Trade-induced structural change and the skill premium*

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Abstract

We study how international trade affects manufacturing employment and the relative wage of unskilled workers when goods and services are traded with different intensities. Manufacturing trade reduces manufacturing prices worldwide, which reduces manufacturing employment if manufactures and services are complements. International trade also raises real income, which reduces manufacturing employment if services are more income elastic than manufactures. Manufacturing production is unskilled-labor intensive, so that these changes increase the skill-premium. We incorporate these mechanisms in a quantitative trade model and show that reductions in trade costs had a negative impact on manufacturing employment and the relative wage of unskilled workers.

Keywords: Trade, Manufacturing Employment, Structural Change, Skill Premium, Gains From Trade.

JEL Codes: F16, F62, F63

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1 Introduction

What is the impact of international trade on manufacturing employment and wage inequality? Policy makers in developed countries are increasingly concerned that competition from poor countries may be shifting manufacturing jobs overseas and hurting unskilled workers. These concerns are in line with the predictions of the standard Heckscher-Ohlin model, which indicates that, as countries open up to trade, sectors where a country has a comparative advantage will expand at the expense of other sectors, while the skill premium will rise in skilled-labor abundant countries and fall in other countries.[1] Manufacturing employment, however, has been falling both in countries that are net importers and net exporters of manufactured goods.

This paper evaluates an alternative mechanism through which international trade can reduce the relative size of the manufacturing sector and the relative wage of unskilled workers simultaneously in all countries. Manufacturing trade lowers the price of manufactured goods relative to services worldwide, and, if manufacturing and services are complements, it also reduces the share of manufactured goods in total value added and in total employment.[2] In addition, trade also reduces the relative size of the manufacturing sector if it raises real income, and if services are more income elastic than manufactures. Thus, if the production of manufacturing goods is unskilled-labor intensive, international trade can raise the skill premium in all countries. We incorporate these mechanisms in a quantitative trade model and measure how reductions in trade costs and changes in comparative advantage affected manufacturing employment and the skill premium across countries between 1995 and 2007.

We first document three features of the data that are key for determining the direction and strength of these mechanisms. First we show that, for a broad set of countries, the pace of trade integration between 1995 and 2007 has been quite uneven across goods-producing (manufacturing, agriculture and mining) and service sectors. While growth in services trade has outpaced growth in goods trade, the share of domestically produced services in total absorption of services has remained roughly constant, whereas the share of domestically produced goods in total absorption of goods has declined dramatically. Second, we document large differences in skill intensities across broad sectors: goods-producing sectors are unskilled-labor intensive, as are some service sectors

[1] See Leamer and Levinsohn (1995) for a survey of the early Heckscher-Ohlin literature, and Goldberg and Pavcnik (2007) for a review of the more recent literature.

[2] The effect of relative price changes on the sectoral composition of the economy was first studied by Baumol (1967). Growth in manufacturing trade is akin to growth in manufacturing productivity, as it allows countries to specialize in the production of manufactured goods in which they have a comparative advantage.

(such as construction and retail), while other service sectors (such as FIRE and health) are skilled-labor intensive. Third, we show that relative to skilled-labor intensive sectors, unskilled-labor intensive sectors (both goods and services) use more intermediate inputs from goods-producing sectors. The first two observations imply that, if goods and services are complements, the changes in trade patterns between 1995 and 2007 were skill-biased, as they induced reallocation of employment out of unskilled-labor intensive goods and into skilled-labor intensive services (i.e. they induced structural change). The third observation implies that the effect of a decline in the relative price of goods is magnified by the intensive use of goods as intermediate inputs in unskilled-labor intensive sectors.

We quantify the importance of these mechanisms using a multi-country, multi-sector model of trade. In the model, trade patterns shape the allocation of workers across sectors that are traded with different intensities and that employ skilled and unskilled workers in different proportions. Our model extends that of Eaton and Kortum (2002) by allowing for a non-unitary elasticity of substitution across sectors, non-homothetic preferences, aggregate trade imbalances, and heterogeneous workers' skills. If (i) the elasticity of substitution across sectors is less than one, or (ii) services are more income elastic than goods, the goods sector shrinks following changes in trade costs or in foreign productivities that reduce the share of domestically produced goods in absorption, as this lowers the relative price of goods and raises real income. In the model as in the data, goods-producing sectors are unskilled-labor intensive, so that a decline in employment in these sectors increases the skill premium. In addition, as the relative price of goods declines, so does the relative price of unskilled-labor intensive sectors that use intermediate goods inputs intensively, magnifying the effects of trade on the skill premium. Finally, as in the standard Heckscher-Ohlin model, an increase in net imports in unskilled-labor intensive sectors also increases the skill premium. We highlight that, while the Heckscher-Ohlin mechanism affects the skill premium through sectoral differences in comparative advantage, trade also affects the skill premium in our model through differences in the extent to which goods and services are traded.

We show that, as in Eaton and Kortum (2002), sectoral domestic expenditure shares are sufficient statistics for how changes in trade costs, foreign technologies, and foreign factor supplies affect relative prices in our model. The other key statistics needed for determining the impact of trade in the skill premium are sectoral net exports in skilled- and unskilled-labor intensive sectors. We build on these results to write changes in sectoral value added shares, employment shares, and the skill premium as functions of changes in sectoral domestic expenditure shares, the ratio of net exports in each sector to economy-wide revenues, domestic productivities, and domestic labor endowments. We show that the key elasticities that determine the strength of our mechanisms are: (i) the elasticity of substitution across sectors, (ii) the sectorial income elasticities, (iii) the elasticity of substitution across workers, and (iv) the trade elasticity in each sector. We follow Herrendorf, Rogerson and Valentinyi (2013) and Comin, Lashkari and Mestieri (2015) and estimate the sectorial substitution and income elasticities from changes in relative prices, real income, and relative expenditures using time series data for the US. We take the remaining key elasticities (iii) and (iv) from the labor and the trade literature respectively.

We use the calibrated model to conduct two counterfactuals to evaluate the quantitative importance of the mechanisms described above. In the first counterfactual we estimate changes in trade costs between 1995 and 2007 from changes in trade shares following Head and Ries (2001), and evaluate how these changes in trade costs affect employment in the goods sector and the skill premium across countries in our model. We show that, as in the data, the goods sector shrinks in most countries in this counterfactual. The employment share of the goods sector declines by about 7.4 percent, about a third of the 21 percent decline observed in the data. For the US these numbers are 12 vs 21 percent, respectively. More importantly, we cannot reject the null hypothesis that the slope of a regression between changes in sectoral employment shares in the data and those in the counterfactual is equal to one, and the same is true when we consider changes in value-added shares. Thus, while the counterfactual misses part of the global decline in the size of the goods sector, the reduction in trade costs substantially contributes to understanding how this decline has differed across countries. The skill premium in this counterfactual increases in almost every country in our sample, by an average of 2.1 percent. Notably, the counterfactual change in the skill premium is larger in developing countries where the goods sector is particularly unskilled labor intensive, such as Turkey, Romania, Portugal or Poland.

The counterfactual described above isolates the effect of changes in trade costs on wages and sectoral employment, and purposely abstracts from other international forces that may affect these variables, such as productivity growth in foreign countries. In our second quantitative exercise, we take a sufficient statistic approach to conduct counterfactuals without having to take a stand on the underlying changes in primitives driving the observed changes in trade patterns. In particular, we change a country's domestic expenditure shares and sectorial net exports from their observed levels in 1995 to those observed in 2007, while keeping domestic technologies and factor endowments fixed. This counterfactual measures, to a first-order approximation, how a country's sectoral employment shares and skill premium respond to all changes in technologies, endowments, and trade costs over this period, relative to the response to these same changes, had that country been in autarky.[3] We show that the observed changes in trade patterns over the 1995-2007 period generate a 10 percent decline in the employment share of the goods sector for the average country, relative to the 25 percent decline observed in the data. These changes in turn affect the skill premium, which increases by 3.7 percent in the average country of our sample between 1995 and 2007.

We assess the importance of the features of the data highlighted above by repeating our first counterfactual under two alternative calibrations. First, we re-calibrate the model under the assumption that there are no intermediate inputs in production. We show that while the qualitative results remain, the changes in the skill premium are only a fifth as large as in our baseline calibration. Second, we calibrate a two-sector model that does not take into account the substantial differences in skill and input intensities that we observe across service sectors. While the counterfactual decline in the share of the goods producing sector is roughly the same as in the baseline three-sector model, the counterfactual increase of the skill premium for the median country is about 25 percent smaller than in our baseline calibration. In addition to these exercises, we provide evidence for the mechanisms in the model by decomposing changes in the share of skilled workers in employment into within-sector skill upgrading and between-sector labor reallocation, and show that the reduction in trade costs is important for understanding how the contribution of each component varies across countries.

Our paper is related to two strands of the literature. The first is a recent literature that studies structural change in open economies. Matsuyama (2009) shows that the growth of manufacturing productivity and the relative size of the manufacturing sector can be decoupled in open economies. Uy, Yi and Zhang (2013) use a two-country growth model featuring a Baumol effect and non-homothetic preferences to study structural change in South Korea, while abstracting from aggregate trade imbalances. Fajgelbaum and Redding (2014) study how changes in trade costs affected structural change and spatial patterns of specialization in Argentina at the end of the 19$^{\text{th}}$ century. Kehoe, Ruhl and Steinberg (2013) build a model of the US and the rest of the world to assess the quantitative impact of U.S. borrowing on goods-sector employment, in a context in which trade costs are fixed. Swiecki (2017) uses a model where goods are tradeable but services are not, and argues that between 1970 and 2005, changes in sectorial productivities are the main drivers of structural change for most countries, though trade can be important for individual countries. Our contribution to this literature is to quantify how trade affects

[3] A similar interpretation to this type of counterfactual was first given by Burstein, Cravino and Vogel (2013) and Burstein, Morales and Vogel (2015).

employment in goods producing sectors using a parsimonious model that allows us to incorporate both trade imbalances and trade costs reductions simultaneously in a setting with arbitrarily many countries. We also use the quantitative model to study the implications of this sectorial reallocation for the skill premium.

Our work is also related to the literature that uses multi-country quantitative general equilibrium models to assess the importance of different channels through which trade affects the skill premium. Recent examples of this literature are Parro (2013) and Burstein, Cravino and Vogel (2013), who measure the effects of capital imports when the production function exhibits capital-skill complementarity, and Burstein and Vogel (2016), who study within-sector factor reallocation across firms with different skill intensities.[4] All of these papers feature homothetic, Cobb-Douglas preferences across goods and services, so that the effects of trade on the skill-premium do not arise from structural change. Our contribution is to propose and quantify a novel mechanism through which trade can affect the skill premium: by inducing reallocation of labor across sectors that are traded with different intensities. To provide a transparent quantification of this new channel, we abstract from the other forces already discussed in thisliterature.

Finally, Buera, Kaboski and Rogerson (2015) document that increases in GDP per capita are associated with a shift in the composition of value added towards service sectors that are intensive in skilled labor. Using a closed-economy, two sector model of structural change driven by price and income effects, they find that these compositional changes account for roughly a quarter of the increase in the skill premium due to technical change. Relative to Buera, Kaboski and Rogerson (2015), we document that, compared to service-producing sectors, goods-producing sectors experienced faster trade opening in the past decades. In our multi-country setup, this makes international trade an additional driver of the observed reallocation of labor out of unskilled labor intensive sectors and the increase in the skill premium. We also highlight the role of differences in input intensities across sectors in magnifying the effects of changes in the price of goods on the skill premium.

The rest of the paper is organized as follows. Section 2 reports differences in trade patterns and in skill and input intensities across sectors for a panel of countries. Section

[4]In other related work, Matsuyama (2007) argues that international trade can simultaneously increase the skill premium in all countries if the activities associated with international trade costs are skilled labor intensive. Epifani and Gancia (2008) use a Krugman trade model to show that if returns to scale are larger in skilled-labor intensive sectors, and there is high substitutability across sectors, more trade can increase the skill premium in all countries. Basco and Mestieri (2013) study how asymmetric globalization patterns across sectors affect wage inequality in a North-South economy. In contrast, our mechanisms rely on either goods and services being traded with different intensities, or on services being more income elastic than goods.

3 introduces our quantitative model and characterizes how trade and net exports shape sectoral employment shares and the skill premium in our framework. Section 4 shows how we parameterize the model. Section 5 presents our quantitative results, and the last section concludes.

2 Sectoral trade patterns and factor and input intensities

This section documents, for a wide set of countries, three differences across broad sectors that determine the effect of recent changes in trade patterns on the skill premium. First, we show that the share of expenditures on domestically produced goods relative to total absorption of goods declined dramatically between 1995 and 2007, while the share of expenditures on domestically produced services relative to total absorption of services remained roughly constant. Second, we show that goods sectors are unskilled-labor intensive. Finally, we show that unskilled-labor intensive sectors use more intermediate inputs from goods-producing sectors.

2.1 Sectoral changes in trade patterns

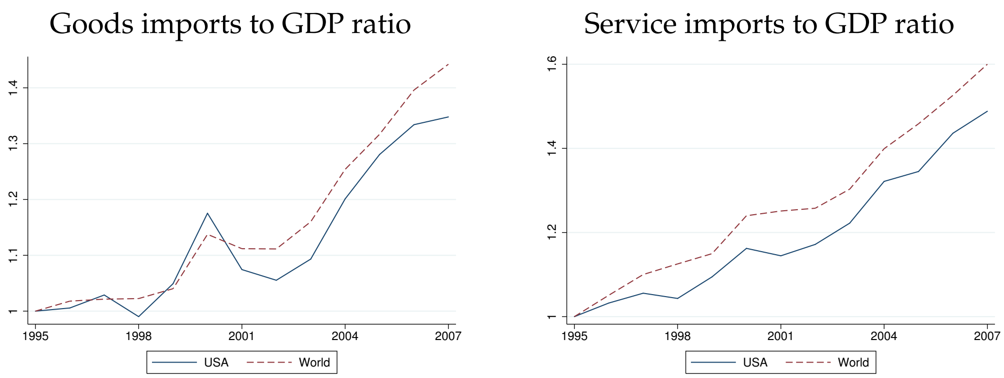
We start by documenting differences in trade patterns across goods sectors and service sectors between 1995 and 2007 using data from the World Input Output Database (WIOD). While the WIOD data covers the 1995-2011 period, we mainly focus on the 1995-2007 period to exclude the great trade collapse and the great recession from our sample. The Online Appendix describes in detail all the data used in this section. Figure 1 shows the dramatic increase in trade relative to GDP over this period.[5] It also shows that imports of services have grown slightly faster than imports of goods. For the US, the ratio of service imports to GDP grew about 49 percent, while the ratio of goods imports to GDP grew only by about 35 percent. Online Appendix Table A4 shows that this pattern is pervasive for the sample of countries we construct based on the WIOD.

We define the 'domestic expenditure share' of each sector j in country i, denoted by $\pi^j_{ii,t}$, as the ratio of expenditures on domestically produced goods or services relative to total expenditures in that sector.[6] Figure 2 reports domestic expenditure shares in 2007

[5] We classify Agriculture, Mining, and Manufacturing industries as goods-producing sectors, and the remaining industries as services. We provide a detailed account of how we group industries in WIOD into goods and services in Section 4 and in the data Online Appendix.

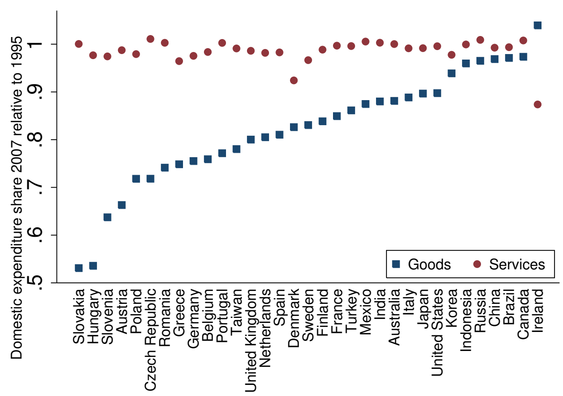
[6] The domestic expenditure share equals one minus the share of imports in total absorption. We focus on changes in domestic expenditure shares because they summarize the effects of trade on relative price movements in our model. This is a feature shared by most workhorse trade models (see Arkolakis, Costinot and Rodriguez-Clare, 2012).

Figure 1: Imports relative to total GDP (1995=1)



Notes: We classify Agriculture, Manufacturing and Mining as goods, and all other sectors as services. Source: WIOD.

Figure 2: Changes in domestic expenditure shares

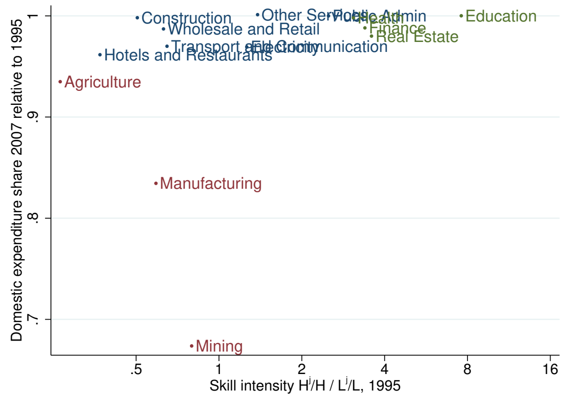


Notes: We classify agriculture, manufacturing and mining as 'Goods', and all other sectors as 'Services.' 'Domestic expenditure shares 2007 relative to 1995' refers to $\pi^j_{ii,2007}/\pi^j_{ii,1995}$, where $\pi^j_{ii,t} \equiv 1 - Imports^j_t / \left[Output^j_i + Imports^j_i - Exports^j_i\right]$. Source: WIOD.

relative to 1995 for the countries in our sample (see Online Appendix Table A5 for the exact values). The figure reveals that domestic expenditure shares in goods sectors declined dramatically in most countries. In contrast, domestic expenditure shares in service sectors remained roughly constant in every country of our sample with the exception of Denmark and Ireland. In the average country, the domestic expenditure share in goods producing sectors declined by 18 percent, relative to only 2 percent for service sectors. For the US these numbers are roughly 10 and 0 percent respectively. We summarize this finding in the following observation:

Observation 1 *Between 1995 and 2007, domestic expenditure shares in goods producing sectors declined dramatically, while domestic expenditure shares on service producing sectors remained roughly constant.*

Figure 3: Skill intensities and tradability across sectors



Notes: 'Domestic expenditure shares 2007 relative to 1995' refers to $\pi^j_{ii,2007}/\pi^j_{ii,1995}$, defined in Figure 2. H^j_i and L^j_i denote the number of unskilled and skilled workers in country i and sector j, and $H_i \equiv \sum_j H^j_i$ and $L_i \equiv \sum_j L^j_i$. The figure reports the average of these measures across the countries in our sample. Source: WIOD.

2.2 Sectoral trade patterns and skill intensities

We now report how skill intensities vary across broad sectors using data on employment and educational attainment by sector from the WIOD Socio Economic Accounts. We classify workers with complete college education as skilled workers, and workers that have not completed college as unskilled workers.[7] In what follows, we let H^j_i and L^j_i denote skilled and unskilled employment in country i and sector j. We refer to the 'skill intensity' of a sector as the ratio of skilled to unskilled workers in the sector relative to the ratio of skilled to unskilled workers in the overall economy.[8]

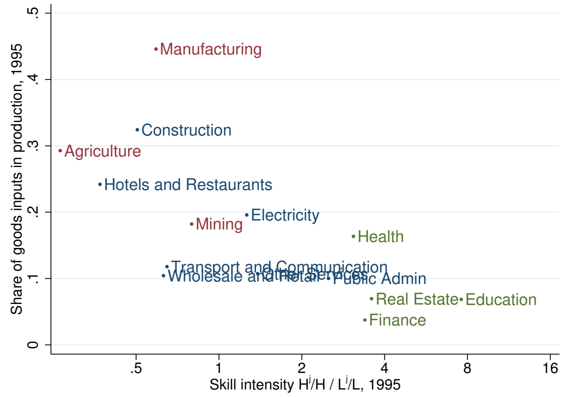
Figure 3 plots the average skill intensities and the 1995-2007 changes in domestic expenditure shares in each one-digit ISIC Rev. 3 sector across countries in our sample. The figure reveals that sectors in which domestic expenditure shares declined the most (Agriculture, Manufacturing and Mining) are unskilled-labor intensive. Among the sectors in which domestic expenditure shares remained roughly constant, some are unskilled-labor intensive (such as Construction and Retail), while some are skilled-labor intensive (such as FIRE and Education). The Online Appendix Figure shows that this pattern is pervasive across countries. We summarize these findings in the following observation:

Observation 2 *Goods-producing sectors (Agriculture, Mining, and Manufacturing) are unskilled-labor intensive,* $L^j_i/H^j_i > L_i/H_i$. *Within the service sectors, Finance and Insurance, Real Estate,*

[7] WIOD Socio Economic Accounts sorts workers into 3 educational groups: "Low" (no college), "Medium" (some college), and "High" (college graduate and above). We classify "Low" and "Medium" education as unskilled workers, and classify the workers with "High" education as skilled workers.

[8] That is, the skill intensity of a sector is given by $\frac{H^j_i/L^j_i}{H_i/L_i}$, with $H_i \equiv \sum_j H^j_i$ and $L_i \equiv \sum_j L^j_i$

Figure 4: Use of inputs from the goods sector



Notes: 'Share of goods inputs in production' is the share of Agriculture, Mining and Manufacturing inputs in total production of the sector. Skill intensities are defined as in Figure 3. The figure reports the average of these measures across the countries in our sample. Source: WIOD.

Health, and Education are skilled-labor intensive, $L_i^j/H_i^j < L_i/H_i$, while the remaining service sectors are unskilled-labor intensive, $L_i^j/H_i^j > L_i/H_i$.

2.3 Skill intensities and intermediate input shares

Finally, we report how the use of intermediate inputs from goods-producing sectors varies across sectors with different skill intensities. In particular, we compute the share of intermediate inputs from goods-producing sectors in total output for each one-digit ISIC Rev. 3 sector using data from the WIOD as described in the Online Appendix.

Figure 4 plots skill intensities and the share of goods inputs by sector for the average country in our sample. The figure reveals that unskilled-labor intensive sectors use more intermediate inputs from goods-producing sectors. This observation applies to both goods-producing sectors (Agriculture, Manufacturing and Mining) and unskilled-labor intensive service sectors (such as Construction and Hotels and Restaurants). In contrast, skilled-labor intensive service sectors use relatively fewer inputs from the goods sector. The Online Appendix Figure documents the finding across countries, which is summarized in the following observation:

Observation 3 *Unskilled-labor intensive sectors use relatively more intermediate inputs from goods producing sectors than skilled-labor intensive sectors.*

2.4 Summary

The data in this section show that the sectors that experienced the sharpest declines in domestic expenditure shares between 1995 and 2007 are unskilled-labor intensive. In addition, unskilled-labor intensive sectors use relatively more highly-traded intermediate inputs than skilled-labor intensive sectors. In the following section, we present a quantitive trade model in which these differences across sectors shape how trade affects the composition of value-added and employment across sectors and the skill premium.

3 Model

3.1 Setup

Preliminaries: We consider a world economy featuring I countries indexed by i and J sectors indexed by j. Each country is endowed with H_i and L_i efficiency units of skilled and unskilled labor. The final output of each sector can be used for consumption or as an intermediate input in the production of any sector. Within each sector j, there are K^j industries indexed by k.[9] Heterogeneous producers use skilled and unskilled labor to produce intermediate varieties in each of the industries. Producers differ in terms of their productivity and the sector in which they produce. All labor and goods markets are perfectly competitive.

Preferences: The utility of the representative household in country i is given by the non-homothetic CES aggregator C_i, that is defined implicitly by:

$$1 = \sum_{j=1} \left[\bar{\phi}_i^{j\frac{1}{\rho}} C_i^{\frac{\epsilon^j}{\rho}} \left[C_i^j \right]^{\frac{\rho-1}{\rho}} \right]. \tag{1}$$

Here C_i^j denotes consumption of the final good from sector j, $\bar{\phi}_i^j$ controls the weight of each sector, and ρ is the elasticity of substitution across sectors in the aggregate consumption

[9] While allowing for industries within sectors is not crucial for the direction of our mechanisms, the quantitative effect of trade on relative prices does depend on the level of disaggregation at which trade elasticities and the domestic expenditure shares are computed. Costinot and Rodriguez-Clare (2014) and Ossa (2015) show that the real wage gains from trade for the average country get larger as one moves from a one-sector to a multi-sector model. Following the recent literature on international trade and real wages (see for example, Costinot and Rodriguez-Clare 2014, Caliendo and Parro 2015, Ossa 2015 and Levchenko and Zhang 2016) we allow for multiple industries within sectors of our model, though we assume that all industries within a given sector have identical factor intensities.

bundle. The parameter ϵ_i^j controls the income elasticity of demand for sector j. This non-homothetic CES aggregator has been recently introduced into the structural change literature by Comin, Lashkari and Mestieri (2015), and boils down to a homothetic CES aggregator in the special case where $\epsilon^j = 1 - \rho$ for all j.

The household's budget constraint is given by

$$w_i L_i + s_i H_i = \sum_j P_i^j C_i^j + NX_i.$$

Here, w_i and s_i denote the wages of unskilled and skilled workers respectively. The skill premium in country i is defined as s_i / w_i. NX_i are net transfers from country i to the rest of the world. Note that if $NX_i < 0$ the country is running a trade deficit.

Sectoral output: Each sector j combines the production of its K^j industries according to a Cobb-Douglas aggregator:

$$Y_i^j = \prod_{k=1}^{K^j} Y_i^j(k)^{\sigma_i^j(k)}. \tag{2}$$

Final output from each sector is non-tradable and can be used for consumption or as intermediates

$$Y_i^j = C_i^j + X_i^j, \tag{3}$$

where X_i^j denotes the quantity of the final output of sector j that is used as intermediate inputs by any of the sectors.

Industrial output: Industry k combines a continuum of intermediate varieties, indexed by $\omega \in [0,1]$, according to a CES production function with country- and industry-specific elasticity of substitution $\eta > 1$,

$$Y_i^j(k) = \left[\int_0^1 y_i^j(\omega, k)^{\frac{\eta-1}{\eta}} d\omega \right]^{\frac{\eta}{\eta-1}}, \tag{4}$$

where $y_i^j(\omega, k)$ is consumption of intermediate variety (ω, k) from sector j in country i. Each intermediate variety (ω, k) is potentially produced in every country, although the industrial output is not traded.

Production of intermediate varieties: Producers of intermediate variety (ω, k) in country i, sector j produce according to the following constant returns to scale production function

$$q_i^j(\omega,k) \quad = \quad A_i^j(k)\, z_i^j(\omega,k)\, m_i^j(\omega,k)^{1-\beta_i^j}\, e_i^j(\omega,k)^{\beta_i^j}, \tag{5}$$

where

$$m_i^j(\omega,k) \quad \equiv \quad \left[\sum_{l=1}^{J}\left[\bar{\alpha}_i^{lj}\right]^{\frac{1}{\rho_m}} x_i^{lj}(\omega,k)^{\frac{\rho_m-1}{\rho_m}}\right]^{\frac{\rho_m}{\rho_m-1}}, \tag{6}$$

and

$$e_i^j(\omega,k) \quad \equiv \quad \left[\left[\bar{\mu}_i^j\right]^{\frac{1}{\gamma}} l_i^j(\omega,k)^{\frac{\gamma-1}{\gamma}} + \left[1-\bar{\mu}_i^j\right]^{\frac{1}{\gamma}} h_i^j(\omega,k)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}.$$

Producers from industry k in sector j combine a bundle of skilled and unskilled workers, $e_i^j(\omega,k)$, and a sector-specific intermediate input bundle, $m_i^j(\omega,k)$, according to a Cobb-Douglas aggregator, with a constant share of value-added in gross output β^j that is common for all industries k within each sector j. The intermediate input bundle $m_i^j(\omega,k)$ aggregates inputs from all sectors, where $x_i^{lj}(\omega,k)$ denotes the use of inputs from sector l in the production of intermediate variety (ω,k) in sector j; the parameter $\bar{\alpha}_i^{lj}$ controls the share of inputs from sector l on total input expenditures in sector j, and is common across industries within sectors. The elasticity of substitution across inputs from different sectors is given by ρ_m. The employment bundle combines unskilled labor, l, and skilled labor, h, with a constant elasticity of substitution γ, and the shares, $\bar{\mu}_i^j$ are sector but not industry specific.[10]

The productivity of country i producers of variety (ω,k) is given by the product of a country-industry specific term, $A_i^j(k)$, shared by all industry k producers in the country, and a country-intermediate-variety specific productivity, $z_i^j(\omega,k)$. Note that, up to the productivity terms $A_i^j(k)\, z_i^j(\omega,k)$, the parameters of the production function are common across all K^j industries within each sector j. The country-intermediate-variety specific productivity is equal to $z_i^j(\omega,k) = u^{-\theta^j(k)}$, where u is an i.i.d random variable that is exponentially distributed with mean and variance 1. A higher value of $\theta^j(k)$ increases the dispersion of productivities across producers within industry k.

[10]We abstract from including capital skill complementarity a la Burstein, Cravino and Vogel (2013) and Parro (2013) in the production function to maintain the tractability of the model and to focus on the new mechanisms proposed in this paper.

International trade Only intermediate varieties can be traded internationally. Delivering a unit of intermediate variety (ω, k) from country i to country n requires producing $\tau^j_{in}(k) \geq 1$ of the good. We assume that trading domestically is costless, $\tau^j_{ii}(k) = 1$.

Equilibrium To construct prices, we first define the unit cost of producers of intermediate variety (ω, k) producing in country i and selling in country n, $c^j_{in}(\omega, k)$,

$$c^j_{in}(\omega, k) = \frac{c^j_i \tau^j_{in}(k)}{A^j_i(k) z^j_i(\omega, k)}.$$

Here c^j_i is the unit cost of producing industry k intermediate inputs for the domestic market for an intermediate producer with productivity $A^j_i(k) z^j_i(\omega, k) = 1$, and is given by:

$$c^j_i = \bar{\beta}^j_i \left[p^j_{v,i}\right]^{\beta^j_i} \left[p^j_{b,i}\right]^{1-\beta^j_i},$$

where $\bar{\beta}^j_i$ is a constant, and $p^j_{v,i}$ and $p^j_{b,i}$ are the unit costs of the labor and input bundles in sector j in country i. These costs are common across all industries in each sector j since production functions are identical across industries within sectors. The price of the intermediate variety (ω, k) in country n is given by

$$p^j_n(\omega, k) = min_i \left\{c^j_{in}(\omega, k)\right\},$$

where we have used the fact that good (ω, k) is perfectly substitutable across all potential source countries that can supply it to country n. The price index of sector j output in country n is

$$P^j_n(k) = \left[\int_0^1 p^j_n(\omega, k)^{1-\eta} d\omega\right]^{\frac{1}{1-\eta}},$$

and the share of country n's expenditure in industry k's goods produced in country i is

$$\pi^j_{in}(k) = \left[\int_0^1 p^j_n(\omega, k)^{1-\eta} \mathbb{I}^j_{in}(\omega, k) d\omega\right] / P^j_n(k)^{1-\eta}; \tag{7}$$

where $\mathbb{I}^j_{in}(\omega, k)$ is an indicator variable that equals one if country n purchases intermediate variety (ω, k) from country i, and equals zero otherwise. Under the assumption of exponentially distributed productivities, Eaton and Kortum (2002) show that in equilibrium:

$$\pi_{in}^{j}(k) = \left[\tau_{in}^{j}(k)\, c_i^j / A_i^j(k)\right]^{-1/\theta^j(k)} / \sum_{i'} \left[\tau_{i'n}^{j}(k)\, c_{i'}^j / A_{i'}^j(k)\right]^{-1/\theta^j(k)}. \tag{8}$$

A competitive equilibrium is a set of prices and quantities such that all markets clear. Each producer satisfies worldwide demand for its output. Sectoral output must satisfy the resource constraints (3). The demand for unskilled and skilled labor across producers must equal the endowments L_i and H_i, respectively. The total demand for intermediate inputs from each sector must equal X_i^j. The household's budget constraints must be satisfied. Online Appendix A.1 fully characterizes the equilibrium.

3.2 A simplified model to illustrate the mechanism

We start by solving a simplified version of our model to clarify the new mechanisms in the paper. Consider a version of the model with two sectors, goods and services, indexed by G and S, with only one industry in each sector. Assume further that the production of goods uses only low-skilled labor, ($\bar{\mu}^G = 1$, and $\beta^G = 1$) that the production of services uses only high-skilled labor ($\bar{\mu}^S = 0$, and $\beta^S = 1$), and that the parameters θ and $\bar{\phi}$ are constant across sectors. Finally, to underscore that the effects of trade on sectorial value-added shares and the skill-premium can go in the same direction in every country, we focus on the case of symmetric countries.[11]

In this version of the model, total compensation to skilled and to unskilled workers equals value-added in the service and the goods sectors respectively. In addition, from balanced trade (which follows from symmetry), and the assumption that there are no intermediate inputs ($\beta^j = 1$), sectorial value-added equals sectorial consumption expenditures. That is:

$$\frac{sH}{wL} = \frac{v^S}{v^G} = \frac{P^S C^S}{P^G C^G} = \left[\frac{P^S}{P^G}\right]^{1-\rho} C^{\epsilon_S - \epsilon_G}, \tag{9}$$

where v^j denotes the share of sector j in total value added, and the last equality follows from the demand function associated with (1). As shown in Eaton and Kortum (2002) under our same distributional assumptions, price indices for final goods are proportional to the domestic expenditure shares:

$$P^j \propto \frac{c^j}{A^j}\left(\pi^j\right)^{\theta}.$$

[11] We therefore drop the country subscripts in this subsection.

If $\mu^G = 1$, $\mu^S = 0$ and $\beta^j = 1$, relative prices are given by:

$$\frac{P^S}{P^G} = \frac{s}{w}\frac{A^G}{A^S}\left[\frac{\pi^S}{\pi^G}\right]^{\theta}, \tag{10}$$

where from the symmetry assumption the domestic expenditure shares depend only on the trade costs, and are given by $\pi^j = \left[1 + [I-1]\left[\tau^j\right]^{-1/\theta}\right]^{-1}$. Equation (10) shows that more trade in goods relative to services ($\pi^G < \pi^S$ or $\tau^G < \tau^S$) results in a lower relative price of goods *in all countries*. Combining equations (9) and (10) we can solve for the skill premium:

$$\frac{s}{w} = \left[\frac{L}{H}\right]^{\frac{1}{\rho}}\left[\frac{A^G}{A^S}\left[\frac{\pi^S}{\pi^G}\right]^{\theta}\right]^{\frac{1-\rho}{\rho}} C^{\frac{\epsilon_S-\epsilon_G}{\rho}}. \tag{11}$$

Finally, substituting in (9), we can write relative value added shares as:

$$\frac{v^S}{v^G} = \left[\frac{L}{H}\frac{A^G}{A^S}\left[\frac{\pi^S}{\pi^G}\right]^{\theta}\right]^{\frac{1-\rho}{\rho}} C^{\frac{\epsilon_S-\epsilon_G}{\rho}}. \tag{12}$$

Equations (11) and (12) show that, if goods and services are complements, $\rho < 1$, more trade in goods relative to services ($\pi^G < \pi^S$ or $\tau^G < \tau^S$) is associated with a larger skill premium and a smaller goods sector in terms of value added *in all countries*.[12] The intuition is that more trade in goods reduces goods prices world wide, as shown in equation (10). In addition, as we will show in the next section, trade in any sector increases aggregate consumption C, which increases both the skill premium and the share of value added in the service sector if the service sector is more income elastic, $\epsilon_S > \epsilon_G$.

3.3 International trade, structural change and the skill premium

We now examine the central forces shaping the skill premium and the sectoral composition of value-added and employment in the general model described in Section 3.1, and determine what are the key elasticities that determine these forces. We start by relating the skill premium to sectorial value added shares. Competitive factor markets and equation

[12] In this example, sectoral employment shares do not depend on trade by construction (as by assumption they are determined by H/L). The general model does not impose this restriction.

(5) imply that

$$\frac{s_i}{w_i} = \frac{\sum_j \left[1-\mu_i^j\right] v_i^j}{\sum_j \mu_i^j v_i^j} \frac{L_i}{H_i}, \tag{13}$$

where $\mu_i^j \equiv \frac{w_i L_i^j}{w_i L_i^j + s_i H_i^j}$ is the share of unskilled labor in sector j's value-added, and v_i^j is the share of sector j in aggregate value-added.[13] From equation (13), changes in country i's skill premium are fully determined by changes in country i's endowments of skilled and unskilled labor and by changes in sectoral value-added shares. Given μ_i^j's, an increase in the size of the skilled labor intensive sectors (i.e. an increase in v_i^j in sectors where μ_i^j is low) increases the skill premium.

Changes in the skill premium will in turn affect factor shares μ_i^j's. To better understand these forces we substitute for μ_i^j and take a first-order approximation to equation (13), which yields:[14]

$$\tilde{s}_i - \tilde{w}_i = \frac{1}{\bar{\gamma}_i}\left[\tilde{L}_i - \tilde{H}_i\right] + \frac{1}{\bar{\gamma}_i}\sum_j \left[\frac{H_i^j}{H_i} - \frac{L_i^j}{L_i}\right] \tilde{v}_i^j, \tag{14}$$

where variables with a tilde denote log changes, and $\bar{\gamma}_i \equiv \gamma\chi_i + [1-\chi_i] > 0$, with $\chi_i \equiv \sum_j \frac{\mu_i^j}{\mu_i}\frac{H_i^j}{H_i}$ and $\mu_i \equiv \frac{w_i L_i}{w_i L_i + s_i H_i}$. Equation (14) shows that the skill premium will increase when the relative supply of unskilled labor increases ($\tilde{L}_i > \tilde{H}_i$) or when the skilled labor intensive sectors grow ($\tilde{v}_i^j > 0$ in sectors where $\frac{H_i^j}{H_i} > \frac{L_i^j}{L_i}$). The direct effects of these changes on the skill premium are magnified or mitigated depending on whether the elasticity of substitution between skilled and unskilled labor is greater than 1 (which determines the value of $\bar{\gamma}_i$). If γ is greater than 1, a change in H_i/L_i or v_i^j's that increases the skill premium is mitigated by an increase in the share of unskilled labor in value-added, μ_i^j's, while the reverse is true when γ is smaller than 1.

We now show how changes in prices, income and sectorial net exports shape changes in value-added shares. To facilitate the exposition, for the remainder of this section, we focus on a special case of the model in which there are no intermediate inputs, $\beta_i^j = 1$, and we abstract from changes in endowments $\tilde{L}_i = \tilde{H}_i = 0$. We make the approximation around an equilibrium in which sectoral net exports are zero (we relax these assumptions for the quantitative exercises of Section 5, which do not rely on approximations). In this

[13] Formally, $v_i^j \equiv \beta_i^j \sum_n \pi_{in} P_n^j Y_n^j / \sum_j \beta_i^j \sum_n \pi_{in} P_n^j Y_n^j$.

[14] Online Appendix B contains the proofs to the statements in this Section.

case, the first-order changes in sectoral value-added shares are given by:

$$\tilde{v}_i^j = [1-\rho]\left[\tilde{P}_i^j - \sum_j v_i^j \tilde{P}_i^j\right] + [\epsilon_j - \bar{\epsilon}]\,\tilde{C}_i + \frac{\tilde{\lambda}_i^j}{v_i^j} - \sum_j \tilde{\lambda}_i^j, \tag{15}$$

where $\bar{\epsilon} \equiv \sum_j v_i^j \epsilon_j$ is the expenditure weighted average income elasticity across sectors, and $\lambda_i^j \equiv 1 + \frac{NX_i^j}{R_i}$ is one plus the ratio of sectorial net exports relative to aggregate revenues, with $R_i \equiv \sum_j \sum_n \pi_{in} P_n^j Y_n^j$ and $NX_i^j \equiv \sum_n \pi_{in} P_n^j Y_n^j - \sum_n \pi_{ni} P_i^j Y_i^j$. The first term in equation (15) captures the effect of price changes on sectoral value-added shares. If the elasticity of substitution across sectors is less than 1 ($\rho < 1$), sector j's value-added share is increasing in its price relative to the price of the other sectors (summarized in $\sum_j v_i^j \tilde{P}_i^j$). The second term captures the effects of changes in real income on sectorial value added shares. An increase in the consumption index C_i raises the share of value added in sector j if the income elasticity of sector j is relatively large, $\epsilon_j > \bar{\epsilon}$. Finally, the last term shows the effect of changes in sectoral trade deficits or surpluses. Other things equal, an increase in a sector's net exports relative to aggregate revenues ($\tilde{\lambda}_i^j > 0$) increases the sector's share in value-added.

Note that sectorial prices and aggregate consumption, P_i^j and C_i, are endogenous, and depend on the entire matrix of trade costs (between each pair of countries and in each sector), changes in net transfers to each country, changes in each country-sector specific productivities, and changes in labor endowments in each country. We can show, however, that there is a set of sufficient statistics that fully determine the equilibrium change in the skill premium. The Online Appendix presents a set of equations from which, given changes in these sufficient statistics, changes in sectorial value-added shares and changes in the skill premium can be calculated for any country i. In particular, given values of the elasticities of substitution (γ, ρ and ρ_m), the income elasticities ϵ_j, the dispersion of productivities in each industry $\theta^j(k)$, and factor shares in the initial equilibrium, the change in country i's skill premium depends only on changes in: (i) a weighted average of the industry-level domestic expenditure shares in each sector, given by $\pi_{ii}^j \equiv \prod_{k=1}^{K_j} \pi_{ii}^j(k)^{\sigma_i^j(k)\theta^j(k)}$; ($ii$) the ratio of sectorial net exports relative to aggregate revenues, λ_i^j, (iii) domestic technologies, $A_i^j(k)$ for all j; and (iv) domestic labor endowments, H_i and L_i. Importantly, conditional on (i) $-$ (iv), changes in trade costs, transfers, changes in other countries' technologies and endowments, and changes in all other trade shares do not affect country i's skill premium. That is, international trade costs, foreign technologies, transfers and foreign endowments only affect country i's skill premium through π_{ii}^j and λ_i^j. Moreover, given changes in π_{ii}^j and λ_i^j, we do not need to compute the multi-country general equilibrium model to calculate the change in country i's skill premium. We highlight that this result does not rely on the approximation. We exploit this property of the model when we conduct Counterfactual 2 in Section 5.

Trade and the skill premium This section provides a first-order approximation for how changes in factor supplies, domestic expenditure shares, and sectorial net exports affect the skill premium. We continue to abstract from intermediate inputs ($\beta_i^j = 1$) and to approximate our results around $\lambda_i^j = 1$ to facilitate exposition. The change in the skill premium is given by:

$$\tilde{s}_i - \tilde{w}_i \;=\; \sum_j \xi_{\pi,i}^j \left[\tilde{\pi}_{ii}^j - \tilde{A}_i^j\right] + \xi_{C,i} \sum_j \left[v_i^j \left[\tilde{A}_i^j - \tilde{\pi}_{ii}^j\right] - \tilde{\lambda}_i^j\right] + \sum_j \xi_{\lambda,i}^j \tilde{\lambda}_i^j, \tag{16}$$

where the elasticities are given by $\xi_{\pi,i}^j \equiv \frac{1-\rho}{\Gamma_i}\left[\frac{H_i^j}{H_i} - \frac{L_i^j}{L_i}\right]$, $\xi_{\lambda,i}^j \equiv \xi_{\pi,i}^j \frac{1}{[1-\rho]v_i^j}$, and $\xi_{C,i} \equiv \sum_j \xi_{\pi,i}^j \frac{\epsilon_j - \bar{\epsilon}}{\bar{\epsilon}}$, with $\Gamma_i \equiv \chi_i \gamma + [1-\chi_i]\,\rho$.

Equation (16) decomposes how trade affects the skill premium. If there are no differences in skill intensities across sectors, $\frac{H_i^j}{H_i} = \frac{L_i^j}{L_i}$, then $\xi_{\pi,i}^j = \xi_{C,i} = \xi_{\lambda,i}^j = 0$ and the skill premium is not affected by trade. More generally, the first term shows how changes in trade patterns affect the skill premium through price effects. The elasticity $\xi_{\pi,i}^j$ is positive if $\frac{H_i^j}{H_i} < \frac{L_i^j}{L_i}$ and $\rho < 1$. In this case, increased trade in unskilled-labor intensive sectors (i.e. a decline in the domestic expenditure share π_{ii}^j in these sectors) results in an increase in the skill premium. The second term shows how trade affects the skill premium through its income effects. The elasticity $\xi_{C,i}$ is positive if sectors that are skilled intensive, $\frac{H_i^j}{H_i} > \frac{L_i^j}{L_i}$, are also high income elastic ($\epsilon_j > \bar{\epsilon}$). Finally, the last term in equation (16) shows how changes in sectoral deficits affect sectoral revenue shares, as explained in equation (15) above. It shows that a decline in net exports in low skill intensive sectors (that is, $\tilde{\lambda}_i^j < 0$ in sectors where $\frac{H_i^j}{H_i} < \frac{L_i^j}{L_i}$) increases the skill premium.

Trade and structural change We conclude this section by relating changes in value-added and employment shares across sectors to changes in trade patterns. To a first-order approximation, changes in sectorial value-added shares can be written as:

$$
\begin{aligned}
\tilde{v}_i^j \;=\;& [1-\rho]\left[\left[\tilde{\pi}_{ii}^j - \tilde{A}_i^j\right] + \sum_j v_i^j \left[\tilde{A}_i^j - \tilde{\pi}_{ii}^j\right] + \left[\mu_i - \mu_i^j\right]\left[\tilde{s}_i - \tilde{w}_i\right]\right] \\
+\;& [1-\rho]\left[\frac{\epsilon_j - \bar{\epsilon}}{\bar{\epsilon}}\right]\left[\sum_j v_i^j \left[\tilde{A}_i^j - \tilde{\pi}_{ii}^j\right] - \sum_j \tilde{\lambda}_i^j\right] \\
+\;& \frac{\tilde{\lambda}_i^j}{v_i^j} - \sum_j \tilde{\lambda}_i^j.
\end{aligned} \tag{17}
$$

See the Online Appendix for a proof and for the analogous expression in terms of changes in employment shares. The first term in equation (17) states that, if ρ is less than one, sectorial value-added and employment shares are increasing in the sector's domestic expenditure shares and decreasing in the sector's productivity due to price effects. The second term captures the income effects, and shows that increased trade or productivity increase the value added share of sectors that have a high income elasticity, $\epsilon_j > \bar{\epsilon}$. Finally, sectorial shares are increasing in sectorial net exports, summarized in λ_i^j. In the following sections, we calibrate the model and conduct two counterfactual exercises to quantify the impact of international trade on structural changes and the skill premium.

4 Data and parameterization

To conduct the counterfactual exercises of the next section we need data on trade flows and we need to assign values to our model's parameters. In what follows, we first describe our data sources and discuss how we map them to the model. We then compute the sectoral factor intensities, which according to equation (16) determine whether changes in trade patterns are skilled biased. Next, we show how we pick values for the parameters and input shares in the model.

4.1 Taking the model to sectoral data

We take the model to the data focusing on 3 sectors motivated by our observations from Section 2: a goods-producing sector, $j = G$; and two service sectors, one that is skilled labor intensive, $j = F$, and one that is unskilled labor intensive, $j = S$. We start by briefly discussing how we aggregate industries to match the sectors in the model. Our main sample combines input-output data from the WIOD with data on employment from the WIOD Socio Economic Accounts. We follow Costinot and Rodriguez-Clare (2014) and include seven small economies in WIOD into the "Rest of the World" category, so that we are left with a sample of 34 countries.[15] While WIOD data covers the 1995-2011 period, we mainly focus on the 1995-2007 to exclude the great trade collapse and the great recession from our sample. We classify the sectors of the IO tables into the three sectors of our model as follows: i) goods G (including Agriculture, Mining, and Manufacturing), ii) skilled-labor intensive services F (including Finance and Insurance, Real Estate, Health, and Education), and iii) unskilled-labor intensive services S (including the remaining services).[16] Within sector G industries k correspond to the most disaggregated industrial classification available in WIOD (see Online Appendix Table A3).

Trade data We use the IO tables to compute bilateral trade shares and the ratios of sectorial net exports to aggregate revenue ratio. The trade shares $\pi_{in}^{j}(k)$ are the spending of country n in imports from country i relative to total absorption in industry k in sector j, where absorption is defined as gross output plus imports minus exports. To calculate the net export to revenue ratios, λ_i^j, we measure revenues as gross output, and net exports at the level of the broad sector j.

4.2 Parameterization

The key moments and parameters that determine how changes in trade patterns affect the skill premium are:[17] (i) the sectoral factor intensities H_i^j/H_i and L_i^j/L_i in the initial equilibrium, (ii) the share of unskilled labor in total labor payments in the initial equilibrium, μ_i, (iii) the industrial shares in aggregate absorption in the goods sector, $\sigma_i^j(k)$, (iv) the sectoral value-added shares, β_i^j, (v) the shares of inputs from each sector that are used in the sectoral input bundles, α_i^{lj}, (vi) the trade elasticities $\theta^j(k)$, (vii) the elasticity of substitution between skilled and unskilled labor, γ, (viii) the elasticities of substitution across sectors in the consumption and input bundles, ρ and ρ_m, and (ix) the income elasticities, $\epsilon_j's$. We describe how we assign these values below.

Factor and input shares The initial shares for all factors and inputs are calibrated to the year 1995. We follow the skill classification described in Section 2 and use data from WIOD Socio Economic Accounts to compute the sectoral skill intensities H_i^j/H_i and

[15] Following Costinot and Rodriguez-Clare (2014), we include Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Luxembourg, and Malta in the expanded ROW category.

[16] That is, Utilities, Construction, Wholesale and Retail Trade, Hotels and Restaurants, Transport and Communications, and Other Community, Social and Personal Services.

[17] See the set of equations characterizing the equilibrium in the Online Appendix.

L_i^j/L_i, which we report in Online Appendix Table A7. We calibrate the share of unskilled labor in total labor payments, μ_i, to match the share of the skilled labor intensive service sector in value added in each country, given the data on H_i^F/H_i and L_i^F/L_i.[18] We use data from IO tables to compute $\sigma_i^G(k)$ as industry k's share in total absorption in the goods sector in the initial year. We calculate the sectoral value-added shares, β_i^j, as the ratio of value-added to gross output in each sector, also using the Input-Output Tables. We construct the input shares in each sector's input bundle, α_i^{lj}, as the share of expenditures in intermediate inputs from sector l relative total input expenditures by sector j. The resulting value-added and input shares are reported in the Online Appendix.

Elasticities Finally, we calibrate the trade elasticities, $1/\theta^j(k)$, and the elasticities of substitution across workers and across sectors, γ, ρ and ρ_m. The first two elasticities are taken directly from the literature. We take the industry-level trade elasticities $1/\theta^j(k)$ from Caliendo and Parro (2015) (see Online Appendix Table A3). We set $\gamma = 1.48$, to match an aggregate elasticity of substitution between skilled and unskilled workers of 1.42 in the US, following Katz and Murphy (1992).

While an extensive literature has studied how low elasticities of substitution across sectors can shape structural change, there are three important differences between the structural parameters ρ and ρ_m in our model and most estimates of the elasticity of substitution across sectors in this literature. First, while the structural transformation literature typically breaks sectors into agriculture, manufacturing and services, the sectoral breakdown in our model is across goods, low-skilled services, and high-skilled services. Second, while the elasticity is typically estimated from consumption data, we need to estimate a separate elasticity ρ_m for the input-bundles. Finally, the definition of consumption expenditures $P_i^jC_i^j$ in our model cannot be mapped directly to either the 'final-expenditure' nor to the 'value-added' data described in Herrendorf, Rogerson and Valentinyi (2013), a point we discuss in detail below.

With this in mind, we estimate ρ, ρ_m and ϵ^j from time series data on prices, real income and expenditure shares in the US in a way that is consistent with our model, following the macro-approach in Herrendorf, Rogerson and Valentinyi (2013) and Comin, Lashkari and Mestieri (2015). In particular, to take the relative demand functions associated with the aggregators (1) and (6) to the data we write

[18] For Korea and Russia, this procedure results in a negative value for μ_i. We assign the median μ_i for these countries.

$$log\left(\frac{P^j_{i,t}C^j_{i,t}}{P^G_{i,t}C^G_{i,t}}\right) = [1-\rho]\,log\left(\frac{P^j_{i,t}}{P^G_{i,t}}\right) + \left[\epsilon^j - \epsilon^G\right] logC_{i,t} + log\left(\frac{\bar{\phi}^j_i}{\bar{\phi}^G_i}\right) + \varepsilon^c_{ij,t}, \quad \text{j=S,F,} \tag{18}$$

and

$$log\left(\frac{P^j_{i,t}x^{jl}_{i,t}}{P^G_{i,t}x^{Gl}_{i,t}}\right) = [1-\rho_m]\,log\left(\frac{P^j_{i,t}}{P^G_{i,t}}\right) + log\left(\frac{\bar{\alpha}^{jl}_i}{\bar{\alpha}^{Gl}_i}\right) + \varepsilon^l_{ij,t}, \quad \text{j=S,F.} \tag{19}$$

Here $P^j_i x^{jl}_i$ denotes expenditures on inputs from sector j by producers in sector $l = S, G, F$.

Herrendorf, Rogerson and Valentinyi (2013) note that elasticity estimates based on final expenditure data are higher than estimates based on value-added data, as final expenditures are produced using intermediate inputs that contain value-added from multiple sectors. As noted above, the expenditure shares and relative prices in our model cannot be measured directly with either final consumption expenditure data nor with the consumption value-added data constructed by Herrendorf, Rogerson and Valentinyi (2013). On the one hand, data on final consumption expenditures includes distribution margins, but our model does not have a distribution sector (note that consumption in retail, wholesale trade, and transport are all included in the unskilled labor intensive service sector in our parameterization). On the other hand, while consumption value-added data as measured by Herrendorf, Rogerson and Valentinyi (2013) subtracts the input content from consumption expenditures, the value of intermediate inputs is included in the sectoral consumption expenditures in our model, $P^j_i C^j_i$.[19] Measuring expenditure shares in a way that is consistent with our model thus requires measuring how the *gross output* of each sector, valued at *producer prices* (i.e. before distribution margins are applied), is used in the economy. The Online Appendix describes in detail how we construct expenditure shares at producer prices using the Input-Output Use Tables for the US, and how we construct sectoral producer price indexes using the Chain-Type Price Indexes for Gross Output published by the BEA.

Appendix Figure A.1 plots the relative prices and relative expenditure shares in consumption and each of the input bundles. Both the price and the expenditure shares of skilled labor intensive services relative to goods rose during this period, which is consistent with an elasticity of substitution smaller than 1. These changes in relative expenditure shares are similar for the consumption and all of the input bundles. In addition, a

[19] That is, while the value of intermediate inputs is not counted in the consumption value-added data, the sectoral production functions in our model are not value-added production functions.

similar pattern arises also for the price and expenditure shares of unskilled labor intensive services relative to goods. Overall, the strong positive comovements of prices and expenditure shares are indicative of complementarities across sectors.

We estimate jointly each set of equations (18) and (19) for $l = S, G, F$ using iterated feasible nonlinear least squares, as Herrendorf, Rogerson and Valentinyi (2013).[20] As in Comin, Lashkari and Mestieri (2015), the identification assumption is that shocks to income and relative prices are uncorrelated to changes in the demand shifters $\bar{\phi}_i^j$ and $\bar{\alpha}_i^{jl}$, which would be captured in the error term. In other words, we assume preferences do not change through time, other than by the income effects. Comin, Lashkari and Mestieri (2015) show that this assumption is likely to hold by reestimating equations analogous to (18) and (19) across different periods, countries and populations.

Table 1 report the results. The estimates for ρ and ρ_m are both statistically less than 1, with an estimated elasticity of substitution of 0.59 in the consumption bundle and of roughly 0 when estimated using the input bundles. In addition, we obtain income elasticities differences of $\epsilon_F - \epsilon_G = 0.81$ and $\epsilon_S - \epsilon_G = 0.42$, indicating that both service sectors are more income elastic than the goods sector, with the skilled intensive service sector being the most income elastic. In what follows we normalize $\epsilon_G = 1$, as in Comin, Lashkari and Mestieri (2015). Appendix Figure A.2 shows that the fitted valued from our regressions closely match the expenditure share data. We note that our estimates are in line with those obtained by the structural change literature using different estimation strategies and samples.[21]

5 Quantitative results

This section quantifies how international trade affects structural change and the skill premium in our model. We conduct two counterfactual exercises to measure these effects,

[20] In particular, to constrain the elasticities of substitution to be positive, we make the transformations $\rho = e^{a_0}$ and $\rho_m = e^{b0}$, and estimate the unconstrained parameters a_0 and $b_0 \in (-\infty, +\infty)$.

[21] For example, Comin, Lashkari and Mestieri (2015) find elasticities of substitution between goods and services in consumption of about 0.6, and estimate a difference between the income elasticity of services and manufacturing between 0.5 and 0.6. Sposi (Forthcoming) follows a similar procedure and obtains an elasticity of substitution of 0.4 in the consumption bundle, and a difference in the income elasticity between services and manufacturing of 0.2. Herrendorf, Rogerson and Valentinyi (2013) estimate an elasticity of 0.85 using final consumption expenditure data, and of roughly 0 when using value-added expenditure data. Kehoe, Ruhl and Steinberg (2013) use an elasticity of 0.65 in the consumption bundle, and of 0.03 in the input bundle following Atalay (2017). Buera, Kaboski and Rogerson (2015) use an elasticity of substitution between goods and services of 0.2.

Table 1: Generalized CES estimates

	Consumption Bundle	Input Bundle
ρ	0.583***	0.000
	(0.099)	(.)
$\epsilon^F - \epsilon^G$	0.818***	
	(0.088)	
$\epsilon^S - \epsilon^G$	0.424***	
	(0.036)	
Observations	36	36

Notes: The table reports the results of estimating equations (18) (Consumption Bundle) and (19) (Input Bundle) for $l = S, G, F$.

compare the implications of the model to the data, provide evidence of the mechanisms in the paper, and show how our quantitative results change under alternative parameterizations.

5.1 Counterfactual 1: Changes in trade costs between 1995 and 2007

Our first counterfactual directly evaluates the effect of changes in trade costs between 1995 and 2007 on the sectorial composition of the economy and on the skill premium across countries. We begin by measuring changes in bilateral trade costs from changes in bilateral expenditure shares, following the approach in Head and Ries (2001). In particular, we use equation (8) to write the change in trade costs between two periods as

$$\hat{\tau}^j_{ni}(k)\,\hat{\tau}^j_{in}(k) = \left[\frac{\hat{\pi}^j_{in}(k)\,\hat{\pi}^j_{ni}(k)}{\hat{\pi}^j_{nn}(k)\,\hat{\pi}^j_{ii}(k)}\right]^{-\theta^j(k)}, \tag{20}$$

where a hat over a variable denotes the ratio of the variable between the final and initial year, that is, $\hat{x} \equiv \frac{x_1}{x_0}$. Assuming symmetric trade costs, $\hat{\tau}^j_{ni}(k) = \hat{\tau}^j_{in}(k)$, and given values for the trade elasticities $\theta^j(k)$, we use equation (20) to estimate the changes in trade costs from observed changes in bilateral trade patterns, $\hat{\pi}^j_{ni}(k)$. We then follow the "exact hat algebra" approach in Dekle, Eaton and Kortum (2008) to compute the equilibrium response to these changes in trade costs.[22]

Appendix Figure A.3 shows that the counterfactual changes in domestic expenditure shares line up well with those observed in the 1995-2007 data. In the goods sector, regress-

[22]The Online Appendix characterizes the equilibrium of our model as a function of the model's fundamentals. Counterfactual 1 is computed by feeding in the changes in trade costs implied by equation (20), and keeping the other fundamentals fixed at their 1995 values.

ing the changes in expenditure shares in the data on those generated by the counterfactual generates an R-squared of 0.8 and a slope that is close to 1. The changes in trade costs also do a good job in accounting for the observed changes in domestic expenditure shares in the service sectors for most countries, with the notable exceptions of Hungary and Slovakia, where expenditure shares decline dramatically in the counterfactual equilibrium but increase in the data. We show below that our results are not driven by these two countries. Crucially, in the counterfactual equilibrium as in the data, the decline in domestic expenditure shares is much larger in the goods sector than in the services sectors for all countries with the exception of Ireland.

5.1.1 Structural change

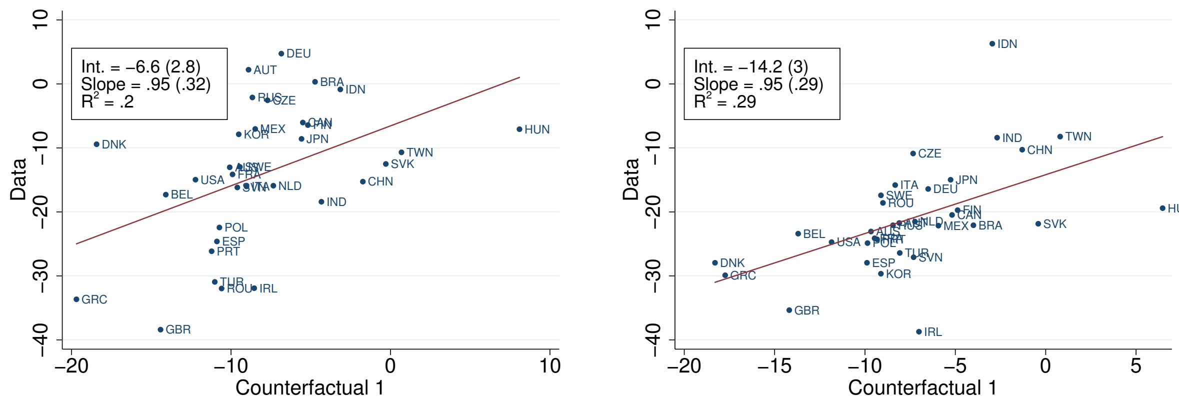
Figures 5a and 5b compare the counterfactual changes in value-added and employment shares in the goods sectors to those observed in the data.[23] As explained in Section 3.3, the declines in domestic expenditure shares in the goods sector reported in Figure A.3 lead to a decline of the goods sector relative to the service sectors. As a result, the counterfactual share of the goods sector in value-added falls in most countries, by 8.15 percent in the average country, and by 12.2 percent in the US. Likewise, the counterfactual share of employment in the goods sector also declines in most countries, by an average of 7.4 percent. Appendix Figures A.4a and A.4b show the changes in value-added and employment shares in the service sectors. The figures reveal a great deal of heterogeneity in these counterfactual changes across sectors and countries, ranging from -20 to 8 percent for goods, and from about -10 to 16 percent in skilled-labor intensive services. In most countries, skilled-labor intensive services expand faster than unskilled-labor intensive services, because in the model, as in the data, the later uses relatively more intermediate inputs from the goods sector.

Figures 5a and 5b also show that the contraction in the data is larger than in the counterfactual. This is not surprising given that the counterfactual abstracts from other forces that could have generated structural change, such as productivity growth in the goods sector (see equation 17). However, there is a statistically significant relation between the changes in the counterfactual and those in the data, and we cannot reject the null hypothesis that the slope of a regression between the observed and counterfactual changes in value-added shares is equal to one (this is also true when we consider changes in employment shares). The intercepts confirm that the change in the size of the goods sector is larger in the data than in the counterfactual. Thus, while the counterfactual misses part

[23] The exact numbers behind this figure are listed in Appendix Table A1.

Figure 5: Trade and structural change, Counterfactual 1

(a) Value-added (b) Employment



Notes: The x-axes show the percent change in the goods sector share of value-added or employment in Counterfactual 1. The y-axis shows the percent change in the goods sector share of value-added or employment between 1995-2007 in the WIOD data.

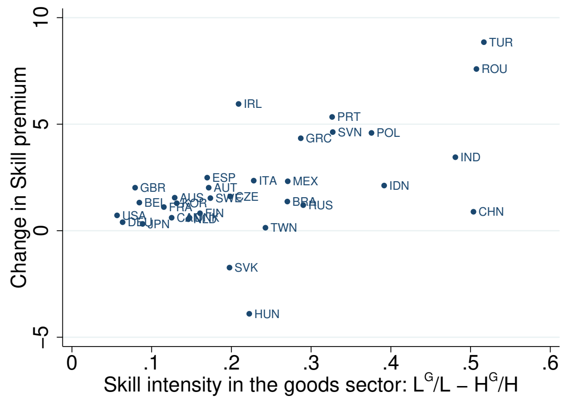
of the global decline in employment in the goods sector (which could be attributed to global changes in productivity), the reduction in trade costs substantially contributes to understanding how the goods-sector decline has differed across countries.[24] Note that an important fraction of the heterogeneity is not captured by the changes in trade costs, reflecting the reality that countries differ along multiple dimensions in addition to the ones emphasized in the counterfactual (such as country-specific changes in productivity, $\tilde{A}_i^j$). In the Online Appendix, we show that the model can also account for the global decline in employment in the goods sector in a counterfactual where we change both trade costs and global productivity in the goods sector, where the change in global productivity is calibrated to match the decline in the goods sector employment share in the US.

5.1.2 Skill premium

Figure 6 and Appendix Table A2 present the changes in the skill premium in Counterfactual 1. The figure relates the counterfactual change in the skill premium, $\frac{\hat{s}_i}{w_i}$, to the skill intensity in the goods sector in each country, measured by $\frac{L_i^G}{L_i} - \frac{H_i^G}{H_i}$. The reduction in trade costs increases the skill premium for almost all countries in the sample, by an average of 2.1 percent. The notable exceptions are Slovakia and Hungary, countries for which the high-skill intensive sector shrinks in the counterfactual equilibrium. The change in the skill premium is especially large in developing countries where the goods sector is par-

[24]These findings are robust to excluding Hungary and Slovakia from the sample.

Figure 6: Change in the skill premium, Counterfactual 1



Notes: The figure reports the percent change in the skill premium in Counterfactual 1 in the y-axis, and the relative skill intensity of the goods sector, given by $\frac{L_i^G}{L_i} - \frac{H_i^G}{H_i}$, in 1995 on the x-axis.

ticularly unskilled-labor intensive, such as Turkey, Romania, Portugal or Poland. In the US, the counterfactual generates a modest increase in the skill premium of 0.72 percent.

To understand the size of the change of the skill premium in this counterfactual, consider equation (16) again. The change in the skill premium depends on the sectoral skill intensities in the initial equilibrium and the changes in domestic expenditure shares. Figure 6 reflects this result, showing that skill intensity in the goods sector in 1995 is positively correlated with the counterfactual changes in the skill premium. Since by 1995 the fraction of both types of workers in the goods sectors was already very small in most developed countries, the decline of the goods sector on wages in those countries has a limited effect. Unfortunately, we cannot extend this counterfactual back in time, since bilateral data on service trade for many of our countries is only available starting in 1995. In the Online Appendix, we build on the theoretical results from Section 3 and take a sufficient statistic approach for measuring the effects of trade on the skill premium for longer time periods.

5.1.3 Mechanisms and robustness

This section explores the mechanisms linking trade with structural change and the skill premium in the model, and evaluates the robustness of our results to alternative parameterizations.

Changes in net exports vs price and income effects As discussed in Section 3.3, changes in trade costs affect the equilibrium both through domestic expenditure shares, π_{ii}^{j}'s, and through sectorial net exports, λ_i^j's. In this section we disentangle the contribution of these two effects to the results presented above. To do so, we re-compute Counterfactual 1 in a calibration where preferences are homothetic and the elasticity of substitution across sectors is set to $\rho = 1$. As noted in equation (17), in this case trade only affects value-added and employment shares through sectorial net exports, summarized in λ_i^j.

Appendix Figure A.5 presents the counterfactual changes in the share of the goods sector in value-added and employment in this calibration. The goods sector grows for about half of the countries; on average it increases by about 1 percent in terms of both its share in value-added and its share in employment. This stands in contrast to the results in Figures 5a and 5b, where the goods sector shrinks in most countries. In addition, both the slope and the R-squared of the regression between the counterfactual predictions and the data fall dramatically relative to the baseline calibration. We conclude that price and income effects play an important role in shaping how the sectorial composition of the economy is affected by trade.

Alternative parameterizations We now evaluate the importance of incorporating intermediate inputs for our quantitative results. To do so, we re-calculate the change in the skill premium in a calibration where the share of the employment bundle is equal to one in each sector, $\beta_i^j = 1$. The resulting changes in the skill premium are compared to those under the baseline parameterization in Appendix Figure A.6a. The figure shows that the skill premium increases in most countries under the two calibrations. However, the increase in the skill premium is smaller in the model with no intermediates relative to the baseline in all countries, and about a fifth of the change in the baseline calibration for the median country. This result reveals that accounting for intermediate inputs is important for establishing the magnitude of our quantitative results.

We also evaluate the importance of incorporating differences in skill intensities across services in our model by calibrating an economy with just two sectors: goods and services. Note that this is equivalent to a three sector economy in which the two service sectors are identical. Hence, we re-calibrate all the sectoral shares in the service sectors to match the aggregate service shares in each economy. Appendix Figure A.6b shows that for the median country, the increase in the skill premium is 25 percent smaller in the two sector model than in our baseline calibration. The differences in the models arise from the fact that, in the baseline model, sector F grows by more than sector S, since it uses relatively more intermediate inputs from the goods sector. Since sector F uses skilled labor more intensively, this magnifies the increase in the skill premium. This effect is not present when the service sectors are identical. We conclude that accounting for the differences in factor intensities across service sectors is important for quantifying the effects of trade integration on structural change and the skill premium.

Within-sector skill upgrading vs between-sector reallocation Trade affects the skill premium in our model by inducing reallocation of labor from unskilled labor intensive sectors to skilled labor intensive sectors. If trade were the only driver of the observed changes in the skill premium, we should expect to see labor reallocating from unskilled labor intensive sectors to skilled labor intensive sectors, coupled skill downgrading within each sector (due to the rise in the skill premium). A large and influential literature has measured the extent of within-sector skill upgrading and between-sector factor reallocation and argued that, since most of the shift in demand for skilled labor is accounted for by within sector skill upgrading, the increase in the skill premium is likely to be driven by skill biased technical change rather than by trade.[25] While this view is consistent with a version of our model that incorporates global skill biased technical change, we ask instead: can trade account for the observed differences in within-sector skill upgrading across countries? The answer speaks directly to our mechanism, since the model predicts that, other things equal, between reallocation should be larger the larger the change in trade costs in the goods sector (and hence the contribution of within skill upgrading should be smaller).

Appendix Figure A.7 shows the contribution of within-sector reallocation to the change in the skilled share of total employment.[26] There is a positive relation between the contribution of within-sector skill upgrading in the counterfactual and in the data. The figure also shows that, if we simulate the model without changes in trade costs, the correlation between the counterfactual and the data falls dramatically. We conclude that reductions in trade costs are an important factor in accounting for the cross-country variation in the contribution of within-sector skill upgrading.

5.2 Counterfactual 2: Observed changes in trade patterns

Our second counterfactual uses the analytical results from Section 3 to calculate how the skill premium and sectoral value-added and employment shares change in response to a given change in domestic expenditure shares and changes in sectorial net exports, $\hat{\pi}_{ii}^{j}$ and $\hat{\lambda}_{i}^{j}$. We conduct this counterfactual country by country, using observed changes in $\hat{\pi}_{ii}^{j}$

[25] See e.g. Berman, Bound and Griliches (1994), Attanasio, Goldberg and Pavcnik (2004) and Haltiwanger et al. (2004).

[26] See Online Appendix D.1 for a detailed description of these calculations.

and $\hat{\lambda}_i^j$ between 1995 and 2007. This allows us to explore a broader notion of the impact of trade on structural change and the skill premium.

A disadvantage of this counterfactual relative to our first exercise is that changes in $\hat{\pi}_{ii}^j$ and $\hat{\lambda}_i^j$ depend not only on international factors, but also potentially depend on changes in domestic fundamentals. We note however that this exercise quantifies the impact of international trade and trade imbalances on sectoral revenue shares and real wages over a given period in the following specific way.[27] Fix the model's parameters $\left\{\theta^j(k), \sigma_i^j(k), \rho, \rho^m, \epsilon^j, \beta_i^j, \alpha_i^{lj}\right\}$, sectoral factor intensities $\left\{H_i^j/H_i,\ L_i^j/L_i,\ \mu_i^j\right\}$, and sectoral revenue shares $\left\{r_i^j\right\}$. Suppose that between two years the primitives of the model –trade costs, technologies, factor endowments and transfers– change in some unobserved manner. These changes in primitives will cause changes in domestic sectoral expenditure shares, $\left\{\tilde{\pi}_{ii}^j\right\}$, sectorial net-exports, $\left\{\tilde{\lambda}_i^j\right\}$, sectoral value-added shares $\left\{\tilde{v}_i^j\right\}$, and factor payments $\{\tilde{s}_i,\ \tilde{w}_i\}$. Now consider a counterfactual environment in which country i is in autarky. Suppose that the same changes in the unobserved primitives occur, excluding the changes in trade costs and transfers (which are always set to infinity and zero respectively in this autarky scenario). The changes in primitives will cause changes in country $i's$ sectoral revenue shares and factor payments which we denote by $\left\{\tilde{v}_i^{A,j},\ \tilde{s}_i^A,\ \tilde{w}_i^A\right\}$. Then, the difference in the change in the skill premium between the environment in which country i trades and the counterfactual environment in which it is in autarky is given by

$$\widetilde{s_i/w_i} - \widetilde{s_i^A/w_i^A} \quad = \quad \sum_j \xi_{i,\pi}^j \tilde{\pi}_{ii}^j - \xi_{C,i} \sum_l \left[\omega_i^l \tilde{\pi}_{ii}^l - \tilde{\lambda}_i^l\right] + \sum_j \xi_{i,\lambda}^j \tilde{\lambda}_i^j. \tag{21}$$

Equation (21) answers the question: What are the additional effects of changes in primitives on the skill premium and real wages in an open economy relative to the effects in a closed economy? From equation (21), we can answer this question (to a first order approximation) using observable changes in domestic sectoral expenditure shares and revenue to absorption ratios, with no need to observe the underlying changes in primitives. The Online Appendix reports the changes in $\pi_{ii}^G$and λ_i^G used to conduct this quantitative exercise.

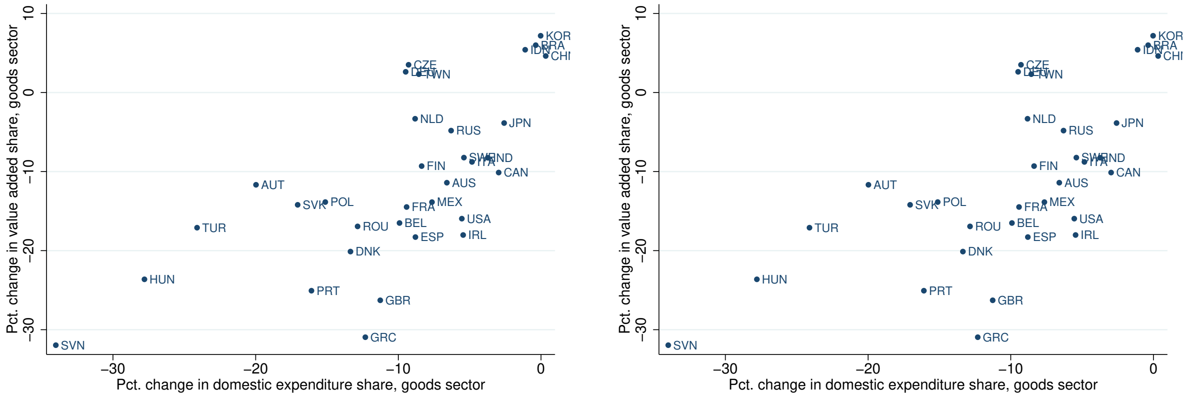
5.2.1 Observed changes in trade patterns, structural change and the skill premium

We start by showing the results of the counterfactual when we use the changes in $\hat{\pi}_{ii}^j$ and $\hat{\lambda}_i^j$ we observe between 1995 and 2007 for each country. The predictions of the second counterfactual in response to the changes in π_{ii}^j and λ_i^j are summarized in Figure 7. Dots

[27] The discussion that follows is based on Corollary 1 in Burstein, Cravino and Vogel (2013).

Figure 7: Trade and structural change, Counterfactual 2

(a) Value-added (b) Employment

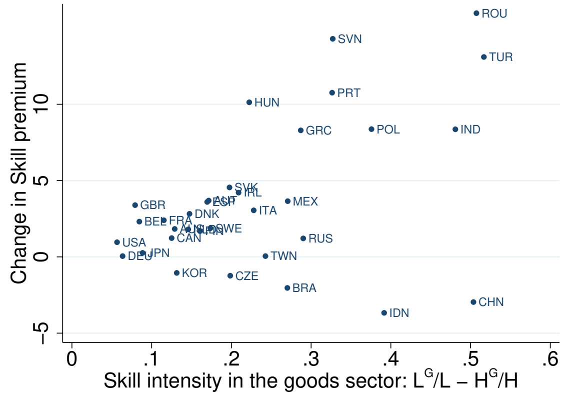


Notes: The figures report the percent change in the share of value-added and employment in the goods sector in Counterfactual 2. The x-axis reports the weighted change in domestic expenditure shares for each country, $\hat{\pi}_{ii}^{G}$, and the y-axis reports the change in value-added and employment shares, $\hat{\vartheta}_i^G$ and $\hat{\omega}_{i,E}^{j}$.

in the figure relate the counterfactual changes in sectoral value-added shares, $\hat{\vartheta}_i^j$, to the counterfactual changes in the domestic expenditure shares in the goods sector. For the average country in our sample, the counterfactual share of the goods sector in value-added declines by approximately 11 percent. Larger declines in the domestic expenditure shares in the goods sector are associated with larger declines of the size of the goods sector. The decline of the goods sector is larger for those countries that experienced a large increase in their goods-trade deficits, such as the US.

The counterfactual changes in the skill premium are summarized in Figure 8. For the average country in our sample, the model generates a 3.7 percent increase in the skill premium in response to the observed changes in trade patterns. Note that the increase is larger in countries with large declines in domestic expenditure shares, such as Hungary, Turkey and Slovenia. The change in the skill premium is especially large in developing countries where the good producing sectors are particularly unskilled labor intensive, with the exception of China and Indonesia, where domestic expenditure shares are constant or mildly increase. For most countries, international factors summarized in these changes either increased the skill premium or had a negligible effect on it. For the skill premium, these changes are larger on average than those in the first counterfactual. For structural change, the difference depends on the country. The reason is that this counterfactual takes into account all the effects of changes in trade patterns, rather than focusing on those that arise from changes in trade costs. For example, even with constant trade costs, cross-country changes in productivity can increase or decrease net exports. In the

Figure 8: Change in the skill premium, Counterfactual 2



Notes: The figure reports the percent change in the skill premium in Counterfactual 2 in the y-axis, and the relative skill intensity of the goods sector, given by $\frac{L_i^G}{L_i} - \frac{H_i^G}{H_i}$, in 1995.

Online Appendix, we extend this exercise for the US, evaluating the effect of changes in trade patterns since 1977. Since the goods producing sector was relatively larger then, the resulting increase in the skill premium is larger, at 3.1 percent.

6 Conclusion

Goods-producing sectors are intensive in unskilled labor. In this paper we used a quantitative model to study how increased trade integration in these sectors affects the skill premium by inducing a reallocation of labor towards service sectors in all countries. Changes in trade costs between 1995 and 2007 generate an 8.2 percent decline in the size of the goods sector in our model, and account well for the cross-country differences in the changes in the size of the goods sector. The observed changes in trade patterns of the past three decades can generate roughly half of the observed decline in the value added share of the goods-producing sector. These changes can in turn generate sizable increases in the skill premium in all countries (2.1 percent on average). The increase in the skill premium is larger in developing countries where the goods sector is particularly unskilled-labor intensive.

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Table A1: Changes in value added and employment shares: Counterfactual 1 vs. Data

	Value Added						Employment					
	Counterfactual 1			Data			Counterfactual 1			Data		
Country	Unskilled services	Goods	Skilled services	Unskilled services	Goods	Skilled services	Unskilled services	Goods	Skilled services	Unskilled services	Goods	Skilled services
Australia	1.61	-10.08	3.45	-6.04	-13.03	15.85	2.07	-9.67	3.66	2.25	-23.06	13.32
Austria	2.35	-8.90	4.74	-8.82	2.22	11.81	3.25	-8.10	5.33	-1.34	-21.74	38.66
Belgium	2.82	-14.09	4.32	0.35	-17.30	10.73	3.30	-13.70	4.65	-5.30	-23.40	25.23
Brazil	1.55	-4.73	1.93	5.78	0.33	-7.35	2.37	-4.00	2.48	11.09	-22.09	19.89
Canada	1.07	-5.50	1.28	3.82	-6.04	0.09	1.40	-5.18	1.50	5.39	-20.48	6.25
China	2.08	-1.73	-1.36	16.06	-15.27	34.07	2.66	-1.30	-0.82	19.53	-10.28	3.63
Czech Republic	3.69	-7.71	3.74	-0.02	-2.56	3.66	4.09	-7.34	3.89	0.64	-10.88	19.46
Germany	1.98	-6.84	2.14	-11.09	4.73	8.28	2.35	-6.50	2.44	-7.59	-16.42	31.97
Denmark	9.99	-18.43	-0.20	-1.05	-9.43	6.92	10.15	-18.30	-0.20	1.71	-27.95	17.83
Spain	2.00	-10.89	5.56	5.56	-24.62	13.18	3.08	-9.89	5.76	8.02	-27.95	18.24
Finland	1.78	-5.18	2.08	-0.87	-6.43	7.29	2.05	-4.87	2.19	6.39	-19.72	11.80
France	2.19	-9.91	2.69	-6.16	-14.14	12.71	2.69	-9.47	2.93	1.10	-24.12	15.68
Great Britain	0.82	-14.42	6.32	1.48	-38.40	26.70	1.10	-14.19	6.13	1.07	-35.35	17.61
Greece	7.38	-19.70	2.54	13.20	-33.66	3.15	9.99	-17.73	3.07	7.37	-29.90	43.83
Hungary	0.61	8.09	-10.51	-1.28	-7.08	10.19	-0.84	6.47	-10.96	8.37	-19.42	19.34
Indonesia	1.86	-3.15	5.76	5.96	-0.86	-14.90	2.04	-2.95	5.81	-7.41	6.28	0.76
India	5.25	-4.33	5.09	14.47	-18.42	21.00	7.34	-2.69	5.85	18.74	-8.40	44.07
Ireland	-3.74	-8.54	14.73	6.29	-31.92	33.50	-2.25	-7.01	14.45	17.55	-38.72	24.94
Italy	2.80	-9.03	3.81	-2.45	-16.01	17.08	3.60	-8.33	4.34	0.15	-15.81	23.97
Japan	2.08	-5.58	0.62	-5.51	-8.59	15.63	2.41	-5.26	0.90	-2.87	-14.98	28.73
Korea	4.92	-9.52	4.80	-6.68	-7.88	21.78	5.28	-9.12	4.95	4.58	-29.66	60.36
Mexico	0.58	-8.48	4.94	10.49	-7.04	-5.51	3.21	-5.94	7.20	11.20	-22.15	29.56
Netherlands	2.63	-7.35	0.73	-0.92	-15.91	12.30	2.74	-7.23	0.72	-5.64	-21.52	22.45
Poland	12.26	-10.73	6.34	1.68	-22.44	36.21	13.20	-9.86	6.33	28.17	-24.88	27.19
Portugal	2.59	-11.22	7.24	5.67	-26.15	14.32	4.93	-9.33	8.78	8.17	-24.29	37.89
Romania	14.82	-10.59	9.47	49.39	-31.97	-0.05	16.92	-9.01	9.82	41.71	-18.59	5.00
Russia	11.69	-8.66	1.38	-11.00	-2.12	45.17	11.94	-8.45	1.38	34.14	-22.08	-0.81
Slovakia	3.64	-0.29	-6.10	13.14	-12.51	-4.12	3.56	-0.41	-5.83	17.28	-21.86	2.92
Slovenia	2.36	-9.60	9.48	10.07	-16.18	5.19	4.90	-7.31	11.06	16.32	-27.09	44.84
Sweden	2.68	-9.44	2.97	-0.39	-12.97	10.02	2.98	-9.12	3.01	-2.18	-17.41	15.73
Turkey	6.22	-11.02	16.22	11.77	-30.94	57.46	10.26	-8.07	19.43	32.04	-26.42	70.25
Taiwan	-1.16	0.69	1.75	1.56	-10.69	11.96	-1.06	0.80	1.80	-5.57	-8.23	46.68
United States	2.04	-12.23	3.11	-5.11	-14.97	14.15	2.49	-11.85	3.41	1.24	-24.73	14.80
Average	**3.50**	**-8.15**	**3.67**	**3.31**	**-14.19**	**13.59**	**4.37**	**-7.42**	**4.10**	**8.07**	**-21.01**	**24.30**

Notes: The Table reports the change in sectoral value added and employment shares in Counterfactual 1 under our baseline calibration and the changes observed in the data.

Table A2: Changes in skill premium and gains from trade ratio, Counterfactuals 1 and 2

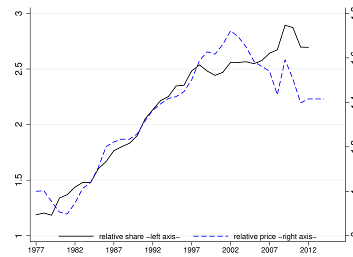
	Counterfactual 1	Counterfactual 2
Australia	1.55	1.83
Austria	2.02	3.69
Belgium	1.32	2.31
Brazil	1.37	-2.04
Canada	0.61	1.23
China	0.89	-2.96
Czech Republic	1.61	-1.24
Germany	0.40	0.05
Denmark	0.61	2.82
Spain	2.49	3.60
Finland	0.82	1.69
France	1.11	2.40
Great Britain	2.02	3.39
Greece	4.34	8.29
Hungary	-3.90	10.13
Indonesia	2.12	-3.67
India	3.45	8.36
Ireland	5.95	4.21
Italy	2.35	3.05
Japan	0.32	0.26
Korea	1.29	-1.05
Mexico	2.32	3.65
Netherlands	0.54	1.80
Poland	4.59	8.37
Portugal	5.34	10.76
Romania	7.59	15.97
Russia	1.20	1.21
Slovakia	-1.73	4.55
Slovenia	4.63	14.29
Sweden	1.53	1.88
Turkey	8.85	13.10
Taiwan	0.14	0.05
United States	0.72	0.96
Average	**2.07**	**3.73**

Notes: This table reports the predicted change in skill premium and real wages under our baseline calibration, in Counterfactuals 1 and 2.

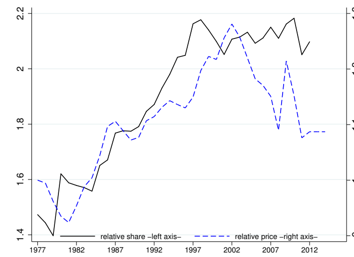
Figure A.1: Relative prices vs. relative expenditure shares

(a) Consumption bundle

Skilled-labor intensive services vs goods

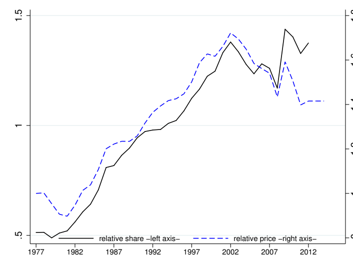


Unskilled-labor intensive vs goods

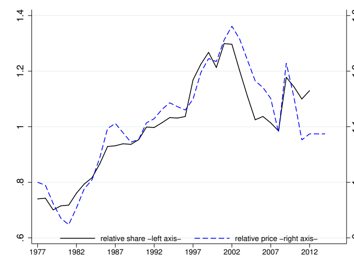


(b) Input bundle used in the unskilled labor intensive service sector

Skilled-labor intensive services vs goods

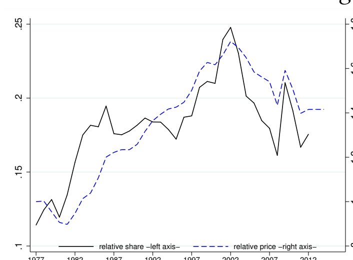


Unskilled-labor intensive vs goods

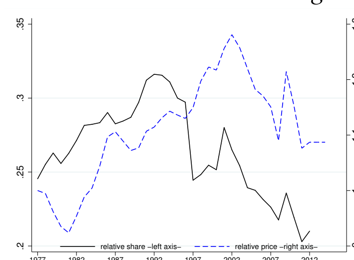


(c) Input bundle used in the goods sector

Skilled-labor intensive services vs goods

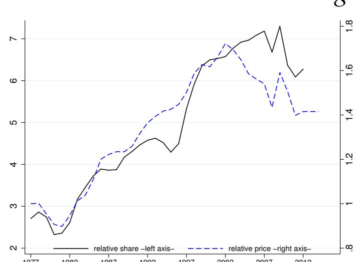


Unskilled-labor intensive vs goods

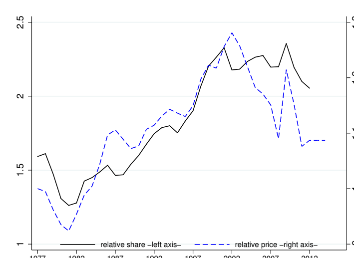


(d) Input bundle used in the skilled labor intensive service sector

Skilled-labor intensive services vs goods

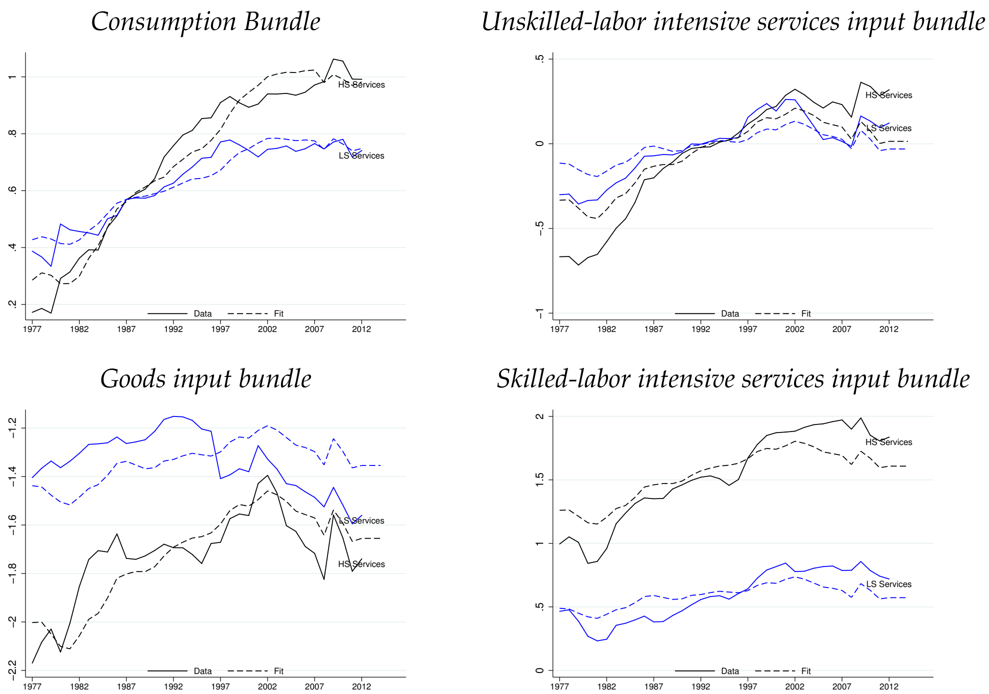


Unskilled-labor intensive services vs goods



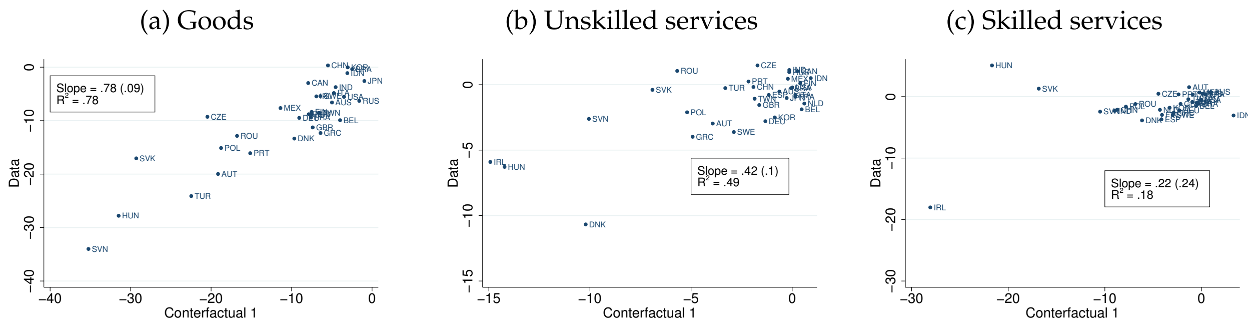
Notes: The figures plot sectoral relative prices and relative expenditures for (a) consumption, and total inputs in (b) the unskilled-labor intensive service sector, (c) the goods sector, and (d) the skilled-labor intensive service sector. Source: Authors calculations based on data from the USE Input-Output Tables for the US, and the Chain-Type Price Indexes for Gross Output published by the BEA.

Figure A.2: Actual vs. predicted expenditure shares



Notes: The figures report the expenditure shares in the data and the fitted values obtained from estimating equations (18) and (19).

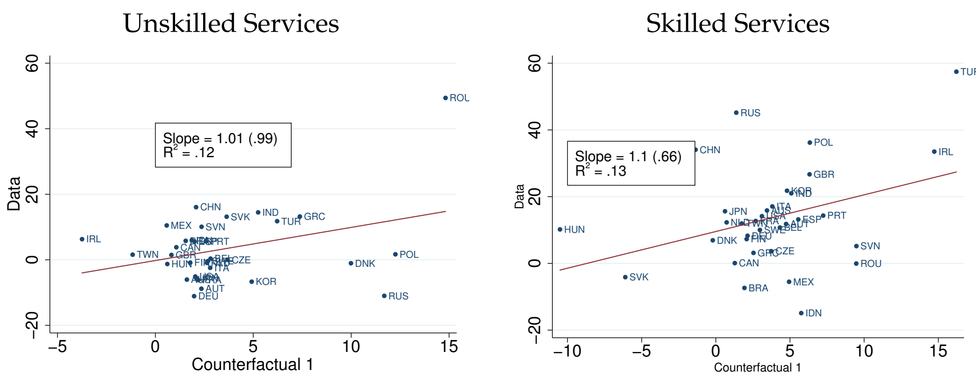
Figure A.3: Changes in domestic expenditure shares, Counterfactual 1



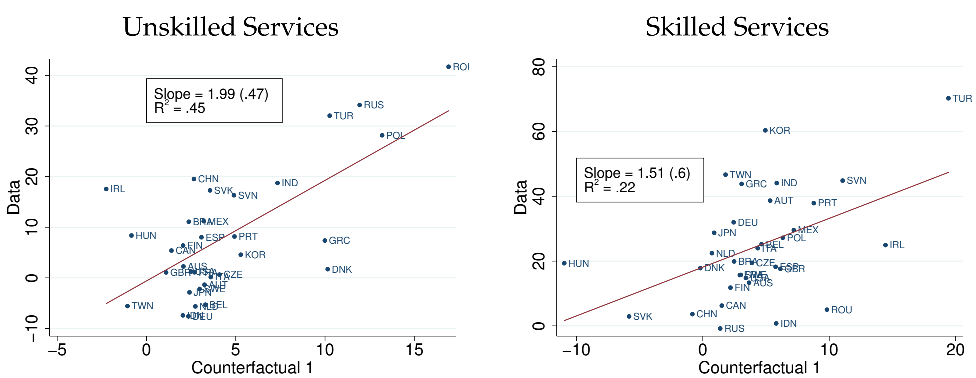
Notes: The figure reports the percent change in the domestic expenditure shares in Counterfactual 1 on the x-axis, and the percent change in domestic expenditure shares between 1995-2007 in the WIOD data on the y-axis.

Figure A.4: Structural change, Counterfactual 1

(a) Changes in sectorial value-added shares



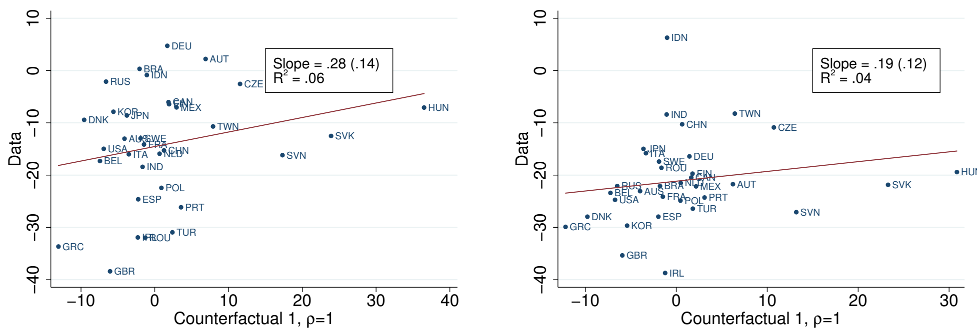
(b) Changes in sectorial employment shares



Notes: The x-axes show the percent change in the sector's share of value-added or employment in Counterfactual 1. The y-axis shows the percent change in the sector's share of value-added or employment between 1995-2007 in the WIOD data.

Figure A.5: Counterfactual change in the goods sector share in value-added and employment, with no price and no income effects

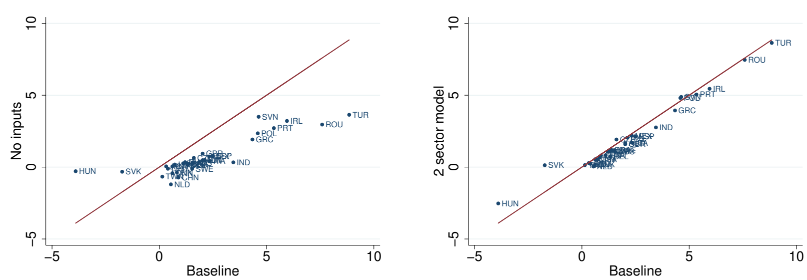
(a) Value-Added (b) Employment



Notes: The x-axis reports the percent change in the goods sector's share in value-added and employment in a version of Counterfactual 1 where we set $\epsilon_j = 1 - \rho\ \forall j$, and $\rho = \rho_m = 1$. The y-axes report the percent change in the goods sector share in value-added and employment between 1995-2007 in the WIOD data.

Figure A.6: Change in the skill premium, baseline vs. alternative parameterizations

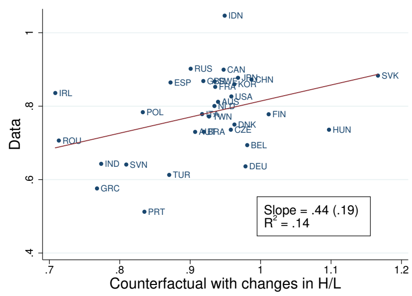
(a) No intermediate inputs (b) Two sector model



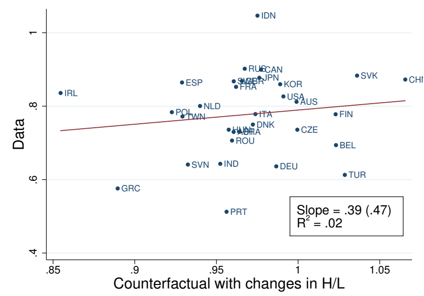
Notes: This figure compares the change in the skill premium under alternative parameterizations with the change in the skill premium under our baseline parameterization (x-axis) in Counterfactual 1. The alternative parameterizations are described in Section 5.1.3.

Figure A.7: Contribution of within sector skill upgrading to changes in the high skilled labor demand

(a) With changes in trade costs



(b) Without changes in trade costs



Notes: The first panel reports the observed within contribution, defined in Appendix D.1 in the y-axis, and the within contribution in a counterfactual that incorporates changes in labor supplies and changes in trade costs in the x-axis. The second panel reports the observed within contribution in the y-axis, and the within contribution in a counterfactual that incorporates changes in labor supplies and but does not incorporate changes in trade costs in the x-axis.

ONLINE APPENDIX
(NOT FOR PUBLICATION)

Appendix A Equilibrium

This Section characterizes the equilibrium of our quantitative model, and shows how to solve for the key variables of interest as a function of domestic expenditure shares, $\pi_{ii}^{j}(k)$, and ratios of net exports to aggregate revenues in each sector, λ_i^j. In addition, we provide the system of equations that we use for computing our counterfactual exercises.

A.1 Equilibrium

An equilibrium is a set of aggregate prices $\{P_i^C, w_i, s_i\}_{i\in I}$, and $\left\{P_i^j, c_i^j, p_{v,i}^j, p_{b,i}^j\right\}_{i\in I, j\in J}$, aggregate quantities $\left\{C_i^j, X_i^j, Y_i^j\right\}_{i\in I, j\in J}$ and $\left\{H_i^j, L_i^j\right\}_{i\in I, j\in J}$, and trade shares $\left\{\pi_{in}^j(k)\right\}_{i,n\in I, k\in K^j, j\in J}$, such that, given factor supplies $\{H_i, L_i\}_{i\in I}$, technologies $\left\{A_i^j(k)\right\}_{i\in I, k\in K^j, j\in J}$, trade costs $\left\{\tau_{in}^j(k)\right\}_{i,n\in I, k\in K^j, j\in J}$, and net exports $\{NX_i\}_{i\in I}$, the following are satisfied:

i. **Households maximize utility subject to their budget constraints.** This implies demands:

$$\frac{P_i^j C_i^j}{\sum_j P_i^j C_i^j} = \bar{\phi}_i^j \left[\frac{P_i^j}{P_i^C}\right]^{1-\rho} C_i^{\epsilon_j}, \tag{A.1}$$

where

$$P_i^C = \left[\sum_j \bar{\phi}_i^j \left[P_i^j\right]^{1-\rho} C_i^{\epsilon_j-[1-\rho]}\right]^{\frac{1}{1-\rho}} \tag{A.2}$$

is the consumption price index in country i, and the budget constraint is:

$$w_i L_i + s_i H_i = P_i^C C_i + NX_i. \tag{A.3}$$

ii. **Producers of intermediate varieties minimize costs.** Cost minimization implies that the prices of the input bundles are given by:

$$c_i^j = \bar{\beta}_i^j \left[p_{b,i}^j\right]^{1-\beta_j} \left[p_{v,i}^j\right]^{\beta_j} \tag{A.4}$$

$$p_{v,i}^j = \left[\bar{\mu}_i^j w_i^{1-\gamma} + \left[1-\bar{\mu}_i^j\right] s_i^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{A.5}$$

$$p_{b,i}^j = \left[\sum_{l=1}^{J} \bar{\alpha}_i^{lj} P_i^{l\,1-\rho_m}\right]^{\frac{1}{1-\rho_m}}. \tag{A.6}$$

Given these definitions, factor demands are given by:

$$
\begin{aligned}
w_i l_{in}^j(\omega,k) &= \bar{\mu}_i^j \left[\frac{p_{v,i}^j}{w_i}\right]^{\gamma-1} \beta_i^j p_n^j(\omega,k)\, q_{in}^j(\omega,k)\, \mathbb{I}_{in}^j(\omega,k) \\
s_i h_{in}^j(\omega,k) &= \left[1-\bar{\mu}_i^j\right] \left[\frac{p_{v,i}^j}{s_i}\right]^{\gamma-1} \beta_i^j p_n^j(\omega,k)\, q_{in}^j(\omega,k)\, \mathbb{I}_{in}^j(\omega,k) \\
P_i^l x_{in}^{lj}(\omega,k) &= \bar{\alpha}_i^{lj} \left[\frac{p_{b,i}^j}{P_i^l}\right]^{\rho_m-1} \left[1-\beta_i^j\right] p_n^j(\omega,k)\, q_{in}^j(\omega,k)\, \mathbb{I}_{in}^j(\omega,k),
\end{aligned}
$$

where $q_{in}^j(\omega,k)$ is the quantity of variety (ω,k) produced in country i and consumed in country n.

iii. **Cost minimization by producers of final goods.** Cost minimization implies that demand for variety (ω,k) is given by:

$$
p_i^j(\omega,k)\, q_i^j(\omega,k) = \left[\frac{p_i^j(\omega,k)}{P_i^j(k)}\right]^{1-\eta} \sigma_i^j(k)\, P_i^j Y_i^j.
$$

As shown in Eaton and Kortum (2002) under our same distributional assumptions, price indices for final goods are given by

$$
P_i^j = \bar{\sigma}_i^j \left[\prod_{k=1}^{K^j} P_i^j(k)^{\sigma_i^j(k)}\right]. \tag{A.7}
$$

where

$$
P_i^j(k) = \Xi_i^j(k) \left[\sum_{l=1}^{I} \left[\tau_{li}^j(k) \frac{c_l^j}{A_l^j(k)}\right]^{-1/\theta^j(k)}\right]^{-\theta^j(k)},
$$

where $\bar{\sigma}_i^j$ and $\Xi_i^j(k)$ are constants. Trade shares between any pair of countries are given by equation (8).

iv. **Aggregate factor market clearing.** Integrating factor demands across producers, adding across all destination countries n, substituting for the demand for each variety $q_i^j(\omega,k)$, using equation (7), and adding across industries and across sectors, factor market clearing requires that the total payments to each type of labor in country i equal total demand:

$$w_i L_i^j = \bar{\mu}_i^j \left[\frac{p_{v,i}^j}{w_i}\right]^{\gamma-1} \beta_i^j R_i^j \tag{A.8}$$

$$s_i H_i^j = \left[1-\bar{\mu}_i^j\right] \left[\frac{p_{v,i}^j}{s_i}\right]^{\gamma-1} \beta_i^j R_i^j, \tag{A.9}$$

where $R_i^j = \sum_n \sum_{k \in K^j} \pi_{in}^j(k) P_n^j(k) Y_n^j(k)$ are aggregate revenues accruing from sales in sector j, and the demand for intermediate inputs in each sector l are given by:

$$P_i^l X_i^l = \sum_j \bar{\alpha}_i^{lj} \left[\frac{p_{b,i}^j}{P_i^l}\right]^{\rho_m-1} \left[1-\beta_i^j\right] R_i^j. \tag{A.10}$$

v. **Labor market clearing.**

$$H_i = \sum_j H_i^j \quad ; \quad L_i^j = \sum_j L_i^j. \tag{A.11}$$

vi. **Final goods market clearing.**

$$Y_i^j = C_i^j + X_i^j. \tag{A.12}$$

Note that, after choosing a numeraire, $(31 \times I - 1 + I \times I \times (K^S + K^G + K^F))$ aggregate variables must be determined in equilibrium. Equations (A.1)-(A.12) and (8) give a system of $(31 \times I - 1 + I \times I \times (K^S + K^G + K^F))$ independent equations, since the market clearing conditions together with the budget constraints and the definition of revenues make one budget constraint redundant.

A.2 Solving in terms of domestic expenditure shares and sectorial net exports

In this section we show how to solve for domestic variables as functions of industrial domestic expenditure shares, $\pi_{ii}^j(k)$, and net exports relative to aggregate revenues, λ_i^j. From equations, (8) and (A.7) we can write the industry-level price indices as functions of domestic expenditure shares:

$$P_i^j(k) = \Xi_i^j(k) \left[c_i^j / A_i^j(k)\right] \pi_{ii}^j(k)^{\theta^j(k)},$$

and the sectoral price indexes as:

$$P_i^j = \bar{\sigma}_i^j \prod_{k=1}^{K^j} \left[\Xi_i^j(k)\left[c_i^j / A_i^j(k)\right]\right] \pi_{ii}^j(k)^{\sigma_j(k)\theta^j(k)}. \tag{A.13}$$

Using equations (A.8) and (A.9) we can write

$$\left[\frac{s_i}{w_i}\right]^\gamma \frac{H_i}{L_i} = \frac{\sum_j \left[1-\bar{\mu}_i^j\right]\left[p_{v,i}^j\right]^{\gamma-1}\beta_i^j r_i^j}{\sum_j \bar{\mu}_i^j \left[p_{v,i}^j\right]^{\gamma-1}\beta_i^j r_i^j}, \tag{A.14}$$

where $r_i^j \equiv R_i^j / R_i$ is the share of sector j in aggregate revenues. From the definition of λ_i^j, we can write r_i^j as:

$$r_i^j = \lambda_i^j - 1 + \frac{P_i^j Y_i^j}{R_i}. \tag{A.15}$$

Equation (A.12) implies

$$\frac{P_i^j Y_i^j}{R_i} = \frac{P_i^j C_i^j}{R_i} + \frac{P_i^j X_i^j}{R_i}. \tag{A.16}$$

Combining (A.1), (A.12), and the definition of λ_i^j, we obtain

$$\frac{P_i^j C_i^j}{R_i} = \bar{\phi}_i^j \left[\frac{P_i^j}{P_i^C}\right]^{1-\rho} C_i^{\epsilon_j}\left[4 - \sum_{j=1}^{3}\lambda_i^j - \frac{\sum_j P_i^j X_i^j}{R_i}\right], \tag{A.17}$$

where (A.10) implies:

$$\frac{\sum_l P_i^l X_i^l}{R_i} = \sum_l \sum_j \bar{\alpha}_i^{lj} \left[\frac{p_{b,i}^j}{P_i^l}\right]^{\rho_m - 1}\left[1-\beta_i^j\right] r_i^j. \tag{A.18}$$

Given values for $\pi_{ii}^j(k)$ and λ_i^j, equations (A.2)-(A.6) and (A.13), -(A.18) give a system of 27 equations that can be used to solve for the 13 relative prices in the economy together with the consumption index C_i, the price index for the consumption bundle, P_i^C, the sectorial revenue shares r_i^j, the ratios of sectorial absorption to aggregate revenues $\frac{P_i^j Y_i^j}{R_i}$, the ratios of sectorial consumption to revenues $\frac{P_i^j C_i^j}{R_i}$, and the ratio of inputs to revenues in the economy $\frac{\sum_j P_i^j X_i^j}{R_i}$.

A.3 Solving for price changes

We now combine equations (A.4), (A.5), (A.6), (A.13), and (A.14) to solve for changes in sectorial value-added shares and the skill premium as a function of changes in domestic expenditure shares and the ratio of sectorial net exports relative to GDP. We solve for all the variables in changes following Dekle, Eaton and Kortum (2008). Define $\hat{x} \equiv x_1/x_0$. We can characterize the change in the skill premium as:

$$\left[\frac{\hat{s}_i}{\hat{w}_i}\right]^{\gamma}\frac{\hat{H}_i}{\hat{L}_i} = \frac{\sum_j \frac{H_i^j}{H_i}\hat{v}_i^{j\,\gamma-1}\hat{r}_i^j}{\sum_j \frac{L_i^j}{L_i}\hat{v}_i^{j\,\gamma-1}\hat{r}_i^j} \tag{A.19}$$

$$\hat{P}_i^j = \left[\hat{c}_i^j/\hat{A}_i^j\right]\prod_{k=1}^{K_j}\hat{\pi}_{ii}^j\left(k\right)^{\sigma_i^j(k)\theta^j(k)} \tag{A.20}$$

$$\hat{c}_i^j = \left[\hat{p}_{b,i}^j\right]^{1-\beta_i^j}\left[\hat{p}_{v,i}^j\right]^{\beta_i^j} \tag{A.21}$$

$$\hat{p}_{b,i}^j = \left[\sum_l \alpha_i^{lj}\left[\hat{P}_i^l\right]^{1-\rho_m}\right]^{\frac{1}{1-\rho_m}} \tag{A.22}$$

$$\hat{p}_{v,i}^j = \left[\mu_i^j\hat{w}_i^{1-\gamma} + \left[1-\mu_i^j\right]\hat{s}_i^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{A.23}$$

and

$$\hat{r}_i^j = \frac{\lambda_i^j}{r_i^j}\hat{\lambda}_i^j - 1 + \frac{P_i^jY_i^j}{R_i^j}\frac{\widehat{P_i^jY_i^j}}{\hat{R}_i} \tag{A.24}$$

$$\frac{\widehat{P_i^jY_i^j}}{\hat{R}_i} = \left[1-\psi_i^j\right]\left[\frac{\widehat{P_i^jC_i^j}}{R_i}\right] + \psi_i^j\left[\frac{\widehat{P_i^jX_i^j}}{R_i}\right] \tag{A.25}$$

$$\frac{\widehat{P_i^jC_i^j}}{R_i} = = \left[\frac{\widehat{P_i^j}}{P_i^C}\right]^{1-\rho}\hat{C}_i^{\epsilon_j}\frac{\sum_l P_i^lY_i^l}{P_i^CC_i}\left[\frac{\sum_j\left[r_i^j\hat{r}_i^j + 1 - \lambda_i^j\hat{\lambda}_i^j\right]}{\sum_j\left[r_i^j + 1 - \lambda_i^j\right]} - \sum_l\frac{P_i^lY_i^l}{\sum_l P_i^lY_i^l}\psi_i^l\left[\frac{\widehat{P_i^lX_i^l}}{R_i}\right]\right] \tag{A.26}$$

$$\widehat{P_i^cC_i} = \mu_i\hat{w}_i\hat{L}_i + \left[1-\mu_i\right]\hat{s}_i\hat{H}_i \tag{A.27}$$

$$\hat{P}_i^c = \left[\sum_j \omega_i^j\left[\hat{P}_i^j\right]^{1-\rho}\hat{C}^{\epsilon_j-[1-\rho]}\right]^{\frac{1}{1-\rho}} \tag{A.28}$$

$$\frac{\widehat{P_i^lX_i^l}}{R_i} = \sum_j \Phi_i^{lj}\left[\frac{\widehat{p}_{b,i}^j}{P_i^l}\right]^{\rho_m-1}\hat{r}_i^j \tag{A.29}$$

where $\alpha_i^{lj} \equiv \bar{\alpha}_i^{lj} \left[\frac{b_i^j}{P_i^j}\right]^{\rho_m - 1}$ is the share of sector $l's$ inputs in total sector $j's$ input usage, and $\Phi_i^{lj} = \frac{\alpha_i^{lj}\left[1-\beta_i^j\right] r_i^j}{\sum_j \alpha_i^{lj}\left[1-\beta_i^j\right] r_i^j}$, is the share of good l intermediate inputs used by sector j.

Equations (A.19)-(A.29) give a system of 27 equations that can be used to solve for the changes in the 13 relative prices in the economy, together with the changes in consumption index $\hat{C}_i$, the change in the price index for the consumption bundle, $\hat{P}_i^C$, the changes in sectorial revenue shares $\hat{r}_i^j$, the ratios of sectorial absorption to aggregate revenues $\widehat{\frac{P_i^j Y_i^j}{R_i}}$, the ratios of sectorial consumption to revenues $\widehat{\frac{P_i^j C_i^j}{R_i}}$, and the ratio of inputs to revenues in the economy $\widehat{\frac{P_i^l X_i^l}{R_i}}$, as a function of changes in domestic technologies, $\hat{A}_i^j(k)$, domestic expenditure shares, $\hat{\pi}_{ii}^j(k)$ and sectoral transfers $\hat{\lambda}_i^l$, and of sectoral factor shares μ_i^j, the skilled and unskilled labor shares, shares $\frac{H_i^j}{H_i}$, and $\frac{L_i^j}{L_i}$, the share of value-added in each sector, β_i^j, the share of absorption used as intermediate inputs in each sector ψ_i^j, Φ_i^{lj}, the elasticities of substitution ρ, ρ_m and γ, and the income elasticities ϵ_j's.

Changes in value-added and employment shares The change in the share of value-added in sector j in total value-added is given by

$$\hat{v}_i^j = \frac{\hat{r}_i^j}{\sum_l \frac{\beta_i^j r_i^l}{\sum_l \beta_i^j r_i^l} \hat{r}_i^j}. \tag{A.30}$$

Finally, note that we can write the change in the share of skilled and unskilled workers employed in sector j, $\omega_{L,i}^j \equiv \frac{L_i^j}{L_i}$, and $\omega_{H,i}^j \equiv \frac{H_i^j}{H_i}$, as:

$$\widehat{\omega_{L,i}^j} = \frac{\hat{\mu}_i^j \hat{r}_i^l}{\sum_j \omega_{L,i}^l \hat{\mu}_i^j \hat{r}_i^l}$$

$$\widehat{\omega_{H,i}^j} = \frac{\left[\widehat{1-\mu_i^j}\right] \hat{r}_i^l}{\sum_j \omega_{H,i}^j \left[\widehat{1-\mu_i^j}\right] \hat{r}_i^l}$$

with:

$$\hat{\mu}_i^j = \left[\left[1-\mu_i^j\right]\left[\widehat{\frac{s_i}{w_i}}\right]^{1-\gamma} + \mu_i^j\right]^{-1}$$
$$\left[\widehat{1-\mu_i^j}\right] = \left[\mu_i^j\left[\widehat{\frac{s_i}{w_i}}\right]^{\gamma-1} + \left[1-\mu_i^j\right]\right]^{-1}.$$

Changes in total sectorial employment shares, $\omega_{E,i}^j \equiv \frac{L_i^j+H_i^j}{L_i+H_i}$ are given by:

$$\widehat{\omega_{E,i}^j} = \frac{L_i^j}{L_i^j+H_i^j}\widehat{\omega_{L,i}^j} + \frac{H_i^j}{L_i^j+H_i^j}\widehat{\omega_{H,i}^j}.$$

Appendix B Proofs

In this section we log-linearize the equilibrium conditions around the initial equilibrium and derive equations (14), (15), (16), and (17) in the paper.

Derivation of Equation (14)

We start by deriving equation (14). To a first order approximation, equation (13) can be written as:

$$\tilde{s}_i - \tilde{w}_i = \sum_j \left[\frac{H_i^j}{H_i} - \frac{L_i^j}{L_i}\right]\tilde{v}_i^j - \sum_j \frac{1}{1-\mu_i}\frac{L^j}{L}\tilde{\mu}_i^j - \left[\tilde{H}_i - \tilde{L}_i\right]. \tag{B.1}$$

Log-differentiating μ_i^j we obtain:

$$\tilde{\mu}_i^j = -\mu_i^j\frac{s_i H_i^j}{w_i L_i^j}\left[\widetilde{\frac{s_i H_i^j}{w_i L_i^j}}\right] = -\left[1-\mu_i^j\right]\left[1-\gamma\right]\left[\tilde{s}_i - \tilde{w}_i\right], \tag{B.2}$$

where the second equality follows from the factor demand equations. Substituting in equation (B.1) and solving for $\tilde{s}_i - \tilde{w}_i$ we obtain equation (14) in the text.

Derivation of Equation (15)

To derive equation (15), we start by differentiating (A.1) and (A.24) around $\lambda_i^j = 1$ for the case $\beta_i^j = 1$:

$$\tilde{r}_i^j = [1-\rho]\left[\tilde{P}_i^j - \tilde{P}_i^c\right] + \frac{\tilde{\lambda}_i^j}{r_i^j} - \sum_j \tilde{\lambda}_i^j + \left[\epsilon_j - \epsilon_j\right]\tilde{C}_i. \tag{B.3}$$

Differentiating (A.28) we obtain

$$\tilde{P}_i^c = \sum_j v_i^j \tilde{P}_i^j + \left[\frac{\bar{\epsilon}}{1-\rho} - 1\right] \tilde{C}_i \tag{B.4}$$

Noting that $v_i^j = r_i^j$ when $\beta_i^j = 1$ and substituting B.4 in the equation above, we obtain equation (15) in the text.

Derivation of equation (16)

We now derive equation (16) in the text in the special version of the model with $\beta_i^j = 1$. Substituting equation (15) into (14) with $\tilde{H}_i = \tilde{L}_i = 0$ we can write:

$$[\tilde{s}_i - \tilde{w}_i]\,\bar{\gamma} \;=\; \sum_j \left[\frac{H_i^j}{H_i} - \frac{L_i^j}{L_i}\right]\left[[1-\rho]\,\tilde{P}_i^j + \frac{\tilde{\lambda}_i^j}{v_i^j} + \epsilon_j \tilde{C}_i\right]. \tag{B.5}$$

Log-linearizing equations (A.4)-(A.6) and (A.20) in the case of $\beta_i^j = 1$, we obtain:

$$\tilde{P}_i^j \;=\; \left[1-\mu_i^j\right][\tilde{s}_i - \tilde{w}_i] + \tilde{w}_i - \tilde{A}_i^j + \tilde{\pi}_{ii}^j. \tag{B.6}$$

And log-linearizing (A.3) gives

$$\tilde{C}_i \;=\; [1-\mu_i]\,[\tilde{s}_i - \tilde{w}_i] + \tilde{w}_i - \tilde{P}_i^c - \sum_j \tilde{\lambda}_i^j. \tag{B.7}$$

Substituting equations (B.4), (B.6), and (B.7) back into equation (B.5) and solving for $\tilde{s}_i - \tilde{w}_i$ gives the expression in the text.

Derivation of equations (17) and expression for employment shares

To obtain equation (17), we substitute equations (B.4), (B.6), and into (15) and solve for $\tilde{v}_i^j$. We can also derive and analogous expression for the employment shares. To do so, define sectorial employment by $E_i^j \equiv L_i^j + H_i^j$ and note that

$$\omega_{E,i}^j \;=\; \tilde{E}_i^j - \sum_l \omega_{E,i}^l \tilde{E}_i^l. \tag{B.8}$$

Log-linearizing sectorial employment we obtain:

$$\tilde{E}_i^j \;= \frac{L_i^j}{L_i + H_i^j}\tilde{L}_i^j + \frac{H_i^j}{L_i^j + H_i^j}\tilde{H}_i^j \quad ,$$

which can be written as:

$$\tilde{E}_i^j \;=\frac{L_i^j}{L_i^j+H_i^j}\left[\tilde{L}_i^j+\tilde{w}_i-\tilde{w}_i-\tilde{v}_i^j\right]+\frac{H_i^j}{L_i^j+H_i^j}\left[\tilde{H}_i^j+\tilde{s}_i-\tilde{s}_i-\tilde{v}_i^j\right]+\tilde{v}_i^j$$

or:

$$\tilde{E}_i^j \;=\frac{L_i^j}{L_i^j+H_i^j}\left[\tilde{\mu}_i^j-\tilde{w}_i\right]+\frac{H_i^j}{L_i^j+H_i^j}\left[\widetilde{\left[1-\mu_i^j\right]}-\tilde{s}_i\right]+\tilde{v}_i^j \quad . \tag{B.9}$$

Appendix C Data and Parameterization

This section first describes our data sources and then explains how these are combined to parameterize our model.

C.1 Data Sources

Our main sample combines two data sources. We use the IO tables from the World Input Output Database (WIOD) to construct changes in domestic expenditure shares, net export to aggregate revenue ratios, intermediate input shares β^j and α^{ij}, and sectorial value-added shares. We use the Socio Economic Accounts included in the WIOD (SEA) to calculate baseline employment shares, H_i^j/H_i and and aggregate employment shares.

In Section D.4, to extend our sample backward in time, we also bring in data on IO tables from the OECD IO tables (1995 version) and data on employment and labor compensation from KLEMS. We use these data in the same way as described in the previous paragraph.

Table A3 provides our own concordance to aggregate industries across datasets and levels of aggregation, and the trade elasticity in each industry and sector. We use different levels of aggregation in the paper, depending on the calculation. The column "Category" lists our most disaggregated industries, which correspond with the index k in the paper. The next column, "One Digit", aggregates the sector G industries that correspond to manufacturing; we use this classification for illustration purposes in Figures 1 and 3. Finally, the column "Sector" classifies industries into goods, unskilled and skilled labor intensive services.

Next we describe the datasets and their use in detail.

World Input-Output Tables For each year between 1995 and 2007, we observe the input output tables and bilateral trade shares from the World Input-Output Tables Database (WIOD), with industries disaggregated according to ISIC rev 3. These data are available at http://www.wiod.org/new_site/database/niots.htm. Column "WIOD code" in Table A3 lists the original industrial classification of the dataset and how we use it to compute industry and sector aggregates. We exclude "Private Households with Employed Persons (P)" from the calculations.

The WIOD also extends the labor and compensation data from KLEMS in its own Socio Economic Accounts module. For each year, we observe the share of total hours employed in each industry, corresponding to the hours of each skill type in {Low, Medium, High}, where "High" includes workers with a college degree. We also observe, for each industry, the total hours employed, which allows us to calculate, for each labor type, the total hours of employment.

OECD Input-Output Tables We download the data from http://www.oecd.org/trade/input-outputtables.htm, 1995 edition (ISIC Rev 2). Coverage for the US starts in 1977. Column "OECD Description" in Table A3 lists all disaggregated industries in this dataset and shows how we aggregate them into the sectors and industries of our model. We exclude the categories "Other producers" , "Statistical discrepancies", and "Private household activities" from the analysis.

One limitation of this dataset is that Education and Health are aggregated into the category "Community, social & personal services." Since we interpret Education as skilled labor intensive and Other services as unskilled labor intensive, we split this category into sectors S and F according to the 1995 share of Education in Education + Other Services for the US, 0.75, from WIOD.

KLEMS We downloaded data at http://www.euklems.net/, March 08 release: (i) Labour input files and (ii) Country basic files. KLEMS provides yearly data from 1970 to 2005, disaggregated by ISIC Rev. 3 industries. We treat these data just as the WIOD SEA data. Finally, we also obtain data on total revenue and absorption. Column "KLEMS Code" in Table A3 relates the original industrial classification in KLEMS to ours. We drop Private Households with Employed Persons (P).

C.2 Data construction

In this section, we discuss details on data construction not contained in the main body of the paper.

C.2.1 Sample

Table A4 reports the countries in our main sample, all of them starting in 1995 and ending in 2007. The resulting sample is the largest possible panel for which we could obtain data on both employment shares and input-output data. We provide next the details of the construction of our variables and the splicing across datasets.

C.2.2 Constructing sectoral changes in trade shares and net exports to total revenue ratios

Table A3 shows the correspondence between the classification in the OECD IO data and the classification in the WIOD data. The table also reports the classification we constructed to bridge the different levels of aggregation of these two classifications (which correspond to k in our model), and how we associated industries to the trade elasticities from Caliendo and Parro (2015). The calculation of the sectoral trade shares requires choosing a single elasticity for the "Auto and Other Transport" and "Electrical, Communication and Medical", and "Basic Metals and Metal Products" categories. In these cases, we chose the average elasticity.

C.2.3 Share of intermediate inputs in total revenue $\left(1-\beta^j\right)$ and share of each sector in the intermediate input bundle $\left(\alpha^{lj}\right)$

For each country and sector, we calculate at the beginning of the sample,

$$1-\beta^j = \frac{\text{Sector } j\text{'s Total Intermediate Use}}{\text{Sector } j's \text{ Total Intermediate Use} + \text{Sector } j's \text{ Value Added}},$$

where Sector $j's$ Total Intermediate Use is measured as Total Intermediate Use of S, G, and F (Imported and Domestic). Sector $j's$ value-added is measured as Sector $j's$ Total Output less **all** inputs purchased by aggregate sector j.

We measure the share of sector l in the intermediate input bundle used in sector j, which we denote by α^{lj}, as

$$\alpha^{lj} = \frac{\text{Sector } j\text{'s Total Intermediate Use of } l}{\text{Sector } j\text{'s Total Intermediate Use}}$$

C.3 Estimating the elasticity of substitution across sectors

To estimate equations (18) and (19), we measure expenditure shares in a way that is consistent with our model, which requires measuring how *gross output* of each sector, valued at *producer prices* (i.e. before distribution margins are applied), is used in the economy. We measure expenditure shares at producer prices using the US Input-Output Use Tables for every year in the 1977-2012 period. In particular, we group the sectors in the Input-Output Tables into the sectors of our model following the definitions from Appendix C and compute the share of each sector in total consumption expenditures and in total intermediate inputs used by the goods, unskilled and skilled intensive service sectors. We construct sector specific price indexes from the Chain-Type Price Indexes for Gross Output by NAICS 2-digit Industry published by the BEA. We aggregate these prices using the yearly expenditure shares of the US Input-Output Tables to construct chain-weighted price indexes for the three broad sectors in our model. We compute aggregate consumption expenditures per capita, C_i, from the Input-Output data Chain-Type Price index data. In particular, we aggregate final private consumption at producer prices and aggregate the Chain-Type Price Indexes using the consumption expenditure shares to construct an aggregate price index for consumption at producers prices that is consistent with our other data. We compute $C_{i,t}$ as final consumption divided by the price index, divided by population.

Appendix D Additional exercises

D.1 Within-sector skill upgrading

This section describes in detail our calculations for figure A.7. We decompose changes in the share of skilled labor in employment, $H_{E,i} \equiv \frac{H_i}{H_i+L_i}$, into changes in skilled labor shares within each industry, $H^j_{E,i} \equiv \frac{H^j_i}{H^j_i+L^j_i}$, and changes in employment shares $\omega^j_{E,i}$ between industries. That is:

$$\Delta H_{E,i} = \underbrace{\sum_j \Delta H^j_{E,i}\bar{\omega}^j_{E,i}}_{\text{within}} + \underbrace{\sum_j \Delta\omega^j_{E,i}\bar{H}^j_{E,i}}_{\text{between}}, \tag{D.1}$$

where $\Delta x \equiv x_{t_1} - x_{t_0}$ denotes the change of a variable between periods t_1 and t_0, and $\bar{x} \equiv \frac{x_{t_1}+x_{t_0}}{2}$ is the average value of the variable across periods. We compare the outcomes of this decomposition in the data and in a version of the counterfactual that incorporates changes in factor supplies.

D.2 Global productivity growth in the goods sector

In this counterfactual we augment Counterfactual 1 with global productivity growth. That is, in addition to declines in trade costs obtained from (20), we assign $\hat{A}^G_i = \hat{A}^G$ to every country i, and we calibrate $\hat{A}^G$ such that the model exactly replicates the decline in the US employment share in the goods sector between 1995 and 2007.

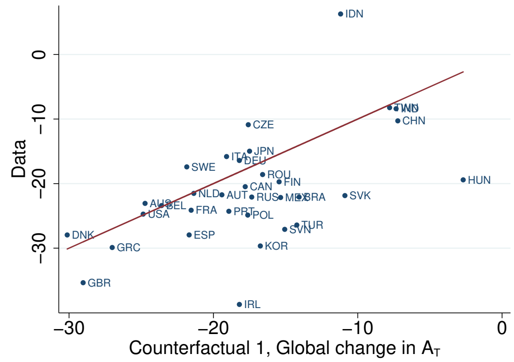
Figure A.1 compares the results of this counterfactual to the data, with a 45-degree line as a reference. The figure shows that once we allow for global productivity change to account for the changes in good employment in the US, then the counterfactual can account quite well for the decline in the share of employment in the goods sector in most countries.

D.3 Measuring the skill premium using the factor content of trade

This section by assesses, in the context of our model, an alternative approach that has been used in the literature to measure the impact of trade on factor prices: the factor content of trade (FCT).[28] The FCT measures the quantity of a factor that is embodied in a country's net exports. Intuitively, an increase in the trade-adjusted supply of a factor should decrease the factor's price. We first use our model to measure changes in the FCT implied by Counterfactuals 1 and 2. Then we show that these measured changes greatly underestimate the model's predictions for the changes in the skill premium.

[28] See e.g. Katz and Murphy (1992).

Figure A.1: Changes in goods employment shares (Counterfactual 1 with global productivity growth)



Notes: The x-axis shows the percent change in the sector's share in employment in a version of Counterfactual 1 that includes productivity growth. The y-axis reports the percent change in the sector's share in employment between 1995-2007 in the WIOD data.

We start by deriving an expression that formally links the FCT to the skill premium. We start by writing equations (A.8) and (A.9), summing over j, as:

$$s_i H_i = \sum_j \left[1 - \mu_i^j\right] \beta_i^j R_i^j = \sum_j \left[1 - \mu_i^j\right] \beta_i^j Y_i^j + s_i FCT_i^H$$

$$w_i L_i = \sum_j \mu_i^j \beta_i^j R_i^j = \sum_j \mu_i^j \beta_i^j Y_i^j + w_i FCT_i^L,$$

where skilled- and unskilled-labor content of trade are $FCT_i^H \equiv \frac{1}{s_i} \sum_j \left(1 - \mu_i^j\right) \beta_i^j \left[R_i^j - Y_i^j\right]$ and $FCT_i^L \equiv \frac{1}{w_i} \sum_j \mu_i^j \beta_i^j \left[R_i^j - Y_i^j\right]$. Solving for the wages s_i and w_i and taking ratios we can write the skill premium as

$$\frac{s_i}{w_i} = \frac{L_i - FCT_i^L}{H_i - FCT_i^H} \times \Phi_i, \tag{D.2}$$

where we defined $\Phi_i \equiv \frac{\sum_j \left(1 - \mu_i^j\right) \beta_i^j Y_i^j}{\sum_j \mu_i^j \beta_i^j Y_i^j}$. Deardorff and Staiger (1988) and Burstein and Vogel (2011) show in a class of models that, if factor shares, μ_i^j, are fixed in each sector and sectoral absorption shares, Y_i^j, are constant, then Φ_i is constant and changes in the skill premium are proportional to changes in factor supplies and the FCT, captured by $\left(L_i - FCT_i^L\right) / \left(H_i - FCT_i^H\right)$. In that context, changes in the FCT are sufficient statistics for the effect of trade on the skill premium. Clearly, these conditions are not satisfied in our model, where both sectoral absorption shares and factor shares change in response to changes in trade patterns.[29] The FCT approach, therefore, does not capture all of the effects of trade on the skill premium.

We next show how we measure changes in the FCT in the model, starting with the expression above in changes:

$$\frac{s_i}{w_i}\frac{\widehat{s_i}}{w_i} = \frac{L\hat{L}}{H\hat{H}}\frac{1-\frac{FCT_i^L\widehat{FCT_i^L}}{L\hat{L}}}{1-\frac{FCT_i^H\widehat{FCT_i^H}}{H\hat{H}}}\Phi_i\hat{\Phi}_i.$$

We next impose that $\hat{\Phi}_i = 1$, to obtain

$$\frac{\widehat{s_i}}{w_i}^{FC} = \frac{\left(1-\frac{FCT_i^L\widehat{FCT_i^L}}{L\hat{L}}\right)/\left(1-\frac{FCT_i^L}{L}\right)}{\left(1-\frac{FCT_i^H\widehat{FCT_i^H}}{H\hat{H}}\right)/\left(1-\frac{FCT_i^H}{H}\right)}.$$

Now, since

$$\frac{FCT_i^L}{L} = \sum_j \frac{L_i^j}{L}\left[1-\frac{1}{\lambda_i^j}\right] = 1-\sum_j \frac{L_i^j}{L}\frac{1}{\lambda_i^j}$$

and

$$\frac{FCT_i^L}{L}\frac{\widehat{FCT_i^L}}{L} = \sum_j \frac{L_i^j}{L}\left[\frac{\hat{L}_i^j}{L}\right]\left[1-\frac{1}{\lambda_i^j\hat{\lambda}_i^j}\right] = \left[1-\sum_j \frac{L_i^j}{L}\left[\frac{\hat{L}_i^j}{L}\right]\frac{1}{\lambda_i^j\hat{\lambda}_i^j}\right],$$

we finally obtain

$$\frac{\widehat{s_i}}{w_i}^{FC} = \frac{\left(\sum_j \frac{H_i^j}{H}\frac{1}{\lambda_i^j}\right)\times\left(\sum_j \frac{L_i^j}{L}\left[\frac{\hat{L}_i^j}{L}\right]\frac{1}{\lambda_i^j\hat{\lambda}_i^j}\right)}{\left(\sum_j \frac{L_i^j}{L}\frac{1}{\lambda_i^j}\right)\times\left(\sum_j \frac{H_i^j}{H}\left[\frac{\hat{H}_i^j}{H}\right]\frac{1}{\lambda_i^j\hat{\lambda}_i^j}\right)}.$$

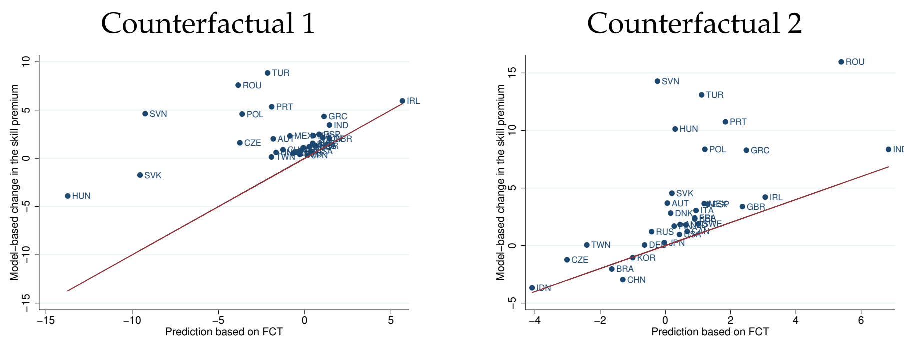
Figure A.2 compares the counterfactual change in the skill premium to the changes in the skill premium that we measure from the counterfactual changes in the first term of equation (D.2).[30] The figures show that the change in the FCT greatly underestimates the counterfactual changes in the skill premium in our model in almost every country. In fact, the FCT-based measure moves in the opposite direction to the counterfactual skill

[29] Burstein and Vogel (2016) also note that the FCT cannot be measured from sectoral data if exporters and domestic firms use different technologies. While the FCT is not a sufficient statistic for the skill premium in their context (the term Φ_i is not constant in their framework), they show that if measured accurately, the FCT does provide a good approximation to the effect of trade on the skill premium. This not the case in our context, even if the FCT is perfectly measured.

[30] That is, we use data generated in the counterfactuals to measure how $\left(L_i - FCT_i^L\right)/\left(H_i - FCT_i^H\right)$ changes, while keeping Φ_i constant.

premium for about half the countries in Counterfactual 1, and for about fifteen percent of the countries in Counterfactual 2.

Figure A.2: Predictions based on the factor content of trade



Notes: This figure compares the change in the skill premium implied by each of our counterfactuals (y-axis) to the change in the skill premium implied by the right hand side of equation (D.2) (x-axis).

D.4 Trade patterns, structural change and the skill premium over longer horizons

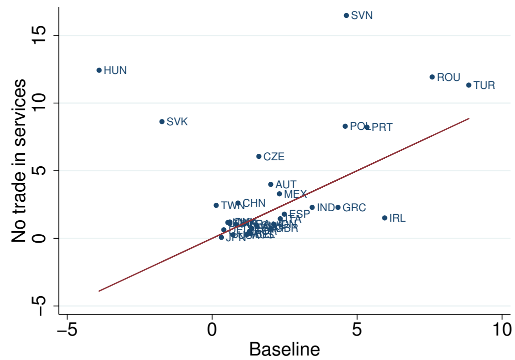
We conclude this section by extending the second counterfactual for the US starting in 1977.[31] Given the large reallocation of activity away from the goods sectors in the US in the decades before 1995, our previous exercise might underestimate the role that trade has played there. The sufficient statistic approach allows us to compute this counterfactual individually for the US.The decline in domestic expenditure shares is over this longer period is 11 percent. As a consequence the associated decline in value-added and employment shares in the goods sector are larger than those in Figure 7. The manufacturing employment share declines by 20 percent in this counterfactual, relative to the 45 percent that we see in the data over this period. In addition, since the share of employment in the goods sector was larger at the beginning of this sample than in 1995, the elasticity of the skill premium with respect to changes in domestic expenditure shares in the goods sector is larger than in the previous counterfactual (see equation 16). Therefore, the associated increase in the skill-premium is also larger, and equals 3.1 percent. However, it is still small relative to the 40 percent estimated by Krueger et al. (2010) for the 1980-2006 period.

D.5 Additional robustness exercises

This section report our counterfactuals under alternative calibrations where (i) Services are not traded, (ii) the shares $\sigma_i^j(k)$ are the same across all countries and equal to those in the US.

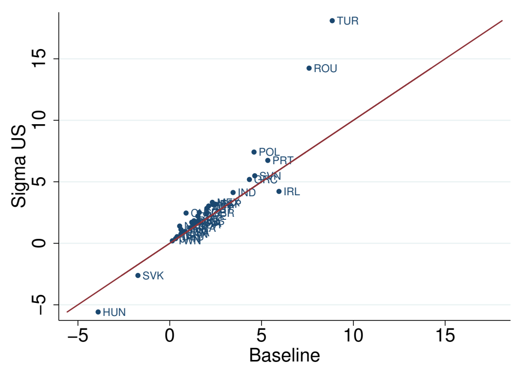
[31] We bring in Input-Output data from the OECD, which ranges from 1977 to 1990 for the US, and we combine it with data on employment and compensation from KLEMS.

Figure A.3: Change in Skill Premium, no-trade in services



Notes: The x-axis reports the change in Counterfactual 1. The y-axis reports the difference in the change in the skill premium in one counterfactual in which services are not traded neither in the initial nor the final equilibrium.

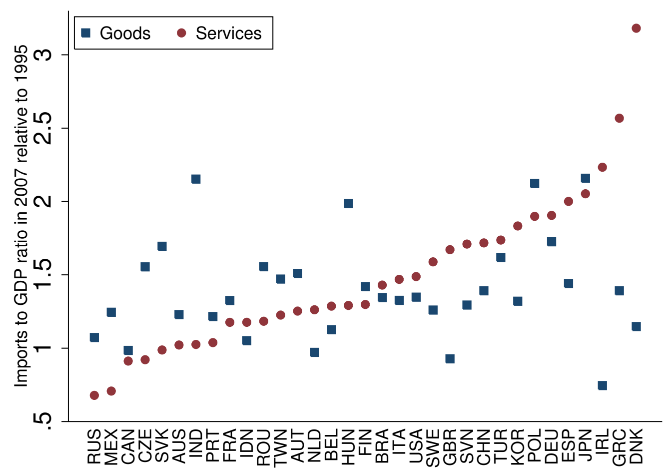
Figure A.4: Change in Skill Premium, $\sigma_i = \sigma_{USA}$



Notes: The x-axis reports the change in Counterfactual 1. The y-axis reports Counterfactual 1 under an alternative calibration where the $\sigma^j(k)'s$ are the same across countries and equal to those observed for the US.

Appendix E Additional tables and figures

Figure A.5: Skill and trade intensities across industries by countries

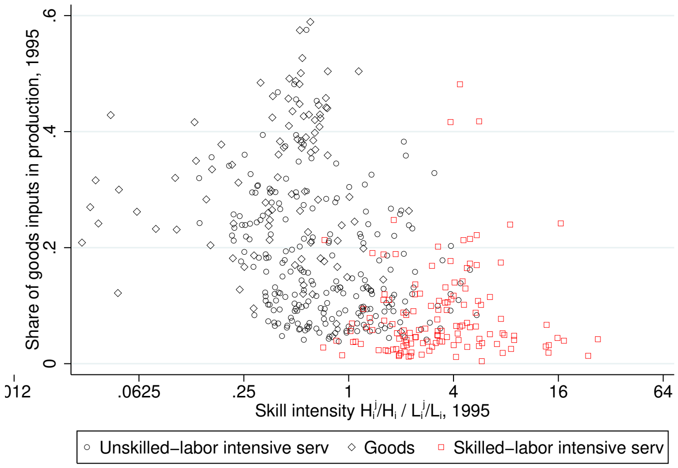


Notes: We classify agriculture, manufacturing and mining as 'Goods', and all other sectors as 'Services.' Source: WIOD.

Figure A.6: Skill and trade intensities across industries by countries

Notes: Each point is a country, one-digit industry pair. 'Domestic expenditure shares 2007 relative to 1995' refers to $\pi^j_{ii,2007}/\pi^j_{ii,1995}$ defined in Figure 2. Skill intensities are defined as in Figure 3. Source: WIOD.

Figure A.7: Intermediate use of inputs from the goods-producing sector, by industries and countries



Notes: Each point is a country-industry pair. Share of goods inputs in production is the share of agriculture, mining and manufacturing inputs in total production of the sector. Skill intensities are defined as in Figure 3. Source: WIOD.

Table A3: Concordance across datasets and sectoral aggregation

Category	One Digit	Sector	OECD Description	WIOD code	KLEMS code	CP Elasticity	Agg. Elasticity
Agriculture	AtB	G	Agriculture, forestry & fishing	AtB	AtB	8.11	8.11
Mining	C	G	Mining & quarrying	C	C	15.72	15.72
Food	D	G	Food, beverages & tobacco	15t16	15t16	2.55	2.55
Textile	D	G	Textiles, apparel & leather	17t18	17t19	5.56	5.56
Textile	D	G	Textiles, apparel & leather	19	17t19	5.56	5.56
Wood	D	G	Wood products & furniture	20	20	10.83	10.83
Paper	D	G	Paper, paper products & printing	21t22	21t22	9.07	9.07
Chemicals	D	G	Industrial chemicals	24	24	4.75	4.75
Chemicals	D	G	Drugs & medicines			4.75	4.75
Petroleum	D	G	Petroleum & coal products	23	23	51.08	51.08
Plastic	D	G	Rubber & plastic products	25	25	1.66	1.66
Minerals	D	G	Non-metallic mineral products	26	26	2.76	2.76
Basic metals and Metal Products	D	G	Iron & steel	27t28	27t28	7.99	6.76
Basic metals and Metal Products	D	G	Non-ferrous metals	27t28	27t28	7.99	6.76
Basic metals and Metal Products	D	G	Metal products			4.3	6.76
Machinery nec	D	G	Non-electrical machinery	29	29	1.52	1.52
Electrical, Communication, Medical	D	G	Office & computing machinery			12.79	10.11
Electrical, Communication, Medical	D	G	Electrical apparatus, nec	30t33	30t33	10.6	10.11
Electrical, Communication, Medical	D	G	Radio, TV & communication equipment			7.07	10.11
Auto and Other Transport	D	G	Shipbuilding & repairing	34t35	34t35	.37	.53
Auto and Other Transport	D	G	Other transport	34t35	34t35	.37	.53
Auto and Other Transport	D	G	Motor vehicles			1.01	.53
Auto and Other Transport	D	G	Aircraft	34t35	34t35	.37	.53
Electrical, Communication, Medical	D	G	Professional goods			9.98	10.11
Other	D	G	Other manufacturing	36t37	36t37	5	5
Electricity	E	S	Electricity, gas & water	E	E	5	5
Construction	F	S	Construction	F	F	5	5
Wholesale and Retail	G	S	Wholesale & retail trade	51	51	5	5
Wholesale and Retail	G	S	Wholesale & retail trade	52	52	5	5
Wholesale and Retail	G	S	Wholesale & retail trade	50	50	5	5
Hotels and Restaurants	H	S	Restaurants & hotels	H	H	5	5
Transport and Communication	I	S	Transport & storage	60	I	5	5
Transport and Communication	I	S	Transport & storage	62	I	5	5
Transport and Communication	I	S	Transport & storage	61	I	5	5
Transport and Communication	I	S	Transport & storage	63	I	5	5
Transport and Communication	I	S	Communication	64	I	5	5
Finance	J	F	Finance & insurance	J	J	5	5
Real Estate	K	F	Real estate & business services	70	70	5	5
Real Estate	K	F	Real estate & business services	71t74	71t74	5	5
Health	N	F	Community, social & personal services	N	N	5	5
Other Services	O	S	Community, social & personal services	O	O	5	5
Education	M	F	Community, social & personal services	M	M	5	5
Public Admin	L	S	Producers of government services	L	L	5	5
Private Households	P	S	Other producers	P	P	5	5

Table A4: Changes in goods and service imports relative to total GDP

Country	Goods	Services	Country	Goods	Services
Australia	1.23	1.02	Italy	1.33	1.47
Austria	1.51	1.25	Japan	2.16	2.05
Belgium	1.13	1.29	Korea	1.32	1.83
Brazil	1.35	1.43	Mexico	1.24	0.71
Canada	0.98	0.91	Netherlands	0.97	1.26
China	1.39	1.72	Poland	2.12	1.90
Czech Republic	1.55	0.92	Portugal	1.22	1.04
Germany	1.73	1.91	Romania	1.56	1.18
Denmark	1.15	3.18	Russia	1.07	0.68
Spain	1.44	2.00	Rest of the World	1.22	1.43
Finland	1.42	1.30	Slovakia	1.69	0.99
France	1.33	1.18	Slovenia	1.29	1.71
Great Britain	0.93	1.67	Sweden	1.26	1.59
Greece	1.39	2.57	Turkey	1.62	1.74
Hungary	1.99	1.29	Taiwan	1.47	1.23
Indonesia	1.05	1.18	United States	1.35	1.49
India	2.15	1.03	World	1.44	1.60
Ireland	0.75	2.23	Average	1.39	1.48

Notes: This table reports imports to total GDP in 2007 relative to 1995 using data from the WIOD. The classification of WIOD industries into Goods and Services is detailed in Section 4.

Table A5: Sectoral changes in domestic-expenditure shares

Country	Goods	Services	Country	Goods	Services
Australia	0.88	1.00	Italy	0.89	0.99
Austria	0.66	0.99	Japan	0.90	0.99
Belgium	0.76	0.98	Korea	0.94	0.98
Brazil	0.97	0.99	Mexico	0.87	1.01
Canada	0.97	1.01	Netherlands	0.81	0.98
China	0.97	0.99	Poland	0.72	0.98
Czech Republic	0.72	1.01	Portugal	0.77	1.00
Germany	0.76	0.98	Romania	0.74	1.00
Denmark	0.83	0.92	Russia	0.97	1.01
Spain	0.81	0.98	Rest of the World	0.89	0.96
Finland	0.84	0.99	Slovakia	0.53	1.00
France	0.85	1.00	Slovenia	0.64	0.97
Great Britain	0.80	0.99	Sweden	0.83	0.97
Greece	0.75	0.96	Turkey	0.86	1.00
Hungary	0.54	0.98	Taiwan	0.78	0.99
Indonesia	0.96	1.00	United States	0.90	1.00
India	0.88	1.00	World	0.90	0.98
Ireland	1.04	0.87	Average	0.82	0.98

Notes: This Table reports the ratio of the 2007 domestic expenditure shares relative to those in 1995 and 2007. Domestic expenditure shares are computed as the ratio of production minus exports to production plus imports minus exports in each sector using data from the WIOD. The grouping of WIOD industries into Goods and Services is detailed in Section 4.

Table A6: Observed changes in domestic expenditure shares and net exports to aggregate revenue ratios

Country	Weighted change in domestic expenditure share	Change in Sectoral Net Exports to Aggregate Revenues ratio
Australia	0.93	1.01
Austria	0.80	0.97
Belgium	0.90	1.01
Brazil	1.00	0.98
Canada	0.97	1.01
China	1.00	0.98
Czech Republic	0.91	0.95
Germany	0.91	0.97
Denmark	0.87	1.02
Spain	0.91	1.03
Finland	0.92	1.01
France	0.91	1.01
Great Britain	0.89	1.03
Greece	0.88	1.05
Hungary	0.72	0.97
Indonesia	0.99	0.97
India	0.96	1.03
Ireland	0.95	1.04
Italy	0.95	1.01
Japan	0.97	1.00
Korea	1.00	0.98
Mexico	0.92	1.01
Netherlands	0.91	0.99
Poland	0.85	1.02
Portugal	0.84	1.02
Romania	0.87	1.07
Russia	0.94	1.00
Slovakia	0.83	0.99
Slovenia	0.66	1.00
Sweden	0.95	1.01
Turkey	0.76	1.01
Taiwan	0.91	0.97
United States	0.94	1.02
Average	**0.90**	**1.00**

Notes: The weighted change in domestic expenditure shares is defined as $\hat{\pi}_{ii} \equiv \prod_{k=1}^{K_j} \hat{\pi}_{ii}^{j}(k)^{\sigma_i^j(k)\theta^j(k)}$. The change in the revenue to absorption ratio is given by $\hat{\lambda}_i^T$.

Table A7: Sectoral factor intensities

Country	H^S/H	L^S/L	Difference	H^G/H	L^G/L	Difference	H^F/H	L^F/L	Difference
Australia	0.29	0.53	-0.24	0.11	0.23	-0.13	0.60	0.24	0.37
Austria	0.31	0.50	-0.20	0.17	0.34	-0.17	0.52	0.15	0.37
Belgium	0.29	0.51	-0.22	0.15	0.23	-0.08	0.57	0.26	0.31
Brazil	0.32	0.49	-0.17	0.13	0.40	-0.27	0.55	0.11	0.44
Canada	0.43	0.57	-0.14	0.11	0.24	-0.13	0.45	0.19	0.26
China	0.61	0.31	0.29	0.14	0.64	-0.50	0.25	0.04	0.21
Czech Republic	0.34	0.48	-0.14	0.18	0.38	-0.20	0.48	0.15	0.34
Germany	0.38	0.51	-0.13	0.22	0.28	-0.06	0.40	0.21	0.19
Denmark	0.30	0.48	-0.18	0.12	0.27	-0.15	0.58	0.25	0.33
Spain	0.39	0.57	-0.19	0.14	0.31	-0.17	0.47	0.11	0.36
Finland	0.38	0.44	-0.06	0.19	0.35	-0.16	0.43	0.21	0.22
France	0.28	0.50	-0.23	0.14	0.25	-0.12	0.59	0.24	0.34
Great Britain	0.30	0.53	-0.23	0.12	0.20	-0.08	0.58	0.27	0.31
Greece	0.44	0.56	-0.12	0.09	0.37	-0.29	0.48	0.07	0.41
Hungary	0.33	0.46	-0.13	0.19	0.41	-0.22	0.49	0.13	0.35
Indonesia	0.53	0.41	0.11	0.11	0.50	-0.39	0.36	0.09	0.28
India	0.38	0.23	0.15	0.27	0.75	-0.48	0.35	0.02	0.33
Ireland	0.28	0.46	-0.18	0.18	0.39	-0.21	0.54	0.15	0.39
Italy	0.24	0.50	-0.26	0.11	0.33	-0.23	0.65	0.16	0.49
Japan	0.48	0.54	-0.06	0.20	0.29	-0.09	0.32	0.17	0.15
Korea	0.51	0.49	0.02	0.27	0.40	-0.13	0.22	0.11	0.11
Mexico	0.52	0.45	0.07	0.17	0.44	-0.27	0.30	0.11	0.20
Netherlands	0.30	0.51	-0.21	0.09	0.24	-0.15	0.61	0.25	0.36
Poland	0.32	0.32	-0.01	0.19	0.57	-0.38	0.49	0.11	0.38
Portugal	0.29	0.48	-0.20	0.08	0.41	-0.33	0.63	0.11	0.53
Romania	0.19	0.27	-0.07	0.15	0.65	-0.51	0.66	0.08	0.58
Russia	0.21	0.33	-0.12	0.22	0.51	-0.29	0.57	0.16	0.41
Slovakia	0.29	0.43	-0.14	0.19	0.38	-0.20	0.52	0.18	0.34
Slovenia	0.34	0.35	-0.01	0.21	0.53	-0.33	0.46	0.12	0.34
Sweden	0.31	0.45	-0.14	0.11	0.28	-0.17	0.59	0.27	0.31
Turkey	0.56	0.31	0.24	0.11	0.63	-0.52	0.33	0.06	0.27
Taiwan	0.51	0.49	0.02	0.18	0.42	-0.24	0.31	0.08	0.23
United States	0.41	0.58	-0.16	0.15	0.21	-0.06	0.44	0.22	0.22
Average	**0.36**	**0.46**	**-0.09**	**0.16**	**0.39**	**-0.23**	**0.48**	**0.15**	**0.32**

Notes: H^j/H measures the fraction of total skilled labor employed in sector $j = S, G, F$. L^J/L is defined analogously. Difference measures $H^j/H - L^j/L$ for each sector j.

Table A8: Intermediate input shares

Country	β_i^S	β_i^G	β_i^F	α_i^{SS}	α_i^{GS}	α_i^{FS}	α_i^{SG}	α_i^{GG}	α_i^{FG}	α_i^{SF}	α_i^{GF}	α_i^{FF}
Australia	0.46	0.41	0.63	0.40	0.31	0.29	0.32	0.57	0.11	0.34	0.11	0.55
Austria	0.61	0.42	0.68	0.43	0.31	0.26	0.27	0.60	0.13	0.36	0.17	0.48
Belgium	0.51	0.33	0.64	0.52	0.22	0.26	0.28	0.63	0.09	0.24	0.16	0.60
Brazil	0.65	0.41	0.73	0.37	0.35	0.27	0.21	0.69	0.10	0.39	0.23	0.37
Canada	0.59	0.40	0.73	0.39	0.32	0.28	0.26	0.65	0.09	0.46	0.12	0.42
China	0.43	0.35	0.57	0.25	0.65	0.10	0.15	0.81	0.05	0.28	0.45	0.27
Czech Republic	0.43	0.32	0.54	0.51	0.33	0.16	0.24	0.69	0.07	0.37	0.29	0.34
Germany	0.59	0.41	0.70	0.39	0.31	0.30	0.24	0.59	0.17	0.26	0.12	0.62
Denmark	0.56	0.41	0.72	0.49	0.27	0.24	0.30	0.60	0.10	0.42	0.16	0.42
Spain	0.54	0.35	0.69	0.44	0.36	0.20	0.26	0.65	0.09	0.41	0.18	0.41
Finland	0.56	0.38	0.68	0.39	0.40	0.21	0.24	0.65	0.10	0.43	0.26	0.31
France	0.56	0.34	0.68	0.47	0.24	0.29	0.26	0.58	0.15	0.28	0.13	0.59
Great Britain	0.52	0.42	0.66	0.45	0.29	0.26	0.25	0.63	0.13	0.34	0.17	0.49
Greece	0.61	0.39	0.77	0.35	0.45	0.21	0.22	0.70	0.08	0.45	0.15	0.40
Hungary	0.51	0.33	0.66	0.35	0.38	0.27	0.20	0.71	0.09	0.29	0.30	0.42
Indonesia	0.55	0.49	0.72	0.33	0.55	0.12	0.17	0.78	0.06	0.33	0.24	0.43
India	0.60	0.41	0.79	0.35	0.53	0.12	0.25	0.69	0.06	0.34	0.39	0.27
Ireland	0.48	0.37	0.64	0.52	0.29	0.20	0.23	0.64	0.14	0.29	0.15	0.57
Italy	0.53	0.35	0.74	0.44	0.33	0.23	0.29	0.63	0.08	0.29	0.16	0.56
Japan	0.57	0.37	0.70	0.40	0.35	0.25	0.23	0.69	0.08	0.39	0.20	0.42
Korea	0.55	0.33	0.70	0.24	0.45	0.31	0.10	0.81	0.08	0.36	0.24	0.39
Mexico	0.64	0.41	0.79	0.29	0.41	0.30	0.17	0.74	0.09	0.23	0.26	0.51
Netherlands	0.53	0.38	0.65	0.43	0.27	0.30	0.27	0.57	0.16	0.32	0.15	0.53
Poland	0.55	0.39	0.66	0.48	0.41	0.11	0.26	0.67	0.07	0.38	0.22	0.40
Portugal	0.53	0.35	0.68	0.46	0.33	0.21	0.22	0.69	0.10	0.33	0.20	0.47
Romania	0.48	0.39	0.69	0.38	0.51	0.11	0.19	0.72	0.08	0.29	0.53	0.18
Russia	0.62	0.43	0.58	0.50	0.43	0.07	0.33	0.65	0.02	0.51	0.29	0.20
Slovakia	0.42	0.33	0.64	0.53	0.34	0.13	0.27	0.67	0.06	0.39	0.27	0.35
Slovenia	0.49	0.38	0.67	0.45	0.33	0.23	0.22	0.69	0.09	0.30	0.29	0.41
Sweden	0.53	0.40	0.64	0.44	0.28	0.28	0.27	0.61	0.12	0.39	0.17	0.44
Turkey	0.68	0.49	0.72	0.27	0.54	0.19	0.27	0.65	0.08	0.33	0.40	0.27
Taiwan	0.58	0.31	0.73	0.29	0.42	0.29	0.18	0.74	0.08	0.18	0.21	0.61
United States	0.62	0.35	0.66	0.36	0.32	0.32	0.19	0.68	0.13	0.25	0.14	0.61
Average	**0.55**	**0.38**	**0.68**	**0.40**	**0.37**	**0.22**	**0.24**	**0.67**	**0.09**	**0.34**	**0.23**	**0.43**

Notes: We calculate β_i^j from Input-Output data as the share of value-added in sector j's total revenues. The input share α_i^{lj} is the share of expenditure in inputs produced in sector l, as a fraction of total input expenditure in sector j.