Time-Varying Sectoral Linkages and Structural Change *

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Abstract

This paper documents two novel facts about the evolution of sectoral input-output shares in South Korea over the period 1971–2014. First, the share of intermediate inputs in agricultural production rose steadily, while manufacturing followed a flattened U-shape pattern. Second, input sourcing became more intersectoral, with agriculture increasingly dependent on inputs from other sectors, even as its role as a supplier diminished. To assess the implications of these facts for structural change, we develop a three-sector open-economy model that incorporates time-varying intermediate input use and evolving sectoral linkages. We show that shifts in input shares and sectoral linkages play a significant role in driving South Korea's structural change. Additionally, we show that evolution of the production structure affect how productivity and trade shocks influence structural change, either by offsetting or amplifying the Baumol and Engel effects. These findings highlight the importance of accounting for the dynamics of input-output structure in the analysis of structural change.

KEYWORDS: Structural Change, Sectoral Linkages, Intermediate-Input Use, International Trade, Productivity Schoks.

JEL Classification: E2, C67, F11, O11, O14, O41

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1 Introduction

As economies progress through different stages of development, some sectors become more important as suppliers of intermediate inputs, while others change how much they depend on the inputs they require. As demand rises for goods that serve as intermediate inputs, production in these sectors expands, leading to an increased need for labor. This process drives the reallocation of labor and other resources toward sectors that supply key intermediate inputs, contributing to structural change over time. While the literature on structural change has made substantial progress in explaining the decline of agriculture's share with development, the rise of services, and the hump-shaped pattern of manufacturing, less attention has been paid to how evolving sectoral linkages and time-varying intermediate input use may contribute to these dynamics. This paper addresses this gap by focusing specifically on the case of South Korea.

The literature highlighted four key mechanisms that drive structural change. The first mechanism is the Engel's effect which posits that income elasticities of demand vary among goods, as noted by Comin et al. (2021) and Kongsamut et al. (2001). The second mechanism is the Baumol effect, based on the principle that the elasticity of substitution between goods is less than one, leads to the reallocation of resources from sectors experiencing higher productivity growth to sectors with slower productivity growth, as illustrated by Baumol (1967) and Ngai & Pissarides (2007). The third mechanism, proposed by Matsuyama (2009) and Uy et al. (2013), pertains to the evolution of comparative advantage within an open economy context. Unlike the Baumol effect, this mechanism proposes that a country that becomes more productive in a specific sector, and thereby acquires a comparative advantage, increases the allocation of resources to that sector to meet higher net exports driven by this enhanced comparative advantage.

The fourth mechanism, introduced by Sposi (2019), highlights the role of sectoral linkages in production, which vary across countries. The study finds that developed economies use intermediate goods more intensively in agriculture and rely more on services across all sectors than developing countries. These differences help explain variations in industrialization paths between developed and developing countries. Sposi (2019) focuses on cross-country heterogeneity in input-output structures but do not account for the evolution of these production structures over time. This raises important questions: Do sectoral production structures evolve alongside a country's development path, or is each country bound to a specific production structure over time? If such evolution occurs, how might it contribute to labor reallocation across sectors over time?

In this study, we document the evolution of sectoral production structures in South Korea from 1971 to 2014. Specifically, we analyze the share of each sectoral good used as an intermediate input in the production of other sectoral goods, as well as the overall weight (share) of these intermediate inputs in each sector's production. Our findings highlight two key features. First, there is a notable increase over time in the share of intermediate inputs in agricultural production, while the share of intermediate inputs in manufacturing gross output exhibits a U-shaped pattern. Second, the proportion of intermediate inputs sourced from other sectors is rising in agricultural production, while the share of agricultural inputs used in producing both agricultural and manufacturing goods continues to decline.

These observed patterns underscore the importance of incorporating the dynamic intermediate input shares and sectoral linkages in structural change models. While traditional models typically assume fixed or static input shares and sectoral linkages, we explicitly incorporate in our framework their time-varying nature. This approach enables a more accurate representation of how evolving production structures affect economic transformations over time. As stressed by Van Neuss (2019), changes in the composition of intermediate goods, that is changes in the input-output linkages, have the potential to dramatically influence the sectoral allocation of labor and structural change.

Specifically, we employ a two-country, open-economy model of structural change, as described in Uy et al. (2013), which allows for non-unitary income and substitution elasticities of demand as well as sector-specific productivity growth. This framework captures the coexistence of Engel and Baumol effects. There are three sectors—agriculture, manufacturing, and services—each with a continuum of varieties. These varieties are aggregated into sector-specific composite goods, which serve both as consumption goods for households and as intermediate inputs for firms. Production of varieties in each sector relies on both labor and intermediate inputs. A representative household in each country supplies labor inelastically to domestic firms and consumes composite goods, deriving welfare through non-homothetic preferences. Only agriculture and manufacturing varieties are tradable, with trade costs modeled as iceberg costs. These costs, along with sectoral productivity growth and time-varying intermediate input shares, shape the structural change observed in the economy. The dynamics of sectoral intermediate input shares influence structural change through multiple channels.

First, a change in the weight of intermediate inputs in a sector's production structure directly impacts labor demand. Specifically, an increase in this weight reduces the labor share, making production more reliant on intermediate inputs relative to labor. As a result, firms substitute labor with intermediate inputs, leading to a decline in labor demand. This mechanism helps explain why labor demand in certain industries decreases over time as production becomes more dependent on intermediate inputs. Conversely, if the weight of intermediate inputs in a sector's production decreases, labor demand in this sector will increase as production shifts back toward a more labor-intensive process.

Second, sectoral linkages and intermediate input intensities shape how Engel effects influence labor reallocation. As income rises, final demand shifts away from agriculture toward services, reducing employment in agriculture. However, if agricultural goods are used as inputs in expanding service sectors, the resulting intermediate demand for agriculture can partially offset its decline. The extent of this offset depends on the structure of production, which may evolve over time. For example, when production shifts away from using agricultural goods as inputs with development, both final and intermediate demand for agriculture fall, amplifying the contraction of labor in the agricultural sector.

Third, positive productivity shocks or reductions in trade costs in a given sector lower the relative price of its varieties, increasing its comparative advantages and expanding its trade shares. This leads to higher labor demand, as well as increased demand for its inputs from all sectors. The strength of this effect depends on the input-output structures. In addition, a decline in trade costs or an improvement in productivity lowers the relative price of a sector's output, reducing its expenditure share, and therefore its labor share, through the Baumol effect.

The magnitude of the Baumol effect depends on how marginal costs of production respond to intermediate input shares and sectoral linkages evolution.

In summary, the differing movements in sectoral linkages and intermediate input shares—rising in some sectors while declining in others—generate a complex set of effects on structural change, as outlined above. Therefore, a quantitative analysis is essential to accurately assess the magnitude of these effects. We calibrate the model to South Korea from 1971 to 2014, a period during which the country transitioned through distinct stages of development, from rapid industrialization to a growing service sector. This transformation provides a useful setting to examine how changing sectoral linkages and intermediate input use have shaped structural change over time. The baseline calibration successfully captures nearly the entire evolution of labor shares in South Korea's agriculture and services sectors, as well as the gradual and sustained increase in the manufacturing labor share until it reaches its peak. Our baseline model also captures a partial portion of the decline in South Korea's manufacturing labor share observed after 1990.

To assess the quantitative impact of evolving sectoral linkages and time-varying intermediate input shares, we conduct a series of counterfactual experiments. We begin by holding the share of each sectoral good used as an intermediate input in the production of other sectoral goods constant at their initial values in 1971, effectively neutralizing their evolution over time. The results indicate that changes in sectoral linkages play a significant role in the decline of agricultural employment share in South Korea and the expansion of the services sector. By 2014, this counterfactual scenario results in an increase of 22 percentage points in agricultural employment share and a decrease of 27 percentage points in services employment share compared to the baseline model.

Furthermore, we conduct a similar counterfactual exercise in an alternative model where the weight of intermediate inputs in each sector's production remains fixed at their initial values. The results indicate that holding these shares constant alters the sectoral employment dynamics, leading to 32 percentage points more workers in agriculture and 30 percentage points fewer workers in services by 2014 compared to the baseline simulations. This suggests that the evolution of the intermediate input shares in sectoral production plays a significant role in shaping the trajectory of structural change in South Korea.

These findings indicate that the decline in the use of agricultural goods as intermediate inputs in both manufacturing and agriculture, coupled with the growing reliance on intermediate inputs in agricultural production over time, has driven workers out of agriculture. Meanwhile, the increasing use of services in other sectors has contributed to draw workers into the service sector. Therefore, assuming that sectoral linkages and intermediate input shares remain constant would artificially sustain agriculture's role in the economy and prevent a decline in its employment share and hindering the rise of the service sector.

Moreover, recent literature suggests that productivity shocks and trade cost shocks are two important mechanisms behind South Korea's structural change. Using our framework, we explore how evolving sectoral linkages and intermediate input shares interact with productivity shocks and trade cost shocks to drive structural change. Our analysis reveals that the impact of these shocks on South Korea's structural change is amplified when the intermediate inputs and sectoral linkage coefficients are held constant. Models that assume fixed intermediate input shares effectively absorb changes in input intensity into the measurement of fundamental productivity. For instance, in South Korea's agriculture, the observed rise in intermediate input use over time would, under such assumptions, be misinterpreted as an increase in fundamental productivity. This misattribution may lead to an overestimation of the effects of trade costs and productivity shocks on structural change. Conversely, in sectors where intermediate input use declines, such models may underestimate productivity improvements. As a result, holding intermediate input shares constant can distort the analysis of structural change by conflating input dynamics with fundamental productivity change.

Related Literature. Among the growing literature on structural change, two studies are particularly closely related to this paper: Berlingieri (2014) and Sposi (2019). The first study highlights the role of "professional and business services" as intermediate inputs in explaining the expansion of the service sector in the United States. However, several key differences distinguish our work from theirs. First, while Berlingieri (2014) employs a partial equilibrium framework, we adopt a general equilibrium model that captures economy-wide interactions. Second, their analysis is conducted within a closed economy model, whereas we explicitly incorporate international trade, allowing us to assess the impact of global integration on structural change. This distinction is important, as incorporating trade into our analysis offers a more comprehensive and realistic depiction of sectoral dynamics. By accounting for both domestic and foreign intermediate input flows, our approach avoids the potential biases inherent in closed-economy models, such as overestimating or underestimating the demand for domestic intermediates when global supply chains play a significant role in countries like South Korea.

The second study by Sposi (2019) emphasizes the role of sectoral linkages in explaining cross-country variations in the hump-shaped pattern of manufacturing value-added shares. Building on this work, our study advances the understanding of the role dynamics of sectoral interdependencies over time in shaping structural change, by explicitly incorporating time-varying input–output relationships—an aspect largely absent from earlier general equilibrium models such as Uy et al. (2013) and Sposi (2019). This dynamic approach allows us to better capture the evolution of sectoral linkages and their influence on structural change across different stages of development. Specifically, our framework enables to analyze how the effects of productivity and trade shocks on structural change vary with shifts in sectoral production structures.

Notably, several authors have investigated the factors explaining variations in sectoral linkages. For instance, Van Neuss (2019) argue that technological progress is a primary driver of the evolving input-output structure of an economy, as firms have increasingly specialized in their core competencies and outsourced non-core activities to external suppliers over recent decades. Similarly, Verspagen (2004) note that the significant changes in the input-output structures of advanced economies throughout their development mirror the broader economic history of technological progress. Our paper complements this literature by showing that technological change, which the literature suggests to shape sectoral linkages, does not affect structural change solely through the Baumol effect and advantage comparative. Rather, it influences structural change by affecting sectoral production structures, and therefore labor reallocation.

Our findings also contribute to the broader literature examining the key forces driving structural change, including sectoral productivity growth differentials, nonhomothetic preferences, and international trade. Recent contributions in this area include Ngai & Pissarides (2007), Matsuyama (2009), Duarte & Restuccia (2010), Herrendorf et al. (2014), Moro (2015), Swiecki (2017), Teignier (2018), Kehoe et al. (2018), and Lewis et al. (2021). By incorporating the dynamic evolution of input-output relationships, our framework complements these studies by shedding new light on how changes in the production structure over time affect the reallocation of labor. Furthermore, our approach aligns with the growing literature emphasizing the macroeconomic implications of sectoral interdependencies. Foerster et al. (2011) explore how sectoral comovement and input-output linkages shape business cycle fluctuations, while Barrot & Sauvagnat (2016) highlight how supply chain disruptions propagate through production networks, illustrating the importance of sectoral interdependencies in shaping aggregate economic fluctuations.

More generally, we contribute to the literature on sectoral linkages and their aggregate macroeconomic implications. McMillan & Rodrik (2011) showed that resource reallocation across sectors can either enhance or hinder economic growth, depending on the sectoral composition of the reallocation. Fadinger et al. (2022) examine the role of input-output linkages and sectoral productivity in explaining cross-country income differences. Their findings suggest that highly connected sectors tend to be more productive in poor countries, whereas in rich economies, the opposite holds. Our paper shows how evolving sectoral input-output structures shape ressources reallocation and then aggregate income. For instance, when high-productivity sectors expand their role as input suppliers or become more labor-intensive, they boost employment and income.

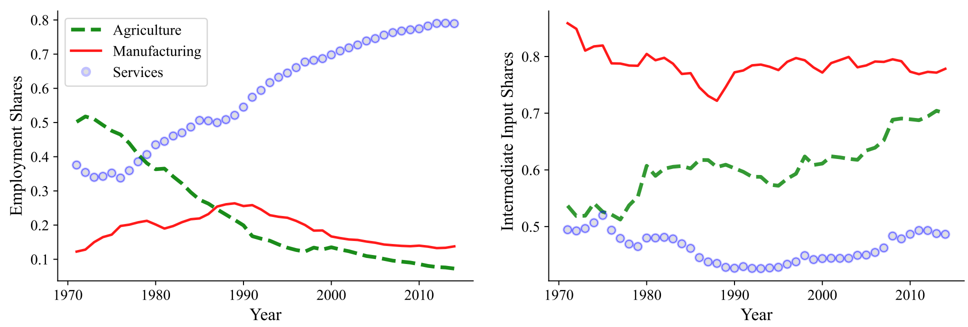
Outline. The remainder of the paper is organized as follows: Section 2 provides detailed insights into the evolution of sectoral input-output structures and their relationship with structural change. Section 3 describes the open-economy model employed to analyze these dynamics. Section 4 details the data and the calibration of the model parameters. Section 5 presents our quantitative analysis, while Section 6 concludes by summarizing the key findings and exploring their potential implications.

2 Time-Varying Input-Output Structure and Structural Change

In this section, we examine intersectoral dependence on intermediate goods and its evolution over time in South Korea between 1971 and 2014. We show that changes over time in intermediate input shares within sectoral gross output correlate with the country's economic transformation. More precisely, as the country progresses through its development process, changes in intermediate input shares consistently trend in the opposite direction to those of labor shares within the economy.

Figure I-**(a)** illustrates[1] the fundamental phenomena that the structural change literature

[1]Refer to Appendix B for detailed information on data sources. Agriculture corresponds to ISIC divisions 1–5 (agriculture, forestry, hunting, and fishing), 10–14 (mining and quarry), 15–16 (food, beverages and tobacco—FBT); Manufacturing corresponds to divisions 17–37 (total manufacturing less FBT); Services corresponds to divisions 40–99 (utilities, construction, wholesale and retail trade, transport, government, financial,



(a) Structural Change in South Korea **(b)** Intermediate Input Shares in Gross Output

FIGURE I: Structural Change in Sectoral Intermediate Input Shares in South Korea

Notes: This figure presents the evolution of sectoral employment shares in the economy and the shares of intermediate inputs in sectoral gross output from 1971 to 2014 in South Korea.

aims to explain: (i) the declining share of agriculture across different levels of development, (ii) the characteristic hump-shaped curve representing the manufacturing sector's share, and (iii) the increasing share of services. Each curve depicts the employment shares of the respective sectors in South Korea from 1971 to 2014.

The degree of structural change varies across countries, with several studies examining the factors that influence the hump-shaped curve of the manufacturing sector's share. Sposi (2019) showed that rich countries use more intermediates in agricultural production, relying primarily on services, whereas poor countries use fewer intermediates and depend more on agricultural inputs like seeds and animal feed. This suggests that structural change may also be shaped by sectoral interconnections through intermediate input use.

Therefore, we compute the contribution of all intermediate inputs in the gross output of each sector over time in South Korea[2]. Our findings indicate that, over time, the services sector consistently exhibits the lowest ratio of input shares in gross output, whereas the manufacturing sector shows the highest ratio, as illustrated in Figure I-(**b**). The manufacturing sector exhibits a decline in intermediate input shares from 1971 to the late 1980s, followed by an increase from the late 1980s onward. This pattern implies a flattened hump-shaped trajectory in the labor contributions to manufacturing gross output, given that labor input in gross output is the complement of intermediate input use. This dynamic is consistent with the broader hump-shaped pattern observed in the manufacturing employment share within the economy, where early industrialization increases the manufacturing labor share, which later decreases as the economy shifts toward services.

The agriculture sector shows a clear upward trend in its intermediate inputs share, reflecting the increasing mechanization and modernization of agricultural production. As South Korea industrialized, agriculture became less labor-intensive and more reliant on inputs. The services sector, while showing a decline in input shares in gross output between 1971 and the 1990s, followed by a slight increase thereafter, consistently exhibits the lowest intermediate input share.

professional, and personal services such as education, health care, and real estate services).

[2]The intermediate input shares are calculated as the ratio of total expenditures on all intermediate inputs to gross output for each sector k. In every sector, the sum of the value-added share and the intermediate input share in gross output equals one. See Appendix B.4 for further details on the calculation.

This suggests that, over time, the contribution of labor and value-added to gross output in the services sector remains higher than in agriculture and manufacturing.

The observed dynamics in input shares are closely tied to the broader pattern of structural change in South Korea. During the early stages of industrialization, labor reallocates from agriculture to manufacturing, a process accompanied by a temporary decline in manufacturing's intermediate input intensity. As economic development progresses, the manufacturing sector becomes increasingly reliant on intermediate inputs, while labor gradually shifts toward services, resulting in deindustrialization. These trends underscore the deep interconnections between evolving sectoral input structures and the trajectory of structural change.

Furthermore, Table I reports statistics on intersectoral dependencies in South Korea from 1971 to 2014, presenting the minimum, average, and maximum values of the share of expenditures[3] on sector n as an intermediate input in the total intermediate input expenses for the production of sector k goods. These linkages exhibit dynamic patterns.

TABLE I: Statistics on Sectoral Production Structure in South Korea (1971-2014)

		Output sector k								
		Agriculture			Manufacturing			Services		
	Input sector n	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Sectoral linkages	Agriculture	0.70	0.62	0.85	0.11	0.04	0.20	0.05	0.03	0.08
	Manufacturing	0.13	0.06	0.16	0.70	0.62	0.75	0.37	0.29	0.45
	Services	0.17	0.09	0.22	0.20	0.17	0.22	0.58	0.51	0.66
Intermediate input		0.61	0.51	0.70	0.79	0.72	0.86	0.46	0.43	0.52

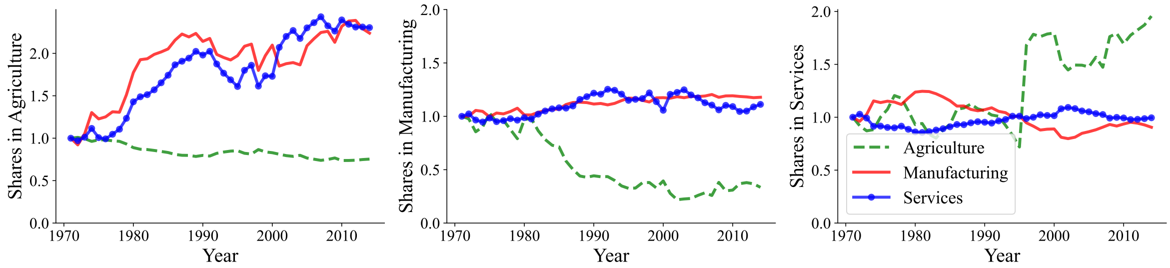
Notes: This table summarizes the sectoral intermediate input shares and sectoral linkage coefficients in South Korea from 1971-2014.

Figure II visually illustrates these dynamics, showing a decline in the contribution of agricultural inputs to production in both the manufacturing and agriculture sectors. At the same time, the shares of manufacturing and services inputs in agricultural production increase over time. Only the services sector shows a slight increase in its use of agricultural inputs beginning in the late 1990s, but even in this case, the overall contribution remains negligible, with a peak share of only[4] 8%. These trends underscore the declining role of agriculture as a supplier of inputs within the broader production structure.

In summary, shifts in sectoral linkages play a central role in shaping structural change, as they modify the relative importance of input-supplying sectors and influence the distribution of value-added and employment across the economy. When a key intermediate input produced by one sector is extensively used by others, changes in its demand or supply can have substantial effects on employment patterns. An increase in demand for such an input may stimulate production and job creation in the supplying sector, while a reduction in availability or a rise in input

[3] To calculate sectoral linkage coefficients we use data sourced from the World Input-Output Database (WIOD), as documented in Timmer et al. (2015). The WIOD dataset encompasses information from 41 countries and 34 economic activities (See more details on data in Appendix B).

[4] Even though an increase in the use of agricultural inputs by the services sector can be observed from the late 1990s, the data show irregularities and do not indicate a sustained upward trend over time.



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE II: Changes in Sectoral Linkage Coefficients in South Korea

Notes: This figure shows the sectoral composition of intermediate input sources used in the production of agricultural goods (Panel a), manufacturing goods (Panel b), and services (Panel c). All series are normalized to 1 in the base year, 1971.

costs can constrain production in downstream sectors, potentially leading to job losses or a shift toward alternative inputs. If substitutes are sourced from different sectors, this reallocation may boost employment in those sectors instead. These interdependencies underscore the important role of sectoral linkages in shaping the path of structural change over time.

The following Section 3 develops an open-economy model to explore how variations in input-use intensities across different sectors contribute to changes in the shares of labor across sectors over time.

3 Model

We consider a two-country, three-sector Eaton-Kortum trade model, as in Uy et al. (2013). This model integrates non-unitary income and substitution elasticities of demand, as well as sector-specific productivity growth. There are three sectors: agriculture, manufacturing, and services indexed by $k = a,\ m,\ s$. In each sector, there is a continuum of varieties, and production relies on both labor and intermediate inputs. Only varieties in agriculture and manufacturing are tradable, with trade costs varying across sectors, country pairs, and over time. To maintain simplicity, trade is assumed to be balanced in each period, and thus, the time subscript is omitted unless explicitly required.

3.1 Technologies

There is a continuum of varieties indexed by $z \in [0, 1]$ in each sector $k \in \{a, m, s\}$. Each country has technologies for producing all varieties in all sectors. The production function for a variety $z \in [0, 1]$ in sector k of country i is:

$$Y_{ik}(z) = A_{ik}(z) L_{ik}(z)^{1-\lambda_{ik}} \left[\prod_{n=a,m,s} M_{ikn}^{\gamma_{ikn}}(z) \right]^{\lambda_{ik}}, \tag{3.1}$$

where $Y_{ik}(z)$ denotes the output, $A_{ik}(z)$ denotes the exogenous productivity of variety z, $L_{ik}(z)$ denotes labor, and $M_{ikn}(z)$ denotes the sector n composite goods used as intermediates in the production of the sector k good. We allowr sectoral input-output structure parameters

λ_{ik} and γ_{ikn} to vary over time. The parameter λ_{ik} denotes the intermediate input shares in sector k production, and γ_{ikn} denotes the share of intermediate inputs sourced from sector n within country i. $A_{ik}(z)$ is the realization of a random variable Z_{ik} drawn from the cumulative distribution function $F_{ik}(x) = \Pr[Z_{ik} \leq x]$. Following Eaton & Kortum (2002), we assume that $F_{ik}(x)$ follows a Fréchet distribution: $F_{ik}(x) = e^{-T_{ik}x^{-\theta}}$, where $T_{ik} > 0$ and $\theta > 1$. The aggregate productivity in sector k of country i, $A_{ik} := \mathbb{E}[A_{ik}(z)]$, is defined as:

$$A_{ik} = T_{ik}^{1/\theta} \cdot \Gamma\left(1 - \frac{1}{\theta}\right), \tag{3.2}$$

where $\Gamma(\cdot)$ is the Gamma function, defined as: $\Gamma(x) = \int_0^\infty t^{x-1}e^{-t}dt$. Equation (3.2) shows that the average productivity A_{ik} increases with the technology parameter T_{ik}, and depends on the shape parameter θ, which governs the dispersion of productivity draws.

Goods markets are perfectly competitive. Prices are determined by marginal costs of production. The cost v_{ik} of an input bundle of all variety z in sector k is:

$$v_{ik} = \Upsilon_{ik} w_i^{1-\lambda_{ik}} \left[\prod_{n=a,m,s} P_{in}^{\gamma_{ikn}}\right]^{\lambda_{ik}}, \tag{3.3}$$

where $\Upsilon_{ik} = (1-\lambda_{ik})^{\lambda_{ik}-1}\left[\lambda_{ik}\gamma_{ika}^{-\gamma_{ika}}\gamma_{ikm}^{-\gamma_{ikm}}\gamma_{iks}^{-\gamma_{iks}}\right]^{-\lambda_{ik}}$, and w_i and P_{in} denote the wage rate and the price of the sector n composite good in country i, respectively.

The marginal cost v_{ik} is influenced by three key components: the wage rate w_i, the prices of intermediate inputs P_{in}, and the structure of production captured by the input cost share λ_{ik} and the input composition parameters γ_{ikn}. A higher reliance on intermediates (larger λ_{ik}) or on more expensive inputs (higher P_{in}) raises marginal cost. The term Υ_{ik} captures the constant returns to scale adjustment implied by the Cobb-Douglas production function and depends on the input-output parameters.

Next, we aggregate individual varieties to define the total factor usage in sector k.

$$L_{ik} = \int L_{ik}(z)dz\ ; \quad M_{ikn} = \int M_{ikn}(z)dz\ ; \quad Y_{ik} = \int Y_{ik}(z)dz.$$

The term L_{ik} represents the total quantity of labor used in sector k in country i. The variable M_{ikn} denotes the quantity of the composite good from sector n used as an intermediate input in the production of a variety in sector k in country i. Finally, Y_{ik} corresponds to the quantity of sector k output produced by country i.

3.2 Composite Goods

The sectoral composite good, Q_{ik}, is an aggregate of the individual varieties goods $Q_{ik}(z)$:

$$Q_{ik} = \left(\int_0^1 Q_{ik}(z)^{(\eta-1)/\eta}dz\right)^{\eta/(\eta-1)}, \tag{3.4}$$

where the elasticity of substitution between any varieties, denoted by η, is constant across countries, sectors, and over time. The variable $Q_{ik}(z)$ represents the demand for intermediate goods z from the lowest-cost supplier. In the services sector, each good z is produced locally, whereas in the tradable sectors, each good z may be either domestically produced or imported. The solution to the problem of the composite intermediate good producer yields the following demand function:

$$Q_{ik}(z) = \left(\frac{p_{ik}(z)}{P_{ik}}\right)^{-\eta} Q_{ik}, \tag{3.5}$$

where P_{ik} represents the price of the sector k composite good in country i, and $p_{ik}(z)$ denotes the minimum price of variety good z across all locations. Thus, the expression for P_{ik} is obtained as follows:[5]

$$P_{ik} = \left[\int_0^1 p_{ik}(z)^{1-\eta} dz\right]^{\frac{1}{1-\eta}}. \tag{3.6}$$

The composite sectoral goods serve two purposes: they are used in domestic final consumption, C_{ik}, and in domestic production as intermediate inputs. This results in the following equilibrium equation for each composite good market:

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s} M_{ink}, \tag{3.7}$$

where M_{ink} represents the quantity of sector k composite goods used in the production of variety goods in sector n. Equation (3.7) represents the equilibrium in the market for composite goods, balancing the total quantity demanded, Q_{ik}, with domestic consumption, C_{ik}, and the aggregate intermediate inputs, M_{ink}, of sectors k goods used in the production of variety goods in sector n. This equilibrium condition is essential for analyzing the interplay between domestic consumption, production, and sectoral linkages.

3.3 Trade Costs and Prices

In our model, international trade involves the exchange of varieties of agriculture and manufacturing goods, which incurs trade costs, encompassing tariffs, transportation costs, and other barriers to trade. To represent these costs, we adopt an iceberg cost formulation. Specifically, when one unit of good z in sector k is shipped from country j, only $1/\tau_{ijk}$ units arrive in the country i, where τ_{ijk} represents the trade cost for this specific trade flow, with $\tau_{ijk} \geq 1$. It is worth noting that we assume trade costs within a country to be zero, indicating that goods can move freely within a country's borders. This assumption is denoted as $\tau_{iia} = \tau_{iim} = 1$, meaning that there are no trade barriers between different regions within the same country for both agriculture and manufacturing goods. This simplifying assumption allows us to focus on the complexities and dynamics of international trade and its impact on the economy without considering intra-country trade costs.

The price at which country j can supply variety z in sector k to country i equals:

$$p_{ijk}(z) = \tau_{ijk} \frac{v_{jk}}{A_{ik}(z)}.$$

Since buyers will naturally choose to purchase from the cheapest source, the price of variety

[5] Refer to Appendix A for the derivation of the composite good price expression.

good z in country i is given by:

$$p_{ik}(z) = \min_j \left\{ \frac{\tau_{ijk} v_{jk}}{A_{ik}(z)} \right\}. \tag{3.8}$$

We model the services sector, which is considered non-tradable, using a similar approach to that of tradable sectors. However, we impose that $\tau_{ijs} = \infty$, indicating that there is an infinite trade cost for any trade flow involving the services sector. This assumption implies that services cannot be traded across borders and are solely produced and consumed locally within each country. Thus :

$$p_{is}(z) = \frac{v_{is}}{A_{is}(z)}. \tag{3.9}$$

The demand for intermediate goods in the services sector is given by:

$$Q_{is}(z) = Y_{is}(z).$$

Under the Fréchet distribution of productivities, Eaton & Kortum (2002) demonstrate that the price of the tradable composite good $k \in \{a, m\}$ in country i is:

$$P_{ik} = \gamma \left[\sum_{j=1}^{2} T_{jk} \left(v_{jk} \tau_{ijk} \right)^{-\theta} \right]^{-\frac{1}{\theta}}, \tag{3.10}$$

and the price of the services composite good is:

$$P_{is} = \gamma v_{is} T_{is}^{-\frac{1}{\theta}}, \tag{3.11}$$

where $\gamma := \left[\Gamma \left(1 + \frac{1-\eta}{\theta} \right) \right]^{\frac{1}{1-\eta}}$ is a constant that is irrelevant for cross-country and cross-sector comparisons. The share of country j's expenditure on sector k goods from country i, denoted as π_{jik}, equals the probability of importing sector k goods from country i in country j, and is given by:

$$\pi_{jik} = \frac{T_{ik} \left(v_{ik} \tau_{jik} \right)^{-\theta}}{\sum_{l} T_{lk} \left(v_{lk} \tau_{jlk} \right)^{-\theta}}. \tag{3.12}$$

This last equation demonstrates how higher productivity, a lower unit cost of input bundles, and lower trade costs within country i contribute to a higher import share by country j. These factors effectively make imports from country i more attractive to country j, leading to a greater proportion of sector-k goods being imported from country i into country j.

3.4 Household

The period utility of the representative household in country i is expressed as:

$$U(C_{ia}, C_{im}, C_{is}) = \left[\omega_a^{\frac{1}{\sigma}} (C_{ia} - \overline{C}_a)^{\frac{\sigma-1}{\sigma}} + \omega_m^{\frac{1}{\sigma}} (C_{im} - \overline{C}_m)^{\frac{\sigma-1}{\sigma}} + \omega_s^{\frac{1}{\sigma}} (C_{is} - \overline{C}_s)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{3.13}$$

where, for each sector $k \in \{a, m, s\}$, C_{ik} represents the consumption of sector k composite goods, and $\overline{C}_k$ is constant over time and refers to the subsistence requirement for sector-k composite goods. A positive value of $\overline{C}_k$ generates an income elasticity of demand for sector k goods less than one. The preference parameters ω_k's are positive and sum to one. The elasticity of substitution across sectoral composite goods is denoted by $\sigma > 0$. If $\sigma > 1$, the sectoral composite goods are substitutes, whereas if $\sigma \leq 1$, the sectoral composite goods are complements. The representative household maximizes their utility (3.13) subject to the following budget constraint in each period:

$$P_{ia}C_{ia} + P_{im}C_{im} + P_{is}C_{is} = w_i L_i, \tag{3.14}$$

where L_i denotes total labor endowment in country i. The household supplies its unit labor endowment inelastically and spends all labor income. These budget constraints ensure that balanced trade holds period-by-period. The first-order conditions imply that sectoral consumption demand satisfies the equation (3.15) below:

$$C_{ik} - \overline{C}_k = \frac{\omega_k}{\omega_l} \left(\frac{P_{ik}}{P_{il}} \right)^{-\sigma} (C_{il} - \overline{C}_l) \quad \forall k, l \in \{a, m, s\}. \tag{3.15}$$

3.5 Equilibrium

Definition. A competitive equilibrium in this framework is a sequence of sectoral goods and factor prices $\{P_{ia},\ P_{im},\ P_{is},\ w_i\}_{i=1;2}$, allocations $\{L_{ia},\ L_{im},\ L_{is},\ Q_{ia},\ Q_{im},\ Q_{is},\ C_{ia},\ C_{im},\ C_{is}\}_{i=1;2}$, and sectoral trade shares $\{\pi_{ija},\quad \pi_{ijm}\}_{i=1;2}$, such that, given prices, the allocations solve the firms' maximization problems associated with the technologies specified in Equation (3.1), as well as the household's maximization problem characterized by Equations (3.14) and (3.15), and satisfy the market-clearing conditions in Equations (3.16) and (3.17).

Market Clearing Conditions. The factor market clearing conditions for labor and sectoral composite goods in each period are as follows:

$$L_i = L_{ia} + L_{im} + L_{is} \tag{3.16}$$

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s} M_{ink}. \tag{3.17}$$

After some manipulation[6], Equation (3.17) can be written as follows:

$$Q_{ik} = C_{ik} + \sum_{n=a,m} \gamma_{ink} \lambda_{in} \sum_{j=1}^{2} \frac{P_{jn} Q_{jn} \pi_{jin}}{P_{ik}} + \gamma_{isk} \lambda_{is} \frac{P_{is} Q_{is}}{P_{ik}}. \tag{3.18}$$

Table II provides a set of equations that characterize the equilibrium of the economy.

[6] See Appendix A for the proof.

TABLE II: Equilibrium Conditions

$D1:$	$C_{ik} - \overline{C}_k = \dfrac{\omega_k}{\omega_m} \left(\dfrac{P_{ik}}{P_{im}}\right)^{-\sigma} \left(C_{im} - \overline{C}_m\right)$	$\forall i \in \{1,2\}$, $\forall k \in \{a,s\}$
$D2:$	$P_{ia}C_{ia} + P_{im}C_{im} + P_{is}C_{is} = w_i L_i$	$\forall i \in \{1,2\}$
$S1:$	$P_{ik} = \gamma \left[\sum_{j=1}^{2} T_{jk} \left(v_{jk}\tau_{ijk}\right)^{-\theta}\right]^{-\frac{1}{\theta}}$	$\forall i \in \{1,2\}$, $\forall k \in \{a,m,s\}$
$S2:$	$v_{ik} = \Upsilon_{ik} w_i^{1-\lambda_{ik}} \left[\prod_{n=a,m,s} P_{in}^{\gamma_{ikn}}\right]^{\lambda_{ik}}$	$\forall i \in \{1,2\}$, $\forall k \in \{a,m,s\}$
$S3:$	$\pi_{ijk} = \dfrac{T_{jk}\left(v_{jk}\tau_{ijk}\right)^{-\theta}}{\sum_{n=1}^{2} T_{nk}\left(v_{nk}\tau_{ink}\right)^{-\theta}}$	$\forall i,j \in \{1,2\}$, $\forall k \in \{a,m\}$
$S4$:	$L_{ik}w_i = (1-\lambda_{ik})\left(P_{1k}Q_{1k}\pi_{1ik} + P_{2k}Q_{2k}\pi_{2ik}\right)$	$\forall i \in \{1,2\}$, $\forall k \in \{a,m\}$
$M1:$	$L_i = L_{ia} + L_{im} + L_{is}$	$\forall i \in \{1,2\}$
$M2:$	$Q_{ik} = C_{ik} + \sum_{n=a,m} \gamma_{ink}\lambda_{in} \sum_{j=1}^{2} \dfrac{P_{jn}Q_{jn}\pi_{jin}}{P_{ik}} + \gamma_{isk}\lambda_{is}\dfrac{P_{is}Q_{is}}{P_{ik}}$	$\forall i \in \{1,2\}$, $\forall k \in \{a,m,s\}$

We now turn to the theoretical mechanisms through which sectoral intermediate input shares (λ_{ik}) and sectoral linkage coefficients (γ_{ikn}) influence the allocation of labor across sectors within a general equilibrium framework.

3.6 Input Share Dynamics and Labor Reallocation

We aim to explain how changes in intermediate input shares and sectoral linkages affect the equilibrium shares of labor across sectors, L_{ik}/L_i. To do this, we derive and analyze the expression for the labor share, examining its main determinants.

We begin with the expression for the equilibrium labor share derived from condition $S4$:

$$\frac{L_{ik}}{L_i} = (1-\lambda_{ik})\left(\frac{P_{1k}Q_{1k}}{w_1L_1}\pi_{1ik} + \frac{P_{2k}Q_{2k}}{w_2L_2}\frac{w_2L_2}{w_1L_1}\pi_{2ik}\right), \tag{3.19}$$

where $P_{ik}Q_{ik}$ denotes sectoral value of output generated by sector k in country i. Equation (3.19) shows that the intermediate input share λ_{ik} and the input composition vector γ_{ikn} influence equilibrium labor allocation both directly, through the technological term $1-\lambda_{ik}$, and indirectly through trade effects, captured by the terms π_{jik}, $j = 1,2$, and sectoral intermediate demand, captured by $P_{ik}Q_{ik}/w_iL_i$, $i = 1,2$.

Direct technological effect. The first mechanism is a direct technological effect. The factor $(1-\lambda_{ik})$ scales labor demand in proportion to the value-added share. As λ_{ik} rises, the sector becomes more input-intensive and less reliant on labor, directly reducing L_{ik}/L_i.

Trade effects. Recall that the trade share π_{jik} is given by:

$$\pi_{jik} = \frac{\left(v_{ik}\frac{\tau_{ijk}}{A_{ik}}\right)^{-\theta}}{\left(v_{1k}\frac{\tau_{i1k}}{A_{1k}}\right)^{-\theta} + \left(v_{2k}\frac{\tau_{i2k}}{A_{2k}}\right)^{-\theta}}. \tag{3.20}$$

This expression shows that π_{jik} depends on relative costs, where lower marginal cost v_{ik}, lower trade cost τ_{ijk}, or higher productivity A_{ik} increases the share of imports sourced from country j. The unit cost v_{ik} is in turn determined by:

$$v_{ik} = (1-\lambda_{ik})^{\lambda_{ik}-1}\lambda_{ik}^{-\lambda_{ik}} w_i^{1-\lambda_{ik}} \left[\prod_{n=a,m,s} (\gamma_{ikn} P_{in})^{\gamma_{ikn}}\right]^{\lambda_{ik}}. \tag{3.21}$$

Equation (3.21) shows how the cost of producing one unit of variety depends on the wage (scaled by the value-added share), the price of intermediate inputs, and the composition of those inputs. Although λ_{ik} and γ_{ikn} do not directly change prices P_{in}, $\forall n \in \{a, m, s\}$, they influence marginal costs, v_{ik}. The exponent λ_{ik} modifies the influence of input prices. As λ_{ik} increases, the sensitivity of costs to upstream prices changes. At given input prices, changes in γ_{ikn} reweight the bundle of inputs used in production, affecting the structure of comparative advantages. The factor $(1-\lambda_{ik})^{\lambda_{ik}-1}\lambda_{ik}^{-\lambda_{ik}}$ is a concave function that increases when $\lambda_{ik} < 0.5$, peaking at $\lambda_{ik} = 0.5$ and decreases thereafter[7].

Sectoral intermediate demand. Sector value of output is given by $P_{ik}Q_{ik}$, which includes both final demand and intermediate demand. Using Equation $M2$, we can see that:

$$P_{ik}Q_{ik} = P_{ik}C_{ik} + \sum_{n=a,m} \gamma_{ink}\lambda_{in} \sum_{j=1}^{2} P_{jn}Q_{jn}\pi_{jin} + \gamma_{isk}\lambda_{is}P_{is}Q_{is}. \tag{3.22}$$

We compute the ratio $P_{ik}Q_{ik}/w_iL_i$, which reflects how much output the sector generates relative to total labor income. This term is affected by consumption preferences and income levels, through the expenditure share[8] $s_{ik} \equiv P_{ik}C_{ik}/w_iL_i$:

$$\frac{P_{ik}Q_{ik}}{w_iL_i} = s_{ik} + \sum_{n=a,m} \gamma_{ink}\lambda_{in} \left(\frac{P_{1n}Q_{1n}}{w_iL_i}\pi_{1in} + \frac{P_{2n}Q_{2n}}{w_iL_i}\pi_{2in}\right) + \gamma_{isk}\lambda_{is}\frac{P_{is}Q_{is}}{w_iL_i}. \tag{3.23}$$

Here, input-output linkages play a key role. A higher γ_{ink} increases the use of sector k's good in producing good n, thereby raising sector k's demand and therefore output and labor in sector k. Likewise, a higher λ_{in} in downstream sectors amplifies the role of intermediates in sector n and thus increases the intermediate input sourced from sector k, further boosting output in sector k.

[7]In the data for South Korea, λ_{1a} and λ_{1m} are greater than 0.5, while λ_{1s} is below 0.5. This implies that variations in intermediate input use do not have a uniform effect—either increasing or decreasing—on the cost component given by the term $(1-\lambda_{ik})^{\lambda_{ik}-1}\lambda_{ik}^{-\lambda_{ik}}$.

[8]The consumtion expenditure of households on good k relative to their income is given by: $s_{ik} = P_{ik}\overline{C}_k/w_iL_i + \omega_k P_{ik}^{1-\sigma}(1 - P_{ik}\overline{C}_k/w_iL_i)/(\omega_a P_{ia}^{1-\sigma} + \omega_m P_{im}^{1-\sigma} + \omega_s P_{is}^{1-\sigma})$.

To summarize, the labor share in a sector depends not just on how labor-intensive it is, but also on how input costs, and demand conditions evolve over time. Increases in λ_{ik} reduce direct labor requirements but may also raise production costs depending on the prices of upstream inputs. The composition vector γ_{ikn} matters because it determines which sectors a given industry relies on for inputs, and thus, how exposed it is to upstream cost pressures.

In addition to their role in shaping intermediate demand, sectoral linkages and intermediate input intensities also influence how Engel effect shapes labor reallocation. As incomes rise, households tend to allocate a smaller share of their spending to agricultural goods and a larger share to services. This shift reduces the final consumption share for agriculture, s_{ia}, and increases it for services, s_{is}, thereby changing sectoral output $P_{ik}Q_{ik}$ for $k \in \{a, m, s\}$, as described in Equation (3.23), and affecting labor shares through the mechanism detailed in Equation (3.19).

However, the total demand for a given good, such as agriculture, is not determined solely by its final consumption. If agricultural products are also used as intermediate inputs in other sectors, particularly in services, a rise in service output driven by Engel effect can indirectly raise the demand for agricultural inputs. In this case, the reduction in final demand for agriculture may be partially offset by an increase in its intermediate demand by services. The strength of this offset depends on the input-output parameters, γ_{isa} and λ_{is}, which determine how much agriculture is used in the production of services and the overall intensity of intermediate input use in services, respectively.

Moreover, if development is accompanied by a restructuring of production—for example, if the service sector reduces its reliance on agricultural inputs ($\gamma_{isa} \downarrow$) or shifts toward lower intermediate input use overall ($\lambda_{is} \downarrow$)—then the mitigating effect of agricultural variety demand on its labor weakens or disappears. In this case, both final and intermediate demand for agricultural goods decline, leading to a sharper fall in agricultural output and, consequently, a greater reduction in the agricultural labor share. Thus, the net impact of Engel effects on labor reallocation is shaped not only by the non-homotheticity of preferences but also by the evolving structure of production.

Additionally, productivity and trade shocks, captured by A_{ik} and τ_{ijk}, interact meaningfully with sectoral linkages and intermediate input shares. An increase in A_{ik} or a decrease in τ_{ijk} raises sectoral efficiency, thereby lowering the price of sector k's output according to:

$$P_{ik} = \Psi \left[\left(v_{1k} \frac{\tau_{i1k}}{A_{1k}} \right)^{-\theta} + \left(v_{2k} \frac{\tau_{i2k}}{A_{2k}} \right)^{-\theta} \right]^{-\frac{1}{\theta}}, \tag{3.24}$$

where $\Psi := \gamma \times \Gamma\left(1 - \frac{1}{\theta}\right)$ is a constant. To assess how the effects of productivity and trade shocks on structural change are shaped by changes in input shares, we recall the expression for the sectoral expenditure share s_{ik} of sector k:

$$s_{ik} = \left[\frac{\omega_a}{\omega_k} \left(\frac{P_{ia}}{P_{ik}} \right)^{1-\sigma} + \frac{\omega_m}{\omega_k} \left(\frac{P_{im}}{P_{ik}} \right)^{1-\sigma} + \frac{\omega_s}{\omega_k} \left(\frac{P_{is}}{P_{ik}} \right)^{1-\sigma} \right]^{-1} \left(\frac{1 - P_{ik}\overline{C}_k}{w_i L_i} \right) + \frac{P_{ik}\overline{C}_k}{w_i L_i}. \tag{3.25}$$

Sectoral linkages and intermediate input shares influence how productivity and trade shocks drive structural change through two distinct channels: relative prices of final goods and comparative advantage.

First, consider a productivity shock or a reduction in trade costs in sector k. This lowers the relative price of sector k compared to others, reducing the expenditure share s_{ik}, and thereby employment share in sector k. This is the traditional channel associated with the Baumol effect. However, when such a shock coincides with changes in the input-output coefficients λ_{ik} and γ_{ikn}, the overall impact on relative prices is no longer determined by the shock alone. It also depends on how these coefficients affect marginal costs v_{ik}, thereby affecting the transmission of productivity and trade shocks to sectoral labor shares, as shown in Equation (3.24).

Second, a positive productivity or trade shock lowers the price of sector k's varieties, increasing its comparative advantages and expanding its trade shares. This leads to higher labor demand in sector k, as well as increased demand for its inputs from all sectors to satisfy rising variety demand. The magnitude of the effect on labor depends on λ_{ik}, while the extent of the increase in intermediate inputs sourced from sector n depends on the product $\lambda_{ik}\gamma_{ikn}$. Thus, variations in production structure influence how productivity and trade shocks propagate through the economy and shape labor reallocation across sectors through this intermediate demand.

These results highlight the importance of time-varying sectoral linkages and intermediate input shares in shaping the process of structural change. Variations in the intensity and composition of intermediate input use across sectors affect both production costs and the structure of comparative advantages. Because these forces may operate in opposing directions, the effect on labor shares is theoretically ambiguous in some cases and must therefore be assessed empirically. We now turn to the calibration exercise to quantify how sectoral linkages and intermediate input use shape labor reallocation in South Korea.

4 Data and Calibration

In this section, we calibrate the model to the South Korean economy and the rest of the world over the period 1971–2014, as South Korea presents a compelling case for studying structural change. Over the past decades, South Korea has progressed through different stages of development, undergoing rapid industrialization followed by a significant shift toward services. This evolution allows us to observe the dynamics of sectoral linkages and the changing contributions of intermediate inputs to gross output at various stages of development. Additionally, South Korea's economic trajectory—characterized by extensive technology adoption, evolving production structures, and deep integration into global trade—provides a rich empirical setting to examine the mechanisms driving structural change. Specifically, we begin by outlining the primary data sources in the first subsection and subsequently describe the calibration procedures, along with the remaining data sources, in the following subsections.

4.1 Data and Sources

The dataset under consideration encompasses 26 countries spanning a diverse array of regions, including Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Germany, Greece, Iran, Iraq, Ireland, Italy, Japan, South Korea, Kuwait, Luxembourg, Mexico, the Netherlands, Portugal, Saudi Arabia, Sweden, the United Kingdom, the United States, and Venezuela. Notably, all countries, with the exception of South Korea, collectively constitute the rest of the world (ROW). The dataset spans the extensive timeframe from 1971 to 2014, providing a longitudinal perspective on economic trends and developments.

Sectoral employment and value-added data are sourced from two primary databases: the EU KLEMS database and the World Input-Output Database (WIOD). The GGDC 10-Sector Database is used to supplement data for certain countries.[9] Trade flow data is sourced from COMTRADE, offering insights into bilateral trade flows by commodity in U.S. dollars. Furthermore, production parameters are calibrated using input-output tables provided by the WIOD.

4.2 Calibration

In this section, we describe our calibration strategy. We begin by discussing the calibration of the time-invariant parameters, followed by the calibration of the model's time-varying components. These include preference and trade parameters, sectoral intermediate input (II) shares, sectoral linkage (SL) coefficients, sectoral fundamental productivities, and sectoral bilateral trade costs. In addition, we incorporate country-specific labor endowments, which are directly obtained from the data as the total number of persons engaged in each sector.

Time Invariant Parameters. Time-invariant parameters include the elasticity of substitution between varieties η, the trade elasticity θ, and the preference parameters $\{\sigma, \omega_a, \omega_m, \omega_s, \bar{C}_a, \bar{C}_s\}$. These parameters are identical for both South Korea and the Rest of the World. Given that our sample covers the same countries and time period as Uy et al. (2013), we directly adopt the preference parameters estimated in their study. As reported in Table III, we also follow Uy et al. (2013) in setting[10] η to 4. For trade elasticity, we rely on Simonovska & Waugh (2014), who estimates the trade elasticity for manufacturing to be 4. We apply this estimate uniformly across all sectors.[11]

Input-Output Shares. The intermediate input share in production, λ_{ik}, for sector k in country i is computed as the ratio of intermediate input expenditure to nominal gross output for each sector. Our findings indicate that, over time, the services sector in South Korea consistently exhibits the lowest intermediate input share, while the manufacturing sector has the highest ratio, as illustrated in Figure I-**(b)**. This pattern aligns with the structural change dynamics and the varying intermediate input intensities across sectors. The services sector, being more labor-intensive and less reliant on intermediate goods, naturally maintains a lower intermediate input expenditure relative to gross output. In contrast, manufacturing requires a significant volume of intermediate inputs due to its more complex production processes, leading to a higher input share.

Moreover, while the intermediate input share in services has remained relatively stable, the agricultural sector has shown a substantial increase in its intermediate input share, reaching

[9] Refer to Appendix B for further details on each country.

[10] The parameter η plays no quantitative role other than satisfying a technical condition: $1 + \frac{1}{\theta}(1-\eta) > 0$.

[11] Sposi (2019) estimated sector-specific trade elasticities and demonstrated the robustness of this result.

nearly half the level of the services sector by 2014. In the early 1970s, agriculture and services had comparable intermediate input shares. However, over time, agriculture has become increasingly dependent on intermediate inputs such as machinery, chemicals, and other goods produced by other sectors. This shift underscores the growing role of technology and modern inputs in agricultural production.

Since sectoral linkages vary systematically across countries, as discussed in Sposi (2019), we construct the sectoral linkage time series, γ_{ikn}, for South Korea and the Rest of the World (ROW) using input-output tables. First, we aggregate the detailed data into our three broad sectors based on the ISIC Rev. 3.1 classification. We then compute γ_{ikn} as the ratio of intermediate inputs sourced from sector n into sector k to the total intermediate inputs used in sector k at time t. The significance of changes in intersectoral dependencies over time in South Korea is depicted in Figure II and detailed in Table I.

Sectoral Productivities. We calibrate the series of sectoral fundamental productivities, A_{ik}, using a two-step approach. The first step focuses on the initial year, 1971. We jointly calibrate initial productivity and trade cost levels so that the model matches South Korea's and the rest of the world's (ROW) sectoral labor shares and South Korea's export and import shares with the ROW in manufacturing and agriculture in 1971. Since two sectoral labor shares determine the third by construction, we require two additional targets. Following Uy et al. (2013), we target South Korea's per capita income relative to the ROW in 1971 and the share of agricultural subsistence expenditure in Korea's total consumption. Table III summarizes the targeted and calibrated values.

The second step involves calibrating productivity shocks after 1971. These shocks are constructed based on the initial productivity levels and sectoral productivity growth rates. To compute these growth rates, we proceed as follows. We first derive the sectoral real value-added production function implied by the model[12]:

$$VA_{ik} = (1-\lambda_{ik}) P_{ik}^{\frac{\lambda_{ik}}{1-\lambda_{ik}}} \left[\lambda_{ik} \prod_{n=a,m,s} \left(\frac{\gamma_{ikn}}{P_{in}} \right)^{\gamma_{ikn}} \right]^{\frac{\lambda_{ik}}{1-\lambda_{ik}}} A_{ik}^{\frac{1}{1-\lambda_{ik}}} L_{ik}. \tag{4.1}$$

Although this equation can be inverted to recover A_{ik}, previous studies—such as Waugh (2010) and Finicelli et al. (2013)—highlight that measured productivity in an open economy reflects not only fundamental (autarky) productivity but also gains from trade-induced specialization. To isolate fundamental productivities, we follow the adjustment method proposed by Finicelli et al. (2013), yielding the expression:

$$A_{ik} = \pi_{iik}^{\frac{1}{\theta}} \left(\frac{VA_{ik}}{L_{ik}} \right)^{1-\lambda_{ik}} (1-\lambda_{ik})^{\lambda_{ik}-1} P_{ik}^{-\lambda_{ik}} \left[\lambda_{ik} \prod_{n=a,m,s} \left(\frac{\gamma_{ikn}}{P_{in}} \right)^{\gamma_{ikn}} \right]^{-\lambda_{ik}}. \tag{4.2}$$

where π_{iik} denotes the domestic absorption ratio.

Finally, we calculate sectoral productivity growth rates using the time series of fundamental productivities and apply these rates to the 1971 levels to construct productivity paths from 1972

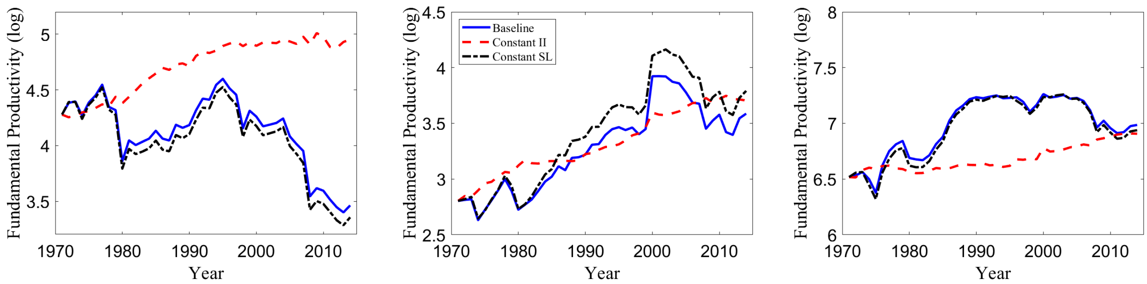
[12] See Appendix A.3 for further details.

onward.

Figure III displays the evolution of the log of total factor productivity for South Korea under three different model specifications. The dashed blue line represents the baseline model, which allows for time-varying intermediate input (II) shares and sectoral linkages (SL). The red cross marker corresponds to the case with constant intermediate input shares, *Constant II*, while the black dash-dot line represents a scenario with constant sectoral linkage coefficients, *Constant SL*, both held fixed at their 1971 values.

In the case with *Constant II*, fundamental productivity shows a steady increase across all sectors, consistent with trends commonly found in the literature. By contrast, the *Constant SL* scenario yields productivity trajectories that closely resemble the baseline for services, are slightly higher for manufacturing, and slightly lower for agriculture.

The baseline estimates exhibit greater variation across sectors and over time, in contrast to the smoother patterns observed under the *Constant II* specification. This increased variation arises from the explicit incorporation of time-varying intermediate input shares and sectoral linkages, which better capture the dynamics in the intensity of use of intermediate goods across sectors and periods. These variations highlight the importance of accounting for evolving production structures when measuring productivity growth.



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE III: Calibrated Productivity Series for South Korea

Notes: This figure shows the calibrated fundamental productivity in each sector under three scenarios: with time-varying intermediate input and sectoral linkage coefficients (*Baseline*), with constant intermediate input shares *Constant II*, and with constant sectoral linkage coefficients (*Constant SL*).

Figure III-**(a)** reveals a new insight: total factor productivity (TFP) in agriculture has been steadily declining in South Korea since the late 1990s. This trend suggests that the increases in agricultural productivity reported in the literature may largely stem from greater reliance on intermediate inputs, such as machinery, chemicals, and other resources sourced from manufacturing or related sectors, rather than from significant advances in technological efficiency, such as higher crop yields from improved seed varieties or farming practices.

These findings underscore the importance of accounting for changes in production structure when measuring TFP. While assuming constant or time-varying values for γ_{ikn} has a relatively limited effect on the estimated A_{ik}, allowing λ_{ik} to vary over time significantly alters the productivity path. This suggests that shifts in the overall intensity of intermediate input use play a more central role in shaping sectoral productivity dynamics. In particular, time-varying input-output coefficients reflect deeper changes in technology, specialization, and sectoral integration that influence the relationship between observed value-added and underlying efficiency. Failing to incorporate these variations can lead to misleading conclusions by attributing input changes to TFP growth when they may instead result from evolving input intensities.

TABLE III: List of Parameter Values and Calibration Targets.

Model parameters			
Parameter	Description	Value	Source
σ	Elasticity of substitution between sectors	0.751	Uy et al. (2013)
ω_a	Preference weight on agriculture goods	0.131	Uy et al. (2013)
ω_m	Preference weight on industry goods	0.214	Uy et al. (2013)
ω_s	Preference weight on services	0.655	Uy et al. (2013)
$\overline{C}_a$	Subsistence requirement for agriculture	696.0	Uy et al. (2013)
$\overline{C}_m$	Subsistence requirement for manufacturing	0.0	Uy et al. (2013)
$\overline{C}_s$	Subsistence requirement for services	0.0	Uy et al. (2013)
θ	Trade elasticity	4	Simonovska & Waugh (2014)
η	Elasticity of substitution between varieties	4	Sposi (2019)

Initial period calibration targets		
Description	Data	Baseline
South Korea agricultural labor share	0.50	0.50
South Korea manufacturing Labor Share	0.12	0.12
South Korea services labor share	0.38	0.38
Rest of world agricultural labor share	0.16	0.16
Rest of world manufacturing labor share	0.23	0.23
Rest of world services labor share	0.61	0.61
South Korea agricultural import share	0.12	0.12
South Korea manufacturing import Share	0.27	0.27
South Korea agricultural export share	0.02	0.02
South Korea manufacturing export Share	0.12	0.12
South Korea agricultural subsistence share	0.51	0.52
Income of rest of world relative to South Korea	5.90	5.87

Notes: This table summarizes the results of calibration. The upper panel of the table presents the list of parameters, their values, and sources. The lower panel reports the indicators targeted at the initial date during the calibration, along with their target values and the values predicted by the model.

Trade costs. Given our objective to assess the model's ability to replicate the evolution of South Korea's sectoral labor shares, we calibrate at each period four trade cost, τ_{ijk}, to align with observed bilateral trade flows between South Korea and the rest of the world (ROW). Specifically, we target South Korea's export and import shares in agriculture and manufacturing over time. The trade costs are determined jointly with the model solution.

As illustrated in Figure IV, trade costs for agricultural goods declined significantly over time for both South Korea and the Rest of the World. In addition, South Korea's manufacturing import costs decreased overall but exhibited some fluctuations, whereas ROW's manufacturing import costs remained relatively stable throughout the period.

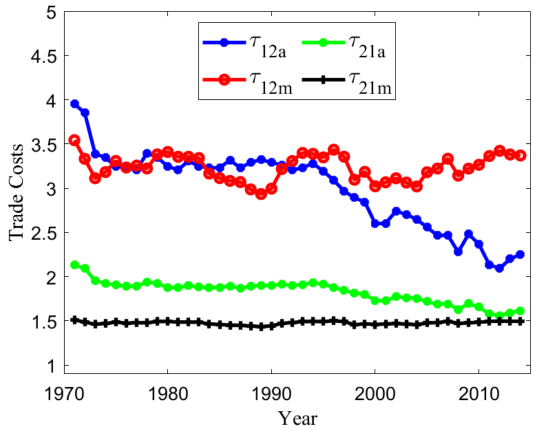
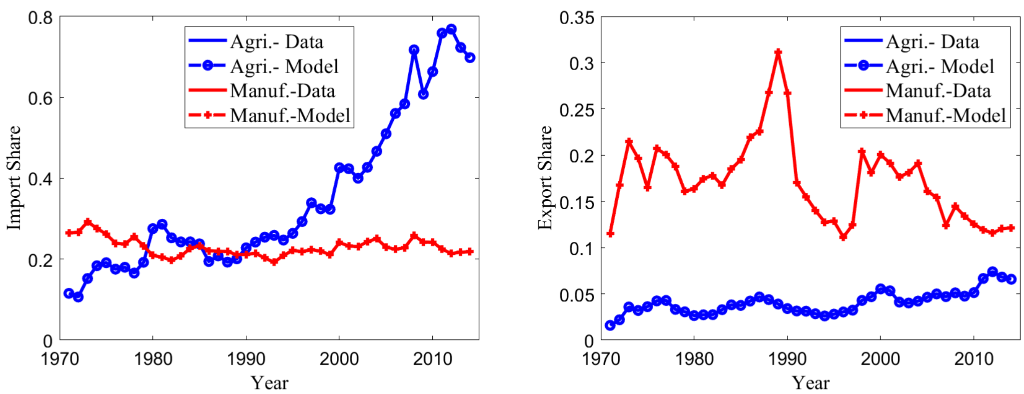


FIGURE IV: Calibrated Trade Costs

Notes: This figure presents the calibrated trade costs for agricultural and manufacturing goods. Recall that τ_{ijk} denotes the trade cost incurred by country i when importing a good from sector k produced in country j.

4.3 Model Fit

Using the calibrated parameters and time-varying processes, we numerically solve the baseline model. We first verify whether the model successfully replicates the initial moments targeted in the calibration. As shown in Table III, the model accurately reproduces the initial sectoral employment shares of Korea and the rest of the world (ROW), as well as South Korea's sectoral import and export shares.



(a) Korean Import Shares **(b)** Korean Export Shares.

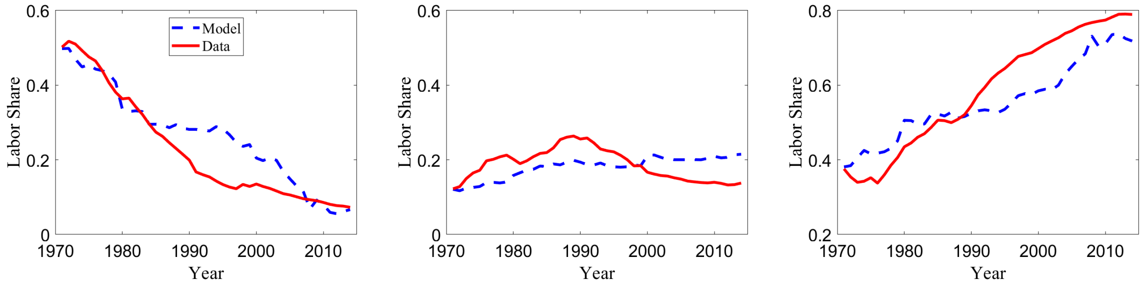
FIGURE V: Calibrated Trade Costs and Korean Trade Shares

Notes: Panels (a) and (b) compare the model's predictions with the observed data on South Korea's sectoral import and export shares.

Panels **(a)** and **(b)** of Figure V show that the model accurately reproduces the actual trajectories of these trade shares. They illustrate notable shifts in South Korea's trade structure between 1971 and 2014. The import share of agricultural goods rose markedly, while agricultural exports remained minimal and relatively stable, suggesting that the rest of the world maintained a comparative advantage in agriculture. As a result, imported agricultural goods increasingly displaced domestic production, likely contributing to labor reallocation away from agriculture.

In contrast, manufacturing displayed a stable import share alongside a pronounced rise and subsequent decline in export intensity, patterns that align with the sector's expansion and evolving position in global markets.

Next, we evaluate the model's ability to capture structural changes over time in sectoral employment shares. Figure VI presents the key results, comparing the model's predicted and observed employment shares across the three broad sectors in South Korea from 1971 to 2014. In each panel of Figure VI, the model's predicted sectoral labor shares are represented by blue dashed lines, while the observed sectoral labor shares are shown as solid red lines.



(a) Agriculture **(b)** Manufacturing **(c)** Services

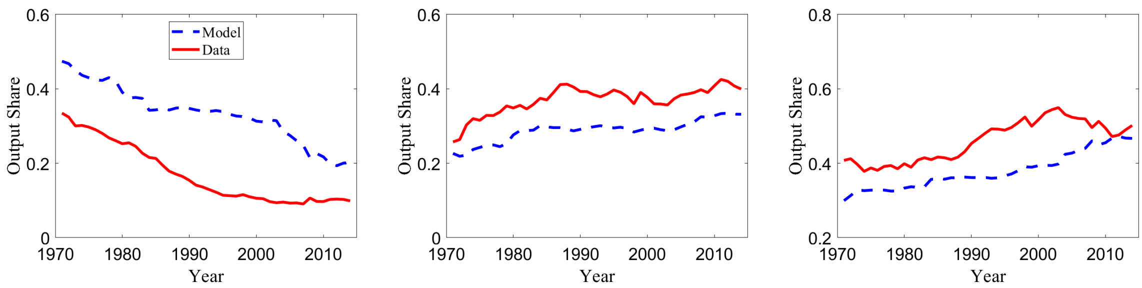
FIGURE VI: Employment shares in South Korea, 1971-2014: Data vs. Baseline Model

Notes: This figure compares the model's predictions (dashed lines) with the data (solid lines) for sectoral employment shares. Only the shares for the year 1971 are targeted in the calibration.

Figure VI-**(a)** illustrates that the model effectively captures the structural shift away from agriculture in South Korea. The agricultural employment share declined sharply from 0.50 in 1971 to 0.07 in 2014, a trend the model accurately reproduces over the entire period. Similarly, Figure VI-**(c)** shows that the baseline model closely tracks the rise in the services employment share, which increased from 0.38 in 1971 to 0.79 in 2014, with the model predicting a rise from 0.38 to 0.72 over the same period. For manufacturing, Figure VI-**(b)** indicates that the model successfully captures the sustained increase in the employment share from 1971 to 1989 (from 0.12 to 0.26 in the data, compared to 0.12 to 0.20 predicted by the model) and a slight decline between 1990 and 2000. However, after 2000, the model predicts a relatively stable manufacturing labor share, whereas the actual data show a continued decline. Overall, the baseline model fits the data well, though it struggles to replicate the decline in manufacturing employment after 2000.

Since our model was calibrated to target initial labor shares for analyzing structural change, we now perform a diagnostic check to see if it also predicts the trends in output shares. Although output shares were not part of the calibration, Figure VII shows how the model performs over time. For agriculture, the model starts with a higher output share than the actual data, but its dynamics lead to a predicted labor share by 2014 that matches the observed value. In manufacturing, the model's output share closely follows the observed data throughout the entire period, capturing the trend more accurately than the employment share. For services, the model begins with a lower output share than observed, but it catches up over time, aligning closely with the actual share by 2014.

We can therefore conclude that the model successfully replicates South Korea's structural



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE VII: Output shares in South Korea, 1971-2014: Data vs. Baseline Model

Notes: This figure compares the model's predictions (dashed lines) with the data (solid lines) for sectoral output shares. Note that output shares are not targeted in the calibration.

change over time. In the following section, we use the model to examine how time-varying intermediate input shares and sectoral linkage coefficients have shaped the observed pattern of structural change. This is achieved through a series of counterfactual experiments that isolate the effects of these components.

5 Quantitative Analysis

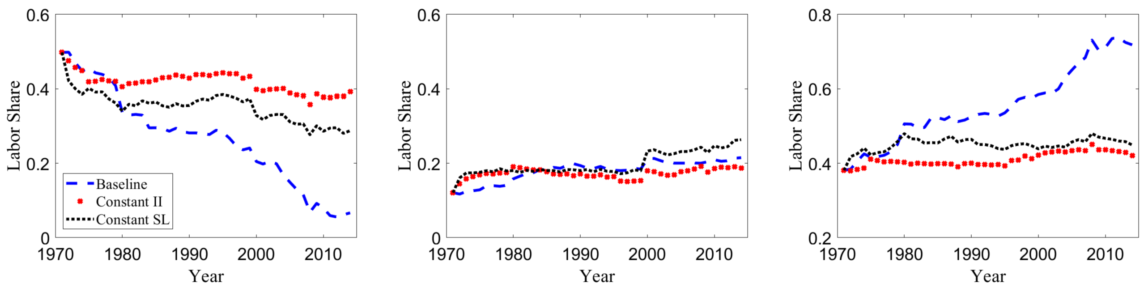
We now turn to the quantitative analysis of our model, using the calibrated baseline version. We quantify how time-varying intermediate input shares and sectoral linkages contribute to structural change, relative to a scenario with fixed input shares. We also examine how international trade and TFP shocks interact with evolving sectoral input-output structures to drive structural change.

5.1 The Role of Time-Varying Intermediate Inputs and Sectoral Linkages

In our baseline model, sectoral intermediate input shares and sectoral linkages evolve over time. To evaluate the impact of these changes on South Korea's structural change, we conduct two counterfactual exercises. In the first exercise, we hold the sectoral intermediate input (II) shares, denoted as λ_{ik}, constant at their initial values for South Korea. We refer to this scenario as *Constant II*. In the second exercise, we fix the sectoral linkage (SL) coefficients, γ_{ikn}, at their initial values for South Korea, defining this scenario as *Constant SL*.

Figure VIII presents the predicted sectoral labor shares for South Korea under each counterfactual exercise. The red cross marker represent the predictions under the *Constant II* scenario, while the black dotted lines depict the predictions under the *Constant SL* scenario. Thedashed blue lines correspond to the predictions of the baseline model.

In the baseline scenario, the agricultural sector undergoes a gradual and persistent decline, while services steadily gain labor. In contrast, the *Constant II* and *Constant SL* scenarios exhibit markedly weaker structural change. Specifically, both counterfactuals show a slower decline in agricultural employment share and a more muted rise in services compared to the baseline. By 2014, agricultural employment share in the *Constant SL* scenario is 22 percentage points higher, and services employment share is 27 percentage points lower compared to the



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE VIII: Korean Structural Change: Constant Intermediate Input Shares and Sectoral Linkage Coefficients

Notes: This figure compares sectoral labor shares predicted by the baseline and counterfactual models. "*Baseline*" refers to the baseline simulation. "*Constant II*" corresponds to the simulation in which sectoral intermediate input shares are held constant at their 1971 levels and do not change. "*Constant SL*" corresponds to the simulation in which sectoral linkage coefficients are fixed at their 1971 levels.

baseline predictions. Under the *Constant II* scenario, these gaps widen further, with agricultural employment share 32 percentage points higher and services employment share 30 percentage points lower. Moreover, in both counterfactuals, the manufacturing sector fails to exhibit a sustained increase in employment.

These findings highlight that, when intermediate input shares are held fixed, the model substantially underestimates labor shifts from agriculture to services, suggesting that the dynamic composition of input use plays a key role in explaining the pace and direction of labor reallocation.

The more pronounced divergence observed under the *Constant II* scenario indicates that shifts in intermediate input shares are particularly influential in shaping sectoral employment paths. Fixing these shares significantly dampens the reallocation of labor away from agriculture and into services. While fixing sectoral linkages also results in a notable deviation from the baseline, the effect is comparatively less pronounced compared to the *Constant II* scenario.

The results indicate that South Korea's structural change was significantly influenced by evolving production structures, highlighting the role played by both the intensifying reliance of agriculture on inputs from manufacturing and services, and the increasing weight of intermediate inputs in agricultural production. Raw data reveal these patterns through several key trends in input-output dynamics from 1971 to 2014.

First, the overall share of intermediate inputs in agriculture's gross output increased substantially, from 51% in 1971 to 70% in 2014, reflecting a shift toward more input-intensive production. Second, the composition of these inputs changed significantly: the share of agricultural goods in total agricultural inputs declined from 85% to 62%, while the shares of agricultural inputs sourced from manufacturing and services rose from 6% to 16% and from 9% to 22%, respectively. Third, the share of agricultural goods used as intermediate inputs in manufacturing declined sharply, from 20% to 4% between 1971 and 2014. Although the share of agricultural inputs in the services sector increased from 3% to 8% between 1995 and 2014, this change remains modest. Given the relatively low reliance on intermediate inputs in the service sector compared to agriculture and manufacturing, this shift does little to offset the broader decline in demand for agricultural intermediates.

These patterns in the data illustrate how the dynamics of sectoral input-output structures operate within the model. As agriculture became increasingly reliant on intermediate inputs, its direct demand for labor declined, accelerating the reallocation of workers out of the sector. Simultaneously, stronger upstream linkages with manufacturing and services increased intermediate demand for their output, raising labor demand and contributing to employment growth in those sectors. Together, these facts help explain the important role played by the evolving input-output structure in South Korea's structural change.

Counterfactually, when intermediate input-output shares are held constant in the simulations, their evolution is effectively shut down. As a result, the decline in the agricultural employment share slows considerably, and the expansion of employment in services is significantly dampened.

5.2 The Role of Productivity Growth and International Trade

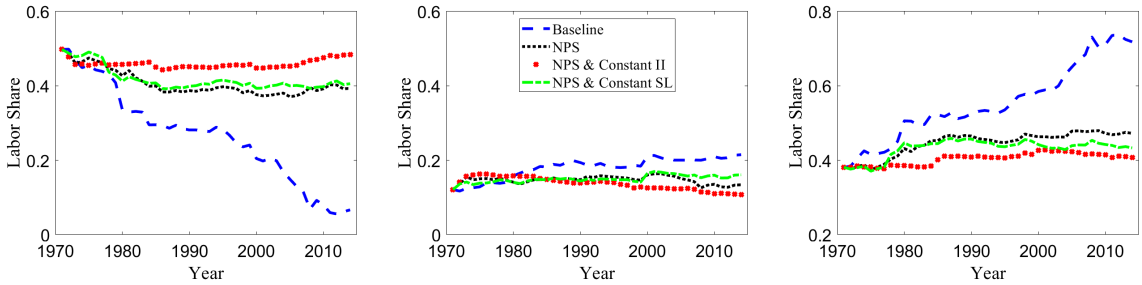
Recent literature, including Sposi et al. (2021), Huneeus & Rogerson (2023), and Uy et al. (2013), highlights sector-biased productivity growth and international trade as key drivers of structural change. Using our model, we assess the relative importance of each driver under both time-varying and fixed intermediate input shares and sectoral linkage coefficients.

To do so, we conduct six additional counterfactual simulations. First, we eliminate sector-biased productivity growth by holding all sectoral productivity levels constant at their initial values, which we refer to as the *No Productivity Shock* (*NPS*) scenario. We then combine this scenario with the *Constant II* and *Constant SL* settings, in which intermediate input and sectoral linkage coefficients are held fixed, respectively.

Figure IX displays the predicted sectoral labor shares for South Korea under each scenario. In the *NPS* scenario (black dotted line), the decline in agriculture is substantially slower, and the rise in services is more muted, while manufacturing remains largely flat. When combined with *Constant II* (red cross marker), the decline in agriculture is even less pronounced and the expansion of the service sector is weaker. The scenario combining *NPS* with *Constant SL* (dash-dotted green line) yields predictions similar to the *NPS* case.

These results highlight significant differences in the extent of structural change across scenarios. The *NPS* scenario underpredicts the labor reallocation from agriculture to services observed in the baseline, suggesting that productivity shocks play an important role in driving this transformation. The gap between the baseline and the *NPS* with constant intermediate input shares is the most pronounced, indicating that fixing these shares significantly slows down the labor shift.

As shown in Figure III, TFP did not rise over the period 1971–2014 in the agricultural sector as it did in manufacturing and services when intermediate input and sectoral linkage coefficients are allowed to vary. Therefore, it may seem surprising that the productivity shock still generates structural change in the baseline model. From the perspective of the Baumol effect, this outcome appears counterintuitive. However, when international trade dynamics are taken into account, the result becomes more understandable. By holding productivities constant at their initial levels, the model effectively assigns a relatively high level of fundamental

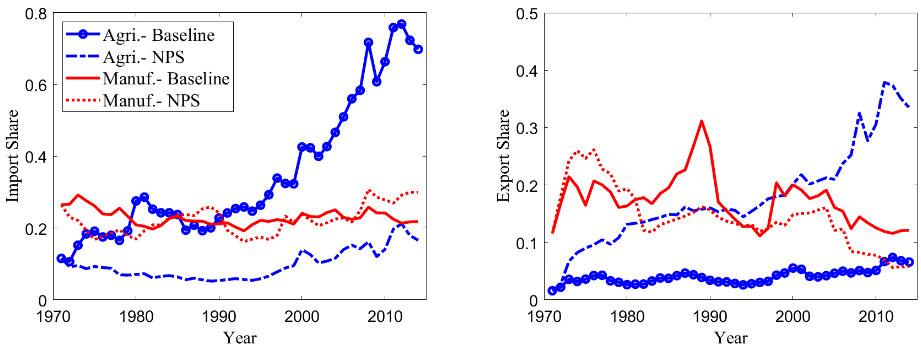


(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE IX: No Productivity Shock, Constant Intermediate Input Shares, and Sectoral Linkage Coefficients

Notes: This figure compares sectoral labor shares predicted by the baseline and counterfactual models. "Baseline" refers to the baseline simulation. "*NPS*" corresponds to the simulation where all sectoral TFP are set at the level of 1971 and do not vary. "*NPS & Constant II*" corresponds to the simulation in which the TFP and intermediate input shares are constant. "*NPS & Constant SL*" corresponds to the simulation in which TFP and sectoral linkage coefficients are constant.

productivity to agriculture over the period. According to the principle of comparative advantage, South Korea's agricultural sector remains more relatively productive than that of the ROW when compared to the baseline. This enhances the country's competitiveness in agriculture, leading to higher export shares and lower import shares in this sector relative to the baseline scenario (as shown in Figure X). As a result, demand for domestic agricultural production rises, increasing labor demand in the sector. Consequently, labor shares in agriculture remain higher than in the baseline model, where declining agricultural competitiveness in South Korea shifts its labor toward manufacturing and services[13].



(a) Import Shares **(b)** Export Shares

FIGURE X: Changes in Sectoral Import and Export Shares in South Korea under Productivity Shocks

Notes: This figure compares sectoral Import and Export shares predicted by the baseline and counterfactual model without productivity shock. "*Baseline*" refers to the baseline simulation. "*NPS*" corresponds to the simulation where all sectoral TFP are set at the level of 1971 and do not vary.

[13]Figure V-(a) illustrates that between 1971 and 2014, the import share of agricultural goods in South Korea increased significantly—from approximately 15% to over 75% of agricultural gross output. This sharp rise indicates that the rest of the world holds a comparative advantage in agriculture, making South Korea's imported agricultural goods more competitive than domestic production. As a result, labor reallocates away from agriculture and into the manufacturing and services sectors.

Next, we examine the role of trade shocks by counterfactually removing the decline in sectoral trade costs, defining this as the *No Trade Shock (NTS)* scenario. As with productivity, we also combine this scenario with the *Constant II* and *Constant SL* scenarios. These counterfactual exercises allow us to isolate the effects of trade liberalization on structural change while accounting for the role of evolving sectoral linkages and the changing weight of inputs in production.

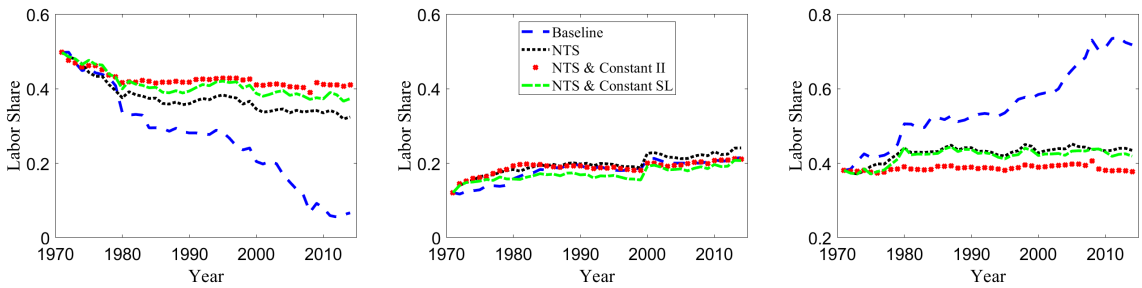
The graphs in Figure XI show sectoral labor shares with distinct patterns across scenarios. The *NTS* scenario (black dotted line) shows a slower agricultural decline and a less pronounced increase in services compared to the baseline (dashed blue line). The *NTS* with *Constant II* scenario (red cross marker), further slows the agricultural decline and substantially limits service sector growth. The *NTS* with *Constant SL* scenario (dashed-dot green line) closely tracks the *NTS* pattern in services and closely *NTS* & *Constant II* in agriculture.

The baseline model reflects South Korea's structural change, driven by declining agricultural trade costs that increase agricultural imports and reallocate labor to other sectors, particularly services. Reduced trade barriers lower import costs, making foreign goods more competitive substitutes for domestic agricultural production. As a result, the sector experiences accelerated labor outflows due to declining competitiveness relative to the ROW.

In the *NTS* scenario, where trade costs remain at their initial levels, structural shifts proceed more slowly. Higher relative import costs increase reliance on domestically produced agricultural goods, leading to greater demand for domestic output and, in turn, higher labor demand in the agricultural sector.

The *NTS* & *Constant II* scenario imposes a stricter constraint by holding intermediate input shares fixed over time. This rigidity limits sectors' ability to adjust their production structures in response to changing economic conditions. In particular, agriculture remains tied to its initial input composition, reducing its capacity to substitute toward inputs from other sectors, as observed in the data. This constraint delays labor reallocation out of agriculture and dampens output growth in services that would otherwise benefit from stronger intersectoral demand.

These findings support that declining trade costs and evolving intermediate input use are key determinants of South Korea's labor reallocation. Constraining either channel reduces the economy's capacity to reallocate labor as evidenced by the substantial divergence observed between baseline and counterfactual scenarios.



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE XI: No Trade Shock and Constant Intermediate Input Shares and Sectoral Linkage Coefficients

Notes: This figure compares sectoral labor shares predicted by the baseline and counterfactual models. "Baseline" refers to the baseline simulation. "*NTS*" corresponds to the simulation where all sectoral trade costs are set at the level of 1971 and do not vary. "*NTS & Constant II*" corresponds to the simulation in which the trade costs and intermediate input shares are constant. "*NTS & Constant SL*" corresponds to the simulation in which trade costs and sectoral linkage coefficients are constant.

6 Conclusion

This study has documented significant dynamics in the input structures of agriculture, manufacturing, and services in South Korea from 1971 to 2014, revealing substantial transformations in intersectoral dependencies over this period. First, we observed a notable increase over time in the share of intermediate inputs in agricultural production, while the share of intermediate inputs in manufacturing gross output exhibits a flattened U-shape pattern. Second, the proportion of intermediate inputs sourced from other sectors is rising in agricultural production, while the share of agricultural inputs used in producing both agricultural and manufacturing goods continues to decline. To better understand the implications of these dynamics for structural change, we employed a three-sector, open-economy model that incorporates time-varying sectoral linkages and intermediate input shares in sectoral production.

The model with time-varying sectoral linkages and intermediate input shares replicates South Korea's structural change with notable accuracy, capturing the sharp decline in agricultural employment share and the steady rise of the service sector. Moreover, the model predicts a more accurate depiction of the manufacturing sector's growth and early decline compared to models with constant shares. However, it slightly underestimates the decline of manufacturing employment share after 2000, suggesting that additional factors out of our framework may have contributed to the continued decline in manufacturing employment.

Moreover, our counterfactual experiments reveal that evolving intermediate input use and sectoral linkages have played an important role in South Korea's structural change. These evolving sectoral input-output structures shape labor reallocation through three main mechanisms. First, changes in intermediate input intensities directly affect labor via technological parameters that determine the labor share in production. Second, they influence marginal costs, which affect trade shares and comparative advantage, thereby redirecting sectoral demand and employment across countries. Third, they determine how sectoral output responds to changes in intermediate demand, amplifying or dampening employment adjustments. These mechanisms do not operate in isolation, they interact with broader forces, such as Engel effects, productivity growth, and trade liberalization, whose effects on labor reallocation are mediated by the structure of production itself.

These findings have important implications for understanding the role of technological progress in structural change. While previous studies have emphasized sector-biased productivity growth as the primary driver, consistent with Baumol's effect, our results highlight an additional channel through which technological progress shapes structural transformation: by changing the production structure itself. As technological progress modifies sectoral interdependencies and the intensity of intermediate input use, it influences the evolution of value-added and employment shares across sectors. This suggests that policies aimed at managing structural change should consider not only TFP differentials across sectors but also the evolving network of input-output relationships that structure the economy over time.

An important avenue for future research is to investigate the determinants of changes in these sectoral input-output structures. While technological progress is a key factor, other variables—such as trade policies, industrial strategies, and institutional developments—may also play significant roles in shaping the evolution of production networks and, consequently, the trajectory of structural change.

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A Mathematical Appendix

A.1 Derivation of Equation (3.18)

The total output of the sectoral composite good in sector k for country i, Q_{ik}, combines final consumption with intermediate inputs sourced from various sectors. This relationship is captured by:

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s} \int M_{ink}(z)\, dz, \tag{A.1}$$

where C_{ik} is final consumption, and the integral sums intermediate inputs $M_{ink}(z)$ over all varieties z for sectors $n = a$ (agriculture), m (manufacturing), and s (services).

To express $M_{ink}(z)$, we use the first-order condition from the profit maximization problem for a producer of intermediate good z in sector k. This condition, balancing production costs and market prices, gives:

$$M_{ink}(z) = \gamma_{ink}\lambda_{in}p_{in}(z)\frac{Y_{in}(z)}{P_{ik}}, \tag{A.2}$$

showing how intermediate inputs depend on sectoral parameters, variety-specific prices and output, and the aggregate price index.

Substituting Equation (A.2) into Equation (A.1), we incorporate the intermediate input expression to rewrite total output:

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s} \int \left(\gamma_{ink}\lambda_{in}p_{in}(z)\frac{Y_{in}(z)}{P_{ik}}\right) dz. \tag{A.3}$$

This step aggregates the contributions of intermediate inputs across all varieties and sectors, maintaining the structure of consumption plus intermediates.

Next, we account for the output of variety z in sector k, which is distributed across countries:

$$Y_{ik}(z) = \sum_{j=1}^{2} \tau_{jik}Y_{jik}(z), \tag{A.4}$$

where τ_{jik} adjusts for trade costs, and $Y_{jik}(z)$ is the output consumed in country j. To convert this into value terms, we multiply both sides by $p_{ik}(z)$:

$$p_{ik}(z)Y_{ik}(z) = \sum_{j=1}^{2} p_{ik}(z)\tau_{jik}Y_{jik}(z) = \sum_{j} P_{jk}Q_{jk}\pi_{jik}, \tag{A.5}$$

linking variety-specific values to aggregate trade flows via trade shares π_{jik}.

Applying this to Equation (A.3), we evaluate the integral by aggregating over varieties, transforming the expression into:

$$Q_{ik} = C_{ik} + \sum_{n=a,m,s} \gamma_{ink}\lambda_{in} \sum_{j=1}^{2} \frac{P_{jn}Q_{jn}\pi_{jin}}{P_{ik}}, \tag{A.6}$$

capturing the value of intermediate inputs weighted by trade shares.

Since services ($n = s$) are not traded, the trade share $\pi_{jis} = 1$ for $j = i$ (domestic services) and 0 otherwise, simplifying the services term. We thus rewrite the equation to isolate this:

$$Q_{ik} = C_{ik} + \sum_{n=a,m} \gamma_{ink}\lambda_{in} \sum_{j=1}^{2} \frac{P_{jn}Q_{jn}\pi_{jin}}{P_{ik}} + \gamma_{isk}\lambda_{is}\frac{P_{is}Q_{is}}{P_{ik}}. \tag{A.7}$$

This final expression, matching Equation (3.18), separates traded sectors (agriculture, manufacturing) from non-traded services, completing the derivation.

A.2 Demonstration of the composite price

The total expenditure on the composite good k in country i is given by:

$$P_{ik}Q_{ik} = \int p_{ik}(z)Q_{ik}(z)dz. \tag{A.8}$$

By using the expression of $Q_{ik}(z)$ given in Equation (3.5) and substituting it into the previous equation, we obtain the following:

$$P_{ik}Q_{ik} = \int p_{ik}(z)\frac{p_{ik}(z)^{-\eta}}{P_{ik}^{-\eta}}Q_{ik}dz. \tag{A.9}$$

From this, we can deduce the expression of the aggregated price P_{ik} of the composite good Q_{ik} in sector k within country i as follows:

$$P_{ik} = \left(\int p_{ik}(z)^{1-\eta}dz\right)^{\frac{1}{1-\eta}}. \tag{A.10}$$

A.3 Sectoral Fundamental Productivities

If we abstract from the continuum of goods and work at an aggregate sectoral level, the profit maximization problem is:

$$\max_{L_{ik},M_{ikn}} P_{ik}Y_{ik} - w_iL_{ik} - \sum_{n=a,m,s} P_{in}M_{ikn}. \tag{A.11}$$

The first order condition gives the demand for intermediate goods:

$$M_{ikn} = \lambda_{ik}\gamma_{ikn}\frac{P_{ik}Y_{ik}}{P_{in}}. \tag{A.12}$$

Substituting for M_{ikn} in the production function and rearranging, we obtained:

$$Y_{ik} = \left[\lambda_{ik}P_{ik}\prod_{n=a,m,s}\left(\frac{\gamma_{ikn}}{P_{in}}\right)^{\gamma_{ikn}}\right]^{\frac{\lambda_{ik}}{1-\lambda_{ik}}} A_{ik}^{\frac{1}{1-\lambda_{ik}}}L_{ik}. \tag{A.13}$$

Therefore we can rewrite the maximization problem as follows:

$$\max_{L_{ik}} \quad (1-\lambda_{ik})P_{ik}^{\frac{1}{1-\lambda_{ik}}}\left[\lambda_{ik}\prod_{n=a,m,s}\left(\frac{\gamma_{ikn}}{P_{in}}\right)^{\gamma_{ikn}}\right]^{\frac{\lambda_{ik}}{1-\lambda_{ik}}} A_{ik}^{\frac{1}{1-\lambda_k}} L_{ik} - w_i L_{ik}. \tag{A.14}$$

Thus, real value added function is:

$$VA_{ik} = (1-\lambda_{ik})P_{ik}^{\frac{\lambda_{ik}}{1-\lambda_{ik}}}\left[\lambda_{ik}\prod_{n=a,m,s}\left(\frac{\gamma_{ikn}}{P_{in}}\right)^{\gamma_{ikn}}\right]^{\frac{\lambda_{ik}}{1-\lambda_{ik}}} A_{ik}^{\frac{1}{1-\lambda_k}} L_{ik}. \tag{A.15}$$

Therefore,

$$\left(\frac{VA_{ik}}{L_{ik}}\right) = (1-\lambda_{ik})P_{ik}^{\frac{\lambda_{ik}}{1-\lambda_{ik}}}\left[\lambda_{ik}\prod_{n=a,m,s}\left(\frac{\gamma_{ikn}}{P_{in}}\right)^{\gamma_{ikn}}\right]^{\frac{\lambda_{ik}}{1-\lambda_{ik}}} A_{ik}^{\frac{1}{1-\lambda_k}}, \tag{A.16}$$

which implies that:

$$\left(\frac{VA_{ik}}{L_{ik}}\right)^{1-\lambda_k} = (1-\lambda_{ik})^{1-\lambda_{ik}}P_{ik}^{\lambda_{ik}}\left[\lambda_{ik}\prod_{n=a,m,s}\left(\frac{\gamma_{ikn}}{P_{in}}\right)^{\gamma_{ikn}}\right]^{\lambda_{ik}} A_{ik}. \tag{A.17}$$

We calibrate the series of sectoral fundamental productivities A_{ik} in two steps. The first step is to compute measured sectoral productivities B_{ik} at each period using real value-added data, VA_{ik}, and employment data L_{ik}. The measured productivity is defined as:

$$B_{ik} \quad = \quad \left(\frac{VA_{ik}}{L_{ik}}\right)^{1-\lambda_{ik}}(1-\lambda_{ik})^{\lambda_{ik}-1}P_{ik}^{-\lambda_{ik}}\left[\lambda_{ik}\prod_{n=a,m,s}\left(\frac{\gamma_{ikn}}{P_{in}}\right)^{\gamma_{ikn}}\right]^{-\lambda_{ik}}. \tag{A.18}$$

The second step is to compute the fundamental productivity, A_{ik}, from the measured productivity, B_{ik}. The productivity B_{ik} captures the fundamental productivity of firms within the country under autarky, and the additional productivity occurring from trade specialization. Following Finicelli et al. (2013), we adjust B_{ik} with the Ricardian selection to obtain the fundamental productivity:

$$A_{ik} = \pi_{iik}^{\frac{1}{\theta}} B_{ik},$$

were π_{iik} is the sectoral domestic absorption ratio.

B Data Appendix

In this section, we describe the sources and construction of the data employed in the analysis.

B.1 Countries, Sample Period, and Sectors

We construct a balanced panel over the period 1971–2014 for 26 countries: Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Germany, Greece, Iran, Iraq, Ireland, Italy, Japan, South Korea, Kuwait, Luxembourg, Mexico, Netherlands, Portugal, Saudi Arabia, Sweden, United Kingdom, United States, and Venezuela[14]. All countries except South Korea make up the rest of the world.

We use the International Standard Industrial Classification, Revision 3 (ISIC III) to construct our three broad sectors. Agriculture corresponds to ISIC divisions 1–5 (agriculture, forestry, hunting, and fishing), 10–14 (mining and quarry), 15–16 (food, beverages and tobacco—FBT); Manufacturing corresponds to divisions 17–37 (total manufacturing less FBT); Services corresponds to divisions 40–99 (utilities, construction, wholesale and retail trade, transport, government, financial, professional, and personal services such as education, health care, and real estate services). For Mexico and Venezuela, the sectoral classification in the GGDC 10-Sector dataset did not allow for the isolation of food, beverages, and tobacco data from the manufacturing sector to reallocate it to the agricultural sector. As a result, this data remained classified within the manufacturing sector.

B.2 Sectoral Employment Shares

The Social Economic Accounts (SEA) database from 2000 to 2014 serves as the primary data source for this period, supplemented by the EU KLEMS database, which is available until 2007 but was used in our analysis only until 1999. These combined sources provide data for Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Germany, Greece, Ireland, Italy, Japan, South Korea, Luxembourg, the Netherlands, Portugal, Sweden, and the United Kingdom. For the United States, sectoral employment data is obtained from the Bureau of Economic Analysis (BEA)[15]. Conversely, for Mexico and Venezuela, we rely on the GGDC 10-Sector Database. To address missing sectoral employment data for Mexico (2013-2014) and Venezuela (2012-2014), we impute values using the average growth rate in sectoral employment over the preceding five years, thereby ensuring continuity and consistency within the dataset.

In cases where sectoral employment data is unavailable for countries such as Iran, Iraq, Kuwait, and Saudi Arabia, we apply imputation methods based on assumptions derived from Venezuela's data. Following Uy et al. (2013), we impute the missing values using population data from the Penn World Tables Version 10.0 (PWT 10.0). Specifically, sectoral employment in each country i for sector k is computed as:

$$L_{ik} = \frac{Pop_i}{Pop_{VEN}} \times L_{VEN,k},$$

where Pop_i is the population of country i, $L_{VEN,k}$ is the employment of Venezuela in sector k and Pop_{VEN} is the population of Venezuela.

Total employment in a country is calculated as the sum of employment across all sectors. To standardize these figures, we normalize total employment in each country by dividing it by the U.S. population in 1971. The sectoral and total employment for the Rest of the World (ROW) is obtained by summing the sectoral and total employment figures across all countries.

[14]Some data was missing for some years for some countries. We'll explain later how we imputed these missing data.

[15]The BEA provides interactive tables of national accounts data for the U.S. on their website.

B.3 Computing Sectoral Gross Output and Value Added

To construct the parameters λ_{ik} for each sector k in South Korea and the Rest of the World, we require data on value-added and gross output for each country. We combined the World Input-Output Database (WIOD) with the Social Economic Accounts to obtain nominal values for these metrics across all countries, except for Kuwait, Iran, Iraq, Saudi Arabia, Venezuela, and Luxembourg. Since the WIOD data is in current U.S. dollars, we converted it into local currencies using exchange rates from the World Development Indicators. For real sectoral value-added, we adjusted the WIOD data (1965-2000) and the Social Economic Accounts data (2000-2014) to 2000 constant prices, then merged these datasets to create a continuous series of real sectoral value added at 2000 constant prices. For Luxembourg, we utilized EUKLEMS data for the period 1971-1999 to complete the sectoral value-added and gross output data in the Social Economic Accounts database. Data on nominal and real sectoral value added for Venezuela was sourced from the GGDC 10-Sector Database (in LCU and 2005 constant LCU prices). We used the PPP exchange rate factor from the OECD database and World Development Indicators (WDI) to transform all current currency values into international U.S. dollars, making them comparable across countries.

Below, we explain how we calculated the real values for sectoral value added. To ensure comparability across countries and over time, we first converted the real value added from EUKLEMS data (for Luxembourg) into 2005 constant prices VAQ_{kt} using the nominal sectoral value added VA_{kt} and sectoral price indices VAP_{kt}:

$$VAQ_{kt} = VA_{kt} \times \frac{VAP_{k2005}}{VAP_{kt}}$$

For data from WIOD and Social Economic Accounts, where we have both nominal values and 2000 constant prices values, we used the formula:

$$VAQ_{kt} = Q_{k2005} \times \frac{VA_{kt}}{VA_{2005}}$$

where Q_{k2005} represents the value of the value added in sector k in 2005 at 2000 constant prices. Since Inklaar et al. (2023) provides sectoral value-added PPP converters for 2005 (in LCU/USD), we calculated the real sectoral value added in 2005 international dollar prices by dividing the previously calculated values by the sectoral 2005 PPP factors.

For the gross output of Venezuela, Kuwait, and Iran, we utilize the UN National Accounts database[16]. The data for Venezuela are available in two local currencies: the Bolivar from 1971 to 2002 and the Bolivar Fuerte from 1997 to 2014. Since we will use the PPP converter in local Bolivar Fuerte currency, we retain data in Bolivar Fuerte from 1997 onward and use the overlapping period from 1997 to 2002, during which data is available in both currencies, to calculate a conversion factor from the Bolivar to the Bolivar Fuerte for the period 1971 to 2002.

To address the missing gross output values for Kuwait from 1971 to 1975, we impute these values by applying the average growth rate observed during the subsequent five years (1976-1980) and extrapolating backward. For nominal and real sectoral value added in Kuwait, Iran, Iraq,

[16]UN National Accounts database is available at https://data.un.org

and Saudi Arabia, we rely on the National Accounts Main Aggregates Database of the National Accounts Section of the United Nations Statistics Division—https://unstats.un.org/unsd/snaama/Index.

We estimate the gross output for Iraq and Saudi Arabia using data from Iran and Kuwait respectively, under the assumption that Iraq and Iran, as well as Saudi Arabia and Kuwait, have similar sectoral contributions of value added in gross output. This estimation is calculated as follows:

$$GO_{ik} = VA_{ik} \times \frac{GO_{jk}}{VA_{jk}}$$

where i Iraq (resp. Saudi Arabia) and j is Iran (resp. Kuwait).

B.4 Sectoral Intermediate Input Share Series

To construct the country-specific, time-varying share of intermediate inputs λ_{ik} and the country-specific, time-varying sectoral linkages coefficients γ_{ikn}, we utilize the WIOD database. First, we aggregate the detailed data into our three broad sectors using the ISIC Rev. 3.1 classification. We then calculate γ_{ikn} by dividing the intermediate inputs in sector k sourced from sector n by the total intermediate inputs used in sector k at time t. Additionally, λ_{ik} is computed from the ratio of value added to gross output for each sector k in country i.

B.5 Trade Data

We use UN Comtrade Database as primary source for trade flows, which reports bilateral trade flows by commodity in U.S. dollars. We construct sectoral trade flows based on the SITC Rev.1 classification. Agriculture includes: 0-Food and live animals; 1-Beverages and tobacco; 2-Crude materials, inedible, except fuels; 3-Mineral fuels, lubricants and related materials; Minus 251-Pulp and waste paper; 26-Pulp and waste paper and 332-Petroleum products. Manufacturing includes; 4-Animal and vegetable oils and fats; 5-Chemicals and related products, nes; 6-Manufactured goods classified chiefly by materials; 7-Machinery and transport equipment; 8-Miscellaneous manufactured articles; 251-Pulp and waste paper; 26-Pulp and waste paper and 332-Petroleum products. We compute the series of bilateral trade π_{ijk} as follows. We compute the sectoral import share by dividing the sectoral imports by the sectoral absorption, which is the difference between sectoral gross output and sectoral net export. When downloading South Korea's imports and exports from the COMTRADE website, we select South Korea as the reporter and the world as the partner. For the ROW, we obtain the combined trade flows between South Korea and the countries in our ROW by choosing our subset of countries as reporters and South Korea as the partner country.