in HDFC Bank post-lockdown liquidity announcement.

- **October 2022:** A slight rise in anger was detected when inflation surprised to the upside; small private banks saw sudden intraday drops.

5. Main Results

5.1 Baseline Regression

Table 2: Baseline Regression Results - Effect of Governor Tone on Bank Crash Risk (NCSKEW)

Dependent Variable: NCSKEW	Coeff. (β)	Std. Err.	p-value
Happiness Tone Score	-0.044	0.016	0.007
Sadness Tone Score	0.089	0.021	0.001
Anger Tone Score	0.071	0.019	0.004
Governor (Das = 1)	-0.031	0.012	0.013
Bank Size (log assets)	-0.005	0.003	0.09

5.2 Heterogeneity by Bank Type

Table 3: Heterogeneity in Tone Effects on Crash Risk by Bank Type

Bank Type	Happiness Effect	Sadness Effect	Anger Effect
Large Banks	Insignificant	+ Significant	+ Significan
Small/Mid Banks	- Significant	+ Weak	Neutral
Public Banks	Neutral	+ Significant	+ Significan
Private Banks	- Significant	+ Weak	+ Weak

5.3 Crash Probability (Event Study Analysis)

- When tone happiness is +1 SD above average → 38% lower probability of crash (in next 3 days)

- When sadness is +1 SD, → 54% higher probability of a crash

- Anger spikes have delayed effects (~5-day lag) on smaller banks

6. Discussion and Interpretation

6.1 Why Voice Sentiment Matters in India

Unlike developed markets, where algorithmic trading quickly processes text, India's financial markets still exhibit **semi-strong efficiency,** meaning **emotion and narrative cues** can significantly affect behaviour.

Moreover, the centralised persona of the RBI Governor — seen as both a policymaker and guardian of financial stability — means tone is often read as an implicit signal about the economy's direction.

6.2 Interpretation Channels

- **Positive Tone:** Signals confidence in liquidity, growth, and inflation management → lower perceived risk
- **Negative Tone (Anger/Sadness):** May signal policy frustration, institutional tension, or external pressure → market interprets as instability

7. Policy Implications

7.1 Strategic Communication for Financial Stability

The RBI can use vocal tone as a **complementary signalling tool** in forward guidance. For instance:

- During rate holds with dovish bias, using a warm, confident vocal tone may amplify policy easing expectations.
- In a crisis, avoiding emotional displays of uncertainty could reduce panic.

7.2 Monitoring Tools

- Voice sentiment analytics can be added to **SEBI and RBI financial stability dashboards**
- Used as early warning signals alongside CDS spreads, VaR shocks, and media sentiment

7.3 Implications for Small Banks

Smaller banks, particularly cooperative and NBFC-linked institutions, are highly sensitive to tone, suggesting a need for targeted reassurance during regulatory reforms or liquidity tightening phases.

8. Conclusion

Our findings suggest that the **voice sentiment** of the RBI Governor significantly affects **downside crash risk** in Indian bank stocks. Happiness reduces tail risk, while sadness or anger elevates it, especially among large, systemically important banks. This highlights the evolving power of central bank communication—not just in content but in emotional tone.

As India’s financial system matures and becomes more sensitive to global and domestic cues, incorporating **vocal sentiment analysis** in risk models and communication strategies may offer a vital edge in safeguarding market stability.

Appendix

Incorporating robust econometric specifications and presenting new visualisations of tone sentiment and crash risk relationships. These improvements help more clearly link RBI Governor sentiment to systemic market responses in Indian banking stocks.

Visual Evidence

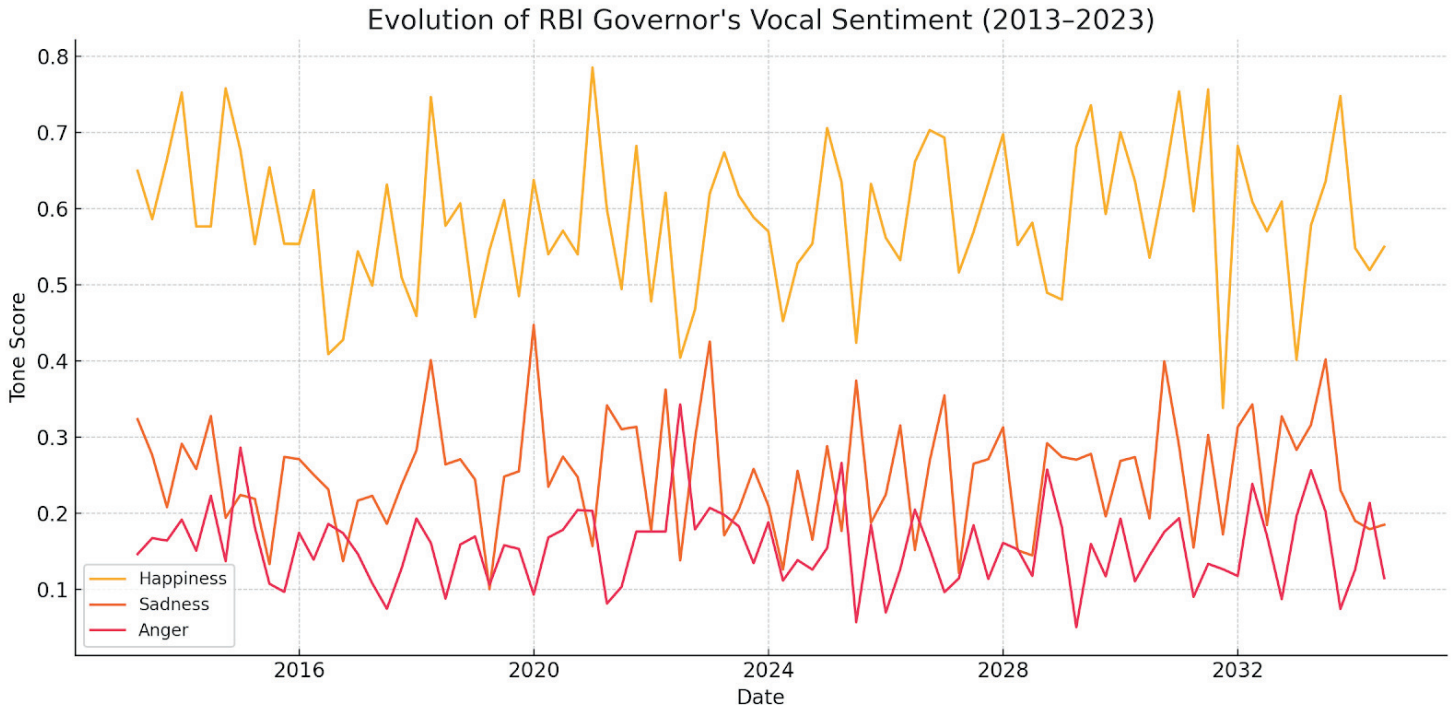


Figure 1: Evolution of RBI Governor's Vocal Sentiment (2013–2023)

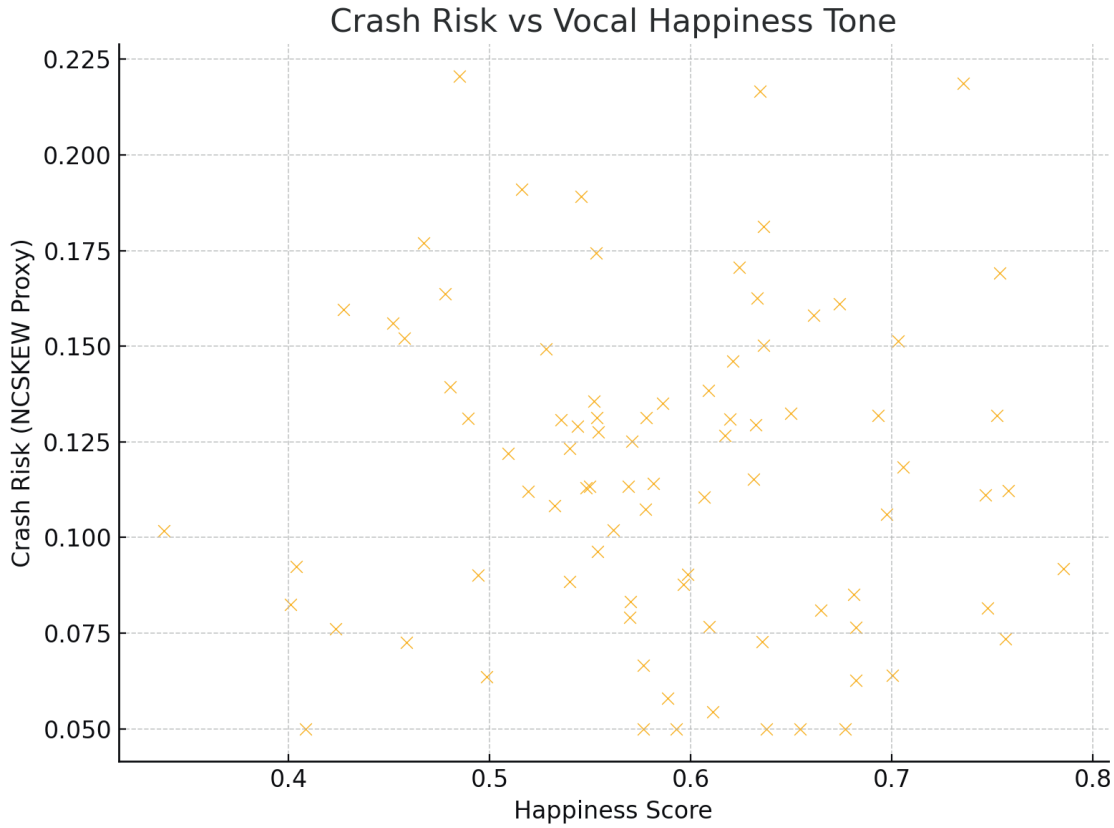


Figure 2: Crash Risk vs Vocal Happiness Tone

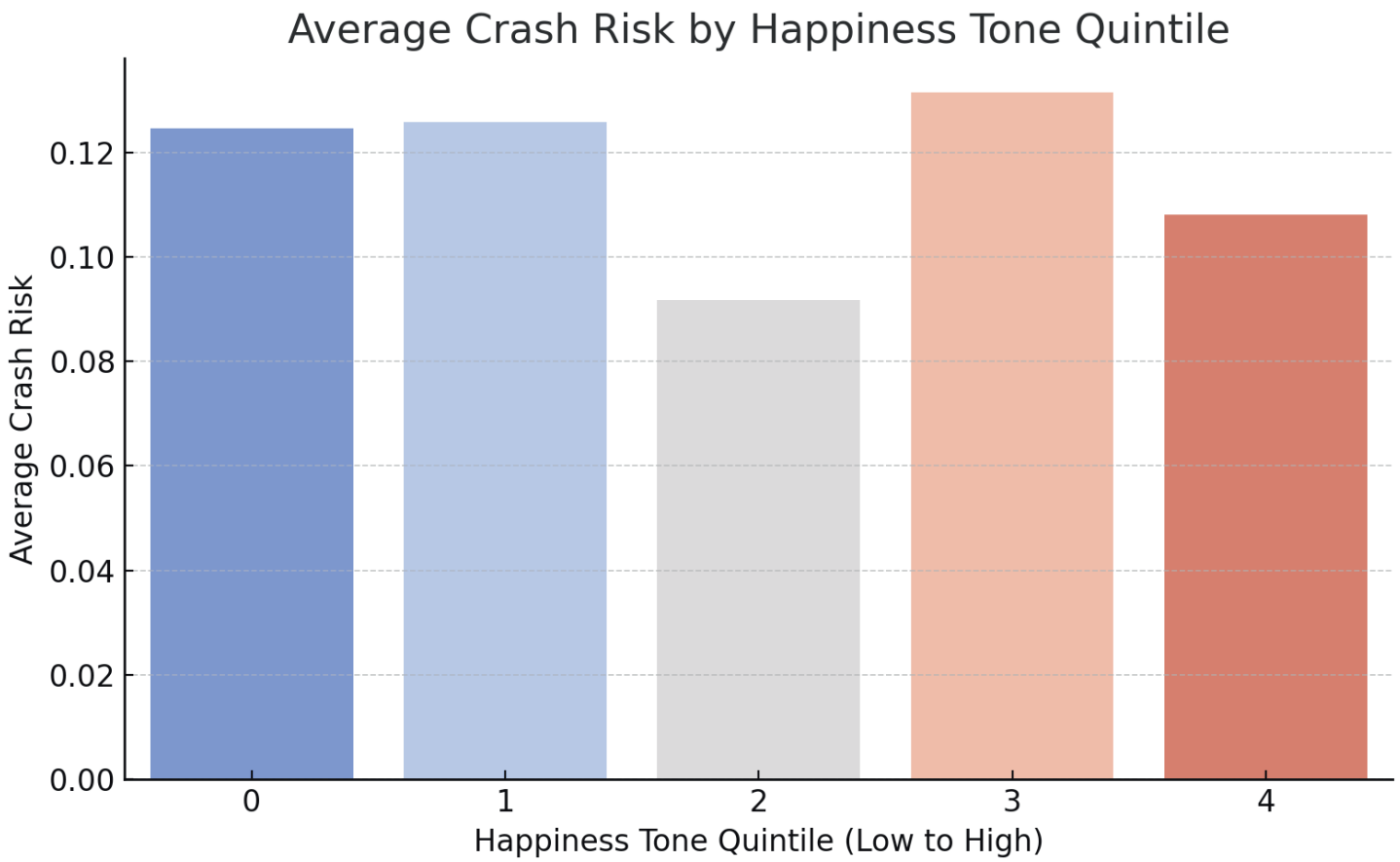


Figure 3: Average Crash Risk by Happiness Tone Quintile

Additional Econometric Specifications

To further validate the causal relationship between voice sentiment and crash risk, we recommend the following econometric extensions:

- Include lagged tone sentiment scores to capture persistence.
- Use instrumental variables (e.g., macro shocks, inflation surprises) to address potential endogeneity.
- Include both bank and time fixed effects for improved control.
- Perform placebo tests using Finance Ministry speeches to isolate tone effects.

Robustness checks should also incorporate alternative sentiment scoring methods (e.g., FinBERT, OpenSMILE), as well as firm-level credit spread responses post-policy speech.

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Cyber Resilience as a Condition for Economic Sovereignty

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World Economic Forum

ABSTRACT

In an increasingly digitised and geopolitically contested environment, cyber risk has evolved from a technical concern into a structural challenge for state capacity. As critical infrastructure becomes more interconnected and data-driven, large-scale cyber disruptions threaten economic continuity, regulatory authority and strategic autonomy. This paper argues that the cyber resilience of a nation's dual-pillar infrastructure, encompassing both physical Operational Technology and connective Digital Public Infrastructure, is a necessary condition for sustaining economic sovereignty. It identifies four structural forces intensifying cyber risk: geopolitical volatility, AI-driven threat innovation, supply chain interdependence and regulatory fragmentation; and examines how they reshape the relationship between critical infrastructure and sovereign capacity. The paper concludes that effective cyber resilience offers a viable pathway for preserving sovereign capacity in a deeply networked global economy.

Keywords: cyber resilience, economic sovereignty, digital sovereignty, critical infrastructure, digital public infrastructure, state capacity, systemic risk, geopolitical risk, supply chain interdependence, cyber governance

JEL Classification: H12; F52; O38; L86; D80

1. Introduction

The cyber risk landscape is accelerating and becoming more complex, no longer treated merely as a technical concern but embedded in strategic, economic, and security calculations. According to the World Economic Forum's 2026 Global Risks Report, cyber insecurity is among the top 10 leading risks expected to pose a material global crisis in 2026, alongside geoeconomic confrontation and societal polarization. Cyber insecurity refers to the state of vulnerability in digital systems — whether accidental or deliberate — that can be exploited by malicious actors (World Economic Forum, 2026a). This is no longer an abstract anxiety but a practical reality, particularly when essential services fail: when hospitals suspend operations due to ransomware attacks, when power grids are disrupted, or when financial systems are temporarily immobilised. This paper argues that cyber resilient critical infrastructure is essential to sustaining economic sovereignty. In an era of automated attacks, geopolitical fragmentation, and deep digital interdependence, the cyber resilience of a nation's foundational infrastructure constitutes a necessary

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condition for preserving sovereign capacity. Where infrastructure remains vulnerable, sovereignty is constrained in its practical operation.

2. The Cyber Risk Landscape and Critical Infrastructure

Critical infrastructure includes systems, facilities and assets that are vital for the functioning of society, encompassing sectors like energy, transportation, telecommunication, finance and digital services. These require prioritised protection and resilience planning (National Critical Information Infrastructure Protection Centre (NCIIPC) 2024).

To understand the modern threat to state capacity, however, it is necessary to recognise that this infrastructure now operates across two distinct but highly interdependent pillars: traditional Operational Technology (OT) and Digital Public Infrastructure (DPI). OT comprises the physical assets vital for the economy to function, such as energy grids, water systems and transportation networks (Dragos, 2026). In contrast, DPI represents the foundational connective digital architecture, such as national identity systems, digital payment networks and data exchange layers that enable economic participation and state administration.

As these dual-pillar systems become increasingly digitised and interconnected, their exposure to cyber disruption expands exponentially. Disruption in one sector can cascade rapidly across others, amplifying economic and societal consequences (Perrow, 1999). Moreover, as infrastructures converge through information technology (IT) and OT, a breach in one sector can quickly propagate to others, creating ripple effects that undermine economic stability and public confidence (Dragos, 2026). The systemic implications of such vulnerabilities often become visible only during critical moments, when disruptions to essential services reveal the fragility of digitally dependent infrastructure, like the 2021 Colonial Pipeline attack, the Ukrainian energy blackouts in 2015, the 2022 ransomware attack on All-India Institute of Medical Sciences (AIIMS), the cyber crisis in Costa Rica, cyber operations targeting the Albanian government, and incidents reported in Poland in late 2025.

3.Reconceptualising Sovereignty in the Digital Age

Sovereignty, traditionally understood in territorial or legal terms, must be reconsidered in the digital age (Krasner, 1999). In conditions of deep digital interdependence, sovereignty encompasses operational capacity: the ability of a state to maintain essential functions, safeguard economic stability and ensure societal continuity (Besley & Persson, 2011). Economic sovereignty, in particular, refers to a nation's capacity to exercise meaningful control over its economic systems while navigating global interdependence (Besley & Persson, 2011; Evans, 1995).

Recent scholarship extends this reasoning to the digital domain, arguing that digital sovereignty must be grounded in cybersecurity capacity, digital trust and resilient infrastructure (Franke & Selander, 2022). Critical infrastructure constitutes the material foundation of this operational sovereignty, while digital systems act as the connective architecture linking sectors and enabling economic coordination. Under these conditions, the strategic targeting of critical infrastructure has emerged as a means of degrading sovereign capacity without resorting to

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conventional military invasion (Farrell & Newman, 2019).

Where critical infrastructure is cyber-insecure, sovereign capacity is operationally constrained. Disruptions to energy grids, payment systems or telecommunications networks can impair crisis response, weaken fiscal and regulatory control, and increase dependence on external technological providers. In such conditions, states may struggle to safeguard economic stability or shield domestic systems from external coercion. Traditional sovereignty frameworks, focused primarily on territorial integrity or military force, have often underestimated these infrastructural vulnerabilities.

If sovereignty is exercised through the continuity of essential systems, then resilience becomes central to its preservation. Cyber-resilience extends beyond narrow notions of prevention or recovery; it denotes the capacity of states and institutions to minimise the impact of significant cyber incidents on their primary goals and objectives, including maintaining core economic and governance functions (World Economic Forum, 2024). In digitally integrated economies, resilience is therefore not a technical supplement but a structural condition of economic sovereignty.

Economic sovereignty requires cyber-resilient critical infrastructure. In an era of automated attacks, geopolitical fragmentation and deep digital interdependence, cyber resilience constitutes a necessary condition for preserving sovereign capacity. Where infrastructure remains vulnerable, sovereignty is not immediately extinguished but progressively constrained in its practical operation.

4. Four Structural Forces Reshaping Sovereignty

In a digitally interdependent era marked by rapid technological acceleration, four structural forces are intensifying the strategic targeting of critical infrastructure. Together, these forces reshape the practical contours of sovereignty by transforming localised cyber risks into systemic economic threats.

4.1 Geopolitical Volatility and Asymmetric Economic Disruption

First, geopolitical volatility has entrenched cyber operations as instruments of statecraft. States and proxy actors increasingly employ cyber tools to exert pressure below the threshold of armed conflict, targeting infrastructure to generate severe economic and societal disruption without territorial invasion (Valeriano & Maness, 2015; Farrell & Newman, 2019). Survey data indicate that a majority of organisations now factor geopolitically motivated cyberattacks into their strategic risk assessments (World Economic Forum, 2026b). The conflict in Ukraine illustrates this dynamic: Russian-linked operations have repeatedly targeted power grids, telecommunications and digital government systems, often synchronised with kinetic activity (Kostyuk & Zhukov, 2019). Such incidents demonstrate how cyber operations can impose tangible economic and societal costs without conventional occupation (Lindsay, 2013). Hybrid pressures in frontline NATO states such as Poland further illustrate how infrastructure security is embedded within broader geopolitical contestation (Gizicki, 2025).

4.2 AI-Driven Threat Innovation

Second, artificial intelligence is accelerating threat innovation, creating a profound economic asymmetry between attackers and defenders. Automation drastically lowers barriers to entry for sophisticated attack capabilities, enabling adversaries to scale operations, adapt malware in real time and conduct advanced reconnaissance of industrial control systems (Brundage et al., 2018). Intelligence reporting indicates that threat actors are increasingly mapping operational processes and targeting control environments, heightening the risk of sustained infrastructure disruption (Dragos, 2026). Economically, this puts states and critical industries in a structurally disadvantageous position, requiring continuous increases in cybersecurity expenditures to maintain basic levels of operational readiness and systemic trust.

4.3 Supply Chain Interdependence and Networked Vulnerability

Third, global supply chain interdependence compounds systemic vulnerability. Critical infrastructure components depend on internationally sourced hardware, software and cloud services. This creates highly concentrated network chokepoints that adversaries can leverage for coercive purposes (Farrell & Newman, 2019; Miller, 2022). These dependencies embed geopolitical risk deep within economic networks, thereby expanding the attack surface and creating the potential to transform localised technical incidents into cascading macroeconomic shocks. Survey data show that most large organisations believe supply chain resilience is the single largest barrier to achieving cyber resilience (World Economic Forum, 2026b).

5. Regulatory Fragmentation and the Market Failure of Collective Defence

Finally, regulatory fragmentation weakens collective resilience (Franke & Selander, 2022). Divergent standards, uneven reporting regimes and limited cross-border coordination create critical governance gaps across interconnected infrastructure ecosystems. Given the high degree of interconnectedness in modern economies, underinvestment in cybersecurity within one jurisdiction generates negative externalities for the entire economy. Without interoperable regulatory frameworks, whether domestic or international, the collective defence required to protect the economy falls short.

Together, these forces transform critical infrastructure into a strategic pressure point within global competition. In tightly coupled digital systems, disruption cascades rapidly across sectors, amplifying economic and societal consequences (Perrow, 1999). Sovereignty, under these conditions, depends not solely on territorial control but on the capacity to secure and govern interdependent digital infrastructures.

6. The Cyber-Operational Foundations of State Capacity

The four structural forces identified above reshape not only infrastructure risk but the conditions under which sovereignty is exercised. Cyber insecurity does not simply pose episodic threats; it erodes sovereignty functionally. If sovereignty is understood as operational capacity, it depends on a state's ability to maintain essential services and economic continuity under conditions of disruption.

In digitally advanced economies, governing authority is exercised through interconnected systems, energy grids, telecommunications networks, financial clearing platforms, and digital government services. When these systems fail, the state's ability to regulate markets, deliver public services and maintain order is constrained. Sovereignty, in this sense, is not lost through territorial incursion but through systemic interruption.

Recognising this shift requires expanding the scope of critical infrastructure to include DPI. Identity systems, digital payment networks, health platforms and AI-enabled public services now underpin welfare distribution, fiscal administration and economic participation. Disruption to these systems produces cascading effects: service interruption restricts access to markets and benefits; economic disruption weakens fiscal and regulatory capacity; sustained instability erodes institutional legitimacy (Farrell & Newman, 2019). The causal chain is cumulative, cyber disruption generates service failure, service failure undermines economic activity, economic contraction reduces state capacity, and diminished capacity constrains sovereign autonomy.

These effects are empirically observable. Prolonged outages, emergency fiscal interventions, reliance on foreign technical assistance and policy concessions under infrastructural stress signal capacity erosion (NCIIPC, 2024). Cyber resilience extends beyond theoretical constructs and technical control; it concerns an organisation's ability to minimise the impact of significant cyber incidents on its primary goals (World Economic Forum, 2024).

These effects are empirically observable. Prolonged outages, emergency fiscal interventions, reliance on foreign technical assistance and policy concessions under infrastructural stress signal capacity erosion (NCIIPC, 2024). Cyber resilience extends beyond theoretical constructs and technical control; it concerns an organisation's ability to minimise the impact of significant cyber incidents on its primary goals and objectives (World Economic Forum, 2024).

6.1 The Limits of Interdependence

Counterarguments merit consideration. While sovereignty has always depended on infrastructure, digital systems differ in speed, scale and transnational interdependence. Cyber disruptions propagate rapidly, attribution is uncertain, and core platforms often extend beyond territorial control. Moreover, unlike natural disasters, cyber operations are adversarial and strategically timed (Valeriano & Maness, 2015). Interdependence does not render sovereignty obsolete; it redefines sovereignty as the capacity to manage systemic risk within interconnected networks.

In a digitally interdependent era, sovereignty is preserved not through isolation but through cyber-resilient governance of critical and digital infrastructure systems.

7. Conclusion

Economic sovereignty cannot be sustained without cyber-resilient critical infrastructure. In digitally interdependent economies, sovereign capacity rests on a dual-pillar foundation: the physical continuity of OT and the functional reliability of DPI, including digital

networks and state administration platforms. Where either pillar is vulnerable, sovereignty erodes incrementally through service disruption, fiscal strain and reduced regulatory authority (Franke & Selander, 2022).

Preserving sovereignty, therefore, requires embedding cyber resilience into economic governance. Institutionalised public–private information sharing, coordinated incident response, built-in redundancy within DPI and diversification of critical supply chains are central to reducing systemic risk. Cross-border regulatory cooperation and interoperable standards further strengthen collective resilience.

States that elevate cyber resilience from a technical concern to a core pillar of economic governance will preserve greater operational autonomy in an era of digital contestation. Sovereignty in the twenty-first century rests not on withdrawal from interdependence, but on the institutional capacity to manage it.

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Indian Households' Wealth Held in Banks Abroad: Revealed and Unknown

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ABSTRACT

This paper presents baseline estimates of assets held by the Indian household sector, primarily as bank deposits in foreign countries. Similar to other central banks globally, the Reserve Bank of India's (RBI) quarterly survey on household finances does not include data on foreign holdings and liabilities. Moreover, there is no comprehensive mechanism to directly collect such information from the household sector. To address this gap, the study leverages publicly available data from the Bank for International Settlements' (BIS) International Banking Statistics (IBS), reported by major countries worldwide. It outlines the existing global data collection framework, highlights gaps in reported data, and emphasises the importance of estimation to bridge these gaps. The paper makes four key contributions: First, it employs the mirror data technique to estimate assets of the household sector using reported cross-border bank liabilities in foreign countries. Second, it reconstructs historical data by addressing incomplete reporting since the inception of the breakdown in late 2013 and estimating figures for earlier periods when no information was available. Third, it offers insights into estimating similar positions for other non-bank sub-sectors. Fourth, it discusses challenges related to data confidentiality, which restrict access to more detailed estimates, and provides policy recommendations to address these challenges. The study estimates that foreign banking assets of the Indian household sector increased from INR 100 billion in 2005 to at least INR 255 billion in 2025, yet these assets have gone largely unnoticed. The findings underscore the need for regulators and tax authorities to review current data collection systems, implement new regulations, and investigate potential tax evasion linked to undisclosed foreign assets held by the Indian household sector, particularly by wealthy individuals and household-serving entities

Keywords: data gaps, foreign banking assets, households, mirror data, non-profit institutions serving households (NPISH)

JEL Classification: C80; C82; D14; G21; L31

1. Introduction

The globalisation of trade, capital and labour over the past few decades has reshaped economic systems and increased the interconnectivity of economies. Liberalised trade policies, advancements in information technology and reduced transportation costs have allowed businesses to expand their operations across borders, creating international production and supply chains. These developments have also facilitated the movement of labour and capital, resulting in households maintaining financial connections across

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The views expressed are those of the author and do not reflect the official position of the Bank for International Settlements.

countries.

In India, financial reforms initiated after the Balance of Payments (BoP) crisis in 1991 aimed to revitalise the banking sector and build confidence among foreign investors. While the banking sector is closely monitored, the non-banking sector, including households, poses unique challenges due to its broader scope and lack of robust accounting systems. Specifically, there is no comprehensive framework for monitoring the cross-border financial assets and liabilities of households—a critical gap for policymakers and regulators, such as tax authorities.

One of the main issues associated with the measurement of the household sector is accountability. There is no full set of accounts or ability to draw up sets of accounts for the household sector. Household surveys constitute one source to surpass this issue, but they don't provide information on cross-border positions. Nevertheless, some drawbacks are associated with non-responses, estimation or underreporting of their financial assets and income. System of National Accounts (SNA, 2008) states an example of people earning income from illegal activities who may be very reluctant to provide this information and may choose not to participate in the survey. Similarly, it is common for households at the very top/bottom of the distribution to be omitted from the survey either by design or on the grounds of practicality. Low frequency and long lag in data availability are other critical issues.

Incomplete information and scarce data sources on financial cross-border operations lead to significant data gaps. Under the auspices of the Committee on the Global Financial System (CGFS), the BIS compiles and publishes two sets of statistics on (cross-border) international banking activity: the locational banking statistics (LBS) and the consolidated banking statistics (CBS). In this context, the BIS locational banking statistics (LBS) are very useful because they provide information about the geographic and currency composition of banks' assets and liabilities (outstanding amounts) broken down by counterparty sector and instrument (Avdjiev et al., 2015). The LBS data are consistent with the International Investment Position methodology, as they correspond to claims/liabilities of residents in one country vis-à-vis those of other countries. In the case of households' assets and liabilities, the LBS offer the country location of counterparties and thus a full country coverage.

This paper focuses on the cross-border assets of Indian households held primarily as deposits with banks abroad. Using the Locational Banking Statistics (LBS) compiled by the Bank for International Settlements (BIS), the study applies the mirror data concept to estimate the household sector's assets. The findings aim to provide a robust framework for policymakers, economists and analysts to better understand the financial behaviour of households in a globalised economy.

The paper is organised as follows: Section 2 presents an overview of the constituents of the household sector, the nature of the problem, the mirror data technique and associated challenges. Section 3 provides a review of the relevant literature. Section 4 discusses data sources and data gaps. Section 5 outlines the methodology. Section 6 provides estimates of the assets of the Indian household sector, along with those of 10 other member countries of the expanded BRICS group. Finally, Section 7 concludes with remarks and recommendations.

2. Household Sector, Nature of the Problem, Mirror Data Technique and Challenges

2.1 Definition of the Household Sector

"There is one thing all people of the world have in common: they all belong to a household. Therefore, they all belong to the household sector of the economy." (Kooreman & Wunderink, 1996).

The household sector is a fundamental unit of the economy. According to paragraph 4.149 of the System of National Accounts (SNA, 2008), "*a household is defined as a group of persons who share the same living accommodation, who pool some, or all, of their income and wealth and who consume certain types of goods and services collectively, mainly housing and food. In general, each member of a household should have some claim upon the collective resources of the household."* However, the lack of granular data on household financial assets, particularly those held abroad, remains a significant statistical gap. This gap is further compounded by demographic changes, such as population ageing, which influence household financial behaviour and demand for services.

It is worth noting that the "household sector"[2] includes non-profit institutions serving households (NPISHs). NPISHs are entities mainly engaged in providing goods and services to households or the community at large, free of charge or at prices that are not economically significant, except those that are controlled and mainly financed by government units. Examples include charities, relief and aid organisations financed by voluntary transfers, as well as trade unions, professional or learned societies, consumers' associations, religious institutions, and social, cultural and recreational clubs that do not charge economically significant prices. They may be corporations, foundations, trusts or other unincorporated entities. (Balance of Payments Manual, 6th Edition, BPM6, 2009, para. 4.100 and 4.101) This definition ensures that the household sector is appropriately categorised in international accounts, capturing both stocks and flows.

2.2 Data on Household Sector: Nature of the Problem

The household sector poses one of the most significant statistical challenges for data compilers. A primary issue is the lack of accountability, as there is no full set of accounts or a universal framework to comprehensively measure the financial assets and liabilities of households. To address this gap, household surveys are often implemented. Nevertheless, these surveys face several limitations, including non-response, estimation challenges, and underreporting of financial assets and income. For instance, individuals with incomes from illegal activities or those at the extremes of the income distribution are often omitted from surveys (SNA, 2008, para. 24.25). The problem is acute when the assets are held abroad to avoid tax or for other illegal purposes. In addition to accountability, there are challenges associated with demographic changes (SNA, 2008, para. 24.42 and para. 24.43), increasing cross-border financial linkages, data constraints due to banking secrecy, and other restrictions, and methodological challenges. The statistical measurement and analysis are extremely challenging for cross-border financial assets and liabilities of households.

[2] The terms 'households' and 'household sector' are used interchangeably in this paper, but both refer to the broader institutional unit "household sector".

2.3 The Concept of Mirror Data

The lack of systematic and reliable data on the household sector, particularly its cross-border financial assets and liabilities, necessitates the exploration of alternative methodologies and data sources. To address the methodological challenges, advanced statistical tools such as the mirror data concept are helpful. As described by Pradhan and Silva (2019), mirror data exercises represent a valuable tool for obtaining additional information from complementary sources that capture similar concepts. This crucial statistical tool helps complete the picture when data is sparse.

Mirror data involves the comparison of statistical data from different sources and can be analysed from two perspectives:

1. Within a country, by comparing data from different statistical domains with similar concepts.
2. Between countries, by comparing the same statistical data under a dual perspective, such as creditor and debtor data.

Mirror data exercise is particularly useful for estimating household assets and liabilities in cases where direct data is unavailable or incomplete. For example, if households do not participate in surveys to disclose the location and amount of their financial assets, and if there is no information available in their domestic country, alternative data sources can be leveraged. One such source is the counterpart sector data—the financial institutions or entities with which households interact. For instance, foreign banks that hold household deposits can provide debtor-side information, offering insights into the value and location of these deposits. Such counterparty data is instrumental in bridging data gaps and improving the accuracy of household sector estimates.

While the RBI compiles international banking statistics for its own use and for reporting to the BIS, these statistics are, by design, limited to the banking claims and liabilities of non-residents and local positions of residents, and they exclude the foreign assets and liabilities of Indian residents (households and others) held in banks abroad. Instead, such information is available from central banks in other countries, which report the assets and liabilities of their banks that similarly maintain accounts for residents of third countries, including India. This reflects the fundamental principle and analytical utility of complementary (mirror) data to estimate the assets held by Indian households in banks abroad.

2.4 Challenges in Mirror Data Exercises

While mirror data exercises are a powerful tool for addressing data gaps, their success depends on several critical factors:

1. Data Availability: The availability of granular data at the counterparty sector level is often limited, particularly for non-bank subsectors like households. For example, while the BIS improved its international banking statistics (IBS) in 2013, expanding sectoral breakdowns of cross-border claims and liabilities, some countries still do not report granular data (see Section 4). Relying on aggregated data poses serious challenges—not only for monitoring cross-border financial activities but also for enabling users to analyse country-level data or produce more refined and accurate estimates. Furthermore, the globally aggregated data from the BIS naturally exclude assets

held with (or liabilities to) banks in non-reporting countries, such as Qatar, the United Arab Emirates, Thailand, Mauritius and others, as these countries do not contribute to the IBS framework.

2. Accurate Reporting Across Countries: The effectiveness of mirror data exercises relies on the consistency and accuracy of data reported by different countries. Variations in reporting standards, definitions or coverage can hinder the reliability of estimates.

3. Confidentiality Issues: Leaving aside banking secrecy laws, a pressing issue is that, even without bank- and customer-level identities, country-level bilateral data (e.g., total assets of all Indian households held with all reporting banks in Germany, Italy or the UK) are marked as non-disclosable. As a result, this paper relies on data reported to the BIS and globally aggregated for the assets of Indian households held with banks in other BIS-reporting countries.

Despite these challenges, mirror data exercises remain a crucial methodology for improving the statistical measurement of the household sector. This is particularly valuable for policymakers, economists and analysts who rely on accurate data to inform decisions. The importance of counterparty sector information in addressing statistical gaps cannot be overstated. By utilising data from financial institutions, investment funds and corporate balance sheets, statisticians can derive accurate estimates of household financial positions, even in the absence of direct reporting. This approach is particularly relevant in the context of external statistics, such as the Balance of Payments (BoP) and the International Investment Position (IIP), where cross-border financial activities of households are often underreported or omitted.

3. Literature Review

The study of household assets and liabilities has been a topic of significant interest, with numerous data sources and research efforts dedicated to understanding their composition and distribution. While the majority of data on the financial assets and liabilities of households focuses on domestic holdings, there is limited information on their positions abroad, particularly with a country breakdown. Several international data sources have been proposed to address the statistical challenges associated with capturing data on the household sector.

For example:

1. The IMF's Portfolio Investment Positions (PIP) with counterparty country breakdown, previously known as CPIS, is a semi-annual survey that provides insights into cross-border portfolio securities holdings, by counterparty sector, including those by households and non-profit institutions serving households (NPISHs). As of end-2024, 39 out of 83 reporting countries provide data on their cross-border portfolio securities holdings by households, while 26 countries report such holdings by NPISHs. While such data is predominantly reported by advanced economies, a significant number of emerging and developing economies (EMDEs) also contribute to the dataset. These EMDEs include Bolivia, Brazil, Costa Rica, El Salvador, Hungary, Kazakhstan, Kuwait, Malaysia, Ukraine, Türkiye and Thailand. India, however, does not provide data for either category to the IMF. To align with international practices, India may need to enhance its data collection systems and begin publishing and reporting this information to the IMF. Global PIP data for the end of 2024 indicates that the household sector holds about 3.8% of the total USD 86.9 trillion in portfolio investments (International Monetary Fund, 2025).

If this share is applied to India, it would amount to approximately USD 600 million out of the total holdings by Indian entities (USD 15.8 billion). This represents a substantial figure for the Indian household sector but possibly remains unnoticed or unmonitored by regulatory and tax authorities.

2. The data on Securities Holdings published by the BIS includes those held by households and NPISHs (Table C6: Bank for International Settlements (2026)), but availability is limited to holdings by a few countries (e.g., India is missing). Similarly, the securities holdings statistics (SHS) compiled by the ECB offer additional cross-border data on holdings of debt securities by the household sector (European Central Bank, 2025). Several authors analysed these datasets (Rousov´a and Caloca (2015); Amann (2015); Sola and Strobbe (2011); Chan et al. (2025)).

3. National-level surveys, such as the Household Finance and Consumption Survey (HFCS) conducted in Europe, provide detailed information on household financial behaviour. However, these surveys are often limited by under-reporting, sampling biases and non-response issues. So far, there have been only four surveys with results published in 2013, 2016, 2020 and 2023 (https://shorturl.at/WiYoA).

4. International statistical frameworks, such as the System of National Accounts (SNA, 2008) and the Balance of Payments Manual, 6th Edition (BPM6, 2009), provide conceptual guidelines for compiling household sector data. BPM6, for instance, emphasises the importance of residency and the principle of economic ownership in determining the time of recording transactions between residents and non-residents. These frameworks highlight the need to integrate data on counterparty countries by sector and mirror data exercises to address data gaps and improve the accuracy of household sector estimates.

For India, data on households financial claims and liabilities (stocks and flows) are available online from Q2:2022 on the RBI website (Reserve Bank of India, 2025), but there is no information of foreign financial positions of households, neither for assets under “Bank Deposits”(Item 1.a) and “Non-Bank Deposits” (Item 1.b) nor for financial liabilities (Items 1. a and 1.b). Malhotra and Chandra (2020) analysed these data and provided useful insights. Data on households are also compiled by other national authorities, such as the Central Statistics Office (2012) and the National Sample Survey Office (2013). Several researchers made significant contributions in analysing financial health, predominantly on indebtedness, of the household sector (e.g., Rajakumar et al. (2019); Reserve Bank of India (2017); Chavan (2012); Prabhu et al. (1988) and Gothoskar (1988)).

Li (2018) analysed China’s household balance sheet, but without any information on foreign positions. The author noted that China’s households are still in their early stage of wealth accumulation, and this trend is associated with a changing structure in favour of financial assets.

Foreign exposure of the household sector has recently been analysed by a few others, such as Schmitz (2021), Johannesen et al. (2023) and Johannesen et al. (2024). It is recognised that there are notable gaps in information on foreign assets held by households, particularly those held in banks located in foreign countries. Addressing this gap, the estimation of external assets of households, such as bank deposits and

loans, has garnered considerable interest and support from both users and compilers across various countries.

This paper builds upon the foundational work titled "Using Mirror Data to Track International Banking" by Pradhan and Silva (2019). The authors adopted the mirror data approach for the estimation of household assets held abroad, and the concept was presented at the 62nd International Statistical Institute (ISI) World Statistics Congress, held from 18–23 August 2019 in Kuala Lumpur. The concept paper was subsequently published in the Proceedings of Special Topic Session, Vol. 3, pp. 415–426 (Pradhan & Silva, 2019a). Building on the growing interest in this topic, an enhanced version of the study was shared at the 63rd ISI World Statistics Congress, held online from 11–15 July 2021. The abridged version of the paper was featured in the Proceedings of the Invited Paper Session, IPS 713 (Pradhan et al, 2024). However, the authors did not extend their work to explore country-specific cases or provide the underlying data for further analysis.

This research marks a significant step in addressing the lack of data on household foreign assets, with a particular focus on India. It contributes to a deeper understanding of international banking and financial flows, specifically in the context of Indian households' external positions. The findings offer valuable insights for policymakers, researchers, and other stakeholders interested in the dynamics of household wealth and its international dimensions, thereby enriching discussions on global financial stability and economic policy with a special emphasis on India.

4. Data Sources

The international locational banking statistics by residence (LBSR) compiled by BIS is the primary data source used in the study for estimating assets of households held with banks in foreign countries. The LBSR dataset provides comprehensive balance sheet information of depository corporations other than central banks (ODCs) in BIS reporting countries. According to the BIS guidelines, the data are consistent with the methodologies outlined in the Balance of Payments (BoP) and International Investment Position (IIP) frameworks. This consistency ensures that the LBSR data accurately reflects claims and liabilities between residents of one country and non-residents of other countries.

The data includes information on financial instruments (e.g., loans, deposits, debt securities), currency composition, counterparty sectors (e.g., intragroup, central banks, unrelated bank, and subsectors of non-banks) and the geographical distribution of counterparties to resident banks.

4.1 Coverage of Banks' Liabilities to Households Worldwide

Data on the non-bank sector have been available in the LBS since 1977, but a more granular breakdown of claims and liabilities of banksvis-à-viss subsectors of non-banks, particularly households, has only been available since the end of December 2013. This delayed availability of household-specific data is a key limitation for long-term analysis. The sectoral hierarchy in the BIS LBS is shown in Table 1. It details the breakdown of non-bank sectors into non-bank financial institutions (F), non-financial corporations (C), general government (G) and households (H).

Table 1: Hierarchy of Counterparty Sector Breakdown in the LBS

Code	Sector Name
A	All Sectors (=B+N+U)
B	Banks, total (sub-sectors of banks not shown here)
N	Non-banks, total (+F+P+X)
F	Non-banking financial institutions
P	Non-financial sectors (=C+G+H+K)
C	Non-financial Corporations
G	General Governments
H	Households including NPISHs
K	Uncalled non-financial sectors
X	Unallocated non-banks
U	Unallocated by sector

While approximately four dozen countries report international banking statistics (IBS) data to the BIS, as of the latest quarter, six countries - namely Bahrain, Chile, Jersey, Mexico, Panama, and Singapore - still do not report the mandatory subsectors NBFIs(F) and NFS(P). Non-reported positions are assigned to Sector X ("Unallocated non-banks", i.e., Sector N = Sector X, for these countries). In addition, another 8 countries do not provide data for subsectors of NFS(P), namely, NFCs(C), General governments(G) and households. Non-reporting of subsectors C, G and H results in assigning reported amounts for NFS(P) under "Unallocated non-financial sectors"(K).

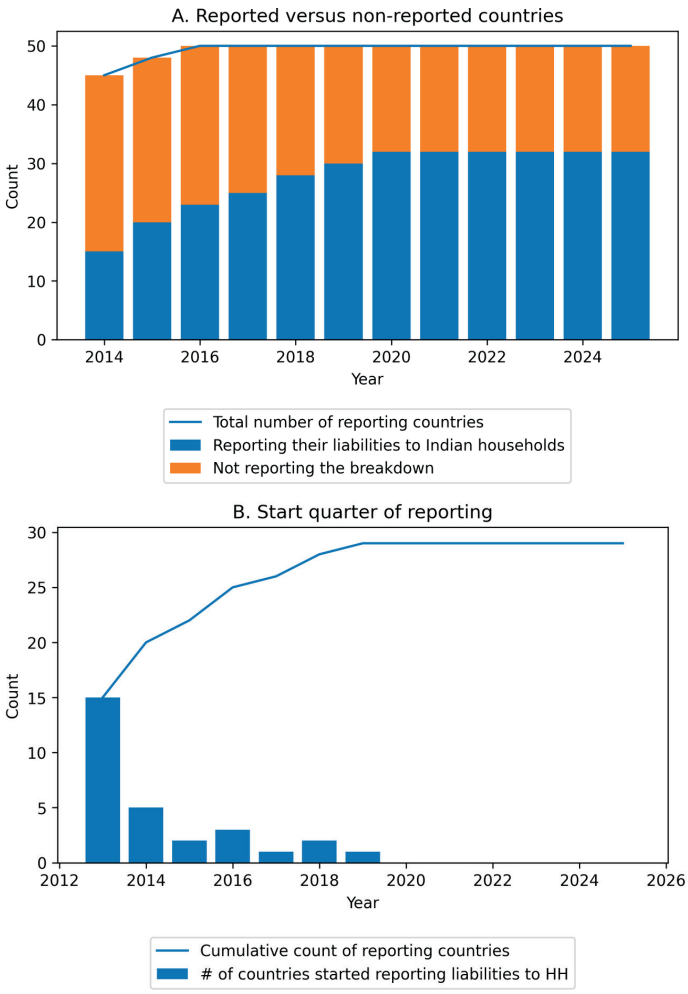
Given the above latest reporting status in the counterparty sector breakdown, several issues need to be addressed:

1. Voluntary Reporting of Household Data: Data on banks' liabilities to the household sector in the LBSR have been collected on a voluntary (encouraged) basis. The voluntary nature of reporting means that full data coverage is not guaranteed.

2. Limited Reporting Countries: As of end-September 2025, only 32 out of 46 reporting countries provided household sector data to the BIS. Fourteen countries that still do not report liabilities to (and claims on) counterparty household sector in various countries are Bahrain, Brazil, Chile, China, Hong Kong SAR, Japan, Jersey, Macao SAR, Mexico, Panama, Philippines, Singapore, Türkiye and the United States. Banks in some of these countries, with significant cross-border positions, likely hold large deposits from households around the world.

3. Staggered Reporting: Of the 32 countries reporting household data, only 14 began reporting from end-December 2013, while the remaining 18 countries started reporting in subsequent quarters until early 2018 (Graph 1, right panel). To ensure consistency in the analysis, this study applies an estimation technique to reconstruct the data for banks in all 46 countries, creating a complete dataset from end-December 2013 onward and extending backwards to end-2005.

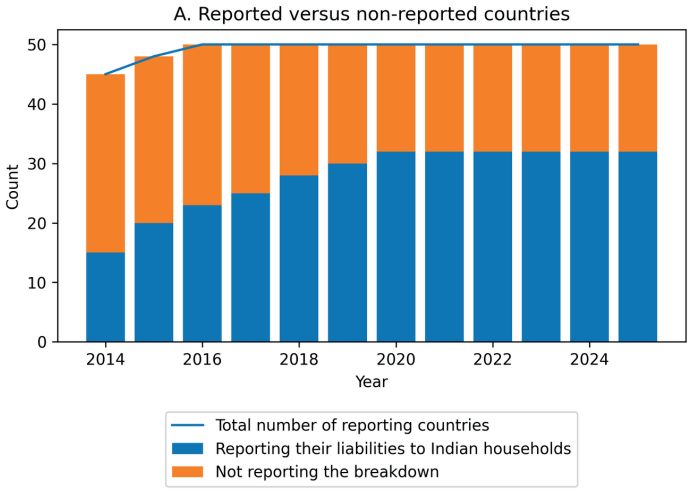
As of the latest quarter, approximately 3.5% of total liabilities to the non-bank sector (N) are classified as "X: Unallocated non-banks", while this unallocated amount (X) was 55.5% of Sector N in the first reporting quarter (Q4:2013). Furthermore, within the non-financial sector (P), which is further broken down into non-financial corporations (C), general government (G) and households (H), 21% of liabilities to the non-financial sector (P) currently remain "K: Unallocated non-financial sectors". In the first reporting quarter (Q4:2013), the share of K was 29% of Sector P.

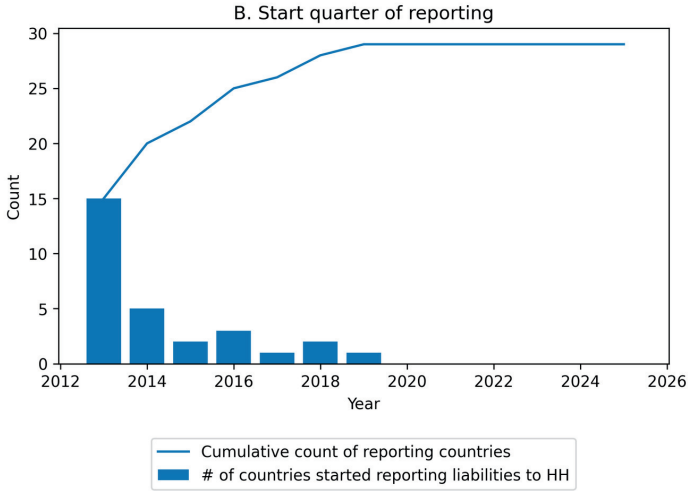


Graph 1: Foreign banks' liabilities to households worldwide, status and gaps

4.2 Coverage of Foreign Banks' Liabilities to Indian Households

While 32 of 46 currently report household sector globally, banks in 31 countries report their liabilities to Indian households (Graph 2 and Table 2).





Graph 2: Foreign banks' liabilities to Indian households, status and gaps

Table 2: First Period of Data Availability by Reporting Country – Liabilities of Banks Abroad to Indian Households

Starting quarter	ISO country code	# of countries	Cumulative count
2013Q4	BE, CH, DE, DK, FI, IE, IM, IT, KR, LU, NO, SE, TW, ZA	14	14
2014Q1	GB	1	15
2014Q2	GG	1	16
2014Q3	BM	1	17
2014Q4	CA, CY, FR, NL, PT	5	22
2015Q1	-	0	22
2015Q2	BS	1	23
2015Q3	-	0	23
2015Q4	RU	1	24
2016Q1	ID	1	25
2016Q2–2016Q3	-	0	25
2016Q4	AT	1	26
2017Q1	ES	1	27
2017Q2	-	0	27
2017Q3	MY	1	28
2017Q4	AU	1	29
2018Q1	SA	1	30
2018Q2–2019Q3	-	0	30
2019Q4	KY	1	31
2020Q1–2025Q3	-	0	31

5. Methodology

Pradhan and Silva (2019) proposed and adopted three alternative mirror data methods (Method-I, Method II, and Method-III) to address incomplete coverage and provide estimates of outstanding cross-border assets held globally.

• Method I, described below, utilises publicly available data from the BIS website (Table A6.1, *https://tinyurl.com/yc8kyhdt*). External users can perform a mirror exercise using the aggregated published data. For instance, the locational banking statistics (LBS) allow each counterparty country to estimate bank assets abroad by its resident sectors—financial corporations (F), private non-financial sectors (P) and subsectors of P, particularly the household sector (H). (See Table 1 for sector codes and classifications)

• Method-II leverages bilateral data (e.g., household assets with banks in the UK), which are not publicly available. However, reporting central banks, such as the RBI, have access to these restricted, unpublished bilateral datasets through the BIS Databank online platform. The lack of access to bilateral data for the public poses a significant challenge for comprehensive analysis. To address this limitation, Method-II relies on the unpublished bilateral data reported by individual countries and applies the principles of Method-I to estimate cross-border assets for each reporting country. Subsequently, Method II uses the share of the estimate sector position from the combined pool of reported data and applies to countries that do not report the breakdown. Finally, the method aggregates the data from both reporting and non-reporting countries to produce improved and more comprehensive estimates.

• Method-III builds upon the foundation of Method-II by addressing the issue of late-reporting countries. It first estimates the non-reported bilateral data for countries that began reporting later than others. Once these estimates are derived, Method-III applies the framework of Method-II to ensure consistency and accuracy. For example, China and Russia began reporting data only at the end of 2015. Method-III accounts for the incremental contribution of these newly reporting countries and uses this information to estimate data for earlier quarters (extending back to 2005).

Method I is particularly valuable for general data users and, specifically, for regulatory and tax authorities in assessing potential tax evasion, addressing loopholes, and enhancing data collection processes. For example, Indian authorities could consider introducing new items in existing household surveys to gather more detailed (country-level) information on cross-border financial assets, such as savings and investments held by Indian households. This would significantly improve the accuracy of the data and support the formulation of evidence-based policies. Moreover, Method I is also suitable for improving estimates for other non-bank subsectors, such as non-bank financial institutions (NBFIs) and non-financial corporations.

Finally, the proposed methods provide an additional advantage by offering complementary backward estimates (approximate) for the quarterly periods from December 2005 to September 2013, during which these data were not reported to the BIS. These backward estimates help fill historical data gaps and enable a more complete analysis of cross-border household assets over time.

5.1 Estimates using BIS aggregated published data (Method I)

Essentially, this method involves three sequential steps to obtain the estimation for each counterparty country[3]

[3] Proportional allocation of residual amounts to reportable sub-sectors is adopted. However, there are possible alternative methods.

Step 1: Estimate aggregate sub-sectors of N (F and P); Step 2: Estimate sub-sectors of P (C/G/H); and Step 3: Estimate non-reported (historical) data backwards.

Step 1: F, P and K are estimated by assuming that the allocation of the reported amounts is representative of the unreported amounts (letters without "est" are the data as reported, while X and K are unallocated amounts):

$$F_q^{\text{est}} = F_q + X_q \left[\frac{F_q}{F_q + P_q}\right],$$
$$P_q^{\text{est}} = P_q + X_q \left[\frac{P_q}{F_q + P_q}\right],$$
$$K_q^{\text{est}} = P_q^{\text{est}} - (C_q + G_q + H_q)$$

Step 2: Estimation for the sub-sectors: C, G and H, with a similar assumption as in the previous step:

$$C_q^{\text{est}} = C_q + K_q^{\text{est}} \left[\frac{C_q}{C_q + G_q + H_q}\right],$$
$$G_q^{\text{est}} = G_q + K_q^{\text{est}} \left[\frac{G}{C_q + G_q + H_q}\right],$$
$$H_q^{\text{est}} = H_q + K_q^{\text{est}} \left[\frac{H_q}{C_q + G_q + H_q}\right]$$

Step 3: To obtain estimated sector H for historical quarters when non-bank subsectors were not at all available, the following sequence is followed:

• First, the ratio of estimated P to reported sector N is calculated for quarters from Q4:2015 to Q3:2025, during which reporting fairly stabilised for the countries reporting these breakdowns (Graph 1 and Graph 2). The average:

$$\frac{1}{40} \sum_{q=Q4:2015}^{Q3:2025} \frac{P_q^{\text{est}}}{N_q}$$

is then multiplied to the reported value of sector N for 40 quarters from Q4:2005 to Q3:2015 to get estimated values for Sector P for the respective quarters.

• Similarly, the ratio of estimated sector H to estimated sector P is calculated for 40 quarters from Q4:2015 to Q3:2025:

$$\frac{1}{40} \sum_{q=Q3:2015}^{Q3:2025} \frac{H_q^{\text{est}}}{P_q^{\text{est}}}$$

and the average ratio is then multiplied by the estimated non-financial sector position (P_q^{est}), obtained in the previous step, to each of the previous quarters, from Q4:2005 to Q3:2015.

The estimates based on advanced methods (II and III) are out of the scope of this paper.

5.2 Numerical Illustration of Method-I

5.2.1 Estimates from Q4:2013 Onwards Using Reported Data with Gaps

The following table illustrates step 1 and step 2 estimation methods, using published data on the BIS website for Q4 of 2024. These steps are adopted in all reported quarters (Table 5). The published numbers in the table below are available on the BIS website Table A6.1 at BIS LBS Data. However, users need to derive the "X: Unallocated non-banks" (= N − F − P) and keep in mind that liabilities of banks are the claims (mirror) for the corresponding counterparty sector.

[4] *https://tinyurl.com/yv9uefum*

Table 3: Reported and estimated assets of Indian households with banks

Q4 2024; amounts outstanding in USD million			
Non-bank sub-sectors	**Published**	**Step I** (estimates F and P)	**Step II** (estimates C, G and H)
N: Non-banks, total (=F + P +X)	12,629.5	**12,629.5**	
F: NBFIs	2,343.6	F^{est} = 2,343.6 + 2,241.7*(2,343.6/10,387.8) =**2,849.4**	
P: NFS (=C + G +H + K)	8,044.2	P^{est} = 8,044.2 + 8,044.2*(2,343.6/10,387.8) = **9,780.2**	
C: NFCs	4,382.2		C^{est} = 5,930.3
G: GG	735.1		G^{est}= 994.8
H: Households	2,109.8		H^{est} =2,855.1
K: Unallocated NFS	**817.2**		
X: Unallocated non-banks	**2,241.7**		
K^{est} = (P_{est} – C – G -H)		**2,553**	

Notes:
Step 1: F^{est} = F + X* F/(F+P); P^{est} = P + X* P/(F+P); F +P = 2,343.6+8,044.2 = 10,387.8
Step 2: C^{est} = C + K^{est}* C/(C+G+H); G^{est} = G + K^{est}* G/(C+G+H); H^{est} = H + K^{est}* H/(C+G+H); C +G +H =7,227.1

The estimated amount above for the Indian household sector's assets (USD 2, 855 million) held with banks in foreign countries is more than 35% higher than the reported and published amount (USD 2, 109.8 million). The quarterly estimates reveal that the published figures are understated due to reporting gaps arising from BIS-reporting countries(subsection 6.2) that do not provide encouraged sectoral breakdowns(C, G, H).

5.2.2 Estimates for Pre-Q4:2013 Periods Without Data for Non-Bank Sub-Sectors

After deriving estimated sector positions, F_q^{est} and P_q^{est} in step I, followed by the sector positions C_q^{est}, G_q^{est} and H_q^{est}, the ratio of F_q^{est} and P_q^{est} to (reported) N are calculated for all quarters from Q4:2013 to the latest available quarter(Q3:2025). The ratios for the initial quarters from Q4:2013 to Q3:2015 are not reliable due to jumps in reporting countries providing the new subsectors during these initial quarters (see Table 2). Further, China and Russia started reporting data from Q4:2015. Consequently, the average of these ratios from Q4:2015 to Q3:2025 is calculated (see Step 3) and this average ratio is then multiplied by (reported) N value of quarters from Q4:2005 to Q3:2015 to get estimate sector F and P positions. Similarly, the average of the ratios for the estimated sector C, G and H to P from Q4:2015 to Q3:2025 are calculated and average ratio of the respective subsector are then multiplied to estimated P (i.e., P_q^{est}) value of historical quarters from Q4:2005 to Q3:2015 to get estimates of the corresponding sector positions for C, G and H.

The table below for India shows that the average ratios fall within 95% confidence interval for the respective subsector. This implies that the estimated values for the prior periods from Q4:2005 to Q3:2015 are robust and reliable.

Table 4: Mean, SD and Confidence Interval of Estimated subsectors for India

Ratio	Full sample period: Q4:2015 to Q3:2025			
	Mean	SD	95% CI Lower limit	95% CI Upper limit
Sub-sectors of N				
F^{est}/N	0.233909	0.052044	0.217264	0.250553
P^{est}/N	0.766091	0.052044	0.749447	0.782736
Sub-sectors of P				
C^{est}/P^{est}	0.543946	0.065774	0.522911	0.564982
G^{est}/P^{est}	0.084169	0.069221	0.062031	0.106306
H^{est}/P^{est}	0.371885	0.072773	0.348611	0.395159

6. Estimated Assets of the Household Sector in India and 10 Other Expanded BRICS Members

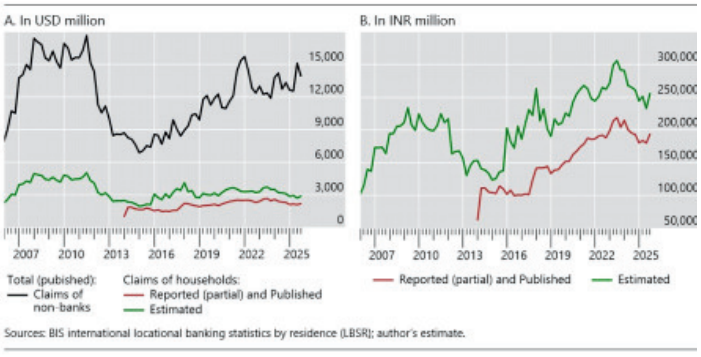
6.1 Known Knowns

Graph 3 below and Table 5 in the Appendix present the reported and estimated assets of the Indian household sector held with banks in foreign countries that provide data to the BIS, starting from the end of 2013. In addition, estimated data for these assets are provided for the period between the end of 2005 and 2013. It is important to note that data for the period prior to the end of 2013 were not reported by any jurisdiction; instead, they were estimated using the proposed

proposed methodology outlined in this study. As of the latest available data (Q3:2025), Indian households' assets with banks are concentrated in Australia, Canada, Germany, Malaysia, Switzerland, and the United Kingdom.

The estimated amounts provide valuable insights into the scale of cross-border banking activity by Indian households in jurisdictions that report to the BIS. For a broader perspective, the Appendix includes graphs showing reported and estimated amounts for all 11 countries in the expanded BRICS group, thus enabling a comparative analysis of India's position relative to other economies within the group.

The size of the estimated household sector's assets depends on its reported (or estimated) share in the non-financial sector (P), which, in turn, is determined by its share in the total non-bank sector (N). The significant gap observed for China and Saudi Arabia (Graph 4) arises because of the large liabilities of banks to non-banks in certain jurisdictions, such as Hong Kong SAR (for China) and China (for Saudi Arabia), to non-financial subsectors, including the household sector, are not reported. However, the reported or estimated share of the household sector may be in line with other countries, such as India. Underlying data for these or additional countries is available upon request.



Graph 3: Assets of Indian Households held with banks in Foreign countries

6.2 Known Unknowns

The estimates are based on BIS-published data, aggregated from countries that report non-bank subsector breakdowns, with gaps in reporting (i.e., countries that do not provide data for non-bank subsectors). The BIS reporting population consists of banks located in approximately 50 jurisdictions out of more than 200 worldwide. While BIS reporting jurisdictions are primarily home to internationally active banks, some other jurisdictions, including certain non-reporting offshore centres, also host internationally active banks. Consequently, the estimates exclude assets held with banks in non-reporting countries, such as Qatar, the Marshall Islands, Mauritius, the United Arab Emirates, Thailand, Seychelles and others, as these countries do not contribute data to the BIS.

It is widely perceived that banks in reporting countries that do not provide data for the household sub-sector, as well as those in non-reporting countries, likely hold substantial deposits from the household sector and other non-bank sectors of India and other countries. While alternative estimation methods could provide further insights, it is evident that the actual amount of household assets is significantly higher when accounting for assets held with banks in non-reporting countries. Therefore, the estimates presented in this paper should be regarded as a conservative lower bound.

7. Concluding Remarks

This paper demonstrates the practical application of Method-I (Pradhan and Silva, 2019) to address critical data gaps in cross-border asset holdings. By leveraging publicly available data, policymakers and tax

authorities can investigate potential tax evasion, estimate non-reported data, and improve the consistency and comprehensiveness of time-series data. The results, which cover India as well as the other 10 member countries of the expanded BRICS group, underscore the importance of back-estimates and mirror data analysis in enhancing statistical coverage and maintaining high-quality standards. These techniques provide valuable information on the potential minimum levels of foreign assets held by households in banks abroad.

The proposed Method-I offers a straightforward and accessible approach using publicly available data from the BIS website. At the same time, the BIS could consider implementing Method-II (and Method-III), which relies on unpublished bilateral data and shares the results with relevant stakeholders or publishes them on the website. These methodologies could also be extended to other non-financial sectors, such as non-bank financial institutions (NBFIs), non-financial corporations (NFCs) and general government (GG). Such extensions would align with the methodology used for the BIS database for total credit to the private non-financial sector, as outlined by Dembiermont et al. (2013).

Furthermore, these methods have broader applications in the compilation of external sector statistics and rest-of-world sector accounts. They can also be adapted for use in other datasets, such as foreign direct investment (FDI), balance of payments (BoP), portfolio investments, and trade statistics. Expanding the scope of these methodologies would enable policymakers and analysts to gain deeper insights into cross-border activities and strengthen the overall quality of global financial statistics. By addressing existing data gaps and leveraging innovative estimation techniques, countries like India can enhance their statistical systems and contribute more effectively to global data initiatives.

From a policy perspective, there are significant implications for improving India's internal data collection systems and its participation in global initiatives. Authorities need to review existing regulations and identify loopholes in frameworks such as the Common Reporting Standard (CRS) and FATCA for both residents and non-residents. Strengthening the approval process and enhancing data collection mechanisms for overseas investments, expanding household surveys to include separate information on foreign assets and liabilities of the household sector and fully utilising the Automatic Exchange of Information (AEOI) framework, similar to OECD initiatives, are critical steps. Additionally, India should consider providing a breakdown of data on securities holdings by the household sector in its submissions to the IMF's Portfolio Investment Position (PIP) dataset. Encouraging further studies based on available data and methodologies, including the one proposed in this study, would also support transparency and help address persistent data gaps.

APPENDIX

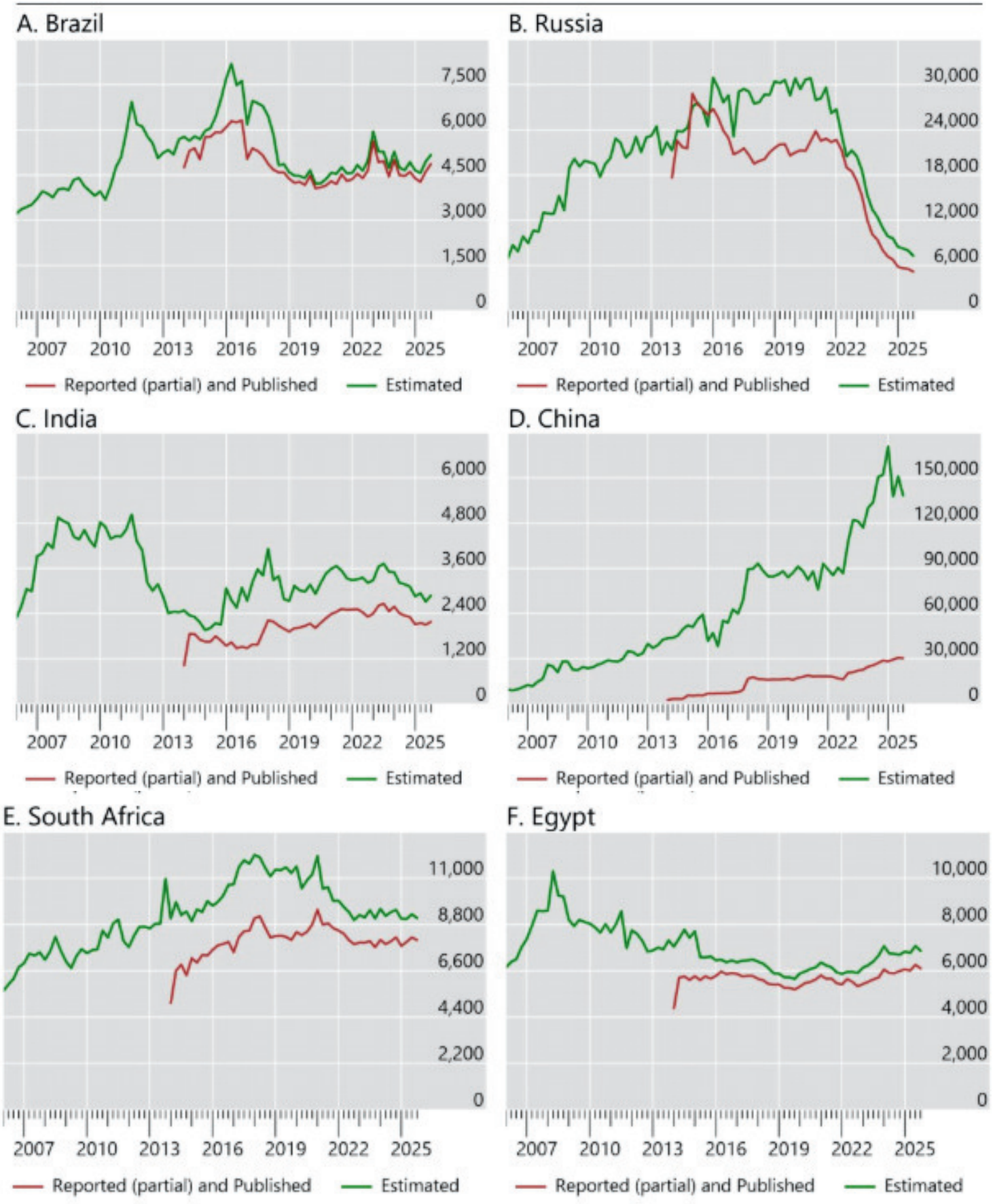
Table 5: Reported and estimated assets of Indian households with banks in foreign countries, from Q4:2005 to Q3:2025

Quarter	Reported ($mn)	Estimated		INR/ USD rate		Quarter	Reported ($ mn)	Estimated		INR/ USD rate
		$ mn	INR mn					$ mn	INR mn	
2005Q4	-	2,259	101,704	45.022		2015Q4	1,542	3,069	202,994	66.154
2006Q1	-	2,593	115,646	44.607		2016Q1	1,634	2,753	182,400	66.254
2006Q2	-	3,050	140,182	45.955		2016Q2	1,480	2,556	172,589	67.520
2006Q3	-	2,993	137,248	45.859		2016Q3	1,517	3,088	205,725	66.630
2006Q4	-	3,923	173,431	44.205		2016Q4	1,483	2,740	186,077	67.919
2007Q1	-	4,001	173,131	43.274		2017Q1	1,579	3,228	209,537	64.911
2007Q2	-	4,268	173,658	40.688		2017Q2	1,574	3,577	231,121	64.620
2007Q3	-	4,134	164,340	39.752		2017Q3	1,897	3,408	222,459	65.280
2007Q4	-	4,953	194,679	39.306		2017Q4	2,219	4,118	263,033	63.875
2008Q1	-	4,857	194,365	40.020		2018Q1	2,184	3,286	214,178	65.170
2008Q2	-	4,790	205,641	42.929		2018Q2	2,077	3,395	232,430	68.462
2008Q3	-	4,440	206,361	46.476		2018Q3	1,997	2,783	201,751	72.491
2008Q4	-	4,369	211,716	48.457		2018Q4	1,920	2,735	190,468	69.633
2009Q1	-	4,617	233,816	50.640		2019Q1	2,009	3,135	216,853	69.176
2009Q2	-	4,348	207,682	47.770		2019Q2	2,025	3,017	208,209	69.002
2009Q3	-	4,176	199,649	47.805		2019Q3	2,070	2,977	210,947	70.862
2009Q4	-	4,820	224,326	46.536		2019Q4	2,131	3,165	225,919	71.379
2010Q1	-	4,707	211,312	44.895		2020Q1	2,014	2,922	221,093	75.665
2010Q2	-	4,385	203,683	46.445		2020Q2	2,152	3,210	242,544	75.570
2010Q3	-	4,454	199,883	44.876		2020Q3	2,275	3,459	254,932	73.709
2010Q4	-	4,449	198,981	44.722		2020Q4	2,385	3,589	262,223	73.067
2011Q1	-	4,639	206,852	44.587		2021Q1	2,444	3,660	267,900	73.188
2011Q2	-	5,028	224,584	44.670		2021Q2	2,524	3,536	262,816	74.322
2011Q3	-	4,318	211,432	48.966		2021Q3	2,500	3,334	247,818	74.339
2011Q4	-	4,085	216,928	53.105		2021Q4	2,509	3,287	244,472	74.368
2012Q1	-	3,218	163,951	50.945		2022Q1	2,517	3,312	250,997	75.790
2012Q2	-	3,003	167,258	55.695		2022Q2	2,432	3,352	264,999	79.054
2012Q3	-	3,180	168,106	52.860		2022Q3	2,311	3,217	262,102	81.478
2012Q4	-	2,850	156,716	54.995		2022Q4	2,402	3,284	271,511	82.665
2013Q1	-	2,406	130,726	54.327		2023Q1	2,606	3,641	299,355	82.206
2013Q2	-	2,452	145,714	59.420		2023Q2	2,665	3,725	305,800	82.097
2013Q3	-	2,437	153,097	62.824		2023Q3	2,459	3,508	291,480	83.081
2013Q4	1,019	2,478	153,412	61.900		2023Q4	2,584	3,496	290,799	83.171
2014Q1	1,860	2,352	140,868	59.892		2024Q1	2,408	3,215	268,069	83.375
2014Q2	1,855	2,310	139,059	60.186		2024Q2	2,343	3,179	265,004	83.372
2014Q3	1,706	2,166	133,998	61.874		2024Q3	2,305	3,113	260,839	83.792
2014Q4	1,653	1,958	123,716	63.190		2024Q4	2,110	2,855	244,403	85.604
2015Q1	1,652	2,016	126,053	62.528		2025Q1	2,152	2,940	251,162	85.433
2015Q2	1,801	2,143	136,357	63.623		2025Q2	2,100	2,717	233,144	85.802
2015Q3	1,681	2,102	137,840	65.590		2025Q3	2,181	2,879	255,613	88.796

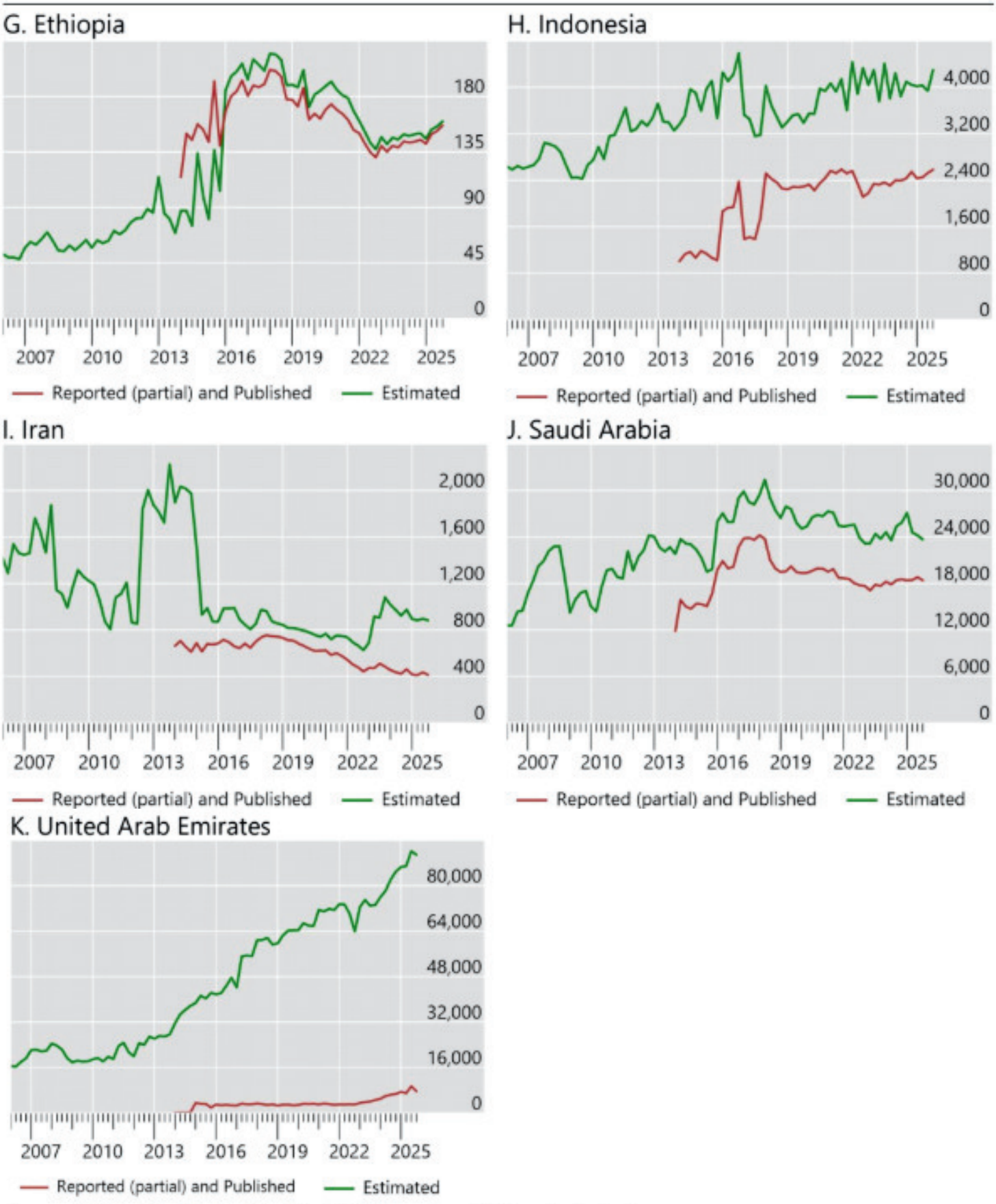
$mn = Amount in USD million; INR mn = Amount in INR million

Note: Claims of households derived (mirrored) as the liabilities to households by banks in the BIS reporting countries.

Sources: BIS international banking statistics by residence (LBSR); author's estimates.



Graph 4 (Contd.): Reported and Estimated Assets Held with Banks in Foreign Countries by Household Sector of Expanded BRICS Countries *(amounts outstanding in USD million)*



Graph 4 (Contd.): Reported and Estimated Assets Held with Banks in Foreign Countries by Household Sector of Expanded BRICS Countries (amounts outstanding in USD million)

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India's Residential Solar Revolution: Progress, Impediments and the Way Forward

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Council on Energy, Environment and Water

ABSTRACT

India's energy transition is at a critical point as the nation addresses growing electricity demand while pursuing decarbonisation goals, especially in the residential sector. Despite an evolving policy framework, India's residential rooftop solar (RTS) adoption remains limited. This study examines the key impediments to the progress of residential rooftop solarisation and highlights the interventions necessary to achieve nationwide success. This article begins by investigating the evolution of India's residential rooftop solar policy landscape, focusing on the progress of the PM Surya Ghar: Muft Bijli Yojana (PMSG: MBY). By mapping national and state-level policies and analysing progress data, the study identifies that while significant capital subsidies and a one-stop national digital portal have made adoption easier, progress varies widely between states. The study finds that impediments to widespread adoption are diverse, including financial, administrative, technical, and policy-related issues that hinder large-scale deployment. The article concludes that achieving a true residential solar revolution requires a multi-dimensional strategy that bridges the policy-to-implementation gap, integrating financial accessibility, policy and regulatory harmonisation, distribution infrastructure upgrades and awareness and trust-building to foster a resilient and inclusive energy future.

Keywords: residential rooftop solar, energy transition, India, solar policy, PM Surya Ghar, distributed energy, renewable energy adoption

JEL Classification: H54, O13, Q28, Q48, R11

1. Introduction

India’s energy landscape is at a critical inflexion point as it is trying to strike a balance between the surging electricity demand and the urgent necessity of decarbonisation. To put things into perspective, in 2024, the power sector contributed a whopping 75.66% to India’s overall carbon emissions (Ministry of Environment, Forest and Climate Change, 2025) while residential electricity needs constituted roughly one fourth of the total electricity consumption (International Energy Agency (IEA), 2024). This pressure is reflected in the rapid growth of individual electricity usage. India's per capita electricity consumption reached approximately 1,460 kWh in 2024-25, with projections aiming to reach 2,000 kWh by 2030 and rising further toward a 2047 target of over 4,000 kWh (Ministry of Power, 2026a). As urbanisation, rising incomes and increasing appliance ownership continue to drive the residential electricity demand, the residential sector will play a pertinent role in shaping India’s energy transition story (Dasgupta &

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Sarangi, 2021). What makes the residential segment unique in comparison to the industrial or commercial segments is its highly distributed load base, thus positioning it to both drive and benefit from distributed clean energy solutions (Proedrou, 2021). India possesses high solar potential, with most regions receiving approximately an average solar insolation of 4–7 kWh/square meter/day for about 300 days annually (Council on Energy, Environment and Water (CEEW) & Natural Resources Defence Council, 2012). Reflecting this vast natural resource, India's total residential rooftop solar potential is 637 GW if all suitable roofs are entirely covered, which reduces to a technical potential of 118 GW when system size is restricted to meet actual household electricity demand (Zachariah et al., 2023). This potential is further reinforced by an evolving policy ecosystem and declining solar photovoltaic (PV) costs, thus improving the suitability of residential rooftop solar (RTS) systems. In this context, central to India's energy transition is the residential solar revolution marked by a shift from centralised fossil fuel-based power generation to a decentralised, grid-connected renewable energy ecosystem.

From a macro perspective, prioritising residential rooftop solar (RTS) adoption is no longer merely an environmental choice but a strategic imperative to ensure affordable energy access for all. At the household level, however, the decision to adopt solar is typically driven by economic pragmatism rather than broader system-level considerations. A survey conducted by the Council on Energy, Environment and Water (CEEW) found that 78 per cent of respondents ranked monthly electricity bill savings as the primary motivation for installing an RTS system (Saji et al., 2019). However, the path to a fully realised solar revolution is complex. While the consumer appetite for lower electricity bills provides a natural catalyst for growth, the leap from consumer interest to installation is rarely a straight line. Despite the high solar potential and policy intent, the uptake of RTS remains unevenly distributed across states and consumer profiles. In this context, this article examines the recent evolution of India's RTS policies for the residential segment, progress toward targets, and initiatives taken to ease RTS adoption. It also highlights persistent obstacles to RTS deployment and outlines the next steps required to achieve residential solar energy targets on time.

2. India's RTS Policy Landscape Mapping

India's contemporary policies pertaining to RTS are driven by the national goal to install 500 gigawatts (GW) of non-fossil fuel capacity by 2030, with a specific target of 30 GW for residential RTS capacity by 2027 (Ministry of New and Renewable Energy (MNRE), 2024). This mapping exercise specifically evaluates the residential landscape and largely draws on an analysis presented in an issue brief by CEEW titled *"How are Indian States Enabling Rooftop Solar Adoption? Analysing Subnational Policies and Regulations"* (Patil et al., 2025).

The Indian solar policy ecosystem is a combination of national programmes and state-level interventions because both the central and state governments have jurisdiction over electricity. The foundation of India's solar journey was laid with the launch of the Jawaharlal Nehru National Solar Mission (NSM) in 2010. The mission was designed as a three-phase programme, with respect to the residential segment; the first phase

primarily focused on establishing an enabling ecosystem for solar deployment, largely through the promotion of off-grid and decentralised solar applications. A stronger emphasis on RTS emerged later under the Grid-Connected Rooftop and Small Solar Power Plants Programme, introduced during the second phase of the mission in 2014 (MNRE, 2014). Under this programme, the MNRE provided CFA for grid-connected RTS projects for installation capacities ranging from 1 kW to 500 kW, and was applicable across multiple consumer categories, including residential, commercial, and industrial segments. Subsequently, in 2019, Phase II of the Grid-Connected Rooftop Solar Programme was launched with a specific focus on the residential sector. Under this programme, the CFA structure was redesigned to prioritise smaller household systems (up to 10 kW). However, adoption remained fragmented among households.

Additionally, the Electricity (Rights of Consumers) Rules, 2020, amended in 2021, formally recognised electricity consumers as "prosumers," referring to consumers who both produce and consume electricity. The rules also outlined standard metering arrangements such as net metering (where excess electricity post self-consumption is exported to the grid and credited at a 1:1 rate for future imports), gross metering (where all generated electricity is exported to the grid at a fixed tariff while all consumed electricity is imported from the grid at a higher tariff), and net billing (where surplus solar generation after self-consumption is sold to the grid at a lower wholesale rate than the retail purchase price) to promote greater regulatory clarity and uniformity across states in the integration of RTS systems.

The most recent policy initiative, the PM Surya Ghar: Muft Bijli Yojana (PMSG: MBY), announced in February 2024 as the successor to the previous RTS programme, aims to install one crore residential RTS systems by March 2027. The scheme provides an increased CFA (roughly double) for residential consumers, covering ₹30,000 per kW for systems up to 2 kW and an additional ₹18,000 per kW for systems between 2 kW and 3 kW, thereby further strengthening financial support for smaller households to go solar. This structure provides a higher per-kW subsidy for smaller systems, with the aim of better aligning with the consumption patterns and socio-economic context of the majority of households at the national level (IEA & CEEW, 2021).

State-specific policies are also important because they take into account the prevailing socio-economic context and then define the localised vision, set targets, and create regulations to encourage adoption within the state. In terms of targets and mandates, 18 state policies have set time-bound targets for installing RTS systems, with progressive states like Assam, Goa, Jharkhand, and Sikkim setting targets by consumer category (Patil et al., 2025). With regard to metering regulations, State Electricity Regulatory Commissions (SERCs) determine the economic viability of solar setups through metering regulations. Most states have adopted net metering for the residential sector (where prosumers are billed only for net electricity imported), and many offer gross metering and net billing as well. Some progressive states have also introduced group net metering and virtual net metering, which allow consumers without adequate roof space to benefit from off-site RTS systems (Patil et al., 2025).

Regarding technical requirements, there is a significant disparity in minimum capacity mandates; 24 of 29 state

and Union Territory (UT) regulations require RTS systems to be larger than 1 kW. This threshold can exclude many households from deploying solar energy, particularly those with lower electricity consumption, though states such as Goa, Himachal Pradesh, Odisha, Tamil Nadu, and Uttarakhand have removed this barrier by imposing no minimum size requirement. Furthermore, individual RTS systems are frequently subject to restrictions based on the consumer's sanctioned load or contract demand, with most states limiting system capacity to 100% of that sanctioned load. While Jammu and Kashmir more strictly restricts system size to 50% of the sanctioned load, other states have moved toward liberalisation: Chhattisgarh permits systems above 100% of the sanctioned load, and Gujarat, Jharkhand, and Uttarakhand have relaxed these restrictions for residential consumers to allow for system oversizing.

Financial incentives at the state level also play a crucial role in improving the affordability and attractiveness of RTS adoption. To address the high upfront costs of the RTS system, several states, such as Assam, Delhi, Goa, and Uttar Pradesh, offer additional capital subsidies to residential consumers that can be stacked with central government support. In addition, many states provide fiscal benefits such as exemptions or reimbursements on State Goods and Services Tax (SGST) and waive state electricity duty on power generated from RTS systems for extended periods, further reducing the overall cost burden for a consumer. Beyond upfront support, some states have been introducing performance-linked incentives to enhance long-term financial viability. For instance, Delhi and Kerala offer generation-based incentives (GBIs), under which consumers receive payments for each unit of electricity generated by their solar installations, thereby improving returns on investment and encouraging greater adoption of RTS systems in these states.

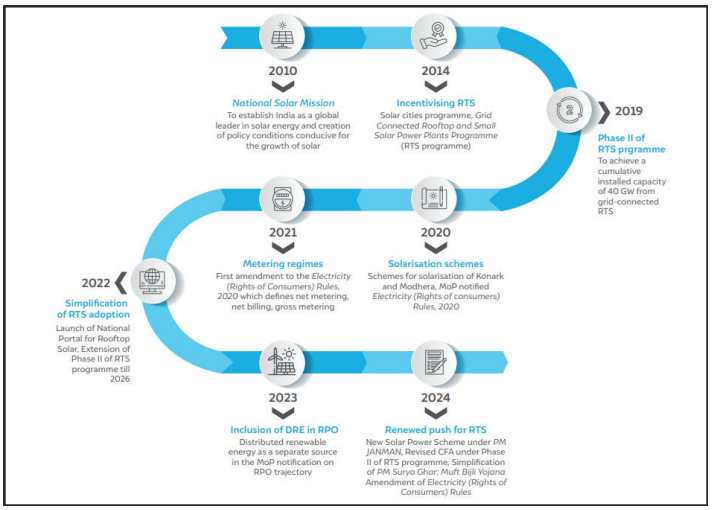


Figure 1: Key programmes and announcements in India's RTS journey

Note. Reprinted from How are Indian states enabling rooftop solar adoption? Analysing subnational policies and regulations, by A. Patil, K. Ramesh, & B. Tyagi, 2025, Council on Energy, Environment and Water.[3]

3. How Much Has Been Achieved Till Now: Tracking Progress Against the Targets

February 2026 marked two years since the launch of PMSG: MBY. As per the Ministry of Power, 31.04 lakh households across India have benefited out of the 1 crore target for March 2027 (Ministry of Power, 2026b). To support these installations, INR 17,682.05 Crore worth central financial assistance (CFA) has been disbursed out of the total allocated financial outlay of INR 75,000 Crore. The aforementioned installations amount to an installed capacity of 8 GW as compared to the overarching 30 GW target (MNRE, 2026). From

[3] Patil, A., Ramesh, K., & Tyagi, B. (2025, April 11). How are Indian states enabling rooftop solar adoption? Council on Energy, Environment and Water. https://www.ceew.in/publications/how-indian-states-are-enabling-rooftop-solar-adoption-with-solar-policies-and-regulations.

a state-wise perspective, the uptake remains uneven as five states, namely Gujarat, Maharashtra, Uttar Pradesh, Kerala and Rajasthan, account for nearly 75 per cent of the total installations (Press Information Bureau, 2025).

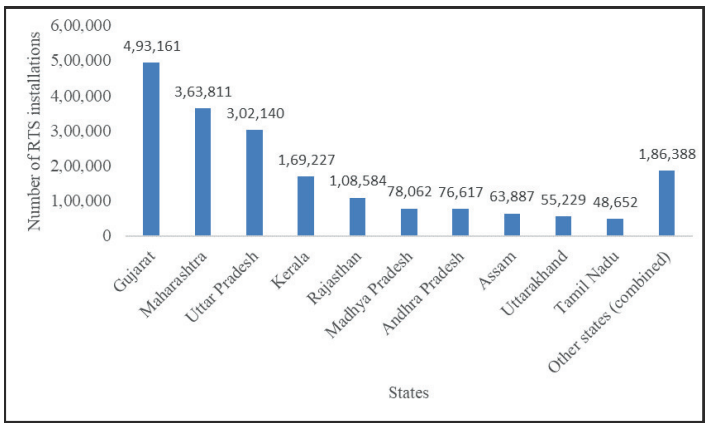


Figure 2: State-wise number of RTS installations made under the PMSG: MBY (as on 09.12.2025)

Source: Press Information Bureau, 2025

Based on a comparative analysis of the states, it can be inferred that Gujarat maintains its top position through highly efficient digital governance, boasting a conversion rate where approximately 85% of applications successfully transition to commissioned systems. Maharashtra follows as a major hub where high electricity tariffs create a strong financial incentive, offering an attractive return on investment for urban housing societies and private homeowners. Uttar Pradesh has rapidly emerged as a frontrunner by pairing the national PM Surya Ghar Yojana with aggressive state-level top-up subsidies of up to INR 30,000, significantly lowering the entry barrier for the middle class. Kerala has turned its geographical challenges into a catalyst, utilising decentralised rooftop solar as the most viable energy solution in a state defined by high environmental awareness and land scarcity. Finally, Rajasthan capitalises on its natural climate, with the highest solar irradiation in the country.

4. Recent Initiatives to Accelerate Residential RTS Adoption

The government has taken several steps in recent years to speed up the adoption of residential RTS. Financially, in addition to capital subsidies from the central and various state governments, nationalised banks are instructed to offer collateral-free loans at lower interest rates to ease cash flow issues. The government has also allowed alternative commercial options, such as the Renewable Energy Service Company (RESCO) and Utility-Led Aggregation (ULA) models, to provide consumers with flexible investment options (MNRE, 2026). The RESCO model allows consumers to avoid high upfront costs by paying only for the solar power generated as per a pre-agreed tariff, while the ULA model offers lower prices achieved through bulk procurement.

The administrative process has been simplified with a national portal that handles everything from initial registration to the final payment of subsidies into beneficiary bank accounts. Regulatory barriers have been further reduced by removing technical feasibility requirements and allowing automatic load increases for installations up to 10 kW. Also, net metering agreements are now included in the national portal's application workflow, which cuts down on delays (MNRE, 2026).

The government has also simplified the vendor registration process to make it easier for more qualified service providers to participate. This strengthens the supply side of the ecosystem, encourages market competition, and helps lower the costs of RTS systems for consumers. The simplified vendor registration is supported by specialised training and capacity building

programs that focus on creating a skilled workforce for the installation and long-term maintenance of RTS systems (MNRE, 2026).

Finally, awareness campaigns in print, electronic, and social media, along with a multilingual call centre that operates in 12 languages, help close the information gap and offer a way to address complaints (MNRE, 2026). Additionally, states like Uttarakhand have started direct engagement initiatives, such as solar fairs and solar vans, to improve consumer awareness and build the trust needed for adoption (ANI, 2024).

5. Impediments to Residential Solar Adoption

Despite diverse initiatives to accelerate residential RTS deployment, secondary research findings reveal that the following factors continue to hinder progress:

Awareness and Trust Gaps

Consumers still struggle with significant gaps in understanding installation costs, financial benefits, procedural requirements, subsidy distribution, and long-term maintenance. These gaps are especially common in states with few demonstration projects and little outreach in local languages. This situation leaves consumers overly reliant on vendor guidance (Sharma et al., 2025). Research indicates that even informed consumers often doubt vendor credibility when it comes to product quality and support after installation. This lack of trust is a major obstacle to adoption (Mohammed & Maheswari, 2025).

Financial Barriers

A standard 3 kW solar system costs between INR 1.5 lakh and INR 2.1 lakh. This is a high upfront cost for low-income households. These consumers usually put their savings toward basic needs like healthcare and education instead of expensive renewable energy. Although subsidies from the PMSG: MBY cover a significant portion of the initial cost, payment is made only after the system is installed and verified by the local DISCOM. This delay in recovering the investment lowers consumer confidence.

Additionally, even though public sector banks are directed to offer collateral-free loans at lower interest rates, loan applications are often delayed or denied. This happens due to poor documentation, unpaid electricity bills, or unresolved land ownership issues, like records tied to deceased relatives. Also, financial institutions often classify RTS systems as non-core assets with little resale value. This classification further restricts credit access for residential consumers (Reuters, 2026).

Administrative Delays

Although the required timeline for RTS commissioning under PMSG: MBY is 30 days, implementation often takes up to 120 days. Delays mainly occur because of shortages of bi-directional meters, poor coordination between DISCOMs and vendors, and unresolved technical issues during system integration (Upadhyay & Sharma, 2025).

Policy Conflicts with State Welfare Schemes

In states like Punjab, Telangana, and Karnataka, welfare schemes that offer a set amount of free electricity each month greatly lower the incentive to adopt RTS (Carbon Copy, 2025). These policies eliminate the economic logic of saving on electricity costs, which weakens the financial appeal of RTS investments for residential users.

Industrial Policy Constraints

Under the "Aatmnirbhar Bharat" initiative, the government requires solar modules that meet the Domestic Content Requirement (DCR) to qualify for central subsidies. While this decision is meant to support local manufacturing, it has created supply-side issues. Domestic production of solar cells is falling short of module assembly, leading to a shortage of DCR-compliant modules. Consequently, these modules are significantly more expensive than non-DCR imported alternatives, which often use more efficient technologies (Puja Das, 2025). This situation creates a 'subsidy paradox' where non-subsidised imported modules can be just as cost-effective as subsidised DCR-compliant modules.

Spatial and Technical Obstacles

Urban adoption of RTS is further limited by restricted rooftop space and complicated ownership arrangements, especially in multi-story Residential Welfare Association (RWA) societies and rental properties. Many existing roofs also do not have the structural strength needed to hold solar arrays. The cost of retrofitting these structures can significantly raise overall investment costs. Additionally, shading from trees and nearby buildings decreases sunlight exposure, which results in lower energy yields and less cost-effectiveness (Shah, 2025).

Grid Integration Challenges

While grid integration is not a pressing issue now, as RTS capacity is still far below its total potential, it could become a major problem as adoption increases. More distributed systems that export energy create a two-way power flow in distribution networks that were originally built for one-way supply. This change can cause power outputs to go beyond the capacity of distribution lines or transformers, leading to congestion and stress on equipment. Moreover, a high concentration of RTS can cause frequent voltage fluctuations, often due to environmental factors like rapid cloud movement (Sageer & Ahmad, 2025). Therefore, keeping voltage stable is a key operational challenge. This situation requires upgrades to the existing grid infrastructure to support the growing RTS energy capacity.

6. Conclusion

Based on the existing policy landscape at the national and state levels, as well as findings on barriers to residential solar adoption, we suggest the following government interventions to improve momentum for residential RTS adoption:

- Simplify loan processing to remove financial barriers for low-income households and ensure equitable distribution of scheme benefits.
- Prioritise the supply of DCR-compliant modules for the residential segment to resolve demand-supply mismatches and prevent project implementation delays.
- Deploy direct engagement initiatives, such as solar vans and school-level literacy programs, to build consumer trust, particularly in rural and semi-urban areas.
- Strengthen the technical and administrative capacities of DISCOMs and vendors to address existing operational bottlenecks and improve service delivery.
- Implement virtual and group net metering policies across states to address urban spatial constraints and tenancy- or ownership-related barriers.

- Realign state welfare policies by transitioning from direct electricity subsidies to the distribution of solar kits to integrate social support with rooftop solarisation goals.
- Modernise distribution infrastructure to pre-emptively mitigate grid-connection bottlenecks and accommodate growing RTS energy capacity.

Achieving residential solar energy targets depends on the effective integration of financial, procedural, policy and regulatory interventions to eliminate systemic barriers. Ultimately, closing the gap between policy objectives and implementation at the grassroots level is fundamental to a sustainable energy transition in the residential sector.

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Moving towards Electronic-Marketing: Computerisation of India's Agriculture

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ABSTRACT

Computerising the administration of agriculture is a major component of India's recent public achievements. Creation of a sub-market (e-NAM) for online transactions within the regulated market is now in process, enabling differentiation of markets in terms of computerisation and evaluation of the technology. A comparison of APMC markets with and without e-NAM for the marketing of a perishable crop, tomato, and a more stable crop, onion, reveals dissimilar performances. Implications for farmers selling in markets with e-NAM seem beneficial, as assessed by higher prices, inter-market equity, farmers' preferences and lower price volatility. The study period is recent but rather stable when movements of prices and arrivals are without secular directions despite volatility and seasonality. Tomato, which is more perishable, seemed to gain in the market through e-NAM, with higher prices and the acquisition of inter-market equity through information dissemination, but post-harvest supply pressures require continued redress.

Keywords: e-NAM, market imperfection, ICT, panel data modelling, information

JEL Classification: Q13, D82, O33, C23, D40

1. Introduction

Agriculture remains a critical sector of the Indian economy in which large sections of the working-class population depend on farming for their livelihood. Not only does it retain its prominence in the nation's food security, but the welfare of the producers in the sector has also increasingly grown in importance in the country's political economy and the development process. While farming was once perceived as a way of life, the sector's competitive strength, its equity across sections and regions, and its potential in the international market can hardly be ignored in the contemporary paradigm. Emerging from a highly fragmented and rather inaccessible and backward state, agriculture needed public support that could not be stopped merely with improved inputs to enhance production. Profitability of farming became an important goal, but communication, information, and updated marketing techniques were constraints. When information technology (IT) began to transform economies at large, it offered potent tools for the government to address these weaknesses.

While benefitting immensely from the green revolution (GR) powered by bio-chemical technology, on the economic side, the resulting production abundance was hurting farmers with low prices. Farm production,

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being highly dependent on weather conditions in a tropical monsoonal climate, exhibits seasonality, which tends to be a feature of price movements. Low prices can force producers to exit the business, leading to the failure of critical product markets.

Volatility of prices is a daunting feature. A spurt in supply, more likely at the harvest time, can crash prices, throwing a market into crisis and farmers into distress. Storage is a limited solution, but for perishable products that need to be consumed and processed fresh, it hardly helps. Marketing of agricultural products is, therefore, a challenging function.

With shifting demand in response to the nutritional consciousness of consumers and the rising public cost of grain storage, the government is encouraging the cultivation of horticultural products, which are expected to generate higher incomes in the farm sector and create secondary income by promoting processing. However, the bulk and proneness to spoilage of agro-products remain challenges in horticultural marketing, thereby encouraging farmers to grow cereals rather than fruits and vegetables. At a larger social level, inability to sell while fresh causes product wastage, garbage disposal issues and environmental degradation with implied over-use of resources at the production stage.

Information transfers across regions may enable enlargement of the market. The integration of the market of a product helps more of its supplies to meet its demand and possibly to fetch the best prices all in good time. Closer and swifter linkages among markets and between potential sellers and buyers, therefore, offer ways of increasing farmers' income, mitigating farmers' harvest-time distress, serving the ecology and, more broadly, of making agriculture competitive, equitable and sustainable.

The government has, in the last three decades, invested heavily in roads in regulated agricultural markets (APMC markets), warehousing and cold chains that eased marketing and helped in drawing private investment in processing. Marketing reforms progressed even with political hurdles inevitable in a federal economy. Alternative channels with better methods have evolved (Ghosh, 2013), but the historical APMC markets remain important for the fair and transparent auctions they have been holding since 1928 and the expertise of risk-taking traders (Ghosh, 2013). The auctions make APMC markets especially influential in price discovery in the country. Intuitively, the advent of IT into agriculture can make this role even more valuable.

Following concerns raised after India’s liberalisation over the degradation of agricultural marketing (Ghosh, 2013), the traditional APMC markets were significantly upgraded with computers for recording data and for networking across markets to enable the sharing of price and sale information. Digitisation proposes a federated farmers’ database structure called IDEA (India Digital Environment of Agriculture), which bridges information gaps between the buyer and the seller and the different APMC markets by computerisation. Part of the IDEA, an e-governance portal called AGMARKNET (Agricultural Marketing Information Network), was launched in March 2000 by the Government of India. Enabling web-based flow of daily arrival and price information from wholesale markets nationwide, it helps traders, researchers, government officials and policymakers make informed decisions, but the main goal is to empower farmers with

timely and accurate information and get the best price.

Equity of market power is a hallmark of the notion of perfect competition. Lack of information, known to be a source of market imperfection (Michler, 2020), leads to inequality among farmers. Formation of monopolies, monopsonies, oligopsonies and even failure of many, if not all, businesses in a sector can be other more extreme outcomes that can jeopardise Indian agriculture. Diminishing interest shown by recent generations in taking up farming as an occupation is well discussed (Michler, 2020). While the APMC laws, as evolved from colonial times, were meant to enforce fairness in marketing, success was elusive.

In reality, traders tended to collude and often remained conformists and even outdated in their practices, even as businesses around the world advanced phenomenally. Corruption added to the problem. Producers had limited access to the larger market, even within the country and remained uninformed of the potential markets. IT can play a major role in retaining and promoting agriculture as a viable and sustainable business (Kaipia et al. 2013, Jedermann et al. 2014, Bohtan et al. 2017). Further, the data generated in real time, as well as historical data, helps in forecasting, planning and reviewing commodity chain activities (Tanksale Patidar et al., 2021). IT began to evolve through the 1980s and 1990s, transforming and integrating the world. IT began to evolve through the 1980s and 1990s, transforming and integrating the world. India's commercial economy embraced IT seriously with the advent of broadband in the early 2000s, but its entry into the farm sector was delayed beyond 2010 and realised only with hand-holding and deliberate support of the government. Public policy began to strengthen the APMC markets with IT. Drawing on public investment, computerisation and the internet not only made APMC markets more informed, but the same intelligence spilling over to other channels created an informed environment. Proposal of a data-stack is under implementation to make technology-enabled easy access to digital and federated agricultural data possible for the benefit of stakeholders and facilitation of various agriculture-related schemes.

In a further innovation from 2016, APMC markets began to be equipped with an online trading platform called e-NAM (electronic National Agriculture Market), which not only shares data among markets but also provides an option for electronic auctioning as opposed to the open and vocal bids practised for price discovery in the rest of the market. Following a successful demonstration in Karnataka, the e-NAM made the data recorded much more factual, real-time and meaningful. Operating as a sub-market in many APMC markets and utilising and taking a share of their space, facilities and even the services of its traders, the e-NAM, by its own demands, is richer in computers.

2. Objective, Data, and Methods

Embodying computerisation at a higher level with accessories, software, networking, maintenance and human resources, e-NAM would add to the enrichment of the larger APMC market that embeds it. Although the intention is to create a national market for any farm product, e-NAM is still nascent; even where installed, the work is still in progress, and has not reached all the APMC markets. At this stage of evolution, although APMC markets are all computerised by now, the incomplete reach of e-NAM could help differentiate the markets by their levels of computerisation and extract the effect of IT. This paper examines whether progress

in IT is showing signs of equalising the APMC markets towards forming a 'one' price ideal for a single product, and if it is helping in mitigating the hardships and uncertainties faced by producers in marketing.

The study, conducted at a time shortly after e-NAM was launched, is based on secondary data collected by the Government of India. It focuses on two dominant horticultural commodities in the Indian diet: (i) tomato in Uttar Pradesh (UP) and (ii) onion in Maharashtra (MH). The choice of the two crops is based on the contrast between the highly perishable nature of the tomato and the relative stability of the onion. Purchased fresh both for direct consumption and processing, the tomato suffers from a short window of harvest and post-harvest period for marketing, while the onion, being relatively more resilient to humidity and heat, lasts longer. Both onion and tomato are multi-season crops. Tomatoes are grown across the country, UP being only one among the growing states. MH, on the other hand, is a major grower of onions, and even within MH, cultivation is concentrated heavily in districts Nasik (12%), Ahmednagar, and Pune.

Samples of APMC markets were selected randomly from across each state, UP and MH, ensuring that the data is available without gaps and about half of the sample markets in each crop-state case have e-NAM. From each market, a time series of monthly data was compiled for the period January 2018 to December 2024, constituting a total of 84 observations. The methodology consists of graphical illustrations and tables to note price movements, marketing preferences, seasonality and inter-market differences in a comparative perspective between two groups of markets: those with e-NAM and those without e-NAM. Taken from the AGMARKNET source, price is measured in value per unit weight (Rs/Quintal) obtained by the seller in the APMC market and 'Arrivals' are expressed in quantity (quintal) units in a market where 100 KG comprises a quintal. Price movement is considered in perspective by comparison with a benchmark of inflation represented by the price index of High-speed Diesel (HSD) from the Office of the Economic Adviser (Website).

Although crop calendars vary within a state, intuitively, both Price and Arrivals can also be subject to seasonality expressed by monthly movements. Decided in open auctions, prices vary from day to day. To avoid bias due to outlying price spikes and missing data (the market is even closed on some days), the modal price is considered the monthly average, but the annual average price is the arithmetic mean of the computed monthly prices. Coefficients of variation (CV) of price are calculated across the sample markets. Prices tend to go down after harvest and shoot up when the crop is in the field. Period of low price (LOW), presumably representing harvest months in the market catchment, and high price (HIGH) are the averages, respectively, of the three lowest and highest annual prices. HIGH and LOW prices are identified using not only numerical assessment but also regression on dummies for months with July as the base, corrected for years.

3. Results

A total of 24 APMC markets are selected for the study of onion in Maharashtra. For tomato in Uttar Pradesh, 20 markets are under study. In both cases, half of the sample markets have e-NAM embedded. Besides rotting easily, a tomato is less dense than the bulky onion. The average price is found to be lower in the markets without e-NAM than in markets with

e-NAM (Table 1). The average Arrivals per market are also more in the markets with e-NAM by over 14 thousand Quintals in the case of onion and by a narrower margin over 1 thousand quintals in the case of tomato. The price advantage could be reflecting efficiency due to access to a larger market enabled by computerisation. Higher arrivals, however, could be reflective of farmers' preferences as well as possibly an intended selectivity of larger markets for setting up e-NAM. Table A1 lists the markets under study, identified as both markets with e-NAM and markets without e-NAM.

Table 1: Sample Market: Number, Average Prices and Average Arrivals in the Sample Period

Markets	Onion			Tomato		
	Number	Price	Arrivals	Number	Price	Arrivals
With e-NAM	12	1715.5	23206.1	10	1704.63	1326.34
Without e-NAM	12	1655.08	8707.19	10	1669.8	185.93
Total	24	1685	15956.7	20	1687.21	761.3

Note: Prices are in ₹/Quintal, and Arrivals are in Quintals/Month in a market. 1 quintal = 100 kg.
*** are prices of onion and tomato per Q so similar? Rs 17/Kg?*****

3.1 Arrivals in Market and Inter-Market Variability

Through the sample period, a mildly increasing trend of the Arrivals in an average market is evident for both crops (Figure 1(a)). For onions, arrivals have grown faster than for tomatoes. Despite volatility, specific seasonality was not marked except that Arrivals tended to rise in the first part of the year. Movements of arrivals are not synchronous between the crops; a sharp peak was noted for onion in March 2023. In July 2023, arrivals of tomato plummeted, even when for onion they peaked. Onion arrivals were more variable than those of tomato, suggesting greater freedom of market disposal, which is not surprising given that onions can be held back longer before sale than tomatoes. Across markets, the CV of arrivals of each crop itself was rather volatile at the beginning of the sample period but stabilised over time, and inter-market price variation was more for tomato than onion (Figure 1(b)).

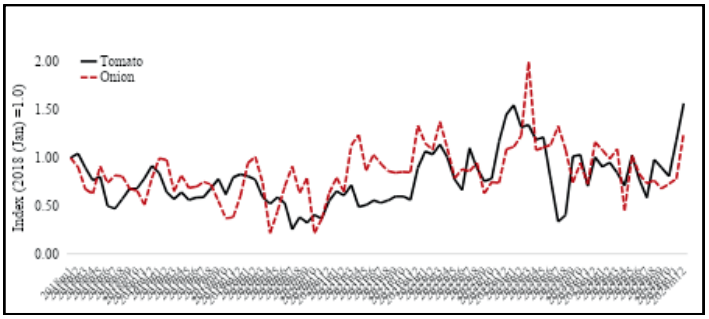


Figure 1 (a): Indices of Arrivals for Markets

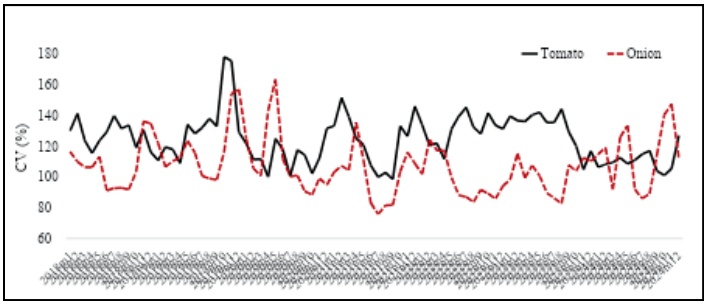


Figure 1 (b): Coefficient of Variation (CV) in Arrivals across the Markets

3.2 Price Movements and Inter-Market Variability

The nominal prices averaged across all sample markets do not show any trend and have not moved with HSD prices that are associated with inflation (Figure 2(a)). Volatility is present in both prices, with a sharp spike observed in the tomato price in July 2023 and in the onion price in October 2019. Tomato prices tend to experience peaks in monsoon months, July and August and onions in the post-monsoon month of November. While any effect of a rise in diesel price is more likely

to hit the consumer than the producer, the price movements relative to January 2018, the start of the sample period, indicate low returns in terms of real prices. Low prices, arguably linked with harvest season, seem to occur in the first few months of the year for both crops.

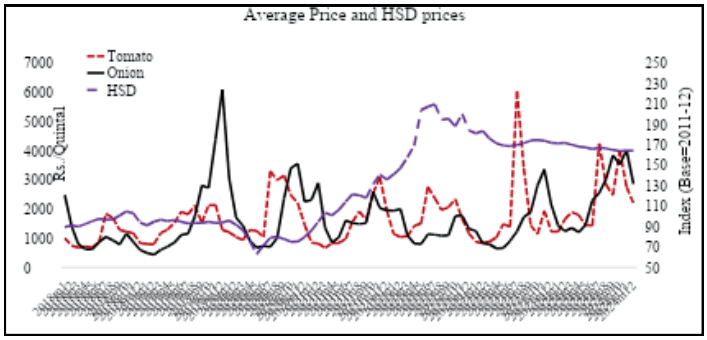


Figure 2 (a): Average monthly market Prices and HSD price index during the sample period

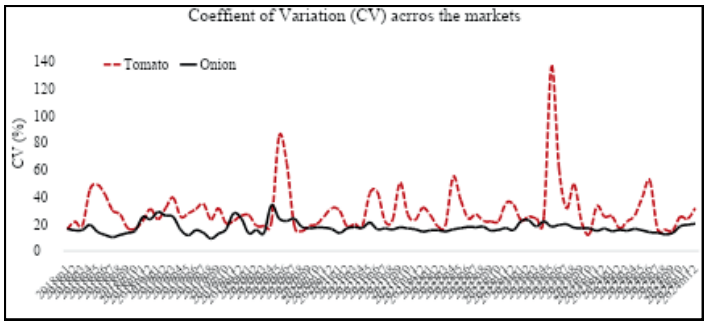


Figure 2 (b): Inter-Market Variation (CV %) of average monthly prices in the sample period

Inter-temporal variability was noted in price movements of both crops (Figure 1(a)), but inter-market price variability holds a different narrative. The graph of CV for onion prices across all sample markets (Figure 2(b)) seems to be decidedly flat compared to that of tomato, even setting aside the outlying spikes. For onions, prices registered are largely uniform across markets and any heterogeneity, if present, has been wiped out over time. Tomato prices have not shown this tendency.

While theoretically perfect competition is associated with uniform prices that make the sellers price takers, in actual practice, the notion rarely meets reality, but performances of food markets are perceived as close to the idea as possible. Comparison to the theoretical ideal and assessment of observed deviations are said to be useful for identifying weaknesses in marketing procedures. For India's agricultural markets, it may be important to mark the deviations for the purpose of addressing inequality among farmers in the catchments of different markets. Admittedly, the idealisation of perfect competition has been critiqued on grounds of inefficiency allowed by the concept (Harvard**).

3.3 Comparison Between Markets with and without e-NAM

Arrivals of onions in a sample APMC market were declining through the period 2018 to 2020, and this was due to a sharp fall in the markets with e-NAM. Onion arrivals in markets with e-NAM picked up pace in 2020-21, even as those in other markets continued growing, but arrivals in both cases slowed down in 2021-22 and again gained momentum in 2022-23. In the last sample year, arrivals in both groups of markets declined, more sharply in markets with e-NAM. Arrivals of tomato behaved likewise. They fell especially in the e-NAM endowed markets up to 2020, picked up pace from 2020 up to 2022 and then declined. In contrast, arrivals in markets without e-NAM largely remained stagnant but grew from 2022, in contrast to markets with e-NAM (Figure 3 (a) and (b)). While arrivals behaved in different ways between the two sets of markets, the e-NAM endowment was more influential on average movements of arrivals.

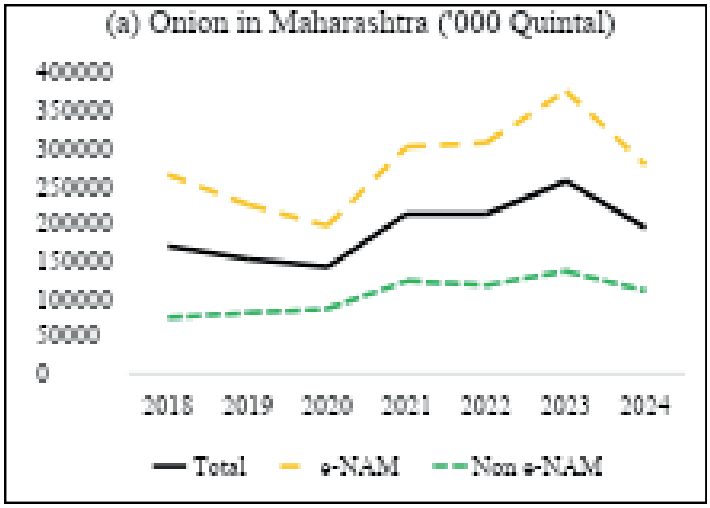


Figure 3 (a): Average Per Market Arrivals for Onion in Maharashtra (Quintal)

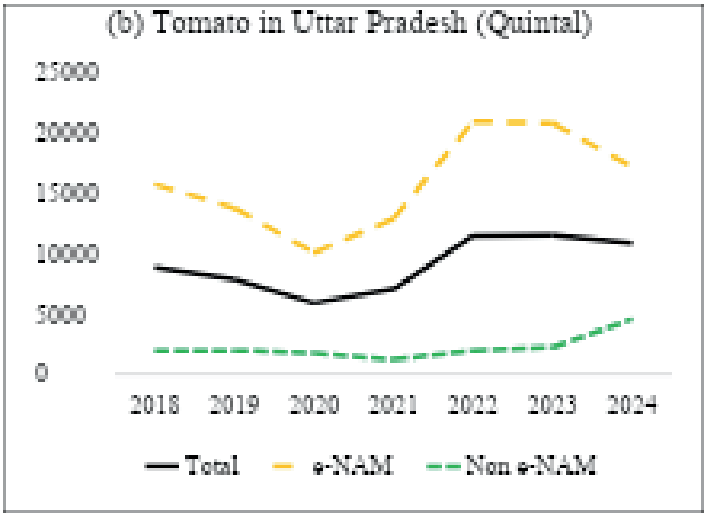


Figure 3 (b): Average Per Market Arrivals for Tomato in Uttar Pradesh(Quintal)

Unlike arrivals, APMC markets differing in their levels of computerisation show largely similar price movements in both cases, indicating information dissemination without bias for or against e-NAM. Prices in markets with e-NAM tend to be higher, more visibly for tomato than for onion (Figures 4 (a) and (b)). While computerisation could be a factor, the differences or lack of them could be accounted for by other reasonable factors. Both markets show volatility and seasonality of prices, and the spikes are sharper in tomato prices.

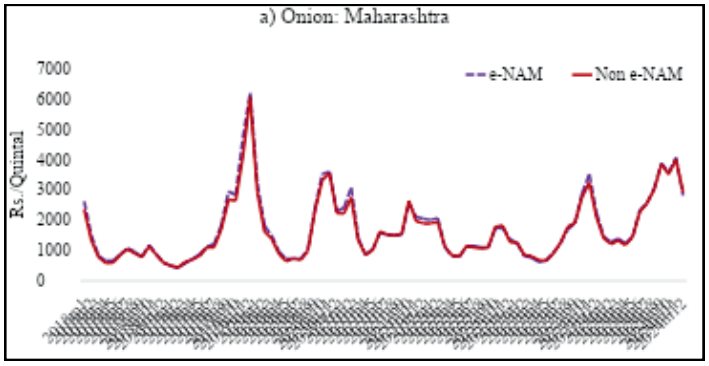


Figure 4(a): Crop-wise onion prices in markets with e-NAM and without e-NAM

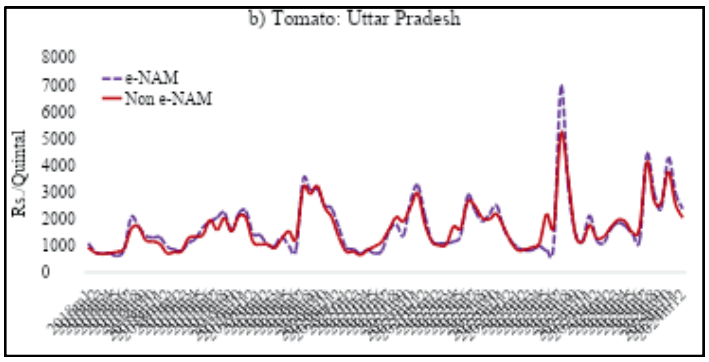
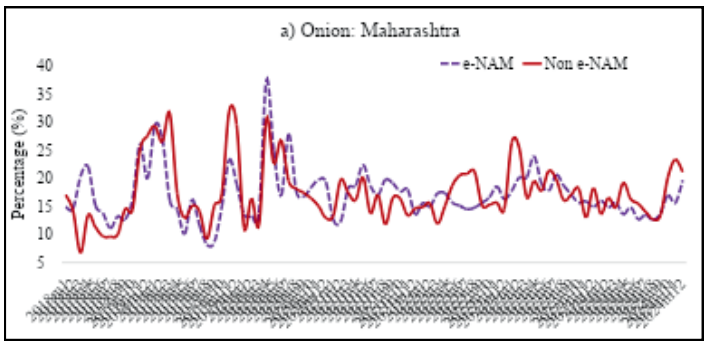


Figure 4(b): Crop-wise tomato prices in markets with e-NAM and without e-NAM

Uniformity of prices among markets (with or without e-NAM) is consistent with inter-market price variability that was observed in Figure 1(b). Variability of prices among different e-NAM possessing markets is, however, relatively strong compared to the other set of markets for onion, but prices are much more uniform across markets with e-NAM than without e-NAM in the case of tomato (Figure 4(a) and (b)). The inter-market CV of price had been observed to be low and flat for onion, and even to that low level of variation, the markets with e-NAM may have contributed significantly, but for tomato, the large inter-market differentials were more due to markets without e-NAM than markets with e-NAM. Although the price behaviours noted through graphs leave much to be explained, it is clear that the two types of markets vary in prices and their variabilities.



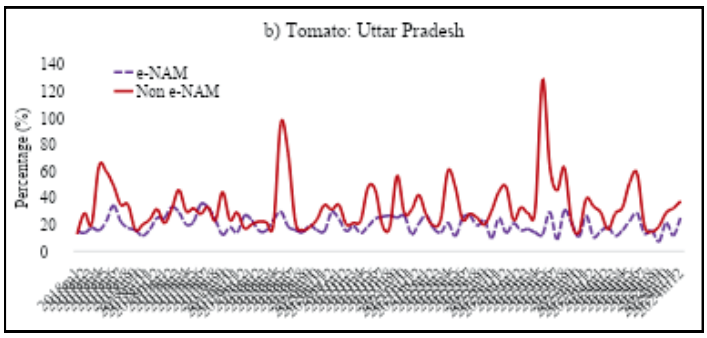


Figure 5(a) and 5(b): Inter-Market Variation (CV %) of Monthly Prices: A Comparison

3.4 Seasonality of Market Arrivals

The analysis so far suggests that the onion prices peak at the end of the year and that of tomato in mid-year. A more rigorous process to identify the patterns would be to regress the prices on dummy variables for months, correcting for years to account for possible trends and larger exogenous shock impacts. Based on an equation estimated from data pooled over 12 months in the sample years and the total number of sample markets using a fixed effect panel data method (Equation A2), three months are identified for the highest prices and three for the lowest prices for each crop. The averages of the prices in each set of three months so identified are classified as HIGH and LOW (Table 2). As with price observations, post-monsoon months are identified in the HIGH category for onion and monsoon months for tomato (Table 2).

It is expected that the LOW price arises due to higher arrivals following a negative price effect of supply and leads to farmers' distress. Implicit is the constraint coming from a rigid demand. On the other hand, the theory of supply suggests a discouraging effect of low prices, which would imply that supplies would increase if prices were higher. Since the production process is already complete, the reality would depend on the ability of farmers to hold on to inventory that might also require better and even technologically refined storage facilities, as well as whether the farmers are enabled. Inverse relations between arrivals representing supplies and prices seen in the scatter diagrams (Figure 6) highlight the importance of demand.

Table 2: Seasonal Pattern of High and Low Prices for Selected Vegetable Crops

Crops	High Price Months (HIGH)	Low Price Months (LOW)
Onion	October, November, December	March, April, May
Tomato	July, August, October	January, February, March

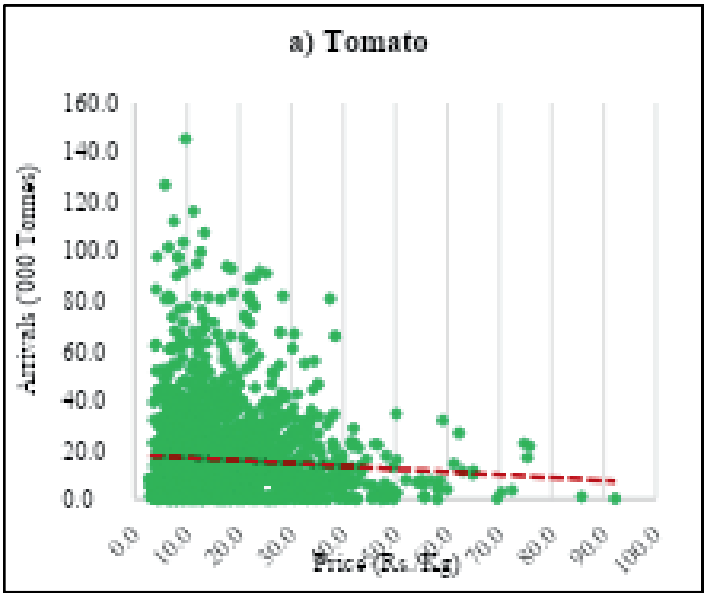


Figure 6(a): Scatter for Tomato Arrivals and Prices

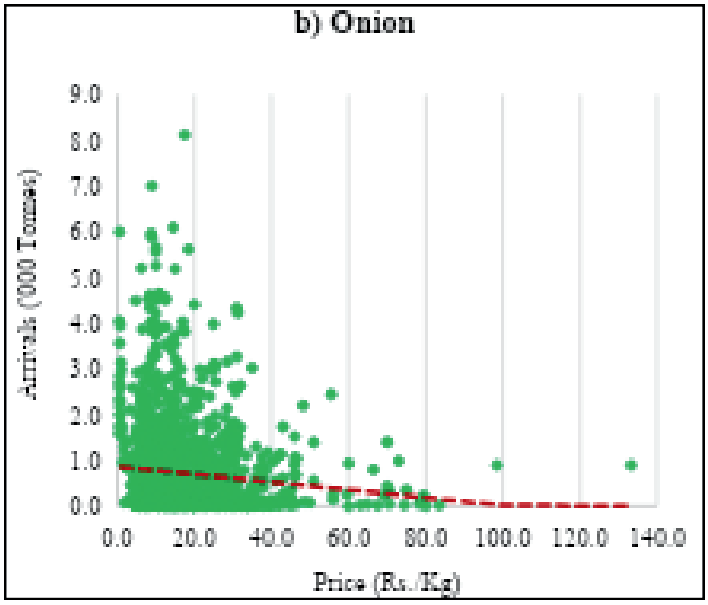


Figure 6(b): Scatter for Onion Arrivals and Prices

Except in the years 2021 and 2024, onion arrivals are higher in the LOW price period than in HIGH price periods, also reflecting demand constraint, causing supply pressure. The difference is about 6% on average, but went up above 50% in two of the sample years. The supply pressure would be higher without e-NAM.

Arrivals of onions are consistently relatively more in the LOW price period in the APMC markets without e-NAM, where the average difference was 70%, differences in most years exceed 70% and even 80% in 2020. In the markets with e-NAM, arrivals were more in the LOW price period than in the HIGH price period to start with, but supply pressure eased so that farmers actually sold more in HIGH price periods subsequently. In the case of tomato, arrivals in the LOW price period were greater than in the HIGH price period in both markets, barring one year each, and the average difference was 40%. Markets with e-NAM did not show any less supply pressure.

Table 3(a): Seasonal Variation in Average Onion Arrivals in Markets with and without e-NAM in Maharashtra

Year	Markets with e-NAM			Markets without e-NAM			All Markets		
Price	LOW	HIGH	% Difference	LOW	HIGH	% Difference	LOW	HIGH	% Difference
2018	20.2	20.2	0.1	7.2	4.1	76.9	13.7	12.1	13.0
2019	18.2	14.1	29.0	8.6	2.8	211.3	13.4	8.4	58.9
2020	11.0	11.6	-5.3	6.3	3.5	82.7	8.7	7.5	15.0
2021	26.0	28.9	-9.9	14.2	8. 9	59.8	8.7	18.9	-54.2
2022	21.1	23.2	-9.0	12.5	8.9	40.5	20.1	17.6	14.0
2023	28.1	26.7	5.2	15.0	8.6	74.5	20.3	13.4	51.4
2024	19.8	27.4	-27.6	12.1	7.1	71.5	16.0	17.2	-7.2
Average	20.6	21.7	-5.0	10.9	6.2	73.6	14.40	13.6	5.80

Note: Arrivals are in '000 Quintals (100 kg)

Table 3(b): Seasonal Variation in Tomato Average Arrivals in Markets with and without e-NAM in Uttar Pradesh

Year	Markets with e-NAM			Markets without e-NAM			All Markets		
Price	LOW	HIGH	% Difference	LOW	HIGH	% Difference	LOW	HIGH	% Difference
2018	1.7	1.0	66.4	0.2	0.1	38.3	0.9	0.6	63.4
2019	1.1	1.15	-2.3	0.2	0.1	44.8	0.7	0.6	2.7
2020	1.2	0.6	107.4	0.2	0.1	139. 7	0.70	0.3	111.8
2021	1.2	1.0	21.7	0.1	0.1	-33.6	0.6	0.5	15.3
2022	1.9	1.6	15.7	0.2	0.1	82.1	1.0	0.9	22.3
2023	2.5	1.2	105.3	0.2	0.1	69.9	1.4	0. 7	101.5
2024	1.4	1.2	16.4	0.3	0.4	-10.3	0.9	0.8	10.1
Average	1.6	1.1	41.3	0.2	0.2	31.7	0. 9	0.6	40.5

Note: Arrivals are in '000 Quintals (100 kg)

4. Conclusion

Increasing development of the electronic market (e-NAM) in the APMC markets is a component of progress in computerisation in agricultural marketing. A comparison of APMC markets with and without e-NAM found similarities as well as dissimilarities between onion and tomato. Both crops are horticultural, but onion is much more resilient to weather, while tomato perishes fast, creating pressure for marketing within the short harvest window. Monthly arrivals in an average market show mild trends with volatility, but inter-market variations of arrivals are greater for tomato.

The average price is found to be lower in the markets without e-NAM than in markets with e-NAM,

indicating that farmers have been able to fetch higher prices with computerisation. There is no bias in price movements for or against e-NAM. While the price advantage probably reflects the efficiency conferred by access to a larger market, other inherent and locational causal factors cannot be ruled out. Arrivals behaved in different ways between the two sets of markets, but larger arrivals in markets with e-NAM are a sign of farmers' rational preferences.

Comparative arrivals are higher in a market with e-NAM, particularly in the case of onions. Arrivals hold a negative relation with prices, suggesting the demand constraint and supply pressure in the marketing season, but for onion, the supply pressure is relatively relaxed in a market without e-NAM, while tomato arrivals rise consistently in periods of low price in markets with and without e-NAM. Both sets of markets show volatility and seasonality of prices, the spikes being sharper and the inter-market variability being considerably more in tomato prices. Onion prices are equally variable, if not more, across different e-NAM possessing markets compared to other markets, while tomato prices are highly uniform across markets with e-NAM but remarkably variable across those without.

Appendix

Table A1: Sample Markets

CROP	Markets	District	Market Type	CROP	Markets	District	Market Type
Onion	Nandgaon	Nashik	With e-NAM	Tomato	Bareilly	Bareilly	With e-NAM
Onion	Rahuri	Ahmednagar	With e-NAM	Tomato	Khalilabad	Sant Kabir Nagar	With e-NAM
Onion	Solapur	Solapur	With e-NAM	Tomato	Jaunpur	Jaunpur	With e-NAM
Onion	Yeola	Nashik	With e-NAM	Tomato	Aligarh	Aligarh	With e-NAM
Onion	Newasa	Ahmednagar	With e-NAM	Tomato	Kanpur	Kanpur	With e-NAM
Onion	Lasalgaon	Nashik	With e-NAM	Tomato	Meerat	Meerat	With e-NAM
Onion	Ahmednagar	Ahmednagar	With e-NAM	Tomato	Gaziabad	Ghaziabad	With e-NAM
Onion	Pune	Pune	With e-NAM	Tomato	Lucknow	Lucknow	With e-NAM
Onion	Chandvad	Nashik	With e-NAM	Tomato	Azamgarh	Azamgarh	With e-NAM
Onion	Satana	Nashik	With e-NAM	Tomato	Gorakhpur	Gorakhpur	With e-NAM
Onion	Vashi	Thane	With e-NAM	Tomato	Muradnagar	Ghaziabad	without e-NAM
Onion	Nagpur	Nagpur	With e-NAM	Tomato	Gazipur	Ghazipur	without e-NAM
Onion	Pimpalgaon	Nashik	without e-NAM	Tomato	Rudauli	Barabanki	without e-NAM
Onion	Manmad	Nashik	without e-NAM	Tomato	Chorichora	Gorakhpur	without e-NAM
Onion	Kalvan	Nashik	without e-NAM	Tomato	Sikandarabad	Bulandshahar	without e-NAM
Onion	Kopargaon	Ahmednagar	without e-NAM	Tomato	Jasra	Prayagraj	without e-NAM
Onion	Niphad	Nashik	without e-NAM	Tomato	Pukharayan	Kanpur Dehat	without e-NAM
Onion	Parner	Ahmednagar	without e-NAM	Tomato	Moth	Jhansi	without e-NAM
Onion	Shevgaon	Ahmednagar	without e-NAM	Tomato	Bijnaur	Bijnor	without e-NAM
Onion	Akole	Ahmednagar	without e-NAM	Tomato	Mehmoodabad	Sitapur	without e-NAM
Onion	Pathardi	Ahmednagar	without e-NAM				
Onion	Amrawati	Amravati	without e-NAM				
Onion	Jamkhed	Ahmednagar	without e-NAM				
Onion	Satara	Satara	without e-NAM				
Tomato	Moth	Jhansi	Non e-NAM				
Tomato	Bijnaur	Bijnor	Non e-NAM				
Tomato	Mehmoodabad	Sitapur	Non e-NAM				

Table A2: Regressions of Price on Month dummies with year effects

Variables	Tomato	Onion
Seasonality	Coeff.	Coeff.
January	-2012.89*** (-21.11)	517.44*** (6.10)
February	-2039.09*** (-21.39)	170.10** (2.00)
March	-1982.89*** (-20.79)	-272.62*** (-3.21)
April	-1832.42*** (-19.22)	-509.93*** (-6.01)
May	-1777.62*** (-18.65)	-463.35*** (-5.46)
June	-1547.07*** (-16.23)	-98.50 (-1.16)
July	*Base*	
August	-608.52*** (-6.38)	240.06*** (2.83)
September	-1083.67*** (-11.37)	711.87*** (8.39)
October	-762.38*** (-7.99)	1,235.91*** (14.56)
November	-887.06*** (-9.31)	1,525.08*** (17.96)
December	-1579.79*** (-16.57)	1,131.71*** (13.33)
Year Trend		
2018	*Base Year*	
2019	483.07*** (6.63)	911.72*** (14.06)
2020	800.13*** (10.98)	803.21*** (12.39)
2021	411.52*** (5.65)	747.74*** (11.53)
2022	646.38*** (8.88)	314.81*** (4.86)
2023	745.54*** (10.24)	507.22*** (7.82)
2024	1269.02*** (17.43)	1,385.21*** (21.36)
Constant	2407.76*** (2.80)	669.21*** (8.19)
Observations	1680	2,016
Number of Markets	20	24

Note: Parenthesis figures are t-statistics. Level of significance at *** is 1%, ** at 5%, and * at 10%.

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How Economics Become Two Distinct Disciplines

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ABSTRACT

Economists commonly attribute the origins of economics to the publication of Adam Smith's (1776) *Inquiry into the Nature and Causes of the Wealth of Nations.* Following Smith were such noted economists as David Ricardo, J.B. Say, and John Stuart Mill, who together established a Classical School of economic Scholarship. Those economists were united in holding a labour theory of value where the prices of goods offered for sale on markets varied with the amount of labour thought to have been employed in producing them. This theory doubtlessly had superficial plausibility considering the technologies employed in the 18th century. That superficial plausibility might account for the ability of the labour theory to hold the attention of economists at that time, but that hold vanished quickly after 1870 with the appearance of a marginal utility theory of economic value. That quickness surely indicates that the allegiance of economists to the labour value theory was weak. While most historians of economics treat economics as having improved between the 18th and 19th centuries with the replacement of the labour value theory by the marginal utility theory, I don't, because I think many economic phenomena have a highly complex character that cannot be reasonably reduced to the analytical simplicity that accompanies the marginal utility theory of value. There are many significant topics that knowledge of economics can illuminate for which value theory is irrelevant. My thesis is that students of economics today are doubly blessed because their studies equip them to deal with problems associated with two distinct fields of human endeavour: (1) problems that arise in administering resources that lie within their domains of personal responsibility, which is the domain of the marginal utility theory; (2) problems that arise through conflicts among those humans who live in proximity with one another, which generates situations calling for the skillful application of knowledge to promote common flourishing in the presence of internal conflict.

Keywords: classical economics, labour theory, marginal utility theory

JEL Classification: B12, B13, B31, D11

1. Introduction

The principle of economising action is universally useful as offering a framework for thinking about economic phenomena, and it lies at the core of two distinct analytical disciplines: resource administration and society itself as an analytical object. The principle of economising action itself entails the proposition that humans, like all mammals, act to improve their circumstances as they perceive and understand them. While the labour theory of value was logically incoherent and rightfully replaced by the marginal utility theory, society retained importance as an analytical object because societies are the objects within which people live. Society, moreover, is not capable of being properly analysed by using the

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marginal utility theory. Why not, a reader might reasonably wonder? After all, there is truly no one who lives outside some society. All the same, societies are not action-taking entities, as the eminent Sociologist James Coleman (1990) explained in his treatise The *Foundations of Sociology.* While marginal utility pertains to conduct by individual humans, society pertains to collections of individuals as ecologies of multiple interacting humans. At this point, we must make contact with some points of social ontology. The attributes we give to the objects in our theories must possess qualities we know they have and not qualities we assign them for our theoretical convenience. Understanding patterns of interaction among sometimes conflicting humans is a distinctly different intellectual challenge from explaining the challenges and choices made by a single mind, as I elaborate in my book from 2010, *Mind, Society, and Human Action: Time and Knowledge in a Theory of Social Economy,* published by Routledge. Both situations pose intellectual challenges, and economising action lies at the core of both disciplines; however, rationality in resource administration and effective living together among differing people comprise distinctly different kinds of problems for different analytical disciplines. All approaches to the humane studies must rest on recognition that all humans, and probably all the mammals studied by ethologists, pursue economising action. But at least two types of theory are required for this theoretical pursuit: (1) the effective use of resources in human conduct and (2) the formation of organised patterns and structures of relationships among the relevant set of humans who interact within a relevant society. The studies that students of economics undertake equip them to pursue their studies in two distinct directions: one which emphasises individual problems of resource administration, which is the domain of neo-classical economics; and the other which equips them to pursue the challenges people face in living together in close geographical proximity, which was of primary interest for the Classical economists starting with the Scottish Enlightenment.

2. Research Methodology: Analytic Narratives

In addressing my claim about the bivalent character of economic analysis, a suitable methodology is that of analytical narrative, a splendid presentation of which is the book *Analytic Narratives*, compiled by Robert H. Bates, Avner Grief, Margaret Levi, Jean-Laurent Rosenthal, and Barry R. Weingast, and published by Princeton University Press in 1999. This book was published at a time when the methodology of economic research had evolved into a stylised pattern of economic research, which began with the formalisation of an abstract, mathematical model, where a formal model was followed by econometric evidence purporting to verify the prime claim of the formal model. *Analytic Narratives* starts with an introductory chapter written by all five authors, which sketches the case for analytical narratives as serving as a suitable methodology for working with the complexity of the phenomena with which economists must work. After the introductory essay, the book continues with free-standing essays by each of the five authors, where each of those authors illustrates how the methodology of analytical narratives can yield valid scientific knowledge despite the social environment of the time, where it was widely presumed that scientific validity required a mathematical model accompanied by econometrics that support the model.

Even more, the eminent philosopher of science, Karl Popper, in three well-cited works, starting with *The Poverty of Historicism,* (1957), continuing with *The Logic of Scientific Discovery* (1959), and ending with *Conjectures and Refutations* (1962), explained in great detail the illogicality of what had become the orthodoxy of economic research by the late 20th century when *Analytic Narratives* was compiled. Throughout this body of work, Popper explains that the scientific method is better equipped to falsify claims (to deny that something is a cause of something) than to verify claims (to assert that something is a cause of something else). The fundamental point of Popper's approach to science is that the logic of scientific inquiry cannot be used to demonstrate that a particular pattern of evidence demonstrates the truth of a scientific proposition. That pattern of evidence may be labelled a scientific proposition by the proposer, but it is not truly a scientific proposition because it exceeds the limits of scientific knowledge. The logic of scientific inquiry is limited to demonstrating that some patterns of evidence cannot be the cause behind the observed evidence, but cannot demonstrate conclusively that one particular pattern must be the cause.

This methodological point is relatively abstract, so some further discussion may help in digesting what is necessarily an abstract theme. In 1950, the eminent statistician Jerzy Neyman's *First Course in Probability and Statistics* featured an extensive treatment of "the problem of the lady tasting tea." This problem featured a lady who claimed she could distinguish between a cup of tea brewed by placing the milk first in the cup and then adding the milk or by placing the tea first in the cup and then adding the milk. Neyman approached the statistical problem from the orientation of a disinterested judge selected to adjudicate the lady's claim. Note that theorists of public finance continually address similar types of claims in discussing whether publicly-supplied goods are under- or over-supplied. Paul A. Samuelson (1954, 1955) authored the canonical statement of the undersupply of public goods through free-market arrangements. To the contrary, James M. Buchanan (1968) probed the illogicality of market failure arguments because any claim that a situation is one of market failure is simultaneously a situation wherein the participants in that situation are knowingly failing to exploit all the gains from trade that currently exist among them. This situation is deeply illogical in a manner that calls for resolution through probing into how those people might be able to develop institutional and organisational arrangements that would enable them to exploit those gains from trade. By doing so, those claims of market failure would evaporate.

Claims ladies might make about their abilities to distinguish among different ways of making tea are different from claims about the under- or over-provision of public goods because of the different subject matters and the settings for human action that are involved. All the same, there is much that renders the two settings comparable. In both cases, there is an objective claim that may or may not be met. The lady may or may not be able to tell how the tea is made. The volume of public goods supplied may or may not equalise marginal benefits and marginal costs across citizens. In either case, there is no unambiguous method to reach a conclusion. With respect to the lady tasting tea, Neyman placed the problem in a judicial context. But that wasn't conclusive. Experiments would be involved in any case, but those experiments could proceed in any number of ways. The lady could be

given pairs of cups and asked to decide how the teas were brewed. Alternatively, she could be given single cups and asked to classify them, and her classification would be judged after having taken several tastes.

Then there is the problem of standards of judgment. Omniscience is neither possible nor reasonable for humans. Humans will make mistakes, and mistakes should not necessarily bring an end to their hopes and dreams. The judicial standard of evaluation of evidence pertaining to the lady's claim should not be perfection, but rather should be a serious and exacting standard, all the same. Complicating matters for this simple situation is recognition that there are numerous forms of experiment that can be used to compile data, along with there being numerous explicitly judicial standards summarised by the two types of error familiar to students of statistics. In short, judgment and politics will unavoidably be present, no matter how strongly economists might labour to abolish the need for judgment by overwhelming the situation through analytical technique. One judge might conclude the lady can tell how the tea is brewed, whereas another judge might conclude she can't, when all that differs is the standard against which the judge reads the evidence.

3. Discussion: Neither Classical nor Neoclassical Because Both Are Useful

The 1870s were a decade when the marginal utility theory took large steps in replacing the labour value theory. While value theories are an important part of economics, there is more to economics than value theory. For modern depictions of the history of economics, textbooks on the history of economics typically portray several schools but mostly stress the cleavage between the Classical and Neo-Classical schools, with the distinction turning on the different value theories. An old and familiar aphorism is "winners write history." Histories after Joseph Schumpeter's (1954) treatise are written mostly by authors who cheer the ascendance of the neo-classical over the classical style. That ascendance is typically ascribed to price and value theories. Surely, one notable feature that would confront any reader who chose to read a significant sample from the classical and neo-classical literature is the wider breadth of the classical literature when judged against the narrowness of the neo-classical literature. To some degree, it can be reasonably noted that the neo-classical urge to be scientific limits allowable modes of expression relatively to the Classical mode, giving the classical writings an impression of having broad coverage as offsetting a lack of depth. But this comparison with respect to breadth and depth entails more than anything, such as counting equations, as I shall explore momentarily.

The coming of the marginal utility theory hastened the demise of the Classical orientation toward political economy, with that demise having some notable drawbacks because of the work economists did after 1870 in bending their formulations to fit the marginal utility theory. For instance, significant controversy arose during the formation of the marginal productivity theory of factor pricing. One prominent claim during that period was that within a fully and freely competitive market system, all productive inputs would receive the marginal values of their contributions to production. Further controversy arose over whether pricing inputs according to marginal productivity would

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enable sufficient payment to compensate all inputs employed in production. It's possible to imagine any of several possible situations. In one situation, which would be free of controversy, all inputs would receive the values of their marginal products, and the total product available for distribution would exactly equal the amount of total production. In other conditions, controversy and social conflict would otherwise remain. One possibility is that total output won't be sufficient to pay everyone the value of their marginal product. Another possibility is that total output is more than what is required to pay everyone the values of their marginal products, suggesting that quarrels will erupt within society to capture some of the surplus beyond compensation based on marginal productivity.

At this point, the controversy turned to the Swiss mathematician Leonhard Euler's work on homogeneous functions. It was Euler whose work with linear and homogeneous functions rendered it possible to show that with linear and homogeneous functions, total output would be distributed among inputs exactly according to marginal products. From this point of analytical departure, the sponsors of the marginal utility theory were able to conclude that the distribution of output by marginal productivity would exactly exhaust the amount of product that had been produced. This resolution over the marginal productivity theory doesn't truly validate the neo-classical theory that was then taking shape, as opposed to contributing to the consolidation of the hold of the marginal utility theory of value on the affections of economists.

While the textbooks henceforth presented the neo-classical theory of pricing and distribution as THE theory of economics, relegating the Classical Theory to a point of historical reference, we should also remember that analysis within the neo-classical framework proceeded more narrowly than it had proceeded under the Classical framework. Questions that were once posed during the Classical period would not have been posed during the Neoclassical period. Even more, problems that would have come to a theorist's mind during the Classical period would never even have sprung into an economist's mind during the neo-classical period. It takes no significant stretch of the imagination to recognise that someone working within a revitalised Classical orientation toward economic phenomena would find different problems and phenomena calling for analytical attention.

4. The Neo-classical Orientation

With the advent of the neo-classical period, the paradox of diamonds and water was often used to express the difference between the two forms of economic theory. According to the labour theory, value depended on the amount of labour embedded in bringing a product to market. While intuitive judgments often supported the labour theory, thoughtful analysis supported the marginal utility theory through invoking the diamond-water paradox. In most places, water was plentiful, and people could use all they wanted. By contrast, diamonds were scarce and only a few people were able to display them on themselves or their clothing. When sold, water brought low prices while diamonds fetched high prices. With all the water people had available, a little more, or a marginal unit of water, would fetch but a low price. In contrast, one more diamond of average size and quality would still fetch a sizeable price. The neo-classical founders recognised that value was

determined by the value people placed on the last or marginal unit. With this new articulation of value, neo-classical economics began to replace the Classical labour theory of value.

As the neo-classical orientation gained adherents and momentum after 1871, it also accumulated a repertoire of models and formulations, with each deepening and enriching the neo-classical tradition. Eventually, neo-classical economics became a rich menu of models and analytical styles. In its early years, neo-classical economics was portrayed as forming an endless series of constrained maximisations. This analytical framework divides reality between a chooser and a reality that contains the objects over which a chooser optimises with respect to some objective function. This analytical framework supports a rich ecology of economically analytical activities where people are using models and data to make better choices on behalf of organisations they represent.

To be sure, a society or nation is an *ecology* of active individuals. It is a category mistake of monumental proportions to reduce an entire nation or society to some single chooser who seeks to optimise some objective function, as I explain in *Macroeconomics as Systems Theory: Transcending the Micro-Macro Dichotomy* (New York: Palgrave-Macmillan, 2020). Economists sometimes make category mistakes by assigning to analytical objects properties that they cannot possibly possess. This mistake often entails an inability to make a choice that the object cannot possibly make. For instance, it is misapplied to characterise the five players on a basketball team as engaged in some exercise of joint optimisation. Coaches may reasonably be characterised as seeking to manage the players they direct to achieve the best attainable outcome. But that fits reality because it speaks to the ability of different coaches to manage their players, and with it being easy to recognise that coaches vary in talent. It's also reasonable to describe individual players as playing well, but performance standards regarding team performance can be attributed reasonably well only to people who hold managerial positions.

The neo-classical orientation dominates economics to the present day, though contemporary economics features a wider variety of styles and orientations than it featured until roughly the start of the 21st century. Economists, whether of classical or neo-classical orientation, thought they were wrestling with the truth of the matter with respect to economic phenomena. Anyway, this is the customary way textbooks present the history of economics, along with offering a smattering of episodes that don't fit the classical-neoclassical dichotomy. This smattering might include the Jesuits associated with the University of Salamanca in the 14th century, to which Marjorie Grice-Hutchinson attributed the formation of a distinctive school of economic scholarship in *The School of Salamanca: Readings in Spanish Monetary Theory, 1544-1605* (Oxford University Press). Those Spanish Jesuits theorised about systems of economic interactions two centuries before the advent of the Scottish Enlightenment.

Furthermore, the 19th century saw the advent of several forms of socialism with respect to the articulation of political programs, as well as the injection of Marxism in a big way into the 20th century with the Russian Revolution, about which I commend Paul Craig Roberts's (1971) *Alienation and the Soviet Economy* (Albuquerque: University of New Mexico Press).

Moreover, and with respect to John Maynard Keynes, I would note that Mark Blaug, undoubtedly the doyen of the history of economics since the death of Joseph Schumpeter, noted in the fifth edition of his *Economic Theory in Retrospect,* that "The Keynesian Revolution is one of the most remarkable episodes in the entire history of economic thought; never before had the economics profession been won over so rapidly and so massively to a new economic theory, and nor has it since (p. 642). Within the space of about a decade, 1936-46, the vast majority of economists throughout the Western world were converted to the Keynesian way of thinking." Keynes's *General Theory of Employment, Interest, and Money* (New York: Harcourt Brace, 1936), injected an aggregative style of thought that had heretofore been unknown to economists. Before Keynes, economics was concerned with problems of social organisation which were common to all societies. Those problem societal problems mostly focused on two large categories of problem: (1) given the people and their talents that inhabit a society along with the resources available to that society, how is the production of goods and services organised within that society; (2) given what has been produced within a society, there must be some method or process through which the different members of society receive title to what has been produced.

My purpose in writing this essay, however, is not to review a menu of possible styles of economic theory. It is rather to explain how fortunate students of economics are because their studies will equip them, depending on their specific analytical interests, to pursue two distinct lines of theoretical inquiry. The classical-neoclassical disjunction does not reflect some choice between valid and invalid theoretical frameworks, even though the two frameworks and textbooks often portray the situation this way. Both frameworks offer useful insights into the problems humans face as they seek to live well together in close geographical proximity among one another. Resource administration entails universal problems that are familiar to the neo-classical scheme of thought, where administrators face problems of administering people and resources to good effect. The study of economics can equip students to face this challenge. Like any large and robust field of study, forms of specialisation abound throughout the study of economics, where a focus resides on such challenges as managing resources efficiently.

5. The Classical Orientation

The study of economics can also equip students to pursue complex problems that arise through people living together in proximity. The Classical economists spoke eagerly of how the division of labour within society enabled a superior standard of living than would otherwise have been achievable. This achievement is attributed to superior resource administration during Classical times, but the prime analytical concern of the Classical economists was on societies as analytical objects. The philosophers of the Scottish Enlightenment, including Adam Smith, recognised that societies were such complex objects that no one could assemble them. They weren't assembled through acts of policy. Policy could be inserted into ongoing societies. The Scottish philosophers recognised that there were moral features resident within humans that generally promoted good order within society, and those philosophers set about uncovering the self-governing logic of societies, led by Adam Smith's (1759) *Theory of Moral Sentiments.* Even though the members of society might live in a generally free society, their

conduct will be governed by their desire to be regarded as upstanding citizens by their fellow citizens. This desire might not be held equally strongly by everyone, but all the same, it will operate to promote some modicum of cohesion within society. Approbation as a natural form of social glue is still at work within the social theories of the Classical economists.

The classical orientation toward political economy emerged among such philosophers of the Scottish Enlightenment as Adam Smith, David Hume, and Adam Ferguson. Social order was the central concern of the Classical economists who operated within the Scottish Enlightenment. These thinkers recognised that the societies with which they were familiar could be said to work effectively in a meaningful sense of the term, even though there was no person or organisation that bore responsibility for ensuring their effective operation. Most of those societies were monarchial, and those Scottish thinkers recognised that monarchial families mostly lacked either the desire or the wisdom to promote flourishing within the societies over which they ruled. Societies varied in some of the qualitative features of their standards of living, but in no way could a disinterested thinker attribute those variations to systematic variations among monarchs in their talents and capacities for monarchial rule.

The classical thinkers recognised they needed to look elsewhere if they were to locate a reasonable explanation for why some societies flourished more strongly than others. The world is a wide and varied place, and the classical thinkers acknowledged the presence of wide differences in standards of living among societies throughout the world. For instance, the first known use of wheels was in Mesopotamia around 3500 BCE. In contrast, they didn't appear in sub-Saharan Africa until the 19th century. More than five millennia separate the first society to discover the wheel in Mesopotamia from the last societies to do so in sub-Saharan Africa. Not all societies were populated at the same time, but in this case, this comparison illustrates that learning and experimentation spread among societies with high variation.

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India's Paperless Border Paradox: Evidence from Empirical Estimations

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ABSTRACT

A nation's efficient participation in global supply chains and accelerated economic growth are driven by trade facilitation. Paperless trade has been a significant reform under the WTO's Trade Facilitation Agreement. Quantifying its potential efficiency in global trade dynamics is essential for informed policy. Therefore, this study undertakes an empirical estimation from India's perspective to understand how the paperless and cross-border paperless reforms have enhanced its efficiency in countries' export–import movements over its other major trading partners. Central to the paper's argument, the study reveals a paradox in paperless-border realities. While this paper captures the positive implications of the reforms, it also highlights the key challenges that hinder the seamless movement of cargo across borders. This study also identifies bottlenecks and highlights an asymmetric pattern of efficiency gains for India, depending on the size of its partner countries' economies. Therefore, strengthening cross-border interoperability and digital and physical infrastructure is essential to ensure that India's paperless trade reforms translate into faster, cheaper, and more reliable trade flows with key partners.

Keywords: trade facilitation, paperless trade, cross-border digitalisation, logistics performance, export competitiveness, digital infrastructure, globalisation, economy, World Trade Organisation (WTO) Trade Facilitation Agreement

JEL Classification: F13, F14, F15, O24, O53, C23, L86

1. Introduction

The historic negotiation of the India-European Union Free Trade Agreement (FTA) marks a turning point in India's integration into global trade. Though tariff reduction is the central key to the agreements, the success of these agreements will depend on India's capacity to efficiently and effectively facilitate the seamless movement of merchandise goods across international borders. In today's world of deeply integrated supply chains, power play, and rising compliance costs, trade competitiveness is determined not just by market access but also by the quality of border infrastructure and the strength of digital trade facilitation infrastructure (Jin & Pan, 2025).

In the context of India's ambition to emerge as one of the world's leading manufacturing hubs and a major, stable trade partner, reducing trade costs through procedural simplification and digitalisation has become a strategic necessity (Kumar, 2024; Banerjee, Mukherjee, & Srishti, 2024). Digitalisation will

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enhance the seamless movement of containers across borders, reducing paperwork and shortening clearance times. Therefore, it depends on the functions of speed, predictability, and data interoperability, which require high-quality paperless trade infrastructure and fully digitalised border infrastructure. Henceforth, next-generation trade facilitation, predominantly paperless and cross-border, has emerged as a significant factor, meeting global trade facilitation (TF) standards and further enabling greater participation in international trade integration (Banga, 2019).

However, India has made significant progress in this area since ratifying the World Trade Organisation's Trade Facilitation Agreement (TFA) in 2016 (WTO, 2016). Reforms such as the Single Window Interface for Facilitating Trade (SWIFT), e-SANCHIT, electronic risk management systems, Direct Port Delivery, and the Authorised Economic Operator program have extensively modernised customs administration (Reddy, 2019).

These initiatives have been further supported by the formation of the National Committee on Trade Facilitation and the implementation of the National Trade Facilitation Action Plan (2024-2027) (UNCTAD, 2024), indicating continued institutional commitment to digital trade reform. Together, these measures provide a coherent framework that aligns domestic reforms with global best practices. They also signal to international partners that India is serious about reducing transaction costs and enhancing transparency in cross-border trade. Such initiatives have led to improved performance on the Logistics Performance Index (LPI) over time (see Figure 1).

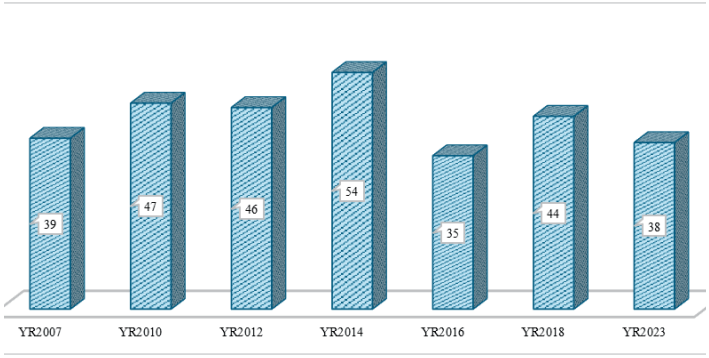


Figure 1: Logistics performance index:
Overall rank for India over the years measured from 2007-2023.

Source: World Development Indicators (WDI), Author's own research

Beneath this hopeful narrative of a seamless, paperless trade environment, however, lies a persistent and frequently disregarded factor that continues to hinder Indian trade: the quality of border infrastructure. At India's border points, paperless trade systems are anything but universal, even though they work well along the main trade routes and gateway ports. Lack of reliable internet access, sufficient digital infrastructure, and agency-level standardisation remain commonplace in many locations (Banga, 2019). When shipments leave the main customs terminals, traders are frequently forced to resort to manual systems because electronic documentation is ineffective beyond the port gates (De & Saji K, 2025).

To investigate these aspects, this paper conducted a thorough literature review to examine India's paperless trade efficiency and the responses of its major partner countries to smooth cargo movements. Therefore, the immediate question the current paper aims to address is: "Has India's EXIM movement gained from the digitalisation and paperless services, or are there gaps persisting, leading to a challenge in its efficiency?" By

utilising panel data that includes India and its most important trading partners, which cover up to 90% of India's overall import and export activities, the overall relationship that exists between trade facilitation performance, logistics connectivity, trade values, and exchange rates is explored when focusing on the value that India does or does not gain from digital trade.

In doing so, it also enriches the literature on trade facilitation and digital trade, while bringing valuable policy insights on how India's trade diplomacy, including its unprecedented partnerships with the EU, can be benchmarked against its border preparedness.

The rest of the paper is organised into five sections. This section introduces the research context and significance. Section 2 reviews the existing literature and identifies key gaps, highlighting the conceptual aspects of paperless trade and its empirical evidence. Section 3 outlines the data sources and methodology used to assess the efficiency in paperless trade for India and its major trading partners. Section 4 presents the empirical results and their implications. Section 5 concludes with key insights and policy recommendations to enhance the implementation of paperless trade, along with a forward-looking policy implication.

2. Review of Literature

2.1 Institutional Foundations of Paperless Trade and Digital Trade Facilitation

The digitalisation of trade and paperless trade are two essential components of TF, referring to the replacement of manual documentation procedures with electronic data exchange systems via an electronic single window, automated customs processes, and interoperable data platforms across different agencies linked to the process (Duval & Mengjing, 2017; Civelek et al., 2017). This streamlines border compliance costs, customs clearance, and logistics coordination across the jurisdiction (Duval, Utoktham, & Kravchenko, 2018).

However, these reforms reduce compliance costs, information asymmetries, procedural uncertainty, and market-entry costs, thereby enhancing firms' participation in the international market. The WTO Trade Facilitation Agreement formalised these principles by making transparency, e-documentation, and risk-based border management the significant components of this reform (WTO, 2013).

Many studies highlight the disproportionate gains from such reforms; nations characterised by high trade costs and substantial 'red tape' benefit most, leading to better integration into regional and international supply chains (Ajewumi, Afolabi, & Joe-Akunne, 2024). Whilst the efficiency benefits rich countries, developing countries, least developed countries (LDCs), and landlocked developing countries (LLDCs) experience the most significant relative impact (Ali & Shakoor, 2020). Time-sensitive goods, global value chain (GVC) trade, and small firms are particularly responsive to such institutional improvements (De, 2023).

Both domestic governance capabilities and international regulatory standardisation influence the institutions driving the development of paperless trade. The provisions on electronic documents in instruments such as the Revised Kyoto Convention, the ASEAN Single Window, and the UNCITRAL Model Law on EDI demonstrate how legal recognition of electronic

documents enables cross-border interoperability (ALsheyab, 2025).

These steps reframe paperless trade not merely as a technical innovation, but as an institutionally driven process through which reform can create new structural opportunities to enhance trade competitiveness and participation in global markets (Khan, 2024). Whilst such initiatives highlight the positive implications of the reforms, significant challenges remain in translating these reforms into reality.

2.2 Review of India's Paperless Trade Opportunity vs Hurdles

The positive implications of electronic document submission include reduced risk-based inspections and digital payments, which, in turn, reduce border delays and enhance export competitiveness, particularly in time-sensitive, GVC-oriented trade (De, 2023). Capturing this perspective, India's digital customs modernisation represents a structural opportunity to deepen integration with the EU while strengthening domestic logistics efficiency.

Although the process appears seamless, a set of persistent constraints lies beneath the surface. Paperless trade can only be fully successful if implemented with strong infrastructural support (Senyo, Effah, & Osabutey, 2021; Bassa, Kwateng, & Kamewor, 2021). Such infrastructure is absent in practice. Whilst digital platforms operate effectively at major maritime gateways, TF outcomes exhibit an asymmetrical balance across Container Freight Stations (CFS), Inland Container Depots (ICDs), Integrated Check Posts (ICPs), and land borders, owing to weak infrastructure leading to congestion, constrained road and rail connectivity, limited laboratory infrastructure, and capacity shortages, resulting in continued delays in cargo release (De & Saji K, 2025). Inadequate physical infrastructure, therefore, undervalues the potential of digital reforms (Manny et al., 2021), which in turn necessitates a manual documentation process.

The underutilisation of information and communication technologies (ICTs) presents a parallel challenge. Even though electronic filing and clearing have been institutionalised in ICEGATE and the DGFT systems, hybrid methods are still utilised in many of India's ports and land borders, which reduces their efficiency advantage (Banga, 2019). The inability of ICT systems to communicate, comprehend, and leverage trade-related data, referred to as Technical Interoperability, however, assumes legal force (Banerjee & Sanganeria, 2023). These highly fragmented software architectures across Customs, Port Authorities, and Participating Government Agencies affect the readiness levels for cross-border data exchange and domestic integration (LPAI, 2022).

These problems compound, especially in cross-border paperless trade, because of the lack of coordination across different national legal and regulatory frameworks and technology platforms (Chang, Iakovou, & Shi, 2019). Moreover, it has been observed, based on international experience, that the advantages accrued through digital 'Certificate of Origin' systems, SPS e-certificates, electronic Bills of Lading, and electronic Customs Declarations would be achieved through harmonised data standards, platforms, and mutual legal recognition, as has been pointed out in. Even with improvements achieved through the SWIFT and DGFT systems, exporters from various FTA/PTA regions in India remain at a disadvantage, as they must

still comply with physical documentation due to regulatory and acceptance issues encountered with these systems (De & Saji K, 2025).

Therefore, the literature converges on a critical insight: while India's paperless trade reforms are part of a broader institutional transformation, they are constrained by significant economic consequences. Digitalisation will not deliver seamless trade unless it is embedded within a harmonised physical, legal, and institutional ecosystem. This underlines significant gaps in policy interventions and the hidden structural frictions. In view of the above, this paper empirically re-evaluates whether paperless trade and cross-border digital facilitation reforms at the frontier actually translate into measurable gains in export and import performance for India by applying a gravity-inspired model across India's major trading partners.

3. Empirical Strategy and Summary Statistics

This study employs a gravity-inspired framework with high-dimensional fixed effects within a Poisson Pseudo-Maximum Likelihood estimator. Fixed effects are used to control for unobserved time-invariant differences across countries. The time-varying country differences allow us to identify the relationship between trade facilitation and trade performance. Although we concentrate on exports and imports to the global market at the country level rather than the bilateral flow, the PPML intuition remains true: the overall volume of trade represents the combined impact of economic size, trade costs, logistical friction, and institutional efficiency in forming a nation's trading network (Baltagi, Egger, & Erhardt, 2024). Therefore, to capture how paperless and digital trade facilitation affected the overall trade performance of India and its most significant trading partners, we grounded a dataset based on an extensive literature review to align with the paper's core arguments. Likewise, the variables are selected to capture both policy-level reforms and intrinsic trad drivers, while remaining consistent with the theoretical structure. The following subsection explores the selection of a particular variable and how that contributes to illuminating trade facilitation dynamics.

3.1 Empirical Models

The dependent variables, ‘y ’, such as exports and imports, are expressed as functions of logistics performance, macroeconomic fundamentals, and indicators of institutional and digital trade facilitation.

$$y_{i,t} = f(LPI_{i,t}, RGDP_{i,t}, ER_{i,t}, PL_{i,t}, CBPL_{i,t}, SCI_{i,t}, EoDB_{i,t}, Expected_time_{i,t}) \quad \ldots. (1)$$

$$y_{i,t} = \alpha + \beta(\text{Macro Economic Terms})_{i,t} + \vartheta(\text{Logistics Parameters})_{i,t} + \theta(\text{India} * X)_{j,t} + \delta_t + \tau_t + \varepsilon_{i,t} \quad \ldots. (2)$$

where *i* denotes partner countries, and t denotes time. India × Xj,t, where “j” represents the India specific India’s paperless, cross-border trade, LPI and EoDB responsiveness differs from the global baseline effects captured by θ, ensuring that country-level differences are captured within a unified framework while preserving the efficiency and consistency of the full-sample estimation. α is the fixed coefficient. β are the coefficients for RGDP and exchange rate, and ϑ are the coefficients for the rest of the logistics parameters. The model incorporates time-fixed effects δ_t, country-specific annual time trends τ_t, and an error term ε_{it}.

The log form is used in this model, except for the score variables, and the data has undergone stationarity checks. All variables are described in Table 1.

Table 1. Variable Description and Sources

Variable	Description	Category	Source
Export	Global export to the world. The paper considers the log form of export	Dependent Variable	WITS, UNCTAD
Import	Global import to the world. The paper considers the log form of import	Dependent Variable	WITS, UNCTAD
LPI	The Logistics Performance Index (LPI) score evaluates how effectively countries manage trade logistics by assessing areas such as customs efficiency, infrastructure quality, shipment arrangement, logistics services, tracking systems, and delivery timeliness.	Independent Variable	WDI
RGDP	Real Gross Domestic Product. The paper considers the log form of RGDP	Independent Variable	World Bank
ER	Real Effective Exchange Rate. The paper considers the log form of the exchange rate	Independent Variable	WDI
PL	Paperless trade in %	Independent Variable	Global Trade Facilitation Survey, UNESCAP.
CBPL	Cross-border Paperless trade in %	Independent Variable	Global Trade Facilitation Survey, UNESCAP.
SCI	Linear Shipping Connectivity Index	Independent Variable	UNCTAD
EoDB	Ease of arranging competitively priced international shipments, score (1=low to 5=high)	Independent Variable	WDI
Expected _time	Frequency with which shipments reach the consignee within the scheduled or expected time, score (1=low to 5=high)	Independent Variable	WDI

Source: Authors' compilation

By including country fixed effects, the approach effectively adjusts for quirks that might not change much over time in India or its trading partners. The intention is that the results now depend only on changes over time in each country, not on how the countries compare with each other. Adding year fixed effects helps address global shocks, business cycle fluctuations, and changes in the pattern of international trade, thereby reducing the significance of omitted variables. Most importantly, the fixed-effects approach helps address endogeneity, particularly reverse causality from trade flows to policy changes in areas such as logistics or digital facilitation, by using the time dimension within each country rather than the cross-country dimension. The fixed-effect version of the PPLE approach therefore provides a robust framework for estimating model results.

Therefore, this enables us to examine the effects of paperless trade facilitation, digital border processes, and logistics performance on India's exports and imports, while controlling for broad macroeconomic fundamentals and structural trade frictions. Doing so, we estimate whether improvements in trade facilitation generate differential export and import gains for India relative to other countries. At the same time, export and import parameters are the most appropriate variables for achieving the research objectives, as they represent the most direct and policy-relevant measures of a country's integration into the global market and the outcomes of TF reforms.

For our purposes, the Logistics Performance Index (LPI) serves as an essential driver, reflecting the efficiencies achieved with customs, timely shipment, tracking/tracing, and the quality of services provided. However, LPI fails to provide direct measures

regarding the efficiencies sought to be achieved through the implementation of paperless or digital trade; hence, specific measures for paperless trade and its cross-border processes are sought to be included.

Time-related trade costs are also incorporated in the model. Including the Liner Shipping Connectivity Index will enable us to assess the world's integration into global shipping connectivity. At the same time, the ease of doing business score reflects the broader operating environment. We also control major macroeconomic indicators, such as real GDP, to measure the size of the economy and the exchange rate to measure relative price competitiveness.

Additionally, India-specific interaction terms are incorporated into the model specification, and these coefficients are estimated from the global baseline effects, ensuring that country-level differences are captured within a unified framework while preserving the efficiency and consistency of the full-sample estimation. The India dummy is absorbed by country fixed effects and therefore omitted; however, interaction terms remain identified and capture India-specific marginal effects. Incorporating interaction terms, it allows a systematic comparison between India's trade responses and the panel average.

3.2. Variables and Summary Statistics.

In line with the objectives of our research, we proceed with Poisson pseudo-maximum likelihood (PPML) regression with high-dimensional fixed effects to account for heteroscedasticity and autocorrelation, yielding consistent and robust estimates of trade flows.

From a methodological perspective, our analysis employs a balanced panel data set, where the number of partner countries in the export equation and the import equation are 48 and 31, respectively, which represents 90% of total merchandise flows from and to India based on the FY 2024 in six time periods, namely 2010, 2012, 2014, 2016, 2018, and 2023. However, the selection of time periods was mainly guided by the availability of data on LPI indicators. The dataset has been collected from various reliable sources worldwide, including the World Bank, UNCTAD, WITS, UNESCAP's Global Trade Facilitation Survey, and the World Development Indicators database (WDI). Given that Table 2 summarises the statistics for both models.

Table 2. Summary Statistics

Variables	*Mean (Export)*	*St. Dev (Export)*	*Mean (Import)*	*St. Dev (Import)*
Export	18.58	1.82		
Import			19.15	1.3
LPI	3.29	0.57	3.34	0.53
RGDP	26.72	1.67	27.39	1.37
ER	4.59	0.17	4.58	0.15
PL	0.52	0.5	0.55	0.49
CBPL	0.45	0.12	0.51	0.23
SCI	47.63	29.65	50.21	30.66
EoDB	3.19	0.48	3.23	0.43
Expected time	3.65	0.53	3.72	0.47

Source: Authors' own calculation.

Note: export is based on 336 observations, and import is based on 217 observations for each parameter

4. Results and Discussions

4.1.1. Results from the Diagnostics Test – Export Model

The diagnostic tests for the export model provide clear guidance for model specification (see Table 3). The VIF (2.77) results confirm the absence of multicollinearity, while the Breusch–Pagan LM test (12.73, p = 0.0004) indicates heterogeneity. However, the Wooldridge (0.31, p = 0.000) and Pesaran CD tests (1.56, p = 0.002) reveal the presence of serial correlation and cross-sectional dependence, suggesting strong temporal persistence and spatial linkages across units.

The Hausman test (χ^2 = 15.83, p = 0.000) decisively favours the fixed-effects specification, underscoring the importance of accounting for unobserved heterogeneity correlated with the regressors.

Table 3: Diagnostic Checks for Export Model

Tests	***Objective to Check***	***Statistic***	***P-value***	***Decision***
VIF	Multicollinearity	2.77		No Multicollinearity
Breusch Pagan	Heteroskedasticity	12.73	0.0004	Heteroscedastic
Wooldridge test	Autocorrelation	0.31	0	Serial Correlation
Pesaran CD Test	Cross-sectional dependence	1.56	0.002	Cross-Sectional Dependence
Hausman Test	Determining Fixed or Random Effects	15.83	0	Fixed Effect

Source: Author's own work

4.1.2. PPML Model Estimation with India Export-specific Implications

Table 4 presents the empirical estimates from the panel model, revealing that countries' export performance is powerfully shaped by logistics efficiency, paperless trade, and macroeconomic size. In comparison, these estimates were captured by three models, which reconfirm its robustness as an estimator. Across, the OLS, two-way fixed-effect model, and preferred PPML specification ensure that real GDP reflects the economic size, which has a strong, positive, and significant effect on exports. Thereby confirming the core prediction of the gravity theory that larger economies lead to more trade.

Table 4. Export Model Results

	OLS	***Two-Way Fixed Effect***	***PPML***
	ln_export	*ln_export*	*ln_export*
eodb	*0.867***	*0.257***	*0.0159**
	(-0.346)	*(-0.13)*	*(-0.00925)*
expected_t~e	*1.083****	*0.232*	*0.0128*
	(-0.361)	*(-0.14)*	*(-0.00983)*
pl	*0.161***	*0.098***	*0.023**
	(-0.067)	*(-0.042)*	*(-0.033)*
cbpl	*0.112*	*0.014*	*0.009*
	(-0.03)	*(-0.023)*	*(-0.01)*
lpi	*1.178***	*0.184***	*0.00891****
	(-0.491)	*(-0.296)*	*(-0.0201)*
sci	*0.00854****	*0.00232 ****	*0.000183****
	(-0.00269)	*(-0.004)*	*(-0.00031)*
ln_rgdp	*0.663****	*0.985****	*0.0589****
	(-0.0429)	*(-0.177)*	*(-0.0229)*
ln_er	*0.178*	*0.0813*	*-0.0128*
	(-0.436)	*(-0.177)*	*(-0.0182)*
india_pl			*0.0261*
			(-0.044)

india_cbpl			*0.007*
			(-0.011)
india_lpi			*0.0404**
			(-0.0562)
india_eodb			*0.0192***
			(-0.0187)
_cons	*-3.254*	*-9.190***	*1.334***
	(-2.347)	*(-4.613)*	*(-0.584)*
r2_w			*0.368*
r2_b			*0.759*
r2_o			*0.753*
chi2			*168*

Source: Author's estimation

Note: Standard errors in parentheses p<0.10, ** p<0.05, *** p<0.01*

Beyond this, the ease of doing business, LPI, shipping index, and paperless trade have the potential to impact, suggesting that any improvement in regulation, digitalisation, and administration directly translates into tangible export gains. On the flip side, the estimated effect of the expected border processing time loses significance in the PPML model, indicating that cross-border processing delays, which are precisely the real-world challenge that multiple developing nations are struggling with. This picture is even more accurate for India, where, across multiple ICEGATEs, asymmetric infrastructure leads to substantial delays and inefficient reductions in dwell times at major ports and customs points, leaving exporters to face continued bottlenecks (Banerjee & Sanganeria, 2023). This friction limits trade efficiency and isolates its gains, suggesting the need for uniform, systemic reforms across all borders.

In India, ease of doing business and the LPI index score have a positive and significant impact on overall exports (see Table 5). Still, there is limited evidence of the significant positive implications of India's paperless, cross-border trade. This again reconfirms that, though digital platforms and other reforms like e-SANCHIT, faceless assessment, SWIFT, and digital bills of entry have a positive impact on the country's LPI structure, they do not significantly translate into the country's (India's) export story. Therefore, for India, where trade deals are important, this also has equal importance in uplifting its infrastructure, which does not just restrict to major ports but also its administrations, customs clearance points, a harmonised legal framework, and e-documentation with more transparent data interpolation to capture infrastructural gaps more prominently.

Table 5: Interpretation of Import Scenarios by Elasticity.

Interpretation expressed as a unit improvement in these parameters' performance translates the increase/decrease in Export by:			
Variable	***All-Countries Effect***	***India-Specific Effect***	***Explanations***
Ease of Doing Business	*↑ 1.6%*	*↑ 1.9%*	*Regulatory efficiency consistently boosts export performance.*
Expected Clearance Time	*↑ 1.3%*	*-*	*Faster border processing improves export competitiveness.*
Paperless Trade	***↑ 2.3%***	*↑ 2.6%*	*Digital procedures significantly enhance export efficiency. But for India, it loses its significance*
Cross-Border Paperless Trade	*↑ 0.9%*	*↑ 0.7%*	*Interoperability modestly strengthens export flows, but it doesn't represent its significant contribution here.*

Logistics Performance Index	↑ ***0.9%***	↑ ***4.04%***	*Logistics improvements strongly promote India's and Global exports.*
Linear Shipping Index	↑ ***0.02%***	-	*Better maritime connectivity marginally raises exports.*
GDP	↑ ***5.8%***	-	*Economic growth expands export supply capacity.*
Exchange Rate (₹/$)	↓ ***1.2%***	-	*Currency depreciation may reduce exports if production relies on imported inputs.*

Source: Based on the authors' own calculation.

Note: The bold figures show the significance based on the PPML model estimation

Henceforth, the results indicate that although there is a mean level of digitalisation at Indian ports, it often reverts to manual or paper verification, both domestically and in partner countries, particularly in landlocked countries. This fragmentation is particularly costly compared to advanced economies, where regulatory requirements are stringent and digital authentication is strictly enforced. Therefore, to meet the regulatory standards of the EU, UK, Russia and USA, which are the major export markets for India, requires deepening institutional readiness for truly seamless, digitally enabled cross-border commerce is essential.

4.2.1. Results from the Diagnostics test – Import Model

The diagnostic tests for the import model are given in Table 6. The results confirm the absence of multicollinearity, indicating heteroscedasticity and autocorrelation and suggesting a fixed effect model.

Table 6: Diagnostic Checks for Import Model

Tests	***Objective to Check***	***Statistic***	***P-value***	***Decision***
VIF	Multicollinearity	3.37		No Multicollinearity
Breusch Pagan	Hetero-skedasticity	4.79	0.02	Heteroscedastic
Wooldridge test	Autocorrelation	0.56	0	Serial Correlation
Pesaran CD Test	Cross-sectional dependence	2.69	0	Cross-Sectional Dependence
Hausman Test	Determining Fixed or Random Effects	18.16	0.0059	Fixed Effect

Source: Author's own work

4.2.2. PPML Model Estimation with India Import-specific Implications

Table 7 presents the import model estimates, along with OLS and two-way fixed-effect estimates. The results show that macroeconomic factors remain the dominant drivers of India's inward trade flows. The partnering countries' GDP had a positive, highly significant effect in this specification. This therefore aligns with the gravity model prediction and highlights that India's import demand continues to be shaped by the market size and production complementarities with trading partners, particularly the advanced partner economies.

The import model shows that the exchange rate has a positive and significant impact, strongly indicating that currency movements, along with structural trade costs and institutional quality, play a role in determining India's sourcing patterns, unlike in the export model (see Table 5).

Table 7: Import Model Results

	OLS	***Two-Way Fixed Effect***	***PPML***
	ln_import	*ln_import*	*ln_import*
eodb	*0.249*	*0.115*	*0.00523*
	(-0.285)	*(-0.151)*	*(-0.00558)*
expected_t~e	*0.384*	*-0.0311*	*-0.0144**
	(-0.348)	*(-0.189)*	*(-0.00842)*
pl	*0.032*	*0.021*	*0.0009*
	(-0.721)	*(-0.349)*	*(-0.013)*
cbpl	*0.112*	*0.067*	*0.053*
	(-0.03)	*(-0.016)*	*(-0.009)*
lpi	*0.0567*	*0.0757*	*0.0226**
	(-0.418)	*(-0.342)*	*(-0.0125)*
sci	*0.00989****	*0.00446*	*0.00057*
	(-0.00165)	*(-0.00519)*	*(-0.000493)*
ln_rgdp	*0.568****	*0.743****	*0.0501****
	(-0.0371)	*(-0.237)*	*(-0.0147)*
ln_er	*0.249*	*0.352**	*0.00656**
	(-0.274)	*(-0.182)*	*(-0.00931)*
india_pl			*0.0456*
			(-0.0128)
india_cbpl			*0.0227*
			(-0.0159)
india_lpi			*-0.0699****
			(-0.0176)
india_eodb			*0.0430****
			(-0.00887)
_cons	*-0.502*	*-2.445*	*1.543****
	(-1.727)	*(-6.17)*	*(-0.385)*
r2_w			*0.258*
r2_b			*0.599*
r2_o			*0.59*
chi^2			*120.94*

Source: Author's estimation

*Note: Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.0*

Trade facilitation variables indicate significant time costs at borders and dampen India's imports. While the expected clearance time shows a negative, significant impact, suggesting that procedural and customs clearance delays act as a barrier to efficient border movements. This highlights India's persistent challenges with port dwell time and congestion at major gateways, such as Nhava Sheva and Chennai ports. Coordination gaps among customs, port authorities, and logistics providers further compound this. This manual execution of border processes still imposes a significant time cost on importers and results in overall delays in consignment movements.

Table 8: Interpretation of Import Scenarios by Elasticity

Interpretation expressed as a unit improvement in these parameters' performance translates the increase/decrease			
Variable	**All-Countrie**	**India-Specific**	**Explanations**
Ease of Doing	↓ 0.5%	↑ **4.3%**	In India, it significantly
Expected Clearance	↓ **1.4%**	-	Improving customs speed is equivalent to
Paperless Trade	↑ 0.09%	↑ 4.5%	Digitalisation intends to simplify import

Cross-Border Paperless Trade	↑ 5.3%	↑ 2.2%	Interoperability strongly stimulates import flows, which also requires infrastructural support to make a significant contribution.
Logistics Performance Index	↑ **2.2%**	↓ **6.9%**	Improved logistics raise global imports, but for India, it means that logistics improvements can substitute imports by making domestic supply chains more efficient and competitive.
Linear Shipping Index	↑ 0.06%	-	Maritime connectivity slightly increases imports.
GDP	↑ **5.01%**	-	Economic expansion raises demand for imported goods.
Exchange Rate (₹/$)	↑ 0.6%	-	Depreciation increases import value due to inelastic demand for essential goods.

Source: Based on the authors' own calculation.
Note: The bold figures show the significance based on the PPML model estimation.

Focusing on the India-specific interaction effects provides a critical insight (see Table 8). The positive coefficient on the India-paperless interaction indicates that digitalisation of customs and clearance procedures can materially improve India's import performance, but does not significantly translate into improved import efficiency. In contrast, the negative interaction between India and logistics performance underscores that physical infrastructure constraints continue to offset some of the gains from digital reforms and again hinder India's import efficiency. This divergence highlights a structural imbalance in India's trade facilitation trajectory. While institutional and procedural reforms are progressing rapidly, upgrades in ports, strengthening the internet across all borders, complete adoption of TIR for the container's movements, and functional animal and plant quarantine at all borders will improve the time cost, and this will be directly translated to the positive gains in India's overall trade dynamics.

5. Conclusion and Policy Recommendations

This study highlights that paperless trade and digitalisation have positive implications, but that efficiency is hindered in practice. India's trade competitiveness is not yet fully reflected in its growth story. Therefore, from a policy perspective, alongside digitalisation and other reforms, India should invest in physical infrastructure that can serve as the backbone of trade facilitation.

Furthermore, India needs to bridge the gaps between agencies to enable the seamless movement of consignments. System-wide interoperability across port authorities, participating government agencies (PGAs), logistics service providers (LSPs), firms, and, most importantly, customs administration should be accelerated, with a focus on standardised, data-driven integration that reduces risk, manual documentation, and associated costs.

Additionally, India should strengthen its cross-border legal and technical systems through more intensified engagement with the UNESCAP Framework

Agreement on Cross-Border Paperless Trade. This initiative should be more focused on landlocked countries, which account for a significant share of India's total trade.

Finally, India should engage more actively in bilateral and FTA-based trade deals, as well as in the mutual recognition of electronic certificates of origin, SPS certifications, and electronic Bills of Lading. Collectively, these measures will contribute to India's trajectory towards a more efficient and sustainable supply chain.

Disclaimer: The views expressed herein are based on the authors' estimations and do not reflect the views of NCAER.

Appendix

Appendix A: India's Major Exporting Partners Constitute 90% of Its Total Exports to the World based on WITS data 2024

India's Major Exporting Partners Constitute 90% of Its Total Exports to the World.		
Australia	Iraq	Qatar
Austria	Israel	Russia
Bangladesh	Italy	Saudi Arabia
Belgium	Japan	Singapore
Brazil	Kenya	South Africa
Canada	Korea	Spain
China	Kuwait	Sri Lanka
Colombia	Malaysia	Switzerland
Czech Republic	Mexico	Tanzania
Egypt, Arab Rep.	Mozambique	Thailand
France	Nepal	Togo
Germany	Netherlands	Turkey
Ghana	Nigeria	UAE
India	Oman	UK
Indonesia	Philippines	USA
Iran, Islamic Rep.	Poland	Vietnam

Source: Author's Compilation

Appendix B: India's Major Importing Partners Constitute 90% of Its Total Imports from the World based on WITS data 2024

India's Major Importing Partners Constitute 90% of Its Total Imports from the World.		
Angola	Italy	Saudi Arabia
Argentina	Japan	Singapore
Australia	Korea	South Africa
Brazil	Kuwait	Switzerland
Canada	Malaysia	Thailand
China	Mexico	UAE
France	Nigeria	United Kingdom
Germany	Oman	United States
India	Peru	Vietnam
Indonesia	Qatar	
Iraq	Russia	

Source: Authors' Compilation

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The Cost of Late Diagnosis: The Economics of Cancer Care in India

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ABSTRACT

Cancer in India is often discussed in clinical terms, yet the economic implications of delayed diagnosis remain underexplored. Drawing on evidence from the National Cancer Registry Programme and nationally representative expenditure data, this article examines late cancer diagnosis through an economic lens. With over 1.46 million new cases annually and a substantial proportion presenting at advanced stages, delayed detection is associated with higher treatment costs, greater out-of-pocket expenditure, and an increased risk of catastrophic health spending. Public health accounts indicate that 47.1% of total health expenditure in India remains out-of-pocket, while survey data show significant reliance on borrowing and asset liquidation for hospitalisation episodes. Beyond immediate financial strain, late diagnosis reduces productive years in the workforce, generates indirect losses through caregiver withdrawal from employment, and creates long-term welfare consequences for vulnerable households. Rather than framing this as a system failure, the article highlights the economic opportunity embedded in timely detection. Strengthening early diagnosis pathways, improving access to screening, and investing in health data systems can preserve human capital, enhance fiscal efficiency, and reduce avoidable financial hardship. Recognising early cancer diagnosis as an economic investment—rather than solely a medical intervention—offers a constructive pathway toward a more resilient and equitable development trajectory for India.

Keywords: cancer care, health economics, late diagnosis, out-of-pocket expenditure, public health, India

JEL Classification: I11, I14, I15, I18

1. Introduction: Late Diagnosis of Cancer as an Economic Concern

Cancer in India is most often discussed in clinical or public health terms: stage at diagnosis, treatment protocols, and survival probabilities. While these dimensions are crucial, they offer only a partial understanding of the broader determinants and consequences of the disease. From an economic perspective, cancer—particularly when diagnosed late—is not merely a health event affecting individuals; it is a systemic unfolding of economic consequences that reverberates across households, labour markets, and public finances.

India faces a substantial and growing cancer burden. According to the National Cancer Registry Programme (NCRP) run by the ICMR National Centre for Disease Informatics and Research, Bengaluru, India, recorded an estimated 1.46 million new cancer cases in 2022, with projections suggesting this number will increase

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to approximately 1.57 million by 2025, reflecting a steady upward trajectory in incidence. NCRP hospital-based registry data show that 57% of breast cancers, 60% of cervical cancers, and 66% of head-and-neck cancers are diagnosed at locally advanced stages (Stage III), while a substantial proportion of lung cancers present with distant metastasis at diagnosis, underscoring the magnitude of delayed presentation in India. A significant proportion of cancer patients in India are diagnosed at advanced stages, when treatment options are limited, costs escalate sharply, and survival prospects decline.

Late diagnosis is typically framed as a problem of awareness, access, or health system capacity. Yet, it is equally important to recognise it as an outcome with substantial economic inefficiencies. The World Health Organization has consistently highlighted that late diagnosis is a major driver of avoidable cancer mortality in low- and middle-income countries, where many cancers are detected only after symptoms become severe and treatment options are limited. Delayed diagnosis converts a potentially manageable condition into a high-cost, low-return intervention, an outcome that economists would readily identify as an inefficient allocation of resources.

This article reframes late cancer diagnosis as an economic concern rather than solely a medical one. It puts forth that delays in diagnosis impose avoidable costs on households, reduce labour productivity, deepen inequalities, and strain public resources. Understanding cancer care through the lens of economic timing and human capital provides important insights for policy and growth strategy in India.

2. Cancer and the Economics of Timing

Why Timing Matters:

In economics, timing plays a critical role in determining costs, returns, and efficiency. Early investments typically yield higher returns, while delayed interventions often require greater expenditure for diminished outcomes. Cancer care follows this logic closely. Early-stage cancer detection generally allows for simpler treatment, shorter care pathways, higher survival rates, and a quicker return to normal economic activity. In contrast, late-stage diagnosis necessitates prolonged and intensive treatment, often involving multiple modalities such as surgery, chemotherapy, and radiotherapy. These treatments are not only expensive but also physically debilitating, resulting in prolonged absences from work and reduced productivity. From an economic standpoint, late diagnosis represents a situation where marginal costs rise sharply while marginal benefits decline. The health system expends more resources but achieves lower health and productivity gains. This mismatch between cost and outcome lies at the heart of the economic inefficiency associated with delayed diagnosis.

Diminishing Returns to Treatment:

As cancer progresses, the effectiveness of treatment declines. While early intervention may result in a cure or long-term remission, late-stage treatment often aims only at extending life or managing symptoms. Despite this, the cost of treatment greatly increases with disease progression. This phenomenon mirrors the concept of diminishing returns in economics. Beyond a certain point, additional inputs—whether financial, medical, or human—yield progressively smaller benefits.

Economic analyses supported by the World Bank show that cancer treatment costs rise steeply with advancing stage at diagnosis, substantially increasing the financial strain on households and health systems when cancers are detected late. Late diagnosis pushes cancer care into precisely this zone of diminishing returns, where the economic justification for expenditure becomes weaker, even as ethical and humanitarian imperatives remain strong.

3. Household Economics of Late Diagnosis

Catastrophic Health Expenditure:

At the household level, late cancer diagnosis frequently translates into catastrophic health expenditure. National cancer surveillance and hospital-based studies in India indicate that a large proportion of patients—often exceeding two-thirds for common cancers—present at stage III or IV, underscoring the systemic nature of delayed diagnosis. Recent Indian studies estimate that the mean direct medical expenditure for cancer hospitalisation ranges between ₹1.2 lakh and ₹2.5 lakh per episode in public facilities, and can exceed ₹4-6 lakh in private hospitals, with advanced-stage cancers incurring significantly higher cumulative costs due to prolonged treatment cycles. Cancer care in India is among the costliest forms of healthcare, and when treatment begins at an advanced stage, cumulative expenditure escalates rapidly due to prolonged hospitalisation, diagnostics, medicines, travel, and supportive care.

Despite the expansion of public health insurance schemes, coverage gaps persist. Many households continue to rely heavily on out-of-pocket spending, particularly for diagnostics and specialised treatment. Out-of-pocket spending remains a major financing mode in India. According to India's National Health Accounts (2020-21), out-of-pocket expenditure constitutes 47.1% of total health expenditure, despite the expansion of public insurance schemes, indicating continued financial vulnerability for high-cost illnesses such as cancer. This reflects continued susceptibility to catastrophic spending for high-cost illnesses such as cancer. Additionally, National Sample Survey (NSS 75th Round) data indicate that nearly 18% of households experiencing hospitalisation incur catastrophic health expenditure, defined as health spending exceeding 10% of annual consumption, with cancer among the leading contributors to high-cost hospital episodes. Late diagnosis increases both the duration and intensity of treatment, amplifying financial strain. For many families, these expenditures exceed a substantial share of annual income, forcing them to borrow, sell assets, or deplete savings. From an economic perspective, such spending represents not planned investment but distress financing—a response to crisis rather than a strategic choice.

Poverty Traps and Long-Term Welfare Loss:

The financial impact of late diagnosis often extends well beyond the treatment period. Debt accumulated during care can take years to repay, if repayment is possible at all. Asset liquidation reduces future income-generating capacity, while the loss of savings undermines financial resilience. NSS data show that over 12% of households finance hospitalisation through borrowings or the sale of assets (e.g., jewellery), and this proportion rises further for high-cost conditions such as cancer, reflecting the long-term economic vulnerability induced by delayed and advanced-stage treatment. Evidence suggests that cancer-related health

spending pushes an estimated 2-3% of affected households below the poverty line annually, particularly among lower consumption quintiles, highlighting the regressive economic impact of delayed diagnosis. These dynamics can deepen existing financial vulnerability and social deprivation. Importantly, the resulting welfare losses are not temporary. They persist long after treatment ends, affecting consumption, education, and investment decisions. Late diagnosis thus creates poverty traps that are difficult to escape, with long-term implications for economic mobility.

Gendered and Social Dimensions:

The economic burden of late cancer diagnosis is not evenly distributed. Women, particularly in the case of breast and cervical cancers, often face delayed diagnosis due to social norms, caregiving responsibilities, and limited autonomy in health decision-making. Rural households encounter additional barriers related to access and travel costs. These disparities mean that late diagnosis reinforces existing social and economic inequalities. The costs are borne disproportionately by those least able to absorb them, compounding disadvantages across gender, geography, and socio-economic status.

4. Productivity Losses and Labour Market Effects

International comparisons led by the International Agency for Research on Cancer show that survival differences between countries are driven less by cancer biology and more by stage at diagnosis and access to timely treatment.

Loss of Prime Working Years:

Many cancers in India occur during economically productive ages (30-60 years). When diagnosis is delayed, the likelihood of survival declines, and even survivors may face long periods of reduced work capacity. Late-stage treatment often involves extended hospital stays and prolonged recovery, reducing the number of productive years an individual can contribute to the labour force. ICMR-NCDIR data on cancer incidence includes a truncated incidence rate specifically for the 35-64 years age group, which is commonly used to summarise the burden among economically productive populations. This indicates that a large share of cancer cases in India occur within this age range, reinforcing the point that cancer disproportionately affects working-age adults in the country. From a macroeconomic perspective, this represents a loss of effective labour supply. Unlike short-term illnesses, cancer-related productivity losses are long-lasting and, in some cases, permanent.

Informality and Employment Insecurity:

India's labour market structure exacerbates these effects. A large proportion of workers are employed in the informal sector, where job security, sick leave, and disability benefits are limited or absent. For informal workers, illness often leads directly to income loss or job loss. Late diagnosis prolongs periods of non-employment and increases the likelihood that individuals will exit the labour force permanently. This not only affects household income but also reduces aggregate labour participation, particularly among middle-aged workers.

Spillover Effects on Caregivers:

Cancer imposes economic costs not only on patients but also on their families. Caregiving responsibilities

often fall on household members, frequently women, who may reduce work hours or exit employment altogether. These indirect productivity losses are rarely captured in economic statistics but contribute significantly to the overall cost of late diagnosis.

5. Late Diagnosis as a Health System Challenge

Information Asymmetry and Delayed Care-Seeking:

From a health economics perspective, late diagnosis reflects information asymmetry between individuals and the health system. Limited awareness of symptoms, fear of diagnosis, and misconceptions about cancer contribute to delayed care-seeking. When individuals underestimate risk or overestimate treatment costs, they postpone medical consultation, increasing the likelihood of advanced disease at diagnosis.

Access Barriers and Transaction Costs:

Even when individuals seek care, they face substantial transaction costs. Geographic distance, fragmented referral pathways, diagnostic delays, and long waiting times discourage timely diagnosis. These barriers disproportionately affect rural and low-income populations. In economic terms, high transaction costs reduce demand for early diagnosis, even when the long-term benefits are substantial. Late diagnosis is therefore not simply a matter of individual choice but an outcome shaped by system-level drivers.

Misaligned Incentives:

Health systems often prioritise tertiary care infrastructure and hospital-based treatment, while underinvesting in primary care, screening, and early detection. This reflects misaligned incentives, where resources flow towards visible, high-cost interventions rather than cost-effective preventive services. The result is a system that responds to disease once it becomes severe, rather than preventing escalation. From an economic standpoint, this represents a suboptimal allocation of public resources.

6. Public Finance Implications

From a system perspective, analyses of publicly financed cancer care indicate that late-stage treatment episodes cost two to three times more than early-stage interventions, placing disproportionate fiscal pressure on public hospitals and insurance schemes when diagnosis is delayed.

Higher Fiscal Burden:

Government hospitals and publicly funded insurance schemes incur higher costs per patient when treatment begins at advanced stages. These expenditures strain limited health budgets and reduce fiscal space for other priorities.

Insurance Design Challenges:

Public health insurance schemes face greater financial risk when a large share of claims arises from late-stage treatment. High-cost claims increase variability and threaten long-term sustainability. Early detection, by contrast, improves predictability and cost containment, strengthening insurance design.

Opportunity Costs:

Resources devoted to expensive late-stage treatment inevitably crowd out other investments. Funds spent on tertiary care could otherwise support preventive services, primary healthcare strengthening, or non-health public goods. Late diagnosis thus imposes

opportunity costs that extend beyond the health sector.

7. Early Detection as a High-Return Economics Investment

WHO guidance on cancer control emphasises that early diagnosis is among the most cost-effective strategies for reducing cancer mortality, as it improves survival while lowering the intensity and cost of treatment.

Screening and Prevention as Public Goods:
Cancer screening exhibits characteristics of a public good. It generates positive externalities by reducing the disease burden, lowering treatment costs, and preserving productivity. Private markets tend to underprovide such services, justifying public investment.

Cost Containment Through Early Action:
Early diagnosis reduces treatment complexity, shortens care pathways, and improves survival. From an economic perspective, it lowers both average and marginal costs of care. Investments in screening and awareness, therefore, yield high returns by preventing escalation into costly late-stage disease.

Distributional Benefits:
Early detection disproportionately benefits disadvantaged populations by reducing catastrophic expenditure and improving survival. It thus advances both efficiency and equity objectives, making it a particularly attractive policy intervention.

8. The Role of Data and Surveillance

Reliable data is essential for effective economic and and health policy. Cancer registries and surveillance systems provide insights into incidence, stage at diagnosis, treatment patterns, and outcomes. These data enable the identification of diagnostic delays, regional disparities, and system bottlenecks. From an economic standpoint, health information systems are a form of infrastructure. They support evidence-based decision-making, efficient resource allocation, and accountability. Without robust data, policies risk being reactive and inefficient. Population Based Cancer Registries (PBCRs) under the National Cancer Registry Programme systematically collect data on all new cancer cases occurring in geographically defined populations. As per the National Centre for Disease Informatics and Research (ICMR-NCDIR), these PBCRs cover about 18% of India's population, forming the core evidence base for nationwide cancer incidence and mortality estimates.

9. Policy Implications: Reframing Cancer Control as an Economic Strategy

Reframing late cancer diagnosis as an economic problem leads to several policy insights:

- Early detection should be viewed as economic risk mitigation, not merely a health intervention.
- Strengthening primary care and referral systems can reduce transaction costs and diagnostic delays.
- Investments in screening and awareness yield high economic returns.
- Financial protection mechanisms must address long-term and indirect costs of cancer care.
- Health data systems are essential for informed economic governance.

These measures are not solely health-sector reforms; they are integral to a sustainable growth strategy.

10. Conclusion

Late diagnosis of cancer in India highlights the substantial economic implications of timing within health systems. When cancers are detected at advanced stages, costs rise, productivity declines, and financial pressures on households and public resources intensify. These outcomes, however, also illuminate a clear opportunity: earlier detection and timely intervention have the potential to generate meaningful health gains while improving economic efficiency.

Viewed through an economic lens, cancer care is not solely a matter of clinical management but also of strategic investment. Strengthening early diagnosis pathways, improving access to screening, and enhancing referral systems can preserve productive years, reduce avoidable financial hardship, and optimise public spending. In this sense, the economic cost of delay underscores the value of timely action. Recognising early diagnosis as an investment in human capital rather than merely a health-sector expenditure offers a constructive pathway toward a more efficient, equitable, and resilient development trajectory for India.

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National Pension System and Structural Transformation of India's Financial and Fiscal Architecture: Capital Formation, Market Deepening and Intergenerational Sustainability

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ABSTRACT

India's transition from the unfunded Old Pension Scheme to the funded, defined-contribution National Pension System (NPS) is changing a key element in the structural design of fiscal public finance. This paper attempts to analyse the reform from an economic point of view to understand the fiscal justification, the macroeconomic effects, the reform's impact on household financial savings and the capital market. With the help of macro-aggregated data on GDP, gross financial savings, pension assets and the savings composition of financial instruments, the authors show how the NPS has developed into a systemically important domestic institutional investor. Between the years of 2010-11 and 2024-25, there was an increase in NPS assets from 0.11% of GDP to 4.34%, and in gross financial savings from 0.47% to almost 8%. At the same time, there was an increase in the market-linked savings instruments and a relative decline in the deposit-based savings instruments. The study concludes that NPS has helped in achieving fiscal sustainability by placing a cap on implicit pension debt. The NPS gives domestic bond markets a stable long-term investor, which decreases the need to rely on foreign portfolio investment, which can be volatile, and overall, the NPS has helped to provide financial stability. The Indian experience exemplifies the fiscal reform, financial development and demographic transition converging in the developing economies.

Keywords: National Pension System, fiscal sustainability, pension reform, domestic capital markets, demographic transition, intergenerational equity

JEL Classification: H55, H63, G23, E62, J26

1. Introduction

The dual functions of modern welfare states' pension systems are distributive and macro-fiscal. The distributive function gives old age income security to the older sections of society and reduces the vulnerability of those who have exited the formal labour sector to provide a smooth consumption function over their life cycle. However, for the macro-fiscal function, the pensions constitute an often large part of the public expenditure wherein these are the explicit and implicit liabilities within committed expenditure, alongside salaries and interest. Thus, the design of a pension system has long-term implications that extend to social protection, intergenerational equity, public debt sustainability and the allocation of fiscal resources to balance current consumption and capital formation.

In India, the imbalance of these fiscal dynamics was most visible under the Old Pension Scheme, which is a non-contributory and defined benefit scheme for the

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Government employees recruited before January 1, 2004, wherein it had a pay-as-you-go financing from current revenues. Benefits were inflation-indexed and linked to a last-drawn salary, but there were no assets accumulated for employees during working life. Consequently, pension liabilities were not explicitly stated as public debt but instead resulted in the steadily increasing revenue expenditure, which created implicit future taxpayer liabilities.

The 1990s saw an intensification of structural and fiscal pressures. Multiple factors contributed to the increase in the outflow of funds for pensions to the government, as a result of rising life expectancy and demographic ageing, expansion of public employment in the preceding decades and multiple revisions of the pay commission. Even with developmental priorities that required larger fiscal space, the Central Government's pension expenditure as a percentage of the GDP doubled between the early 1990s and the early 2000s. These trends illustrate the challenges of sustainability with an unfunded defined benefit system.

It was in this background that the need for NPS was necessitated for the newly appointed Central Government employees, effective January 1, 2004. By 2009, it had been extended to the majority of the State Governments along with the private sector and the general public on a voluntary basis. This reform constituted a remarkable departure from the system of unfunded defined benefits to a system of funded defined contributions. Under the NPS, retirement accounts are maintained by contributions from employees and employers and the balances are invested by pension funds, which are regulated by the Pension Fund Regulatory and Development Authority (PFRDA), in various financial instruments. This shift reduced the state's unfunded fiscal liabilities and increased long-term savings, as benefits were more closely aligned with an individual's contributions and the performance of the investment.

For more than two decades, NPS has become a pivotal part of the Indian financial ecosystem. The passing of the PFRDA Act, 2013, established the regulator's statutory framework and reinforced the institutional structure of the intermediary`s framework, investment policies, risk management and protection of subscribers. New products such as the e-Shramik framework, the Multiple Scheme Framework (MSF) and the Atal Pension Yojana (APY) targeted the unorganised sector workers and improved the digital practices, which have improved access and operational efficiency. The recent implementation of the Unified Pension Scheme (UPS) and the deliberations around pension credits display the ongoing efforts to balance the predictability of benefits against the fiscal sustainability of a funded architecture.

Positioned against this institutional change, this paper attempts to answer four interconnected questions. First, how far has NPS been able to mobilise domestic capital for the long term, considering its growth, asset structure, and role in contractual savings? Second, what is the role of NPS in the development of domestic financial markets, and how do its investments in government securities, corporate bonds and equities affect the liquidity and yields of the different segments of the capital market and the overall stability of the capital market? Third, has the transition from OPS to NPS contributed to long-term fiscal sustainability through the reduction of implicit pension liabilities and the enhancement of intergenerational equity? Lastly, how effective is NPS in the context of the pension

system coverage and financial inclusion in an informal and volatile income economy, particularly regarding the growth of subscribers, contributions, and retirement savings? All these are contrasted to the growth of the economy and to the structure of formal and informal employment.

2. Capital Mobilisation & Domestic Savings

Over the past 15 years, NPS assets growth has marked a change in the direction of household savings and shifts in the behavioural patterns of institutional investors. The growth in the size of NPS assets has expanded at a much higher rate than that of GDP growth. This shows the development of a new formal and market-based retirement savings system in the economy. While India's total financial savings have remained approximately 10-12% of GDP, the share of NPS has increased significantly from less than 0.5% in 2010-11 to 8% in 2023-24. This has been due to the fact that new recruitments for the Government sector need to mandatorily enrol in the NPS, whereas for the private sector, it has been seen that there has been a gradual increase in voluntary participation. This has been complemented by regulatory changes, improvements in investment performance and there has been an increase in awareness of longevity risk.

Analysis of savings behaviour since 2010-11 identifies three interrelated yet analytically distinct trends. These trends are macroeconomic stability of aggregate financial savings, a sharp increase in the uptake of the NPS and a quantifiable change in the household financial intermediation that shifted towards market-linked instruments of longer duration and higher risk. Nominal GDP between 2010-11 and 2023-24 grew at a CAGR of approximately 11.14 per cent, and in the same period gross financial savings (GFS) demonstrated a CAGR of 11.48. This indicates that although there are cyclical variations, the savings rate in the economy has remained stable. For most of this period, the GFS as a share of GDP was pegged between 10-12%, further indicating the structural resilience of household behaviour. The most significant divergence from this was in 2020-21 when GFS increased in an unprecedented manner (15.26 % of GDP). This was a result of increased economic uncertainty, income instability, and mobility concerns stemming from the COVID-19 pandemic. By 2023-24, this normalised to 11.39 % of GDP, indicating that this deviation was cyclical and not structural.

Table 1: NPS as % of GDP and GFS

Year	GFS/GDP (%)	NPS/GFS (%)	NPS/GDP (%)
2010-11	10.94	0.47	0.11
2015-16	10.86	2.53	0.86
2020-21	15.26	5.2	2.9
2023-24	11.39	7.95	3.87
2024-25	NA	NA	4.34

Source: Handbook of Statistics on Indian Economy, RBI, Author's Calculation

NPS assets showcase a disproportionate increase over the years compared to the GFS ratio. NPS assets increased by roughly at 38.6% CAGR since 2010-11. This number is far greater than the growth of GFS and the nominal GDP. This growth increases NPS's share of GDP from 0.11% in 2010-11 to 3.87% in 2023-24 and a projected 4.34% in March 2025. This shows the NPS to GDP ratio has increased over a span of 15 years, showcasing asset deepening. This was also the

case in the NPS share of gross financial savings. In 2010-11, NPS accounted for less than 0.5% of GFS, eventually reaching 7.95% by 2023-24. This means that compared to fewer than 0.5% of the GFS at the start of the decade, almost 8% of the GFS were being invested through a retirement vehicle in 2023-24.

The trends are indicative of a shift in how households distribute their financial portfolios and not merely a statistical change. The GFS as a percentage of GDP remaining relatively constant indicates that the rapid NPS growth has occurred as a result of compositional substitution rather than an increase in savings. The NPS has been progressively capturing financial savings flows, a departure from conventional deposit-based and administratively priced instruments to a greater degree, market-based, diversified and linked to retirement accounts. These transformations are associated with financial sector reforms, digital onboarding with a simplified procedure, tax incentives under Section 80CCD and mandated coverage of new Central and State Government employees, which have been in place since 2004. The implementation of auto-choice lifecycle funds (which adjust equity and debt based on the age of the subscriber) has also improved the suitability and alignment with the risk of the funds.

The factors driving the growth of NPS can be classified as policy, institutional and behavioural. Regarding governmental policy, the shift from a DB to a DC scheme created a continuous line of contributions from new government sector recruitments. Since the expansion to the private corporate sector and the provision of voluntary participation from the year 2009, the scheme's participation has increased. The APY also provided participation from lower-income and informal sector workers. The provision of an additional tax deduction under Section 80CCD(1B) has provided a financial reason for voluntary participation.

Regarding institutional factors, the growth of digital systems has played an important role. The eNPS system, Aadhaar authentication, integration of eNPS with fintech systems, and low management fees have together lowered the costs of transactions and improved the ease of use of the products under the NPS architecture. The comparable low cost structure with those of similar multi-asset allocation products, when taken over a long period of time, helps improve net returns on investment products. In line with the behavioural factors, the consistent returns over the long term of the equity-oriented funds and the increase in awareness of the impact on life expectancy, as was showcased by the pandemic, have reinforced the decision of people to invest in retirement savings over short-term savings.

Examining the structural rebalancing in other household financial instruments offers further clarity. In the pre-2010 period (1995-96 to 2009-10), the small savings schemes and bank term deposits grew at CAGRs of 13.96 and 17.26 per cent, respectively. This shows the preference of household portfolios for fixed income, capital-protected instruments. However, in the post-2010 phase (2010-11 to 2023-24), small savings and bank term deposits recorded a growth of 8.65 and 11.57 per cent, respectively. The deceleration in growth is conspicuously visible when compared to the expansion of market-linked instruments. During the same period, mutual fund AUM grew by approximately 17.12 per cent, and the NPS recorded a staggering 46.19 per cent in the earlier years of high growth, followed by a range of 38-39 per cent in the recently consolidated period. This growth divergence suggests

both higher nominal growth, as well as a growing willingness of investors to bear risk in capital markets for longer duration investments.

Table 2: % Share of savings in various financial instruments

Year	Small Saving Schemes of the Post Office	Banks' Time Deposits	AUM of Mutual Funds	Life Insurance Premium	AUM of NPS
2010-11	10.20	75.12	9.74	4.80	0.14
2015-16	6.28	77.86	11.38	3.39	1.09
2016-17	5.82	75.48	13.98	3.33	1.39
2017-18	5.87	73.46	15.60	3.35	1.71
2018-19	6.05	72.85	15.67	3.35	2.09
2019-20	6.64	73.57	13.70	3.53	2.56
2020-21	6.68	70.27	16.66	3.33	3.05
2021-22	6.96	68.41	17.86	3.29	3.49
2022-23	7.08	68.61	17.05	3.38	3.87
2023-24	6.85	66.21	19.61	3.05	4.29
CAGR % (2010-11 to 2023-24)	8.65	11.57	17.12	8.37	46.49

Source: Handbook of Statistics on Indian Economy, RBI, PFRDA

The rise of NPS has significant implications of structure from a macroeconomic point of view. NPS assets are projected to be around 4.34 per cent of GDP during 2024-25, and comprise a significant pool of long-gestation domestic capital. Considering regulatory investment norms, a significant portion of these funds is invested in government securities, state development loans and high-quality corporate bonds, therefore establishing a consistent demand for sovereign borrowings and corporate debt issuances. Such a sustained domestic institutional engagement reduces the reliance on volatile FPIs & FIIs and has the potential to cap the long-term sovereign yields during an external financial stress. Furthermore, the diversified portfolio structure that includes government securities, corporate debt, and equities, including gold, silver, REITs, and INVITs, aids in the balanced growth of the capital market and avoids the crowding out of private sector credit.

The combination of stable total savings rates and increasing NPS penetration points to an evolution of financial systems from intermediation, which was predominantly towards banks shifting towards the capital markets. The increase in the share of NPS relative to GDP and GFS shows the deepening of financial systems, combined with the incorporation of retirement savings into household savings and investment portfolios. If the NPS coverage gaps, especially for informal and self-employed workers, start closing and voluntary contributions increase, the NPS share of GFS could exceed ten per cent in the medium term, substantially changing the trajectory of long-term capital formation in India and old age income security. The evidence thus indicates structural transformation rather than cyclical rebalancing, wherein a stable macro-saving base moves towards a reallocation from informal saving to funded, regulated retirement accounts, wherein the NPS has become a systemically important institutional investor.

Examining household financial assets from 2010–11 to 2023–24, we see similar trends for these years. A typical savings vehicle, being used as a bank time deposit, has seen its usage rates go from 75.12 per cent down to 66.21 per cent. This trend helps demonstrate the rapid deposition rates growing at a consistent 11 per cent annual rate. In contrast to this, other instruments (especially mutual funds and NPS) have increased more rapidly. This shift is also seen against a background of consistent growth of nominal GDP, a prolonged period of low to moderate rates on deposits, a decrease in compression of real rates of return and a change toward a more diversified portfolio.

For small savings schemes, the postal savings scheme has seen a small decrease in inter relative importance in usage schemes to 10.20 per cent, to 6.85 per cent, over that same period of time. Though a means of risk-

averse saving, this element of an administered part of the market yields seem to be advantageous towards young people who have long investment horizons.

Another important component of contractual savings, which is life insurance premiums, experienced a slight decline in its composition. Their contribution to total financial assets declined from 4.80 per cent to 3.05 per cent, even with nominal growth. While insurance is important for risk protection, relative to market instruments, the role of insurance in a savings portfolio has been declining.

The trends noted here can be considered as the beginnings of a household financial intermediation rebalancing. That is, a shift from administratively priced, deposit-driven instruments to more equitable, market-based and diversified instruments linked to institutions such as NPS. By comparison, mutual funds and the NPS have continued to grow strongly. From the financial year 2010-11 to 2023-24, the AUM of mutual funds more than doubled, increasing from 9.74% to 19.61% of all financial assets. Over this period, the AUM of mutual funds grew at a CAGR of 17.12%, which is more than the growth rates of GDP and bank deposits. This rapid growth has partly been due to Systematic Investment Plans. Monthly SIP inflows have hit ₹31,000 crore by the end of 2025. Retail investment in equity and debt markets has been transformed by SIPs from casual participation through lump sum investments to regular, disciplined investments through systematic investment plans, leading to much greater participation. The growth of NPS has been even more significant, albeit benefiting from a base effect phenomenon. NPS AUM constituted only 0.14 per cent of total financial assets during 2010-11. This proportion increased to 1.09 per cent in 2015-16, and 4.29 per cent in 2023-24. NPS recorded a CAGR of 46.49 per cent, which is the highest across all major financial instruments. While part of this growth can be attributed to the base effect, the continuous high double-digit growth over more than a decade suggests structural changes rather than a temporary acceleration. Significantly, the NPS share increase occurred in a period where the financial savings to GDP ratio was stable, suggesting a savings portfolio shift rather than an increase in overall savings.

Analysing the data, it supports the hypothesis of a gradual evolution in the instrument composition of financing, starting from short-term, administrative and bank-dominated savings instruments, followed by a transition towards longer-term market-linked instruments. This evolution has been documented in the literature of pension and financial sector reforms. Gillingham and Kanda, as well as Asher, identified the pre-reform weaknesses in India's pension and provident systems, particularly in the absence of a negative/real return, and the investments were diversified. The regulation of investments, the quasi-fiscal use of accumulated balances and a lack of transparency in performance measurement were most notably the issues that were highlighted. Government Securities were primarily invested in, and there were no clear benchmarks to evaluate performance.

The NPS framework was able to address these weaknesses by achieving benchmark transparency, daily NAV transparency and competition amongst pension funds. The asset allocation framework, rules-based trustee fund management and professionalised management of funds addressed these weaknesses by dividing investments across equities, corporate debt and government securities under the terms of the investment

guidelines with a risk-based mechanism and lifecycle adjustments. The auto-choice option, in particular, allows for age-determined alignment of equity investment and proximity to retirement, thereby risk-adjusting equity to the protection of invested capital through diversified investment with aligned risk and regulatory oversight. Research shows that NPS equity-based schemes have given a CAGR of 12–14 per cent on average in the long-run, which is higher than the average bank deposit rates for the same duration. Even NPS debt-based schemes have been competitive, especially considering NPS has one of the lowest expense ratios for the fee charged by the pension funds for the management of the AUM of the subscriber. This means that their cost structure is extremely beneficial for long-term investors.

On the macro-financial scale, the growth of the NPS and mutual funds has solidified the institutional investor base and deepened the Indian capital markets. Long-term contracts in the form of retirement funds create a steady demand for government and corporate bonds, which helps stabilise the impact of foreign capital flow volatility. This is in line with the diversification from bank deposits, which can improve the intermediation structure and decrease the concentration risk in the banking system. This all shows that the NPS has evolved the structure of retirement savings towards a system that is more funded, regulated and professionally managed.

3. Financial Market Deepening & Capital Market Stability

The expansion of NPS should not be viewed exclusively as an NPS reform, but rather as a signal that NPS is reshaping the financial market by deepening the stabilisation of the capital market. NPS is, by design, a funded DC scheme wherein the liabilities have long durations as retirement payouts span several decades. Such a liability profile mandates an asset-liability matching that is contingent upon the investment of such funds in long-term or long-duration financial instruments. Accordingly, NPS subscribers are required, by scheme design, to invest in a diverse portfolio that includes Government securities, high-grade corporate debt bonds and equity. The structural alignment of long-term liabilities and long-term assets makes NPS the most appropriate institution for absorbing duration risk in the Indian financial system. The stabilising function can also be seen in the data for portfolio composition. More than 54% of total NPS assets are Government securities and sovereign instruments such as SDLs. With pension funds regulated by PFRDA around ₹8 trillion in Government securities as of December 2025, NPS is structurally significant in participating in India's public debt market, and this level of participation is significant relative to the Central Government's annual gross market borrowings. NPS provides a stable long-term investor base and, by doing so, decreases rollover risk, aids in the implementation of maturity extension strategies and reduces volatility in the secondary market, particularly during FPIS and FII outflows and global volatility.

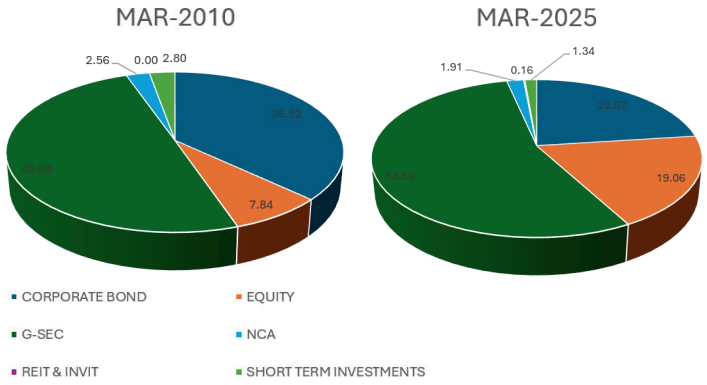


Figure 1: Comparison between allocation of NPS funds in various financial assets

Source: PFRDA

The expansion of NPS poses significant macro-fiscal implications. A government bond market funded domestically and being sensitive to institutional investors, NPS investment enhances fiscal resilience. With stable and sustained demand from the domestic market, the government can be less vulnerable to external capital flows, enhancing its ability to stabilise its fiscal position in the medium term. Compared to other investors, pension funds are more likely to remain in a market for a significant period, which diminishes short-term changes in yields due to a reduction in market demand. International examples indicate that funded pensions increase participation in government bond auctions, improve pricing and increase the liquidity of the long-term bonds, which is of relevance to the current situation in India.

NPS's stabilising effect is not limited to sovereign debt. Investment regulations grant investments in NPS into high-quality corporate bonds and securities listed in the top 250 of the equities market (NSE). The bond and equity holdings are expected to position the NPS as one of the significant domestic institutional investors in the capital markets.

Through the corporate debt market, NPS helps to diversify away from a credit intermediation system dominated by banks. India's financial system has historically depended on banks for corporate financing. With NPS, there is a growing demand for corporate bonds, including those with longer terms that are necessary for financing infrastructure. When pension funds participate, there is a positive impact on the volume of debt issued, the discipline of disclosure and the transparency of pricing. NPS adds to the equity markets by providing capital that is stable and has a longer duration. Exposure limits in the early stages are more conservative from a prudential standpoint. Lifecycle funds are designed to reduce equity exposure as one approaches retirement and reduce their impact on the portfolios owing to any volatility.

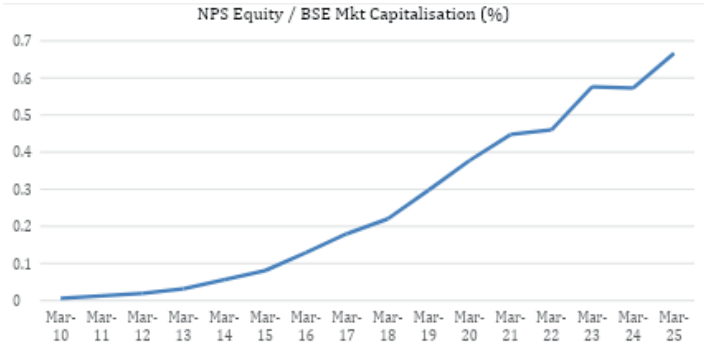


Figure 2: % NPS equity investment to BSE Market Capitalisation

A major part of this liberalisation occurred in June 2019 when PFRDA expanded the Active Choice equity ceiling from 50 per cent to 75 per cent. This reform substantially increased the potential growth in the portfolios of the younger subscribers, contributing to the rapid increases in the equity part of AUM, which has since then grown at a compound rate of more than 50 per cent since inception. Further innovation occurred in October 2025 when the MSF was introduced, allowing schemes to have 100 per cent equity allocation for aggressive investors, especially those in the long accumulation phase and higher risk appetite. It is important to note that in the LCs, protections and guardrails are embedded, wherein at the age of 50 and above, equity exposure is reduced annually by 2.5 percentage points, down to 50 per cent by age 60. This glide path approach retains the optimal risk management and ensures participatory growth.

NPS has a threefold impact on fiscal financing, corporate capital formation and the depth of the equity market, as it allocates funds across government securities, corporate bonds and equities. In contrast to

short-term bank deposits, reprising or withdrawing the entire sum is not a possibility for a long term (at least 15 years) with respect to NPS contributions. This characteristic affords systemic term transformation, as it effectively integrates household savings to long-term assets needed for the development of infrastructure, the expansion of industry and the borrowing of a government, without posing liquidity mismatches.

NPS has made institutional depth to the financial market infrastructure by its unbundled structure of pension fund managers, custodians, central recordkeeping agencies, trustees and distribution channels via the points of presence and others. This structure and the robust settlement, cybersecurity, supervisory and data management systems of the unbundled NPS architecture have allowed depth to institutional systems, which generate positive spillovers to the financial system, resulting in improved operational resilience and regulatory coordination. Governance and market discipline have been further strengthened through the open disclosure of NAV and performance evaluation.

Continued market development has been facilitated by the NPS's gradual liberalisation of investment norms. Broadening the investment universe to Nifty250 has allowed for diversification beyond the large-cap stocks into the mid-cap stocks with prudential guardrails and robust regulatory structure. The infrastructure investment exposure is also provided through the InvITs and REITs, which allow for controlled investments. The NPS serves as the infrastructure investment portal of the country, wherein the pension savings are aligned with the national infrastructure priorities.

For macroeconomic purposes, NPS assets of over 4% of GDP indicate expansion of India's domestic institutional investor base. With pension assets having a long-term horizon, they act as a counterweight stabiliser as their value provides a steady flow during global financial stress periods. Also, they increase transmission of monetary and fiscal policies by providing stability during yield curve shifts and supporting a country's credibility regarding management of debt in the medium-term. Overall, NPS is a reflection of financial deepening. It shows a dynamic regulatory effort in balancing growth, stability and retirement security through the evolution of conservative allocation caps to more diversified and market-linked portfolios.

4. Fiscal Sustainability & Public Finance

Govt. employees who were recruited before January 01, 2004, were placed under the OPS, wherein retirement benefits are non-contributory and with defined benefits. Employees are entitled to a pension that lasts a lifetime and is eventually extended to their spouse as well. The pension is 50% of the last drawn basic salary and is subject to dearness relief to account for inflation. The pension was financed on a PAYG scheme with no prior savings on the part of the employee, as there were no contributory assets to fund the same. There were no systematic evaluations for the actuarial value of the pension liabilities on future public bios. The liabilities would remain unrecorded on the books of the government.

Unfunded defined benefit plans create, for example, negative pension debt, an amount the agency debtors promise to pay future employees, but do not pay,

thereby creating a debt that must be paid from future cash flows. Implicit pension debt is not recorded like other sovereign debts. Unlike other sovereign debts, however, implicit pension debt constitutes a legal claim against future cash flows. Where life expectancy continues to increase, coupled with low effective retirement ages and wage increases due to resignations and reappointments to new positions, pension debt will grow rapidly and control future cash flows. Where pension plans are exceedingly beneficial, and the benefit structure is not strongly aligned to contributions, the problem is compounded.

The earliest studies on the pension system in the country identified such issues. In the early 2000's, studies showed that the portion of public pension expenditures within the country, the percentage of total government expenditures and the civil service pension payments under the OPS were steadily increasing. The studies emphasised that pension commitments were revenue consumptive and that the country would ultimately be unable to economically develop due to a lack of physical infrastructure, uninvested social capital and underdeveloped social services. As a result, the OPS pension obligations became an extremely fiscally binding constraint on the country's public civil service pension obligations.

The macro-fiscal perspective is further reinforced by state finances. Subnational debt dynamics reveal that pension payments, as well as salary and interest payments, are a notable element of committed expenditure in a number of states. In certain states, there are concerns that pension payments are an increasing concern with respect to revenue receipts and Gross State Domestic Product, thus constraining fiscal space for capital expenditure. Under unchanged policy projections, it is evident that there are no reforms to mitigate the fact that pension payments will, increasingly, be a dominant component of state expenditures, invariably increasing the risk to debt sustainability and reducing the scope for expenditure on development.

Recent analytical studies by Dongare and Singh *(Unpublished)* use actuarial methods to model potential fiscal burdens under OPS and NPS scenarios, creating a more refined comparative assessment. These studies project pension obligations over decades using individual-level contribution data and assumptions about salary growth, improvements in longevity and discount rates. Findings indicate that reverting to OPS across states would yield total fiscal burdens several times greater than remaining in the funded NPS. This difference occurs because, with demographic ageing and wage indexing, OPS liabilities grow, while NPS obligations are largely prefunded due to defined contributions and investment returns. The fiscal gap is greater in states with higher longevity and more rapid wage growth, which demonstrates the vulnerability of unfunded defined benefit systems to macroeconomic and demographic changes.

Additional data via modelling state-specific record-level NPS statistics presents pension cash-flow-out predictions under OPS-equivalent benefit formulas for funded NPS paths. The modelling presents much greater fiscal costs long-term with OPS-based commitments, especially with future longevity increases factored into the actuaries' projections. Also, the political phenomenon of temporarily suspending or delaying employer contributions to the NPS can diminish the discipline of prefunding and increase fiscal impacts. The research demonstrates the

importance of the sustained discipline of contributions to the unfunded and funded regimes.

Fiscally stressed demographic shifts are rapidly becoming a defining characteristic of India's economy. For instance, India's population aged 60+ is growing more rapidly than the total population. Moreover, India's population is projected to become older in the coming decades. Now, while India is still considered younger than the advanced economies, the old-age dependency ratio is expected to rise structurally. Given these circumstances, an unfunded DB scheme focused on a small segment of Government employees creates multiple intergenerational inequities from a wide tax base to a small beneficiary group. The transfers have a significant opportunity cost as tax resources allocated to civil service pensions are resources that could go to expanding the coverage for more elderly people who are outside the formal systems or to fund developmental public investment.

These fiscal and demographic considerations provided the primary rationale for moving from the OPS to the NPS. For instance, new government entrants from 2004 onwards have had the introduction of NPS, which replaced open-ended promises of benefits with a defined contribution and funded approach. With the NPS, retirement benefits are determined by a person's lifetime contributions and the performance of the investments made, which in turn diminishes the growth of implicit pension debt and ensures fiscal predictability. Although the structural change carries a 'double burden' by paying for legacy OPS pensions while also paying into NPS accounts for new recruits, the long-term outlook is, nonetheless, more predictable and contained under NPS.

The announcement of UPS in January 2025 for eligible central government employees signifies a further advancement in pension design. UPS, which is implemented through amendments to the NPS regulations, is the first operationalisation of a hybrid approach to pension design by introducing defined benefit-like features within the funded approach. This approach responds to concerns regarding the adequacy and predictability of benefits in a system reliant solely on defined contributions. As such, the UPS may be understood as a hybrid approach by incorporating some guarantees within an asset-backed approach.

In contrast to OPS, UPS does not revert to an unfunded pay-as-you-go structure. Instead, it makes use of the NPS institutional framework concerning regulated fund management, individual accounts, and clear valuation of assets, along with some adjusted benefit guarantees. The state takes on further, clear commitments that are aimed at fostering certainty of income, but these are set within a prefunded ecosystem rather than open-ended implicit obligations.

For policymakers, the central analytical challenge is to distribute economic benefit certainty and sufficiency without reproducing the fiscal risks of OPS. The international empirical evidence on hybrid models shows that when clear funding and actuarial discipline are used, sufficiency, risk-sharing, and sustainability are achievable. The most important long-term fiscal implications of UPS will critically depend on contribution rates, the guarantees offered and the extent to which more obligations are explicitly funded rather than left deferred.

Looking at the OPS, the concentration of longevity and

wage-indexation risks on the public purse created large implicit liabilities and limited fiscal space. With the NPS, investment and longevity risks were partially transferred to individuals, but there were gains in transparency, overall system sustainability and in the development of the relevant segment of the capital market. The UPS attempts to rebalance this by offering limited design guarantees within a (partially) funded system. For pension reform to be sustainable, the principles of actuarial transparency, explicit recognition of contingent liabilities, disciplined (self) contributions and a fiscal commitment to a funded system that is aligned with the prevailing demographic realities must be present. Only then can the pension system design fulfil the objectives of adequate retirement income, intergenerational equity and economic growth.

5. Financial Inclusion & Institutional Development

India's demographic transition provides a macroeconomic valuation for the growth and scenario analysis for the sustainability of NPS, driven primarily by the demographic transition of India. With the onset of positive demographic transition in India during the last 15 years, the country is witnessing growth in the working-age population (15-59 years). India's working-age population (i.e. 15-59 years) is expected to cross 914 million by 2025, an addition of almost 180 million potentially gainfully employed persons during a span of 14 years (2011-2025). India is one of the small set of developing economies which is likely to experience the most pronounced growth in the working-age population.

The two primary macroeconomic effects of this demographic growth focus on the increasing working-age population and its effects on contributory bases and the sustainability of the system. Funded and defined benefit NPS architecture is dependent on a DC framework, wherein increased participant cohorts lead to greater inflows. This, in turn, reinforces the effects of compounding and improves the NPS sustainability and its ability to support multi-asset allocation strategies. Additionally, the growing demographics correlate with gradual population ageing and will lead to a significant structural shift. This gradual change will be felt more in India than in other developing countries as the old-age dependency ratio increases. This demographic window currently has a high ratio of working-age populace to population of dependents and reflects a growing opportunity to financially prepare for the impending ageing pressures.

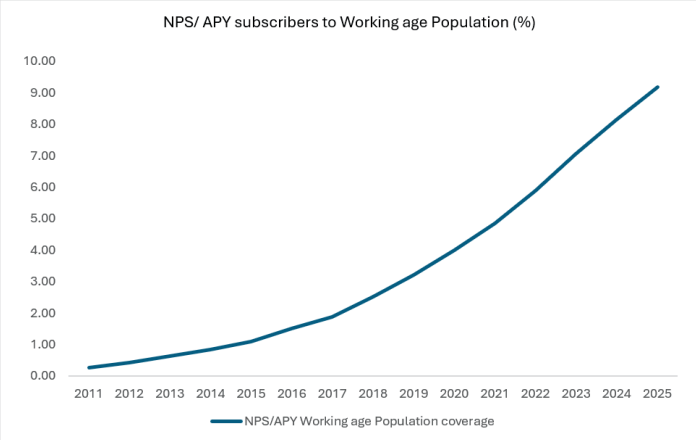


Figure 3: % of NPS/APY subscribers to Working Age Population

Pension penetration, which started from low levels at the inception of NPS, has been correlated with increase with the increase in the demographic scale. The working-age coverage of the NPS increased from 0.25 per cent in 2011 to 9.19 per cent in 2025. This translates to an increase in the number of subscribers from 87.5 lakh in March 2015 to 198.6 lakh in March 2025, which is an 8.5 per cent CAGR under NPS. This level of progress provides evidence of improvement, but also shows a high level of potential left to be realised. Even with working-age coverage of 9.19,

more than 90 per cent of this population is left outside of the NPS. The formalisation and enrolment of this segment will have a positive impact on the accumulation of long-term capital, and the NPS will also contribute to the domestic capital markets.

In India's evolving economy, demographic shifts and labour market structure changes interact closely, particularly in how informal work and weak employer-employee relations impact employer attachment and engagement in formal systems (i.e. the financial system, regular banking). Such environments create barriers for formal pension systems anywhere and lead to pension coverage remaining low and fragmented. An account-based pension scheme's regular contributions are dependent on the scheme's members maintaining a stable income (contributions) and being able to continue income (i.e. long-term horizons/accumulation), as well as active participation and placement of all the necessary system structures (identity, record keeping and payment systems) in place to support mobility.

In response to these informal employment challenges, policymakers created hybrid layers of pension systems that incorporate components of both social and pension schemes. The pension scheme, Atal Pension Yojana, is a hybrid system and has social scheme benchmarks as it is designed for the low-wage and informal sector populace. The scheme encourages participation via a government-funded pension where subscribers are required to pay a small contribution. Monthly government pensions of ₹1,000 to ₹5,000 are provided to subscribers after the age of 60. By the end of December 2025, APY reached 82 million enrollees, creating basic pension systems in vulnerable households financially. This form of layered policy provides the pension architecture wherein the NPS acts as a market-based, funded retirement option to formal and informal employees, while APY serves as the social safety net income support to low-income employees.

Segmentation-specific modifications within the NPS framework have incorporated the heterogeneity of the labour market. NPS e-Shramik (Platform Service Partner) model caters to gig and platform workers involved with digital aggregators. It uses aggregator interfaces, digital onboarding and facilitated worker contributions to reduce transaction costs and improve the continuity of contributions for variable employment. Another sector-specific modification is the introduction of the NPS Vatsalya. NPS Vatsalya is for minors and, through guardian-managed accounts, encourages early saving and increases horizons for accumulation.

Institutional outreach has bolstered innovation in the services offered. NPS operates through a multi-channel distribution system, including public and private sector banks, regional rural banks, non-banking financial companies, post offices, pension fund managers, fintech partners, etc. A high number of new private enrolments are coming through banks and their digital offerings. The e-NPS portal, Aadhaar-based e-KYC and online grievance redressal systems have reduced onboarding barriers and administrative costs, especially for users with digital literacy.

In addition to prudential oversight, PFRDA has taken a developmental approach to regulation. The combining of different circulars into Master Circulars on different themes and streamlined processes for reviews has increased the legal clarity and reduced the compliance

burden for the regulated entities. The NCFE and PFRDA's joint work emphasises the importance of awareness and the behavioural shift for a wide uptake of voluntary retirement savings, and as part of the Financial Literacy campaigns, integrating pension literacy into financial literacy projects has been given primacy.

Evaluating the quantitative metrics related to participation and accumulation allows us to assess the intricacies involved in the process of expansion and adequacy. Total contributions registered a growth from ₹64,177 crore to ₹9,99,243 crore between March 2015 and March 2025, recording a CAGR of 31.6 per cent. Contributions per subscriber have increased from ₹0.73 lakh to ₹5.03 lakh from 2015 to 2025, showing a CAGR of 21.3 per cent. Due to the divergence between the periods of subscriber growth (8.5 per cent CAGR) and growth within the total contributions (31.6 per cent CAGR), it can be inferred that participation within the subscriber base is deepening as existing subscribers are stepping up their contributions in NPS.

Table 3: No. of Subscribers under NPS and their contribution

Metric	March 2015	March 2025	CAGR (%)
Subscribers (Lakh)	**87.5**	**198.6**	**8.5**
Total Contributions (Rs Cr)	**64,177**	**9,99,243**	**31.6**
Contribution per subscriber (Rs. Lakh)	**0.73**	**5.03**	**21.3**

However, concerns about adequacy persist. From a relative perspective, the average accumulation per subscriber has increased significantly, but it is still low compared to the median income levels and adequacy replacement rate benchmarks. Given India's median annual income (approximately gross ₹3.5−4 lakh), it implies that the corpus necessary to provide sufficient post-retirement income (even assuming conservative, post-retirement annuity rates and considering rising life expectancies) is well above the current averages of most subscribers. This indicates that although both coverage and contribution levels have improved, there is a continued need for improvement in the area of contribution density, contribution continuity and voluntary contribution top-ups.

The most recent increase in the rate of contribution growth adds to the evidence of momentum. From 2024 to 2025, there was a nearly 10 per cent annual increase in the number of subscribers, while total contributions grew by about 22 per cent. This is indicative of a greater intensity and outreach to the informal and semi-formal sector. It appears that demographic changes, digital capabilities, regulatory changes, and deliberate measures to target the previously excluded are beginning to work together.

6. Conclusion

India's transition from OPS to NPS is indicative of the radical change taking place in public finance and policy. The transformation from unfunded defined benefits to funded defined contribution accounts was a consequence of increasing implicit pension debt and increasing fiscal rigidity. After a while, the reform has had macroeconomic consequences that go beyond what was initially intended. Furthermore, significant

shifts have been witnessed in household portfolios, as household portfolio restructuring shows NPS assets growing faster than GDP and GFS. Financial markets appear to be entering a phase of deeper development, as households gradually shift their savings away from traditional bank and small savings deposits toward products that offer market-linked returns, along with a willingness to commit savings for longer periods. This change reflects a growing preference of people beyond safe but low-yield deposits and shows greater confidence in diversified, long-term investment options that have the potential to generate higher returns over time.

NPS has grown to be one of the largest domestic institutional investors in the country, and the importance of NPS has positively affected the Government Securities market and Corporate Securities market, and it has also reduced the susceptibility of the country to foreign portfolio investments. The stability of the NPS has improved the stability of the economy as well as the stability of the government.

The challenges of expanding coverage to the informal sector and providing an adequate income during retirement are being addressed through the development of policies such as lifecycle funds, digital coverage and hybrid pension plans. India's pension system reform has proven that a well-designed system can increase a country's fiscal sustainability, the depth of the financial market, and promote financial stability in the long run. The evolution of NPS in India will be a key driver in determining the country's economy in the future.

Wealth Effect: The Impact of Capital Gains from Real Assets and Equities on Consumption and Aggregate Demand in India

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ABSTRACT

This study examines the impact of capital gains from real estate, gold, and equities on private final consumption expenditure (PFCE) in India, where household wealth is concentrated in tangible assets rather than equities as in advanced economies using a mixed-methods approach. A Vector Error Correction Model (VECM) analyses quarterly data from 2011–12 to 2023–24 to study long-run and short-run relationships among PFCE, GDP, gold prices, housing prices, and the Nifty 50 index. A primary household survey complements this by assessing perceptions of wealth changes, spending behaviour, realised and unrealised gains, and responses to interest-rate shifts.

The results confirm significant wealth effects. A 1 per cent increase in GDP raises PFCE by ₹17,313 crore, making income the strongest driver. A 1 per cent rise in the Nifty 50, housing prices, and gold prices increases PFCE by ₹7,942 crore, ₹6,491 crore, and ₹5,050 crore, respectively. The VECM forecasts PFCE accurately, with a −2.86 per cent error for Q1 FY 2025. Survey findings show that moderate interest-rate changes have limited immediate effects, though lower rates encourage shifts toward equities, gold, and real estate. Realised gains show weak correlation with spending, indicating that unrealised wealth changes exert a stronger influence. Policymakers should therefore monitor asset-price trends as early signals of shifts in aggregate demand.

Keywords: wealth effect, consumption, gold, stock market index, real estate

JEL Classification: R3, G1, H2

1. Introduction

The wealth effect refers to how an increase in a household's wealth can lead to higher consumption spending. When people see the value of their assets, such as real estate, stocks, or gold, rise, they feel more financially secure and are more likely to spend money on goods and services. This happens even if their current income doesn't change. As a result, rising household wealth can boost overall consumption and support economic growth.

This effect works in two main ways:

1. Direct effect: As asset prices rise, people may feel confident enough to spend more because their net worth has increased.
2. Collateral effect: Higher asset values improve household balance sheets, making it easier to borrow money. For example, if home prices go up, households may take loans against their property to fund additional purchases.

The reverse is also true: If asset values fall, people may feel less wealthy and cut back on spending, which can

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reduce overall demand and slow down the economy. In simple terms, the wealth effect shows how changes in people's wealth, not just their income, can shape how much they spend.

If rising wealth leads to higher consumption, this should push up aggregate demand and create inflationary pressure. To analyse the relationship between capital gains and consumption, secondary data will be used to track movements in real estate, gold, and stock market indices, and examine their cause-and-effect relation to Private Final Consumption Expenditure (PFCE). A key example of how asset values can affect consumption in the economy is the 2008 Global Financial Crisis, where the crash of real estate values triggered the recession in America.

The research also includes primary household surveys to determine the effects of perceived and realised capital gains/losses on spending changes and borrowing responses.

Gold Prices and Indian Consumer Behaviour

In India, gold is a significant asset for many households. Indian women hold 11% of the world's gold, which is more than the top five countries combined (World Gold Council,2023). When gold prices increase, families often feel a sense of increased wealth and may spend more on weddings and festivals, leading to a boost in consumption. Conversely, when gold prices drop, there can be a notable decrease in expenditure as households tighten their budgets.

2. Theoretical Framework

Earlier Keynesian models (Keynes,1936) suggest that consumption depends primarily on current household income. This formed the basis for traditional consumption functions where GDP was the main explanatory variable.

Later theories, such as the Permanent Income Hypothesis (Friedman, 1957) and Life Cycle Hypothesis (Modigliani, 1966), expanded the idea by suggesting that households base spending not only on current income but also on expected lifetime income and accumulated wealth (refer to section 3.1.1).

More recent macroeconomic models, particularly New Keynesian frameworks (Clarida, Galí, & Gertler, 1999; Woodford, 2003), incorporate financial market imperfections, interest rate channels, and asset price effects to explain consumption behaviour beyond income-driven models (refer to section 3.1.2).

This paper draws from this broader framework by treating Capital gains, GDP (Income), and interest rates as key explanatory variables for household consumption. In doing so, it extends the traditional income-based view by including additional financial drivers that are particularly relevant in the Indian context.

This study highlights the importance of improved tracking of asset price trends as potential leading indicators of consumption and demand. By analysing these wealth effects, we aim to provide a more comprehensive understanding of economic activity in India, where capital gains from real estate and gold play a significant role in influencing consumer spending.

2.1 Household Saving Behaviour In India

To understand the potential magnitude of wealth effects in India, it is important to first examine the composition of Indian household savings.

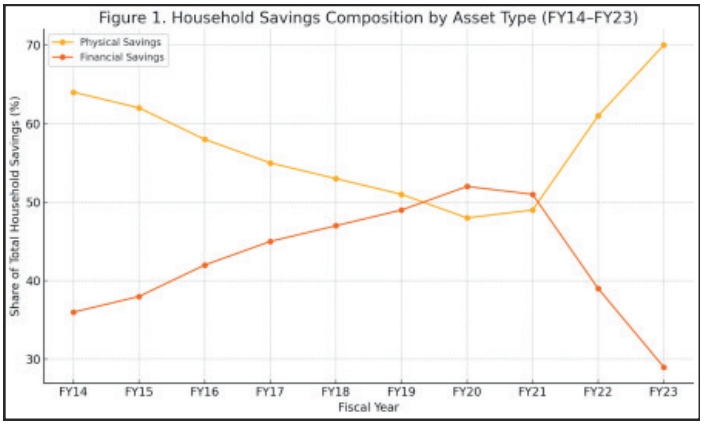


Figure 1: Household Savings Composition by Asset Type

Source: *RBI*

Over the past decade, the share of real assets within household savings has shifted significantly. It declined from approximately 64% in FY14 to a low of 48% in FY20, before rebounding sharply to 70% by FY23 (Reserve Bank of India, 2023).[2] Over the same period, the share of financial assets, including bank deposits, bonds, and equities, rose from 36% in FY14 to 52% in FY20, before falling back to about 30% by FY23 (Figure 1). Interestingly, there was a clear trend of households moving toward financial assets until FY20. However, the trend reversed post-FY20, with a renewed preference for real assets. One possible explanation is that uncertainty during the pandemic prompted households to prefer tangible physical assets like real estate and gold over financial instruments.

Note: *Direct data for the share of equities (stocks and mutual funds) was unavailable, although some sources suggest it rose from 1% in FY14 to 5% in FY23 (ASK Capital, 2025).*

An average of 57% across the last 10 years of total household savings has been invested into real assets (Figure 1), thereby highlighting the importance of studying the wealth effects arising from price changes in these assets, which constitute well over half of a household's wealth.

The rest of the paper is organised as follows. In Section 3, we review the literature covering theoretical and empirical studies, and in Section 4, we form the research framework by identifying gaps in previous studies and developing the methodology. Sections 5 and 6 include the formation and results of secondary and primary data, respectively, and Section 7 concludes and summarises the results of the research.

3. Literature Review

3.1 Theoretical Studies

3.1.1 Contemporary Keynesian Models

Keynes' General Theory (1936) asserted that consumption is primarily a function of current income, expressed by the equation:

$C = a + bY$

Where:

C = Consumption

a = Autonomous consumption (consumption at zero income)

b = Marginal Propensity to Consume (MPC)

Y = Current income

Keynes emphasised that $0 < b < 1$, indicating that although consumption increases with income, households tend to save a portion of any incremental income. Only income from productive activities [wages, rent, salary, interest, and dividends] is considered part of the Y component.

[2] Reserve Bank of India. (2023a). Database on the Indian economy. https://dbie.rbi.org.in

Hence, any changes in household wealth, whether realised or unrealised, would not affect Consumption (Keynes, 1936).

Building upon this, Friedman's Permanent Income Hypothesis (1957) argued that households base their spending not only on current income but also on expected long-term income. For example, if a person receives income only on Fridays, we do not expect them to consume only on that day. Hence, expected future income influences current consumption.

Friedman's model divides income (Y) into two components:

Y = Permanent income

Y_t = Transitory income

Only Y affects consumption. Persistent capital gains (e.g., multi-year appreciation in real estate or steady dividends) would raise Y and increase consumption, while short-term gains, like brief spikes in equity prices, would be classified as Y_t and have little effect. The model does not distinguish between realised and unrealised gains but considers them only to the extent that they influence perceived permanent income (Friedman, 1957).

Modigliani and Brumberg's Life Cycle Hypothesis (LCH) treats consumption as a function of total lifetime resources, including labour income and accumulated wealth. Households smooth spending by saving during peak earning years and drawing down assets [real estate, gold, equities] in retirement. Permanent increases in wealth directly raise annuitised consumption, while one-off gains carry less weight.

The LCH aggregates all assets, ignoring that liquid [equities, gold] and illiquid [land, housing] gains differ in liquidity and ease in monetisation. It overlooks credit-based channels [such as home equity or gold loans] and behavioural factors [like uncertainty about permanent income and loss aversion], and it is calibrated mainly for advanced economies rather than India.

3.1.2 New Keynesian Dynamic Stochastic General Equilibrium (DSGE) Models

New Keynesian DSGE models explain Consumption as driven by income, wealth, and substitution effects. In these models, an increase in wealth, whether realised or unrealised, long-term or short-term, is said to increase current consumption, which is explained by the Wealth Effect.

Interest rates are considered inversely proportional to consumption. A cut in rates on bank deposits induces households to increase current consumption as the opportunity cost (returns forgone by not saving) decreases. A hike in rates induces households to decrease current consumption as returns on savings increase. This is the Substitution Effect. Central Banks (RBI) often use this effect to decrease/increase consumption in times of high inflation/deflation, respectively.

Despite regulation by the RBI, the effect of interest rates is often argued to be ambiguous. The income effect can induce an opposite reaction. Consider a household that relies on interest income, like retirees. Lowering interest rates decreases their household income, causing them to restrict their spending and vice versa.

An important extension of this logic is that such households (which were reliant on interest income) may divert their investments from savings accounts

(FDs, savings A/c etc.) into financial/real assets which provide regular income (mutual funds, rental property, bonds), especially as they have historically outperformed bank deposits in India. This can also have dual effects. This diversion can tie into the positive wealth effect, boosting consumption, but would also decrease the deposits available with banks, restricting their ability to create credit and hence decreasing consumption.

3.2 Empirical Studies

3.2.1 Stock Market Wealth Effects

Case, Quigley, and Shiller (2005) use a vector autoregression model on U.S. data from 1952 to 2002 to estimate the impact of unexpected stock market wealth changes on consumption.

They find that a 1% increase in stock market wealth raises consumption by approximately 0.1% over two years, with peak effects around the eighth quarter. Their analysis isolates unanticipated shocks, distinguishing between permanent and transitory movements in equity prices. The study emphasises the relevance of stock wealth for macroeconomic consumption behaviour, especially when price changes are perceived as long-lasting.

Jappelli and Pistaferri (2010), using U.S. Consumer Expenditure Survey microdata linked to local equity-price changes, estimate marginal propensities to consume (MPCs) out of stock wealth of about 3–5 cents per dollar of gain, consistent with Permanent Income Theory. The study emphasises heterogeneity in consumption responses based on household characteristics and stock ownership, suggesting that wealth effects may be concentrated among stockholders with direct exposure.

Kumar and Dhankar (2010) examine the Indian stock market's impact on consumption using macro-level data and basic regression analysis. They find that a 10 per cent increase in stock market wealth leads to only a 0.3 per cent rise in consumption. This effect is notably weaker than in developed markets, which the authors attribute to India's lower direct equity participation and dominance of real assets in household wealth. Their study provides an early Indian benchmark for understanding stock market wealth effects in emerging market settings.

2.2.2 Housing Market Wealth Effecgs

Housing-wealth shocks typically exert a stronger effect. Mian, Rao, and Sufi (2013) exploit geographic variation in U.S. housing-price declines during the Great Recession, applying a difference-in-differences design to Consumer Expenditure Survey panels. They find that a 10% drop in housing wealth reduces nondurable consumption by 2.5% among highly leveraged, housing-rich households. The study identifies the balance sheet channel as the main transmission mechanism, emphasising how declining home equity constrains household borrowing and spending. Their findings provide strong empirical support for the collateral effect of housing wealth.

Benjamin, Chinloy, and Jud (2004) compare the relative impact of housing and financial wealth on consumption across a range of countries. Using aggregate data, they find that housing wealth effects are two to six times larger than stock wealth effects. This result holds across both developed and emerging economies, particularly where housing comprises a major portion of household net worth. The authors argue that housing functions both as a consumption

good and an investment asset, making its effect on spending behaviour more direct.

3.2.3 Gold

In emerging markets, gold plays a similar role to housing. The World Gold Council (2023) regressed festival-season retail sales in India on monthly gold-price changes (2010–2022) and found that a sustained 5% rise in gold prices correlated with a 1.2% uptick in discretionary spending during weddings and festivals, highlighting a cultural liquidity channel.

Baur and Lucey (2010) also analyse whether gold functions as a hedge or a haven using data from the US, UK, and Germany between 1985 and 2005. They find that gold consistently acts as a hedge against stock market movements and serves as a haven during periods of financial stress, particularly in the US. While the study does not directly examine consumption, it highlights gold's role as a stabilising asset in investor portfolios. This supports the interpretation of gold as a counter-cyclical store of value, which can influence household spending patterns in economies with high gold ownership like India.

3.2.4 India-Specific Evidence

Swamy (2017) studies how changes in household wealth affect private consumption in India using quarterly data from 2005 to 2016. The analysis is based on a Vector Error Correction Model that captures both long-run and short-run relationships. Financial wealth is measured using stock market capitalisation as a share of GDP, while housing wealth is represented by a property price index. The results depict that both forms of wealth significantly influence consumption over the long run, with housing wealth having a stronger effect. Granger causality tests indicate two-way causality between housing wealth and consumption, and one-way causality from financial wealth. Impulse responses show that consumption reacts more strongly to changes in housing wealth.

Pandey, Patnaik, and Sane (2019) use state-level panel regressions (2004–2014), instrumenting capital-gains tax exemptions to proxy realised wealth change. Their results show muted effects on PFCE, likely due to underreporting of gains, pointing to the importance of unrealised/unreported wealth.

4. Research Framework

4.1 Research Gap

The literature on the wealth effect in advanced economies has largely emphasised capital gains from equity markets as the main channel through which household wealth influences consumption. However, as our review of India-focused work (Pandey, Patnaik, & Sane, 2019; World Gold Council studies; RBI, 2023) reveals, Indian households derive most of their net worth from real assets (real estate, gold) rather than equities.

Further, existing India-centric analyses often rely on capital gains tax records to proxy wealth changes, but this approach suffers from these key limitations:

1. Tax filings capture only realised gains, omitting unrealised fluctuations that nonetheless shape spending decisions.
2. Estate transactions are frequently undervalued for tax purposes, obscuring true asset-price movements.
3. Only about 5 percent of individuals file income tax returns, and fewer report capital gains; hence, tax

data gives an incomplete picture of broad-based wealth dynamics.

These gaps demonstrate the need for an alternative proxy, one that captures both realised and unrealised gains across real and financial assets, to more accurately assess how wealth changes drive consumption.

Swamy (2017) applies a similar approach to this study; however, there are a few limitations in that study's approach. Firstly, it omits gold, which is a major component of Indian household balance sheets with important cultural significance. Secondly, the study does not include Income (GDP) in the cointegrating relationship, which is the primary driver of private consumption, without which effects on consumption could be misattributed to wealth effects when instead caused by general income/output growth.

4.2 Methodology

To address this gap, this study combines secondary price-index analysis with primary consumer surveys, linking each element directly back to the limitations identified above.

5. Secondary Data

Secondary data was collected in the form of quarterly observations from FY 2011-12 to FY 2023-24 from RBI's Database on the Indian Economy and Quarterly Estimates of National Income published by MoSPI. Wherever data was available in a monthly form, it was averaged to estimate quarterly data.

Asset-Price Proxies: For Real Estate, we used the Housing Price Index published by the RBI to proxy for real estate prices. For gold, we used the Domestic [Mumbai] Monthly Average Gold Prices series (RBI) Finally, Equity prices were proxied through historical Nifty 50 Index values from the NSE.

Consumption: For PFCE at current prices, Quarterly Provisional Estimates of National Income (MoSPI) were used. The All-India CPI Index series (RBI, DBIE) was used for Inflation.

Income: GDP at current prices from Quarterly Provisional Estimates of National Income (MoSPI) were used.

Interest Rates: Various banking rates such as Repo Rate, Savings deposit rates, Lending rates, call money rates from RBI's DBIE.

Empirical Model:

$PFCE = \alpha + \beta1(GDP) + \beta2(Capital\ Gains) + \beta3(Interest\ rates)$

Hypotheses:

H1: $\beta1>0$(higher GDP raises PFCE)

H2: $\beta2>0$ (rising asset prices boost PFCE)

H3: $\beta3<0$ (higher interest rates dampen PFCE)

5.1 Statistical Methods Used and Jutification

The Vector Error Correction Model was used to analyse the quarterly data based on the following observations:

Given that the variables were integrated of order one (I(1)), and Johansen tests confirmed cointegration, the Vector Error Correction Model (VECM) was chosen to capture both long-run equilibrium relationships and short-run dynamics.

The final model included PFCE, Gold Prices, GDP, Housing Index, and Nifty 50. Interest rate-related variables were collected, but due to several limitations, they were excluded from the final model.

Publications which include relevant rates (e.g. Weighted Average Lending Rates/Deposit Rates, RBI) have been started recently and are in yearly/biyearly form in some cases. Other well-documented rates, like call money rates or headline rates like repo rates, are not adequate representatives of rates faced by households; hence, the analysis of interest rate effects was shifted to the primary household survey

CPI was initially intended to be an explanatory variable due to its repeated citations in primary survey findings; however, since all the data are in current price form, Inflation is inherently accounted for in the model.

5.2 Data Analysis and Econometric Modelling

Table 1 summarises basic statistics like mean, standard deviation, minimum, and maximum value of all the collected variables:

Table 1: Summary Statistics

Variable	Nifty (Index)	Gold (Rs)	Housing Index	PFCE (Rs Crore)	GDP (Rs Crore)
Mean	10,774	36,637	221	26,00,465	43,53,544
Standard Deviation	4,651	11,479	65	10,00,224	16,42,270
Maximum Value	22,012	63,189	304	48,04,547	78,28,292
Minimum Value	4,928	21,938	94	11,97,461	19,79,274

Source: Author's own work

5.2.1 Stationarity Testing

We conducted the Augmented Dickey Fuller (ADF) test to test for stationarity of the variables.

Table 2: ADF Stationarity Test Result

Variable	p-value (Level)	Stationary at Level?	p-value (1st Diff)	Stationary after 1st Diff?	Integration Order
Nifty	1.000	No	0.003	Yes	I(1)
Housing	0.990	No	0.047	Yes	I(1)
PFCE	0.684	No	0.016	Yes	I(1)
GDP	0.894	No	0.021	Yes	I(1)

Source: Author's own work

As all variables are of I(1), a VECM can be estimated.

5.2.2 Cointegration Testing

Johansen cointegration tests were applied to examine long-run relationships among the variables. The tests indicated the presence of two cointegrating vectors at the 5% significance level, justifying the use of the Vector Error Correction Model.

Table 3: Johansen Cointegration Test Result

Hypothesized No. of Cointegrating Relations (r)	Trace Statistic	5% Critical Value	Max Eigenvalue Statistic	5% Critical Value	Conclusion
0	72.94	69.82	45.92	40.08	Reject H_0 ($r = 0$)
≤ 1	27.01	47.21	17.48	33.88	Do not reject H_0 ($r \leq 1$)
≤ 2	9.53	29.68	7.91	27.07	Do not reject H_0 ($r \leq 2$)

Source: Author's own work

5.2.3 Model Selection and Specification

Given the non-stationarity and the cointegrating relationships found, the VECM model was chosen with Estimated Lag 1 and Cointegration rank 2 as per Johansen and information criteria (Table 4).

Table 4: VECM Model Specification

Model	AIC Lag	BIC Lag	HQIC Lag	Selected Lag
VECM	1	1	1	1

Source: Author's own work

5.2.4 Long Run Cointegrating Relationships

We estimated long-run equilibrium links among PFCE, Gold, GDP, and Housing via Johansen Cointegration, normalising each vector on PFCE (Coefficient of PFCE = 1).

Eq1: $PFCE + 1410.3 * Nifty + 0 * Housing - 3.27 * GDP - 370 * Gold = C$

Eq2: $PFCE + 0 * Nifty + 1009\ Housing - 0.65 * GDP + 0.61 * Gold = C$

Some results might be counter-intuitive, such as GDP having a negative coefficient, but that may be because PFCE and GDP are highly correlated, since PFCE is a

5.2.5 Short Run Dynamics (Error Correction Terms and Coefficients)

Short-run dynamics are presented in Table 5. PFCE adjusts by 8.9% of disequilibrium per quarter, indicating that the correction occurs over several quarters. A similar correction to the long-run equilibrium can be seen with respect to the Nifty 50, Housing, and Gold.

Table 5: Short Run Error Correction Terms

Variable	Adjustment to CI Vector 1	Adjustment to CI Vector 2
PFCE	-0.089	-0.006
GDP	-4.08	-0.11
Nifty 50	-0.00056	0.14
Housing	-0.0025	-0.017
Gold	-11.88	0.029

Source: Author's own work

Table 6: Short Term Coefficients

Variable (Delta)	Short Term Coefficients	t-ratios
PFCE	0.133	2.56
GDP	-0.001	-0.02
Nifty 50	88.59	2.61
Housing	183.29	4.07
Gold	-0.018	-1.80

Source: Author's own work

Table 6 shows the Short-Term Coefficients of the variables in differenced form; coefficients of Nifty and Housing are of high magnitudes since they are indices of low numerical values, but overall show a significant positive relationship. GDP has an insignificant t-ratio, which means that it has no meaningful short-run effect. Gold shows a negative coefficient of marginal significance; this might be due to periods of uncertainty (pandemic, demonetisation) leading to an influx of investments in gold, as was seen in a high price rise in gold during 2020. PFCE's own values also have a significant positive short-run effect.

5.2.6 Forecasting Performance

The VECM model was estimated with quarterly data from April 1st 2011, to March 31st 2024. The model was then used to forecast PFCE for Q1 of FY 25, i.e., 1st April 2024 - 31st June 2024.

Table 7: Forecast Results Q1 FY 254

Model	Forecast (₹ crores) (current prices)	Official PFCE (Provisional Estimates)	Forecast Error (%)
VECM Lag 1	4,615,232	4,751,288	-2.86

4.2.7 Quantitative Results (Effects of Variables on PFCE)

The following are the estimated impacts of a 1% rise in explanatory variables in this quarter on PFCE in absolute terms in the next quarter.

Table 8: Estimated Impact of Rise in Variables

Variable(1% rise)	Estimated Impact on PFCE (₹ crores)
PFCE (own lagged value)	7,610
GDP	17,313
Nifty 50	7,942
Housing Prices	6,491
Gold Prices	5,050

Source: Author's own work

Figure 2 presents the IRFs of 1% change in explanatory variables on PFCE. Values in Table 8 were derived from the IRF (Figure 2) for the next quarter.

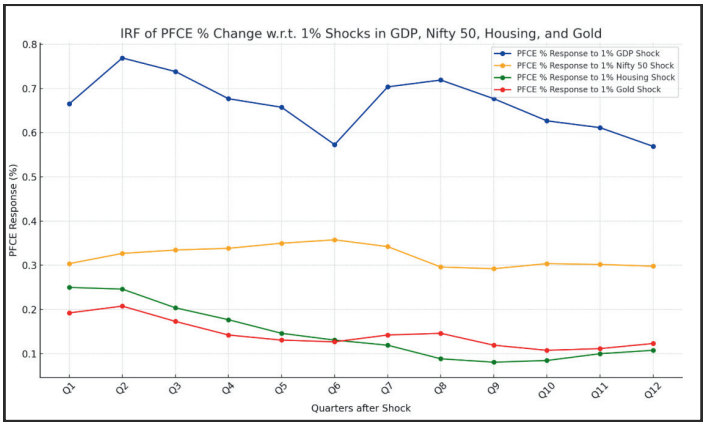


Figure 2: IRF of % change in PFCE w.r.t 1% change in explanatory variables

As can be seen from Figure 1, the impact of a change in GDP and other variables lasts several quarters. As expected, GDP has the highest impact, this is followed by NIFTY, Housing and Gold, respectively.

5.2.8 Residual Testing

We checked whether the residuals from our VECM exhibited serial correlation. If they did, our model's forecasts and inferences could be misleading. To do this, we applied the Ljung-Box Q test at lag 10, which evaluates the joint significance of autocorrelations up to the specified lag.

Table 9: Ljung-Box Test Result

Variable	LB Statistic	p-value	Interpretation
Nifty50	9.30	0.50	No significant autocorrelation
Housing	20.12	0.03	Mild evidence of autocorrelation
PFCE	19.57	0.03	Mild evidence of autocorrelation
GDP	14.76	0.14	No significant autocorrelation
Gold	6.40	0.78	No significant autocorrelation

Source: Author's own work

6. Primary Data

A survey was conducted (Annexure 1) with the survey population largely including working-class urban households, focusing on household consumption and how changes in asset values, income, and interest rates influence spending decisions across diverse demographic groups. The questionnaire collected detailed data on age, income, wealth allocation across property, gold, and equities, and perceived asset value changes over the past year. Respondents also reported the proportion of gains or losses realised and their confidence and likelihood to adjust spending based on expected financial fluctuations.

From the original dataset, after removing incomplete or invalid responses and discarding entries with irrelevant or missing key data, a total of 100 out of 115 complete responses were retained for the final analysis.

The survey also included hypothetical scenarios which involved a change in spending/investing/saving behaviour in response to a rise or fall in interest rates on bank deposits.

6.1 Impact of Interest Rates on Consumption with Respect to Age

Respondents were posed two hypothetical questions regarding a rise or fall in bank deposit interest rates to investigate the ambiguous effects of substitution and income on consumption behaviour.

Caution must be taken when analysing the % based graph, as younger age groups had low total responses, hence single responses would vary the data greatly.

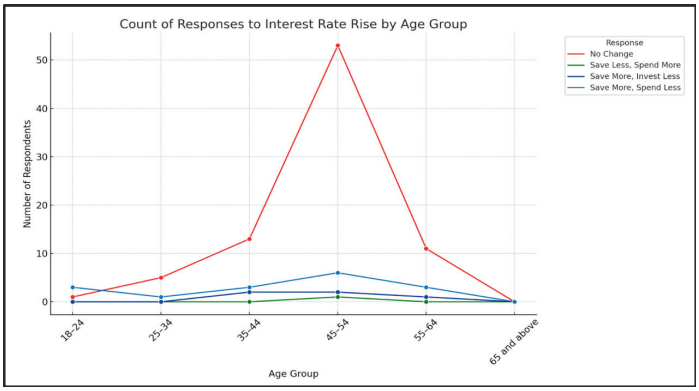


Figure 3: Response to Interest Rate Rise by Age Group

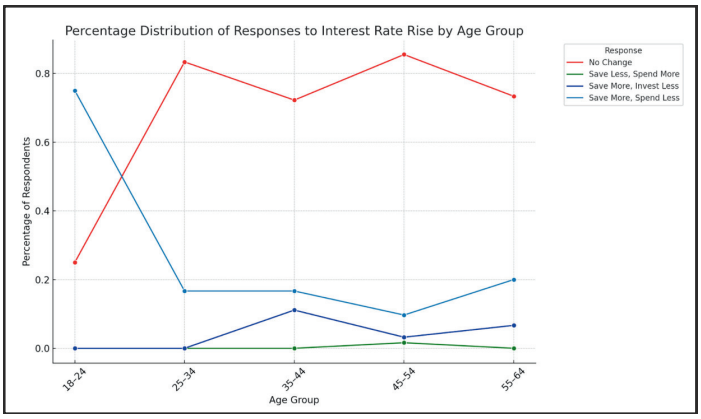


Figure 4: Percentage Distribution of Response to Rate Rise by Age

Note: Both graphs were prepared by the authors for the study.

Rise in Interest Rates

The dominant response from both younger (<35) and older(>35) age groups is no change in response to an increase in rates, with 50-80% of responses varying with age groups. The second most common response involved increasing savings and reducing spending, indicative of a modest substitution effect.

Responses reflecting wealth diversion from savings or increased spending due to the income effect were minimal.

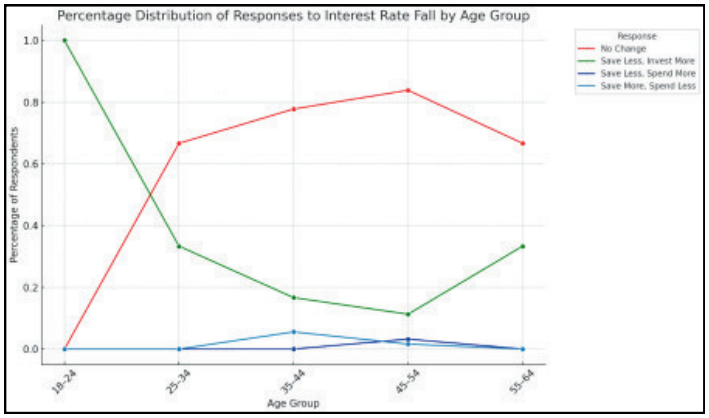


Figure 5: Distribution of Response to Rate Fall by Age.

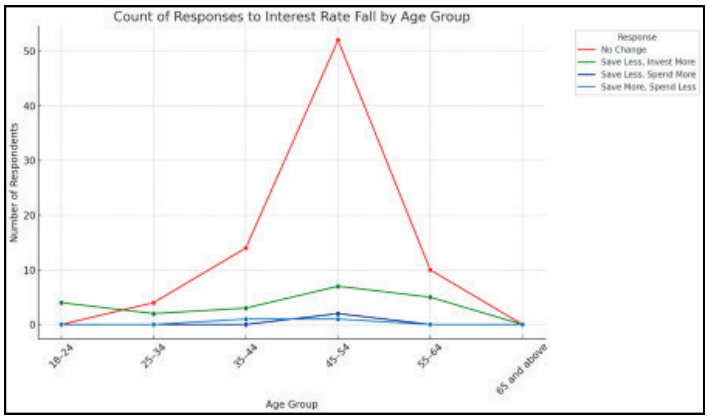


Figure 6: Response to Interest Rate Rise by Age Group

Note: Both graphs prepared by the authors for the study.

Fall in Interest Rate

Once again, the dominant response is no change in financial behaviour in response to a fall in interest rates by both age groups.

Notably, in Figure 5, a substantial proportion (~35%) of respondents across both age groups (excluding 18-24 due to low sample size) indicated saving less and investing more into Real Estate, Gold and Equities, supporting the earlier hypothesis about portfolio reallocation.

Other behaviours, such as increased saving with reduced spending or increased spending with reduced saving, were infrequently reported.

Conclusion: Consistent with secondary data, these findings suggest that moderate changes in savings rates show minimal change in household financial behaviour. If a change does occur, the substitution effect appears slightly more pronounced than the income effect, both exhibiting limited to moderate influence on consumption patterns.

6.2 Relation Between the Percentage of Capital Gains Realised and the Increase/Decrease in Spending

Respondents were asked two questions regarding their overall increase % in spending over the last year and the % realised of any capital gains they experienced over the past year to investigate whether there was a relation between the realisation of gains and the increase in spending.

The accompanying scatter plot (Figure 7) illustrates the relationship between gains realisation (defined as selling or borrowing against the asset) and the increase in spending.

Spearman's rank correlation coefficient was calculated

to be 0.072, while Pearson's correlation coefficient was 0.044, both indicating a very weak and statistically insignificant association.

These findings suggest that the proportion of gains realised does not influence spending changes related to capital gains. This supports the earlier assumption that tax data, which only captures realised gains, is insufficient as a proxy for assessing the wealth effect.

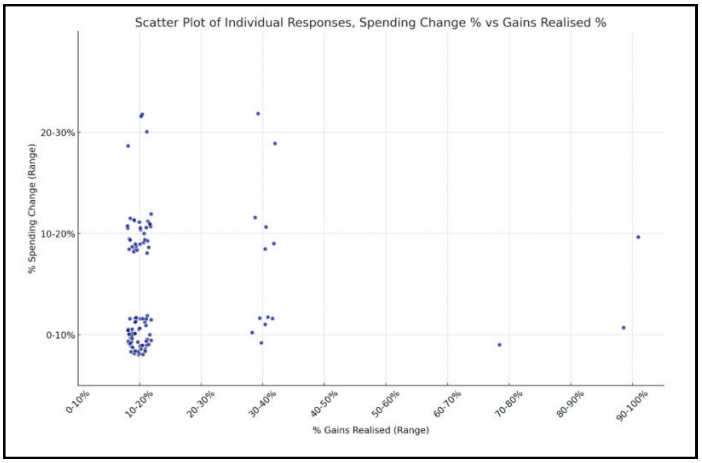


Figure 7: Scatter Plot comparing Spending Change % and Realisation %

Note: Graph prepared by the authors for the study.

7. Results and Conclusions

The objective of this study was to investigate the impact of capital gains from equities and real assets, specifically gold and real estate, on private final consumption expenditure (PFCE) in India, along with the influence of interest rates on household spending decisions. Using quarterly data from FY12 to FY24 and applying a Vector Error Correction Model (VECM) alongside a household survey, the research addressed a gap in the literature where most studies focus on advanced economies and equity market fluctuations, while Indian household wealth is largely in tangible assets.

The results confirm that capital gains have a significant positive effect on consumption. GDP remains the largest determinant of PFCE, with a 1 per cent increase in GDP associated with a rise of ₹17,313 crore in PFCE. Capital gains in equities, real estate, and gold also had notable effects: a 1 percent increase in the Nifty 50 index, housing prices, and gold prices corresponded to increases in PFCE of ₹7,942 crore, ₹6,491 crore, and ₹5,050 crore, respectively. These findings are consistent with the Permanent Income Hypothesis and the Life Cycle Hypothesis, which state that households base spending decisions on long-term resources and wealth as well as income. Gold plays an important role not only because of its cultural significance but also because it is widely held in India, and because it is a liquid store of value and a safe-haven asset that can be monetised when needed.

Compared with earlier research, this study both confirms and extends existing evidence. Swamy (2017), using a similar VECM for 2005–2016, found that housing wealth had a stronger effect on PFCE than financial wealth. In contrast, the present study finds a slightly larger marginal impact from equities than from housing. The difference may be due to Swamy (2017) using stock market capitalisation as a share of GDP, while this study uses the Nifty 50 index, which reflects market movements more directly. Kumar and Dhankar (2010) reported that a 10 per cent increase in stock market wealth raised consumption by only 0.3 percent, which is smaller than the effect found here, possibly due to greater equity participation in recent years. The housing effect estimated here is close to the mid-range values reported by Benjamin et al. (2004) in economies where housing forms a large share in household net worth. Including gold in the analysis adds to earlier frameworks by accounting for an asset that is both

widely held and economically important in India.

The findings have important policy implications. Policymakers should integrate asset price movements into models for forecasting PFCE and aggregate demand, develop early-warning systems to detect excessive asset price growth, and apply targeted macroprudential measures such as adjusting loan-to-value ratios. Gold prices should also be monitored alongside housing and equity indicators.

The study has several limitations. Interest rates were excluded from the statistical model due to a lack of consistent household-level data. The household survey sample was skewed toward urban and working-class respondents, which may understate rural sensitivity to changes in gold and real estate prices. There is also the possibility of reverse causality, where higher consumption contributes to rising asset prices. Future research should use more representative datasets, stronger identification strategies and examine sector-specific consumption responses.

Finally, survey results show differences across demographic groups. Younger households were more likely to reallocate savings to financial assets when interest rates fell, while older households kept a larger share in real assets. Understanding how capital gains influence PFCE is important for stabilising aggregate demand and supporting long-term economic growth in India.

8. Data Availability Statement

The datasets generated and analysed during this study are openly available.

Primary data:

The anonymised household survey dataset, along with the cleaned dataset and variable codebook, has been deposited on Zenodo and is available at: *10.5281/zenodo.17623811.*

Secondary data:

The complete secondary dataset, including all raw variables, cleaned series, transformations, and the Variables Tracker file used for the econometric analysis, has been deposited on Zenodo and is available at: *10.5281/zenodo.17623833*

All external secondary data used in this study were originally obtained from publicly accessible sources such as the Reserve Bank of India (DBIE), the Ministry of Statistics and Programme Implementation (MoSPI), and the National Stock Exchange of India (NSE).

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Annexure 1: Household Survey

Household Wealth Effect Survey

This short survey is part of an academic study on how changes in household wealth (property, gold, stocks) affect spending habits. Your responses will remain anonymous and confidential. The data will be used only for research purposes. By continuing, you consent to participate.

Q1. Which age group do you belong to?

Q2. What is your pre-tax total household income(INR) for the past year?

Q3. How much of your wealth is allocated across Property/Gold/Equities? (should add up to 100%)

% in Property:

% in Gold:

% in Equities:

Q4. How much did your house/property/real estate value go up or down over the past year?

Q5. How much did your stocks/mutual funds/equities value go up or down over the past year?

Q6. Of the gains/losses you reported above, approximately what % did you cash in or borrow against?

Q7. In the past year, by approximately what % did your income change?

Q8. Which spending area changed the most due to a change in wealth?

Q9. If bank deposit interest rates were to rise by 1% next year, which of the following best describes how you would respond?

Q10. If bank deposit interest rates were to fall by 1% next year, which of the following best describes how you would respond?

Q11. If the value of your investments(Real Estate, Gold, Equity) fell next year, how confident are you that you could keep spending at the same level? (on a scale of 1-5)

*Q12. If the value of your investments(Real Estate, Gold, Equity) rose significantly next year, how likely are you to increase your spending? (on a scale of 1-5)

Q13. In the past year, (approximately) how much did your overall household spending change?

(Think about a grocery bill from last year compared to this month's.)

Q14. Is there any other factor which affects your spending? (eg - Inflation) *Short-answer text*

Individual Attributes Shape Emotional Labour in Organisational Life: A Study on the Healthcare Providers in Kolkata

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ABSTRACT

The healthcare industry experiences emotions differently in customer service interactions. Although it is assumed that healthcare providers are more concerned with patients' illnesses and health conditions than with emotional expression, this has undergone a drastic shift over time, and the way medical professionals behave with their patients and their families has come under intense scrutiny. The goal of the current study is to determine the unique characteristics of healthcare providers and determine whether there is a connection between these characteristics and the emotions that these people express while providing care and service. The phrase "emotional labour" was used to describe the control of emotions in the workplace. The present study aims to examine the effects of emotional labour in the healthcare sector by establishing relationships between the individual attributes and emotions displayed while at work. When medical professionals interact directly with the patients and the family members of the patients, they experience a critical situation and controlling and monitoring their emotions has become a major concern. It becomes essential for healthcare providers to comprehend the emotions that patients and their families exhibit when they have direct interaction with them. This is what has been identified and propounded by the researchers as Emotional Labour. Arlie Hochschild first came up with this concept and coined it as emotional labour, which is distinct from emotional intelligence. Although all service sectors experience emotional labour as service providers and service receivers come in direct interaction with each other, the healthcare sector must be managed with extreme caution and responsibility as it involves a great deal of emotion. It is expected of the healthcare providers to carry out their tasks with consideration for the recipients' feelings and mental health. Our study has been carried out in the healthcare sector, and the healthcare providers have been included as respondents in our study. The analysis has been carried out primarily to identify whether there is any relation between the different attributes of the healthcare providers and emotions displayed by them. The relation identified henceforth provides a significant insight towards the relevance of emotional labour during service encounters.

Keywords: emotional labour, service encounter, individual attributes

JEL Classification: I11, J24, D23, J81

1. Introduction

Background of the Study

Human beings have two minds and two different kinds of intelligence i.e. rational and emotional. Individuals differ from one another in their behaviour, expression and attitudes towards others. There are patterns which enable us to define the dimensions of individual differences. Psychologists have tried to identify the reasons behind such differences.

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Commonly, psychometric tests are conducted to understand how and why people are similar to or different from one another. In terms of emotions, this difference becomes very vivid and over the years, its relevance in service sectors has been identified and observed. Management experts have coined the term service encounter in this respect to emphasise the direct interaction between the service providers and service receivers at the point of the service delivery process.

Researchers started considering emotional expressivity (Friedman, Prince, Riggio, & DiMatteo, 1980), emotion regulation (Cote and Morgan, 2002), emotion control and management and such others as their fields of study. Eventually, the concept of emotional labour was propounded by Arlie Hochschild (The Managed Heart, 1983). Emotional labour can be expressed as a component of emotion which deals with emotion management at work place. With time, this became more relevant in the healthcare sector as the interaction between the healthcare providers, the patients, and the family members of the patients became very crucial. It becomes even more complex in situations when keeping control of one's own emotions and displaying the emotion that is required in a specific situation becomes more difficult. Researchers at different points in time have carried out studies to understand the mental conditions of the healthcare providers and how controlling emotions leads to exhaustion, mental stress and eventually burnout.

Psychologist and emotional researcher at Stanford University, James J. Gross, established a model highlighting the two antecedents of emotional labour, namely individual factors and organisational factors. While organisational factors are quite easy to understand, and Gross's model clearly depicts the impact of organisational factors on emotional labour; individual factors are difficult to analyse.

Hence, the present study tries to identify whether the differences in emotional labour are due to differences in the individual attributes of the healthcare providers.

2. Literature Review

The literature review narrows down the problem from the original broad base and defines the issues of concern clearly. Research papers, articles, journals, books and various websites have provided relevant information about emotions, different dimensions of emotions and emotional labour.

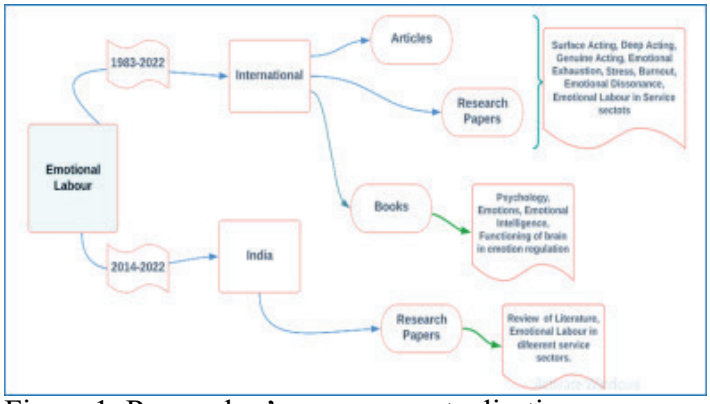


Figure 1: Researcher's own conceptualisation

Table 1: Studies on emotional labour - Studies outside India

Author & Year	Article Names	Objectives	Major Findings
Maslach and Jackson (1981)	The measurement of experienced burnout.	Various aspects of burnout syndrome among service providers	Three principal factors behind this burnout: i)Emotional exhaustion, ii)Depersonalisation iii) Personal accomplishment iv) Conceptualisation of the terms - Emotional Labour - Burnout
Maslach and Jackson (1982)	After-effects of job related stress: families as victims	Job stress experienced by workers in the helping professionals.	Display of anger, tension, anxiousness, complaining mood as well as the physical exhaustion. Focus on job stress and formulating a new scale of measurement, Maslach Burnout Inventory (MBI)

Arlie Russell Hochschild (1983)	The Managed Heart	Exploring and analysing emotional labour among flight attendants	Two main ways to manage emotions: Surface acting Deep Acting
Michael Robert Solomon (1985)	A role theory perspective on dyadic interactions: the service encounter	Identifying role played by service providers and introducing a new dimension to role theory.	Role theory was that individual difference variables can be considered to be as moderating factors rather than as determinants of behaviour. Role enactment is determined by the reactions of others.
Rafaeli, A. and Sutton (1987,1989)	Expression of emotion as part of the work role	Identifying the intensity of expressed emotion and whether it is a result of organizational individual financial outcomes.	More one's internalised feelings rule for a particular role, the less emotional dissonance one experiences when complying with feeling rules on the job
Vincent R. Waldron and Kathleen J. Krone (1991)	The Experience and Expression of Emotion in the Workplace: A Study of a Corrections Organization	Examining the descriptions of emotional interactions	Valence of the felt emotion had a strong effect on whether the emotion was expressed. Quantitative and qualitative descriptions of emotional interactions among members of a state government organization
Ashforth B.E. & Humphrey, R.H. (1993)	Emotional labour in Service Roles: The Influence of identity"	Including the role of social identity and integrating it into the study of emotion and their expression at work	Emotional labour is a kind of impression management in which employees attempt to exhibit a certain perception of themselves to others.
Bewettinck, K. and Buyens, D. (2006)	Linking Behavioural control to Frontline Employee Commitment and Performance: A Test of two alternative explanation using motivational theories	Studied whether the behavioural control can be linked to frontline employee commitment and performance	Concluded that situational learning orientation is an important consideration in linking behavioural control to performance. Job autonomy shows to be important in explaining employee outcomes but is only marginally related to behavioural control.
Julian C. (2008)	Emotional dissonance and customer service: an exploratory study	Focussed on emotional dissonance and its importance in marketing	Influence of customer role internalisation on emotional dissonance and further suggested examining the impact of emotional dissonance on key job outcome variables namely, customer oriented behaviours and job satisfaction.
Cote S., Miners C., (2010)	Emotional intelligence and leadership emergence in small groups	Find out the association between emotional intelligence and leadership emergence in small groups.	Emotional intelligence was measured with an ability test. It was also concluded that among the dimensions of emotional intelligence, the ability to understand emotions was most consistently associated with leadership emergence.
Julian, C.C. and Ramaseshan, B. (1994)	The role of customer oriented personnel in the marketing of a retail bank's services	Focus on emotional dissonance and its importance to customer contact personnel and marketing.	The study focussed on customer-facing employees who often experience emotional dissonance due to the discrepancy between required emotional displays and their genuine feelings, and they may not feel adequately rewarded or supported.
Nuvian Daniel (2008)	Understanding the moderating role of the professional service encounter in consumer health service risks	Examining the role of the professional service encounter as a moderator of risk perception.	Role of emotional labour is dependent on the professional content in which health service is offered and the relative position status of the health service consumers.

Source: Authors' compilation

Table 2: Emotional labour in the Indian Context

Author & Year	**Article Names**	**Objectives**	**Major Findings**
Vijayta Doshi (2014)	Nursing Industry: Where Rescuers become the Victims	To understand the emotional labour performed by nurse their relatives, doctors and the organisation To investigate the consequences of emotional labour.	Nurses face emotional dilemmas with patients, patients' relatives and with respect to patients and organisational demands. Emphasis was on depersonalisation and prolonged emotional exhaustion.
Sandeep Kaur (2014)	Influence of Emotional Labour Burnout in selected hospitals of Punjab: structural equation modelling approach.	To understand the influence of emotional labour on job satisfaction in selected public and private hospitals of Punjab.	A positive and significant correlation exists between emotional labour and burnout. Hospital authorities should provide emotional assistance to their employees by providing them with recreational clubs, yoga training, seminars etc.
Madhuree Modekurti, Mahato, Pranab Kumar (2014)	Impact of emotional labour on organisational role stress, a study in the service sector in India.	To identify the impact of emotional labour on role related outcomes like organisational stress in service sectors.	There exists a positive and moderate relationship between emotional labour and organisational role stress irrespective of the demographic influences.
Anand Sharma, Prantosh Banerjee, Rama Shankar Yadav, Sanket Sunand Dash (2015)	Role of Emotional Labour in Interactive Service Roles: A Study of Indian Restaurants	(i) To extend research in order to encompass the Indian hospitality industry (ii) To identify the role emotions played in the performance of interactive work roles in restaurants.	The study suggested the importance of on-the-job training in interpreting emotional cues and overall experience in building a steward's capacity for deep acting. It also asserted the need for structured training on emotional labour to stewards, especially on deep acting.

Source: Authors' compilation

3. Research Gap

The literature surveyed by the different researchers so far is not adequate enough to shed insights on the study; a cursory overview would reveal a certain genuine gap that persists in this domain of study.

1. **Concept gap**: It has already been stated that researchers have primarily worked on the situational antecedents to study emotional labour. Although researchers have put forward the individual antecedent in the emotional labour framework, no significant research has been conducted in this context.
   - **Importance of study:** The extent to which individual attributes or personality traits are responsible for emotional labour in the workplace and whether such emotions can be managed and regulated can be analysed for a better understanding of emotional labour.
2. **Application gap**: Researchers have conducted thorough research on EL in different service sectors like airline, bank, police force, front office jobs and to a limited extent on nurses and doctors of mental patients.
   - **Importance of study:** Research on healthcare professionals comprising doctors, nurses, and administrative units, as a whole, has not been conducted so far. A study on the same has become quite essential in the present social structure.
3. **Knowledge gap**: There is a lack of clarity regarding proper construct development in the existing literature on emotional labour. The existing literature fails to collectively bring out the relevant dimensions of "individual attributes" and "emotional labour" with an understanding of their relationship framework among the healthcare providers.
   - **Importance of study**: It would be ideal to consider an appropriate understanding of the relationship between individual attributes and the emotional labour of the healthcare providers.

Certain domains need to be worked on in this respect, as the relevance of emotional labour and the degree of its importance have taken shape over the years. Further studies on the background literature shall throw open the doors to identify further gaps and hence reinforce and strengthen the present study. Identification of the research gaps shall pave the way for the development of the research design and facilitate the outlining of the research objectives pertinent to the present study.

4. Objective

The objective of this study is twofold. In the first place, we have tried to analyse the reasons for differences in the individual attributes of the healthcare providers that regulate their emotions while at service.

Secondly, we have tried to identify the relationship between the individual attributes and the emotion regulation of the healthcare providers. We have taken the demographic factors of the respondents, i.e. gender and age, their job profile, i.e. profession and workplace, and have tried to identify the relations that exist between the demographic factors, job profile, individual attributes and emotion regulation. Based on the objectives, the following hypotheses have been developed.

5. Hypothesis Formulation

- H_1: There is a significant relationship between demographic factors and individual attributes of healthcare providers.

- H_2: There is a significant relationship between job profile and individual attributes of healthcare providers.
- H_3: There is a significant relationship between demographic factors and emotion regulation of healthcare providers.
- H_4: There is a significant relationship between job profile and emotion regulation of healthcare providers.
- H_5: There is a significant relationship between individual attributes and emotion regulation of healthcare providers.

6. Research Model

A research model has been developed in order to test the various hypotheses formulated for the research study. The proposed research model of the study comprises four constructs, namely the demographic factors, job profile, individual attributes and emotion regulation. The model presents a simple flow of relationships, like:

- Demographic Profile → Individual Attributes → Emotion Regulation
- Job Profile → Individual Attributes → Emotion Regulation
- Demographic Profile → Emotion Regulation
- Job Profile → Emotion Regulation

7. Sampling Method

Breakwell (2006) defines a sample as a group of units drawn randomly from the population, which are used to test a population hypothesis. In our study, the sample comprises doctors and nurses who encounter face-to-face interactions with patients and the family members of the patients daily and experience emotional turmoil and disturbance.

As the present study will be focused on the healthcare providers and more precisely on the doctors and nurses, we have considered the hospitals located in and around Kolkata. The study used a multistage sampling technique as its sampling method.

Multistage sampling is a probability sampling technique. It uses successive levels of selection of respondents from a large population in order to narrow down the sample. The process goes as follows:

i) From a general population, subpopulation blocks are selected.

ii) From those blocks, smaller groups are selected.

iii) Even smaller groups can be selected from the above.

iv) Finally, arrive at an efficient sample.

In the first stage, we have divided all of the hospitals of Kolkata into five zones, i.e. East, West, North, South and Central Kolkata, by locating the hospitals coming under the categories of both Public and Private. As the number of hospitals is huge, an appropriate sampling approach has been employed to determine the required number of hospitals for the study, from which respondents were considered. Hospitals are categorised on the basis of their speciality, like Super speciality, Multispecialty, Speciality, and General category.

Following the determination of the sample size for tertiary sampling units, 18 hospitals were selected among the categories according to the calculated proportions. However, as the number of hospitals is higher in the south and central parts of Kolkata, more focus has been laid on these two zones. There is no public hospital in the west zone, and the number of private hospitals is also negligible. For this, the west

zone has not been considered for the study. To maintain the uniformity in the sample collection, the strength of doctors and nurses from the respective hospitals was extracted, and they were then divided into a sample per cluster to get responses, with simple sampling to calculate the number of respondents.

A simple sampling method has been used at each level in the most basic variant of multistage sampling. As a consequence, a simple sampling procedure has been used to select clusters (hospitals) from each zone under the categories private and public. The number of personnel in each hospital varied based on the structure and size of the hospital. Our sample population was 550 people out of a total population of 74054.

Table 3: Multistage Sampling Procedure

Stage 1 – Primary Units:
A sample of public hospitals were selected from each zone i.e. north, south, east and central Kolkata. The selection was on the basis of speciality of the hospitals. For our study we have considered the multi-speciality hospitals, primarily for the private hospitals in order to get an access to all the varied departments in the hospitals.
Stage 2 – Secondary Units:
Within each hospital, departments were selected on the basis of maximum patient counts and then a proportion of doctors and nurses were selected within each department.
Stage 3 – Tertiary Units:
Within each selected department, individual doctors and nurses were selected to participate in the survey.

Source: Author's own work

8. Data Collection

The study is based on a survey administered to 546 healthcare professionals, including 298 doctors and 248 nurses. The questionnaire covered demographic information, personality traits, and emotional labour components using Likert scale-based responses. Additionally, qualitative responses were collected to provide insights into participants' emotional experiences in their work environments.

Data Coding:

Responses were categorised as per a structured coding framework, ensuring uniformity in data processing. Categorical variables were converted into numerical values for analysis, and missing data were handled through mean imputation methods.

Instruments:

The devices or methods used to collect data in research are known as data collecting tools (Zikmund, 2003). The data for this study were collected using different scales. The scales were well-structured questionnaires adapted from previous studies on the variables. The first and second sections comprise the demographic and job profile of the respondents. Big Five Personality Factor, designed by McCrae and John (1992), is used to assess personality traits. The personality traits of the healthcare providers have been identified from the Big Five Inventory (BFI) developed by John et al. (1991). The emotional labour scale has been developed with the help of the Eysenck Personality Questionnaire (EPQ) to assess emotional labour. A structured questionnaire has been developed comprising a total number of 38 questions with 28 sub-questions under 4 broad segments, namely Socio-Demographic, Job Profile, Individual Attributes, Emotion, Emotion Stress, and

Emotion Regulation Dimension. There are four questions under the socio-demographic segment, five questions under job profile, one question with eight sub-questions under individual attributes and one question with twenty sub-questions under emotion, emotion stress and emotion regulation dimension.

Scaling Technique:

Statistical techniques are mathematical tools that are used to analyse data, make predictions, and draw conclusions from a given data set. These techniques comprise various tools and approaches, including descriptive statistics, inferential statistics, and hypothesis testing, establishing correlation and so on.

The present research study resorts to using "emotion regulation" as a broad scaling technique and chooses the "Likert Scale" as a specific scaling technique.

A "Likert Scale" of 5-point ratings has been used to measure the perceptions of the respondents (healthcare providers), where "1=Strongly Agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly Disagree". A rating scale has also been used to assess the personality of the respondents. The respondents were asked to rate themselves from 1 to 5, where 5 =shows an absolute match, 4=shows a moderate match, 3= matches in some cases, but not in all cases, 2=negligible match, 1=no match at all.

For our study, we have divided the data analysis into four parts, i.e. Reliability and Validity test, Normality test, Test of hypothesis and Statistical analysis, including Univariate, Bivariate and Multivariate analysis.

1. Reliability and Validity:
   - Cronbach's Alpha is used to test reliability.
   - Validity ensured through expert reviews and pilot testing.

2. Normality Test:
   - Kolmogorov-Smirnov (K-S) test and Shapiro- Wilk test

3. Test of Hypothesis:
   - Wilcoxon Signed Rank Test

4. Analysis:
   - Univariate: Descriptive statistics, Mann-Whitney U test
   - Bivariate: Correlation
   - Multivariate: Exploratory Factor Analysis, Spearman's Rho

9. Reliability test: Cronbach's Alpha

A reliability test has been conducted to assess the internal consistency of the items. Cronbach's Alpha has been used for the purpose, which shows a result of .785 (the standard value is .7 and above), suggesting that the items have internal consistency.

Table 4: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.785	0.768	38

Source: Author's own work

Reliability Analysis: - Internal Consistency: Cronbach's alpha

Item Analysis: Item-total correlations

10. Demographic Analysis

The research design used in this study is exploratory data analysis to identify the general pattern of the data. By this technique, we have tried to analyse and investigate individual attributes together with their

relationships with the variable emotional labour and henceforth summarise the main characteristics. To understand the demographic profile of the respondents, we have prepared the frequency distribution table as shown below.

Table 5: Demographic Profile

Demographic Construct	Classifications	Population statistics	Percentage
Gender	Male Female	303 246	55.1% 44.7%
Age	20-29 30-39 40-49 50 and above	151 265 71 62	27.4 48.2 12.9 11.3
Marital status	Married Single	259 289	47.1 52.5
Profession	Doctors Nurses	298 247	54.2 44.9
Work Place	Government Hospitals Private Hospitals	154 175	28 31.8
No. of years of service	Less than a year 1-5 years 6-10 years More than 10 years	36 223 131 156	6.5 40.5 23.5 29.5
Patient Population	Senior Citizens Adults Couples Adolescents Children	11 22 43 468 6	2 4 7.8 55.1 1.1

Source: Author's own work

A cross tab has also been prepared to establish the relationship between the variables in the demography of the respondents.

10.1 Age and Profession Correlation

The majority of respondents (48.2%) are in their 30s, and comprise a doctor's group. · This suggests many professionals enter the workforce in their late 20s or early 30s.

10.2 Gender and Professional Distribution

Since doctors make up 54.2% and males make up 55.1%, it's likely that more men are in the doctor category.

Conversely, since nurses are 44.9%, and females are 44.7%, a strong correlation likely exists between nursing and female professionals.

Table 6: Age and Profession Correlation - Crosstab

	Profession				Total
Age	Doctor	Nurse	Others	5	
20-29	67	82	2	0	151
30-39	148	116	1	0	265
40-49	47	24	0	0	71
50 and above 50	36	24	1	1	62
	0	1	0	0	1
Total	298	247	4	1	550

Source: Author's own work

Table 7: Gender and Profession Distribution - Crosstab

	Profession				Total
Gender	Doctor	Nurse	Others	5	
Male	174	128	1	0	303
Female	124	118	3	1	246
4	0	1	0	0	1
Total	298	247	4	1	550

Source: Author's own work

11. Normality Test

The Kolmogorov-Smirnov (K-S) test and the Shapiro-Wilk test has been conducted to assess whether the data

data follows a normal distribution.

11.1 Tests of Normality

The test shows that:

- Significance (Sig.) values for all variables are 0.000
  - Since all p-values (Sig.) are less than 0.05, this means none of the variables follow a normal distribution.
  - Both tests strongly reject the null hypothesis of normality.
- Shapiro-Wilk values are lower than 0.9 for all categories
  - This confirms significant deviations from normality

Table 8: Tests of Normality for Study Variables

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Gender	.364	550	.000	.642	550	.000
Age	.293	550	.000	.829	550	.000
Marital status	.343	550	.000	.652	550	.000
Profession	.353	550	.000	.657	550	.000
Work Place	.220	550	.000	.856	550	.000
Number of years at the service	.258	550	.000	.839	550	.000
Patient Population	.492	550	.000	.450	550	.000

Source: Author's own work

12. Hypothesis Testing

H_1: "There is a significant relationship between demographic profile and individual attributes of healthcare providers."

We are using the Wilcoxon Signed-Rank test to examine the impact of demographic profiles on individual attributes. For our study, we are considering age and gender among the demographic factors for the hypothesis testing. We are using the Wilcoxon Signed-Rank test to examine the impact of demographic profiles on individual attributes. For our study we are considering age and gender among the demographic factors for the hypothesis testing.

Table 9: Demographic factors and Individual attributes

Hypothesis	Demographic Profiles	Interpretation of Wilcoxon Signed-Rank Test Results (Age Factor) Z-Scores Interpretation	Interpretation of Wilcoxon Signed-Rank Test Results (Age Factor) P-Values (Asymp. Sig. = .000)
H_1: There is significant relationship between demographic profile and individual attributes of healthcare providers.	Age and individual attributes	The more negative the Z-score, the greater the difference between age groups. Attributes (e.g., Compassion, Communication, and Trustworthiness) have stronger Z-values, meaning they are more influenced by Age.	All p-values are < 0.001, indicating highly significant differences. This means that age has a significant influence on individual attributes.
	Gender and Individual Attributes	Highly negative Z-values suggest stronger differences between genders in individual attributes. Communication, compassion, trustworthiness, and confidentiality have the most extreme Z-values (around -20), meaning they are highly influenced by Gender.	All p-values are < 0.001, meaning that Gender has a statistically significant effect on all assessed skills. This suggests a notable difference in how different genders perceive or demonstrate their individual characteristics.

Source: Author's own work

Table 9 shows that for both age and gender, we have negative Z-values, which suggests that there lies a strong relation between the demographic factors and individual attributes, and henceforth reject the null hypothesis and accept the alternative hypothesis, confirming that both age and gender have a statistically significant relationship with individual attributes.

Table 10 shows that for both profession and workplace we have negative Z- values, which suggests that there lies a strong relation between the job profile and individual attributes, and henceforth reject the null hypothesis and accept the alternative hypothesis, confirming that both profession and workplace have

statistically significant relation with individual attributes.

Table 10: Job profile and Individual attributes

Hypothesis	Job Profiles	Interpretation of Wilcoxon Signed-Rank Test Results (Age Factor) Z-Scores Interpretation	Interpretation of Wilcoxon Signed-Rank Test Results (Age Factor) P-Values (Asymp. Sig. = .000)
H_2: There is a significant relationship between job profile and individual attributes of healthcare providers.	Profession and individual attributes	The Z-score indicates how far the observed difference deviates from the null hypothesis (no difference). Negative Z-values suggest that there lies differences in the attributes of the doctors and nurses.	All p-values are < 0.001, meaning the differences are statistically highly significant. This suggests that due to profession individual attributes like counselling, listening, communication, compassion, work under pressure, empathy, confidentiality, and trustworthiness significantly differ.
	Work place and Individual Attributes	The Z-values are all negative, suggesting that there lies differences in the attributes in different workplace.	All p-values are < 0.001, indicating highly significant differences. This suggests that the workplace significantly affects perceptions of attributes like counselling, listening, communication, compassion, handling pressure, empathy, confidentiality, and trustworthiness.

Source: Author's own work

Table 11 on Demographic Factors and Emotional labour shows that for both age and gender, we have negative Z-values, which suggest that there lies a strong relation between the demographic factors and emotion regulation, and henceforth reject the null hypothesis and accept the alternative hypothesis, confirming that both age and gender have a statistically significant relation with emotion regulation.

Table 12 on Job Profile and Emotional Labour shows that for both profession and workplace, we have negative Z-values, which suggest that there lies a strong relation between the job profile and emotion regulation, and henceforth reject the null hypothesis and accept the alternative hypothesis, confirming that both profession and workplace have a statistically significant relation with emotion regulation.

Table 11: Demographic Factors and Emotional labour

Hypothesis	Demography and emotional labour	Interpretation of Wilcoxon Signed Rank Test Results (Age Factor) Z-Scores Interpretation	Interpretation of Wilcoxon Signed-Rank Test Results (Age Factor) P-Values (Asymp. Sig. = .000)
H_3: There is significant relationship between demographic profile and emotion regulation of healthcare providers.	Age & Emotional Labour	The Z-values are showing varying levels of age-based differences.	Almost all factors have p < 0.001, meaning age significantly impacts them. However, three factors are not statistically significant: "Unable to satisfy patient queries" (p = 0.431) "Understanding patient mentality" (p = 0.057, borderline) "Convincing patients to follow instructions" (p = 0.023, small effect) "Understanding how patients feel" (p = 0.001, still significant but weaker than others)
	Gender and Emotional Labour	The Z-values range are indicating varying levels of gender-based differences across different emotional work aspects.	All p-values are < 0.001, meaning that Gender significantly influences all these emotional work factors. This suggests that men and women experience these emotional challenges differently in patient care.

Source: Author's own work

Table 12: Job Profile and Emotional Labour

Hypothesis	Job profile and emotional labour	Interpretation of Wilcoxon Signed Rank Test Results (Age Factor) Z-Scores Interpretation	Interpretation of Wilcoxon Signed-Rank Test Results (Age Factor) P-Values (Asymp. Sig. = .000)
H_4: There is a significant relationship between job profile and emotion regulation of healthcare providers.	Profession & Emotional Labour	The Z-values are indicating strong profession-based differences in emotional work experiences.	All p-values are < 0.001, meaning profession has a highly significant effect on all these emotional work factors.

	Work Place and Emotional Labour	The Z-values are showing varying degrees of workplace related differences in emotional work experiences.	Almost all factors have p < 0.001, meaning workplace has a highly significant effect on them. Only one factor has a slightly higher p-value (0.017) but is still statistically significant: "Creating a relaxed atmosphere for patients" (p = 0.017)

Source: Author's own work

The Wilcoxon Signed Rank Test suggests that demographic factors, job profile, and emotional labour are directly related. Henceforth, we can say that due to changes in the demographic factors and job profile, the emotional display of the individuals (healthcare providers in this case) changes.

We further conducted the Mann-Whitney U Test in order to make a comparison between the two categories of respondents, i.e. doctors and nurses, who have been considered for our study.

The Mann-Whitney U Test, also known as the Wilcoxon Rank Sum Test, is a non-parametric statistical test used to compare two samples or groups.

The Mann-Whitney U Test assesses whether two sampled groups are likely to derive from the same population, and essentially asks, do these two populations have the same shape about their data? In other words, we want evidence as to whether the groups are drawn from populations with different levels of a variable of interest.

It follows that the hypotheses in a Mann-Whitney U Test are:

- The null hypothesis (H_0) is that the two populations are equal.
- The alternative hypothesis (H_1) is that the two populations are not equal.

Some researchers interpret this as comparing the medians between the two populations (in contrast, parametric tests compare the means between two independent groups). In certain situations, where the data are similarly shaped (see assumptions), this is valid – but it should be noted that the medians are not actually involved in the calculation of the Mann-Whitney U test statistic. Two groups could have the same median and be significantly different according to the Mann-Whitney U test.

A Mann-Whitney test is used when we have a continuous level variable measured for all observations in two groups, and we want to test if the distribution of this variable is different in the two groups, but we are unable to assume normality in both groups. The data are assumed to have a non-normal or skewed distribution.

Table 13: Mann Whitney U test

Personality traits	**Doctors (SD)**	**Nurses (SD)**	**P – Value**
Counseling Skill	4(SD = 0.85)	3.94(SD = 0.95)	0.704
Listening Skill	4.23(SD = 0.88)	4.14 (SD=0.89)	0.138
Communicative ability	4.08 (SD = 0.93)	3.96 (SD= 0.93)	0.071
Compassionate	4.29 (SD= 0.87	4.17 (SD=1.03)	0.384
Empathy	4.11 (SD = 0.94)	3.92 (SD = 0.96)	0.008 (significant)
Ability to Work Under Pressure	3.98 (SD= 0.92)	3.90 (SD =0.99)	0.416
Respect Patient Confidentiality	4.51 (SD=0.79)	4.45 (SD=0.94)	0.997
Responsible and Trustworthiness	4.48(SD= 0.88)	4.39 (SD=0.94)	0.217

Source: Author's own calculation

- Significance Testing: Mann-Whitney U test

- Multiple Comparison Correction: Bonferroni

The only significant difference observed in the study is empathy, where doctors scored higher than nurses (P-value = 0.008).

All other traits (counselling skill, listening skill, communicative ability, compassion, ability to work under pressure, respect for patient confidentiality, and trustworthiness) showed no significant differences between doctors and nurses.

The study suggests that while doctors and nurses are similar in most personality traits, empathy stands out as a significant difference between the two groups, with doctors showing a higher level of empathy. However, no other traits tested showed meaningful differences between the two professions.

13. Box Plots

A box plot is a graphical representation of the distribution of a dataset. It displays key summary statistics such as the median, quartiles, and potential outliers in a concise and visual manner. By using a box plot, we can provide a summary of the distribution, identify potential issues, and compare different datasets in a compact and visual manner. A box plot is a graphical method to visualise data distribution for gaining insights and making informed decisions. A box plot is a type of chart that depicts a group of numerical data through its quartiles.

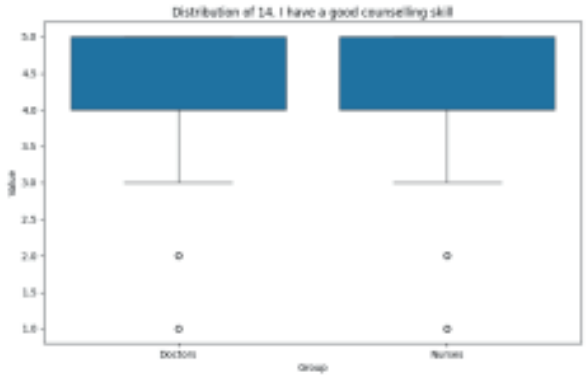


Figure 2: Counselling Skill

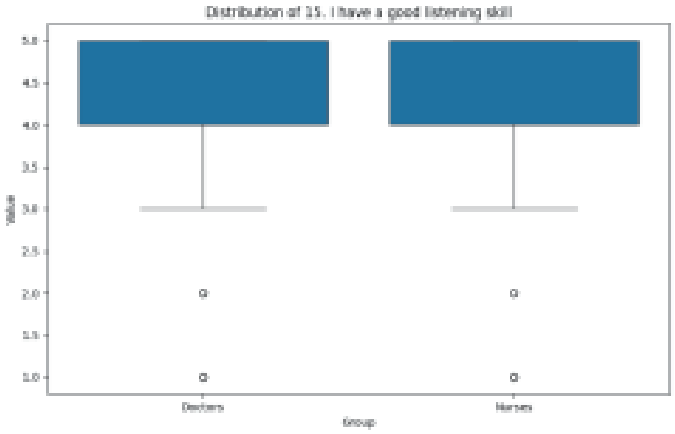


Figure 3: Listening Skill

Nurses have more communication ability than doctors.

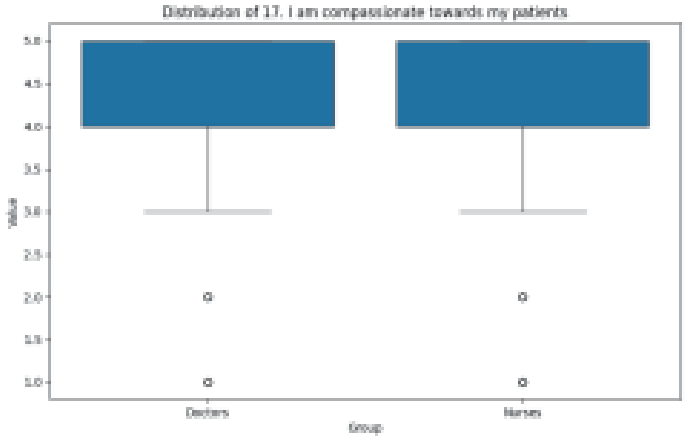


Figure 4: Compassionate towards patients

Nurses can work under more pressure than doctors can.

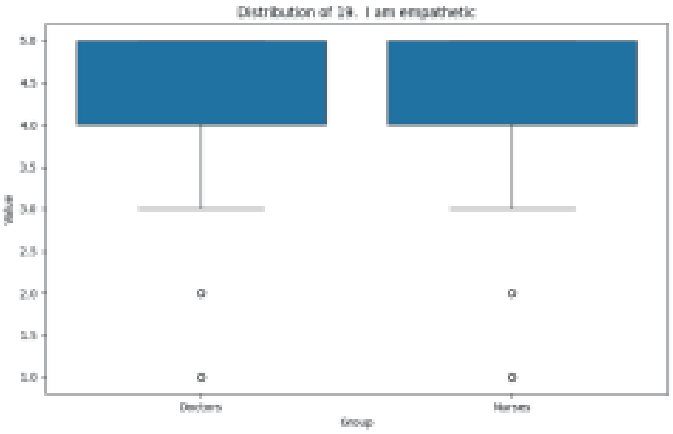


Figure 5: Empathetic

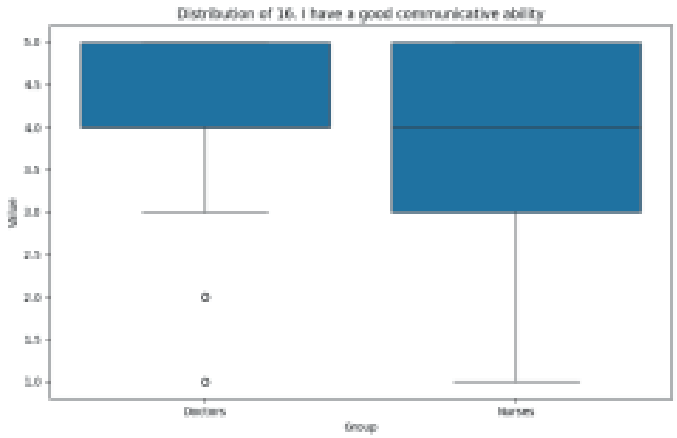


Figure 6: Communicative Ability

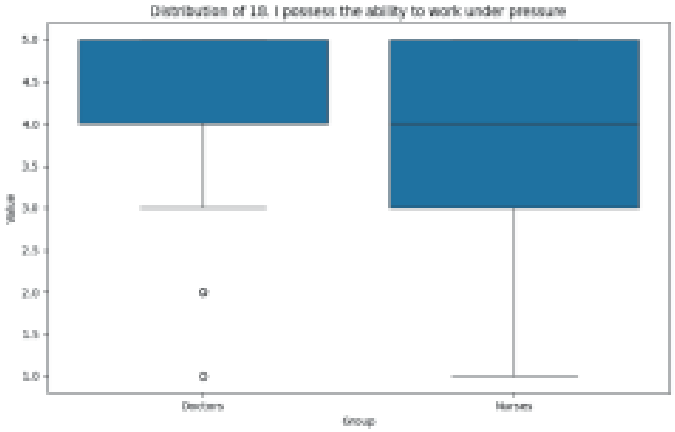


Figure 7: Ability to work under pressure

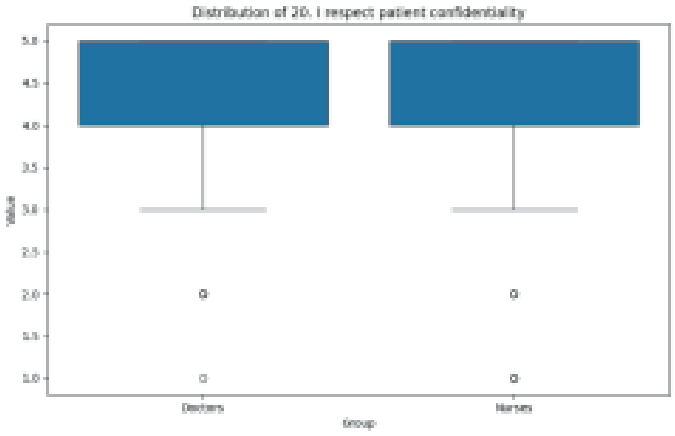


Figure 8: Respect Patient's Confidentiality

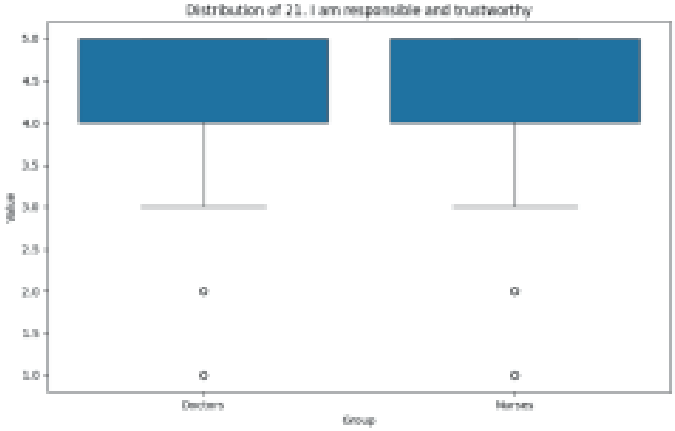


Figure 9: Responsible and Trustworthy

Source: Author's own calculation

Box plots have been used to make a comparative analysis between doctors and nurses, considering their individual attributes. It is found that nurses have more communicative ability in comparison to doctors, and nurses can work under pressure much better than doctors. Apart from these two, for all the other traits, doctors and nurses score almost the same score and exhibit similar behaviour.

Demographic comparison between the doctors and nurses presented through the box plots shows that nurses have more communicative ability than doctors, and they are also more capable of working under pressure in comparison to doctors.

However, the box plots that are developed to assess the differences in individual attributes among the doctors and nurses show that there is no difference in regard to empathy between the doctors and nurses, which again emphasises the fact that empathy is significant for both the doctors and nurses for emotion regulation.

To sum up, we can say that healthcare providers differ from one another due to their differences in

demographic factor and job profile. The differences in the display of emotion among healthcare providers may be due to these different demographic factors and different job profiles. But this may not necessarily be the only reason for different emotional displays.

The primary components of the study are individual attributes of healthcare providers and emotional labour. Here, individual attributes are considered as independent variables, and emotional labour has been considered as a dependent variable, and our objective was to identify whether emotional labour is dependent on the individual attributes or not.

As the respondents have been categorised into two segments, i.e. doctors and nurses, for better understanding, we have developed heat maps separately for the two categories of respondents. Firstly, we have generated the heat map for the doctors, depicting their individual attributes and emotional labour. This heat map clearly indicates the individual attributes that influence doctors' ability to manage emotional labour.

14. Relationship Between Individual Attributes and Emotional Engagement: Doctors Group

The chart below (Figure 10) is a heat map showing the relationship between individual attributes and emotional labour components in a group of doctors, where the rows show the emotional engagement and the columns show the individual attributes. The colours represent correlation coefficients, indicating the strength and direction of the relationships between individual attributes and emotional labour components.

Doctors with strong communication skills and the

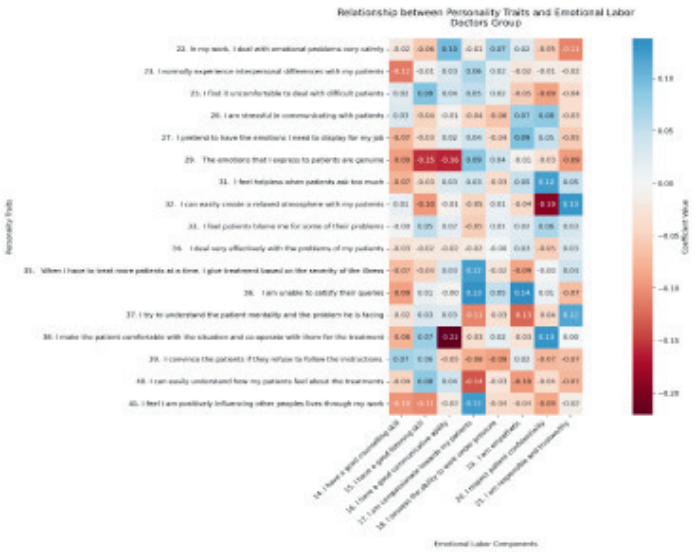


Figure 10: Heat Map depicting the relationship for the Doctors Group

Source: Author's own calculations

ability to remain calm tends to perform better in emotional labour aspects. On the other hand, those who experience stress or difficulty dealing with patients may struggle in these areas.

A similar heat map has been developed for the nurses, where the relationship between the individual attributes and emotional labour of nurses has been plotted.

15. Relationship Between Individual Attributes and Emotional Engagement: Nurses Group

The heat map below in Figure 11 has helped us to identify the nurses' reactions and control over their emotions and how that is influenced by their individual attributes.

Nurses are found to have a stronger correlation between their emotional labour components and individual attributes. They are found to be compassionate and have good communication skills. A very interesting aspect has been identified among the nurses, that is, nurses who feel blamed by patients might still show compassion. However, for both the doctors and the

nurses, it has been found that interpersonal conflicts harm emotional labour.

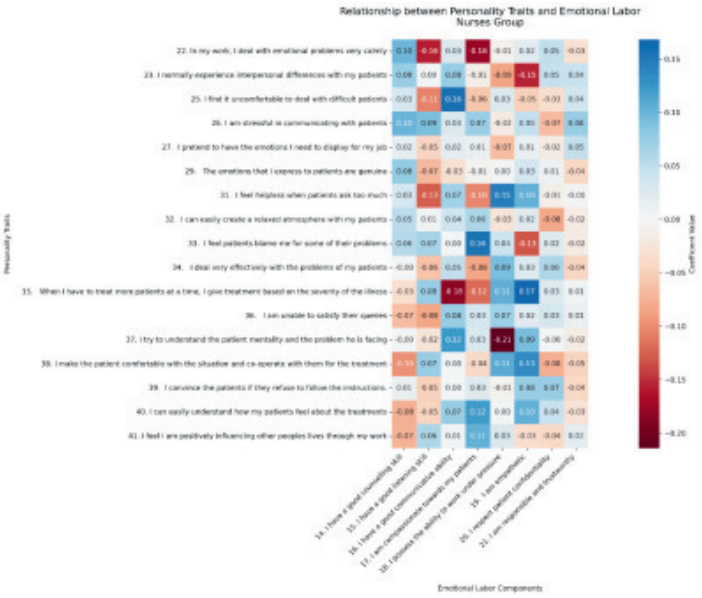


Figure 11: Heat Map Depicting the Relationship for Nurses Group

Source: Author's own calculation

The heat maps help us to assess the differences between the doctors and nurses in their service delivery process in regard to their emotional management and control. The major differences can be summed up as:

It has been found that nurses are more emotionally affected by patient interactions. Nurses have stronger correlations between emotional responses and emotional labour, which may be because nurses' work involves more direct and frequent patient interaction, making their emotional labour more intense.

On the other side, doctors show more control over emotions in comparison to nurses, while nurses show more compassion. This may be due to the fact that doctors may suppress emotions more for professionalism. Meanwhile, nurses rely more on emotional connection and compassion to manage patient relationships. Interpersonal conflicts impact nurses more than doctors. Nurses' relationships with patients play a bigger role in their emotional labour than doctors'. Nurses also find it difficult to handle patients. Nurses may struggle more with difficult patients due to the higher emotional labour demand in their role.

Further, we have conducted Principal Component Analysis (PCA) in order to reduce the factors so that we can easily establish the correlation between the individual attributes, emotional labour and performance-related factors.

At first, PCA was conducted on the emotional labour components of the respondents. Out of the twenty components as specified in the study, six factors have been extracted based on the factor loadings. However, before proceeding with the EFA, KMO and Bartlett's Test have been carried out to confirm that EFA can be conducted on the data set.

16. Principal Component Analysis for Emotional Labour

Table 14: KMO and Bartlett's Test

KMO Test	Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.597
Bartlett's Test of Sphericity	Approx. Chi-Square	474.5
	df	190
	Sig.	0

Source: Author's own work

The KMO value is 0.597, which indicates that the sample may be at the moderate level for factor analysis. But for the Bartlett's Test of Sphericity, we have obtained an approximate chi-square value of 474.500 with 190 degrees of freedom and a significance level (p-value) of 0.000, which is highly significant. This suggests that the correlations among variables are sufficient for factor analysis. Hence, while the KMO value suggests that the sampling adequacy is moderate, Bartlett's Test indicates that there are significant correlations among variables suitable for factor analysis, suggesting that we may proceed with EFA.

The "KMO and Bartlett's Test" has been succeeded by the "Total Variance Explained" (TVE), as illustrated in the following table. The TVE will deliver results from which we will derive factors on the condition that "Eigen Values" are more significant than 1 (Eigen Values>1). Eigenvalues are "a special set of scalars associated with a linear system of equations". It produces six factors since, for others, the "Eigen Values" are less than unity and are not reported thus.

Principal Component Analysis for emotional labour has been conducted to extract six components from a total of twenty components. The Total Variance Explained (TVE) Table comprises three primary columns. The component column shows the Principal components (1-20) as our data set has 20 original values. We have an Initial Eigenvalues column, which presents the eigenvalue of each component, the variance explained before extraction and the cumulative variance explained by all components. The next column comprises the Extraction Sums of Squared Loadings (SS Loadings). This shows how much variance is explained by each component after applying PCA, using only the components that have an eigenvalue >1. The last column of the PCA is the Rotation SS Loadings. This column appears after a rotation method has been applied. We have used Varimax Rotation as it is an orthogonal method applied for factors which are uncorrelated, independent and represent distinct dimensions of the data.

From our given data set, we retain the six components with an eigenvalue>1.

Table 15: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var	Cumulative %	Total	% of Var	Cumulative %	Total	% of Var	Cumulative %
1	1.94	9.701	9.701	1.94	9.701	9.701	1.801	9.004	9.004
2	1.615	8.073	17.774	1.615	8.073	17.774	1.49	7.452	16.456
3	1.35	6.749	24.523	1.35	6.749	24.523	1.375	6.874	23.33
4	1.173	5.867	30.39	1.173	5.867	30.39	1.236	6.18	29.51
5	1.11	5.552	35.942	1.11	5.552	35.942	1.203	6.014	35.524
6	1.077	5.384	41.326	1.077	5.384	41.326	1.16	5.802	41.326
7	1.03	5.151	46.477						
8	1.007	5.037	51.514						
9	0.998	4.988	56.502						
10	0.943	4.715	61.216						
11	0.91	4.546	65.767						
12	0.898	4.49	70.257						
13	0.851	4.257	74.514						
14	0.831	4.156	78.669						
15	0.814	4.071	82.74						
16	0.775	3.875	86.615						
17	0.744	3.719	90.334						
18	0.714	3.569	93.903						
19									
20									

Extraction Method: Principal Component Analysis.

Source: Author's own work

The six components together explain 41.326% of the total variance, based on the extraction method. After rotation the total variance remains the same, but has been redistributed differently for better interpretability.

For our study, we have decided on a common threshold of 0.4 and above (in absolute value) to consider a loading significant. Loading above this threshold suggests a meaningful association between the variable and the component.

A scree plot has also been prepared to provide a better understanding of the extraction of the components. Developed by Cattell (1966), the "Scree Plot" is the graphical representation of "Eigenvalues" versus their "Component Numbers". It can be described as "a graphical display of variance of each component in the data set, which is used to determine how many components should be retained to explain a high percentage of variation in the data". The length or distance from one node to another captures the Eigenvalues. The scree plot, as shown above, clearly presents that the six components having an eigenvalue above 1 have been considered as the Principal Components.

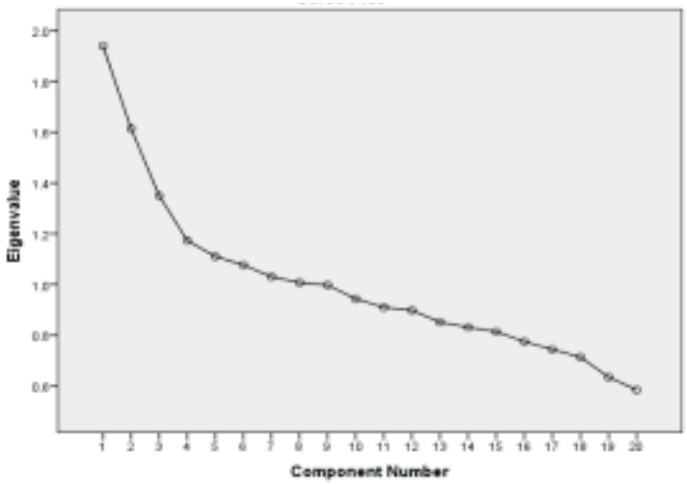


Figure 12: Scree Plot for Emotional Labour
Source: Author's own calculation

Henceforth, we conduct the Rotated Component Matrix (RCM) that represents the six components as from "Principal Component Analysis" (PCA). The RCM ensures the accommodation of the variables in the factors based on their "factor loadings", thus, providing the final results.

For each variable, components having the highest absolute loading above the threshold (0.4) have been determined. After assigning the variables to components by interpreting the common theme, they have been named or labelled following thematic labelling. This has been done guided by theoretical considerations and the nature of the variable.

Table 16: Component Matrix

Item	C1	C2	C3	C4	C5	C6
In my work, I deal with emotional problems very calmly	−.176	0.091	0.664	0.207	0.152	−.096
Experience interpersonal differences with my patients	−.156	0.125	0.665	−.059	0.011	−.118
Uncertain about what to tell a patient or the family members about the patient's condition or treatment	0.181	0.154	−.229	0.46	0.365	−.173
Uncomfortable to deal with difficult patients	−.220	0.228	−.108	0.422	−.213	0.438
Stressful in communicating with patients	−.334	0.415	0.001	−.175	−.091	−.378
Pretend to have the emotions that need to be displayed for the job	−.349	0.342	−.278	0.038	−.277	−.242
Experience the emotions that must be shown to patient	−.273	0.428	−.054	−.279	0.072	0.231
Emotions expressed to patients are genuine	−.178	0.287	−.111	−.262	−.407	0.085
When there is disagreement with the patients, serve according to the patients' requirement without any emotional change	0.026	0.273	0.048	−.487	0.31	0.179
Feel helpless when patients ask too much or am unable to satisfy their queries	0.178	0.161	−.371	0.215	−.044	−.127
I can easily create a relaxed atmosphere with my patients	0.073	0.203	−.134	−.109	0.188	0.481
I feel patients blame me for some of their problems	−.278	0.392	0.149	0.211	−.188	−.109

Source: Author's own work

I deal very effectively with the problems of my patients	0.419	0.299	−.085	−.324	0.163	−.165
When I have to treat more patients at a time, I give treatment based on the severity of the illness	−.290	0.294	0.073	0.189	0.224	0.245
I am unable to satisfy their queries	0.407	0.326	0.096	0.082	0.21	0.094
I try to understand the patient's mentality and the problem he is facing	0.312	0.344	0.199	0.239	−.090	0.209
I make the patient comfortable with the situation and co-operate with them for the treatment	−.336	0.284	−.220	0.107	0.406	−.254
I convince the patients if they refuse to follow instructions	0.475	0.204	0.127	0.017	−.431	0.067
I can easily understand how my patients feel about the treatments	0.489	0.22	0.06	−.003	−.059	−.246
I feel I am positively influencing other people's lives through my work	0.499	0.307	0.029	0.043	−.043	−.097

Table 17: Rotated Component Matrix

Item	C1	C2	C3	C4	C5	C6
In my work, I deal with emotional problems very calmly	0.02	-0.012	0.723	-0.08	0.101	0.119
Experience interpersonal differences with my patients	0.04	0.095	0.69	0.014	-0.048	-0.101
Uncertain about what to tell a patient or the family members about the patient's condition or treatment	0.225	-0.071	-0.141	-0.126	0.102	0.618
Uncomfortable to deal with difficult patients	-0.032	0.102	-0.092	0.016	0.712	-0.013
Stressful in communicating with patients	-0.019	0.639	0.143	0.089	-0.147	0.081
Pretend to have the emotions that need to be displayed for the job	-0.074	0.636	-0.16	-0.063	0.103	0.052
Experience the emotions that must be shown to patient	-0.061	0.301	0.028	0.533	0.129	-0.032
Emotions expressed to patients are genuine	0.005	0.431	-0.122	0.17	0.094	-0.36
When there is disagreement with the patients, serve according to the patients' requirement without any emotional change	0.06	0.001	0.073	0.627	-0.202	-0.017
Feel helpless when patients ask too much or am unable to satisfy their queries	0.221	0.126	-0.357	-0.129	0.068	0.215
I can easily create a relaxed atmosphere with my patients	0.067	-0.165	-0.154	0.483	0.233	-0.001
I feel patients blame me for some of their problems	0.07	0.447	0.239	-0.062	0.275	0.06
I deal very effectively with the problems of my patients	0.442	0.045	-0.118	0.28	-0.37	0.065
When I have to treat more patients at a time, I give treatment based on the severity of the illness	-0.09	0.088	0.184	0.269	0.374	0.244
I am unable to satisfy their queries	0.493	-0.144	0.055	0.202	0.056	0.172
I try to understand the patient's mentality and the problem he is facing	0.487	-0.057	0.123	0.051	0.325	-0.029
I make the patient comfortable with the situation and co-operate with them for the treatment	-0.161	0.315	0.001	0.158	-0.031	0.576
I convince the patients if they refuse to follow instructions	0.559	0.013	-0.048	-0.117	0.092	-0.369
I can easily understand how my patients feel about the treatments	0.551	0.025	-0.017	-0.092	-0.203	0.02
I feel I am positively influencing other people's lives through my work	0.591	0	-0.052	0.004	-0.061	0.03

Source: Author's own work

16.1 Renaming of Emotional Labour Components: Emotional Labour Factors Extracted:

- Factor 1: Emotional engagement and professional fulfilment
- Factor 2: Pretentious Emotion (Surface Acting)
- Factor 3: Emotion regulation in patient interaction
- Factor 4: Felt Emotion (Deep Acting)
- Factor 5: Conflict and interpersonal tension
- Factor 6: Emotional exhaustion

Table 18: Factor Analysis of Emotional Labour Components

Factor 1 Emotional Engagement & professional fulfilment	Factor 2 Pretentious Emotion (Surface Acting)	Factor 3 Emotion regulation in patient interaction	Factor 4 Felt Emotion (Deep acting)	Factor 5 Conflict & Interpersonal Tension	Factor 6 Emotional exhaustion
"I convince the patients if they refuse to follow instructions. " (Loading: 0.559)	"Stressful in communicating with patients." (Loading: 0.639)	"In my work, I deal with emotional problems very calmly." (Loading: 0.723)	"When there is disagreement with the patients, serve according to the patients' requirement without any emotional change." (Loading: 0.627)	"Uncomfortable to deal with difficult patients." (Loading: 0.712)	"Uncertain about what to tell a patient or the family members about the patient's condition or treatment." (Loading: 0.618)
"I feel I am positively influencing other people's lives through my work." (Loading: 0.591)	"Pretend to have the emotions that need to be displayed for the job." (Loading: 0.636)	"Experience interpersonal differences with my patients." (Loading: 0.690)	"Experience the emotions that must be shown to patient." (Loading: 0.533)		"I make the patient comfortable with the situation and co-operate with them for the treatment." (Loading:
"I can easily understand how my patients feel about the treatments." (Loading: 0.551)	"I feel patients blame me for some of their problems." (Loading: 0.447)		"I can easily create a relaxed atmosphere with my patients." (Loading: 0.483)		
"I try to understand the patient's mentality and the problem he is facing." (Loading: 0.487)	"The emotions that I express to patients are genuine ." (Loading: .431)				
"I deal very effectively with the problems of my patients." (Loading: 0.442)					
"I am unable to satisfy their queries " (Loading: .493)					

Source: Author's own work

17. PCA on Individual Attributes

Principal Component Analysis has been conducted on the individual attributes of the respondents. Out of the eight attributes as specified in the study, three factors have been extracted based on the factor loadings. However, before proceeding with the PCA, KMO and Bartlett's Test have been carried out to confirm that PCA can be conducted. on the data set.

Table 19: KMO and Bartlett's Test

KMO Test	Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.693
Bartlett's Test of Sphericity	Approx. Chi-Square	185.692
	df	28
	Sig.	0.000

Source: Author's own work

The above table provides a KMO value of 0.693, which falls into the "mediocre" category, suggesting that the data is suitable for factor analysis. For the Bartlett's Test of Sphericity, we have obtained an approximate chi-square value of 185.692, 28 degrees of freedom, and a p-value of 0.000, indicating that Bartlett's Test is significant. Both tests suggest that the data are appropriate for factor analysis. While the KMO measure indicates a mediocre level of sampling adequacy, the significant Bartlett's Test confirms that the variables have adequate correlations for this analytical approach. This suggests that the actor analysis.

Following the KMO and Bartlett's Test of Sphericity, we continue with the Principal Component Analysis (PCA) and derive the Total Variance Explained.

Principal Component Analysis for individual attributes has been conducted to extract three components from a

total of eight factors.

The Total Variance Explained (TVE) Table, as shown below, comprises three primary columns. The component column shows the Principal components, numbered from 1 to 8, as our data set has 8 original values.

From our given data set, we retain the three components with an eigenvalue>1. The three components together explain 48.395% of the total variance, based on the extraction method. After rotation, the total variance remains the same but has been redistributed differently for better interpretability. For our study, we have decided on a common threshold of 0.4 and above (in absolute value) to consider a loading significant. Loading above this threshold suggests a meaningful association between the variable and the component.

Table 20: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.835	22.941	22.941	1.835	22.941	22.941	1.809	22.614	22.614
2	1.063	13.282	36.224	1.063	13.282	36.224	1.034	12.93	35.544
3	0.974	12.172	48.395	0.974	12.172	48.395	1.028	12.851	48.395
4	0.925	11.566	59.961						
5	0.894	11.18	71.141						
6	0.839	10.492	81.633						
7	0.754	9.421	91.054						
8	0.716	8.946	100						

Extraction Method: Principal Component Analysis.

Source: Author's own work

A scree plot has also been prepared to provide a better understanding of the extraction of the components. The scree plot, as shown below, clearly presents that the three components having Eigenvalue above 1 have been considered as the Principal Components. We conduct the Rotated Component Matrix (RCM) that represents the three components from "Principal Component Analysis" (PCA). Final results have been derived as the RCM ensures the acceptability of the variables in the factors based on their "factor loadings".

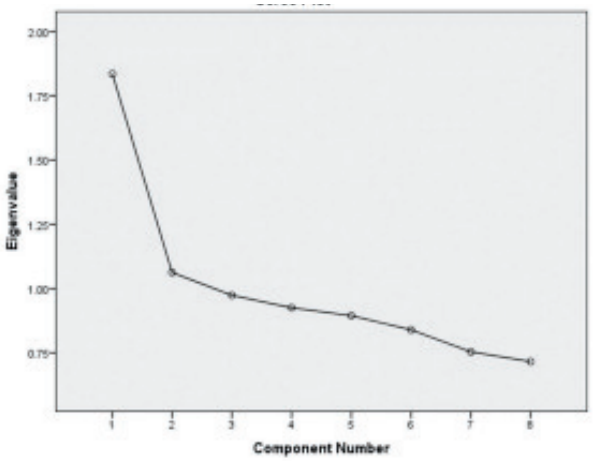


Figure 13: Scree Plot for Individual Attributes

Source: Author's own calculation

Table 21: Component Matrix

Variable	Component 1	Component 2	Component 3
Good counselling skill	-0.091	0.752	-0.519
Good listening skill	-0.207	0.644	0.621
Good communicative ability	0.553	0.01	-0.148
Compassionate towards patients	0.59	0.01	-0.016
Ability to work under pressure	0.524	0.034	0.408
Empathetic	0.505	0.12	-0.322
Respect patients' confidentiality	0.49	0.258	0.078
Responsible and trustworthy	0.601	-0.023	0.139

Extraction Method: Principal Component Analysis.

Source: Author's own work

Table 22: Rotated Component Matrix

Variable	Component 1	Component 2	Component 3
Counselling skill	-0.015	0.102	0.913
Listening skill	-0.047	0.912	0.095
Communicative ability	0.533	-0.2	0.068
Compassionate towards patients	0.58	-0.106	-0.02
Ability to work under pressure	0.556	0.241	-0.274
Empathetic	0.487	-0.253	0.268
Respect patients' confidentiality	0.529	0.139	0.113
Responsible and Trustworthy	0.599	-0.012	-0.147

Note: Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalisation.

a. Rotation converged in 7 iterations.

Source: Author's own work

17.1 Renaming of Individual attribute components

- Factor 1: Counselling Skill-Ability to provide guidance and emotional support to patients.
- Factor 2: Empathy-Understanding and sharing the feelings of patients.
- Factor 3: Trustworthiness-Reliability and integrity in professional interactions.

The eight attributes also comprise the performance-related attributes of the respondents. Hence, with the same, we have further carried out PCA to extract two performance-related factors out of the eight attributes, based on the SS loadings.

Table 23: Factor Analysis of Individual Attributes

Factor 1: Personal and professional attributes (Empathy and	**Factor 2: Listening Skill**	**Factor 3: Counselling skill**
Compassionate towards my patients (Loading: .580)	Listening skill (loading: .912)	Counselling skill (Loading: .913)
Empathetic (Loading : .487)		
Communicative ability (Loading: .533)		
Ability to work under pressure (Loading: .556)		
Respect patient confidentiality (Loading: .529)		
Responsible and trustworthy (Loading: .599)		

Source: Author's own work

18. Correlation Coefficient

Spearman's Rho correlation coefficient has been conducted among nine variables, six related to emotional labour and three related to individual attributes, in a sample of 546 respondents. Spearman's rho establishes the relationship between the two variables that can be described by a monotonic function, i.e. as one variable is increasing, the other variable is also increasing or decreasing. The correlation has been carried out as we want to establish the relationship between the emotions of the healthcare providers and their individual attributes. As we have already obtained the principal components from factor reduction, we are conducting the correlation with those factors. Hence, we have three components from individual attributes and six components from emotion regulation.

The Significance Level for Spearman's Rho correlation coefficient = 0.01, where the threshold for statistical significance is $p < 0.01$.

This is a strict (conservative) level of significance, meaning there is less than a 1% chance that the observed correlation occurred due to random chance.

H_5: There is a significant relationship between individual attributes and the emotion regulation of healthcare providers.

Table 24: Spearman's Rank Correlation Coefficients

Variables	Statistical Measures	Counselling skill	Empathy	Trustworthiness
Emotional engagement and professional fulfilment	Correlation Coefficient	-0.046	0.007	-0.017
	Sig. (2-tailed)	0.278	0.878	0.684
	N	546	546	546
Pretentious Emotion (Surface acting)	Correlation Coefficient	0.035	0.014	-0.038
	Sig. (2-tailed)	0.416	0.747	0.377
	N	546	546	546
Emotion Regulation in patient interaction	Correlation Coefficient	0.183**	-0.038	-0.083
	Sig. (2-tailed)	0	0.375	0.052
	N	546	546	546
Felt Emotion (Deep Acting)	Correlation Coefficient	0.024	-0.048	0.025
	Sig. (2-tailed)	0.567	0.262	0.561
	N	546	546	546
Conflict and interpersonal tension	Correlation Coefficient	-0.02	-0.078	-0.066
	Sig. (2-tailed)	0.641	0.066	0.12
	N	546	546	546
Emotional Exhaustion	Correlation Coefficient	0.035	0.013	0.057
	Sig. (2-tailed)	0.415	0.766	0.182
	N	546	546	546

*Note: In the table above, correlations marked with "**" are statistically significant at p < .01.*

Table 25: Correlation Analysis between Counselling Skill and Emotion Regulation

Variable Pair	Correlation coefficient	Significance level p < .001	Interpretation
Counselling Skill ↔ Emotion Regulation	0.183	p = .000	Better emotion regulation with patients relates better counselling skill.

Source: Author's own work

In the above correlation table, we find only one significant relation between emotional labour and individual attributes, and that is between counselling skill and emotion regulation. This indicates that those better at regulating emotions with patients are more likely to report higher counselling skills. Most of the other relationships are either weak or non-significant, suggesting individual attributes do not necessarily influence emotional labour strategies. Still, we cannot totally ignore the impact of individual attributes on the emotional labour of the respondents.

19. Findings

The major findings of the study can be summarised as follows:

1. Demographic and job profiles significantly influence individual attributes of healthcare providers.

- Age and gender affect attributes like communication, compassion, trustworthiness, and confidentiality.
- Job profile (doctor vs. nurse) and workplace (government vs. private) also have a strong effect on these traits.

2. Demographic and job profiles are strongly related to emotional labour.

- Both age and gender significantly influence emotional regulation.

** Correlation is significant at the 0.01 level (2-tailed).

- Profession and workplace type also shape how emotional labour is experienced.

3. Individual attributes affect emotional labour, with counselling skills being the strongest link.
- Higher counselling skills correlate with better emotional regulation.
- Other traits like empathy and trustworthiness show weak or non-significant direct relationships.

4. Differences between doctors and nurses in individual attributes and emotional labour:
- Doctors scored significantly higher on empathy ($p = 0.008$).
- Nurses demonstrated better communication skills and greater ability to work under pressure (from box plots).
- Emotional fatigue is more pronounced among nurses due to more intense patient contact.

5. Emotional labour factors extracted via PCA:
- Six key components:
  - Emotional engagement & professional fulfilment
  - Pretentious emotion (surface acting)
  - Emotion regulation in patient interaction
  - Felt emotion (deep acting)
  - Conflict & interpersonal tension
  - Emotional exhaustion

6. Individual attributes are grouped into three factors: Counselling skill, Empathy, and Trustworthiness.

7. Insights from heat maps:
- Nurses' emotional labour is more strongly linked to individual attributes.
- Nurses rely heavily on compassion and emotional connection, making them more vulnerable to emotional strain.
- Doctors display more emotional detachment and control, relying on professionalism over emotional connection.

8. Empathy as a pivotal trait:
- Empathy drives deep acting (genuine emotional expression), linked with higher job satisfaction, patient satisfaction, and performance.
- Surface acting (pretentious emotion) correlates with emotional exhaustion and lower job satisfaction.

20. Conclusion and Recommendation

Individual attributes do have an impact on the behaviour of the healthcare providers while at service and play a significant role in regulating and monitoring their emotions. The present study has identified personality traits like counselling, communicative ability, compassion, ability to work under pressure and respect for a patient's confidentiality, which show a relationship with gender, age and also marital status.

However, there are many other attributes which regulate and monitor the emotions of the healthcare providers, but since they do not depend on the demographic profile of the individuals, researchers need to investigate this context.

Emotional labour has taken up a pivotal role in the healthcare service delivery system, especially among service providers such as doctors and nurses who are constantly engaged in emotionally intense service encounters. The present study examined the intricate

empathy—and the performance of emotional labour among healthcare providers. Drawing from both theoretical understanding and empirical observations, the study has deepened insights into how individual attributes play a role in the emotional regulation of healthcare providers.

One of the most significant findings of this study is the role of individual attributes, especially empathy, in influencing the mode and intensity of emotional labour. Empathy enables healthcare workers to connect authentically with patients, making them more inclined toward deep acting (termed as Felt Emotion in this study), which involves genuinely experiencing and expressing required emotions. This form of emotional labour has been positively associated with higher job satisfaction, patient satisfaction, and work efficiency.

Conversely, surface acting (referred to as Pretentious Emotion)—where healthcare workers simulate emotional expressions without genuinely feeling them —has been linked with emotional exhaustion, psychological strain, and diminished job satisfaction. This form of dissonant emotional expression was found to be more harmful in prolonged care contexts.

The study also revealed notable differences between doctors and nurses in terms of emotional engagement. Nurses, owing to their more frequent and intensive interactions with patients, are more susceptible to emotional fatigue. Their professional role demands a higher degree of compassion and emotional expression, making their emotional labour more visible and emotionally taxing. Emotional exhaustion among nurses is thus more pronounced, driven by both deep emotional involvement and workload stressors. Doctors, in contrast, tend to manage their emotional engagement through cognitive appraisal and emotional detachment. In their role, rational decision-making and maintaining professional composure are crucial, often requiring them to suppress their emotions. While this strategy helps in maintaining objectivity, it may also limit the emotional connection with patients.

In essence, the study underscores that emotional labour is not only a professional expectation in healthcare but also a psychological process deeply influenced by personal traits, job roles, and organisational culture. The distinctions in emotional regulation strategies between nurses and doctors highlight the need for role-specific support mechanisms that acknowledge and address emotional demands in healthcare professions.

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