Stagnant Manufacturing in India: The Role of TFP and Trade *

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Abstract: Manufacturing is crucial for economic development, yet it faces stagnation or decline in many developing and underdeveloped countries today. India, in particular, has experienced stagnant manufacturing compared to other recently industrialized Asian nations like South Korea and China, while its services sector has thrived. Using a three-country, three-sector open economy general equilibrium model, the paper attempts to understand the role of various channels of structural change in India. The model builds in the income effects, asymmetric TFP growth, and trade effects as significant channels for analysis and is calibrated using the relevant data for India, China, and the Rest of the World. Then, some counterfactual experiments are done to analyze the structural change. Counterfactual experiments reveal that while trade has provided some compensation, sloppy TFP growth in Indian manufacturing rather than services explains the sectoral growth bias towards the services. The direct comparison with China suggests little structural divergence, even if TFP would have grown to the Chinese equivalent. Moreover, TFP growth and trade liberalization alone cannot fully account for the prolonged stagnation of India's manufacturing sector in this model.

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1 Introduction

The evolution of an economy's sectoral composition, particularly in terms of employment (EMP) and value-added (VA), is a defining characteristic of its developmental trajectory. Throughout history, this structural transformation has followed a distinct pattern, often correlating with income levels. As economies progress, we typically observe a decline in EMP and VA shares in agriculture, accompanied by a rise in the services sector. Meanwhile, the manufacturing sector initially experiences growth in EMP and VA, reaching a peak at a certain income threshold before declining, exhibiting a hump-shaped pattern. [Herrendorf et al. (2014)] have extensively analyzed this trend over a 200-year period spanning 1800 to 2000, particularly focusing on today's affluent nations, confirming these observed patterns (left panels of figure 1).

Manufacturing holds significant importance in driving economic growth for several reasons [Cantore et al. (2017)], [Szirmai (2013)], [Rodrik (2013)]. Firstly, it serves as an absorber of low-skilled labor transitioning from agriculture, fostering industrialization. Secondly, manufacturing often exhibits faster labor productivity growth and unconditional convergence, driving overall productivity gains even during periods of stagnation in other sectors. Additionally, growth in EMP and VA within the manufacturing sector spurs investment in infrastructure and skill development, which is critical for developing economies. Thirdly, tradable goods produced by the manufacturing sector facilitate comparative advantage and productivity growth, as exemplified by economies like South Korea [Uy et al. (2013)]. This tradability also enables manufacturing to act as an engine of growth in the context of structural transformation.

While much of the literature on structural transformation focuses on early industrialized and growth miracle countries, less attention has been paid to middle- and low-income nations. Premature deindustrialization, characterized by a decline in manufacturing shares at lower income levels, has emerged as a concerning trend in these countries [Rodrik (2016)]. Figure 1 presents evidence of de-industrialization by comparing sectoral VA and EMP trends in early and late industrialized countries. Comparisons between early and late industrializers highlight disparities in sectoral trends, with late industrializers exhibiting lower manufacturing shares and higher service shares at similar income levels. Continued adherence to these trends could lead to slower growth and exacerbate inequality between nations.

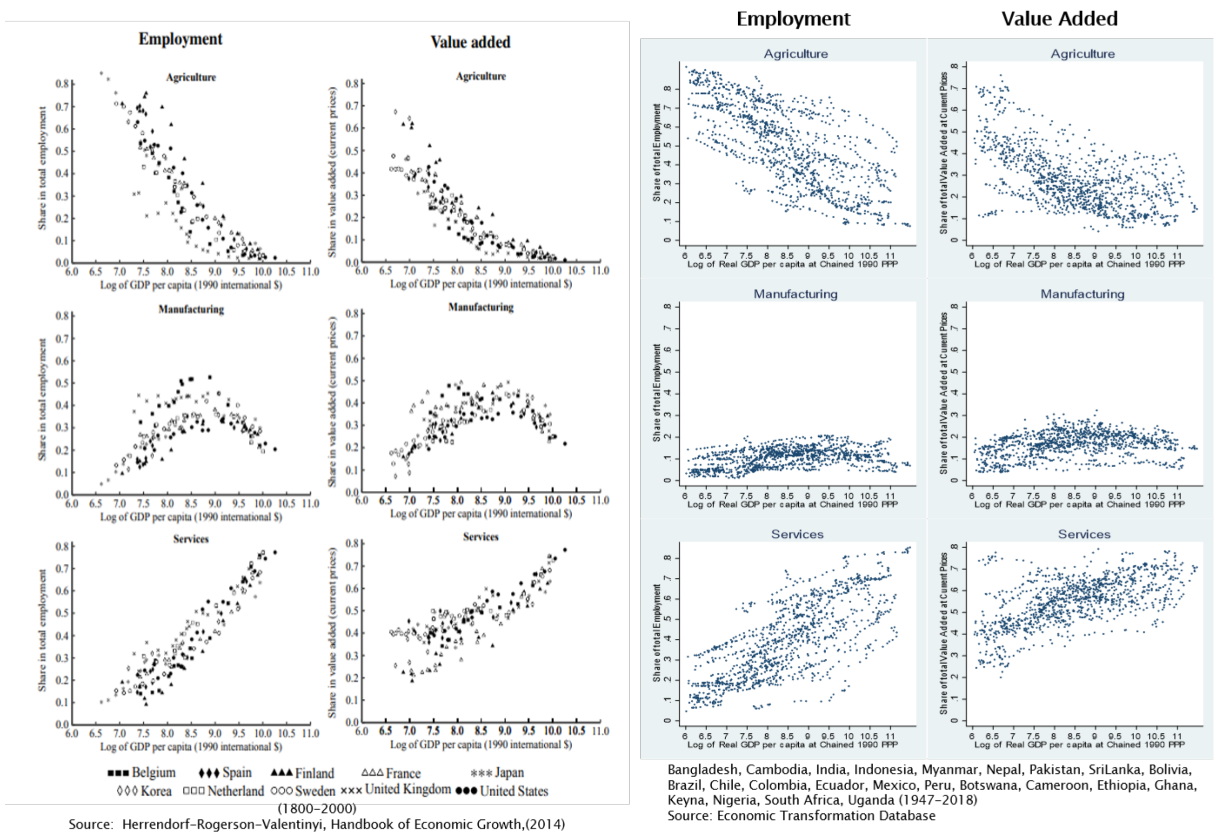

Figure 1: Manufacturing peaked at less than 20% in terms of EMP share and nearly 25% in terms of value-added share for late industrializers, in contrast to about 35% and 45% respectively for early industrializers. Source: Economic Transformation Database

The structural transformation of economies is explained through three significant channels. The Engel Effect, driven by changing preferences, sees households shift their consumption from agriculture to manufacturing and services as incomes rise [Matsuyama (2019)] [Comin et al. (2021)]. The Baumol Effect, based on asymmetric productivity, pushes labor from agriculture to manufacturing and then to services. These effects have been extensively studied by [Baumol (1967)], [Ngai and Pissarides (2007)] [Buera and Kaboski (2012)] who emphasize their importance in economic transformation. In recent literature, there's been a shift towards multi-sector open economy models, with international trade playing a pivotal role. Trade reallocates resources to higher productivity sectors, countering the Baumol Effect. Studies on South Korea by [Uy et al. (2013)] demonstrate the impact of trade reforms on the shift from agriculture to manufacturing. [Świkecki (2017)] and [Sposi (2019)], [Sposi et al. (2021)] find that international trade significantly influences sectoral transition and industrial polarization.

Global integration between advanced and developing countries is one of the many factors attributed to the stagnant industrialization in developing countries. International trade can affect structural transformation mainly through two channels. Firstly, lower trade costs can shape specialization through comparative advantage/disadvantage and economies of scale. For example, when a country opens up for trade, low tariffs, and unconstrained demand can reallocate the resources to the higher productivity sector, building comparative advantage and increasing the VA and EMP share in the sector. Secondly, a technology shock, given the set of trade barriers, can shape the sectoral composition of economic activities in the given sector. For example, in an open economy with lower trade barriers, countries transitioning from agriculture towards manufacturing may not be able to compete with the incumbent countries with higher productivity/lower prices, and sectoral composition may shift towards non-manufacturing sectors.

This paper explores the mechanisms driving structural change in open economies, specifically focusing on India. Despite opening up to international trade in 1991, India's structural transformation has been puzzling. While agriculture has declined steadily over the past four decades, the services sector has grown rapidly, comprising a significant portion of GDP. However, the manufacturing sector has remained stagnant, with minimal growth in EMP shares [Mehrotra and Parida (2021)], [Erumban et al. (2019)], [Tejani (2016)], [Cortuk and Singh (2011)], [Kannan and Raveendran (2009)], [Bhalotra (1998)]. Comparisons with neighboring countries like South Korea and China underscore the divergence in structural transformation trajectories. Most of the papers in the context have been focused on empirical analysis.

As shown in Figure 2, the Indian EMP share in agriculture has declined from 71% to 54%, whereas the real value-added (RVA) share in agriculture has declined from 49% to 21%. On the other hand, the services sector's EMP share has risen from 19% to 35% and RVA share from 37% to 58% over the four decades. The evolution of the manufacturing sector is more puzzling, where labor and real value-added share had very slow changes between 10-11% and 14-21%, respectively. India started opening for trade in 1991, a decade later than its neighboring budding manufacturing hub, China. In the same period, China's GDP and Value-added in manufacturing have grown from 11% to 20% and from 23% to 37%, respectively. An important thing to notice here is that the structural change is sharper when we look at the RVA shares across sectors but gets slower regarding EMP shares.

Using a three-country, three-sector open economy general equilibrium model, the paper

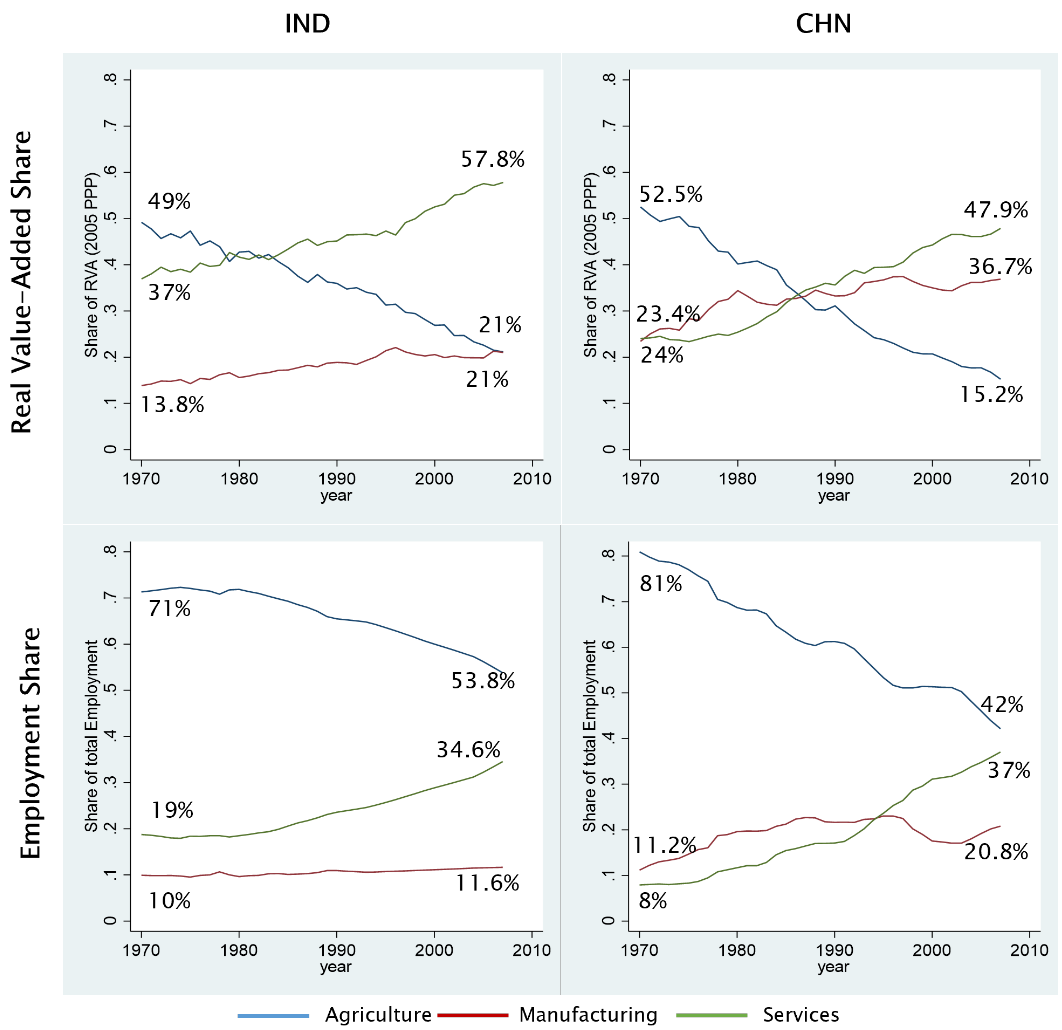

Figure 2: In India, the EMP share of manufacturing has remained nearly constant over the last 40 years, whereas the RVA share has increased but at a very slow rate, whereas in China, EMP and VA shares seem to be rising in the same period.

attempts to understand the role of various channels of structural change in India and its divergence vis-a-vis China's transformation path. By incorporating China as a separate entity, we account for the divergent paths taken by these neighboring nations. India and China started growing almost in the same period, but China witnessed rapid industrialization, whereas India saw a boom in its services sector. The model builds in the income effects, asymmetric TFP growth, and trade effects as significant channels for analysis and is calibrated using the relevant data for India, China, and the Rest of the World. Then, the model is simulated to decompose the effects of TFP and trade through counterfactual experiments. The counterfactuals reveal slower TFP growth in Indian manufacturing than in services, explaining the sectoral growth bias towards the services. To the question, if Indian TFP had grown at the same rate as Chinese in all three sectors, would the Indian story be more manufacturing and fewer services, the study says no in the answer. The comparison with China suggests little structural divergence, even if TFP would have grown to the Chinese equivalent. The TFP growth and trade liberalization aren't sufficient factors explaining China's manufacturing prowess or India's sectoral stagnancy in this model environment.

The remainder of this paper is structured as follows: Section 2 outlines the model used in our analysis. Section 3 presents the analytical results derived from the model. Section 4 describes the data. Section 5 provides the details of calibration and estimation of the parameters and exogenous processes. Section 6 presents the quantitative results and counterfactuals. Finally, Section 7 concludes the paper with a summary of key findings and avenues for future research.

2 Model

In this section, I describe the model used in the study. I use a multi-country, multi-sector general equilibrium model like [Uy et al. (2013)]; [Sposi (2019)]. It has three countries. Two countries starting at a similar level of income take different development paths. The third country in the model is the aggregate of the rest of the world, primarily aimed at capturing all significant trading partners. The model has three sectors – Agriculture (a), manufacturing (m), and services (s). Goods from all three sectors are tradeable with standard iceberg trade costs. There is a continuum of goods in each sector. The heterogeneity among the countries is drawn from the labor endowment and the country and sector-specific productivities and trade costs. Once the exogenous factors are realized, firms and households solve their static optimization problem at the sectoral aggregate level, and then the same problem is repeated every period. The dynamics are derived from the evolution of persons employed, productivity, and trade cost in the model.

2.1 Technology

The production function for various goods $z \in [0, 1]$ in sector $k \in \{a, m, s\}$ of country i is a Cobb-Douglas aggregator of labor and composite intermediate good M.

$$Y_{ik}(z) = A_{ik}(z) L_{ik}(z)^{\phi_{ik}} \left[\prod_{n=\{a,m,s\}} M_{ikn}^{\gamma_{ikn}}(z) \right]^{1-\phi_{ik}} \tag{1a}$$

The sector-specific technology differs in terms of the composition of inputs (ϕ_{ik}) for all countries. The intermediate aggregate is sourced from n sectors in the proportion of γ_{ikn} for production in sector k. An inelastic, perfectly mobile labor supply facilitates equal wages across sectors in a country. The country-specific factor share is heterogeneous among sectors but is the same for all sectoral varieties enabling identical unit variable cost in a sector. Hence, the firms' optimization problem can be represented in the sectoral aggregate form. The wage rate in country 1 (India) is normalized to one (numeraire in the model).

$$\max_{L_{ik}, M_{ikn}} p_{ik} \left[A_{ik} L_{ik}{}^{\phi_{ik}} \left[\prod_{n=a,m,s} M_{ikn}^{\gamma_{ikn}} \right]^{1-\phi_{ik}} \right] - w_i L_{ik} - \sum_{n=\{a,m,s\}} \left[p_{in} M_{ikn} \right]$$

The A_{ik} is the sectoral aggregate productivity. A detailed discussion on this is in the following subsection. As markets are perfectly competitive, prices are equal to the marginal cost of production.

$$w_i L_{ik} = \phi_{ik} p_{ik} Y_{ik} \tag{1b}$$

$$p_{in} M_{ikn} = \gamma_{ikn} (1 - \phi_{ik}) p_{ik} Y_{ik} \tag{1c}$$

$$p_{ik} = \frac{1}{A_{ik}} \frac{w_i^{\phi_{ik}} \left(\prod_{n=a,m,s} \left(\frac{p_{in}}{\gamma_{ikn}} \right)^{\gamma_{ikn}} \right)^{1-\phi_{ik}}}{\phi_{ik}^{\phi_{ik}} (1 - \phi_{ik})^{1-\phi_{ik}}} \equiv \frac{v_{ik}}{A_{ik}} \tag{1d}$$

The first-order factor marginal conditions define a sector's unit variable cost (v_{ik}).

2.2 Productivity and Prices

The $A_{ik}(z)$ (equation (1a)) is an exogenous time, country, and sector-specific productivity drawn from a Fréchet distribution following the seminal paper [Eaton and Kortum (2002)]. It is a realization of z_{ik} drawn from a cumulative distribution $F_{ik}(A) = Pr[z_{ik} \leq A] = e^{-T_{ik} A^{-\theta}}$. $T_{ik}^{1/\theta}$ is the country and sector-specific scale parameter of the Frechet distribution, whereas θ is the shape parameter representing the heterogeneity in the productivity across varieties.

When a variety travels beyond the country's border, the price is increased by the standard iceberg trade cost defined as only a fraction ($1/d_{ijk}$) of the good produced in the country j is utilized in the country i. Hence, the price of a variety z in a sector $k \in \{a, m, s\}$ in country i is $p_{ijk}(z) = d_{ijk}\Big(v_{ijk}/A_{ijk}(z)\Big)$(eqn 1d). Each country has the technology to produce all varieties, but the buyers will choose to buy from the country with the lowest prices. Therefore, the market price of a variety in a country is defined as $p_{ik}(z) \equiv min_j\{p_{ijk}(z)\}$. The total composite supply of all varieties in a sector, Q_{ik}, is a CES aggregator with an elasticity of substitution across varieties denoted by ρ.

$$Q_{ik} = \left(\int_0^1 Q_{ik}(z)^{\frac{\rho-1}{\rho}})dz \right)^{\frac{\rho}{\rho-1}} \tag{2a}$$

By the law of large numbers and the Recardian selection of varieties across the border, the prices become the joint probability of a variety having superior productivity. Hence, the price of the sectoral composite in sector k in country i is

$$p_{ik} = \xi(\Phi_{ik})^{-1/\theta} \tag{2b}$$

where ξ is the Euler gamma function evaluated at $(1 - (\rho - 1)/\theta)$ and raised to the power $1/(1 - \rho)$. For any sectors, $k = \{a, m, s\}$, $\Phi_{ik} = \sum_{j=1,2,3} T_{jk}(v_{jk}d_{ijk})^{-\theta}$. These aggregate prices map to the prices found in equation (1d). The detailed derivation is discussed in the appendix of the paper.

Given the sectoral prices, the trade share (π_{jik}) of country i in the expenditure of country j is the ratio of the effective productivity of country i over the total effective productivity of the world.

$$\pi_{jik} = \frac{T_{ik}(v_{ik}d_{jik})^{-\theta}}{\Phi_{jk}} = \frac{T_{ik}(v_{ik}d_{jik})^{-\theta}}{\sum_{i=1,2,3} T_{ik}(v_{ik}d_{jik})^{-\theta}} \tag{2c}$$

Under Ricardian selection, the sectoral aggregate productivity A_{ik} (equation (1d)) is the aggregate productivity of all the domestic varieties that have superior productivity. (The derivation is discussed in the appendix.)

$$A_{ik} = T_{ik}^{1/\theta}\xi^{-1}\pi_{iik}^{-1/\theta} \tag{2d}$$

The share of domestic absorption $\pi_{iik} < 1$. In the closed economy $\pi_{iik} = 1$. Therefore, $A_{ik,o}/A_{ik,c} = \pi_{iik}^{-1/\theta} > 1$ reflecting that the aggregate productivity is higher when there is trade (subscript 'o' and 'c' are used for open and closed economy respectively.) [Amiti and Konings (2007)] [Topalova and Khandelwal (2011)].

All the firm's optimization problem variables are obtained at the sectoral aggregate level. The prices for each sector for all countries are determined as a function of labor endowments, productivity, trade cost, and exogenous parameters of the model. The entire production side problem is now reduced in the form of sectoral aggregates.

2.3 Preferences

Households have non-homothetic CES preferences with non-unitary income and substitution elasticity of demand. A positive $\bar{c}_k$ implies the income elasticity less than 1, whereas $\bar{c}_k = 0$ implies unitary elasticity in a sector. Households across countries have identical preferences.

$$U(c_{ik}) = \left[\sum_{k=\{a,m,s\}} \omega_k^{\frac{1}{\sigma}} (c_{ik} - \bar{c_k})^{1-\frac{1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{3a}$$

The ω_k is the sectoral expenditure share parameter such that $\omega_k \geq 0$ for $k \in \{a, m, s\}$, and $\sum_{k=\{a,m,s\}} \omega_k = 1$. The sectoral elasticity of substitution σ is assumed to be less than one, implying that the goods across sectors are gross complements.

$$\sum_{k=\{a,m,s\}} p_{ik} c_{ik} = w_i \tag{3b}$$

The households are maximizing their utilities given the budget constraints where w_i is the uniform wage in all sectors in the country i. A country's optimal aggregate household consumption can be expressed as a function of aggregate sectoral prices and wages.

$$C_{ik} = c_{ik} L_i = \bar{C_k} + \frac{\omega_k}{p_{ik}^{\sigma}} \left[\frac{w_i L_i - \sum_{n=\{a,m,s\}} (p_{in} \bar{C_n})}{\sum_{n=\{a,m,s\}} (\omega_n p_{in}^{1-\sigma})} \right] \tag{3c}$$

The capital letter (C) represents the aggregate sectoral consumption of the entire country, whereas the small letter (c) is the individual household's sectoral consumption.

2.4 Market Clearing Conditions

Given the uniform sectoral wages, the labor income of the country is the sum of the VA of all the sectors. The same is summarized as the country-specific labor market clearing conditions.

$$\sum_{k=a,m,s} \left[\phi_{ik} \underbrace{\left(\sum_{j=1,2,3} \left(\pi_{jik} p_{jk} Q_{jk} \right) \right)}_{p_{ik} Y_{ik}} \right] = w_i L_i \tag{4a}$$

Every period, trade is balanced. The sectoral composite good Q_{ik} is used for domestic demand of final consumption goods, intermediate inputs demand for the home, and foreign production.

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s} \left[(1-\phi_{in})\gamma_{ink} \sum_{j=1,2,3} \left(\pi_{jin} \frac{p_{jn} Q_{jn}}{p_{ik}} \right) \right] \tag{4b}$$

The above-said goods market clearing condition is derived by substituting equation 1c for the composite intermediate demand M_{ikn}.

2.5 Equilibrium

In this model economy, the time-variant country-specific labor endowment processes $\{L_i\}$, trade cost processes $\{d_{ijk}\}_{k=\{a,m,s\}}$, productivity processes $\{T_{ik}\}_{k=\{a,m,s\}}$, and the time-invariant common structural parameters $\{\sigma, \rho, \theta, \{\phi_{ik}, \gamma_{ikn}, \bar{C}_k, \omega_k\}_{n,k=a,m,s}\}$ are exogenously determined. Given these exogenous parameters and processes, a competitive equilibrium is a sequence of goods prices $\{P_{ia}, P_{im}, P_{is},\}$ and factor prices $\{w_i\}$, goods allocations $\{Q_{ia}, Q_{im}, Q_{is}\}$, $\{C_{ia}, C_{im}, C_{is}\}$ and factor allocation $\{L_{ia}, L_{im}, L_{is}\}$, and trade shares $\{\pi_{ijk}\}_{k=\{a,m,s\}}$, such that given the prices and allocations, firms maximize profit, households maximize their utilities and all labor and goods markets clear in all countries.

3 Analytical Results

In the context of this paper, I define structural change as the change in labor allocation across sectors over time. The model determines the prices through asymmetric technology across sectors and countries. The sectoral prices are an aggregate of domestic and import prices of the various varieties and, therefore, determine the degree of specialization and trade shares. Given the prices, households choose their income allocation to the three sectors. The elasticity of income and substitution affect the households' choices. Taking the household demand given, the firms choose their sectoral labor allocation. As a result, this general equilibrium framework captures the complex interplay of multiple factors that influence labor allocation within an economy.

The sectoral EMP share calculated using model results (Q_{ik} from the goods market clearing condition)[1] is as follows.

$$l_{ik} = \frac{L_{ik}}{L_i} = \frac{w_i L_{ik}}{w_i L_i} = \phi_{ik}\frac{p_{ik}Y_{ik}}{w_i L_i} = \phi_{ik}\left(\frac{p_{ik}Q_{ik} + NX_{ik}}{w_i L_i}\right)$$

The capital letter (L) represents a country's aggregate sectoral labor allocation, whereas the small letter (l) represents the corresponding sectoral EMP share.

$$l_{ik,o} = \phi_{ik}\frac{X_{ik} + \left\{\sum\limits_{j\neq i}\sum\limits_{n=a,m}\pi_{jin}\gamma_{ink}\frac{(1-\phi_{in})}{\phi_{in}}l_{jn}\frac{w_j L_j}{w_i L_i}\right\} + \left\{\sum\limits_{n\neq k}\pi_{iin}\gamma_{ink}\frac{(1-\phi_{in})}{\phi_{in}}l_{in}\right\}}{1-\pi_{iik}\gamma_{ikk}\frac{(1-\phi_{ik})}{\phi_{ik}}} \tag{6a}$$

$$l_{ik,o} = \frac{\phi_{ik}X_{ik} + \frac{\phi_{ik}}{w_i L_i}\left\{\left\{\sum\limits_{j\neq i}\sum_{n=a,m}\pi_{jin}M_{jnk}\right\} + \sum\limits_{n\neq k}\pi_{iik}M_{ink}\right\}}{1-\pi_{iik}\gamma_{ikk}\frac{(1-\phi_{ik})}{\phi_{ik}}}$$

The expenditure share is defined as $X_{ik} \equiv (p_{ik}C_{ik})/(w_i L_i)$. The sectoral EMP share depends on the sectoral domestic expenditure share (X_{ik}), the prices $(p_{in})_{n=\{a,m,s\}}$, the extend of specializations (π_{jin}), relative size of the importing countries (L_j/L_i) and the EMP shares in other sectors and in other countries that procure intermediate inputs from the sector (l_{jn}). Since intermediates are input in the production process, the EMP share in the intermediate sector also indirectly affects the EMP share of the output sector. Further, the expenditure share in the sector depends upon the income and substitution elasticity and the relative productivity of the sector.

The closed economy is counterfactual for the EMP shares $l_{ik,c}$ is obtained by setting the domestic absorption to 1.

$$l_{ik,c} = \phi_{ik}\frac{X_{ik} + \left\{\sum\limits_{n\neq k}\gamma_{ink}\frac{(1-\phi_{in})}{\phi_{in}}l_{in}\right\}}{1-\gamma_{ikk}\frac{(1-\phi_{ik})}{\phi_{ik}}} = \frac{\phi_{ik}X_{ik} + \left\{\frac{\phi_{ik}}{w_i L_i}\sum\limits_{n\neq k}M_{ink}\right\}}{1-\gamma_{ikk}\frac{(1-\phi_{ik})}{\phi_{ik}}} \tag{6b}$$

The EMP share in the closed economy depends upon the expenditure share and the EMP share in the other sectors. Higher relative sectoral productivity and substitution elasticity of less than 1 translate into declining expenditure share and, in turn, declining EMP share in the sector in the closed economy.

In the presence of trade, rising intermediate net exports demand (second term on the right-hand side of Eqn 6a) with increasing productivity works in the opposite direction. Suppose the relative size of the importing country is large enough, then the trade channel

[1]Open economy results are presented with subscript 'o' and closed economy results with 'c.'

dominates, and the sector with rising productivity has a comparative advantage in production and exports and larger world market access. Therefore, the EMP share in the sector increases over time. There are two components to the trade - exports and imports. Rising exports have favorable implications for the growing sector McCaig and Pavcnik (2018), Erten and Leight (2021), but trade creates competition for domestic varieties in the sectors where imports are higher, and if trade dominates in the sector where domestic productivity is not reasonably strong (the second term in Eqn 6a is negative, then it can lead to declining EMP share or dying firms in the sector Menezes-Filho and Muendler (2011), McCaig and S. McMillan (2020).

If it is assumed that only labor is used in the production ($\phi_{ik} = 1$) and allows the trade in final consumption goods, Eqn 6a and 6c can be simplified further.

$$l_{ik,o} = \pi_{iik} X_{ik} + \sum_{j \neq i} \left\{ \pi_{jik} X_{jk} \frac{w_j L_j}{w_i L_i} \right\}$$

$$l_{ik,o} = X_{ik} + \frac{\sum_{j \neq i} (\pi_{jik} X_{jk} w_j L_j - \pi_{ijk} X_{ik} w_i L_i)}{w_i L_i} = X_{ik} + N_{ik}$$

The EMP share in the closed economy is the same as the expenditure shares ($l_{ik,c} = X_{ik}$) whereas, in the open economy, they also depend upon the expenditure share of the importing country, trade shares (the level of specialization) and the relative size of the countries. $N_{ik} = \sum_{j \neq i} (\pi_{jik} X_{jk} w_j L_j - \pi_{ijk} X_{ik} w_i L_i)$ is the net export. The results change from the non-unitary VA parameter only to the extent that the indirect effect through the intermediate input is missing in this formulation. Sposi (2019) finds that differences in input-output tables across countries can account for about three-fourths of the hump-shaped pattern in the value-added industry share as per capita income evolves.

Expenditure share captures the transmission channel through which preferences affect the labor allocation in different sectors. The non-homothetic preferences play an important role in structural change. As income grows, households allocate more income away from agriculture towards manufacturing and services.

$$X_{ik} = \frac{p_{ik} C_{ik}}{w_i L_i} = \frac{p_{ik} \bar{c_k}}{w_i} + \omega_k \left(\frac{p_{ik}}{p_i} \right)^{1-\sigma} \left\{ 1 - \sum_n \frac{(p_{in} \bar{c_n})}{w_i} \right\} \tag{6c}$$

If homothetic preferences are assumed, the expenditure share only depends on prices (productivity) and substitution elasticity of demand. It is clear from the relationship between expenditure share and the relative sectoral prices that the sectoral labor declines as prices (productivity) decline (grow) over time, same as Ngai and Pissarides (2007).

4 Data

Next, I apply the model to the data to quantitatively understand the structural change in India from 1970-2007. The time frame is chosen to capture the effect of pre and post-changes of globalization policy in India and China.

4.1 Countries and Sample Period

I use the data from 1970 to 2007 for India, China, and the aggregate of the rest of the world (ROW) to calibrate and simulate the model. ROW is an aggregate of the major trading partners of India. It includes 56 countries from across the globe. 20 rich countries from Europe and others (Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, and the United States), 11 Asian Countries (Egypt, Hong Kong, Indonesia, Japan, Malaysia, Mauritius, Philippines, Singapore, South Korea, Taiwan, and Thailand), 7 Latin American countries (Bolivia, Argentina, Chile, Colombia, Costa Rica, Mexico, and Peru) and 18 African countries (Botswana, Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Morocco, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda, and Zambia)

4.2 Definition of Sectors

The sectors are defined per the International Standard Industrial Classification, Revision 3 code definitions.

Agriculture includes agriculture, hunting, forestry, fishing (AtB), mining, and quarrying (C).

The manufacturing is an aggregate of food, beverages, and tobacco (15-16), Textiles, Textile Products, Leather and Footwear (17-19), Wood and Products of wood (20), Pulp, Paper, Paper Products, Printing and Publishing (21-22), Coke, Refined Petroleum Products and Nuclear fuel (23), Chemicals and Chemical Products (24), Rubber and Plastic Products (25), Other Non-Metallic Mineral Products (26), Basic Metals and Fabricated Metal Products (27-28), Machinery (29), Electrical and Optical Equipment (30-33), Transport Equipment (34-35), miscellaneous manufacturing and recycling (36-37), and Electricity, Gas, and Water Supply (E).

Services is an aggregate of Construction (F), Trade (G), Hotels and Restaurants (H), Transport and Storage (60t63), Post and Telecommunication (64), Financial Services (J), Business Service (71t74), Public Administration and Defense and other compulsory Social Security (L), Education (M), Health and Social Work (N) and Other services (70+O+P).

4.3 Sectoral EMP share

For the data on EMP share (l_{ik}), I mainly rely on three data sets:

1. GGDC Economic Transformation Database Historic series[2] De Vries et al. (2021).

2. The EU KLEMS database, 2009 release (updated in 2011) for years 1970-2007 [3].

3. The Penn World Table version 10.0[4].

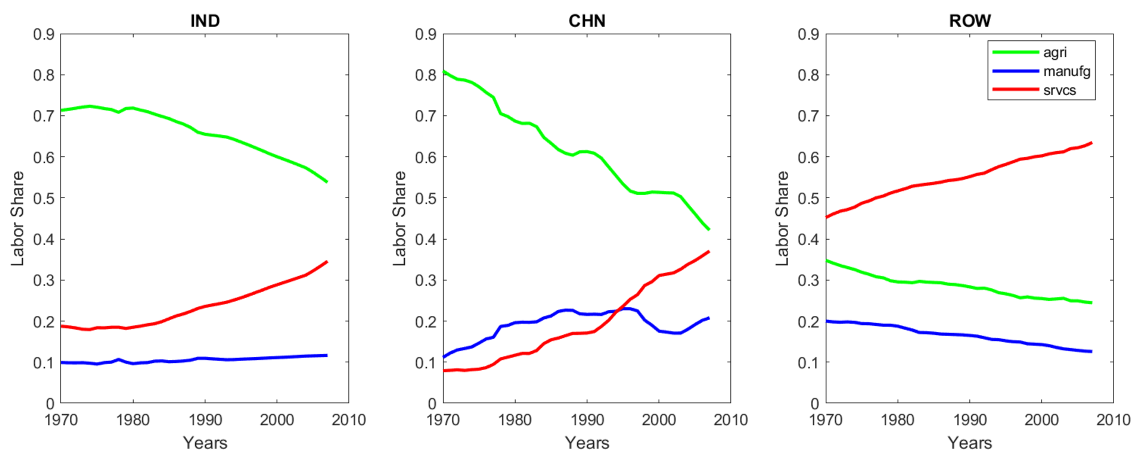

Figure 3: Sectoral EMP share in of India, China and Rest of the World. The EMP share in manufacturing is relatively constant in India, whereas it is growing in China and declining in the ROW(dominated by developed countries)

The EMP share for the ROW is built by simple addition across countries in the sample for the three sectors. The total labor endowment (L_i) for each country in the model is taken from the Penn World Table database.

[2]https://www.rug.nl/ggdc/structuralchange/etd/
[3]http://www.euklems.net/index.html and http://www.euklems.net/index_TCB_201807.shtml
[4]https://www.rug.nl/ggdc/productivity/pwt/

4.4 Sectoral Trade Share

Another primary source of data is the World Input-Output Database (WIOD). I append Long-run WIOD (1965-2000)[5] and WIOT 2013 release (1995-2011)[6]. The database provides information on bilateral trade between each country and sector. I collapse the subsectors into three sectors consistent with the definition mentioned above.

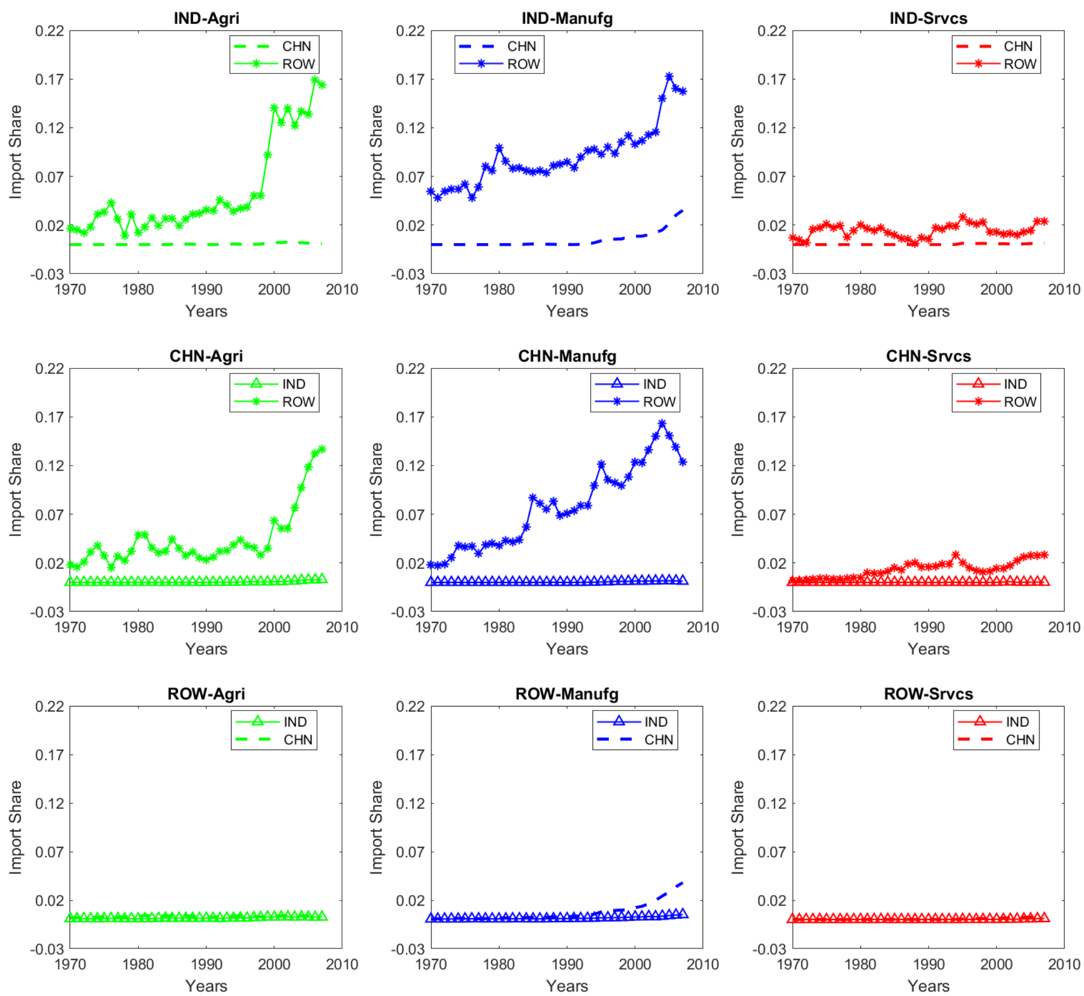

Figure 4: Sectoral Import share in the model: The trade volume seems more significant in manufacturing in all countries.

[5] Woltjer, P., Gouma, R. and Timmer, M. P. (2021), "Long-run World Input-Output Database: Version 1.1 Sources and Methods", GGDC Research Memorandum 190

[6] Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), "An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production," Review of International Economics., 23: 575–605

The bilateral trade share for each pair in each sector following Uy et al. (2013), Sposi (2019), is defined as follows:

$$\pi_{ijk} = \frac{X_{ijk}}{ABS_{ik}}$$

where X_{ijk} is the trade flow from country j to i in sector k. ABS_{ik} is the domestic absorption of the country i in sector k, obtained by subtracting the net exports from the Gross Output at the current prices. The Sectoral Gross Output data is also obtained from the same source (WIOD).

5 Calibration

In this section, I explain how I calibrate all the time-variant and time-invariant country and sector-specific parameters of the model.

5.1 Preference Parameters

The time-invariant common preference parameters are $\{\sigma, \omega_k, \bar{C}_k\}_{\{k=a,m,s\}}$. To estimate these parameters, I use marginal conditions that emerge from the demand side.

$$\frac{p_{kt}C_{kt}}{p_t C_t} = \frac{p_{kt}\bar{C_{kt}}}{p_t C_t} + \frac{\omega_k p_{kt}^{1-\sigma}}{p_t C_t}\left\{\frac{1 - \sum_{n=\{a,m,s\}} p_{nt}\bar{C}_n}{\sum_{n=\{a,m,s\}} \omega_k p_{kt}^{1-\sigma}}\right\}$$

I adopt the final expenditure approach similar to Uy et al. (2013) and Herrendorf et al. (2013). I calculate the sectoral expenditure share (s_{kt}) of households from the data and the model ($\frac{p_{kt}C_{kt}}{p_t C_t}$). The parameter values are then chosen to minimize the squared deviation of the actual and model-calculated consumption shares across sectors and time.

$$\textbf{Min}_{\sigma,\omega_k,\bar{C}_k} \sum_t \sum_{\{k=a,m,s\}} \left[s_{kt} - \frac{p_{kt}\bar{C_{kt}}}{p_t C_t} + \frac{\omega_k p_{kt}^{1-\sigma}}{p_t C_t}\left\{\frac{1 - \sum_{n=\{a,m,s\}} p_{nt}\bar{C}_n}{\sum_{n=\{a,m,s\}} \omega_k p_{kt}^{1-\sigma}}\right\}\right]^2$$

I collate the time series data for Indian aggregate final private consumption expenditure ($p_t C_t$) by sectors from the Annual National Accounts Statistics published by Ministry of Statistics and Programme Implementation, Government of India[7]. The time series is available at current and constant 2011-12 prices. I convert them to 2005 prices. The data for aggregate

[7]https://www.mospi.gov.in/web/mospi/reports-publications

final expenditure by sector is not available. Therefore, the private final consumption share data is assumed to reflect the aggregate final consumption expenditure share. I aggregate these series into three broad sectors by the purpose of utilization as per table 1 below[8].

Table 1: Classification of the final Consumption expenditure into three sectors by purpose

Agriculture	Manufacturing	Services
1	3-5	2, 6-11
Food, Beverages, Tobacco	Clothing, and Footwear; Housing, Fuel, and Power; Furniture and Furnishing; Appliances	Hotels, and Restaurants; Medical Care and Health Services; Transport, Communication, and Recreation; Education, Misc. Good and Services

The time series for sectoral final private consumption at the current price ($\hat{C}_{kt}$) and the constant price ($\hat{C}_{kt}^{2005}$) is then converted into PPP USD using the PPP for private consumption data from OECD National Accounts Statistics[9] [10]. The population data is obtained from the Penn World Table. The time series for sectoral final consumption expenditure share (s_{kt}), the aggregate per capita consumption expenditure ($\hat{p}_t\hat{C}_t$), and the sectoral relative prices ($\hat{p}_{kt}$) are then calculated.

$$s_{kt} = \frac{\hat{C}_{kt}}{\sum_{k=a,m,s}\hat{C}_{kt}}; \quad \hat{p}_t\hat{C}_t = \frac{\sum_{k=a,m,s}\hat{C}_{kt}}{PPP_tPOP_t}; \quad \hat{p}_{kt} = \frac{\hat{C}_{kt}/PPP_t}{\hat{C}_{kt}^{2005}/PPP_{2005}}$$

The time series for aggregate per capita consumption expenditure ($\hat{p}_t\hat{C}_t$) and the sectoral relative prices ($\hat{p}_{kt}$) are then applied to equation (7) to obtain the model calculated sectoral consumption expenditure share.

Table 2: Preference Parameters

σ	ω_a	ω_m	ω_s	$\bar{c}_a$	$\bar{c}_m$	$\bar{c}_s$
0.3609	0.2023	0.1872	0.6104	165	0	-779

[8] the data for FBT is not available separately; therefore, FBT has been clubbed in agriculture

[9] Purchasing Power Parities for Private Consumption in Table 4 (PPPs and Exchange Rates) https://stats.oecd.org/viewhtml.aspx?datasetcode=SNA_TABLE4&lang=en

[10] the OECD database for PPP for private consumption for India is a time series starting 1990 therefore for 1970-89, PPP for GDP from the same source is used

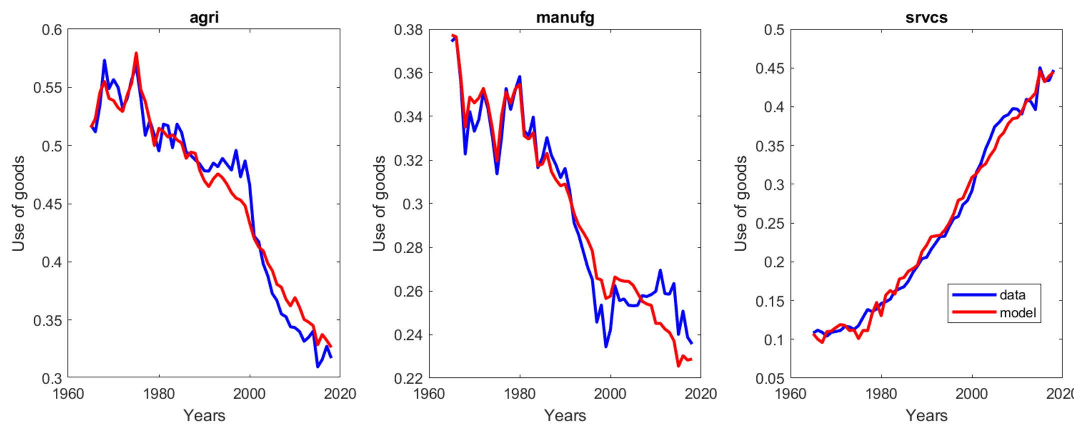

Figure 5: Model calculated consumption share using calibrated parameters and data for all three sectors in India

The minimization problem yields the preference parameter values described in Table 2. The share parameters obtained here are quite similar to Uy et al. (2013) that also uses Stone-Geary non-homothetic CES preferences. However, the elasticity of substitution parameters is different. Uy et al. (2013) sets the subsistence level in manufacturing and services to zero and finds σ to be 0.75. I set the subsistence parameter in manufacturing to zero, and my estimate for σ is closer to 0.36. Sposi (2019) finds σ equal to 0.40 for a similar analysis with the same preferences assumption. They also do a robustness check using generalized CES and find that the two models produce only slightly different results. The model calculated sectoral consumption share at the estimated parameters fit well with the data, as shown in figure 5. The root mean square errors are 0.140, 0.0060, and 0.0082 in agriculture, manufacturing, and services.

An important caveat that needs to be mentioned here is that I am using the final consumption and purchase price data to calibrate my parameters. This gives a different combination of substitution and income elasticities compared to the one where valued-added consumption data at the producer's cost price is used, in which the substitution elasticity is a small number, which acts more as a complementary. Also, the value for subsistence parameters differs depending on the choice of the base year, as it is a quantity measure. However, it does not affect the quantitative results of the model.

5.2 Production Parameters

I calculate the time-invariant country-specific, technology parameters, $\{\gamma_{ikn}\}_{k,n=\{a,m,s\}}$ using the World Input-output Database. I reduce the commodity-industry absorption table for every year into three sectors. The share of all the sectors' commodities absorption in the three aggregated industries gives a 3x3 matrix for intermediate share parameters. The parameters are reported in Table 3. The parameter values are the elements-wise sample mean of the all-year matrix.

Table 3: Production Parameters of the model (Intermediate shares)

γ_{ikn}	Agriculture	Manufacturing	Services
IND			
Agriculture	0.5688	0.2105	0.2207
Manufacturing	0.2382	0.4922	0.2697
Services	0.0798	0.4785	0.4417
CHN			
Agriculture	0.4020	0.4497	0.1483
Manufacturing	0.2155	0.6371	0.1473
Services	0.0703	0.5893	0.3404
ROW			
Agriculture	0.3578	0.3410	0.3012
Manufacturing	0.1760	0.5621	0.2619
Services	0.0205	0.3412	0.6384

The table shows that India's share of intermediates is relatively higher from the primary agriculture sector than that of the modern manufacturing and services sector in the production process in all three sectors compared to that of China and ROW. Sposi (2019) also finds similar results.

The VA parameters $\{\phi_{ik}\}_{k=\{a,m,s\}}$ are obtained by calculating the share of VA in the gross output for each sector in each country, presented in table 4.

Table 4: Production Parameters of the model (VA share)

ϕ_{ik}	Agriculture	Manufacturing	Services
IND	0.7545	0.2873	0.6420
CHN	0.6413	0.3057	0.4587
ROW	0.5934	0.3576	0.6169

The shape parameter of the Frechet distribution (θ) and elasticity of substitution (ρ) between sectoral varieties are set to 4, following the findings in the literature Uy et al. (2013), Waugh (2010).

5.3 Productivity and trade shocks

Since the detailed sectoral intermediates data series derived from the input-output table is only available for some countries, TFP can not be estimated directly from the production technology. I refer to Uy et al. (2013) to calibrate the productivity shock in three steps.

1. In the first step, I calibrate the 9 productivity parameters $\{T_{ik}\}_{k=\{a,m,s\}}$ and 18 trade cost parameters $\{d_{ijk}\}_{k=\{a,m,s\}}$ from the model for the year 1970 such the chosen 27 target moments are matched. The details are given in Table 5.

2. In the second step, I need to extrapolate the initial values of TFP and trade cost to complete the time series. To do that, again, I use a three-step process.

   (a) In the first step, I calculate VA productivity from the model. By substituting the optimal allocation of intermediates (Eqn 1c) into the sectoral aggregate production function, the sectoral optimization problem can be written only in terms of labor input, and the VA production function takes the form $A_{ik}^{\frac{1}{\phi_{ik}}} L_{ik}$.

$$Y_{ik} = \left[(1-\phi_{ik}) p_{ik} \prod_{n=\{a,m,s\}} \left(\frac{\gamma_{ikn}}{p_{in}} \right)^{\gamma_{ikn}} \right]^{\frac{1-\phi_{ik}}{\phi_{ik}}} A_{ik}^{\frac{1}{\phi_{ik}}} L_{ik}$$

$$\underbrace{\phi_{ik} P_{ik} Y_{ik}}_{\text{value-added}} = \underbrace{\phi_{ik} P_{ik}^{\frac{1}{\phi_{ik}}} \left((1-\phi_{ik}) \prod_{n=\{a,m,s\}} \left(\frac{\gamma_{ikn}}{P_{in}} \right)^{\gamma_{ikn}} \right)^{\frac{1-\phi_{ik}}{\phi_{ik}}}}_{\text{value-added prices}} \underbrace{A_{ik}^{\frac{1}{\phi_{ik}}} L_{ik}}_{\text{value-added quantity}}$$

   To calculate productivity this way, I need Real Value-Added (RVA) and EMP share for all three sectors in all countries. I have described developing the time series of EMP shares in the above sections.

   To calculate the RVA series, I rely on two data sources: GGDC Economic Transformation Database Historic series[11] De Vries et al. (2021), and the EU KLEMS

[11]https://www.rug.nl/ggdc/structuralchange/etd/

Table 5: Initial Shock level Calibration (1970)

Variables	Data	Model
IND Agricultural EMP share	71.32%	71.05%
IND Manufacturing EMP share	9.92%	10.18%
CHN Agricultural EMP share	80.91%	78.97%
CHN Manufacturing EMP share	11.16%	14.26%
ROW Agricultural EMP share	34.19%	34.82%
ROW Manufacturing EMP share	20.00%	19.69%
IND Agricultural import share from CHN	0%	0%
IND Agricultural import share from ROW	1.66%	1.66%
IND Manufacturing import share from CHN	0%	0%
IND Manufacturing import share from ROW	5.48%	5.48%
IND Services import share from CHN	0%	0%
IND Services import share from ROW	0.74%	0.74%
CHN Agricultural import share from IND	0%	0%
CHN Agricultural import share from ROW	1.77%	1.77%
CHN Manufacturing import share from IND	0%	0%
CHN Manufacturing import share from ROW	1.82%	1.11%
CHN Services import share from IND	0%	0%
CHN Services import share from ROW	0.22%	0.22%
ROW Agricultural import share from IND	0.096%	0.096%
ROW Agricultural import share from CHN	0.17%	0.17%
ROW Manufacturing import share from IND	0.062%	0.062%
ROW Manufacturing import share from CHN	0.08%	0.08%
ROW Services import share from IND	0.0138%	0.014%
ROW Services import share from CHN	0.01%	0.01%
CHN-IND Income ratio	1.01	0.97
ROW-IND Income ratio	11.03	9.10
IND's Agricultural subsistence share	0.24	0.31

database, 2009 release (updated in 2011) for years 1970-2007 [12]. GGDC ETD Historic series provides data on VA at current and constant prices (2015) in local currencies. I use PPP from Penn World Table to convert it into PPP dollars. VA at constant prices (2015) is re-normalized at 2005 prices. I calculate the weighted growth rates for sub-sectors in all three sectors using the VA at the constant prices series. For the EU countries, I go to the EU KLEMS data and obtain the time series data for VA at current prices and quantity indices(QI) with the base year

[12] http://www.euklems.net/index.html and http://www.euklems.net/index_TCB_201807.shtml

1995 from the same source and collapse them to the sectoral level. I follow the Tornqvist Method. To calculate the RVA series from the nominal VA in 2005, the series is iterated forward and backward using the annual growth rate. To calculate the annual growth rate, I use the implied growth rate weighted by the sub-sectoral share of VA[13]. Thus, the gross output TFP is then estimated by the relation $A_{ikt} = \left(\frac{RVA_{ikt}}{L_{ikt}}\right)^{\phi_{ik}}$.

(b) Given the gross output TFP, I calculate the TFP parameters (T_{ik}) using the following relationship shown by Finicelli et al. (2013)

$$T_{ikt} = \left(\xi A_{ikt} \pi_{iikt}^{1/\theta}\right)^{\theta}$$

For this, I need the share of domestic absorption for all three sectors for all countries. The process for calculating it is explained in section 5.4. The proxy for the fundamental TFP thus calculated is used to obtain the productivity growth rate series.

$$(1 + g_T) = T_{ik,t+1}/T_{ik,t}$$

Thus found growth rate is then applied to 1970s TFP (obtained in step 1) to find the time series for the entire period.

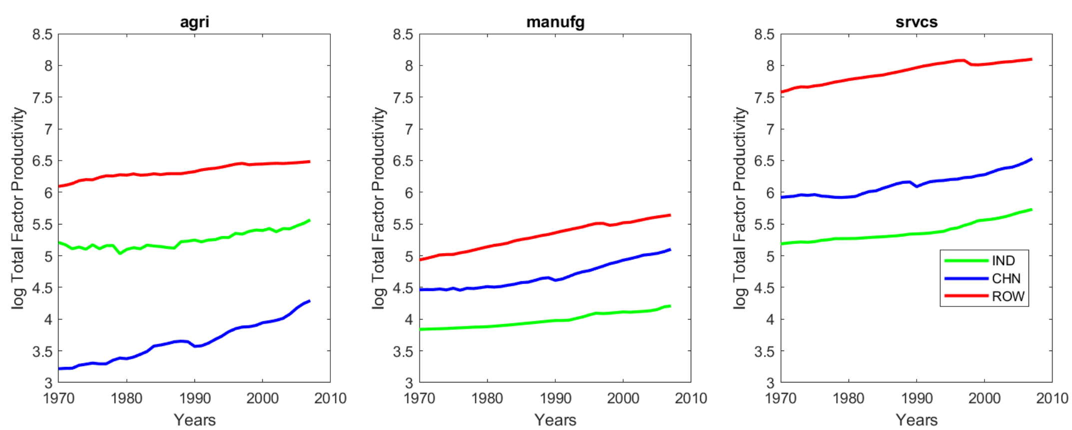

Figure 6: Sectoral logged TFPs in of India, China and Rest of the World: A cross-country comparison in all three sectors

The time series of the logged TFP series is summarized in Figure 6. Figure 6 provides the cross-country intra-sector comparison. TFP is higher in all three

[13] Uy et al. (2013) explains the entire step-wise details in its appendix

sectors in ROW. The calibrated TFP level is higher in India than in China in agriculture but much lower than the ROW. From 1970 to 2017, Agriculture TFP grew by 48% in ROW and 193% in China but merely 43% in India. Even though the level of TFP is higher in India, it is growing much slower than in China. In manufacturing and Services, not only is Indian TFP lower than China, but its growth rate is also much lower. During this period, Indian TFP grew to 45% in manufacturing and 72.5% in Services, whereas Chinese grew to 88% and 84%, respectively.

The annualized TFP growth rates were 0.95% in agriculture, 0.98% in manufacturing, and 1.45% in services in India during this period. In China, they were 2.87% in agriculture, 1.68% in manufacturing, and 1.62% in services. In ROW, TFP grew at the rate of 1.04% in agriculture, 1.88% in manufacturing, and 1.38% in services. China's TFP grows at a much faster rate than that of India, particularly in agriculture and manufacturing, which facilitates first the shift out of agriculture and then increasing EMP share in manufacturing.

3. After finding the initial level of trade cost, I use the model to compute the entire series. The trade cost for each period is chosen so that the model calculated trade share matches trade share data. The calibrated trade cost series is summarized in Figure 7.

   The model-calibrated trade share and its fit with the data is presented in Figure 8 below, where the solid black line is data, and the colored red, green, and blue lines are model-calculated shares for the various trading partners.

$$d_{ijk} = \mathbf{Max}\left[\left(\frac{\pi_{ijk}}{\pi_{jjk}}\right)\left(\frac{p_{ik}}{p_{jk}}\right), 1\right]$$

   The bilateral trade cost with China was very high before 1990 in all three sectors. However, from the 1990s onward, the bilateral trade cost between India and China declined significantly in all three sectors. The bilateral trade cost between India and ROW is relatively lower than that of China and has remained relatively constant. India's import cost in agriculture and manufacturing has been lower than that of services. Services have been largely non-tradeable, reflected in the trade share. Therefore, the trade cost in services only reflects those tradeable services.

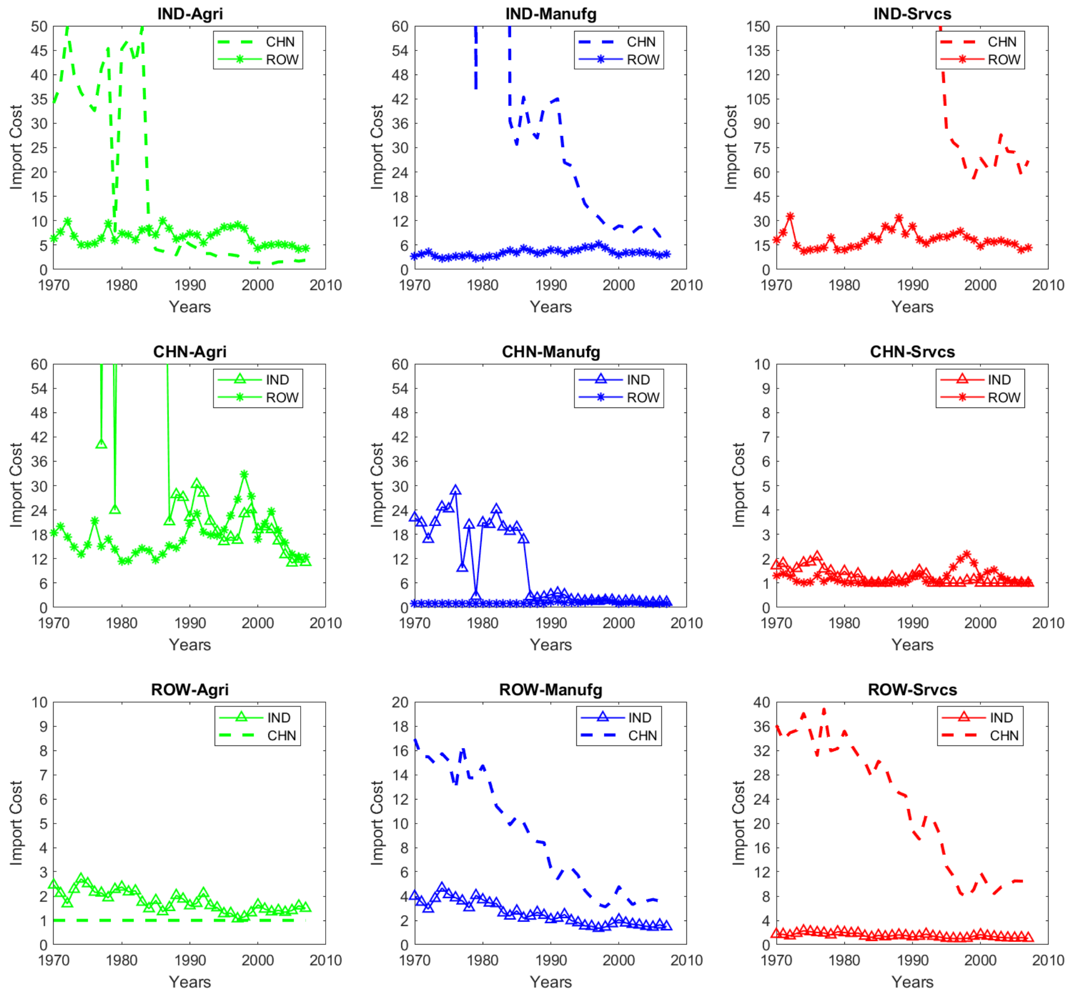

Figure 7: Sectoral bilateral trade cost. 1, 2, and 3 stand for India, China, and ROW, respectively.

6 Quantitative Results and Counterfactual

I now assess the quantitative importance of productivity and trade cost in India's structural transformation.

The key features of my baseline model are non-homothetic preferences with the elasticity of substitution of less than 1, asymmetric and evolving productivities & trade cost over time across sectors. I simulate the effect of calibrated TFP and trade cost in my model (Figure 9). The blue line represents the data, whereas the red represents the model-predicted EMP share.

Overall, the baseline model has a good fit with the data. It replicates the trends in all three sectors, agriculture, manufacturing, and services, quite well. The Root Mean

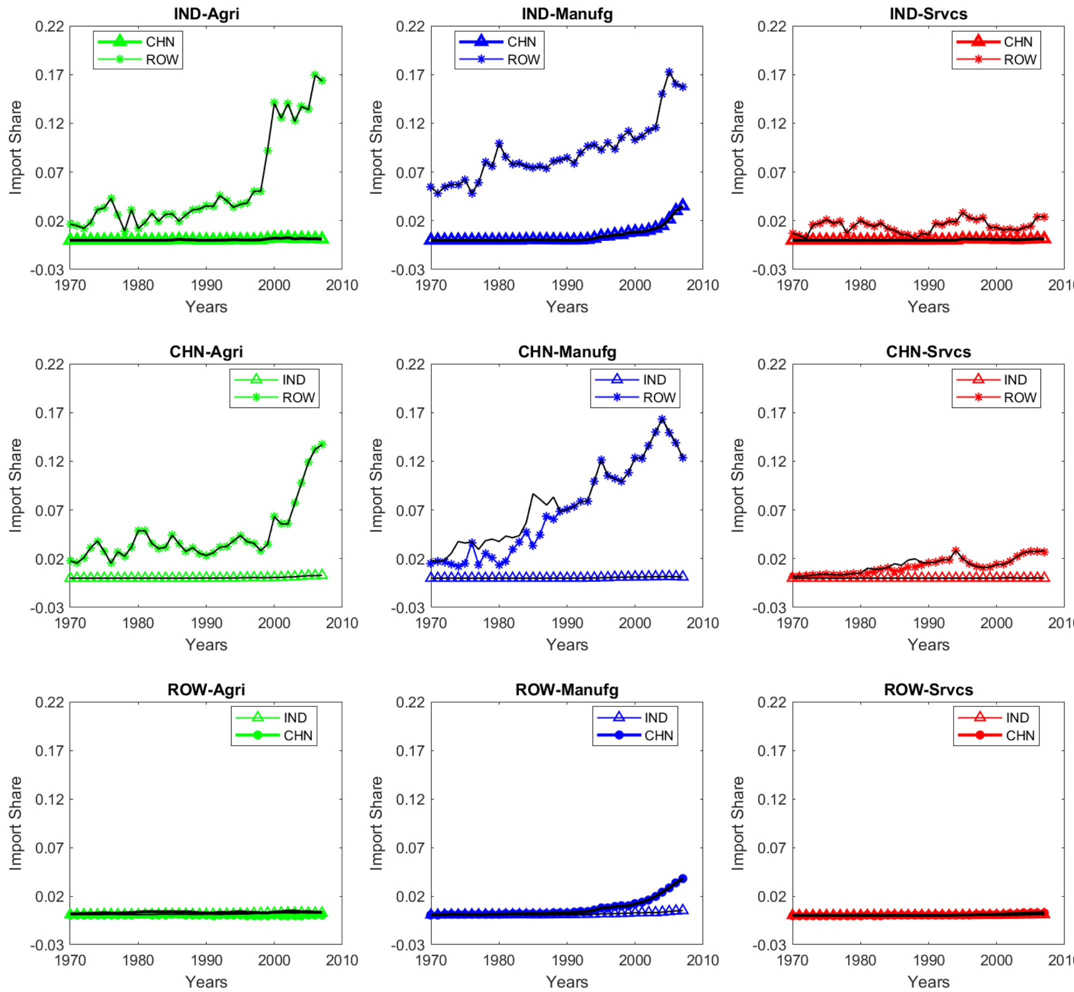

Figure 8: The model calculated trade share fit the data. The solid black line represents the data, whereas the green, blue, and red colored line represents the trade share of the various partners in agriculture, manufacturing, and services, respectively.

Square Error (RMSE) of baseline prediction of EMP share is 0.0101 in agriculture, 0.0018 in manufacturing, and 0.0053 in services.

The growing TFP in the agricultural sector leads to decreased labor allocation. However, the effect of slow TFP growth in the manufacturing sector is offset by the declining trade cost over time, resulting in minimal changes in the manufacturing sector. In contrast, in the services sector, the trade cost is relatively high, while TFP growth is faster than that of other sectors. Therefore, most labor displaced from agriculture is absorbed into the manufacturing sector, increasing the labor share over time.

I run three counterfactuals; the first two are to decompose the effect of the evolution

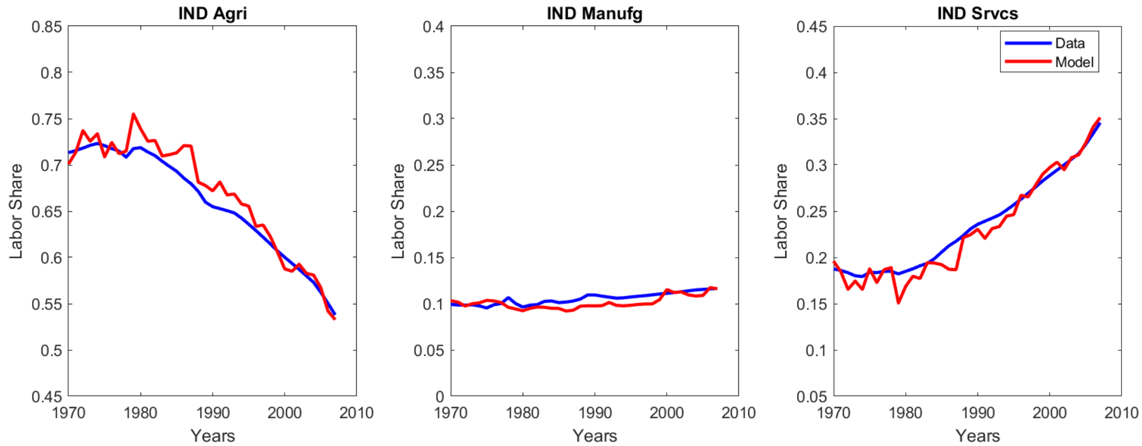

Figure 9: Sectoral EMP Share predicted by the baseline model

of TFP and trade cost and its contribution to structural change in India, and the third one is to compare it with Chinese structural transformation.

6.1 Counterfactual 1: Decomposing the effect of TFP

I simulate the model by setting the TFP for India to the initial level of 1970, keeping all the other variables of the model the same as the baseline model.

The baseline model (red in Figure 10) considers both factors (productivity and trade processes) and predicts the year-wise labor share in three sectors over time. The brown line in Figure 11 shows the predicted employment share in all three sectors based on the counterfactual where TFP in India is kept constant at the 1970s level, keeping everything the same as baseline (trade costs decline, and TFP in other countries continues to grow).

The interpretation can be divided into three parts by comparing the counterfactual results with the baseline model. First, from 1970 to 1987, the two plots (red and brown) almost show the same trend in all three sectors. Some fluctuations in agriculture and services can be because of modeling errors. India (the entire period) and China (the 1970-1980 period) were closed economies, so trade was not at play in this period. Employment share responded little purely due to India's very slow rate of TFP growth. This was also the period when many agricultural reforms were being carried out in India.

Second, from 1988 to 1998, China, followed by India, opened up for trade. The brown line is almost flat, reflecting no significant immediate effect of opening up; instead, there is some upward slope in agriculture and a slight negative slope in manufacturing in the brown

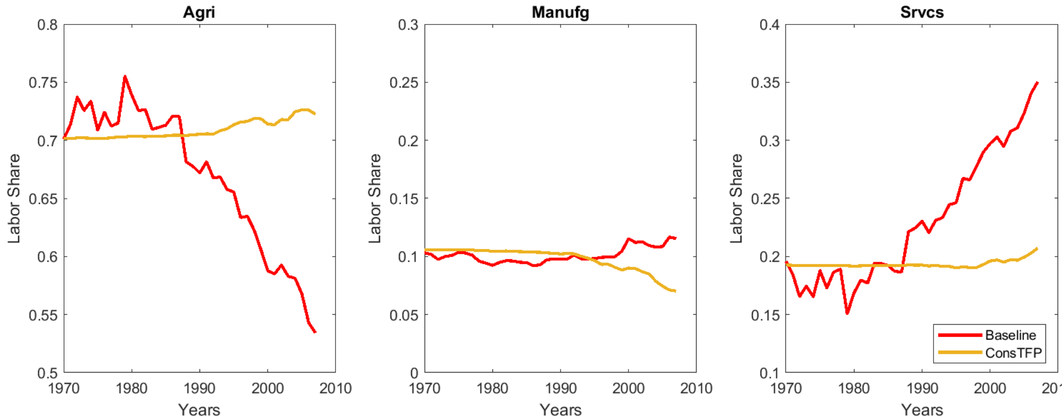

Figure 10: Sectoral EMP Share predicted by setting the TFP constant for all the periods ceteris paribus and its comparison with baseline

line. This can be an effect of changes in agriculture policies due to reforms in the last decade. Over time the gap between red and brown, contributed mainly by TFP growth, broadened. During this period, change in TFP contributes a 7.4% decline in EMP share in agriculture that is primarily absorbed in services, reflected by an increase of about 5.9%. In contrast, manufacturing gains are smaller by about 1.5%.

Third, after 1998, India saw significant economic changes due to international trade. China was performing exceptionally well in terms of manufacturing exports. The deviation between the baseline and counterfactual grows to be about 16.56% in agriculture, 5.1% in manufacturing, and 11.5% in services. The gains in manufacturing are smaller compared to the other two sectors; which reflects the sluggish TFP growth in the manufacturing sector.

6.2 Counterfactual 2: Decomposing the effect of Trade cost

I create another counterfactual where I simulate the model by setting the trade cost for India to the initial level of 1970, keeping all the other variables of the model the same as the baseline model. In Figure 11, the red color represents the baseline model, and the green color represents the simulation results of the counterfactual.

The baseline and the counterfactual match almost entirely till 1988. There are some minor changes due to trade between 1988-1998. Post 1998, the deviation between the baseline and counterfactual grows to be about 4.1% in agriculture, 2.87% in manufacturing, and 1.2% in services. Trade explains significant changes in India's EMP share post-1998 (global-

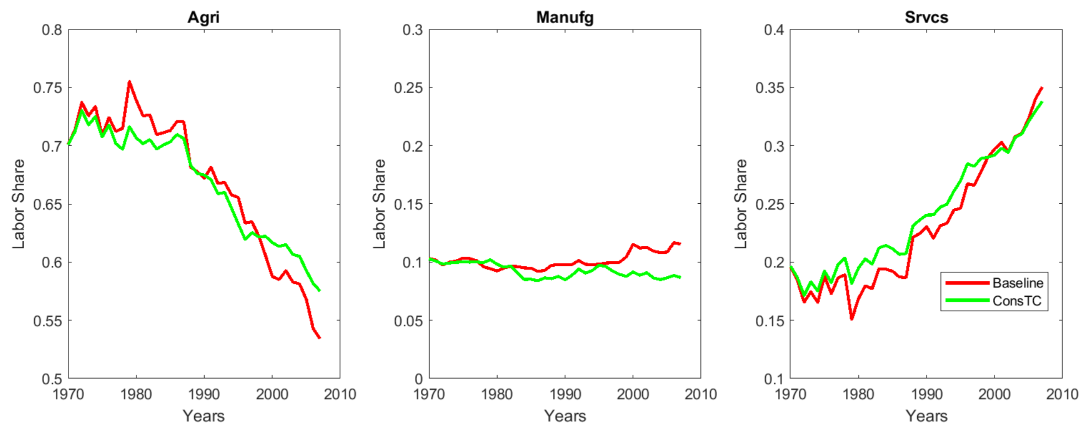

Figure 11: Sectoral EMP Share predicted by setting the Trade cost constant for all the periods ceteris paribus and its comparison with baseline

ization era). Also, It is evident that trade has stimulated labor share in the manufacturing sector rather than impeding it. Sometimes, it is argued that the manufacturing giant in the neighborhood impedes domestic growth because of competition, but that does not seem true here.

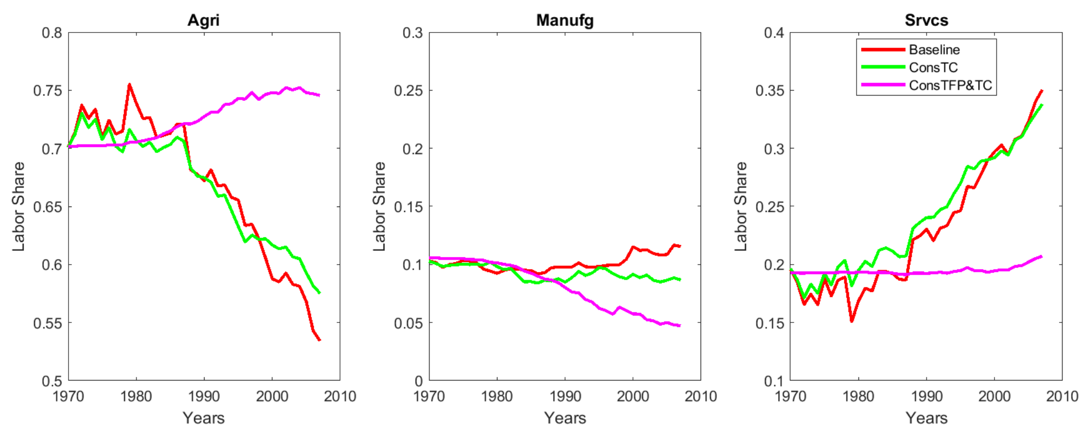

Figure 12: Sectoral EMP Share predicted by baseline and two counterfactual: one where both shocks are set to constant, and the other where TFP shock is at play but trade shocks are set constant.

We can draw some crucial inferences by combining the results of the above two counterfactuals. In Figure 12, the pink line represents no TFP growth and no trade in India, ceteris paribus. The green represents no trade, but TFP is growing at the same rate as a baseline, and the red represents the baseline. In the closed economy, India had a comparative advantage in Agriculture, and in the absence of TFP growth, the share in agriculture would have instead increased over time, leading to stronger deindustrialization.

As described in Figure 13, during 1988-1998, agricultural labor share declined by 8.25% due to TFP gain and about 0.2% due to trade factors. In the same period, services gained 5.6% due to TFP changes and about 0.14% due to trade factors. In the manufacturing sector, 0.12% gain in labor share is attributed to trade factors, whereas about 2.7% is contributed due to productivity gain. The trade effect is weaker in this period.

However, post-1998, agriculture share declined further by about 9.2%, of which 5% is due to TFP gains and about 4.2% due to trade. This decline is mostly compensated by gain in about 6% services sector, where TFP contributed 3.7% and trade 2.3%. The manufacturing sector's employment share increased in this period by only 3.14%, out of which trade contributed a larger share of about 1.83%. Most employment share gain in manufacturing is explained by trade, which indicates that trade does not hinder EMP generation in the manufacturing sector.

6.3 Counterfactual 3: Comparison with China

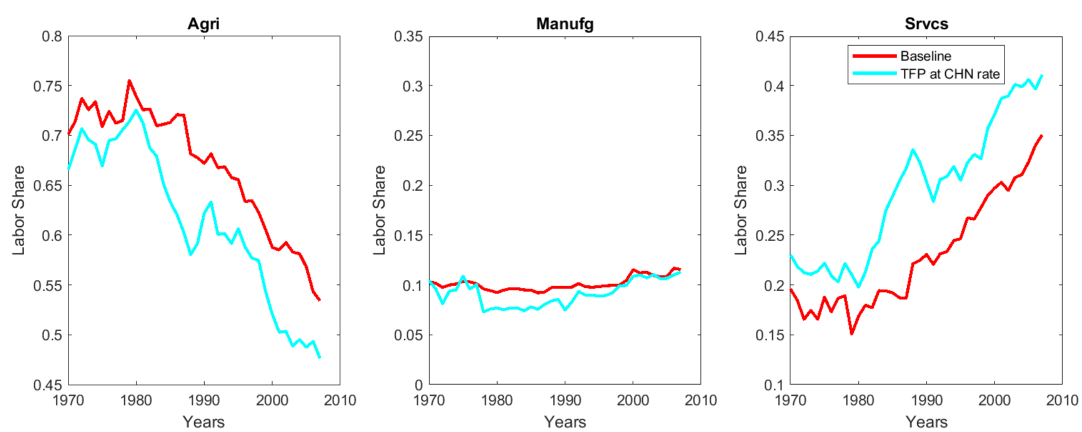

Figure 13: Sectoral EMP Share predicted by baseline and the counterfactual where Indian TFP is growing at the rate of growth of the China TFP in each sector ceteris paribus

India and China started at relatively same income levels in the 1970s but witnessed different economic growth stories. It generates curiosity that if Indian TFP would have grown at the same rate as Chinese in all three sectors, would the Indian story be more manufacturing and fewer services? This study says no in the answer. The light blue path in Figure 13 would depict the Indian structural transformation if the TFP grew at the same rate as the Chinese. More labor is moving away from agriculture towards services. The structural change is faster but still biased against the manufacturing sector. The prediction of this counterfactual nearly coincides with the baseline in the manufacturing sector, indicating no increase in the EMP share.

The results of counterfactual 2 and counterfactual 3 tell us that productivity growth alone is insufficient for faster growth of the EMP share in manufacturing. It needs to be complemented by the export-promoting policies. The low income of domestic consumers does not produce enough Engel effects, so foreign demand is essential to provide the necessary push. Once the sector grows and generates enough employment, the wage increases, and so does the demand for manufacturing goods, and multiplier effects stimulate the transformation.

7 Conclusion

In conclusion, the study underscores the critical role of total factor productivity (TFP) in driving structural change and economic growth, particularly in the context of India's manufacturing sector. Despite the liberalization of the economy and increased international trade, the sluggish growth of TFP has hindered the competitiveness of the manufacturing sector, exacerbating its stagnation and impeding the country's structural transformation. The sharp shift of labor away from the agricultural sector shows that the structural transformation is happening, but all are jumping to services, missing the manufacturing in-between. Faster TFP growth in services is causing this services-biased growth to some extent. Furthermore, international trade seems to be giving some compensation to the manufacturing sector. However, enhancing manufacturing productivity alone may not suffice to drive substantial transformation. The direct comparison with China suggests little structural divergence, even if TFP would have grown to the Chinese equivalent.

Drawing insights from the experiences of countries like China and South Korea, implementing export-led policies, such as fostering bilateral and multilateral trade partnerships and enhancing the production of export-oriented goods and varieties, should be emphasized to capitalize on the potential of the manufacturing sector for growth and structural transformation.

Nevertheless, it is essential to acknowledge the limitations of the study. Firstly, the results are based on a static model, which may not capture the dynamic evolution of exogenous processes over time. Additionally, the absence of capital in the model precludes the analysis of capital accumulation dynamics and its implications. Addressing these limitations in future research will provide a more comprehensive understanding of structural change and its drivers in emerging economies like India.

A Equilibrium Conditions

F1	$w_{it}L_{ikt} = \phi_{ik}p_{ikt}Y_{ikt}$	$\forall(i,k,t)$
F2	$p_{int}M_{iknt} = \gamma_{ikn}(1-\phi_{ik})p_{ikt}Y_{ikt}$	$\forall(i,k,n,t)$
F3	$p_{ikt} = \frac{1}{A_{ikt}}\left(\frac{w_{it}^{\phi_{ik}}\left(\prod_{n=a,m,s}\left(\frac{p_{int}}{\gamma_{ikn}}\right)^{\gamma_{ikn}}\right)^{1-\phi_{ik}}}{\phi_{ik}^{\phi_{ik}}(1-\phi_{ik})^{1-\phi_{ik}}}\right) \equiv \frac{v_{ikt}}{A_{ikt}}$	$\forall(i,k,t)$
F4	$Q_{ikt} = \left(\int_0^1 Q_{ikt}(z)^{\frac{\rho-1}{\rho}})dz\right)^{\frac{\rho}{\rho-1}}$	$\forall(i,k,t)$
F5	$p_{ikt} = \xi\Big(\sum_{j=1,2,3}T_{jkt}(v_{jkt}d_{ijkt})^{-\theta}\Big)^{-1/\theta}$	$\forall(i,k,t)$
F6	$\pi_{jikt} = \left(\frac{T_{ikt}(v_{ikt}d_{jikt})^{-\theta}}{\sum_{i=1,2,3}T_{ikt}(v_{ikt}d_{jikt})^{-\theta}}\right)$	$\forall(i,j,k,t)$
F7	$A_{ikt} = T_{ikt}^{1/\theta}\xi^{-1}\pi_{iikt}^{-1/\theta}$	$\forall(i,k,t)$
F8	$\phi_{ik}P_{ikt}Y_{ikt} = \phi_{ik}P_{ikt}^{\frac{1}{\phi_{ik}}}\left((1-\phi_{ik})\prod_{n=\{a,m,s\}}\left(\frac{\gamma_{ikn}}{P_{int}}\right)^{\gamma_{ikn}}\right)^{\frac{1-\phi_{ik}}{\phi_{ik}}}A_{ikt}^{\frac{1}{\phi_{ik}}}L_{ikt}$	$\forall(i,k,t)$
F9	$d_{ijkt} = \mathbf{Max}\left[\left(\frac{\pi_{ijkt}}{\pi_{jjkt}}\right)\left(\frac{p_{ikt}}{p_{jkt}}\right),1\right]$	$\forall(i,j,k,t)$
F10	$p_{ikt}Y_{ikt} = \sum_{j=1,2,3}\Big(p_{jkt}Q_{jkt}\pi_{jikt}\Big) = p_{ikt}Q_{ikt} + NX_{ikt}$	$\forall(i,k,t)$
F11	$l_{ikt} = \phi_{ik}\left(\frac{p_{ikt}Y_{ikt}}{w_{it}L_{it}}\right) = \phi_{ik}\left(\frac{p_{ikt}Q_{ikt}+NX_{ikt}}{w_{it}L_{it}}\right)$	$\forall(i,k,t)$
H1	$\sum_{k=\{a,m,s\}}p_{ikt}c_{ikt} = w_{it}$	$\forall(i,t)$
H2	$C_{ikt} = c_{ikt}L_{it} = \bar{C}_k + \frac{\omega_k}{p_{ikt}^{\sigma}}\left[\frac{w_{it}L_{it}-\sum_{n=\{a,m,s\}}(p_{int}\bar{C}_n)}{\sum_{n=\{a,m,s\}}(\omega_n p_{int}^{1-\sigma})}\right]$	$\forall(i,k,t)$
H3	$\frac{p_{ikt}C_{ikt}}{p_{it}C_{it}} = \frac{p_{ikt}\bar{C_{ikt}}}{p_{it}C_{it}} + \frac{\omega_k p_{ikt}^{1-\sigma}}{p_{it}C_{it}}\left\{\frac{1-\sum_{n=\{a,m,s\}}p_{int}\bar{C_n}}{\sum_{n=\{a,m,s\}}\omega_k p_{ikt}^{1-\sigma}}\right\}$	$\forall(i,k,t)$
M1	$\sum_{k=a,m,s}\left[\phi_{ik}\left(\sum_{j=1,2,3}\left(\pi_{jikt}p_{jkt}Q_{jkt}\right)\right)\right] = w_{it}L_{it}$	$\forall(i,t)$
M2	$Q_{ikt} = C_{ikt} + \sum_{n=a,m,s}\left[(w_{it}-\phi_{in})\gamma_{ink}\sum_{j=1,2,3}\left(\pi_{jint}\frac{p_{jnt}Q_{jnt}}{p_{ikt}}\right)\right]$	$\forall(i,k,t)$

B Derivation of Model Results

B.1 Aggregate Sectoral Prices

The production function for good $z \in [0,1]$ in sector $k \in \{a,m,s\}$ of country i is -

$$Y_{ik}(z) = A_{ik}(z)L_{ik}(z)^{\phi_{ik}}\Big[\prod_{n=a,m,s} M_{ikn}(z)^{\gamma_{ikn}}\Big]^{1-\phi_{ik}}$$

$$p_{ik}(z) = \frac{1}{A_{ik}(z)}\frac{w_i^{\phi_k}\left(\prod_{n=a,m,s}\left(\frac{p_{in}(z)}{\gamma_{kn}}\right)^{\gamma_{kn}}\right)^{1-\phi_k}}{\phi_k^{\phi_k}\left(1-\phi_k\right)^{1-\phi_k}} \equiv \frac{v_{ik}(z)}{A_{ik}(z)}$$

In the open economy context $p_{ik}(z) \equiv d_{ijk}\frac{v_{ik}(z)}{A_{ik}(z)}$. Given that productivity follows Frechet distribution and prices are a function of productivity, the cumulative distribution of prices for a variety z represented by $(G(p(z)))$ is:

$$G_{ijk}(p(z)) = Pr[p_{ijk}(z) \leq p] = 1 - e^{-T_{ik}z_{ik}^{-\theta}} = 1 - e^{-\left[T_{ik}\left\{\frac{(v_{ik}d_{ijk})}{p}\right\}^{-\theta}\right]}$$

Now, one chooses to buy from the cheapest source, so the price of good z in the country i is

$$p_{ik}(z) = min_j\{P_{ijk}(z)\}$$

and that follows the distribution

$$G_{ik}(p) = 1 - \prod_i [1 - G_{ijk}(p(z))] = 1 - e^{-\left[\sum_i T_{ik}\left\{\frac{(v_{ik}d_{ijk})}{p}\right\}^{-\theta}\right]} = 1 - e^{-\Phi_{ik}\frac{1}{p}^{-\theta}}$$

The aggregate quantity and, therefore, prices are CES aggregate as follows

$$Q_{ik} = \left(\int_0^1 Q_{ik}(z)^{\frac{\rho-1}{\rho}})dz\right)^{\frac{\rho}{\rho-1}}; p_{ik} = \left[\int_0^1 (p_{ik}(z))^{1-\rho}\right]^{\frac{1}{1-\rho}}$$

Therefore, Aggregate sectoral prices will be the aggregate expected probability of the lowest prices/largest productivity.

$$p_{ik} = \mathbf{E}\left[\int_0^1 (e^{-\Phi_{ik}z^{-\theta}})^{1-\rho}\right]^{\frac{1}{1-\rho}} = \left\{\Phi_{ik}^{-\frac{1-\rho}{\theta}}\Gamma\Big[1-\frac{\rho-1}{\theta}\Big]\right\}^{\frac{1}{1-\rho}} = \Phi_{ik}^{-\frac{1}{\theta}}\left\{\Gamma\Big[1-\frac{\rho-1}{\theta}\Big]\right\}^{\frac{1}{1-\rho}} = \xi\Phi_{ik}^{-\frac{1}{\theta}}$$

The same result is shown in equation (2b).

B.2 Average Sectoral Productivity

The price in sector k in country i as derives the section above is $p_{ik} = \xi\Phi_{ik}^{-1/\theta}$ In a three-countries framework, the price in the sector k in country 1 can be written as follows:

$$p_{1k} = \xi\Big[T_{1k}(v_{1k}d_{11k})^{-\theta} + T_{2k}(v_{2k}d_{12k})^{-\theta} + T_{3k}(v_{3k}d_{13k})^{-\theta}\Big]^{-1/\theta}$$

$$p_{1k} = \xi T_{1k}^{-1/\theta} v_{1k}\left[\frac{T_{1k}(v_{1k}d_{11k})^{-\theta} + T_{2k}(v_{2k}d_{12k})^{-\theta} + T_{3k}(v_{3k}d_{13k})^{-\theta}}{T_{1k}(v_{1k}d_{11k})^{-\theta}}\right]^{-1/\theta}$$

$$p_{1k} = \xi T_{1k}^{-1/\theta} v_{1k}\left(\frac{1}{\pi_{11k}}\right)^{-1/\theta} \Rightarrow \frac{v_{1k}}{p_{1k}} = A_{1k} = \frac{1}{\xi}T_{1k}^{1/\theta}\pi_{11k}^{-1/\theta}$$

As we defined sectoral level aggregates, the measured sectoral aggregate productivity as represented in equation (2d)

$$A_{ik} = \frac{v_{1k}}{p_{1k}} = \frac{1}{\xi}T_{1k}^{1/\theta}\pi_{11k}^{-1/\theta}$$

Since the domestic absorption is 100% in the closed economy, the sectoral aggregate productivity in the closed economy, also called the fundamental total factor productivity, is

$$\tilde{A}_{ik} = A_{ik}(\pi_{iik} = 1) = \frac{1}{\xi}T_{1k}^{1/\theta}$$

B.3 Sectoral VA and Sectoral Expenditure

From the goods market clearing conditions in equation 4(b), we have

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\sum_{j=1,2,3}\left(\pi_{jin}\frac{p_{jn}Q_{jn}}{p_{ik}}\right)\right]$$

Multiplying both sides by p_{ik}

$$p_{ik}Q_{ik} = p_{ik}C_{ik} + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\sum_{j=1,2,3}\Big(\pi_{jin}p_{jn}Q_{jn}\Big)\right]$$

$$p_{ik}Q_{ik} = p_{ik}C_{ik} + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\Big\{\pi_{iin}p_{in}Q_{in} + \sum_{j\neq i}\Big(\pi_{jin}p_{jn}Q_{jn}\Big\}\Big)\right]$$

$$p_{ik}Q_{ik} = p_{ik}C_{ik} + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\Big\{p_{in}Q_{in}\sum_{j\neq i}(1-\pi_{ijn}) + \sum_{j\neq i}\Big(\pi_{jin}p_{jn}Q_{jn}\Big)\Big\}\right]$$

$$p_{ik}Q_{ik} = p_{ik}C_{ik} + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\Big\{p_{in}Q_{in} + \sum_{j\neq i}\Big(\pi_{jin}p_{jn}Q_{jn} - \pi_{ijn}p_{in}Q_{in}\Big)\Big\}\right]$$

$$p_{ik}Q_{ik} = p_{ik}C_{ik} + \sum_{n=a,m,s}(1-\phi_n)\gamma_{nk}p_{in}Q_{in} + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\underbrace{\sum_{j\neq i}\Big(\pi_{jin}p_{jn}Q_{jn} - \pi_{ijn}p_{in}Q_{in}\Big)}_{\text{Net Exports}}\right]$$

$$p_{ik}Q_{ik} = p_{ik}C_{ik} + \sum_{n=a,m,s}(1-\phi_n)\gamma_{nk}\Big(p_{in}Q_{in} + NX_{in}\Big)$$

From the marginal condition for the labor input, we know that

$$w_iL_{ik} = \phi_{ik}p_{ik}Y_{ik}$$

The output value produced by a country i equals all countries' purchases from country i.

$$p_{ik}Y_{ik} = \sum_{j=1,2,3} p_{jk}Q_{jk}\pi_{jik} = p_{ik}Q_{ik} + \sum_{j\neq i}\Big(\pi_{jik}p_{jk}Q_{jk} - \pi_{ijk}p_{ik}Q_{ik}\Big)$$

$$p_{ik}Y_{ik} = p_{ik}Q_{ik} + NX_{ik}$$

So, combining the above results;

$$\frac{w_iL_{ik}}{\phi_{ik}} = p_{ik}C_{ik} + \sum_{n=a,m,s}(1-\phi_n)\gamma_{nk}\Big(p_{in}Q_{in} + NX_{in}\Big) + NX_{ik}$$

$$\frac{w_iL_{ik}}{\phi_{ik}} = p_{ik}C_{ik} + NX_{ik} + \sum_{n=a,m,s}(1-\phi_n)\gamma_{nk}\Big(\frac{w_iL_{in}}{\phi_n}\Big)$$

$$w_iL_{ik} = \phi_{ik}\Big(p_{ik}C_{ik} + NX_{ik}\Big) + \sum_{n=a,m,s}(1-\phi_n)\gamma_{nk}\Big(\frac{\phi_{ik}}{\phi_n}\Big)w_iL_{in}$$

$$VA_{ik} = \phi_{ik}\Big(E_{ik} + NX_{ik}\Big) + \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\Big(\frac{\phi_{ik}}{\phi_n}\Big)VA_{in}\right]$$

$$E_{ik} = \frac{1}{\phi_{ik}}\left(VA_{ik} - \sum_{n=a,m,s}\left[(1-\phi_n)\gamma_{nk}\Big(\frac{\phi_{ik}}{\phi_n}\Big)VA_{in}\right]\right) - NX_{ik}$$

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