The Non-Physical Capital Imperative: Digital Public Infrastructure, Human Capital Transformation, and Geopolitical Risk in India's $30T Journey (2025–2047)

Dr. B. Arun

Department of Economics, Osmania University

Abstract

This investigation systematically analyses the role of non-physical capital specifically **Digital Public Infrastructure (DPI)**, **Human Capital Transformation**, and **Geopolitical Risk Management** in the realization of India's $30.0 trillion economic goal by 2047. Employing a **Temporal Decomposition Analysis (TDA)** across 5-year intervals, the study establishes that the critical challenge is not capital expenditure alone, but the generation of sustained Total Factor Productivity (**TFP**) gains, which must accelerate from ≈1.5% in 2025 to ≈3.5% by 2047. The paper demonstrates that DPI acts as the primary TFP multiplier, linking financial inclusion to macroeconomic scaling. Furthermore, it posits that active, phase-specific risk mitigation against external geopolitical shocks is essential to maintain the nominal **7.6% CAGR** required for the ambitious trajectory, providing an indispensable framework for policy formulation directed toward national resilience.

Keywords: Non-Physical Capital; Digital Public Infrastructure (DPI); Human Capital Transformation; Total Factor Productivity (TFP); Economic Growth Pathway; Temporal Decomposition Analysis (TDA); Productivity Acceleration; Financial Inclusion; Geopolitical Risk Management; Macroeconomic Stability; Growth Resilience; India 2047; *Viksit Bharat* Vision

1. Introduction: Shifting from Investment to Productivity

1.1 The Necessity of Non-Physical Capital

The economic literature on national transitions to high-income status consistently highlights the diminishing returns of physical capital investment (Gross Fixed Capital Formation, GFCF) once an economy achieves scale. For India's journey from $4.0 trillion (2025) to $30.0 trillion (2047), growth must increasingly rely on **Total Factor Productivity (TFP)**, which encapsulates technological advancement, efficiency gains, and human skill density. This paper argues that India's unique path mandates leveraging its existing **Digital Public Infrastructure (DPI)** as the core catalyst for TFP and treating human capital development as a critical industrial policy.

1.2 Research Focus and Structure

While our complementary analysis (Paper 1) examined the structural shift of GDP, this research isolates and scrutinises the non-physical drivers. The central hypothesis is that the success of the Industrial Jump (required 25%→30% share increase) and the Services sector scale-up (60%→65% share increase) depends entirely on the concurrent, phase-matched acceleration of skill development and digital adoption. The analysis uses the same five-year temporal intervals (TDA) to map policy implementation against required productivity gains.

2. Methodology: Linking TDA to Productivity Benchmarks

2.1 TFP and Human Capital Modelling

The Temporal Decomposition Analysis (TDA) used the required 7.6% nominal CAGR to establish the macroeconomic milestones (GDP and PCI) across the 5-year intervals. To analyse the feasibility of achieving these milestones, we model the necessary growth in key productivity metrics:

1. **Labour Force Participation Rate (LFPR) and FLFPR:** The model requires the female participation rate (FLFPR) to rise significantly (35%→50%) by t5 to maximize the demographic dividend.
2. **TFP Contribution:** TFP is calculated as the residual growth not explained by labor and capital accumulation. Our model requires TFP growth to more than double over the 22year period, becoming the dominant engine of real economic expansion by Phase 4 (t4).

Table 1: Key Macroeconomic and Productivity Benchmarks (2025-2047)

Year (t)	GDP (Trillion USD)	PCI (K USD)	Required Nominal CAGR (%)	Required FLFPR (%)	Estimated TFP Growth (%)
2025 (t0)	4.0	2.8	N/A	35	≈1.5
2030 (t1)	6.5	4.2	10.2	38	≈2.0
2035 (t2)	10.5	6.5	10.0	42	≈2.5
2040 (t3)	16.5	10.0	9.4	46	≈3.0
2045 (t4)	23.0	14.0	7.6	48	≈3.3
2047 (t5)	30.0	18.0	7.6 (Overall)	50	≈3.5

3. Human Capital and Skill Alignment (Figures 2 and 3)

3.1 The Demographic Dividend vs. The Skilling Deficit

The shift in the economic structure (shown in **Figure 2**) dictates an urgent transformation in the skill base. The gradual decline of Agriculture's share necessitates the effective re-skilling and transition of low-skilled labour into the formal Industrial and high-value Services sectors.

- **Phase 1 & 2 (t0 to t2):** The primary focus must be on **Manufacturing-Ready Skills**. This includes vocational training in construction, logistics, and specialized production lines required by the expanding PLI schemes. The goal is to raise the productivity of the newly industrialized workforce to sustain the industry sector's growth from $1.0T to $2.94T (**Figure 3**). Failure to achieve the 42% FLFPR target by t2 will immediately constrain labor availability in export-oriented manufacturing, undermining competitiveness.

- **Phase 3 & 4 (t3 to t5):** The focus shifts to **Digital/AI Fluency**. As the Services sector scales to nearly $20.0T, the demand for knowledge-based, high-end workers in fields like data science, cybersecurity, and green technology R&D will dominate. TFP growth must peak in this period ($\approx 3.5\%$) because the marginal efficiency of new labor diminishes; only technological and skill upgrades can justify the astronomical increase in absolute value.

Table 2: Human Capital Imperatives by Economic Phase (2025-2047)

Phase	Economic Challenge	Required Skill Shift	TFP Lever
2025-2030	Initial Industrial Jump	Mass Vocational and Manufacturing Skills	DPI for Government Service Delivery
2030-2035	Middle-Income Trap Avoidance	High-Precision, Complex Manufacturing, Logistics	Formalisation of Labour Market (Digital Traceability)
2035-2040	Scaling Services and High-Tech Industry	Data Science, Cloud Computing, AI Integration	Advanced Regulatory Frameworks (IP, Data Governance)
2040-2047	Wealth Distribution and Sustainability	Green Technology Engineering, Climate Resilience Planning	Clean Energy Innovation and Efficiency

4. Digital Public Infrastructure (DPI) as a Productivity Multiplier

DPI is arguably India's most unique competitive advantage, serving as the connective tissue between financial inclusion, government efficiency, and market scale.

4.1 Financial Inclusion and Consumption Demand

The rapid growth in PCI ($2.8K$\rightarrow$$18.0K) depends on broad-based consumption. DPI platforms facilitate direct benefit transfers (DBT) and credit delivery to previously unbanked rural and informal populations. This translates directly into stable private final consumption expenditure (PFCE), which supports the domestic-demand-driven growth essential for macroeconomic stability. The efficiency gains derived from cashless transactions and paperless governance are a measurable component of the required TFP growth, particularly in Phase 1 (t0 to t1).

4.2 DPI for Governance and GFCF Efficiency

DPI reduces transaction costs for businesses, streamlining bureaucratic processes.

TFP Gain=Weighted average of Capital and Labour InputsGDP Output

By simplifying tax compliance (GST), land registration, and cross-border trade documentation, DPI reduces the deadweight loss of bureaucracy, effectively making the existing capital stock more productive. This efficiency gain is crucial to bridging the **GFCF gap** (increasing investment from 33% to 40% of GDP), as foreign investors are more likely to commit capital when the regulatory environment is digitally predictable.

5. Geopolitical Risk Management and Economic Resilience

The ambition to become a \$30T economy thrusts India into the core of global economic leadership, simultaneously increasing its exposure to systemic risks. Geopolitical strategy must be integrated into economic planning across all 5-year phases.

5.1 Trade Diversification and Protectionism

As global trade fragments, India must strategically manage its trade balance and export mix.

- **Risk:** Rising global protectionism (tariffs, non-tariff barriers) could dampen the exportdriven growth necessary for the Industry sector to achieve its 30% share by $t4$.
- **Mitigation Policy (Phase 1-3):** Aggressive pursuit of Free Trade Agreements (FTAs) with non-traditional partners (e.g., European Union, key African nations) to balance dependency on volatile regions. Investment in **logistics infrastructure** (ports, corridors) must reduce trade lead times to match global benchmarks.

5.2 Securing High-Tech Sovereignty

The dependence on external supply chains for critical components, particularly semiconductors and advanced electronics, presents a profound systemic risk to the growth of both Industry and Services sectors.

- **Risk:** Supply chain disruption or technology denial could halt the TFP-driven growth expected in Phase 3 ($t3$).
- **Mitigation Policy (Phase 2-4):** Strategic public-private investment in establishing domestic **high-tech manufacturing hubs** (semiconductors, solar PV cells) is non-
  - negotiable. This is a deliberate policy choice to increase national resilience, even if initial costs exceed immediate global market benchmarks.

5.3 Climate Resilience as a Fiscal Risk

While the Green Transition is an economic opportunity, unchecked climate change presents a fiscal and social risk that could undermine the TDA milestones.

- **Risk:** Increased frequency of climate events could damage critical infrastructure (highways, power grids) and devastate the Agriculture sector, leading to unbudgeted state expenditure and inflationary pressures, which depress consumption and increase the cost of capital.
- **Mitigation Policy (Continuous):** Investing in climate-resilient infrastructure (e.g., hardened data centres, elevated highways, water management) and introducing mandatory climate risk disclosure for large financial institutions to internalise climate costs.

6. Conclusion and Future Research Directions

The journey from $4.0 trillion to $30.0 trillion is a testament to the power of compound growth, but its success is critically dependent on non-physical capital formation. This TDA demonstrates that the required **TFP acceleration** (from 1.5% to 3.5%) is achievable only through a unified strategy where DPI facilitates massive skill upgrades and formalisation, while strategic geopolitical maneuvers shield the growing economy from external volatility.

The most challenging period remains **2030–2040 (Phase 2 and 3)**, where simultaneous execution of human capital, middle-income trap avoidance, and global market anchoring must occur. Future research should focus on developing **sub-national models** that measure the TFP return on DPI investment across varying state-level governance environments, thereby optimising resource allocation for equitable and sustained growth.

References

1. *NITI Aayog. (2025). Vision for Viksit Bharat @ 2047: An Approach Paper. Government of India Publication.*
2. *World Bank Group. (2025). Becoming a High-Income Economy in a Generation: India's Policy Imperatives. Washington, D.C.*
3. *Sharma, A. (2024). The Macroeconomics of the Middle-Income Trap: Lessons for Asia. Journal of Economic Policy, 45(3), 112-135.*
4. *Kapoor, R. (2025). Decoupling Growth from Carbon: The $12 Trillion Green Investment Opportunity. Global Energy Economics Review, 12(1), 50-78.*
5. *Economic Survey of India. (2025). Leveraging DPI for Sustained Productivity Gains. Ministry of Finance, Government of India.*
6. *Reserve Bank of India. (2024). Financial Stability Report: Geopolitical Risks and Domestic Resilience. RBI Publication.*