# Foreign Direct Investment and Sector-Level Productivity in India (1990-2020)

Omar Khalaf

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omar@khalaf.us

github.com/okhalaf123

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# Project Background

This project analyzes the impact of foreign direct investment (FDI) on total factor productivity (TFP) in India's manufacturing sector from 1990 to 2020. The study was motivated by the formation of India's National Manufacturing Competitiveness Council (NMCC) in 2004, which aimed to attract FDI and improve industrial performance. By combining macroeconomic indicators with industry-level productivity data, the project evaluates whether FDI inflows were associated with improvements in TFP, a key economic growth factor.

# Objective

To determine whether policies promoting FDI, particularly the formation of the NMCC in 2004, had a measurable effect on TFP growth in India's manufacturing sector and to understand whether the FDI's impact varies across sectors. This involves:

- Identifying trends in FDI and productivity before and after the policy change
- Running regression analyses to test the strength of the relationship between FDI and TFP across sectors
- Comparing the manufacturing sector with other industries as a form of internal benchmarking
- Offering actionable insights for industrial and investment policy in emerging markets

# Tools

The analysis was built entirely in R, using a mix of tidyverse and base functions.

**Key tools included:**

- `dplyr` and `tidyr` for data wrangling
- `readxl` to load Excel-based macroeconomic and sector datasets
- `zoo` for computing moving averages
- `ggplot2` for time series visualizations and comparative plots

- `car` for calculating variance inflation factors (VIFs) in multicollinearity checks
- `Base R` functions for linear regression and basic diagnostics

The code is modular and split across scripts by function: importing, data cleaning, regression setup, exploratory analysis, modeling, plotting, and diagnostic testing.

# Methodology

Three primary datasets were used:

- **Penn World Table (PWT) 10.0** for macroeconomic variables like real GDP, capital stock, and labor input
- **World Development Indicators (WDI)** for FDI inflows as a percentage of GDP and macroeconomic controls
- **India KLEMS** for sector-level TFP growth across 27 industries

### 1. Data Cleaning & Integration:

Merged time-series data across sources using the year dimension. Special care was taken to include 1986-1989 for lagged calculations and moving averages for visualizations.

### 2. Growth Accounting:

Applied the Solow residual method to derive TFP using labor share, capital, and labor inputs.

$$\log(y_t) = \underbrace{\gamma \cdot t}_{\text{Trend}} + \underbrace{\frac{1}{1-\alpha}\log(Z_t)}_{\text{Productivity}} + \underbrace{\frac{\alpha}{1-\alpha}\log\left(\frac{k_t}{y_t}\right)}_{\text{Capital}} + \underbrace{\log(h_t)}_{\text{Hours}}$$

### 3. Regression Dataset Construction:

Calculated year-over-year percentage changes for macroeconomic variables (e.g., exports, imports, capital formation) to capture short-run economic movements. Aligned

TFP growth in the manufacturing sector as the dependent variable.

## 4. Exploratory Data Analysis:

Visualized sectoral trends, moving averages, and correlation patterns between FDI and TFP across industries to support and contextualize the regression findings.

## 5. Regression Modeling:

Conducted using Ordinary Least Squares (OLS) method. Based on Equation (8) from Malik et al. 2021:

$$\Delta \text{TFP}_t = \beta_0 + \beta_1 \text{FDI} + \text{Controls} + \epsilon$$

**Control Variables: Variable (definition) → "Dataset Label"**

- Δ CPI (inflation/price stability) → "CPI_Growth"
- Δ GCF (domestic investment) → "Gross_capital_form_percent_change"
- Δ PC (private credit) → "Priv_Credit_Growth"
- Δ EXP (exports/signal for trade openness) → "Export_percent_change"
- Δ IMP (imports/signal for trade openness) → "Import_percent_change"
- Δ GC (government expenditure) → "Gov_spending_percent_change",
- Δ DR (crop production index which serves as a proxy for drought/natural calamaties) → "Crop_prod_growth"
- *These control for other determinants of total factor productivity established by previous literature.

**Use of Chemical Sector as Placebo**

- Provides a benchmark for differential effects of FDI on TFP between manufacturing and a sector with lower FDI exposure (Bhardwaj, 2023).

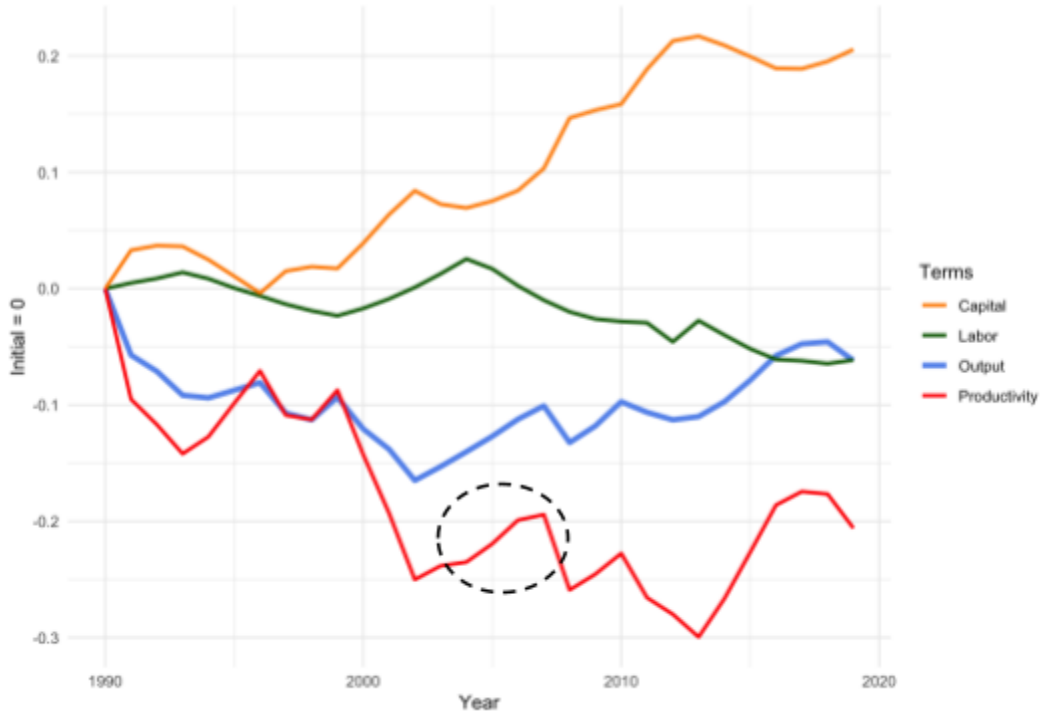
# Overview of Findings

India's FDI inflows increased significantly after the early 2000s, but productivity gains were uneven across sectors. While manufacturing as a whole did not show statistically significant improvements, industries like Textiles and Wood Products showed significant positive effects with FDI, indicating that the NMCC benefited adjacent sectors more directly. These patterns point to the importance of not only selecting target sectors for investment but also considering how industries are linked and positioned to absorb foreign capital effectively.

# Key Visualizations

## Core Visualizations (Motivating the Analysis)

### 1. Growth Accounting in India (1990-2020)



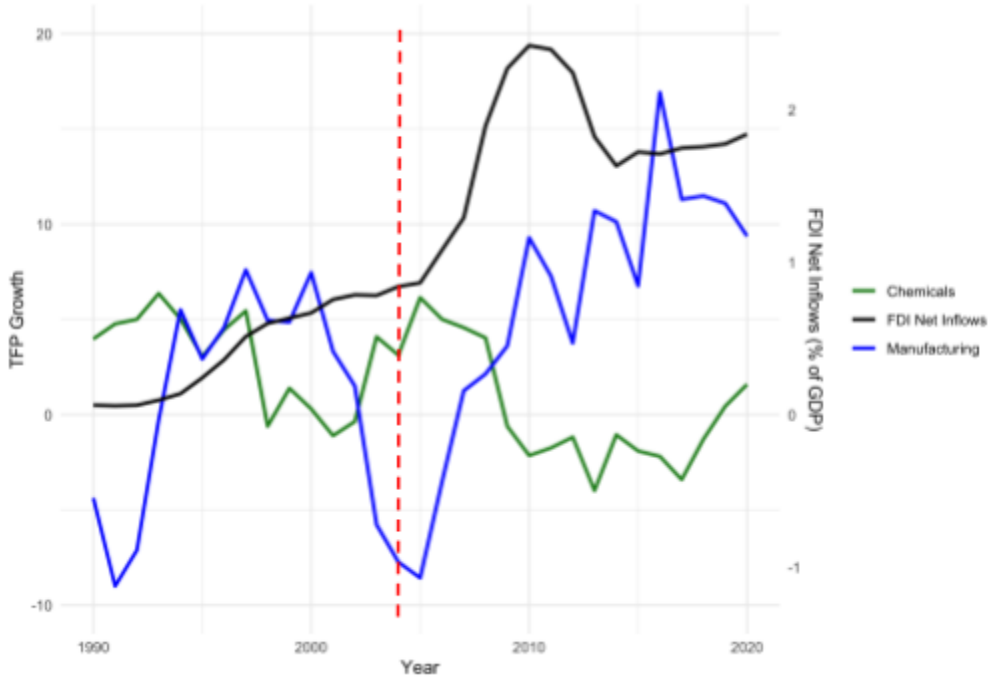

This chart shows the contributions of capital, labor, and productivity to India's output

growth from 1990 to 2020, with all values normalized to zero in the base year to enable relative comparison.

**Insights**

- **Capital increased from 1990 to 2020 and was the most consistent contributor to output growth.**
- **Labor input grew modestly**, but its contribution to growth declined after the mid-2000s.
- Productivity, measured as total factor productivity (TFP), declined sharply during the 1990s and early 2000s, dragging down the overall efficiency of input use.
- **While productivity remained negative throughout, its trajectory started improving around 2004.** In other words, the rate of productivity loss slowed, suggesting some recovery.
- **This timing coincides with the creation of India's National Manufacturing Competitiveness Council (NMCC) in 2004**, a policy initiative aimed at strengthening industrial performance. Though this correlation doesn't imply causation, it motivates further investigation into sector-level drivers of productivity, particularly in manufacturing.

**2. 5-Year Moving Average of TFP Growth and FDI Net Inflows**




This chart compares the 5-year moving average of total factor productivity (TFP) growth in India's manufacturing and chemical sectors with the 5-year moving average of FDI net inflows as a percentage of GDP from 1990 to 2020.

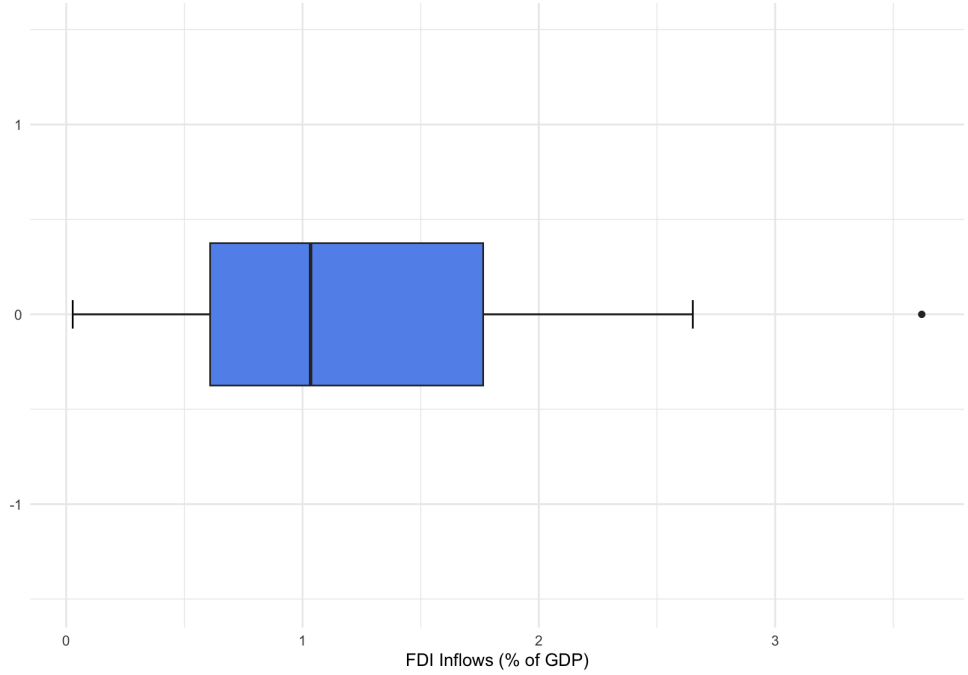
**Insights**

- **FDI inflows (% of GDP) increased steadily from the early 1990s through the mid-2000s**, before leveling off at 19%. This upward trend reflects India's gradual economic liberalization and growing attractiveness to foreign investors.
- **Manufacturing TFP growth shows periods of strong acceleration that coincide with rising FDI, especially between 2004 and 2012**. This overlap helps support the hypothesis that FDI contributes to productivity gains in this sector.
- In contrast, **TFP growth in the chemicals sector remains relatively flat or inconsistent, despite the increase in FDI**. This sector's trend does not appear to mirror inflow patterns.

- **Chemicals historically attracted lower levels of FDI**, which makes its weak alignment with national FDI a useful benchmark in later regression analysis.

## Exploratory Insights (Supporting Evidence)

### 3. Distribution of FDI Inflows (% of GDP)

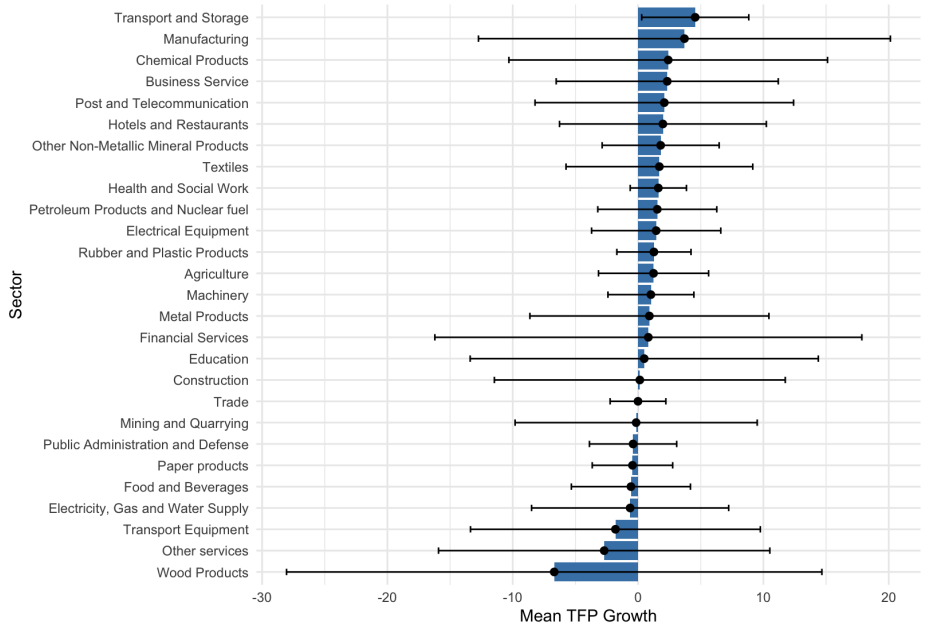



This histogram shows the distribution of India's FDI net inflows as a percentage of GDP over the years included in the analysis.

**Insights:**

- **50% of FDI inflow values fall between 0.6% and 1.75% of GDP.** This suggests that moderate inflows were prominent during the study period as global.
- 25% of years experienced lower FDI levels (under 0.6%), which include the earlier years post-liberalization and years of global financial volatility.
- Very high FDI inflows (above 2.5 % of GDP) are rare and only appear in 1 year, indicating outlier periods rather than a sustained trend.
- **FDI inflows as a share of GDP are right-skewed**, with most years showing moderate levels and a few years, especially 2006-2008 and 2011-2013, showing unusually high inflows.
- **This skew means that observed relationships between FDI and productivity growth will be influenced by a small number of peak years**, so any correlations should be interpreted with caution.

## 4. Average TFP Growth by Sector




This bar chart displays the average total factor productivity (TFP) growth by sector in India from 1990 to 2020. Each black dot marks the mean TFP growth for a sector, while the horizontal error bars represent the standard deviation

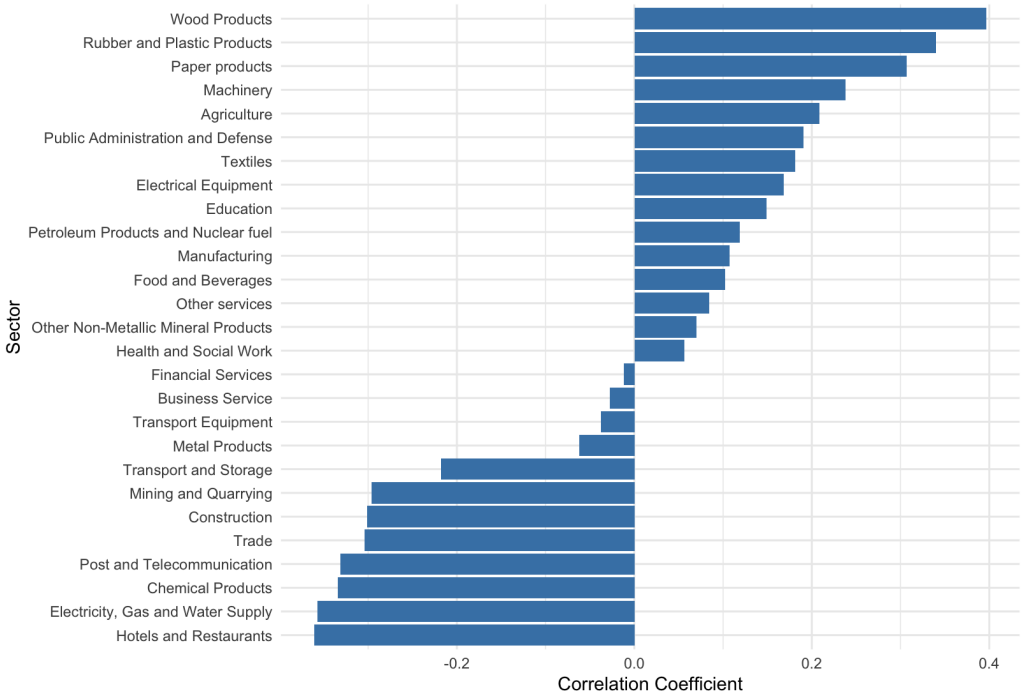
**Insights:**

- **TFP growth patterns differ across sectors.** Transport and Storage, Manufacturing, and Chemical Products recorded the highest average TFP growth. In contrast, sectors such as Wood Products and Other Services experienced negative average growth, with greater variability as shown by their wider standard deviations. This suggests that productivity in these sectors not only declined but did so inconsistently due to structural challenges, weak capital investment, or lack of technological innovation.
- **Manufacturing recorded one of the highest average TFP growth rates, with above-average variability.** Its standard deviation (9.66) exceeds the mean (8.34) and median (7.86) of all sectors. This makes manufacturing both

high-performing and volatile, suggesting it is a productive but potentially a sensitive sector that was responsive to policy shifts.

- **Several sectors showed little to no productivity gains over the 30-year period.** Sectors such as Education, Construction, and Food and Beverages hovered around zero average TFP growth. These industries tend to be more labor-intensive and less exposed to foreign competition or technology spillovers, which may limit incentives or capacity for productivity improvement.

## 5. Correlation Between FDI Inflows and Sector-Level TFP Growth




This bar chart displays the Pearson correlation coefficients between annual FDI inflows (as a percentage of GDP) and sector-level total factor productivity (TFP) growth from 1990 to 2020 across 27 Indian industries. Higher coefficients suggest a stronger co-movement between FDI inflows and sector productivity.

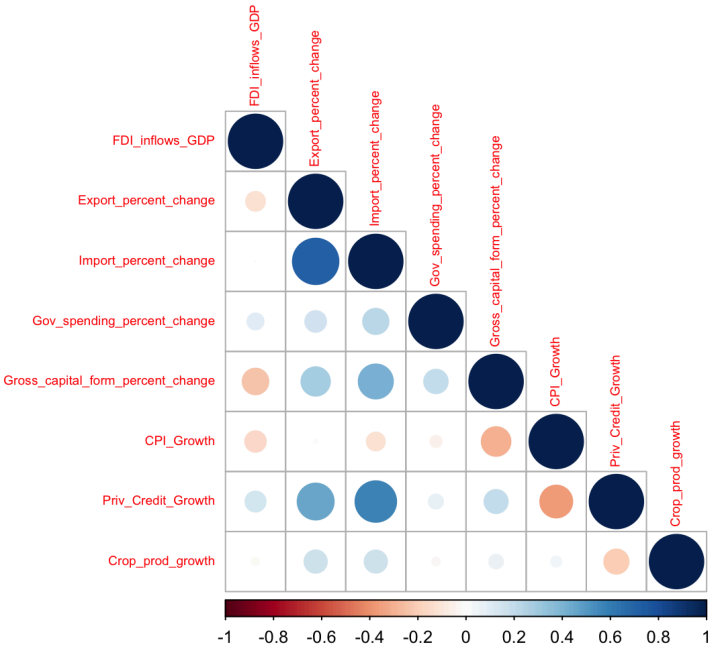
### Insights

- **Several sectors such as Wood Products, Rubber and Plastic Products, and Paper Products exhibit moderate positive correlations (0.3 to 0.4) with national FDI inflows.** This suggests that productivity growth in

these sectors tended to move in the same direction as national FDI trends, even if we cannot determine which variable is influencing the other. This likely due to these sectors being open to capital-intensive upgrades or spillovers through imported technologies and responsive to global demand.

- **Electricity, Gas and Water Supply and Hotels and Restaurants show strong negative correlations (-0.3 to -0.35)**, meaning that their productivity growth tended to move in the opposite direction of national FDI inflows over time. This is because these sectors are influenced by domestic factors or structural inefficiencies rather than external capital availability.
- **Manufacturing shows a weak positive correlation (0.1) with FDI inflows.** While not among the strongest, this still reflects some alignment with national investment trends.

### 6. Correlation Matrix of Regression Variables



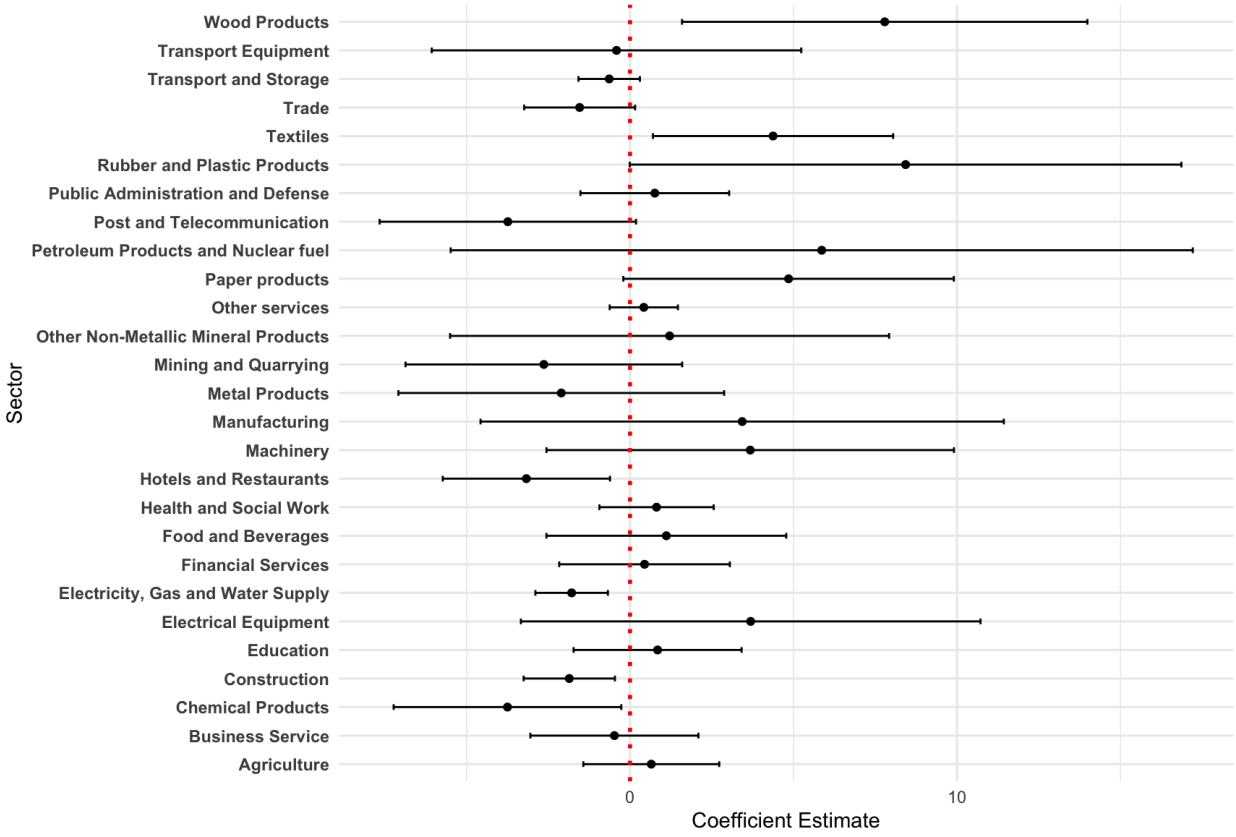

This matrix shows pairwise Pearson correlation coefficients between the independent variables used in the regression analysis. Circle size and color indicate the strength and direction of correlations, ranging from -1 (perfect negative) to +1 (perfect positive).

### Insights

- **Most variables are weakly correlated, so multicollinearity is not a major concern.**
- Exports and imports are strongly positively correlated (ρ = 0.72), which is expected since trade flows often move together.
- Private credit growth is moderately positively correlated with imports (ρ = 0.46) and exports (0.58).
- **FDI inflows (% of GDP) is weakly correlated with all other variables (all ρ <= 0.24), supporting its use as a distinct predictor.**
- Government spending, CPI and crop production growth have weak or no correlation with other variables.

# Results

## FDI Coefficients by Sector



This chart displays the estimated effect of FDI inflows (% of GDP) on TFP growth by sector, along with 95% confidence intervals. Coefficients whose intervals do not cross zero are statistically significant.

## Insights

- **Wood Products (β = 7.78, *p* = .02) and Textiles (β = 4.37, *p* = .02) had statistically significant positive coefficients.** This means productivity growth in these sectors increased by 7.78% and 4.37% for Wood Products and Textiles respectively for every 1% increase in FDI as % of GDP.
- Both sectors are closely tied to the manufacturing ecosystem since they involve labor-intensive production and benefit from technology transfer, extensive use of capital, and access to export markets.
- **Although manufacturing itself had a positive coefficient (β = 3.43, *p* = .3828), it was not statistically significant.** Still, the positive and significant results in these adjacent sectors reinforce the idea that FDI be more beneficial for productivity in tradable sectors with relatively low entry barriers (attributable to the NMC policy).
- **Hotels and Restaurants (β = -3.17, *p* = .02), Electricity Gas and Water Supply (β = -1.79, *p* = .003), Construction (β = -1.86, *p* = .01), and Chemical Products (β = -3.75, *p* = .04) had statistically significant negative coefficients**. This suggests that higher FDI inflows into these sectors resulted in lower productivity growth.
- These sectors may have absorbed capital without accompanying gains in efficiency due to higher regulations, long project timelines, or misallocation of investment toward firms focused on favorable contracts or treatment rather than improving productivity.
- In the case of Chemical Products, where TFP growth was among the highest on average (see earlier figure), the negative FDI coefficient further supports its role as a placebo in that productivity gains were likely driven by internal or domestic factors, not FDI.
- **For all other sectors, including Manufacturing, the confidence intervals crossed zero. This means no statistically significant link between FDI inflows and productivity growth can be inferred based on this model.**

# Recommendations

Based on the insights and findings above, we recommend that the Ministry of Commerce and Industry and supporting government institutes consider the following:

- Wood Products and Textiles, sectors closely linked to manufacturing, had statistically significant positive associations between FDI and productivity growth. So, India should **focus on FDI-facilitating policies (e.g., fast-track approvals, tax incentives) for small to mid-scale manufacturing-adjacent industries that showed responsiveness to foreign capital.**
- Manufacturing showed relatively high average TFP growth with above-average variability, yet no significant FDI effect was detected. Policymakers should **investigate non-FDI factors for productivity in manufacturing (e.g., automation, domestic investment, infrastructure bottlenecks) to identify where complementary policies could increase the effect of foreign capital.**
- Hotels & Restaurants, Construction, and Electricity, Gas & Water Supply showed statistically significant negative associations between FDI and productivity growth. The Ministry of Finance and sectoral regulators should **screen the quality and allocation of FDI in these sectors more closely, with emphasis on ensuring capital is directed toward productivity-enhancing activities rather than speculative or inefficient projects.**
- The chemical sector, used as a placebo, had high average productivity growth but a significant negative FDI coefficient, meaning that there was internal factors driving productivity. The Ministry of Chemicals and Fertilizers should **identify successful domestic factors in the chemical sector (e.g., R&D intensity, worker skill formation) such that these strategies be adapted and replicated in other sectors with limited foreign exposure and low productivity.**

- Several sectors such as Education and Food & Beverages showed minimal productivity gains and little variation over time. The NITI Aayog and relevant sectoral ministries should consider long-term reforms to **encourage innovation and private sector investment in these stagnant industries and improve workforce skills.**

# Limitations

While the analysis provides meaningful insights, several limitations should be noted:

- **The lack of sector-specific FDI data** meant relying on national FDI inflows as a proxy. This leads to uncertainty in how foreign investment behaves at the industry level and makes it harder to draw precise conclusions about which sectors benefit most directly.
- Although an increase in productivity around 2004 aligns with the formation of the National Manufacturing Competitiveness Council (NMCC), **we cannot isolate its effects from other reforms or external shocks.** An event study approach would have helped clarify the timing and magnitude of the policy's influence on TFP growth.
- **The regression assumptions did not hold consistently across all sectors.** Some sector models showed clear violations of normality in Q-Q plots. Others had insignificant F-statistics and/or low adjusted R-squared value, particularly in sectors like Agriculture, Mining, Non-Metallic Mineral Products, Basic Metals, Machinery, and Electrical & Optical Equipment. This means that linear models may be a poor fit for these cases.
- **Export growth, import growth, and private credit growth variables frequently exhibited multicollinearity, as reflected by high VIF scores**. While they were retained for theoretical completeness, the interpretation of their individual effects requires caution.