Who Contributes More on Productivity Improvement? A Cross-country and Cross-industry Analysis

Ting-Wei Lai*, Shin-Kun Peng†, Raymond Riezman**, and Ping Wang‡

(Preliminary Version)

January 11, 2024

Abstract

In this paper, we assess productivity changes at the country level and investigate the factors contributing to a significant proportion of these changes. Using data covering OECD countries, we then categorize them into three groups. We find that in high- and low-income countries, productivity changes are primarily driven by country-specific technology, while in middle-income countries, capital is the most significant factor, contributing up to 43.0% of the changes. We then examine whether the productivity changes are strong enough to account for structural transformation, which manifests as the evolution of the dominance of output share in a specific industry. We find that in industries where high-, middle-, or low-income countries can maintain their dominance in output share, comparative advantages in productivity changes are driven by all factors (mainly country-specific technology and capital) excluding tariffs. The comparative edges in the changes in capital and unskilled labor shares serve as complementary explanations for the continuity of dominance. For most industries where one group of countries overtakes another, the primary cause is the changes in the shares of capital and skilled labor, rather than factor-induced productivity changes.

*Department of Economics, National Chengchi University
†Institute of Economics, Academia Sinica
**Aarhus University/UC-Santa Barbara/University of Iowa
‡Department of Economics, Washington University in St Louis

1 Introduction

What are the sources of domestic productivity improvement over the course of trade liberalization and how much do they influence the progress of structural change? In this paper, we investigate changes in productivity across countries and industries by using a quantitative general-equilibrium model in which the linkages among multiple countries and industries are considered through the lens of trade in intermediate goods.

Most of the existing measures of total factor productivity more or less rely on the accounting methodology and assumptions on the properties of residual terms.[1] However, the extension of Solow (1957)'s method to analyze cross-country and cross-industry productivity may understate the importance of the endogenous linkages. This is because for most of the major countries, in addition to labor and capital, a larger proportion of production inputs are traded across borders rather than domestically supplied with the integration of supply chain.[2] The demand for the intermediate inputs in the network is endogenously determined by relative productivity among trading partners, and thus the changes in productivity are reflected by comparative advantages in production costs in the general equilibrium.

Given these considerations, we extend a workhorse model of the global economy and use it to back out the measure of productivity implied from the data. To allow for flows of trade, let us consider a multi-country and multi-sector version of Ricardian model, which is featured by perfect competition and frictionless domestic factor markets.[3] We combine data of OECD countries from multiple sources and carry out mapping from the country- and industry-level data to the model. This application can help us lessen the measurement problem regarding production inputs, such as the efficiency unit of labor and the stock of industry-specific capital, as our work sheds light on how the observed factor prices can deliver information on productivity changes.

The analysis based on the baseline model suggests that for high-income countries, productivity progress in manufacturing is more significant than other countries during the period 1996-2007; meanwhile, low-income countries enjoys greater productivity growth in primary industries (i.e., Agriculture and Mining). We further assess how much each determinant contributes to the industry-level productivity changes. The result suggests the findings for low-income countries: (i) skilled labor is most important to catch up in productivity; (ii) capital is important only in capital-intensive industries (i.e., Mining, Petroleum, and Metal); (iii) unskilled

[1] See Del Gatto et al. (2011) for a detailed literature survey.

[2] Using the data we will introduce later, we can see that in the case of the US, even though the share of intermediate goods to total output is roughly unchanged between 1995 and 2007, slightly decreasing from 65.5% to 65.2%, the share of domestically produced intermediate goods falls a lot from 88.5% to 82.0%.

[3] An relative extension to labor-market search frictions across sectors and non-employment issues can refer to Dix-Carneiro and Traiberman (2023) for example.

labor is inconsequential; (iv) tariff reductions only matter for low-income countries in a few industries, such as Paper. For high-income countries, skilled labor and country-specific (CS henceforth) technology are important determinants in accounting for productivity growth in most of industries. As for middle-income countries, both skilled labor and capital are the key factors driving productivity growth.

The quantitative result also reveals the effect of productivity growth on structural change. The progress of structural change can be evident and it appears to shift the dominance of output share in some industries from high-income countries to low-income ones; meanwhile, in other industries the dominance can be reversely shifted back from lower-income countries to high-income ones. We decompose the importance of each factor in accounting for these changes and this turns out the following implications. First, CS technology is important for high-income countries maintaining dominance in Paper, Metal and Transportation, skilled labor is critical in Chemicals, and capital and unskilled labor are equally important in Machinery. Moreover, CS technology and capital are key factors accounting for why low-income countries keep dominance in Mining and Agriculture, respectively. Finally, the catch-up behavior in Food, Textiles, and Peteroleum can be explained by productivity changes mostly driven by CS technology, skilled labor and capital, respectively.

main takeaways:

1. main drivers of productivity changes in high, middle and low-income countries:
   (a) CS tech is the main and exclusive driver of productivity changes in high-income countries,
   (b) Skilled, unskilled and capital are the main drivers of productivity changes in middle-income countries, with capital being the most important,
   (c) CS tech is the main driver of productivity changes in low-income countries, followed by skilled labor.
2. main driver of endowment share changes: In high/middle/low income countries, endowment shares shift from unskilled to skilled and capital by 4.0/5.5/3.1 percentage points, respectively, with middle-income countries experiencing the largest shift.
3. Dynamics:
   (a) persistent dominance:
      i. High-income countries maintain dominance in Paper, Chemicals, Metal, Machinery, and Transportation due to comparative advantages in productivity induced by all factors except tariffs, and competitive edges in unskilled and capital shares.

   ii. Middle-income countries maintain dominance in Leather due to competitive edges in skilled share
   iii. Low-income countries dominate throughout in Primary due to comparative advantages in productivity induced by capital and CS tech and competitive edges in unskilled share, as well as in Wood due to competitive edges in capital share.

(b) Overtaking:

   i. High-income countries overtake middle-income countries in Petroleum due to comparative advantages in productivity induced by capital and competitive edges in capital share.
   ii. Middle-income countries overtake high-income countries in Plastics and Electrical due to competitive edges in skilled and capital shares, respectively. They also overtake low-income countries in Textiles by competitive edges in skilled and capital shares.
   iii. Low-income countries overtake middle-income countries in Food comparative advantages in productivity induced by CS tech and competitive edges in capital share and in Minerals due to competitive edges in capital share exclusively.

Our work is related to the literature that provides a model-based measure of sectoral TFP (e.g., Fadinger and Fleiss, 2011) and examines the driving factors to TFP changes (e.g., Bernard and Jones, 1996). This paper also complements the studies that provide the estimate of multifactor productivity at the industry level (e.g., O'Mahony and Timmer, 2009). The channels through which trade liberalization can lead to productivity gains have been well studied by theoretical work: for example, severe competition forcing low-productivity firms to exit (e.g., Melitz, 2003).[4] This paper also explores whether the productivity catch-up prevails among all industries and examines whether this can broadly account for the concurrent structrual change (e.g., Herrendorf et al., 2015).

The remainder of this paper will proceed as follows. Section 2 develops the theoretical model and presents the associated equilibrium conditions. Section 3 describes the data sources. Section 4 discusses the determination of model parameters. Section 5 shows the way of conducting quantitative analysis. Section 6 reports the results by showing a baseline decomposition of productivity changes and the extent to which each factor accounts for the catch-up behavior. Section 7 summarizes our future work and shortly concludes this paper.

[4] Other explanations are the improvement in the quality of intermediate inputs (e.g., Grossman and Helpman, 1991a) and international knowledge spillovers (e.g., Grossman and Helpman, 1991b)

2 The Model

We build a multi-country model to investigate sectoral productivity changes across countries by using data. It follows the canonical Ricardian trade model under a perfect competition environment à la Eaton and Kortun (2002). We stress the importance of international trade in intermediate goods, taking into account linkages among N countries and J sectors in line with Caliendo and Parro (2015). To shed light on the sources of productivity changes, we decompose factors into skilled and unskilled labor and capital. All factors are freely mobile across sectors within a country but not allowed to move across borders. Notice that in the following sections, we add a subscript t to variables/parameters to provide an explicit representation of their time-varying characteristics. In addition, we will use interchangeably between sector and industry.

2.1 The Intermediate good sector

The domestic intermediate good firm produces variety ω^j in industry j and in country n according to the Cobb-Douglas production function:

$$q^j_{n,t}(\omega^j) = z^j_{n,t}(\omega^j)\left[s^j_{n,t}(\omega^j)\right]^{\gamma^j_{n,t}} \prod_{\kappa=1}^{J}\left[m^{\kappa,j}_{n,t}(\omega^j)\right]^{\gamma^{\kappa,j}_{n,t}}, \tag{1}$$

where $z^j_{n,t}(\omega^j)$ is productivity efficiency drawn from a industry-specific distribution, $s^j_{n,t}(\omega^j)$ is a composite of factors in physical capital $K^j_{n,t}(\omega^j)$ and the labor composite $L^j_{n,t}(\omega^j)$, and $m^{\kappa,j}_{n,t}(\omega^j)$ is an intermediate good composite from sector κ. The parameters $\gamma^j_{n,t}$ and $\gamma^{\kappa,j}_{n,t}$ denote the shares of inputs $s^j_{n,t}(\omega^j)$ and $m^{\kappa,j}_{n,t}(\omega^j)$ used in producing variety ω^j.

We consider that $s^j_{n,t}(\omega^j)$ in Eq. (1) is a capital-labor composite is in a CES formulation:

$$s^j_{n,t}(\omega^j) = \left[(1-b^j_{n,t})L^j_{n,t}(\omega^j)^{\frac{\rho_n-1}{\rho_n}} + b^j_{n,t}K^j_{n,t}(\omega^j)^{\frac{\rho_n-1}{\rho_n}}\right]^{\frac{\rho_n}{\rho_n-1}}, \tag{2}$$

where ρ_n denotes the elasticity of substitution between capital and labor and $b^j_{n,t}$ governs the share of capital relative to labor. Also, the labor composite used for producing intermediate inputs is composed of high-skilled labor $h^j_n(\omega^j)$ and low-skilled labor $l^j_n(\omega^j)$ and is given by a CES form:

$$L^j_{n,t}(\omega^j) = \left[(1-a^j_{n,t})l^j_{n,t}(\omega^j)^{\frac{\eta_n-1}{\eta_n}} + a^j_{n,t}h^j_{n,t}(\omega^j)^{\frac{\eta_n-1}{\eta_n}}\right]^{\frac{\eta_n}{\eta_n-1}}, \tag{3}$$

where η_n denotes the elasticity of substitution between two types of labor and $a^j_{n,t}$ controls for the shares of skilled and unskilled labor.[5]

The relative demand for skilled and unskilled labor can be obtained by using Eq. (3):

$$\frac{l^j_{n,t}(\omega^j)}{h^j_{n,t}(\omega^j)} = \left(\frac{1-a^j_{n,t}}{a^j_{n,t}} \frac{w^{h,j}_{n,t}}{w^{l,j}_{n,t}} \right)^{\eta_n}; \tag{4}$$

where $w^{h,j}_{n,t}$ and $w^{l,j}_{n,t}$ are real wage rates of skilled and unskilled labor in sector j. Similarly, the relative demand for captial and the labor composite and is given by:

$$\frac{K^j_{n,t}(\omega^j)}{L^j_{n,t}(\omega^j)} = \left(\frac{b^j_{n,t}}{1-b^j_{n,t}} \frac{w^{L,j}_{n,t}}{r^j_{n,t}} \right)^{\rho_n} \tag{5}$$

where $r^j_{n,t}$ and $w^{L,j}_{n,t}$ denote the real rental price of capital and the wage rate of the labor composite. As a result of the CES formulation in Eq. (3), we can express the corresponding wage rate of the labor composite as:

$$w^{L,j}_{n,t} = \left[(1-a^j_{n,t})^{\eta_n} (w^{l,j}_{n,t})^{1-\eta_n} + (a^j_{n,t})^{\eta_n} (w^{h,j}_{n,t})^{1-\eta_n} \right]^{\frac{1}{1-\eta_n}}. \tag{6}$$

We can also solve for the per unit cost in producing $s^j_{n,t}$ in Eq. (2) as:

$$\phi^j_{n,t} = \left[(1-b^j_{n,t})^{\rho_n} (w^{L,j}_{n,t})^{1-\rho_n} + (b^j_{n,t})^{\rho_n} (r^j_{n,t})^{1-\rho_n} \right]^{\frac{1}{1-\rho_n}}. \tag{7}$$

Using Eq. (1), we can derive the cost of producing a unit of good $c^j_{n,t}/z^j_{n,t}(\omega^j)$ and the cost of the input bundle:

$$c^j_{n,t} = \Upsilon^j_{n,t} (\phi^j_{n,t})^{\gamma^j_{n,t}} \prod_{\kappa=1}^{J} (P^\kappa_{n,t})^{\gamma^{\kappa,j}_{n,t}}, \tag{8}$$

where $\Upsilon^j_{n,t} = \left(\gamma^j_{n,t}\right)^{-\gamma^j_{n,t}} \prod_{\kappa=1}^{J} \left(\gamma^{\kappa,j}_{n,t}\right)^{-\gamma^{\kappa,j}_{n,t}}$ is a function of share parameters and $P^\kappa_{n,t}$ is the price of the intermediate good composite from sector κ.

2.2 The intermediate good composite

Firms that produce the composite of intermediate goods for variety ω^j from the lowest-cost suppliers across countries. The CES production function of the intermediate good composite Q^j_n is thus an aggregate of the

[5] The setting is different from Krusell et al. (2000) and Parro (2013), who highlight the elasticity of substitution between capital and skilled labor and that between capital and unskilled labor.

quantity of demand for variety $\omega^j \in (0,1)$, i.e., $v^j_{n,t}(\omega^j)$:

$$Q^j_{n,t} = \left[\int_0^1 v^j_{n,t}(\omega^j)^{\frac{\sigma-1}{\sigma}} d\omega^j\right]^{\frac{\sigma}{\sigma-1}},$$

where σ is elasticity of substitution between varieties. Given the price of intermediate variety $p^j_{n,t}(\omega^j)$, the demand for ω^j can be expressed as:

$$v^j_{n,t}(\omega^j) = \left(\frac{p^j_{n,t}(\omega^j)}{P^j_{n,t}}\right)^{-\sigma} Q^j_{n,t},$$

where $P^j_{n,t}$ is the unit price of $Q^j_{n,t}$:

$$P^j_{n,t} = \left[\int_0^1 p^j_{n,t}(\omega^j)^{1-\sigma} d\omega^j\right]^{\frac{1}{1-\sigma}}. \tag{9}$$

We assume that tariffs are the only costs of shipping one unit of tradeable goods from one country to another: the ad-valorem tariff rate between importing/destination country n and exporting/source country i is denoted as $\tau^j_{ni,t} \geq 1$ and the domestic rates $\tau^j_{nn,t} = 1$.[6] The price of intermediate variety ω^j in country n is determined by the lowest-cost suppliers:

$$p^j_n(\omega^j) = \min_i \left\{\frac{c^j_{i,t}\tau^j_{ni,t}}{z^j_{i,t}(\omega^j)}\right\}.$$

We also assume that the production efficiency $z^j_{i,t}(\omega^j)$ is a realization of a random variable $Z^j_{i,t}$. It is independently drawn from a Fréchet distribution, which is characterized by a time-varying location parameter $\lambda^j_{i,t} > 0$ that varies by country and sector and a shape parameter θ^j (with $\theta^j > \sigma - 1$) that solely differs by sector:

$$\Pr(Z^j_{i,t} \leqslant z) = F^j_{n,t}(z) = \exp(-\lambda^j_{i,t} z^{-\theta^j}).$$

As a result, the mean level of industrial productivity equals

$$\text{Mean Productivity} = (\lambda^j_{i,t})^{1/\theta^j}\Gamma(1 - 1/\theta^j), \tag{10}$$

where $\Gamma(.)$ is a gamma function.

Based on the distributional assumption, the equilibrium price in Eq. (9) can be analytically solved as:

[6] The triangular inequality is also assumed to hold: $\tau^j_{ni',t}\tau^j_{i'i,t} \geq \tau^j_{ni,t}$ for country n, i and $i' \neq i$ and for all t.

$$P_{n,t}^j = A^j \left[\sum_{i=1}^N \lambda_{i,t}^j \left(c_{i,t}^j \tau_{ni,t}^j \right)^{-\theta^j} \right]^{-1/\theta^j}, \tag{11}$$

where the constant $A^j = A^j(\sigma, \theta^j) = \left[\Gamma \left(\frac{\theta^j + 1 - \sigma}{\theta^j} \right) \right]^{1/(1-\sigma)}$. Obviously, the country n's price index is an increasing function of proudction costs in the source countries and n's tariffs imposed on its imports.

We let $X_{n,t}^j = P_{n,t}^j Q_{n,t}^j$ denote the total expenditure of destination n on sector-j goods and $X_{ni,t}^j$ denote the expenditure on the same goods imported from country i. Based on the model setup, it can be shown that the bilateral trade share will be equivalent to the probability of which country i provides the lowest-price goods in destination n:

$$\pi_{ni,t}^j = \frac{X_{ni,t}^j}{X_{n,t}^j} = \frac{\lambda_{i,t}^j \left(c_{i,t}^j \tau_{ni,t}^j \right)^{-\theta^j}}{\sum_{x=1}^N \lambda_{x,t}^j \left(c_{x,t}^j \tau_{nx,t}^j \right)^{-\theta^j}}. \tag{12}$$

2.3 Households

Consider a continuum of large households of mass 1, each consisting of unskilled and skilled labor of masses $N_{n,t}^l$ and $N_{n,t}^h$, that also owns capital $K_{n,t}$. A household optimally allocates the endowments among domestic sectors in terms of relative factor prices. The utility function of a household over goods from sector j takes a Cobb-Douglas form:

$$u(C_{n,t}) = \prod_{j=1}^J \left(C_{n,t}^j \right)^{\alpha_{n,t}^j}; \quad \sum_{j=1}^J \alpha_{n,t}^j = 1 \text{ for all } t, \tag{13}$$

where $\alpha_{n,t}^j$ denotes the household expenditure shares of intermediate good composite from sector j. The budget constraint of the unitary household is given by:

$$\sum_{j=1}^J \left(P_{n,t}^j / P_{n,t} \right) C_{n,t}^j = \sum_{j=1}^J w_{n,t}^{h,j} N_{n,t}^{h,j} + \sum_{j=1}^J w_{n,t}^{l,j} N_{n,t}^{l,j} + \sum_{j=1}^J r_{n,t}^j K_{n,t}^j + R_{n,t} - \sum_{j=1}^J \delta_{n,t}^j K_{n,t}^j$$

where $N_{n,t}^{h,j}$, $N_{n,t}^{l,j}$ and $K_{n,t}^j$ respectively denote skilled labor, unskilled labor and capital employed by sector j. In addition, the household's net income, which is gross income net of capital depreciation, is augmented with tariff revenues in the form of lump-sum transfers $R_{n,t} = \sum_{j=1}^J \sum_{i=1}^N \tau_{ni,t}^j M_{ni,t}^j$. Simply put, country n's aggregate trade deficit and tariff revenue equal the sum of deficits and revenues over all sectors and partner countries. In the household problem, the two aggregates are taken as given.

As a result of the Cobb-Douglas preference in (12), the consumption price index can be expressed as:

$$P_{n,t} = \prod_{j=1}^{J} \left(P_{n,t}^{j} / \alpha_{n,t}^{j} \right)^{\alpha_{n,t}^{j}}. \tag{14}$$

2.4 Market clearing conditions

The intermediate good composite is used for production in the intermediate-good sector or for domestic expenditures made by the households. From the input-output table, gross output j is the sum of aggregate intermediate goods j from all domestic and foreign sources and final consumption and investment goods demand:

$$Q_{n,t}^{j} = C_{n,t}^{j} + I_{n,t}^{j} + \sum_{\kappa=1}^{J} \int m_{n,t}^{j,\kappa}(\omega^{\kappa}) d\omega^{\kappa},$$

where $I_{n,t}^{j}$ is sectoral investment in physical capital whose value in the steady state is equal to sector-specific capital depreciation $\delta_{n,t}^{j} K_{n,t}^{j}$. The share of gross output of industry j to the aggregate output is hence defined as:

$$\Psi_{n,t}^{j} = \frac{Q_{n,t}^{j}}{\sum_{j=1}^{J} Q_{n,t}^{j}}.$$

Given the assumption that labor is inelastically supplied by the household, the market-clearing conditions for skilled and unskilled labor are in turn expressed as:

$$N_{n,t}^{l} = \sum_{j=1}^{J} N_{n,t}^{l,j} = \sum_{j=1}^{J} \int_{0}^{1} l_{n,t}^{j}(\omega^{j}) d\omega^{j};$$

$$N_{n,t}^{h} = \sum_{j=1}^{J} N_{n,t}^{h,j} = \sum_{j=1}^{J} \int_{0}^{1} h_{n,t}^{j}(\omega^{j}) d\omega^{j}.$$

All factors are assumed perfectly mobile across sectors within each country and capital is fully depreciated after one period.

3 The Data

We construct a dataset, in which the data are obtained from multiple sources. The dataset covers 29 countries and 35 industries, 16 of which are tradeable ones. The other industries that consist of electricity, construction and services are non-tradeable. The time span of our dataset is 1995-2007 prior to the Great Recession. All of the sectors in the model are correspondingly mapped into 2-digit ISIC Rev.3 industries.

First, we use input-output tables from the World Input-Output Database (WIOD) in the 2013 release.[7] Second, as for the factor prices and quantity of inputs used for production, we consider the data provided by WIOD's Socio Economic Accounts (SEA), which are informative about the dynamics of factor uses over a long span and with a consistent measure. Combining data from the above sources enables us to study the factor composition of the input bundle at the industry level. In particular, they provide industry-specific statistics not only on labor and capital compensations but also on a comprehensive decomposition of the labor input in terms of skill levels (i.e., high-, medium- and low-skilled ones, respectively).[8] We treat the sum of high- and medium-skilled workers as the skilled labor in the mapping from data to our model. Factor prices are derived from nominal labor and capital compensations divided by the quantity of the factors used (e.g., total hours of worked and nominal gross fixed capital formation). All of the nominal variables are turned into constant 1995 USD and then converted into real ones by dividing with the price levels of gross value added.

Third, to estimate the gravity equation on the basis of the model equilibrium, we further combine the data on bilateral trade flows in goods at the industry level from STAN Bilateral Trade Database in OECD Statistics. To reduce discrepancy across different databases, we adopt the industry classification that is basically consistent with WIOD and SEA. The data reveal that the trade share of an importing country with trade partners in non-tradeable industries is rather small.[9] Moreover, even though the share of domestic expenditures for most of countries is not reported, we can observe that for the reporting countries, the value is also small and negligible.[10]

Lastly, the data on import tariff rates are from the United Nations Conference on Trade and Development, Trade Analysis Information System (UNCTAD-TRAINS). We treat reporters as import countries and take weighted average of import tariffs across products classified in the same industry. To have the mean tariff rates, we use the corresponding import values of products as the weights. Notice that we solely use data from countries whose statistics are available over all of the above sources. Recall that with the assumption that the tariffs in non-tradeable industries are infinite in Section 2, we can thereby ignore these industries. This simplification helps resolve the issue that the relevant data on bilateral trade flows in non-tradeable

[7] Refer to Timmer et al. (2015) for a detailed description of the data construction.

[8] For European countries, the data on employment and factor compensation are mainly from EU KLEMS and Eurostat databases. For most of non-European countries, the data are from country-level labor force or establishment surveys (see, Erumban et al., 2012).

[9] For example, the trade amount between the US and the other 28 countries in these non-tradeable industries only accounts for 0.56%-0.88% of total trade in goods during the period 1995-2007.

[10] Specifically, only four of the countries considered in this paper report the share of domestic expenditure: they are Australia, Canada, France, Ireland and Italy. Their shares are respectively 0.11%, 1.88%, 1.50%, 0.01% and 0.00% in 1995.

industries are absent. The industries of study and their corresponding ISIC code are reported in the first two columns of Table 1.

4 Parameterization of the Benchmark Model

In this section, we parameterize the benchmark model, in which the parameters are divided in two groups. They are either estimated or calibrated to match the data. To proceed the model parameterization, we first estimate the gravity equation so as to identify industry-specific trade elasticities as well as exporting and importing CS effects. Using data from WIOD and SEA, we then compute the factor shares in Eq. (1) and the household expenditure shares in Eq. (13). In addition, the values of elasticities of substitution between inputs are set by running log-linear regressions, which in turn give the updated shares of inputs in Eqs. (2) and (3).

4.1 Fixed-effect Estimation

Using the expression for the equilibrium bilateral trade share in Eq. (12) delivers the share of foreign goods relative to domestically produced goods:

$$\frac{\pi^j_{ni,t}}{\pi^j_{nn,t}} = \frac{\lambda^j_{i,t}\left(c^j_{i,t}\tau^j_{ni,t}\right)^{-\theta^j}}{\lambda^j_{n,t}\left(c^j_{n,t}\tau^j_{nn,t}\right)^{-\theta^j}} = \frac{\exp(S^j_{i,t})}{\exp(S^j_{n,t})}\left(\tau^j_{ni,t}\right)^{-\theta^j}, \tag{15}$$

where $\tau^j_{nn,t} = 1$ and $S^j_{i,t} = \log(\lambda^j_{i,t}(c^j_{i,t})^{-\theta^j})$ and $S^j_{n,t} = \log(\lambda^j_{n,t}(c^j_{n,t})^{-\theta^j})$ respectively represent the time-varying exporting and importing country factors. In particular, the importing CS factor $S^j_{n,t}$ captures country n's relative advantage in domestic expenditure over exporting country i in industry j.

As a result of the gravity equation (15), we regress relative expenditure shares on tariff rates and control for the time-varying fixed effects without the constant term:[11]

$$\log\left(\frac{\pi^j_{ni,t}}{\pi^j_{nn,t}}\right) = S^j_{i,t} + S^j_{n,t} - \theta^j \log\left(\tau^j_{ni,t}\right) + \varepsilon^j_{ni,t}, \tag{16}$$

where $\varepsilon^j_{ni,t}$ denotes an error term. To better capture the time-varying property of $S^j_{i,t}$ and $S^j_{n,t}$ in Eq. (16), we add interaction terms so that $S^j_{i,t} = S^j_i + S^j_i V_t$ and $S^j_{n,t} = S^j_n + S^j_n V_t$, where S^j_i and S^j_n are exporting and importing CS dummies and V_t is a time dummy. In Table 1, we report the estimate of θ^j for 16 tradeable

[11] Following Eaton and Kortum (2002), the variable $S^j_{i,t}$ can be explained as a measure of country i's competitiveness in industry j, which is a reflection of the state of technology adjusted by the production cost in Eq. (8).

industries. We choose the U.S. to be the baseline for comparison and then re-evluate the above factors by considering the relative terms:

$$\hat{S}^{j}_{i,t} = \tilde{S}^{j}_{i,t} - \tilde{S}^{j}_{i=US,t}; \tag{17}$$

$$\hat{S}^{j}_{n,t} = \tilde{S}^{j}_{n,t} - \tilde{S}^{j}_{n=US,t}, \tag{18}$$

where $\tilde{S}^{j}_{i,t}$ and $\tilde{S}^{j}_{n,t}$ denote the estimate for $S^{j}_{i,t}$ and $S^{j}_{n,t}$ in Eq. (16). Notice that in the following analysis, we denote a variable with the symbol " $\wedge$ " if it is computed or estimated from equailibirum conditions instead of being dirived from the data.

4.2 The productivity levels

With the aid of Eq. (11), we can get the price of intermediate good composite in each country n and sector j:

$$\hat{P}^{j}_{n,t} = \hat{A}^{j} \left[\sum_{i=1}^{N} \hat{S}^{j}_{i,t} \left(\tau^{j}_{ni,t} \right)^{-\hat{\theta}^{j}} \right]^{-1/\hat{\theta}^{j}}, \tag{19}$$

where $\hat{A}^{j} = \hat{A}^{j}(\sigma, \hat{\theta}^{j})$ and $\hat{\theta}^{j}$ denotes the estimate of sector-specific trade elasticity in Eq. (16). Using Eq. (8) and the sector-level prices in Eq. (19), we can thus derive the cost function in Eq. (8), which is given by:

$$\hat{c}^{j}_{n,t} = \Upsilon^{j}_{n} (\phi^{j}_{n,t})^{\gamma^{j}_{n,t}} \prod\nolimits_{\kappa=1}^{J} (\hat{P}^{\kappa}_{n,t})^{\gamma^{\kappa,j}_{n,t}}. \tag{20}$$

In addition, the equilibrium price index is obtained by using Eq. (14):

$$\hat{P}_{n,t} = \prod_{j=1}^{J} \left(\hat{P}^{j}_{n,t} / \alpha^{j}_{n,t} \right)^{\alpha^{j}_{n,t}}. \tag{21}$$

To quantitatively evaluate the productivity of a domestic industry (relative to the U.S. level), we exploit the definition of $S^{j}_{n,t}$ and the estimate $\hat{S}^{j}_{n,t}$ from Eq. (18), which give the location parameter that governs the average productivity:

$$\log(\hat{\lambda}^j_{n,t}) = \hat{S}^j_{n,t} + \hat{\theta}^j \left(\log(\hat{c}^j_{n,t}) - \log(\hat{c}^j_{n=US,t})\right). \tag{22}$$

Using Eq. (10), we can also obtain:

$$\log(\text{Mean Productivity}) = (1/\hat{\theta}^j)\log(\hat{\lambda}^j_{n,t}) + \log\left(\Gamma(1 - 1/\hat{\theta}^j)\right).$$

Notice that $\hat{\lambda}^j_{n,t}$ is a parametric measure of the implied technology level, which as pointed out by Eaton and Kortum (2002), reflects country n's absolute advantages in producing industry-j goods. This productivity can play a key role in accounting for the domestic expenditure share. Since we have assumed that the trade elasticity is time-invariant, any changes in the mean value of Fréchet productivity distribution can be fully captured by variations in $\hat{\lambda}^j_{n,t}$.

4.3 Calibration of parameters

We first set the elasticity of substitution between varieties to be 3.27 in line with the estimate in Broda and Weinstein (2006), which is ranging between 3.1 and 3.7.[12] Then, we follow the calibration strategy in Caliendo and Parro (2015) and select the rest of model parameters by using data from WIOD's input-output tables and SEA. In what follows, we describe the steps entitled in determining the values of these parameters.

Under symmetry, the first-order conditions for the intermediate goods producer's problem on $m^{\kappa,j}_{n,t}$ (whose prices are $P^j_{n,t}$) and $s^j_{n,t}$ (whose prices are $\phi^j_{n,t}$) are

$$\gamma^{\kappa,j}_{n,t} = \frac{P^j_{n,t} m^{\kappa,j}_{n,t}}{P^j_{n,t} q^j_{n,t}},$$

$$\gamma^j_{n,t} = \frac{\phi^j_{n,t} s^j_{n,t}}{P^j_{n,t} q^j_{n,t}}.$$

Accordingly, we can obtain these share parameters by using nominal values of $P^j_{n,t}q^j_{n,t}$ from the vectors of total output, $\phi^j_{n,t}s^j_{n,t}$ from the vectors of gross value added, and $P^j_{n,t}m^{\kappa,j}_{n,t}$ from the cells of the intermediate goods matrix in the input-output tables. Similarly, the household problem yields the optimality condition:

$$\alpha^j_{n,t} = \frac{P^j_{n,t} C^j_{n,t}}{P_{n,t} R_{n,t}},$$

[12] The other concern is regarding the restriction on the location parameter: $\theta^j > \sigma - 1$. In light of this, we set the value slightly below the estimate: $\min_j\{1 + \hat{\theta}^j\} = 3.272$. Please refer to the column of full-sample estimate reported in Table 1.

by which we can compute the above shares by using columns of the domestic final-good expenditure matrix.[13] Table 2 summarizes the calibration result regarding the aforementioned parameters.

Moreover, we can determine the parameters in Eq. (6) and (7) in the symmetric equilibrium, in which all firms within the same sector will choose the same $h^j_{n,t}/l^j_{n,t}$ and $L^j_{n,t}/K^j_{n,t}$ ratios. Specifically, as a result of demand for skilled and unskilled labor in Eqs. (4) and (5), we can run the regression to estimate the elasticity of substitution between two types of labor:

$$\Delta \log \left(\frac{w^{h,j}_{n,t}}{w^{l,j}_{n,t}} \right) = \mu_n + \beta_n \Delta \log \left(\frac{h^j_{n,t}}{l^j_{n,t}} \right) + \varepsilon^j_t, \tag{23}$$

where ε^j_t is the serially uncorrelated error term and $\Delta \log(.)$ stands for the log-difference of a variable and its lagged term. The estimate $\hat{\beta}_n$ in regression (23) is used to indentify the parameters of interest in Eq. (3):

$$\eta_n = -1/\hat{\beta}_n, \tag{24}$$

$$\Delta \log \left(\frac{a^j_{n,t}}{1 - a^j_{n,t}} \right) = \Delta \log \left(\frac{w^{h,j}_{n,t}}{w^{l,j}_{n,t}} \right) + (1/\eta_n) \Delta \log \left(\frac{h^j_{n,t}}{l^j_{n,t}} \right), \tag{25}$$

given the initial value of the share parameter at $t = t_0$, which satisfies

$$\frac{a^j_{n,t_0}}{1 - a^j_{n,t_0}} = \frac{w^{h,j}_{n,t_0}}{w^{l,j}_{n,t_0}} \left(\frac{h^j_{n,t_0}}{l^j_{n,t_0}} \right)^{1/\eta_n}. \tag{26}$$

As mentioned, the share parameter $a^j_{n,t}$ is modeled as being time-variant and the above identification scheme allows us to pin down a sequence of the parameters over time. This arrangement also helps us eliminate the effect of variations in shares when we account for the contribution of each factor on productivity changes later in Section 5.

Following similar steps, we can determine the elasticity of substitution between capital and labor ρ_n as well as the sequence of share parameters $b^j_{n,t}$ in Eq. (2). That is, using the above parameterization and with Eq. (6), we run the regression:

$$\Delta \log \left(\frac{r^j_{n,t}}{w^{L,j}_{n,t}} \right) = \upsilon_n + \vartheta_n \Delta \log \left(\frac{K^j_{n,t}}{L^j_{n,t}} \right) + \xi^j_t, \tag{27}$$

[13] We sum up the final-good expenditures for household consumption, government purchases, fixed capital formation, and for other uses in each industry. This implies that we only consider domestic expenditures and disregard expenditures made by foreign sectors.

where ξ_t^j is the serially uncorrelated error term. In turn, we can identify the remaining parameters:

$$\rho_n = -1/\hat{\vartheta}_n, \tag{28}$$

$$\Delta \log \left(\frac{b_{n,t}^j}{1 - b_{n,t}^j} \right) = \Delta \log \left(\frac{r_{n,t}^j}{w_{n,t}^{L,j}} \right) + (1/\rho_n) \Delta \log \left(\frac{K_{n,t}^j}{L_{n,t}^j} \right), \tag{29}$$

given the initial value of the share parameter satisfying

$$\frac{b_{n,t_0}^j}{1 - b_{n,t_0}^j} = \frac{r_{n,t_0}^j}{w_{n,t_0}^{L,j}} \left(\frac{K_{n,t_0}^j}{L_{n,t_0}^j} \right)^{1/\rho_n}. \tag{30}$$

Using the parameters η_n and ρ_n and the sequences of shares $a_{n,t}^j$ and $b_{n,t}^j$, we can construct the factors prices $\phi_{n,t}^j$ in Eq. (9) under the competitive equilibrium.

5 Quantitative Analysis

Using the data described in Section 3 and the basline model in Section 4, we can quantify the average productivity level by industry and decompose the contribution of each factor to productivity changes.

5.1 The Baseline Values

With the aid of Eq. (22), we can assess changes in the relative productivity level for every importing country. A simple factor decomposistion exhibits that the rate of productivity changes results from year-to-year variations in the importing CS factor $\Delta \hat{S}_{n,t}^j$ and in the relative production costs $\hat{c}_{n,t}^j$:

$$\Delta \log(\hat{\lambda}_{n,t}^j) = \Delta \hat{S}_{n,t}^j + \hat{\theta}^j \left(\Delta \log(\hat{c}_{n,t}^j) - \Delta \log(\hat{c}_{n=US,t}^j) \right), \tag{31}$$

where $\hat{c}_{n,t}^j$ is derived from Eq. (20) and is composed of variations in factor prices. Based on Eq. (18), the variations in the importing CS factor are expressed relative to the US level, namely $\Delta \hat{S}_{n,t}^j = (\tilde{S}_{n,t}^j - \tilde{S}_{n,t-1}^j) - (\tilde{S}_{n=US,t}^j - \tilde{S}_{n=US,t-1}^j)$, and so are productivity changes in Eq. (22). More specifically, a positive sign of $\Delta \log(\hat{\lambda}_{n,t}^j)$ means that country n experiences more rapid productivity growth than the US in industry j during the same period.

It should be noted that in what follows, we restrict our benchmark analysis to productivity changes during the period 1996-2007 because of data limitations.[14] We find that overall, more than 80% of productivity increases in (31) come from the cost channel. Noticeably, extreme values are effective for the CS factor in explaining these changes. The mean value for the full sample, which covers all countries and all tradeable sectors, shows that the CS factor and relative production cost account for 15.4% and 84.6%. However, after we disregard 5% outliers, the former component only performs an even limited role in accounting for the productivity changes (i.e., 4.9%).

5.2 The Counterfactual Exercises

To understand the relative importance of individual factor in accounting for productivity changes, we carry out counterfactual exercises in which variations on each factor price in Eq. (31) are in turn shut down. To put it differently, one of the referred factor prices, including $w^{h,j}_{n,t}, w^{l,j}_{n,t}$, $r^j_{n,t}$, and tariffs $\tau^j_{ni,t}$, and the CS factor $\tilde{S}^j_{n,t}$ in t is counterfactually set equal to its level in 1996 while the others are kept the same as in the benchmark case.

Given that the other prices are unchanged, we separately re-compute the percentage changes in $\hat{\lambda}^j_{n,t}$ and they can be simply denoted as $\Delta\log(\hat{\lambda}^j_{n,t}|_{w^{h,j}_{n,t}=w^{h,j}_{n,1996}})$, $\Delta\log(\hat{\lambda}^j_{n,t}|_{w^{l,j}_{n,t}=w^{l,j}_{n,1996}})$, $\Delta\log(\hat{\lambda}^j_{n,t}|_{r^j_{n,t}=r^j_{n,1996}})$, $\Delta\log(\hat{\lambda}^j_{n,t}|_{\tau^j_{ni,t}=\tau^j_{ni,1996}})$ and $\Delta\log(\hat{\lambda}^j_{n,t}|_{\tilde{S}^j_{n,t}=\tilde{S}^j_{n,1996}})$. As a consequence, we can measure the differences in productivity changes between the benchmark case and each of the counterfactual cases in order. That is, for example, the term $(1/\hat{\theta}^j)(\Delta\log(\hat{\lambda}^j_{n,t}) - \Delta\log(\hat{\lambda}^j_{n,t}|_{w^{h,j}_{n,t}=w^{h,j}_{n,t-1}}))$ means the difference in industry-j's productivity changes between the benchmark case and the case where skilled-labor wages are fixed.

We sum up these differences, thereby yielding an aggregate of differences in counterfactual productivity changes. Then, we divide each component by the aggregate, resulting in a country- and industry-specific fraction. This ratio evaluates how important the component is in accounting for domestic productivity changes in industry j.

5.3 The Country Classification

To investigate productivity changes over the course of development, we classify countries into three broad categories: high-income, middle-income and low-income countries. We refers to a report by World Bank; specifically, 'Global Economic Prospects and the Developing Countries: 1995' (pp. 94-95).

[14] The SEA database released in 2014 version provides data spanning from 1995 to 2011 and more than one-third of observations are missing after 2007. In addition, the data in the first year 1995 have been used to conduct the first-difference estimation in Eqs. (23) and (27). As a consequence, we can only measure annual percentage changes in productivity during the period 1996-2007.

To ensure a sufficient number of countries in each category, we adopt the following classification: Low and middle-lower income countries are grouped as low-income countries; middle-upper income countries are classified as middle-income countries; high-income countries remain classified as high-income countries.

By adopting this classification, we obtain 16, 8, and 5 countries in the high-, middle-, and low-income categories, respectively, and they account for 85.2%, 7.4% and 7.3% of total gross output in 2002.[15] For detailed descriptions, refer to Table A in the Appendix.

The classification is designed to facilitate the comparison of productivity across countries by development level and to draw conclusions in a consistent manner. With the above country classification, we calculate the average output shares of tradeable industries concerning the three development levels. The results are reported in Table 3.

6 Drivers of Catchup: Productivity vs. Factor Endowment Effects

To illustrate how output shares and industry-level productivity have varied over time, we focus on variables for the years 1995, 2002, and 2007.

The pattern of structural change, as indicated by changes in output shares, is presented in Table 3. In 1995, Low-income countries specialize in primary industries (e.g., Agriculture and Mining) and unskilled-labor-intensive manufacturing industries (e.g., Wood). High-income countries, in general, exhibit higher output shares than other countries in industries with an intensive use of skilled labor (e.g., Machinery and Electrical). A comparison of columns in 1995, 2002, and 2007 reveals that low-income countries have experienced moderate progress in most skilled-labor-intensive industries and larger decreases in output shares, especially in Agriculture and Textiles.

Based on the information in Table 3, we outline the evolution of industrial dominance in terms of output share. In summary, high-income countries feature larger output shares in Paper, Chemicals, Metal, Machinery, and Transportation than other countries throughout. Their output share in Petroleum overtook that of middle-income countries in 2002, while it lagged behind in Plastics in 2002 and Electrical in 2007. Middle-income countries maintain the largest output share in Leather throughout, and their output share

[15] The criteria that World Bank adopts is gross national product per capita in 1993. We have considered a robustness check by using annual real gross output per employee in 1995 (in US dollars) provided by SEA. We simply categorize countries with above 50%, between 15% and 50%, and below 15% of the US level into the three groups. The cutoff values are set so as to give a sufficient number of countries in each group. As a result, the high-income countries include Australia, Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, UK, Greece, Ireland, Italy, Japan, Korea, Netherlands, Sweden and US. The middle-income countries are Brazil, Hungary, Mexico, Portugal, Slovenia and Turkey. The others are low-income countries: China, Estonia, India, Indonesia and Latvia. The alternative classification will not cause substantial differences in our main result.

overtook that of low-income countries in Textiles in 2002. Low-income countries consistently have the largest output shares in Agriculture, Mining and Wood; their output share overtook that of middle-income countries in Food and Mineral in 2007.

To illustrate this pattern, we summarize the transition of dominance in Table 4. Our analysis sheds light on how, in some industries, the output share is dominated throughout by countries of a certain development level, while in other industries, the output share gradually shifts to countries of a different development level.

To this end, we divide fifteen industries into two cases: one where a certain group of countries maintains unchanged dominance of output share (namely, Agriculture, Mining, Wood, Leather, Paper, Chemicals, Metal, Machinery and Transportation); and another where a group of countries gains comparative advantages over another group (namely, Food, Textiles, Petroleum, Plastics, Mineral and Electrical).[16]

6.1 Productivity Changes

We investigate the impact of productivity changes on dominance at different development levels and highlight the main drivers of these changes.

6.1.1 Productivity Changes by Industry

The baseline results in Section 5.1 are categorized using the country classification and then presented in Table 5. Productivity changes from 1996 to 2007 are evaluated relative to the US level.[17] Using gross output in 2002 as the weight, we calculate the weighted average over countries in the same classification and derive productivity changes by industry and development level.[18]

The US is treated as the baseline country. Referring to Table 4, we first examine industries where a certain group of countries can maintain their dominance in output share throughout (i.e., Agriculture, Mining, Wood, Leather, Paper, Chemicals, Metal, Machinery and Transportation). During 1996-2007, high-income countries experienced more pronounced productivity growth in Paper (7.3%) and Chemicals (13.1%), weaker productivity declines in Machinery (-3.2%) and Transportation (0%) than other countries, and stronger productivity rises solely than middle-income countries in Metal (15.0%).

Meanwhile, middle-income countries suffered *greater productivity losses in Leather (-55.9%) compared to*

[16] For example, in Table 3, low-income countries can always keep a higher output share than other countries in Agriculture, while they gradually gain dominance in Food from middle-income countries during 1996-2007 (i.e., 15.21%>15.12% in 2002 and 13.44%<13.82% in 2007).

[17] Recall that the observations from the initial year 1995 have been used to determine the baseline parameters; thus, the measure of the initial productivity level is not available.

[18] This is because output growth can be much pronounced, especially in low- and middle-income countries. Hence, we choose the mid-point year as a compromise.

high- and low-income countries. Low-income countries experienced larger productivity growth in Agriculture (38.6%) and Mining (111.6%), as well as *larger productivity losses in Wood (-37.0%)* than other countries.

To elaborate on how the above-mentioned productivity changes were uneven over time, we can divide the entire time span into two shorter sub-periods and separately report productivity growth rate during 1996-2002 and 2002-2007 in Table 5 for comparison. In particular, the figures in the column of high-income countries suggest that productivity growth in Chemicals and Metal predominantly takes place from 2002 and onwards. Despite productivity losses in Machinery during the whole period 1996-2007, high-income countries, in effect, have positive productivity changes (5.6%) during 2002-2007. Moreover, productivity losses in Leather mainly occurs from 1996 to 2002 for middle-income countries (i.e., -56%), while for low-income countries most of productivity growth in Mining takes place during 2002-2007. For the rest of industries that we have highlighted, productivity changes remain relatively stable over the two sub-periods.

1. Let us turn to discuss industries where the dominance of high-income countries is overtaken by middle-income ones (i.e., Plastics and Electrical).

   (a) *We find that high-income countries undergo smaller productivity losses than middle-income ones during 1996-2002 (i.e., -6.3% vs. -23.6% in Plastics and -50.4% vs. -110.3% in Electrical).*

2. In industries where middle-income countries are later overtaken by low-income countries in 2007 (i.e., Food and Mineral):

   (a) Productivity increases during 1996-2007 in the former countries are smaller in Food (i.e., 29.2% vs. 43.3%) *whereas productivity losses are smaller in Mineral (e.g., -8.2% vs. -10.7%).*

3. In industries where middle-income countries are later overtaken by high-income ones in 2002 (i.e., Petroleum):

   (a) Productivity declines in former countries are also larger than those in the later ones (i.e., -66.9% vs. -48.6% during 1996-2007 and -93.1% vs. -61.6% during 1996-2002).

4. Middle-income countries overtake low-income ones in Textiles in 2002:

   (a) Both suffered reductions in productivity of a similar size (-50.6% vs. -49.9%) during 1996-2007.

   (b) Productivity declines in middle-income countries are indeed smaller than low-income ones during 2002-2007 (-39.2% vs. -44.4%).

Based on the above results, we examine the importance of each factor in contributing to the connection between the shift of dominance and productivity improvement in more detail.

6.1.2 Factors-induced Productivity Changes

The counterfactual experiments are conducted using the framework outlined in Section 5.2. We evaluate the impact of each factor, and then calculate a weighted average across countries based on their development level. We employ the cross-country averaging technique described in Section 6.1.1, using the gross output share in 2002 as the weighting factor. Our analysis adheres to the country classification outlined in Section 5.3. Table 6 summarizes the effect of each factor on aggregate productivity changes across all industries:

1. CS technology is critical for both high- and low-income countries, while skilled labor ranks as the second most important factor in middle- and low-income countries.
2. The most important two factors in middle-income countries are **capital and skilled labor**.

Next, we examine the effects on individual industries in more detail. Table 7 illustrates the varying significance of each factor in accounting for productivity changes across different development levels.

1. First, we find that for low-income countries:
   (a) Skilled labor is the most important factor to catch-up in productivity for most of industries including Textiles, Leather, Wood, Paper, Chemicals, Plastics, Machinery, Electrical, and Transportation. CS technology is more important than all other factors in Agriculture, Food, and Mineral.
   (b) Capital dominates only in Mining, Petroleum, and Metal.
   (c) Unskilled labor is inconsequential.
   (d) Tariffs may play a more significant role in low-income countries than in others, whereas other than a few industries, such as Paper, trade liberation would not be the key determinant inducing productivity catch-up.
2. Second, for high-income countries:
   (a) Both skilled labor and CS technology are the main determinants accounting for productivity changes in all industries, except for Petroleum, Mineral and Machinery.
   (b) In these three industries, capital plays the key role instead.

(c) Unskilled labor dominates only in Machinery, and tariffs are negligible.

3. Lastly, for middle-income countries:

   (a) The two primary drivers in all industries, except for Mining, Machinery, and Transportation, are skilled labor and capital.

   (b) Either unskilled labor and CS technology is the most important in these three industries and the impact of tariff is still minor.

6.1.3 Drivers of Structural Change

A central question arises from Table 4: What are the primary drivers that induce productivity catch-up in an industry where changes in output shares are significant? To address this question, we propose the following explanations. Productivity rises can be advantageous for countries in maintaining their dominance. Alternatively, the improvement in productivity can be dramatic, leading to changes such that countries of a certain development level have overtaken the dominance of output share in an industry. In cases where productivity catchup is absent or inconsequential, the evolution of dominance can be attributed to changes in factor endowment instead.

The relation between structural changes and productivity catchup can be summarized as follows.

1. We first consider industries where the dominance is always kept by the same category of countries throughout, and productivity changes in these countries are pronounced in the same period.

   (a) For industries where high-income countries always keep their dominance (i.e., Paper, Chemicals, Metal, Machinery, and Transportation):

      i. Both CS technology and capital are important factors in Paper (i.e., 113.58% and 35.73%).

      ii. CS technology is much more important than other factors in accounting for the changes in dominance in Metal and Transportation (i.e., 102.54% and 593.64%).

      iii. The two main driving forces leading to productivity rises in Chemicals are skilled and unskilled labor (i.e., 77.55% and 56.59%)

      iv. The key factors in Machinery are unskilled labor and capital (i.e., 43.69 and 42.56%).

   (b) For industries that low-income countries dominate in output share throughout (i.e., Agriculture, Mining, and Wood):

   i. The importance of capital (i.e., 136.53%) outweighs the other factors in accounting for productivity changes in Mining.
   ii. Low-income countries are keeping dominance in Agriculture mostly because of CS technology, including effects of weather and fertile land, as it leads to 121.38% of productivity changes.

2. For industries where the dominance of a certain group of countries is overtaken by another group.
   (a) Low-income countries have been gaining dominance in Food from middle-income ones and have higher productivity growth during 1996-2007 (i.e., 43.3% vs. 29.2%).
      i. The main driving factor is CS technology (i.e., 113.42%).
   (b) Similarly, the dominance of middle-income countries in Petroleum is overtaken by high-income ones that experienced smaller productivity losses during 1996-2007 (-48.6% vs. -66.9%).
      i. The key driving factor is capital, which accounts for most of productivity changes in both high- and middle-income countries (i.e., 98.34% and 95.75%).
3. Differences in productivity growth may not be the only reason that triggers structural change when the dominance of output share shifts from one category of countries to another.

For example, Low-income countries have been gaining dominance in Food from middle-income ones despite lower productivity growth during 2002-2007 (i.e., -14.8% vs. -6.8%). Moreover, even though middle-income countries always kept dominance in Leather, productivity enhancement in these countries is, in effect, smaller than that in the others. Hence, for the remaining industries that we have not thoroughly explained so far through the lens of productivity catchup (**i.e., Textiles, Leather, Wood, Mineral, Plastics, and Electrical**), we consider the effects arising from changes in factor intensity (or endowment) to reconcile these cases.

6.2 Factor Endowment Changes

It can be derived from Eqs. (4) and (5) that changes in factor endowment are reflected in changes in factor shares, resulting in variations in factor prices at equilibrium. We utilize SEA data to evaluate changes in factor endowment, as measured by variations in the share parameters in country n and industry j during the periods 1996-2002 and 2002-2007. Then, we can calculate the weighted average of changes in the share parameters across countries within the same category. Following the averaging methodology in Section 6.2.1, we choose gross output in 2002 as the weights.

The findings are summarized as follows.

- Skilled labor and capital shares increase, while unskilled labor share decreases for all-income countries
- The same trend is observed in the secondary industry, except for capital share in middle-income countries
- Similarly, the same pattern occurs for primary industry except for skilled-labor share in middle-income countries and capital share in low-income countries

Let us examine the industries that we have not yet explained well through the lens of productivity changes so far:

1. Middle-income countries dominates initially but they are eventually overtaken by low-income ones in **Mineral** in 2007.
   (a) The main driver of structural change is a sizeable reduction in capital intensity during 2002-2007 (i.e., -13.6%).
2. The same reasoning applies to **Plastics** and **Electrical** where high-income countries are overtaken by middle-income ones in 2002 and 2007.
   (a) The main drivers are capital and skilled labor. That is, the capital share in high-income and middle-income countries increases by -2.8% and 2.8% in Plastics during 1996-2002. The share of skilled labor increases by -4.7% and 3.3% in Electrical during 2002-2007, respectively.
3. We turn to the case of **Leather** in which middle-income countries dominate throughout, and the case of **Wood** in which low-income ones keep their dominance throughout.
   (a) Even though there is a lack of productivity gains in these countries, middle-income countries overall have a larger increase in the use of skilled labor in Leather (10.6%) while low-income ones have a smaller decline in unskilled labor share during 1996-2007 (-2.3%) in Wood.

6.2.1 Decomposition Analysis

In summary, the resulting structural changes can be attributed to either factor-induced productivity changes or variations in factor shares.

- Agriculture: Low-income countries dominate (L-dominate) throughout, due to stronger growth in CS technology (121.38%) and the faster rises in unskilled labor share (0.017>-0.039>-0.058) during 1996-2007
- Mining: L-dominate due to capital-induced productivity growth (136.53%) and the rises in skilled-labor share (0.05>-0.017>-0.118) during 1996-2007
- Food: Middle-income countries dominate initially but are overtaken by low-income countries later (in 2007), due to CS technology growing (113.42%) and capital share declining at a faster pace than low-income countries during 2002-2007 (-0.165<-0.002)
- Textiles: L-dominate initially but are overtaken by middle-income countries (in 2002) due to a slower rise in the skilled-labor share (0.038<0.065) and a faster decline in capital share (-0.038<-0.015) during 1996-2002
- Leather: Middle-income countries dominate (M-dominate) throughout because of the rising skilled-labor share (0.106>0.027>-0.008) and the declining unskilled labor share at a slower pace (-0.043> -0.074>-0.108) during 1996-2007
- Wood: L-dominate throughout because of slower declines in unskilled labor share (-0.023>-0.068>-0.074) during 1996-2007
- Paper: High-income countries dominate (H-dominate) throughout due to capital and CS technology induced productivity enhancement (35.73% and 113.58%) and slower declines in unskilled labor share (-0.032>-0.075>-0.076) during 1996-2007
- Petroleum: M-dominate initially but are overtaken by high-income countries later (in 2002) because of capital-induced productivity enhancement (98.34%) and faster declines in both unskilled labor share and capital share (-0.040<-0.008 and -0.032<-0.021) during 1996-2002
- Chemicals: H-dominate throughout due to skilled- and unskilled-labor induced productivity enhancement (77.55% and 56.59%), faster skilled labor share rise (0.019>0.007>-0.006), and slower unskilled labor share decline (-0.028>-0.049>-0.052) during 1996-2007

- Plastics: H-dominate initially but are overtaken by middle ones later (in 2002) because capital share is outgrown by middle-income countries (-0.028<0.028) during 1996-2002
- Mineral: M-dominate initially but are overtaken by low-income countries later (in 2007) due to a sizeable reduction in capital intensity during 2002-2007 (-0.136<0.137)
- Metal: H-dominate because of CS technology induced productivity enhancement (102.54%) and slower decline in unskilled labor share (-0.051>-0.081>-0.099)
- Machinery: H-dominate throughout because of unskilled-labor and capital induced productivity enhancement (43.69% and 42.56%) and slightly slower declines in unskilled-labor share (-0.045>-0.047>-0.079) during 1996-2007
- Electrical: H-dominate initially but overtaken by middle-income countries later (in 2007) because the former countries undergo the declines in share of skilled labor during 2002-2007 (-0.047<0.033)
- Transportation: H-dominate throughout because of **positive productivity growth driven by CS technology (593.64%)** and rapidly rising capital share during (0.034>-0.010>-0.014)
- Others: L-dominate

The above findings presented in section 6.3 can be summarized in Table 8.

6.3 Main Takeaways:

1. main drivers of productivity changes in high, middle and low-income countries:
   (a) CS tech is the main and exclusive driver of productivity changes in high-income countries, accounting for more than 100% of such changes.
   (b) Skilled, unskilled and capital are the main drivers of productivity changes in middle-income countries, with capital being the most important, accounting for 43.0% of the changes.
   (c) CS tech is the main driver of productivity changes in low-income countries, followed by skilled labor, accounting for 56.2% and 40.2% of the changes, respectively.
2. main driver of endowment share changes: In high, middle, and low income countries, endowment shares shift from unskilled to skilled and capital by 4.0, 5.5, and 3.1 percentage points, respectively, with middle-income countries experiencing the largest shift.

3. Dynamics:

   (a) persistent dominance:

      i. High-income countries maintain dominance in Paper, Chemicals, Metal, Machinery, and Transportation due to comparative advantages in productivity induced by all factors except tariffs, and competitive edges in unskilled and capital shares.

      ii. Middle-income countries maintain dominance in Leather due to competitive edges in skilled share

      iii. Low-income countries dominate throughout in Primary due to comparative advantages in productivity induced by capital and CS tech and competitive edges in unskilled share, as well as in Wood due to competitive edges in capital share.

   (b) Overtaking:

      i. High-income countries overtake middle-income countries in Petroleum due to comparative advantages in productivity induced by capital and competitive edges in capital share.

      ii. Middle-income countries overtake high-income countries in Plastics and Electrical due to competitive edges in skilled and capital shares, respectively. They also overtake low-income countries in Textiles by competitive edges in skilled and capital shares.

      iii. Low-income countries overtake middle-income countries in Food comparative advantages in productivity induced by CS tech and competitive edges in capital share and in Minerals due to competitive edges in capital share exclusively.

7 Concluding remarks

In this paper, we build a Ricardian model to quantitatively assess sectoral productivity changes using cross-country industry-level data. The results suggest that, in the course of globalization, high-income countries experience more significant productivity progress in manufacturing compared to other countries. Meanwhile, low-income countries enjoy substantial productivity growth in primary industries.

Another issue of interest is the extent to which each determinant contributes to these productivity changes. Our quantitative result suggests the following findings for low-income countries: (i) skilled labor is the most important factor for catching up in productivity; (ii) capital is important only for capital-intensive industries (i.e., Mining, Petroleum, and Metal); (iii) unskilled labor is inconsequential; (iv) tariff reductions only matter for low-income countries. For high-income countries, skilled labor and CS technology are important determinants accounting for productivity growth in most industries. As for middle-income countries, both skilled labor and capital are the key factors driving productivity growth.

Table 1: The OLS estimate of the trade elasticity

Industry	ISIC code	Full sample	99% of sample	97.5% of sample
Agriculture	AtoB	2.27 (0.73)	1.93 (0.67)	1.82 (0.69)
Mining	C	20.72 (2.13)	19.45 (2.07)	17.25 (2.08)
Food	D15to16	6.14 (0.38)	6.32 (0.38)	7.27 (0.40)
Textiles	D17to18	17.68 (0.78)	18.02 (0.75)	18.79 (0.72)
Leather	D19	16.81 (0.94)	16.56 (0.91)	16.67 (0.91)
Wood	D20	24.77 (1.80)	24.36 (1.78)	24.69 (1.78)
Paper	D21to22	20.80 (2.69)	28.86 (2.08)	33.43 (1.99)
Petroleum	D23	57.32 (4.69)	55.65 (4.48)	54.41 (4.39)
Chemicals	D24	29.43 (1.07)	29.40 (1.04)	29.96 (1.01)
Plastics	D25	24.77 (1.12)	27.83 (1.04)	29.16 (1.01)
Mineral	D26	26.70 (1.51)	28.26 (1.43)	29.24 (1.40)
Metal	D27to28	39.78 (1.69)	41.72 (1.61)	43.56 (1.57)
Machinery	D29	27.22 (2.19)	30.43 (2.10)	33.58 (1.93)
Electrical	D30to33	16.84 (1.71)	17.40 (1.44)	19.09 (1.34)
Transportation	D34to35	7.98 (1.10)	9.44 (0.97)	9.53 (0.95)
Others	D36to37	21.34 (1.57)	21.57 (1.57)	22.18 (1.52)

Note: The other industries include recycling n.e.c. in manufacturing. OLS standard errors are displayed in parentheses. The results shown in the fourth and fifth columns are the estimates derived from a removal of 1% and 2.5% outliers.

Table 2: Summary of model calibration

Parameter	Value	Explanation (Reference Source)
σ	3.27	The elasticity of substitution in varieties (Broda and Weinstein, 2006)
$\gamma^{j}_{n,t}$	[0.13, 0.8]	The share of inputs of capital and labor (WIOD-SEA)
$\gamma^{\kappa,j}_{n,t}$	[0, 0.15]	The share of intermediate goods (WIOD's IO-tables)
$\alpha^{j}_{n,t}$	[0, 0.11]	The household expenditure share (WIOD's IO-tables)
$\tau^{j}_{ni,t}$	[0, 0.28]	The weighted average of effectively applied rates (WITS-TRAINS)
θ^{j}	[2.27, 57.32]	The shape parameter of Fréchet distribution (Gravity-based estimation)

Table 3: The share of output by industries and by development levels

Year	1995			2002			2007		
Industry\Level	High	Middle	Low	High	Middle	Low	High	Middle	Low
Agriculture	9.62%	13.97%	22.27%	7.56%	11.82%	18.44%	6.46%	9.81%	15.73%
Mining	3.01%	3.35%	3.89%	3.39%	3.44%	4.29%	4.79%	4.47%	5.68%
Food	14.94%	16.09%	15.86%	13.64%	15.21%	15.12%	12.31%	13.44%	13.82%
Textiles	3.96%	8.36%	9.93%	3.03%	8.67%	8.48%	2.01%	6.92%	5.95%
Leather	0.72%	1.94%	1.24%	0.54%	1.69%	1.10%	0.39%	1.28%	0.73%
Wood	2.36%	2.25%	6.19%	2.25%	1.85%	6.73%	2.19%	1.85%	7.31%
Paper	8.36%	5.10%	3.68%	7.76%	4.68%	3.54%	6.69%	4.15%	3.64%
Petroleum	3.08%	4.37%	2.14%	4.12%	3.85%	3.16%	6.28%	5.19%	3.71%
Chemicals	8.40%	7.35%	5.85%	9.79%	7.12%	5.97%	9.68%	7.54%	5.81%
Plastics	3.10%	2.89%	2.06%	3.16%	3.20%	2.64%	3.07%	3.44%	3.02%
Mineral	3.09%	3.47%	3.38%	3.04%	3.50%	3.27%	2.97%	3.46%	4.05%
Metal	10.93%	8.99%	7.33%	10.49%	8.43%	7.31%	12.86%	10.35%	9.96%
Machinery	7.03%	4.30%	3.26%	6.99%	4.63%	3.35%	7.54%	5.11%	3.96%
Electrical	9.56%	7.15%	4.85%	10.82%	10.27%	8.47%	9.89%	10.63%	7.55%
Transportation	9.04%	7.57%	4.98%	10.56%	8.79%	4.98%	10.23%	9.65%	5.52%
Others	2.81%	2.86%	3.08%	2.85%	2.84%	3.16%	2.64%	2.71%	3.54%

Table 4: Change in industrial dominance

02-07 / 96	Low-income	Middle-income	High-income
Low	Agriculture: CS tech/unskilled share Mining: capital/unskilled share Wood: capital share	Textiles: skilled & capital shares	
Middle	Food: CS tech/capital share Mineral: capital share	Leather: skilled share	Petroleum: capital/capital share
High		Plastics: skilled share Electrical: capital share	Paper: capital & CS tech/unskilled Chemicals: skilled & unskilled/unskil Metal: CS tech/unskilled share Machinery: capital & unskilled/capita Transportation: capital share

Table 5: The baseline result of productivity changes by development level

Year	1996-2007			1996-2002			2002-2007		
Industry \ Level	High	Middle	Low	High	Middle	Low	High	Middle	Low
Agriculture	0.36	-0.33	0.39	0.20	0.13	0.23	0.17	-0.37	0.16
Mining	0.30	0.77	1.12	-0.10	0.03	0.20	0.40	0.73	0.92
Food	0.16	0.29	0.43	0.09	0.32	0.57	0.09	-0.03	-0.14
Textiles	-0.24	-0.51	-0.50	-0.12	-0.11	-0.05	-0.12	-0.39	-0.44
Leather	-0.44	-0.56	-0.52	-0.58	-0.56	-0.64	0.14	0.00	0.12
Wood	-0.03	0.17	-0.37	-0.02	-0.05	-0.15	-0.02	0.21	-0.22
Paper	0.07	0.03	-0.06	0.03	-0.01	0.14	0.05	0.04	-0.21
Petroleum	-0.49	-0.67	-0.63	-0.62	-0.93	-0.72	0.12	0.26	0.09
Chemicals	0.13	-0.10	-0.06	0.02	-0.11	0.04	0.12	0.01	-0.12
Plastics	0.09	-0.22	-0.18	-0.06	-0.24	-0.05	0.15	0.02	-0.13
Mineral	0.03	-0.08	-0.11	-0.14	-0.21	-0.09	0.17	0.13	-0.02
Metal	0.15	0.08	0.34	0.00	-0.14	0.16	0.17	0.22	0.18
Machinery	-0.03	-0.22	-0.28	-0.08	-0.24	-0.03	0.06	0.02	-0.25
Electrical	-0.92	-2.08	-2.38	-0.50	-1.10	-1.24	-0.41	-0.98	-1.14
Transportation	0.00	-0.09	-0.33	0.00	0.12	-0.12	0.00	-0.03	-0.21
Others	-0.45	-0.97	-1.08	-0.09	-0.17	-0.02	-0.36	-0.79	-1.06

Table 6: The determinants of productivity changes by development level

	High	Middle	Low
skilled labor		$*$	$*$
unskilled labor	$*$		
capital		✓	
tariffs			
CS technology	✓		✓

Note: The most important and the second most important factors are marked by symbols ✓ and $*$.

Table 7: The counterfactual result

Industry\Factor	High					Middle					Low				
	skilled labor	unskilled labor	capital	tariffs	CS technology	skilled labor	unskilled labor	capital	tariffs	CS technology	skilled labor	unskilled labor	capital	tariffs	CS technology
Agriculture	-15.11%	-0.45%	-4.46%	-0.08%	120.10%	96.58%	67.23%	64.38%	-1.30%	-126.89%	-19.01%	1.77%	-2.36%	-1.78%	121.38%
Mining	9.94%	-4.37%	-1.41%	0.67%	95.17%	7.16%	-14.98%	46.34%	-0.50%	61.98%	-13.23%	5.95%	136.53%	2.06%	-31.30%
Food	-4.01%	4.24%	-0.78%	-0.49%	101.05%	7.79%	1.49%	52.11%	-3.72%	42.15%	-3.27%	6.26%	1.18%	-17.59%	113.42%
Textiles	61.99%	41.55%	0.16%	-0.67%	-3.03%	55.38%	27.68%	19.71%	4.23%	-7.01%	88.09%	30.20%	-65.73%	4.76%	42.67%
Leather	78.22%	31.03%	-5.17%	-1.57%	-2.52%	59.86%	26.32%	5.75%	1.02%	7.06%	49.41%	27.60%	-16.28%	7.60%	31.67%
Wood	196.60%	54.63%	3.81%	-3.08%	-151.97%	-7.74%	22.59%	51.67%	10.33%	22.84%	72.37%	18.67%	-54.20%	14.32%	48.84%
Paper	-68.36%	17.59%	35.73%	1.45%	113.58%	-18.35%	38.81%	59.05%	-15.98%	36.47%	88.98%	23.86%	-103.47%	39.78%	50.85%
Petroleum	2.20%	1.68%	98.34%	-0.25%	-1.97%	0.23%	0.99%	95.75%	3.11%	-0.08%	-3.06%	-1.43%	104.04%	3.56%	-3.10%
Chemicals	77.55%	56.59%	-60.98%	-0.40%	27.24%	85.24%	43.64%	-25.92%	5.85%	-8.81%	204.36%	11.98%	-116.20%	11.82%	-11.96%
Plastics	-19.63%	17.33%	10.77%	3.68%	87.85%	-73.86%	-0.68%	118.21%	1.50%	54.83%	127.32%	20.87%	-64.15%	15.57%	-0.60%
Mineral	17.52%	32.53%	33.50%	0.66%	15.79%	-11.14%	29.15%	95.87%	-11.02%	-2.85%	97.38%	-26.81%	-134.01%	11.69%	151.75%
Metal	-17.71%	4.15%	3.35%	7.66%	102.54%	-12.13%	15.74%	121.92%	-33.80%	8.27%	-4.39%	5.10%	81.61%	1.54%	16.14%
Machinery	8.49%	43.69%	42.56%	2.16%	3.10%	21.55%	62.74%	-2.51%	0.96%	17.25%	69.34%	14.03%	-17.58%	3.00%	31.21%
Electrical	65.74%	38.06%	-0.37%	-0.15%	-3.28%	63.99%	35.84%	1.11%	0.98%	-1.91%	60.96%	37.00%	-0.58%	0.61%	2.01%
Transportation	-87.66%	-39.36%	-339.06%	-27.56%	593.64%	4.41%	19.43%	-1.52%	-5.40%	83.08%	37.25%	12.46%	-3.13%	17.58%	35.84%
Others	53.53%	12.25%	48.45%	-0.55%	-13.67%	46.78%	13.29%	44.54%	1.88%	-6.49%	32.66%	7.84%	38.10%	2.41%	19.00%

Table 8: A summary of the main drivers to structural changes by industry

Panel A: Classification of industries by joint effect of factor-induced productivity changes and endowment

Category	Industries
Factor endowment only	Textiles, Leather, Wood, Plastics, Mineral, Electrical
Factor endowment and skilled-labor induced productivity	Chemicals
Factor endowment and unskilled-labor induced productivity	Chemicals, Machinery
Factor endowment and capital induced productivity	Mining, Paper, Petroleum, Machinery
Factor endowment and CS technology induced productivity	Agriculture, Food, Paper, Metal, Transportation

Panel B: Classification of industries by factor-induced productivity changes and endowment

Productivity \ endowment	Skilled-labor share	Unskilled-labor share	Capital share
Skilled labor	Chemicals	Chemicals	-
Unskilled labor	Chemicals	Chemicals	Machinery
Capital	Mining	Paper	Petroleum, Machinery
Tariffs	-	-	-
CS technology	-	Agriculture, Paper, Metal	Food, Transportation
Negligible productivity effect	Textiles, Leather, Electrical	Leather, Wood	Textiles, Plastics, Mineral

References

1. Bernard, Andrew B. and Charles I. Jones (1996). "Productivity Across Industries and Countries: Time Series Theory and Evidence." *Review of Economics and Statistics*, **78 (1)**, 135–146.

2. Broda, Christian and David E. Weinstein (2006). "Globalization and the Gains From Variety." *Quarterly Journal of Economics*, **121 (2)**, 541–585.

3. Caliendo, Lorenzo and Fernando Parro (2015). "Estimates of the Trade and Welfare Effects of NAFTA." *Review of Economic Studies*, **82 (1)**, 1–44.

4. Del Gatto, Massimo, Adriana Di Liberto, and Carmelo Petraglia (2011). "Measuring Productivity." *Journal of Economic Surveys*, **25 (5)**, 952–1008.

5. Dix-Carneiro, Rafael and Sharon Traiberman (2023). "Globalization, Trade Imbalances and Inequality." *Journal of Monetary Economics*, **133**, 48–72.

6. Eaton, Jonathan and Samuel Kortum (2002) "Technology, Geography, and Trade." *Econometrica*, **70 (5)**, 1741–1779.

7. Fadinger, Harald and Pablo Fleiss (2011). "Trade and Sectoral Productivity." *Economic Journal*, **121 (555)**, 958–989.

8. Grossman, Gene M. and Elhanan Helpman (1991a). "Quality Ladders in the Theory of Growth." *Review of Economic Studies*, **58 (1)**, 43–61.

9. Grossman, Gene M. and Elhanan Helpman (1991b). "Trade, Knowledge Spillovers, and Growth." *European Economic Review*, **35 (2–3)**, 517–526.

10. Herrendorf Berthold, Christopher Herrington, and Ákos Valentinyi (2015). "Sectoral Technology and Structural Transformation." *American Economic Journal: Macroeconomics*, **7 (4)**, 104–133.

11. Krusell, Per, Lee Ohanian, José-Víctor Ríos-Rull, and Giovanni Violante (2000). "Capital-skill Complementarity and Inequality: A Macroeconomic Analysis." *Econometrica*, **68 (5)**, 1029–1053.

12. Melitz, Marc J. (2003). "Industry Reallocations and Aggregate Industry Productivity." *Econometrica*, **71 (6)**, 1695–1725.

13. O'Mahony, Mary and Marcel P. Timmer (2009). "Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database" *Economic Journal*, **119 (538)**, F374–F403.

14. Parro, Fernando (2013). "Capital-Skill Complementarity and the Skill Premium in a Quantitative Model of Trade." *American Economic Journal: Macroeconomics*, **5 (2)**, 72–117.

15. Solow, Robert M. (1957). "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics*, **39 (3)**, 312–320.

16. Timmer, Marcel P., Erik Dietzenbacher, Bart Los, Robert Stehrer and Gaaitzen J. de Vries (2015). "An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production." *Review of International Economics*, **23 (3)**, 575–605.

17. World Bank. "Global Economic Prospects and the Developing Countries: 1995." Washington, D.C., 1995.

Table A: The classification of countries by development level in 1995

Country	World Bank's Classification	Re-classification	Classification by WIOD
Australia	High-income	High-income	High-income
Austria	High-income	High-income	High-income
Belgium	High-income	High-income	High-income
Brazil	Middle-upper-income	Middle-income	Middle-income
Canada	High-income	High-income	High-income
China	Low-income	Low-income	Low-income
Denmark	High-income	High-income	High-income
Estonia	Middle-upper-income	Middle-income	Low-income
Finland	High-income	High-income	High-income
France	High-income	High-income	High-income
Germany	High-income	High-income	High-income
Greece	Middle-upper-income	Middle-income	High-income
Hungary	Middle-upper-income	Middle-income	Middle-income
India	Low-income	Low-income	Low-income
Indonesia	Middle-lower-income	Low-income	Low-income
Ireland	High-income	High-income	High-income
Italy	High-income	High-income	High-income
Japan	High-income	High-income	High-income
Korea	Middle-upper-income	Middle-income	High-income
Latvia	Middle-lower-income	Low-income	Low-income
Mexico	Middle-upper-income	Middle-income	Middle-income
Netherlands	High-income	High-income	High-income
Portugal	Middle-upper-income	Middle-income	Middle-income
Slovenia	Middle-upper-income	Middle-income	Middle-income
Spain	High-income	High-income	High-income
Sweden	High-income	High-income	High-income
Turkey	Middle-lower-income	Low-income	Middle-income
UK	High-income	High-income	High-income
US	High-income	High-income	High-income