# Determinants of TFP Growth in India

7TH WORLD KLEMS CONFERENCE, MANCHESTER

BY

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# Scheme of Presentation

- **Motivation and Objective**
- **Review of Literature**
- **Stylized Facts**
- **Methodology**
- **Results**
  - **Time Series**
  - **Panel Data**
- **Summary and Conclusion**

# Motivation and Objective

# Motivation and Objective

- Growth slowdown before COVID-19 pandemic in India, accompanied by sharp decline in TFP growth rate.
- Aggregate TFP growth post-GFC mainly driven by non-market services (viz. Public admin, education, social works), while TFP growth in market-based activities deteriorated.
- India's high growth phase between 2003-04 and 2007-08 was driven by growth in the factors of production, mainly the stock of capital, while TFP explained only about 15 percent of India's aggregate GDP growth.
- These raise doubt about the sustainability of TFP growth in India.

- Globally, the evidence suggests that robust growth in GDP, in the long run, is supported by sustained growth in TFP
- In the light of the above evidence, this paper examines the structural determinants of TFP growth in India.

# Note: What We Look At

- Structural determinants of TFP growth are those macroeconomic variables that are either directly a part of the production function or directly associated with the production processes.
- Some variables that we may regard as the structural factors driving TFP growth are: capital deepening; growth in labour quality; growth in the unit cost of capital; input use intensity; participation in the global value chains (GVCs) and international trade; use of information and communication technology (ICT); research and development expenditure; and foreign direct investment.
- This paper aims at:

- Providing empirical estimates of the influence of these potential determinants of TFP growth in the Indian economy.

# Review of Literature

***Global**: Aggregate/Sectoral Evidences*

- **Kumar and Russel (2002)** - Capital deepening.
- **Jorgenson and Stiroh (2000), Oliner and Sichel (2000), Jorgenson and Stiroh (2000)** - Investment in ICT and technological progress in high-tech industries in the context of USA.
- **Benhabib and Spiegel (2003), OECD (2015), World Bank (2020)** – Labour Quality, Human Capital.
- **Maestas, Mullen, and Powell (2016)** - Age composition of labour.
- **Klasen and Silva (2018), De Jong and Tsiachristas (2008), Loko and Diouf (2014)** – Gender Composition of labour.

# Review of Literature (Contd.)

***India**: Limited to firm-level Evidences (manufacturing)*

- De and Nagraj 2013, Dougherty et. al. (2009), Pradhan and Barik (1999), Bhaumik et. al. (2006), Topalova and Khandelwal (2011), Goldar et al. (2020), Goldar and Kumari (2003), Das (2016)

- To the best of our knowledge, ours is the first attempt at estimating these impacts across all sectors of the Indian economy, viz. agriculture, industries and services.

# Stylized Facts

- The global productivity growth has slowed down since 2010

  - the slowdown was widespread

  - The global TFP growth declined from 1.5 per cent in 2010 to -0.3 per cent in 2019.

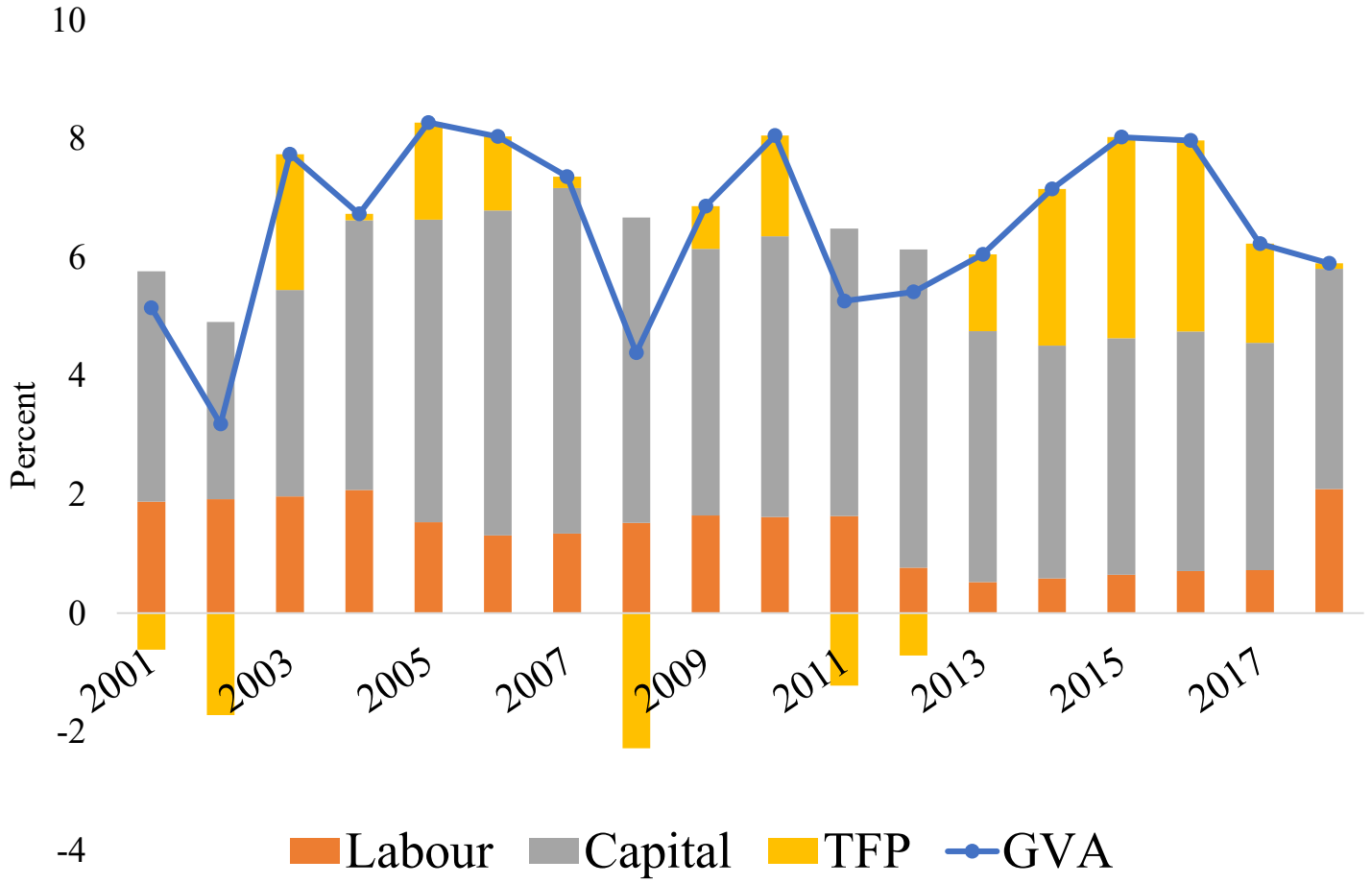
  - much sharper in case of the emerging and developing economies

  - Globally, the slowdown in productivity growth is attributed to weaker investment, tepid employment generation in developed economies, reduced global value chain participation, fading gains from the factor reallocation, etc.

- In contrast, India witnessed only a moderate decline in TFP growth in recent years.

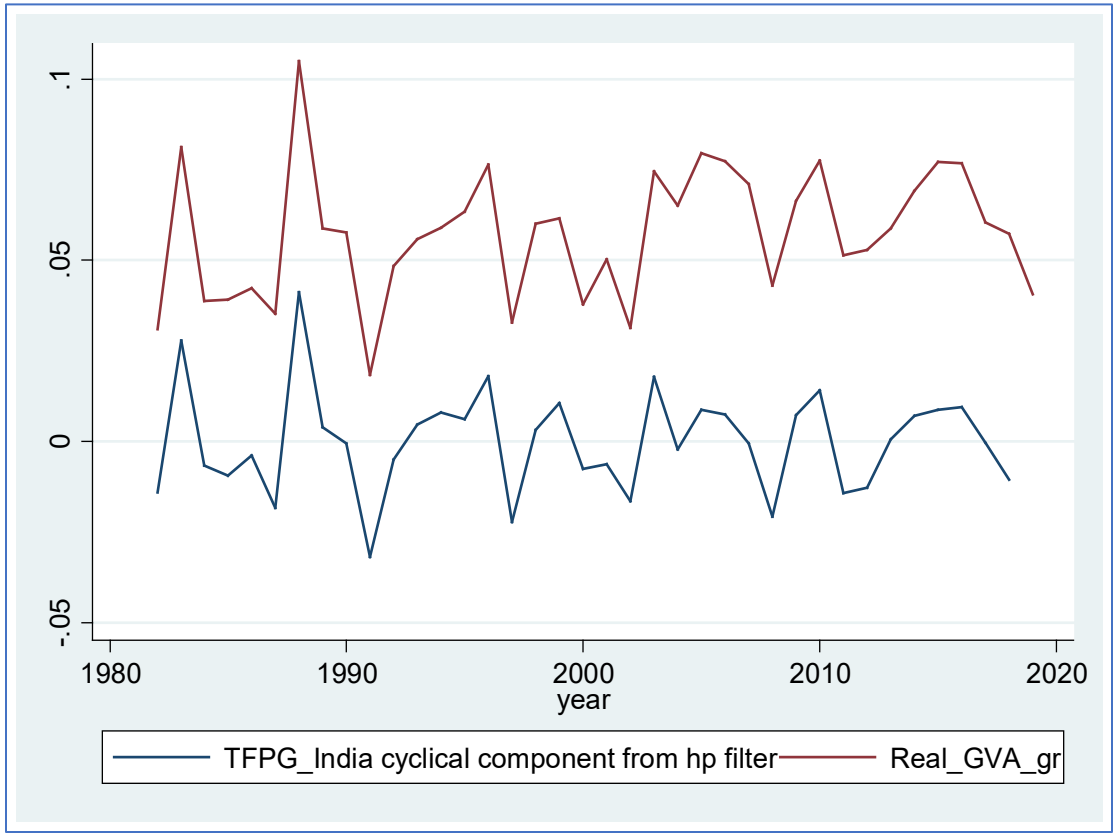
- TFP growth in India, though moderated since 2017, the average growth rate from 2010 to 2019 is estimated at 2.2 per cent, which is much higher than the emerging market average growth (-0.3 %).

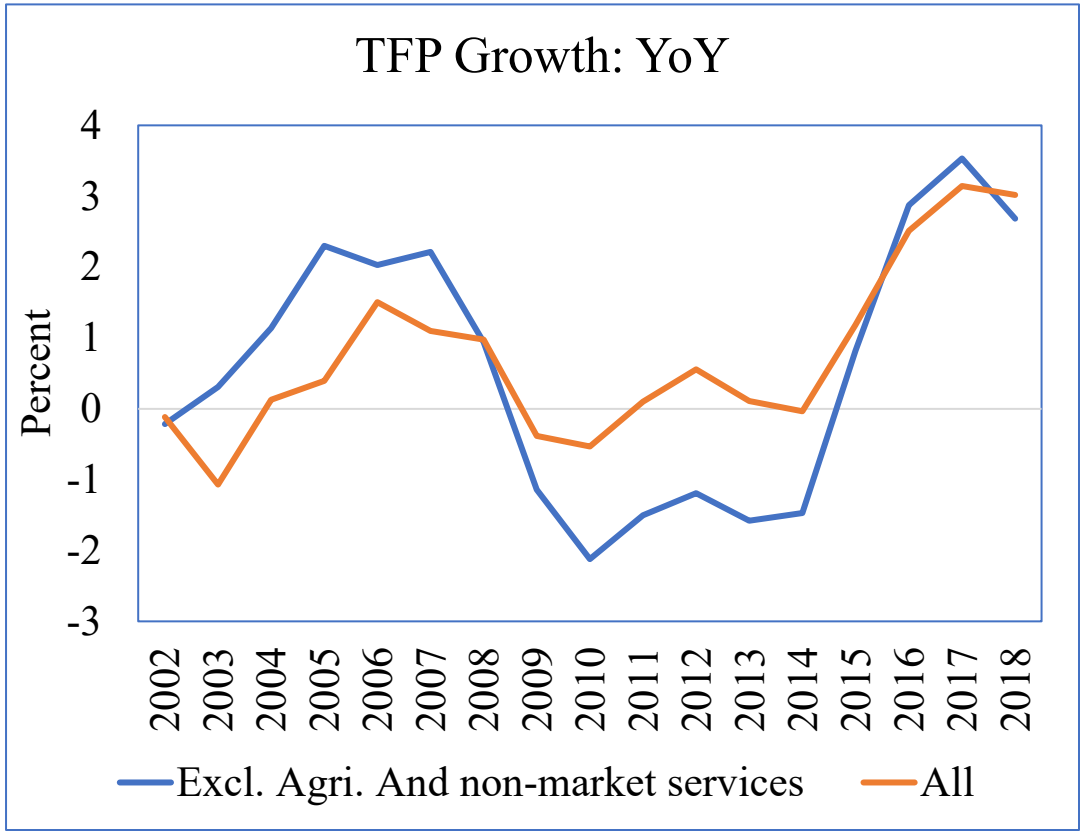
# Decomposition of Growth in India




- TFP explained 1/3rd of GVA growth between 2014 and 2017
- Contribution from TFP during 2003-2007 was 1/10th of GVA
- TFP is the driver of sustained economic growth in the long-run.

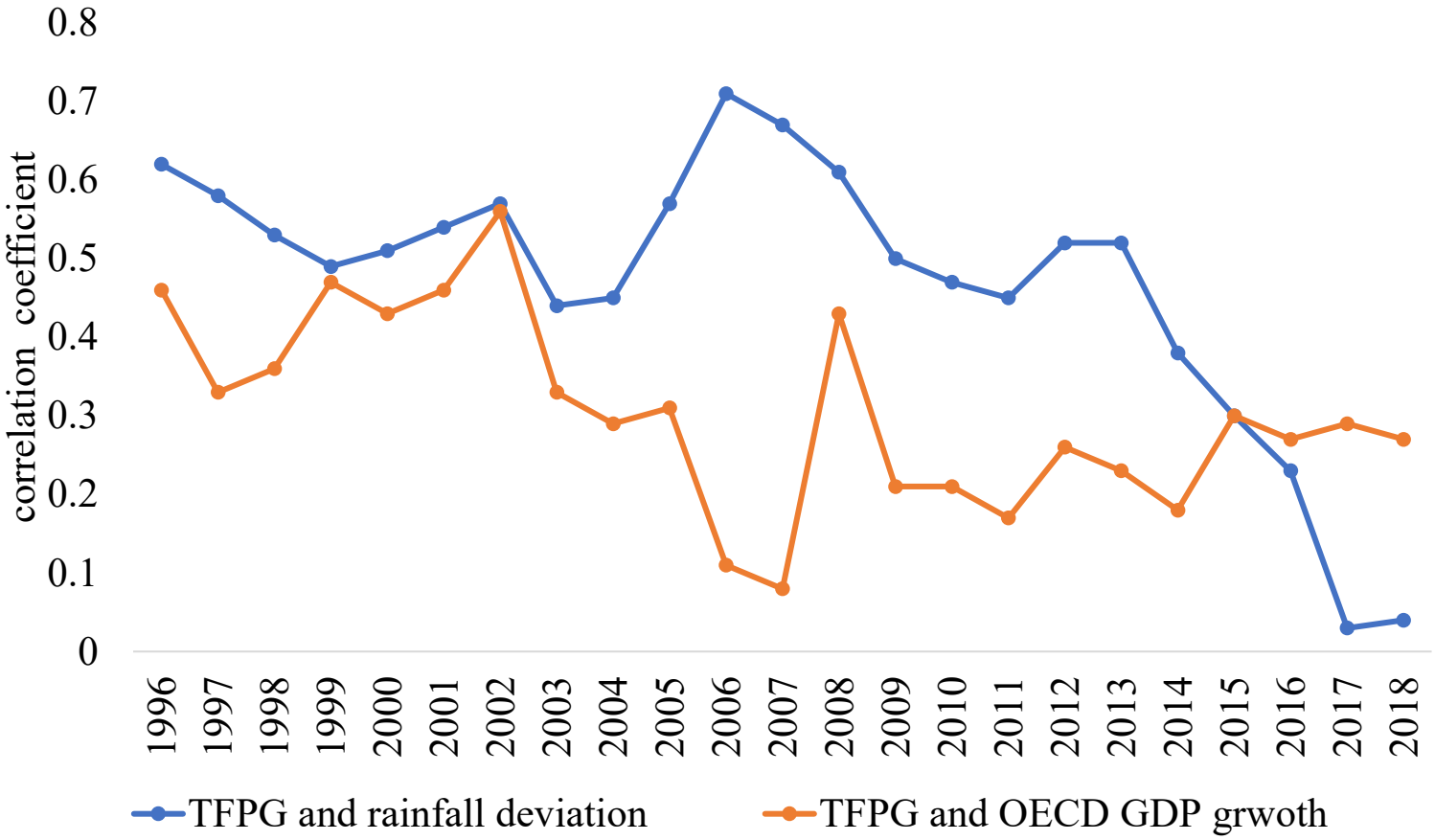
# A: TFP displays patterns




Domestic and external factors that influence short-term fluctuation in GDP/GVA might be associated with TFP as well.

# B: TFP Growth Correlated with ‘shocks’




Need to Separate-out to understand a more ‘structural’ TFP Growth

# Data and Methodology

The empirical methodology is divided into the following two parts, both having pros and cons:

**Aggregate Estimates: Time Series**

**Exogenous**

- Rainfall Deviation
- GDP growth in OECD
- TFP Growth in trade-partners

**Weakly Endogenous**

- ICT Capital
- TFP-Infrastructure
- Public Investment in Infrastructure
- FDI

**Industry Estimates: Panel Data**

**Weakly Endogenous**

- TFP in Input Sector
- Exports
- Equipment-Structure Ratio

**Endogenous**

- Fixed Investment/ Capital Deepening
- Labour Quality
- Capital Composition
- Intermediate Inputs

# Models

- **Time Series**

ARDL Models (Kripfganz and Schneiderand, 2022)

$$TFPG_t = \alpha + \lambda t + \sum_{i=1}^{p} \phi_i TFPG_{t-i} + \sum_{j=0}^{q} \beta_j X_{t-j} + \eta' Z_t + u_t$$

- **Panel Data**

Pooled Group Mean Estimation (Pesaran, et. al. (1999))

$$\widehat{tfp_{k,t}} = \alpha + \beta * \widehat{tfp}_{k,t}^{in} + \gamma * eqstr_{k,t} + \gamma * \log(x_{k,t}) + u_{it}$$

2SLS Instrumental Variable

$$\widehat{tfp_{k,t}} = \alpha + \sum_{l=1}^{3} \beta_l \widehat{tfp_{k,t-l}} + \sum_{l=0}^{1} \gamma_l \widehat{k_{k,t-l}} + \sum_{l=0}^{1} \delta_l \widehat{lq_{k,t-l}} + \sum_{l=0}^{1} \sigma_l \widehat{kq_{k,t-l}} + \mu \widehat{ii_{k,t-2}} + £ \widehat{va_{k,t-2}} + year_{FE} + sector_{FE} + u_{k,t}$$

# Data-sets

Time Series Analysis:

- India KLEMS
- Economic and Political Weekly Research Foundation (EPWRF) - Rainfall
- OECD, World Bank
- India’s National Account Statistics
- Penn World Table 10.0

Panel Data Analysis:

- KLEMS database
- CEIC
- Input-Output Table 2015-16

# Results: Time Series

**Table 1: Estimates of the ARDL Model Explaining TFPG at the Economy Level: Long-run Coefficients**

**Dependent Variable:** Year-on-year growth in aggregate TFP

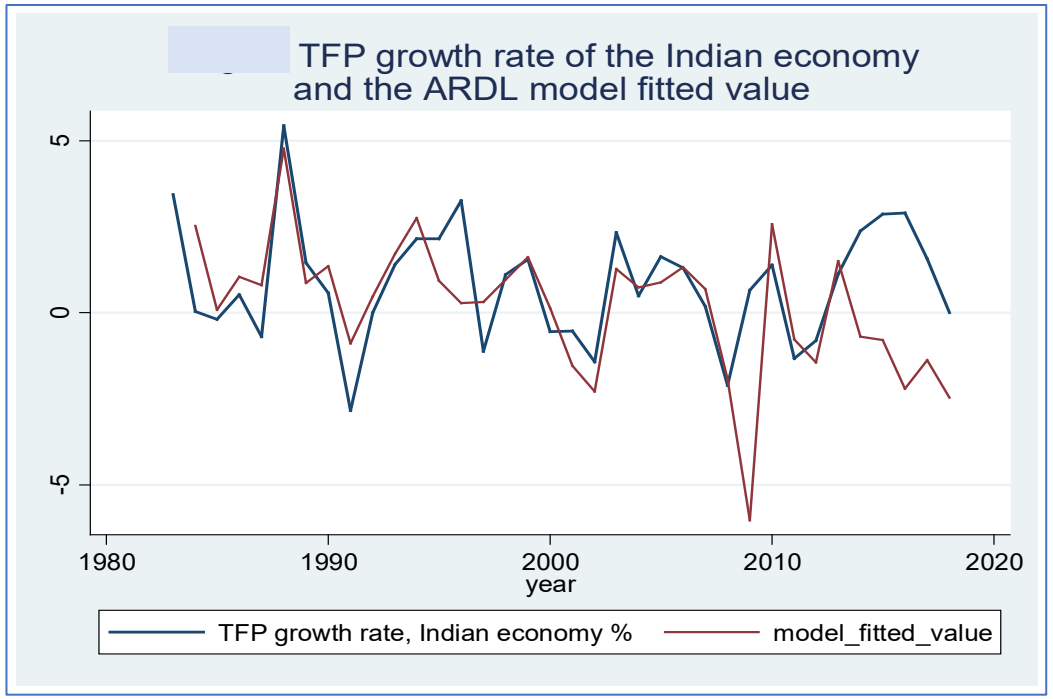
| **Explanatory variables** | **Coefficients** |
|---|---|
| Deviation of rainfall from the long-period average (Per cent) | 0.083*** (4.05) |
| Year-on-year growth in GDP of OECD countries | 0.509*** (3.04) |
| Adjustment coefficient | -1.66*** (-7.31) |
| $R^2$ of the error correction model | 0.81 |
| Pesaran, Shin, and Smith (2001) bounds test | F=20.6; t=-7.3 |
| No. of observations | 23 (1986-2008) |

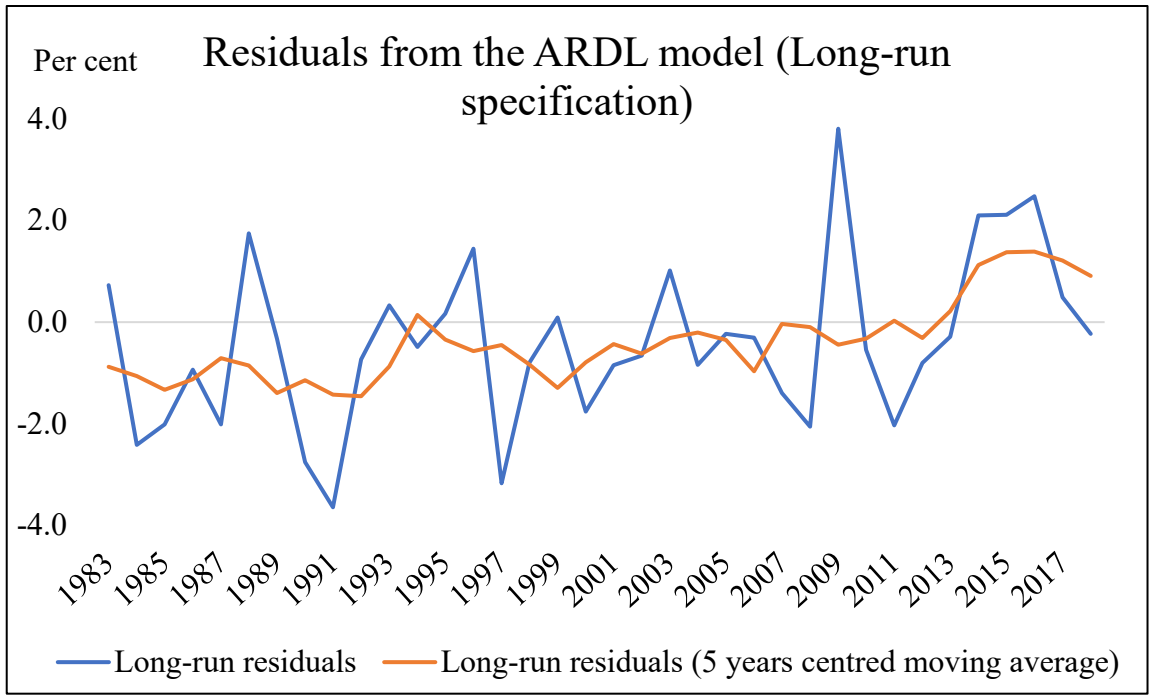
Source: Authors' computations.

Note: ARDL structure (2,0,0) is used. The optimal lag lengths are determined by Bayesian information criteria. t-statistics are in the parentheses.

*** indicates statistical significance of the coefficients at 1 per cent.

# How much of TFP estimates are ‘shocks?’: ARDL Fitted Values




- ‘Shocks’ explain significant part of estimated TFP growth in India KLEMS.
- **Residuals (orange line in right chart) represent a more ‘structural’ TFP growth. It shows gradual improvement over decades.**

## Table 2: Estimates of the ARDL Model Explaining TFPG at the Economy Level: Long-run Coefficients

| Explanatory variables | Dependent Variable: Year-on-year rowth in TFP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Year-on-year growth in trade-weighted TFP for India's 34 trade-partners | 0.143<br>(0.58) | | 0.154<br>(0.64) | | | | 0.130<br>(0.47) | 0.933**<br>(2.27) | |
| Annual rate of change in the share of ICT capital assets in the stock of all fixed assets | 4.30*<br>(1.97) | | 5.91***<br>(3.43) | | 5.36**<br>(2.79) | 6.09***<br>(5.69) | | | |
| TFP growth rate in infrastructure industries | | 0.26***<br>(3.10) | | | | | 0.27**<br>(2.79) | 0.09<br>(0.88) | |
| Net cumulative public investment in infrastructure normalized by GDP | 0.36**<br>(2.46) | 0.24<br>(1.34) | 0.41**<br>(2.53) | | 0.27<br>(1.43) | 0.20*<br>(2.03) | | 0.45***<br>(3.08) | 0.26<br>(1.01) |
| Ratio of cumulative FDI in the past five years to GDP | | 0.56***<br>(3.39) | 0.30<br>(1.85)* | -0.08<br>(-0.30) | 0.34*<br>(1.87) | | 0.18*<br>(1.82) | | 0.58**<br>(2.43) |
| Growth rate in GDP of OECD countries | | | | 0.43*<br>(1.79) | | | | | |
| Trend | Included | | | Included | | | | Included | |
| ARDL lag structure | (1,0,0,1) | (1,1,1,0) | (1,0,1,0,0) | (1,1,0) | (1,0,1,0) | (3,1,0) | (1,0,0,0) | (1,3,1,2) | (1,1,0) |
| Adjustment coefficient | -1.09***<br>(6.20) | -1.12***<br>(-6.29) | -1.10<br>(-6.27) | -0.96***<br>(-4.18) | -0.99***<br>(-6.40) | -1.67***<br>(-5.20) | -0.97***<br>(-5.76) | -1.12***<br>(-5.30) | -0.82***<br>(-5.20) |
| $R^2$ of error correction model | 0.76 | 0.79 | 0.77 | 0.51 | 0.78 | 0.80 | 0.58 | 0.85 | 0.70 |
| Pesaran, Shin, and Smith (2001) bounds test | F=12.1;<br>t=(-)6.2 | F=13.0;<br>t=(-)6.3 | F=10.2;<br>t=(-)6.3 | F=6.4<br>t=(-)4.2 | F=12.6;<br>t=(-)6.4 | F=11.6;<br>t=(-)5.2 | F=8.7;<br>t=(-)5.8 | F=10.0;<br>t=(-)5.3 | F=11.5;<br>t=(-)5.2 |
| Inference about the existence of level relationship:<br>Null hypothesis of no level relationship is | ected at a 1% level | rejected at a 1% level | rejected at a 1% level | rejected at a 10% level | rejected at a 1% level | rejected at a 1% level | rejected at a 1% level | rejected at a 1% level | rejected at a 1% level |
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Note: t-values in parentheses. *** prob. <0.01; ** prob. <0.05; * prob. <0.1

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# Results: Panel Data

# Data Description

**Sectors:**

- Agriculture and allied
- Infrastructure
- Low-tech Manufacturing
- Med- to high-tech Manufacturing
- Market Services
- Non-market services
- Financial Services

**Instruments (for 2SLS IV):**

- Investment Growth: Growth in Intermediate Inputs
- Labour Quality: Lagged Labour/Capital Ratio
- Capital Composition: Lagged Investment Growth

## Table 3: Estimates of Panel ARDL (Pooled Group Mean): Long-run Coefficients

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Dependent Variable: Δlog(TFP) | | | | | |
| TFP in Input Producing Sector | 0.76*** | 0.68*** | 0.80** | 1.22*** | 1.20*** | 1.42*** |
| | (0.15) | (0.14) | (0.33) | (0.29) | (0.29) | (0.31) |
| Exports (INR) | 0.058*** | 0.064*** | 0.099*** | 0.063*** | 0.063*** | 0.066*** |
| | (0.0059) | (0.0047) | (0.014) | (0.0091) | (0.0089) | (0.0094) |
| Equipment-Structure Ratio | -0.12*** | -0.16*** | | | | |
| | (0.032) | (0.031) | | | | |
| Δ(Equipment-Structure Ratio) | | | -1.31** | | | |
| | | | (0.51) | | | |
| Δ(Equipment-Structure Ratio)-1year lag | | | | 0.055 | 0.043 | -0.16 |
| | | | | (0.22) | (0.22) | (0.23) |
| Adjustment coefficient | -0.25* | -0.33* | -0.20** | -0.23** | -0.23** | -0.21** |
| | (0.14) | (0.18) | (0.085) | (0.100) | (0.10) | (0.094) |
| Constant | -0.17 | -0.25* | -0.25** | -0.20** | -0.20* | -0.20* |
| | (0.11) | (0.15) | (0.10) | (0.10) | (0.10) | (0.10) |
| *N* | 126 | 120 | 120 | 120 | 120 | 120 |
| Log Likelihood | 272.66 | 267.06 | 267.95 | 262.45 | 263.54 | 273.09 |

Note: TFP: Total Factor Productivity Index (FY1991-92=1)
Indices for TFP and the values of exports are expressed in natural logarithm.
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

**Table 4: Estimates from 2SLS-IV: All Sectors**

| | (1) | (2) |
|---|---|---|
| | Dependent Variable: Δ(TFP) | |
| Δ(TFP)-1year lag | 0.07<br>(0.08) | 0.11<br>(0.07) |
| **Δ(Capital Stock)** | **5.82**$^{**}$<br>**(2.06)** | **6.13**$^{**}$<br>**(2.08)** |
| Δ(Labour Quality) | 9.71<br>(13.92) | **51.11**$^{**}$<br>**(18.49)** |
| Δ(Capital Composition) | -14.40<br>(8.91) | -11.17<br>(11.31) |
| Δ(Intermediate Inputs)-2 years lag | 0.14$^{*}$<br>(0.07) | 0.15$^{*}$<br>(0.07) |
| Δ(GVA)-2 years lag | -0.09<br>(0.11) | -0.10<br>(0.10) |
| Δ(Capital Stock)-1 year lag | | -1.41<br>(1.06) |
| Δ(Labour Quality)-1 year lag | | -46.74$^{**}$<br>(12.76) |
| Δ(Capital Composition)-1 year lag | | -5.35<br>(3.87) |
| Constant | 0.03<br>(0.02) | 0.00<br>(0.03) |
| *N* | 161 | 154 |
| $R^2$ Overall | 0.28 | 0.31 |

## Table 5: Estimates from 2SLS-IV: Sector Dummy Interactions

| | (1) Agriculture and allied activities | (2) Infrastructure industries | (3) Low technology manufacturing | (4) Mid-high technology manufacturing | (5) Market Services | (6) Financial Services | (7) Non-market Services |
|---|---|---|---|---|---|---|---|
| | Dependent Variable: Δ(TFP) | | | | | | |
| Δ(Capital Stock) | 1.61 | -0.08 | 8.86*** | 6.75** | 11.43*** | 1.61 | 2.20 |
| | (1.22) | (3.75) | (0.98) | (2.27) | (2.96) | (2.14) | (2.47) |
| Δ(Labour Quality) | 52.76*** | -92.52 | -33.26 | -50.00 | -235.03 | -70.88 | -38.75 |
| | (9.53) | (61.20) | (24.94) | (86.04) | (126.43) | (43.40) | (64.14) |
| Δ(Capital Composition) | -99.07*** | 72.25** | 89.06** | 78.26** | 121.88*** | 112.99*** | 76.74*** |
| | (25.12) | (20.81) | (27.23) | (22.38) | (32.73) | (28.07) | (19.45) |

Model uses 161 observations in all and has an overall $R^2$ of 0.14.

Notes: Model controls for 1-3 years of lags on TFP, second lags of intermediate input growth and GVA growth.

All variables are in their natural logarithm

Model includes a constant, dummies for individual years and sector fixed-effects.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# Summing Up

- Exogenous ‘shocks’ like **GDP growth in OECD** and **rainfall deviation** explain much of fluctuation in TFP growth

- The TFP growth after accounting for these ‘shocks’ are more stable and improved over decades.

- Investment and productivity in **public infrastructure**, **ICT capital**, **external openness** (exports and FDI) and **labour quality** are associated with higher TFP growth.

- Increase in a sector’s TFP growth has second-round effect on another sector when used as **inputs**.

# Summing Up (Contd.)

- **Capital Deepening** is associated with improved TFP growth in manufacturing and market-services. For other sectors (agriculture, mining, infrastructure, public service etc.), we do not observe any significant association.

- **Capital Composition** is associated with improved TFP growth rates in market services and financial services only.

# Thank You