Structural Transformation and Network Effects*

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Abstract

This paper examines the network effects of differences in sectoral total factor productivity (TFP) in explaining differences in income across countries. Using the 2014 World Input-Output Database (WIOD), we categorize sectors into agriculture, industry, modern services, and traditional services. We document an increase over time in the share of modern services used as intermediate inputs in other sectors, while it decreases for industry and agriculture. We also observe significant gaps in GDP per worker relative to the United States, with the largest gaps in agriculture and industry. To quantify these effects we develop and calibrate a general equilibrium model where sectors are connected through intermediate inputs. Our initial calibration indicates that modern services exhibit higher productivity; thus, reallocating labor to this sector can contribute more to reducing income gaps. We also show that in a world where countries' share of intermediate inputs converges to that of the U.S. economy could widen the income gap, especially in industrially efficient countries like China. Additionally, we show that improving industrial TFP has a greater average effect on GDP per worker and aggregate TFP compared to other sectors.

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1 Introduction

Sectoral total factor productivity (TFP) and the interdependence between sectors through the use of intermediate goods is important in explaining the disparities in income levels across countries (Jones, 2011b; Herrendorf et al., 2014; Valentinyi, 2021; Fadinger et al., 2022; Kazekami, 2024). The interdependence arises from using intermediate inputs, where productivity gains in one sector propagate through the economy, benefiting other sectors reliant on those inputs (Jones, 2011b). This paper examines how shifts in sector-specific productivity affect other sectors through intermediate goods in a world where sectors depend more on services.

We developed a static general equilibrium model based on Carvalho and Tahbaz-Salehi (2019) and Ferreira et al. (2021), where sectors use labor and intermediate inputs produced by other sectors through a Cobb-Douglas production function. There is a representative consumer that inelastically supplies labor and consumes the different goods according to a Stone-Geary utility function. Then, differences in sectoral productivity affect the economy through changes in relative prices that cause labor reallocation and generate different flows of intermediate inputs through the production network. We calibrate our model to 39 countries using the World Input-Output Database (WIOD) and categorize the 56 sectors available in the dataset into four major sectors: agriculture, industry, modern, and traditional services.

According to the results, in 2014 (the last year available in the dataset), modern services exhibited higher productivity on average than other sectors. Furthermore, we show significant GDP per worker disparities across countries at sectoral and aggregate levels, with the largest gaps toward the U.S. economy in agriculture and the smallest in traditional services. We also estimate a panel regression using information from 2000 to 2014 and 43 sectors. We found that the share of intermediate inputs in industry and agriculture decreased over time while it increased in modern and traditional services. This structural shift reflects a growing dependence on services in production, even in countries where agriculture and industry are predominant.

We analyze a scenario where all economies converge to the same economic structure observed in the U.S., i.e., we introduced the U.S. elasticity of production relative to intermediate goods in other countries. Results show that aligning the elasticity of intermediate goods with U.S. levels drives countries toward a more service-oriented economy. However, this shift may widen the income gap for countries like China, which are more efficient in industry than services. Additionally, we evaluate the effects of aligning sectoral TFP to that observed in the U.S., one sector at a time, and show that increasing TFP in the industry most significantly enhances both GDP per worker and aggregate productivity.

There is a vast literature on the impact of structural transformation on aggregate productivity. Bah and Brada (2009) found that manufacturing productivity exceeds services in nine transition economies, which implies that reallocation of labor to services might reduce aggregate productivity. Duarte and Restuccia (2010) observed that moving labor from agriculture to manufacturing boosts productivity, while a shift to services diminishes it in 29 countries between 1956 and 2004. Ferreira and Silva (2015) noted that the low productivity of the traditional services sector in nine Latin American countries hinders overall productivity growth despite absorbing substantial labor. Our research suggests that the TFP of the modern services sector is, on average, around six times higher than that of traditional services; therefore, the reallocation of labor to modern services could increase GDP per worker and aggregate TFP.

Our research also aligns with a branch of literature that studies the network effects of intermediate goods (Jones, 2011b; Moro, 2012; Baqaee, 2018; Frohm and Gunnella, 2021; Valentinyi, 2021; Miranda-Pinto, 2021; Kazekami, 2024). Kazekami (2024), for instance, emphasizes that stronger linkages between intermediate goods facilitate spillover effects. Some studies suggest that shocks propagated through sectoral production networks can explain the origins of volatility in aggregate output (Barrot and Sauvagnat, 2016; Atalay, 2017; Baqaee, 2018; Boehm et al., 2019; Frohm and Gunnella, 2021). According to Moro (2012), the sectoral share of intermediate goods is fundamental to assessing the impact of shocks or changes in production processes. Furthermore, Miranda-Pinto (2021) shows that diversification of the production network reduces volatility in GDP growth, especially in service-oriented economies. We add to this literature by calibrating our model to 43 countries and showing that industry is the sector that most stimulates the demand for intermediate goods in the other sectors.

Rodrik (2016) documented premature deindustrialization in low and middle-income countries, transitioning to service economies without adequate industrialization, negatively impacting growth. Our counterfactuals illustrate that productivity improvements in industry substantially narrow the GDP per worker and aggregate TFP gaps. A 1% TFP increase in industry reduces the GDP per worker gap by 1.62% sectorally and 1.2% in aggregate; on aggregate TFP gap, the reduction is 0.4%. Using the Bonacich-Katz centrality index, we confirm the industry's central role in less developed economies' productive structures due to its capacity to drive intermediate goods demand.

We also examine the effects of the convergence of the production network in all countries in our sample toward the American structure. A shift towards service-oriented economies revealed no average benefits, as many countries would inefficiently redirect resources from their most productive sectors, exacerbating income disparities. Additionally, our study relates to the literature on the service sector's role in economic development. Eichengreen and Gupta (2013) emphasized the rising GDP share of modern services since the 1970s due to technological advances enhancing traditional and modern services complementarity. We find that TFP changes in modern services have a greater impact on GDP per worker than traditional services. However, the large share of value-added and labor in traditional services has a comparable effect on aggregate TFP. Traditional services also exhibit higher sectoral centrality, stimulating demand across other sectors.

This paper is organized as follows: Section 2 presents the dataset and stylized facts on value added per worker gaps and sectoral intermediate goods trends. Section 3 outlines our general equilibrium model. Section 4 details the model calibration for 39 countries. Section 5 compares the calibration results with empirical facts and presents our counterfactual exercises. Finally, Section 6 concludes with our findings.

2 Datasets and Stylized Facts

In this section, we present the dataset used in the article and some stylized facts observed in this dataset. We begin the section by describing the World Input and Output Database (WIOD) and the Socio-Economic Accounts (SEA). Next, we discuss the trend in the participation of intermediate goods in the production of economies and finally we show that there are gaps in GDP per worker at sectoral and aggregate levels.

2.1 Dataset

We use the World Input-Output Database (WIOD). This dataset offers a time series of input-output matrices (IO) that spans 2000 to 2014, and covers 43 countries and 56 sectors. Additionally, WIOD provides data pertaining to input quantity, prices, and volumes, including information on value added, capital stock, workers, and hours worked. These datasets are available within the Socio-Economic Accounts (SEA).[1]

We exclude countries with populations of fewer than one million inhabitants, namely Luxembourg and Malta, from our sample. Additionally, due to a lack of available data, we excluded Taiwan and Croatia, resulting in a sample size of 39 countries. We provide the names and acronyms of each country in Table B1 in appendix B. Furthermore, to facilitate cross-country comparisons of monetary values, we employ Purchasing Power Parity (PPP) data provided by the Organization for Economic Cooperation and Development (OECD); this indicator is measured in terms of national currency per U.S. dollar.[2]

Based on International Standard Industrial Classification of All Economic Activities (ISIC 4) we have classified the 56 sectors identified in the Socio-Economic Accounts (SEA) into three broad sectors: agriculture, industry, and services.[3] The agriculture sector encompasses activities such as animal production, hunting, fishing, forestry, and logging. The industry sector covers manufacturing, electricity, gas, water, mining and quarrying, waste treatment and disposal, and construction.

Regarding the services sector, we follow Ferreira and Silva (2015) and divide it into

[1] For a more comprehensive introduction to this database see Timmer et al. (2015).
[2] This indicator can be accessed on the OECD website: https://data.oecd.org.
[3] ISIC can be view in United Nations website: https://unstats.un.org.

two: modern services and traditional services. We consider modern services to be the sectors within services that have the highest average added value per worker. Modern services include financial services, real estate activities, insurance, scientific research, management consultancy, among others. In contrast, traditional services include educational services, healthcare, postal and courier activities, transportation, public administration and defense, and other related activities.[4] On average, the value added per worker of modern services is 2.4 times higher than in traditional services.

We adopted this approach because the services sector is quite heterogeneous, that is, various activities within this sector involve workers with varying skill levels, distinct levels of productivity, and varying degrees of economic significance. For example, employees in the educational services sector typically have different skills and exhibit different levels of productivity compared to those in the tourism sector. Our sector classification can be seen in Table E1 in appendix E.

2.2 Stylized Facts

2.2.1 Intermediate Inputs

The IO matrix represents the flow of intermediate goods between different sectors. The flow of intermediate goods determines the pattern of trade across sectors and creates networks between then, acting as a shock propagation mechanism, that is, a positive (negative) shock in the productivity of an important sector has a positive (negative) impact on all other sectors (Jones, 2011a; Carvalho and Tahbaz-Salehi, 2019; Boehm et al., 2019; Fadinger et al., 2022).

In more developed countries, intermediate goods production is more focused on service sectors, while in less developed countries, production is more focused on agriculture and industry. For example, the correlation between GDP per worker and the share of intermediate goods from agriculture and industry is -0.56 and -0.66, respectively. On the other hand, the correlation with the traditional services and modern services sec-

[4] A similar approach was employed by Rogerson (2008), Eichengreen and Gupta (2011) and Eichengreen and Gupta (2013).

tors is 0.43 and 0.66, respectively.[5] This observation is consistent with the literature on structural change (Eichengreen and Gupta, 2013; Herrendorf et al., 2014; Herrendorf and Schoellman, 2018; Sposi, 2019).

Although industry has great importance in the productive structure of less developed countries, it tends to lose share as economies specialize in the services sector. Rodrik (2016) documents that there is a trend towards premature deindustrialization in low and middle-income countries, that is, low- and middle-income countries are becoming service economies. To verify whether deindustrialization has been faster in recent periods, Rodrik (2016) used an econometric model with panel data in which the dependent variable is the share of labor in manufacturing, and the controls are the effects of demographic and income trends, as well as fixed effects of countries.[6]

We follow Rodrik (2016) and estimate a similar econometric specification; however, our objective is to analyze the trend in sectoral share of intermediate inputs. Our specification is the following:

$$\begin{aligned} II_{jt}^{share} = \beta_0 + \beta_1 \ln pop_{jt} + \beta_2 (\ln pop_{jt})^2 + \beta_3 \ln y_{jt} + \beta_4 (\ln y_{jt})^2 + \\ \sum_j \gamma_j C_j + \sum_T \omega_T D_T + \epsilon_{jt}, \end{aligned} \tag{1}$$

where II_{jt}^{share} is the share of intermediate inputs of country j in period t, pop is the population, y_{jt} is the GDP per capita, also there are quadratic terms for $\ln pop_{jt}$ and $\ln y_{jt}$, C_j are country fixed effects, D_T are period dummies, and ϵ_{jt} is an error term. Here, we use data from 2000 to 2014 and capture sectoral trends using period dummies for the 2003 – 2005, 2006 – 2008, 2009 – 2011, and 2012 – 2014.

Table 1 reports the results of the regression estimated using Equation 1 for the four sectors. Key parameters of interest are those for the time fixed effects, D05, D08, D11, and D14. These parameters shows the share of intermediate inputs of each period relative to the excluded period 2000 – 2002. Columns 1 and 2 present the estimates for agriculture

[5] We consider data from 2014.

[6] In alternative specifications Rodrik (2016) also uses as dependent variable the share of value added in real values and the share of value added in current values.

and industry and indicate that both sectors, especially industry, have been losing share in total intermediate inputs as time progresses. Columns 3 and 4 present the estimates for modern and traditional services and point to a contrary pattern to the first two sectors, that is, as in Rodrik (2016), as time progresses, the share of both sectors in the total of intermediate inputs increases, that is, these economies are becoming service sector-oriented economies.[7]

Table 1: Panel Regression Models - Sectoral Share of Intermediate Inputs, 2000:2014

	Dependent Variable: Share of Intermediate Inputs			
	(1)	(2)	(3)	(4)
	Agriculture	Industry	Modern Services	Traditional Services
Ln GDP per Capita	-0.184^{***}	0.006	0.141^{**}	0.038
Ln GDP per Capita Squared	0.008^{***}	0.003	-0.008^{***}	-0.003
Ln Population	-0.314^{***}	-0.875^{***}	0.848^{***}	0.340^{***}
Ln Population Squared	0.009^{***}	0.025^{***}	-0.025^{***}	-0.009^{**}
D05	-0.001	-0.007^{**}	0.004^{*}	0.004^{**}
D08	-0.001	-0.007	0.008^{**}	0.001
D11	0.001	-0.030^{***}	0.019^{***}	0.011^{***}
D14	0.003	-0.035^{***}	0.023^{***}	0.009^{**}
Country Fixed Effects	✓	✓	✓	✓
Observations	585	585	585	585
R^2	0.628	0.261	0.124	0.115
Adjusted R^2	0.596	0.198	0.050	0.040
F Statistic (df = 8; 538)	113.361^{***}	23.728^{***}	9.561^{***}	8.759^{***}

Notes: Statistical significance is indicated at the $***p < 0.01$, $**p < 0.05$, and $*p < 0.1$ levels. Our dataset comprises data from 2000 to 2014. We use four time dummies variables: D05, D08, D11, and D14 that indicate whether the period goes from 2003 to 2005, 2006 to 2008, 2009 to 2011 and 2012 to 2014, respectively. Note that we exclude dummy that indicates the period goes from 2000 to 2002.

If economies actually converge towards a structure in which the service sector, both modern and traditional, are more important than the others, would this lead to a reduction in the income gap between countries? This question is explored in the following sections.

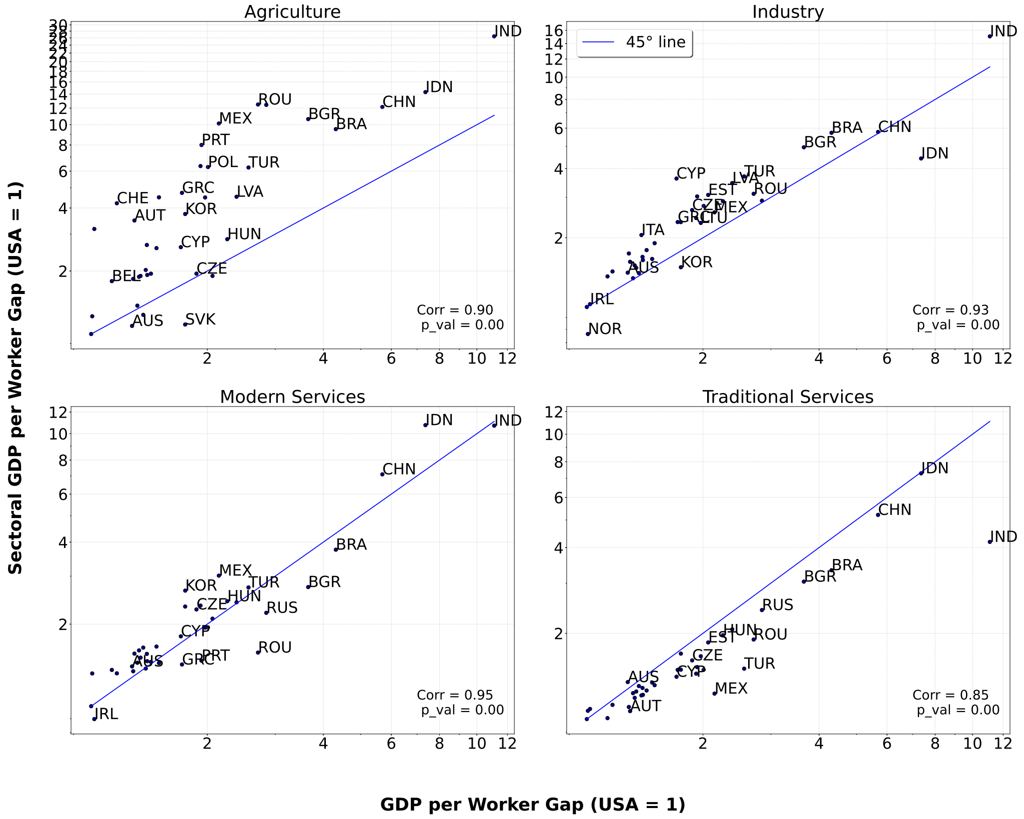
[7]In Table D1 in appendix D we show that the share of sectoral value added presents a similar pattern to the share of sectoral intermediate inputs.

2.2.2 GDP per worker

In this section, we document the gaps in GDP per worker, both at the sectoral and aggregate levels, between the countries in the sample and the U.S. This measure is defined as the ratio of GDP per worker in the U.S. to that of other countries. We use the U.S. as a reference because this country is one of the countries that comes closest to the technological frontier (Herrendorf et al., 2022).

Figure 1 presents the GDP per work gap between countries in our dataset and the USA. The points below (above) the 45-degree line indicate countries where the gap in aggregate GDP is greater (lower) than the gap in sectoral GDP. We highlight two facts. Firstly, the GDP gap in agriculture is larger than in other sectors in most countries. The average gap in agriculture is 5.2, indicating that the value added per worker in the U.S. is 5.2 times higher than in the other countries on average. Furthermore, on average, the gap in agriculture is greater than in the aggregate, which is 2.28. This result is consistent with the findings of Restuccia et al. (2008), Herrendorf and Valentinyi (2012), Gollin et al. (2014), and Herrendorf et al. (2022). In industry, the gap is smaller than in agriculture, on average 2.75, but is larger than in the aggregate. Secondly, the GDP per worker gap in the traditional and modern service sectors are, on average, 1.83 and 2.43, respectively.

Figure 1: GDP per Worker Gap, Aggregated and Sectorial - 2014



Notes: This figure is on logarithmic scale. Points below (above) the 45-degree line indicating countries where the gap in aggregate GDP is greater (lower) than the gap in sectoral GDP.

The total aggregate productivity factor (TFP) depends on the sectoral productivity and labor share, and one of the channels to fill these gaps is to reallocate labor to sectors where productivity is higher. In this context, agriculture, normally the least productive sector, plays a crucial role in explaining income differences between countries, since less developed countries allocate a significant part of the workforce in this sector.[8] Therefore, income disparities between the least developed and most developed countries would tend to decrease if the labor force was reallocated from agriculture to the most productive sectors of the economy (Restuccia et al., 2008; McMillan and Rodrik, 2011; Herrendorf et al., 2022).

Despite significant contributions from labor reallocation, the potential for further gains in total factor productivity (TFP) may be limited, as much of the workforce is

[8]In India, in Indonesia and China, the percentage of labor in agriculture is 45%, 31%, and 24%, respectively

already concentrated in the most productive sectors. To bridge these gaps and drive economic growth, improving productive efficiency within sectors becomes crucial. This raises important questions: Which sector would most effectively boost income and economic growth if labor were reallocated from agriculture? Alternatively, if TFP were to increase across sectors, which one would have the greatest impact on reducing income gaps? Additionally, considering the interconnections created by intermediate inputs between sectors, which sector has the strongest potential to stimulate overall production? To answer this question and others raised in Section 2.2.1, we developed a general equilibrium model in which we make explicit the importance of productivity and intermediate goods in the production function. We calibrate the model and conducted a series of counterfactual exercises.

3 Model

In this section we provide an overview of the model. First, we describe the problem of the firm and the representative consumer. Next, we present the equilibrium conditions and the optimal solution of the model, and finally, we discuss how changes in productivity affect the production chain and the economy's final product.

3.1 Firms

In this economy, there is a continuum of homogeneous and competitive firms in each of the N productive sectors. They maximize profits by optimally choosing how much to employ labor and how much to use each of the intermediate goods. The production technology is given by:

$$Q_i = A_i L_i^{\sigma_i} \left(\prod_{j \in N} X_{ij}^{\beta_{ij}} \right)^{1-\sigma_i}, \quad i \in N, \tag{2}$$

where Q_i is the gross product of sector i, A_i is the total factor productivity (TFP), L_i is the amount of labor employed and X_{ij} is the matrix of intermediate goods where the columns indicate the sector of the origin of goods and services while the rows indicate the sector of destination. Furthermore, σ_i is the elasticity of the good of sector i with respect to labor and β_{ij} is the elasticity of the set of intermediate goods i with respect to the specific intermediate good j. Specifically, a high β_{ij} indicates that sector j produces more intermediate inputs for sector i, while $\beta_{ij} = 0$ indicates that input j is not needed in the production of good i, we also assume that for all i $\sum_{j \in N} \beta_{ij} = 1$.

The firm's problem can be written as:

$$\underset{X_{ij}, L_i}{\text{Max}} \quad p_i Q_i - w L_i - \sum_{j \in N} p_j X_{ij}, \tag{3}$$

$$\text{st:} \quad Q_i = A_i L_i^{\sigma_i} \left(\prod_{j \in N} X_{ij}^{\beta_{ij}} \right)^{1-\sigma_i},$$

where w is the amount of wage. From the first order conditions of the problem we have:

$$X_{ij} = (1 - \sigma_i) \frac{p_i}{p_j} Q_i \beta_{ij}, \tag{4}$$

$$L_i = \frac{\sigma_i p_i Q_i}{w}. \tag{5}$$

3.2 Consumers

The economy is populated by an infinite number of homogeneous individuals who inelastically supply an amount of labor L. The representative individual has preference Stone-Geary over the consumption of N goods offered in the economy and chooses consumption c_i to solve the following problem:[9]

$$\begin{aligned} \underset{c}{\text{Max}} \quad & \log \left[\prod_{i \in N} (c_i - \bar{c}_i)^{\alpha_i} \right] \\ \text{st:} \quad & \sum_{i \in N} p_i c_i = wL, \end{aligned} \tag{6}$$

where $\bar{c}_i$ are the minimum level of the consumption, α_i are nonnegative weights, p_i are prices and w is the amount of wage. We also assume that $\sum_i^N \alpha_i = 1$.

[9]This type of preference function is common in the literature and can be view in Herrendorf et al. (2013) and Herrendorf et al. (2014).

The first order conditions of the problem give us the optimal consumption:

$$c_i = \bar{c}_i + \frac{\alpha_i}{p_i}\left(w - \sum_{j=1}^{4} p_j \bar{c}_j\right). \tag{7}$$

3.3 Equilibrium

3.3.1 Conditions

A competitive equilibrium is a set of prices p_i, wages w, and allocations $c_i, Y_i, L_i, Q_i, X_{ij}$ such that:

1. c_i solve the consumer problem, taking p_i and w as given.
2. L_i, and X_{ij} solve the firm's problem, taking p_i and w as given.
3. Markets clear conditions:
   (a) The demand for labor by firms must be equal to the supply of individuals:

$$\sum_{i \in N} L_i = L. \tag{8}$$

   (b) The consumption of each good must be equal to the supply of the product intended for consumption:

$$Y_i = c_i, \qquad \forall i \in N. \tag{9}$$

   (c) The supply of product must equal the demand of firms and individuals:

$$Q_i = Y_i + \sum_{j \in N} X_{ij}, \qquad \forall i \in N. \tag{10}$$

The solution of the model can be view in appendix A.

3.4 Propagation Channels

Production technology, given by Equation (2), takes into account an important characteristic of the productive structure of any economy, which is the interdependence between sectors through the use of intermediate goods. This network allows the impact of TFP changes in a specific sector to spill over to other sectors of the economy. For example, if a specific sector experiences an improvement in efficiency for a certain reason (innovation, factor reallocation, technological advancement, etc.) and increases its TFP, the sectors that use its goods and services start producing more.

Suppose that there are only two sectors in the economy, A and B. If the TFP of sector A experiences a positive change, the amount of intermediate goods produced by sector A increases and the price decreases. The price reduction has a positive impact on the sector B, which begins to demand more inputs from A and consequently increases its production. As a result, the prices of goods produced by sector B decrease, leading sector A to demand more goods from sector B. The magnitude of the effect of the initial variation will depend on β_{ij}, and σ_i.

4 Calibration

In this section, we describe the steps of the empirical investigation. First, we discuss how we calibrate the constant parameters of the model presented in the previous section. Then we detail how we calibrate the model and present the result of the adjustment.

4.1 Exogenous Calibration

We need to define four parameters of the model, α_i, β_{ij}, σ_i, and L. All parameters are calculated using input-output matrices (IO) and Socio-Economic Accounts (SEA) data. We calculated the weights of consumption in the utility function, α_i, as the ratio of consumption of good i in relation to total income. The elasticity of the set of intermediate goods with respect to the intermediate good j, β_{ij}, is calculated directly using the input-output matrix for each country. Specifically, β_{ij} represents the share of intermediate goods of sector j used in the production of sector i. The elasticity of good in sector i with respect to labor, σ_i, is given by the ratio between the compensation of the employees and the gross output of the industry.[10] Finally, the total amount of labor, L, is associated with the number of people engaged in production in each respective country.

4.2 Endogenous Calibration

We calibrated the model for 39 countries in the sample with data from 2014. Our calibration strategy consists of selecting values for sectoral productivity, A_i, and agricultural subsistence consumption, $\bar{c}_{agr}$, in such a way that the value added per worker and the labor share of agriculture, resulting from the equilibrium of the model, coincide with the values present in the data.[11] We define the following objective function for our numerical routine:

$$D = \sum_{i=1}^{N} \left(\frac{VA_i^M - VA_i^T}{VA_i^T} \right)^2 + \left(\frac{Lsh_{agr}^M - Lsh_{agr}^T}{Lsh_{agr}^T} \right)^2 \tag{11}$$

where VA is the value added per worker, Lsh_{agr} is the labor share of agriculture, and the superscripts M and T indicate the model and target statistics. The value added per worker from the model, VA_i^M, is calculated as follows:

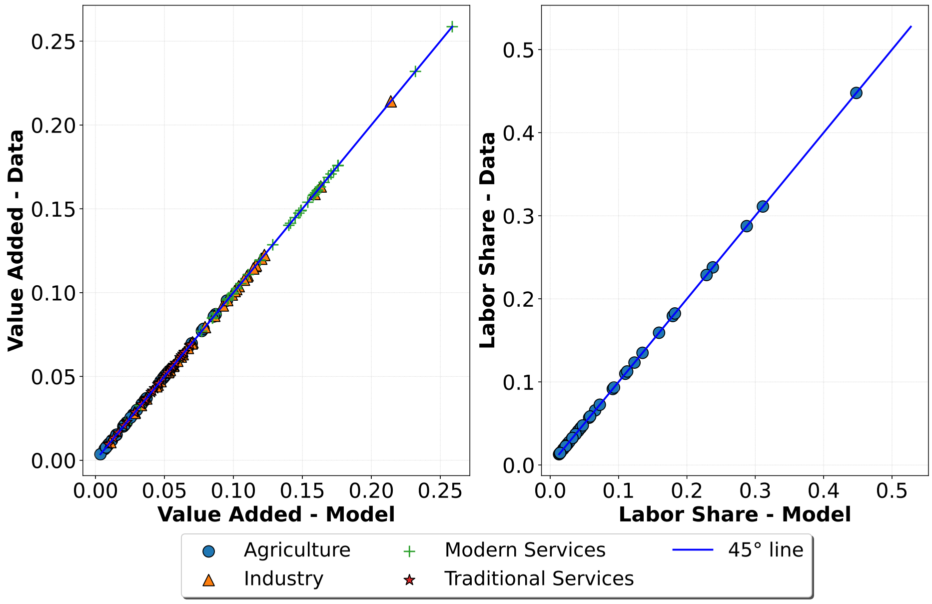
$$VA_i^M = \frac{p_i^{USA} c_i}{L_i^M}, \tag{12}$$

where p_i^{USA} is USA prices of good i, c_i is the consumption, and L_i^M is the labor amount. Calibration is performed for each country independently of the others, and, in all, we calibrated 195 parameters. Figure 2 shows the added value present in the data (y-axis) and the added value resulting from the equilibrium of the model (x-axis). The model fits well with the empirical data, as the points are well fitted to the 45-degree line.

[10] The calculation of σ_i is a direct consequence of Equation (5).

[11] Note that we only calibrate subsistence consumption in agriculture, in other sectors we consider it as zero.

Figure 2: Model Adjustment to Data



Notes: We consider only labor share from agriculture.

5 Results

In this section, we present the results of the paper. Initially, we discuss the calibrated Total Factor Productivity (TFP) and demonstrate that some model outcomes are aligned with empirical facts. Next, we address the results of two counterfactual exercises we conducted. In the first exercise, we apply the elasticity of intermediate goods from the U.S. to other countries and show the effects on the GDP per worker gap. In the second exercise, we apply the U.S. sectoral TFP to other countries, analyze the impacts on the GDP per worker gap at both the sectoral and aggregate levels, and explore the implications for the production chain through intermediate goods. Additionally, we examine the effects of this exercise on aggregate TFP.

5.1 Total Factor Productivity

In Figure 3, we present calibrated sectoral TFP alongside GDP per worker.[12] As expected, the productivity of the four sectors is positively associated with the level of development in the countries, which means that the more developed countries tend to

[12]The calibrated sectoral TFP for each country can be seen in appendix B.

be more productive in all sectors. The relationship between sectoral productivity and GDP per worker is direct, meaning that a potential positive shock in productivity can contribute to its rise.

Figure 3: Total Factor Productivity

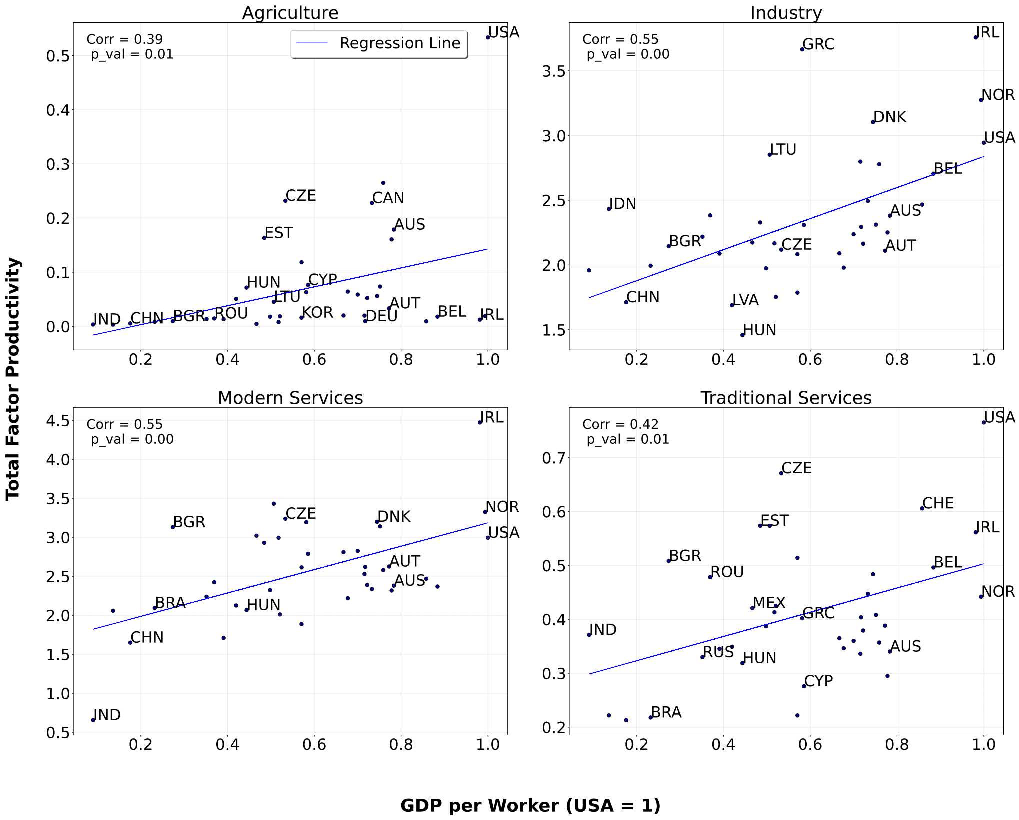


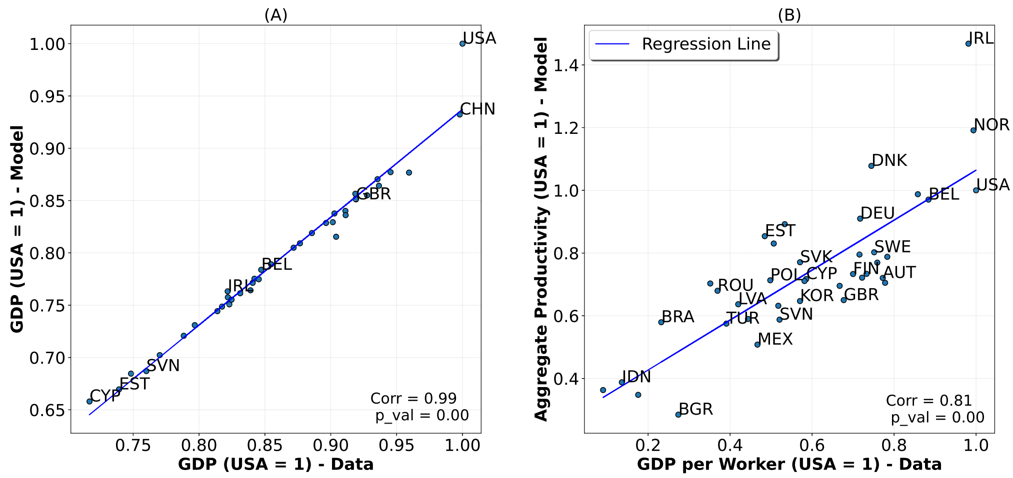
Table 2 provides descriptive statistics for the calibrated TFP. On average, the modern services sector is the most productive sector, followed by the industry. This result comes from the fact that modern services cover subsectors that have added value per worker well above the average, for example, real estate activities, financial services, and insurance and reinsurance. This finding suggests that reallocating labor from agriculture to modern services has a more positive effect on aggregate productivity than if labor were directed to industry, for example.

Table 2: Descriptive Statistics of TFP

Sectors	Mean	Std	Min	25%	Median	75%	Max
Agriculture	0.07	0.10	0.00	0.01	0.02	0.07	0.53
Industry	2.34	0.50	1.46	2.09	2.24	2.48	3.76
Modern Services	2.57	0.63	0.66	2.23	2.53	2.99	4.47
Traditional Services	0.41	0.12	0.21	0.34	0.39	0.48	0.77

Figure 4 (A) compares the GDP data with GDP and TFP values generated by our model. It is observed that the GDP of the calibrated model fits well with the GDP of the data, and the correlation between these two sets of data is close to unity and statistically significant at the confidence level 1%. Figure 4 (B) compares aggregate TFP and GDP per worker from data, it is observed that aggregate TFP also has a positive correlation with the level of income per worker of the countries.[13] Note that Bulgaria, India, Russia, and China are the countries with the lowest aggregate TFP, while Ireland, Norway, Denmark, and the U.S. are the most productive.[14]

Figure 4: Comparison Between Data and Model Results



Note: We have logarithmized GDP to improve the scale of the figure.

5.2 Services-Oriented Economies

In this section, we analyze what would happen to the economies of the sample countries if their production structures converged to that of the U.S. Thus, we conduct a

[13] Aggregate TFP is the sum of sectoral TFP weighted by labor share in each sector.

[14] Our model also replicates well other important characteristics of economies, for example, the share of intermediate goods, gross product, and labor. See Figure B1 in the appendix for a detailed comparison of these shares between the model and observed data.

counterfactual exercise in which we insert the elasticity of the set of intermediate goods i in relation to the specific intermediate good j, β_{ij}, of the U.S. into the other countries. Specifically, by doing this, we make the importance of good j in the production of good i equal to that of the U.S.

In Table 3, we present the average sectoral shares of intermediate inputs and labor before and after this counterfactual exercise, along with those of the U.S. It is observed that the average share of intermediate inputs before the exercise is higher in the industry (72.15%), followed by modern services (19.23%). On the other hand, the labor share is higher in traditional services (46.45%), followed by the industry (32.94%). However, after the exercise, the shares of intermediate inputs and labor become more similar to those of the U.S. In other words, the industry loses its share and economies become more service-oriented, with modern and traditional services gaining a larger share. Note that what we did was reduce the gap in the share of intermediate inputs and labor to almost zero.

Table 3: Counterfactual 1 - Average Percentage Share of Intermediate Inputs and Labor

	Intermediate Inputs			Labor		
Sectors	Before	After	USA	Before	After	USA
Agriculture	0.18	0.22	0.59	2.51	1.92	1.65
Industry	72.15	53.06	50.46	32.94	23.04	22.55
Modern S.	19.23	29.59	30.94	18.30	18.61	21.25
Traditional S.	8.44	17.13	18.01	46.25	56.43	54.55

Table 4 demonstrates the average percentage change in the sectoral GDP gap per worker in three different scenarios: when exclusively modifying the parameter β_{ij}, when modifying only the TFP and, finally, when change both simultaneously. It is noticeable that, in the first scenario, there was a considerable increase in GDP gaps per worker in all sectors.

This negative average effect on economies can be explain by the fact that if β_{ij} increases, the dependency of sector i on input j increases. This means that sector i now uses a larger proportion of input j for its production. As a result, the demand for intermediate inputs X_{ij} increases. According to Equation (4), this implies that, to maintain equilibrium, the relative price p_i/p_j must also adjust, leading to an increase in the price p_i if p_j remains constant or also increases. This pressure on the prices of intermediate inputs translates into higher costs for the sectors that depend on them, resulting in higher prices for the final goods. Consequently, this reduces the quantity consumed of each good c_i.

In China, for example, the industrial sector supplies many inputs to itself. However, structural changes have led to increased dependency on the service sector. Although more labor has been directed to the service sector, it is not enough to meet the demand for goods. Consequently, the prices of goods and services provided by the service sector increase. This rise in costs causes the Chinese industrial sector to produce less, making final goods more expensive, which in turn leads to a reduction in consumption.

In the second scenario, as expected, we noticed a reduction in the gap. In the third scenario, it is noted that there was also a reduction in the gap, this is due to the fact that along with the structural change there was an increase in productivity, which means the sectors produce more intermediate inputs and are able to meet demand. These findings suggest that structural change alone, without an appropriate increase in TFP, is not capable of reducing income gaps between countries.

Table 4: Counterfactual 1 - Average Percentage Change Sectoral GDP per Worker Gap

	% Change in sectoral GDP per worker gap		
Sectors	Change β_{ij}	Change TFP	Change Both
Agriculture	44.84	-91.43	-92.58
Industry	35.46	-78.27	-78.03
Modern Services	80.83	-71.56	-61.69
Traditional Services	58.26	-78.68	-72.23

5.3 Sectoral TFP and Economic Development

To investigate which sectors have the greatest capacity to boost economies and reduce the gap in GDP per worker, in relation to the U.S., given an improvement in productive efficiency, we conducted the following counterfactual exercise: (i) We calculate the GDP per worker gap at the sectoral and aggregate level;[15] (ii) We then enter the U.S. sectoral TFP, one at a time, into each of the sectors analyzed;[16] (iii) We calculate the percentage change in TFP; (iv) We repeat step (i), and measure the percentage change in the GDP gap per worker at the sectoral and aggregate level. We then analyze the effects on GDP per worker, intermediate goods, and aggregate productivity.

5.3.1 GDP per Worker

First, we will analyze the effects on GDP per worker. This allows us to assess the extent to which an increase in sectoral TFP reduces the gap in GDP per worker between the U.S. and the other countries, both at the sectoral and aggregate levels. Figure 5 illustrates the results of this exercise at the aggregate level. The x-axis presents the percentage change in the GDP gap per worker, while the y-axis presents the percentage change in TFP. It is also noted that there is a negative correlation between both variables, that is, where there have been greater increases in TFP, there have also been greater reductions in the GDP per worker gap.

[15] Recall that the GDP per worker gap is calculated as the ratio between the GDP per worker of the U.S. and that of the other countries in the sample .

[16] U.S. TFP in agriculture, industry, modern services, and traditional services is 0.54 , 2.94 , 2.99, 0.76, respectively.

Figure 5: Counterfactual 2 - Percentual Changes in GDP per Worker Gap

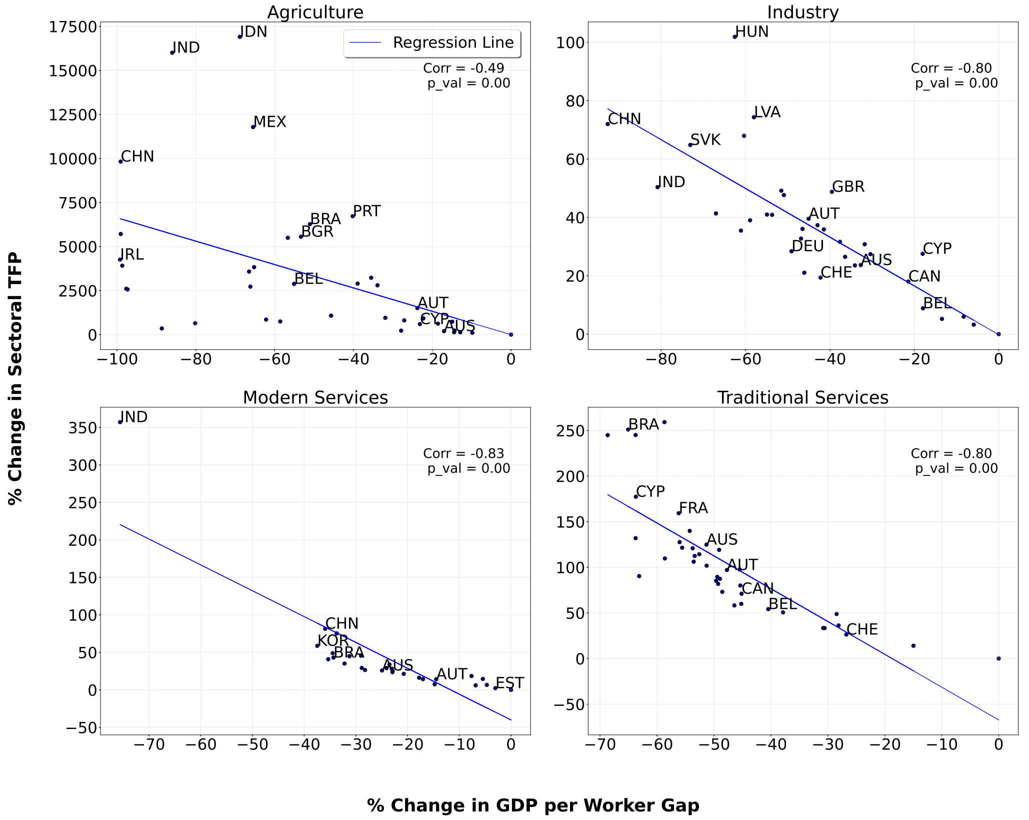


Table 5 presents the average results of this counterfactual exercise. The first column of the table shows the average percentage change in TFP. The second and third columns show the average percentage reduction in the GDP gap per worker at the sectoral and aggregate level, respectively. The last two columns are the ratios between columns three and four, and column two. Both columns illustrate the proportional effect of variations in TFP on the variation in the GDP gap per worker, at the sectoral and aggregate levels, respectively. In agriculture, for example, the 3,432.02% increase in TFP resulted in average reductions of 88.18% and 51.76% in the difference in GDP per worker at the sectoral and aggregate level, respectively. When analyzing proportional effects, we find that a 1% increase in TFP translates, on average, into a decrease of 0.03% and 0.02% in the GDP per worker gap at the sectoral and aggregate level, respectively.

If we combine with the results provided in the fourth and fifth columns, we note that there is a clear order of the average impact of sectoral TFP changes on the GDP per worker gap at sectoral and aggregate levels. The impact of productivity changes in the industrial sector is greater than in the modern services sector, which in turn exceeds the impact in traditional services and is ultimately greater than in the agricultural sector.

Table 5: Counterfactual 2 - Average Percentage Change in GDP per Worker Gap

	(1)	(2)	(3)	(4)	(5)
	Average % Change				
Sectors	TFP	**Sectoral** GDP Per Worker gap	GDP Per Worker gap	Ratio 1 (2)/(1)	Ratio 2 (3)/(1)
Agriculture	3432.02	-88.18	-51.76	-0.03	-0.02
Industry	36.98	-60.07	-44.50	-1.62	-1.20
Modern Services	40.45	-33.62	-23.80	-0.83	-0.59
Traditional Services	106.20	-68.31	-48.72	-0.64	-0.46

5.3.2 Intermediate Goods as Channels for Propagating Changes in Productivity

The effect of sectoral TFP changes on GDP per worker gap can be attributed to two main factors. First, by increasing the productivity of a sector, there is a reallocation of workers in the economy; that is, the positive variation in the productivity of a sector is associated with a positive variation in labor share. The shift of labor from low productivity sectors, for example agriculture, to high productivity sectors such as modern services and industry is a driver to further increase the final product of economies.

Second, interdependence between sectors causes the effect of the impact of a productivity change on a specific sector to spread to other sectors of the economy. For example, in the sector that receives the productivity change, prices decrease, so there is a greater demand for intermediate goods. Hence, sectors that use the now more productive goods and services as intermediate inputs will also benefit indirectly, and so on. In Table 6 we present the average percentage change in intermediate inputs after counterfactual exercise, the columns of the table indicate the sector that received the shock, while the rows indicate the average percentage change in intermediate inputs of the respective sector.

We highlight two facts. First, a productivity change in a specific sector has a greater effect on the supply of intermediate goods within that same sector. For example, inserting the TFP of the U.S. industry into the industry of other countries resulted in an average increase of 416.24% in the supply of intermediate goods within the same sector. Secondly, given the change in the TFP, industry and traditional services were the sectors that most stimulated the supply of intermediate goods in other sectors of the economy, on average.

Table 6: Counterfactual 2 - Average Percentage Change in Supply of Intermediate Inputs

Sectors	Agriculture	Industry	Modern Services	Traditional Services
Agriculture	1285.73	63.97	3.81	30.15
Industry	85.38	416.24	10.45	88.06
Modern Services	74.20	98.02	103.83	100.80
Traditional Services	69.09	93.01	8.52	328.13

This high effect of productivity changes in industry and traditional services, in the production chain, can be attributed to the fact that both sectors are, on average, the most central. Central sectors are those that are most closely linked in production networks with other sectors, which implies that positive productivity changes in these sectors tend to have a greater impact on the production chain and GDP compared to more peripheral sectors.

To measure how central a sector is, we calculated the Bonacich-Katz centrality index, which measures the importance of a sector as a supplier to the economy and has been applied in the recent literature on the diffusion of macroeconomic shocks (Acemoglu et al., 2012; Carvalho, 2014; Grassi and Sauvagnat, 2019). The centrality index is, on average, higher in traditional service sectors and industry, 0.75 in both. Agriculture and modern services have a Bonacich-Katz centrality index, on average, equal to 0.32 and 0.41, respectively.[17]

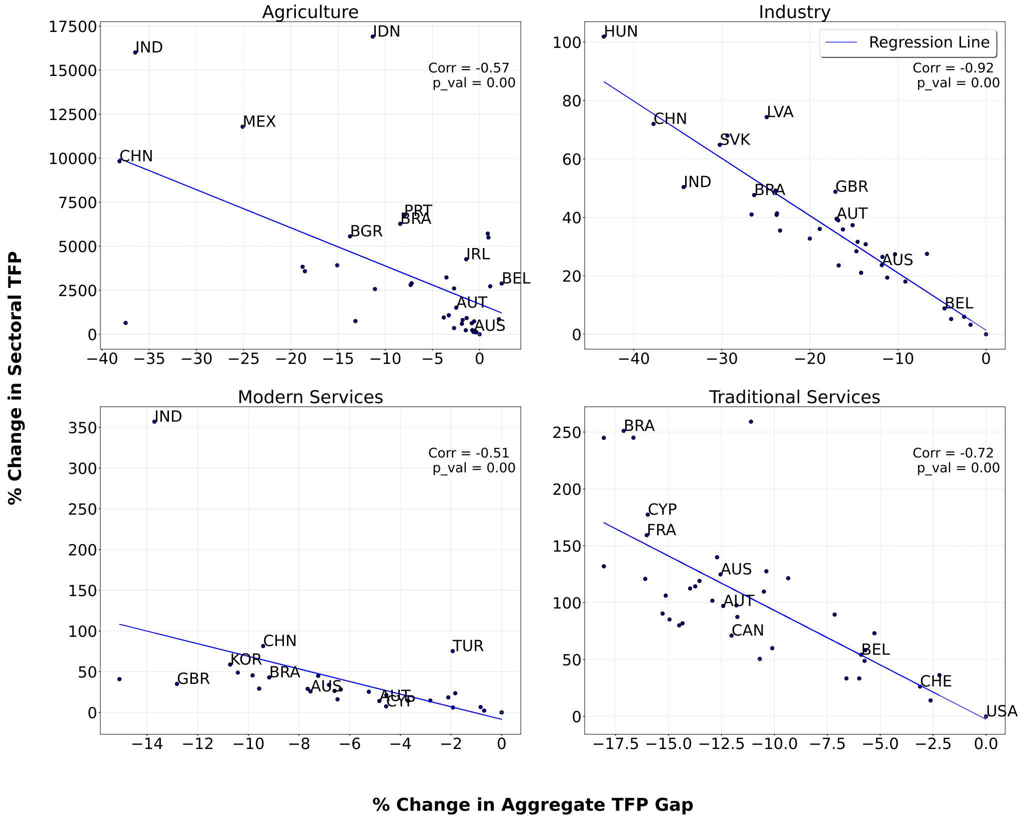
5.3.3 Aggregate Productivity

In Section 5.3.1, we evaluated the effects of TFP changes on GDP per worker at both the sectoral and aggregate levels. In this section, we examine the effects of the same exercise on aggregate TFP. The aggregate TFP is simply the sum of sectoral TFPs, weighted by labor share.

[17]In appendix C we provide the method for calculating the Bonacich-Katz centrality index.

The Figure 6 presents the results of the analysis. On the x-axis, we have the percentage change in the aggregate TFP gap, while on the y-axis we have the percentage change in the sectoral TFP. A negative correlation is observed between these two variables in all sectors. In other words, the observed pattern is consistent with the results discussed in the previous section, where significant increases in sectoral TFP resulted in steeper reductions at the aggregate level.

Figure 6: Counterfactual 2 - Percentual Changes in Aggregate TFP Gap



The Table 7, similar to the table presented in the previous section, presents the average results of the counterfactual. It is observed that industry demonstrated a more significant proportional effect than other sectors, indicating that a 1% increase in industry TFP results in an average reduction of 0.4% in the aggregate TFP gap (see column 3).

Table 7: Counterfactual 2 - Average Percentage Change in the Aggregate TFP Gap

	(1)	(2)	(3)
	Average % Change		
Sectors	TFP	Aggregate TFP gap	Ratio 1
			(2)/(1)
Agriculture	3432.02	-7.52	-0.00
Industry	36.98	-14.90	-0.40
Modern Services	40.45	-3.81	-0.09
Traditional Services	106.20	-11.08	-0.10

When comparing this exercise with that of the previous section, an interesting particularity can be noted in the services sector. Modern services demonstrate a greater average impact on the GDP gap per worker when subject to changes in TFP, in contrast to traditional services. On the other hand, it is observed that traditional services exert a very similar average impact on aggregate productivity when subject to changes in sectoral TFP, compared to modern services (0.09 versus 0.1). This distinction occurs because, on average, the traditional services sector concentrates the majority of the workforce, which results in a significant weight in the calculation of aggregate TFP. Therefore, TFP changes in this sector also have a substantial influence on aggregate TFP, as indicated by the fact that, on average, traditional services hold 44% of the labor share.

In the case of agriculture, changes in TFP have little effect on aggregate TFP. This is because in this sector, labor share and TFP are relatively small compared to other sectors. As can be seen in Table 7, on average an increase of 3432.02% in sectoral TFP only resulted in a reduction of 7.52% in the aggregate. Column 3 shows that the proportional effect was close to zero.

6 Final Remarks

In this article we develop a general equilibrium model to quantitatively evaluate the effects of changes in TFP and changes in the productive structure on income disparity in developed and developing countries. We used WIOD data from 2014 and calibrated the model for 39 countries. We carried out two counterfactual exercises, in the first we imputed the elasticity of US intermediate goods in other countries and evaluated the effects on the income gap per worker. In the second exercise, we imputed the US TFP in the other countries and evaluated the effects on the income gap per worker, on the aggregate TFP and on the supply of intermediate inputs.

Our findings show that TFP in modern services is, on average, higher than in other sectors. However, closing the industry TFP gap, relative to the U.S., results in a greater average reduction in the gaps in income per worker and aggregate productivity gaps. Furthermore, industry is, on average, the most central sector; therefore, this sector has a greater capacity to transmit productivity changes and, consequently, to stimulate production in other sectors. In this context, prioritizing policies that improve TFP in industry can have a significant impact on reducing differences in income and productivity, especially in developing countries.

We also show that if economies became more service-oriented, without the necessary increase in TFP, this would further increase the income gap per worker. This arises from the fact that some countries have a very productive industrial sector, therefore, a structural change that causes these countries to produce more intermediate inputs in the service sectors causes these economies to move resources from more productive sectors to the services sector, which in turn harms economic development. Therefore, policies that aim to increase TFP in services, are crucial so that structural change does not result in an increase in the income gap. Investments in technology, innovation and training in the services sector are necessary to keep up with the increased share of this sector in the economy. A future avenue of research is to identify the drivers that cause economies to become more service-oriented.

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Appendix A Model Solution

To solve the equilibrium first we calculate the labor amount L_i and then the prices p_i. First, to calculate the labour we can rewrite Equation (5) as: $Q_i = wL_i/(\sigma_i p_i)$, and replace in Equation (4) to get the demand of X_{ij} in terms of L_i:

$$X_{ij} = wL_i \left(\frac{1-\sigma_i}{\sigma_i} \right) \frac{\beta_{ij}}{p_j}. \tag{13}$$

Replacing Equation (13) in Equation (2) we have:

$$Q_i = wA_i L_i \left(\frac{1-\sigma_i}{\sigma_i} \right)^{(1-\sigma_i)} \prod_{j \in N} \left(\frac{\beta_{ij}}{p_j} \right)^{(1-\sigma_i)\beta_{ij}}. \tag{14}$$

To get the solution of equilibrium we can use Equations (9), (13) and (14) to rewrite Equation (10) as:

$$G_i L_i = \sum_{j \in N} B_{ij} L_i + c_i. \tag{15}$$

Note that G_i and B_{ij} are simply Q_i and X_{ij} divided by L_i, respectively. The next steps are to divide both sides of the Equation (15) by G_i, transform the system of equations into matrix form and solve to find the amount of labor L_i in each sector:

$$\mathbf{L} = \left(\mathbf{I} - \hat{\mathbf{B}}' \right)^{-1} \hat{\mathbf{c}}, \tag{16}$$

where $\mathbf{I}$ is the identity matrix, and $\hat{\mathbf{B}}$ and $\hat{\mathbf{c}}$ are B_{ij} and c_i divided by G_i, respectively.

To obtain prices, we substitute Equation (14) into (5) and take the logarithm, which implies:

$$\ln p_i - (1-\sigma_i) \sum_j \beta_{ij} \ln p_j = \Phi_i, \tag{17}$$

where $\Phi_i = -\ln A_i - \ln(1-\sigma_i)^{1-\sigma_i} \sigma_i^{\sigma_i} + (1-\sigma_i) \sum_j \beta_{ij} \ln \beta_{ij}$. This system of equations can be written in matrix form

$$\hat{\mathbf{p}} - \mathbf{D}\boldsymbol{\beta}\hat{\mathbf{p}} = \boldsymbol{\Phi},$$

and solved to find vector prices $\hat{\mathbf{p}}$:

$$\hat{\mathbf{p}} = (\mathbf{I} - \mathbf{D}\boldsymbol{\beta})^{-1} \boldsymbol{\Phi}, \tag{18}$$

where $\hat{\mathbf{p}}$ is the logarithm of vector prices and $\mathbf{D}$ is a diagonal matrix defined as $\mathbf{D} = \text{diag}(1-\sigma_i, \cdots, 1-\sigma_N)$. If we take the exponential of $\hat{\mathbf{p}}$ we then have a vector of sectoral prices that depend on TFP, and constants.

Appendix B Model Results

Table B1: Sectoral TFP

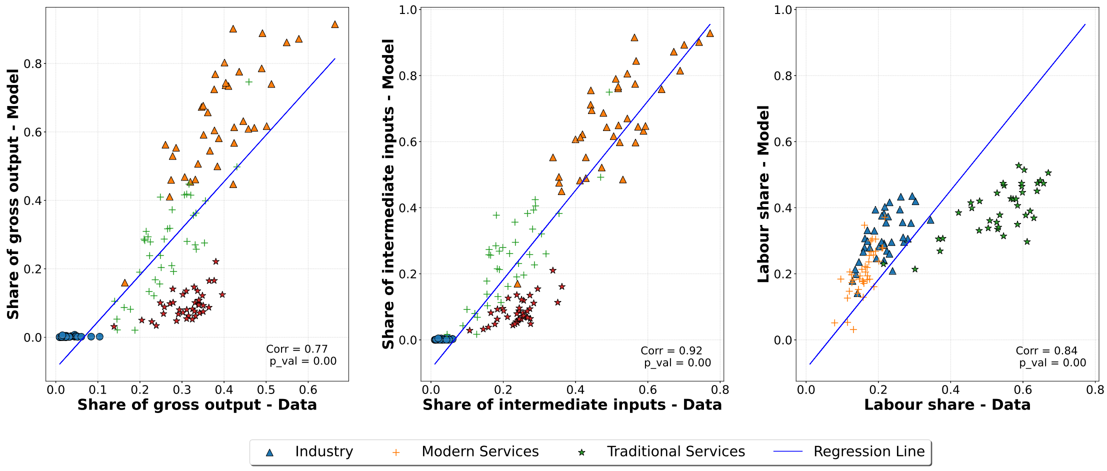
Country	Code	Agriculture	Industry	Modern Services	Traditional Services
Australia	AUS	0.18	2.38	2.38	0.34
Austria	AUT	0.03	2.11	2.62	0.39
Belgium	BEL	0.02	2.71	2.37	0.50
Brazil	BRA	0.01	1.99	2.09	0.22
Bulgaria	BGR	0.01	2.14	3.13	0.51
Canada	CAN	0.23	2.49	2.34	0.45
China	CHN	0.01	1.71	1.65	0.21
Cyprus	CYP	0.08	2.31	2.79	0.28
Czech Republic	CZE	0.23	2.12	3.24	0.67
Denmark	DNK	0.06	3.10	3.20	0.48
Estonia	EST	0.16	2.33	2.93	0.57
Finland	FIN	0.06	2.24	2.83	0.36
France	FRA	0.16	2.25	2.32	0.30
Germany	DEU	0.01	2.29	2.62	0.40
Greece	GRC	0.06	3.67	3.19	0.40
Hungary	HUN	0.07	1.46	2.07	0.32
India	IND	0.00	1.96	0.66	0.37
Indonesia	IDN	0.00	2.43	2.06	0.22

Continued on next page

Table B1: Sectoral TFP (Continued)

Country	Code	Agriculture	Industry	Modern Services	Traditional Services
Ireland	IRL	0.01	3.76	4.47	0.56
Italy	ITA	0.05	2.16	2.39	0.38
Japan	JPN	0.02	2.09	2.81	0.36
Latvia	LVA	0.05	1.69	2.13	0.35
Lithuania	LTU	0.05	2.85	3.43	0.57
Mexico	MEX	0.00	2.17	3.02	0.42
Netherlands	NLD	0.26	2.78	2.58	0.36
Norway	NOR	0.02	3.27	3.32	0.44
Poland	POL	0.02	1.97	2.32	0.39
Portugal	PRT	0.01	2.17	2.99	0.41
Rep. of Korea	KOR	0.02	2.08	1.89	0.22
Romania	ROU	0.01	2.38	2.42	0.48
Russia	RUS	0.01	2.22	2.24	0.33
Slovakia	SVK	0.12	1.79	2.61	0.51
Slovenia	SVN	0.02	1.75	2.01	0.42
Spain	ESP	0.02	2.80	2.53	0.34
Sweden	SWE	0.07	2.31	3.14	0.41
Switzerland	CHE	0.01	2.47	2.47	0.61
Turkey	TUR	0.01	2.09	1.71	0.35
United Kingdom	GBR	0.06	1.98	2.22	0.35
United States	USA	0.53	2.94	2.99	0.77

Figure B1: Comparison Between Data and Model Results



Note: We exclude labor share from agriculture.

Appendix C Bonacich-Katz Centrality Index

In this section, we describe how to calculate Bonacich-Katz centrality index that measure the importance of a sector as supplier to economy. According to Grassi and

Sauvagnat (2019) Bonacich-Katz centrality index can be defined by:

$$b_i = \beta_i + \sum_j b_j \Sigma_{ji}, \tag{19}$$

where $\beta_i = \frac{C_i+G_i+I_i+X_i}{GDP}$ is the importance of sector i as supplier to final demand, and is known as Domar Weights, and $\Sigma_{ji} = \frac{X_{ij}}{Q_i}$, where Q_i is the gross product and X_{ij} is the input output matrix.[18] This shows that the centrality of a sector is equal to the importance of that sector as a supplier to the final demand plus the weighted sum of the centrality of its customer sectors. This equation is a system with four equations with four unknowns, that is, the Bonacity-Katz centrality index for each sector. The solution of this system can be written as follows.

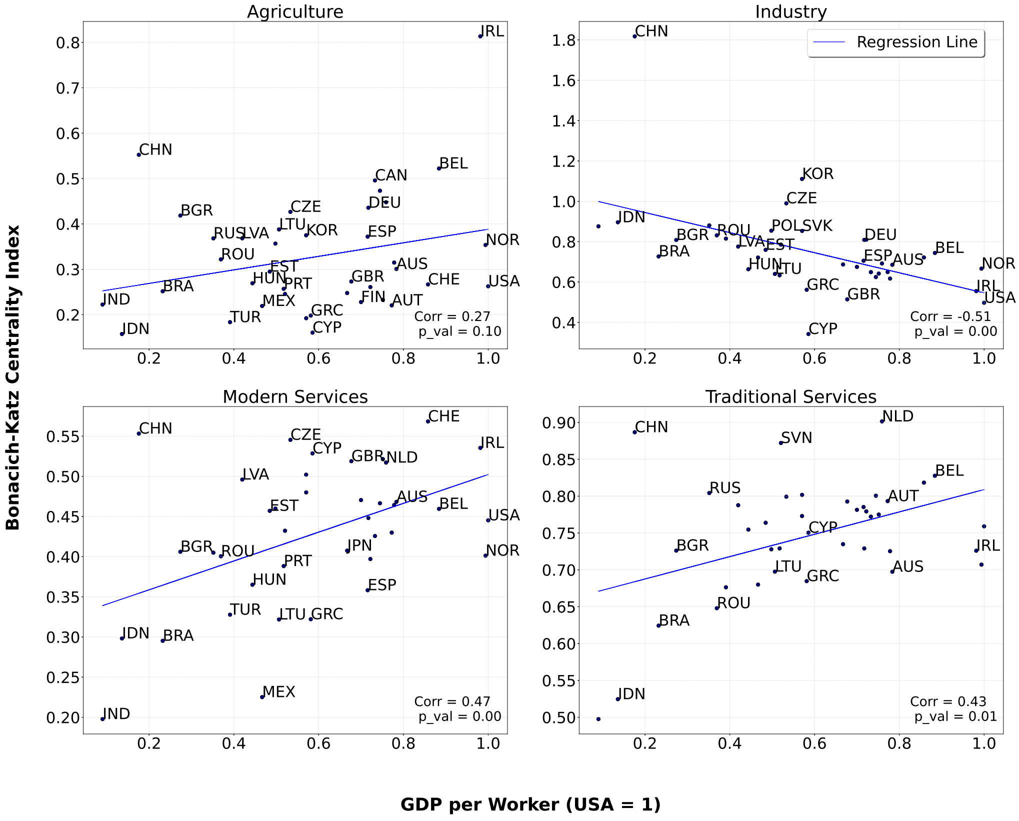
$$b' = \beta'(I - \Sigma)^{-1} = \beta' + \beta'\Sigma + \beta'\Sigma^2 + \beta'\Sigma^3 + \cdots + \beta'\Sigma^k + \cdots , \tag{20}$$

where b' is the centrality vector and $(I - \Sigma)^{-1}$ is the Leontief inverse matrix.

In Figure C1 we present this measure together with GDP per worker. The Bonacich-Katz centrality index of traditional and modern services is positively associated with the countries' level of development; the correlation of the centrality index of these sectors with GDP per worker is 0.36 and 0.51, respectively, both statistically significant at 1%. On the other hand, the industry centrality index is negatively correlated with the countries' income level, and in agriculture there is no statistically significant relationship.

[18] We highlight that C_i, G_i, I_i and X_i are consumption, government spend, investments and net exports, respectively.

Figure C1: Bonacich-Katz Centrality Index - 2014



Appendix D Sectoral Trends

Table D1: Panel Regression Models, Sectoral Share of Value Added - 2000:2014

	Dependent Variable: Share of Added Value			
	(1)	(2)	(3)	(4)
	Agriculture	Industry	Modern Services	Traditional Services
Ln GDP per Capita	-0.298^{***}	-0.116^{**}	0.312^{***}	0.101^{**}
Ln GDP per Capita Squared	0.014^{***}	0.009^{***}	-0.018^{***}	-0.006^{**}
Ln Population	-0.381^{***}	-1.016^{***}	0.701^{***}	0.696^{***}
Ln Population Squared	0.012^{***}	0.030^{***}	-0.023^{***}	-0.019^{***}
D05	-0.003^{***}	-0.011^{***}	0.009^{***}	0.004^{**}
D08	-0.007^{***}	-0.020^{***}	0.025^{***}	0.002
D11	-0.007^{***}	-0.042^{***}	0.036^{***}	0.013^{***}
D14	-0.007^{***}	-0.055^{***}	0.047^{***}	0.014^{***}
Country Fixed Effects	✓	✓	✓	✓
Observations	585	585	585	585
R^2	0.657	0.450	0.399	0.245
Adjusted R^2	0.627	0.403	0.347	0.181
F Statistic (df = 8; 538)	128.627^{***}	54.991^{***}	44.590^{***}	21.845^{***}

Notes: Statistical significance is indicated at the $***p < 0.01$, $**p < 0.05$, and $*p < 0.1$ levels. Our dataset comprises data from 2000 to 2014. We use four time dummies variables: D05, D08, D11, and D14 that indicate whether the period goes from 2003 to 2005, 2006 to 2008, 2009 to 2011 and 2012 to 2014, respectively. Note that we exclude dummy that indicates the period goes from 2000 to 2002.

Appendix E Sectoral Classification

Table E1: Sectoral classification

Sector names	Sector group
Crop and animal production, hunting and related service activities	Agriculture
Forestry and logging	Agriculture
Fishing and aquaculture	Agriculture
Mining and quarrying	Industry
Manufacture of food products, beverages and tobacco products	Industry
Manufacture of textiles, wearing apparel and leather products	Industry
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Industry
Manufacture of paper and paper products	Industry

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Table E1: Sectoral classification (Continued)

Sector names	Sector group
Printing and reproduction of recorded media	Industry
Manufacture of coke and refined petroleum products	Industry
Manufacture of chemicals and chemical products	Industry
Manufacture of basic pharmaceutical products and pharmaceutical preparations	Industry
Manufacture of rubber and plastic products	Industry
Manufacture of other non-metallic mineral products	Industry
Manufacture of basic metals	Industry
Manufacture of fabricated metal products, except machinery and equipment	Industry
Manufacture of computer, electronic and optical products	Industry
Manufacture of electrical equipment	Industry
Manufacture of machinery and equipment n.e.c.	Industry
Manufacture of motor vehicles, trailers and semi-trailers	Industry
Manufacture of other transport equipment	Industry
Manufacture of furniture; other manufacturing	Industry
Repair and installation of machinery and equipment	Industry
Electricity, gas, steam and air conditioning supply	Industry
Water collection, treatment and supply	Industry
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	Industry
Construction	Industry
Wholesale and retail trade and repair of motor vehicles and motorcycles	Traditional Services
Wholesale trade, except of motor vehicles and motorcycles	Traditional Services
Retail trade, except of motor vehicles and motorcycles	Traditional Services
Land transport and transport via pipelines	Traditional Services
Water transport	Modern Services
Air transport	Modern Services
Warehousing and support activities for transportation	Modern Services
Postal and courier activities	Traditional Services
Accommodation and food service activities	Traditional Services
Publishing activities	Modern Services
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	Modern Services
Telecommunications	Modern Services
Computer programming, consultancy and related activities; information service activities	Modern Services
Financial service activities, except insurance and pension funding	Modern Services
Insurance, reinsurance and pension funding, except compulsory social security	Modern Services
Activities auxiliary to financial services and insurance activities	Modern Services
Real estate activities	Modern Services
Legal and accounting activities; activities of head offices; management consultancy activities	Modern Services
Architectural and engineering activities; technical testing and analysis	Traditional Services
Scientific research and development	Modern Services
Advertising and market research	Traditional Services
Other professional, scientific and technical activities; veterinary activities	Traditional Services
Administrative and support service activities	Traditional Services
Public administration and defence; compulsory social security	Traditional Services
Education	Traditional Services
Human health and social work activities	Traditional Services

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Table E1: Sectoral classification (Continued)

Sector names	Sector group
Other service activities	Traditional Services
Activities of households as employers; undifferentiated goods-and services-producing activities of households for own use	Traditional Services
Activities of extraterritorial organizations and bodies	Modern Services

Notes： Adapted from World Input-Output Database.