Per Capita Income and the Demand for Skills

Justin Caron, Thibault Fally and James Markusen*†

November 2019

Abstract

Almost all of the literature about the growth of income inequality and the relationship between skilled and unskilled wages approaches the issue from the production side of general equilibrium (skill-biased technical change, international trade). We add a role for income-dependent demand interacted with factor intensities in production. We explore how income growth and trade liberalization influence the demand for skilled labor when preferences are non-homothetic and when income-elastic goods are more intensive in skilled labor, an empirical regularity documented in Caron, Fally and Markusen (2014). To do so, we simulate the growth in both income and exports observed between 1995 and 2010 by adjusting sector-neutral productivity and trade costs. Relative to what we would obtain with homothetic preferences, we show that these changes lead to significant increases in the skill premium, especially in developing countries. Our results are mostly driven by productivity growth shifting consumption towards skill-intensive goods, but non-homothetic preferences also matter when evaluating the effect of trade. Overall, the negative effect of trade cost reductions on the skill premium predicted for developing countries under homothetic preferences (Stolper-Samuelson) is strongly mitigated, and sometimes reversed.

Keywords: Non-homothetic preferences, skill premium, per capita income, structural change, international trade.

JEL Classification: F10, O10, F16, J31.

---

*Justin Caron: Department of Applied Economics, HEC Montreal. Thibault Fally: Department of Agricultural and Resource Economics, University of California Berkeley; James Markusen: Shandong University and University of Colorado-Boulder.

†This paper was part of the working paper Caron, Fally and Markusen (NBER 2011, CEPR 2012) which was divided in two, the first part published as Caron, Fally and Markusen (2014). The work presented here is a much expanded development of the second part and has not been published elsewhere. We thank Donald Davis, Peter Egger, Ana-Cecilia Fieler, Lionel Fontanie, Juan Carlos Hallak, Gordon Hanson, Jerry Hausman, Larry Karp, Wolfgang Keller, Ethan Ligon, Keith Maskus, Faiz Moosa, Tobias Seidel, Ina Simonovska, David Weinstein, conference and seminar participants for helpful comments.

1 Introduction

Income inequality, especially between skilled and unskilled workers, has increased considerably over the past three decades. This observation has led to a large body of research aiming to explain these changes, often focusing on the roles of trade and (or versus) skill-biased technological change.[1] Other recent work has highlighted the role of several alternative channels in explaining these changes, such as trade and offshoring through Heckscher-Ohlin-type mechanisms,[2] heterogeneous technology adoption across firms,[3] changes in matching patterns between heterogeneous workers and firms,[4] and quality upgrading encouraged by trade liberalization.[5] While this significant body of work concentrates on the production side of general equilibrium, there is a smaller literature that considers shifting patterns of demand across sectors that require different types of skills.[6] The sources of these demand shifts are in some cases modeled explicitly and in others simply taken as exogenous. Our paper relates to this demand-driven literature, though we link characteristics of goods in consumption to characteristics of goods in production in a very explicit way. We will first describe our approach, and then explain how it contrasts to other literature later in the section.

In this paper, we illustrate how income growth and reductions in trade costs affect the skill premium when preferences are non-homothetic. Our results rely on the correlation between income elasticity in consumption and skill intensity in production across goods, shown to be very large in Caron, Fally and Markusen (2014). This correlation implies that homogeneous productivity growth across sectors is no longer neutral for the skill premium in general equilibrium. As countries grow richer, their consumers increase their relative consumption of goods that are more skill-intensive in production, thereby increasing the returns to skilled labor relative to unskilled labor. The effects of trade cost reductions on the skill premium also differ when preferences are non-homothetic and when income-elastic goods are more skill intensive: the net skilled-labor content of trade and the effect of trade-driven income growth are both different under these conditions.

To quantify these mechanisms, our analysis proceeds in three steps. In step 1, we describe a model of production, trade and consumption in general equilibrium. In step 2, we estimate the preference, trade cost and technology parameters of the model. We take a cross-sectional approach which allows us to identify the role of income in explaining shifts in consumption. In step 3, we simulate various counterfactual equilibria to quantify and illustrate the impact of productivity growth and trade cost reductions on the skill premium. Before proceeding, we wish to emphasize that while we do show that non-homothetic preferences push the model's predictions closer to observed estimates of the skill premium, our methodology does not permit us to empirically evaluate the contributions of growth and trade relative to the alternative theories of the skill premium mentioned above.

The first step of our analysis is to develop a model combining non-homothetic preferences with a

[1] Katz and Murphy (1992), Goldberg and Pavcnik (2007), Autor et al. (2015)
[2] Krugman (2000), Feenstra and Hanson (1997)
[3] Bustos (2011), Burstein and Vogel (2017)
[4] Card et al. (2013), Helpman et al. (2017)
[5] Hallak (2010), Feenstra and Romalis (2014), Fieler, Eslava and Xu (2016)
[6] Buera and Kaboski (2012), Johnson and Keane (2013)

standard multi-sector and multi-factor model on the supply side. Consumption patterns are derived from "constant relative income elasticity" (CRIE) preferences as in Caron et al. (2014) and Fieler (2011). The supply-side structure is an extension of Costinot et al. (2012) and Eaton and Kortum (2002) with multiple factors of production and an input-output structure as in Caliendo and Parro (2014). The model can be used to derive first-order approximations of the response of the skill premium to uniform changes in productivity and trade costs, with and without taking into account the demand for intermediate goods. These approximations help develop the intuition behind the mechanisms and emphasize the role played by the correlation between income elasticity and skill intensity.

In a second step, we estimate preference, trade cost and technology parameters. Our estimations rely on the Global Trade Analysis Project (GTAP) dataset. In order to test whether our mechanisms have quantitative relevance in explaining changes in the skill premium going back several decades, we estimate our model using version 5 of the dataset (Dimaranan and McDougall, 2002), which is based on 1997 data. GTAP 5 comprises 66 countries with a wide range of income levels, 56 broad sectors including manufacturing and services, and 5 factors of production including the disaggregation of skilled and unskilled labor.[7] This dataset is uniquely suited to our purposes, as it contains a consistent and reconciled cross-section of production, input-output, consumption and trade data. However, the broad categories of goods and services make it unsuitable for the discussion of issues related to product quality and within-industry heterogeneity.

We follow the same estimation method as Caron et al. (2014). We first estimate gravity equations within each sector, which allows us to identify patterns of comparative advantage and to construct price indices across importers and sectors. We then estimate consumer preferences, adjusting for these price index differences. To account for endogeneity, we also instrument prices with indices that do not depend on domestic demand. This strategy allows us to estimate and identify price and income elasticity parameters for a large range of sectors, which is usually complicated by the lack of consistent price and expenditure data, as well as by endogenous prices. We find that per capita income plays a crucial role in determining demand patterns across countries and sectors. Income-elasticity in consumption varies largely across goods and is highly correlated with skill intensity in production, as also documented in Caron et al. (2014), with an estimated correlation above 40 percent across all goods, whether or not we exclude services.

In a third step, we use our estimates of preferences, trade cost and technology parameters for counterfactual simulations in general equilibrium. Our objective is to quantitatively assess whether historical rates of growth in income and trade liberalization may have affected the skill premium, with a focus on the role of non-homothetic changes in consumption. To do so, we first calibrate growth in productivity and reductions in trade costs to match observed growth in real per capita income and trade/GDP ratios between 1995 and 2010. Counterfactuals then examine how these productivity and trade shocks affect the skill premium, allowing for non-homotheticity in demand. Even if these shocks are uniform across sectors, their effects are not. Our simulation results reveal an increase in the skill

[7] We also document that all central results hold for more recent data based on 2007, GTAP8 (Narayanan et al., 2012), which covers 109 countries.

premium in almost all countries. The increases are particularly large in the developing world, with an average of 9.3% in low-income countries. With homothetic preferences, the model predicts a 0.6% *reduction* in the skill premium in these countries. For China, the model predicts a 17% increase in the skill premium; for India, 22%; for Vietnam, 21%. The predicted increase is also substantial in many African countries. Changes are on average smaller in middle- and high-income countries, at 2.4%, but remain significantly larger than with homothetic preferences (0.5%).

We then decompose these results to disentangle the relative contributions of growth and openness to trade. To pinpoint the role of growth in per capita income, we first re-simulate the changes in the skill premium caused by our estimated 1995-2010 productivity shocks (holding trade costs fixed at 1995 levels). Results suggest a large potential for income growth to affect the skill premium. The strong correlation between skill intensity and income elasticity induces a quantitatively large shift in demand towards skill-intensive goods as per capita income increases. This effect is quantitatively important and explains most of the overall changes in the skill premium found in the unified counterfactual where trade costs also change. This is particularly true for developing countries, which are rapidly transitioning out of unskilled-labor intensive sectors such as agriculture and basic manufacturing. The increase in the skill premium explained by productivity growth is 7.9% higher with non-homothetic than with homothetic preferences in low-income countries (9.6% vs. 1.7%). The difference is 10% in China and 19% in India, but only 1.8% on average in middle- and high-income countries. We show that the higher increase in low-income countries is not primarily driven by differences in growth rates across countries, and is robust to a number of assumptions underlying our exercise, including the choice of demand system.

Note that the main mechanism in this 'growth-only' counterfactual does not rely on trade linkages and we obtain no sizable difference between closed and open economy simulations, except for a few small open countries. On the other hand, input-output linkages play an important role. Industries upstream of skill-intensive industries tend to be skill intensive themselves, but on average less so, such that there is less variation in skill intensities when intermediate goods are accounted for. Still, the correlation between skill intensity and income elasticity is similar with or without intermediates. Thus, while input-output linkages dampen the link between changes in consumption and changes in the skill premium, they by far do not eliminate it.

We then examine how preferences affect the relationship between trade liberalization and the skill premium by re-simulating the estimated 1995-2010 changes in trade costs (holding productivity fixed at 1995 levels). We highlight and quantify four channels through which non-homothetic preferences affect results. The first channel reflects how non-homothetic preferences affect predicted trade patterns and the strength of Stolper-Samuelson forces. The standard Stolper-Samuelson argument, which holds with homothetic preferences, suggests that in countries abundant in unskilled labor, the direct effect of trade cost reductions is a decrease in the relative demand for skilled workers, while the reverse is true for skill-abundant countries. Our results suggest that the introduction of non-homothetic preferences into the model substantially moderates this prediction. As documented in Caron et al. (2014), non-homothetic preferences lead to less trade between high- and low-income countries, and smaller net factor content of trade in skilled and unskilled labor. This weakens the Stolper-Samuelson effect, especially for developing countries for which the net factor content of trade is significantly lower under non-homotheticity.

A second channel highlights the income effect of trade. As trade costs decline, gains from trade make countries richer. Similar to the effect productivity growth, consumption thus shifts towards income-elastic and skill intensive goods. Simulations show that the trade-induced income effect is quantitatively significant in many developing countries. We also illustrate the role of input-output linkages (magnifying our results) and general-equilibrium feedbacks (mitigating our results), but we find that these last two channels only moderately affect the first two. Combined, these mechanisms suggest that non-homothetic preferences generate a higher skill premium for the same amount of trade liberalization in all but the richest countries. The difference is strong in developing countries, many of which see the negative effect of trade on the skill premium predicted under homotheticity disappear altogether.

Our simulated changes in the skill premium suggest that demand-driven mechanisms may have played a quantitatively important role in driving observed changes in relative wages – comparable in magnitude to other mechanisms discussed in the literature such as skill-biased technological change (Autor et al., 1998). These alternative mechanisms are likely to confound and interact with demand-side forces and are not captured in our model, so we cannot identify the relative importance of non-homothetic preferences. Still, a simple correlation exercise suggests that they might help explain patterns of historical growth in the skill premium across countries, especially for low-income countries where growth in both income and the skill premium has been strongest and where the demand effect is strongest. For 40 countries, we compare our simulated estimates to observed 1995 to 2010 changes in the skill premium described in the WIOD dataset (used, among others, in Cravino and Sotelo, 2018). We find that allowing for non-homothetic preferences significantly increases the correlation between simulated and observed changes in the skill premium. For several countries, the effect is remarkable. In China, for instance, the 17% simulated increase relative to the homothetic case can be contrasted with the 51% increase observed in the WIOD data. In rich countries the effect is smaller, but not negligible: the mechanism generates an increase in the skill premium that represents about 20% of the observed increase in the US over that period (using an estimate from Parro, 2013).

As noted at the onset, the literature on the skill premium is large. Since we are not attempting to run a horse race among competing explanations, our review of the literature is not exhaustive and omits numerous papers focusing on skill-biased technical change and standard Heckscher-Ohlin type trade mechanisms. These models and results are clearly empirically important, but for the sake of exposition we instead focus on work more related to our own, i.e. related to the demand side.

In the international trade literature, Markusen (2013) theoretically identified some of the potential consumption-driven impacts on the skill premium that we quantify. In a stylized model, he postulates that non-homothetic preferences and a possible correlation between income elasticity in consumption and skill intensity in production would cause neutral productivity growth to increase the relative wage of skilled workers. Caron, Fally and Markusen (2014) show that the correlation is empirically strong and illustrate the consequences for trade patterns, trade-to-GDP ratios, and the missing trade puzzle. Here, we examine and quantify the implications of this correlation for the skill premium.[8]

More generally, this paper is part of a renewed interest in non-homothetic preferences in open-economy settings in the trade literature. Fieler (2011), Simonovska (2015), Fajgelbaum and Khandelwal (2016) also incorporate non-homotheticities in consumption, adding to a literature initiated by Markusen (1986), Flam and Helpman (1987), Matsuyama (2000) among others. While related to our work in terms of non-homotheticity, these papers concentrate on issues other than the skill premium, such as explaining trade volumes and patterns, and markups in relation to per-capita incomes. Matsuyama (2019) pushes this literature further by endogenizing the relationship between non-homothetic preferences and differential productivity growth rates across sectors and patterns of specialization.

Conversely, work on trade and the skill premium has mostly focused on the supply side. A few papers have confirmed Stolper-Samuelson effects for developing countries (e.g. Robertson 2004 for Mexico, Gonzaga et al. 2006 for Brazil), which are often at odds with the increasing wage inequality that we observe in most countries (Goldberg and Pavcnik, 2007). Most of the recent literature on trade and the skill premium thus aims to explain why trade may lead to a larger increase (a more positive or less negative change) in the skill premium than suggested by the standard Heckscher-Ohlin model. Bustos (2011) proposes a mechanism whereby access to foreign markets triggers the adoption of skill-biased technologies and provides supportive evidence from Argentinian firm-level data. Burstein and Vogel (2017) also examine how the heterogeneous effect of trade across firms influences the relative demand for skilled labor, and show that this within-sector reallocation channel can be potentially much larger than standard Heckscher-Ohlin channels. Costinot and Vogel (2010) indicate that poor countries facing large demand for skill-intensive goods from rich countries might experience a positive effect of trade on the skill premium, but do not examine this claim empirically. Cravino and Sotelo (2018) show that a reduction in trade costs leads to a relative expansion of the service sector relative to the manufacturing sector when these sectors are strong complements. Since service activities are more intensive in skilled labor, this leads to a larger increase in the skill premium.

Non-homotheticity in consumption also plays an important role in the literature on trade and quality (e.g. Hallak, 2010, Feenstra and Romalis, 2014). If the production of higher-quality goods requires relatively more skilled labor, the idea developed here can be applied to link the skill premium to the demand for quality.[9] Opening to trade with richer countries, as well as increasing income per capita, should lead to increasing demand for higher-quality goods and an increase in the skill premium. The link between quality and skilled labor is present in the work of Fieler et al. (2018) who, without explicitly modeling final demand, examine the effect of trade liberalization in Colombia. They argue that opening to trade led to an increase in the demand for skilled workers due to the increase in the quality of goods being produced.

[8]A working paper version, Caron et al. (2012), included some of our results on the skill premium. The working paper had to be split in two and these results are not part of the published version, Caron et al. (2014).

[9]A very recent paper by Jaimovich et al. (2019) exploits that idea, focusing on quality upgrading.

Since our model and approach rely on shifts in the composition of demand across sectors, at least two papers that provide strong evidence for these shifts should be noted. In the literature examining the source and consequences of structural change, Buera and Kaboski (2012) discuss how productivity growth leads to an increase in the skill premium. They develop and calibrate a two-sector model in which growth leads to a higher share of services, which are more skill intensive. They do not, however, estimate or quantify the role of non-homothetic preferences, nor do they discuss the correlation between skill intensity and income elasticity beyond the two-sector approach. Our estimated income elasticities tend to be larger for services sectors, but the correlation between skill intensity and income elasticity holds even when we exclude services. Since it holds for traded goods, the correlation also has implications for the composition of trade and can help us explain why trade can have a positive effect on the skill premium in developing countries relative to standard models.

A second paper is Johnson and Keane (2013), who examine how sectoral shifts in consumption influence the demand for many different types of labor. In particular, they document the importance of demand shifts across occupations, such as the shift toward (heavily female) service occupations.[10] However, Johnson and Keane (2013) do not model or explain these sectoral demand shifts, a primary purpose of our paper.

Finally, a growing literature examines the differential effect of trade on the cost of living across workers and households within a country. This channel has been examined, among others, by Fajgelbaum and Kandelwahl (2016), Nigai (2016) and He and Zhang (2017).[11] For most countries, Fajgelbaum and Kandelwahl (2016) estimate that poor households gain relatively more from trade through cost-of-living effects, while Nigai (2016) tends to find the opposite. He and Zhang (2017) extend Fajgelbaum and Khandelwal (2016) to allow for worker sorting across multiple sectors, and show that the effect of trade on the cost of living can be quantitatively larger than the effects on nominal income. While we acknowledge that cost-of-living effects matter for welfare, we focus here on the channels through which trade (and growth) affects the skill premium in nominal terms.[12] Our approach is closer to the Heckscher-Ohlin tradition of multiple factors of production, so we can easily analyze skilled versus unskilled wages and distinguish sectors by factor intensities, which is exactly what we have in our data.

The rest of the paper is organized in three sections. We describe our theoretical framework in Section 2, our empirical strategy and estimation results in Section 3, and the quantitative implications for the skill premium in Section 4.

[10]Parenthetically, they document a number of other facts that cast doubt on the proposition that skill-biased technical change is the main culprit behind the skill premium.

[11]See also Porto (2006) for Argentina, Faber (2014), Cravino and Levchenko (2016) for Mexico, Faber and Fally (2017) for the US.

[12]Our approach allows us to generate predictions of the change in the relative wage of skilled vs. unskilled workers even if there is no available data on initial wages by skill category in most of the developing countries in our sample. Adjusting for cost-of-living effects would instead require data on initial wage differences between types of workers and the distribution within each type.

2 Theoretical framework

2.1 Benchmark Model set-up

The model closely follows Caron et al. (2014) with the same non-homothetic preferences but a more flexible production function in terms of skilled and unskilled workers.

Demand The economy is constituted of heterogeneous industries. In turn, each industry k is composed of a continuum of product varieties indexed by $j_k \in [0, 1]$. Preferences take the form:

$$U = \sum_k \alpha_{1,k} Q_k^{\frac{\sigma_k - 1}{\sigma_k}}$$

where $\alpha_{1,k}$ is a constant (for each industry k) and Q_k is a CES aggregate:

$$Q_k = \left(\int_{j_k=0}^{1} q(j_k)^{\frac{\xi_k - 1}{\xi_k}} dj_k \right)^{\frac{\xi_k}{\xi_k - 1}}$$

Preferences are identical across countries, but non-homothetic if σ_k varies across industries. If $\sigma_k = \sigma$, we are back to traditional homothetic CES preferences.[13]

The CES price index of goods from industry k in country n is $P_{nk} = \left(\int_0^1 p_{nk}(j_k)^{1-\xi_k} dj_k \right)^{\frac{1}{1-\xi_k}}$. Given this price index, individual expenditures ($P_{nk}Q_{nk}$) in country n for goods in industry k equal:

$$x_{nk} = \lambda_n^{-\sigma_k} \alpha_{2,k} (P_{nk})^{1-\sigma_k} \tag{1}$$

where λ_n is the Lagrange multiplier associated with the budget constraint of individuals in country n, and $\alpha_{2,k} = (\alpha_{1,k} \frac{\sigma_k - 1}{\sigma_k})^{\sigma_k}$. The income elasticity of demand η_{nk} for goods in industry k and country n equals:

$$\eta_{nk} \equiv \frac{\partial \log x_{nk}}{\partial \log e_n} = \sigma_k \cdot \frac{\sum_{k'} x_{nk'}}{\sum_{k'} \sigma_{k'} x_{nk'}} \tag{2}$$

(where e_n denotes per capita income) which implies that the ratio of the income elasticities of any pair of goods k and k' equals the ratio of their σ parameters: $\frac{\eta_{nk}}{\eta_{nk'}} = \frac{\sigma_k}{\sigma_{k'}}$ and is constant across countries. The income elasticity of any given sector, however, decreases as income increases (holding prices fixed).[14]

Production We assume a constant-returns-to-scale production function that depends on several factors and bundles of intermediate goods from each industry. We assume that factors of production are perfectly mobile across sectors but immobile across countries. We denote by γ_{kh} the share of the

[13]These preferences are used in Fieler (2011) and Ligon (2016), with early analyses and applications found in Hanoch (1975) and Chao and Manne (1982). To the best of our knowledge, there is no common name attached to these preferences, so we refer to them as constant relative income elasticity (CRIE) tastes.

[14]Note also that CRIE preferences (and separable preferences in general) preclude any inferior good: the income elasticity of demand is always positive for any good.

input bundles from industry h in total costs of industry k (direct input-output coefficient), and each input bundle is a CES aggregate of all varieties available in this industry (for the sake of exposition we assume that the elasticity of substitution between varieties is the same as for final goods). We denote by w_{if} the price of factor f in country i. Total factor productivity $Z_{ik}(j_k)$ varies by country, industry and variety. Labor inputs, comprised of unskilled or low-skill labor ($f = L$) and high-skilled labor ($f = H$), are combined into a CES aggregate with elasticity of substitution ρ.

As is common in the trade literature, we assume iceberg transport costs $d_{nik} \geq 1$ from country i to country n in sector k. The unit cost of supplying variety j_k to country n from country i equals:

$$p_{nik}(j_k) = \frac{d_{nik}}{Z_{ik}(j_k)} \, (c_{ikLab})^{\gamma_{kLab}} \prod_{f \notin Lab} (w_{if})^{\gamma_{kf}} \prod_{h} (P_{ih})^{\gamma_{kh}} \tag{3}$$

where P_{ih} is the price index of goods h in country i and $\sum_f \gamma_{kf} + \sum_h \gamma_{kh} = 1$ to ensure constant returns to scale in each industry k. The cost of labor c_{ikLab} is a CES aggregate of the wage of high-skilled and low-skilled workers:

$$c_{ikLab} = \left[\mu_{ikL} \, w_{iL}^{1-\rho} + \mu_{ikH} \, w_{iH}^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{4}$$

Parameters μ_{ikH} and μ_{ikL} capture the high and low-skilled-labor intensity of sector k in country i, and ρ the elasticity of substitution between types of labor.

There is perfect competition for the supply of each variety j_k. Hence, the price of variety j_k in country n in industry k equals:

$$p_{nk}(j_k) = \min_i \{ p_{nik}(j_k) \}$$

We follow Eaton and Kortum (2002) and assume that productivity $Z_{ik}(j_k)$ is a random variable with a Frechet distribution. This setting generates gravity within each sector. Productivity is independently drawn in each country i and industry k, with a cumulative distribution:

$$F_{ik}(z) = \exp\left[-(z/z_{ik})^{-\theta_k} \right]$$

where z_{ik} is a productivity shifter reflecting average TFP of country i in sector k. As in Eaton and Kortum (2002), θ_k is related to the inverse of productivity dispersion across varieties within each sector.[15] As in Costinot, Donaldson and Komunjer (2012), we also allow the shift parameter z_{ik} to vary across exporters and industries, keeping a flexible structure on the supply side and controlling for any pattern of Ricardian comparative advantage forces at the sector level.

Endowments Each country i is populated by a number L_i of individuals. The total supply of factor f is fixed in each country and denoted by V_{if}. Each person is endowed by V_{if}/L_i units of factor V_{if} implying no within-country income inequality.[16]

[15] Note that we also assume $\theta_k > \xi_k - 1$ for all k to ensure a well-defined CES price index for each industry.

[16] We show in Caron et al. (2014) that we obtain very similar preference estimates when account for the distribution of income across quintiles for a subset of countries.

2.2 Equilibrium

Equilibrium is defined by the following equations. On the demand side, total expenditures D_{nk} of country n in final goods k simply equals population L_n times individual expenditures as shown in (1). This gives:

$$D_{nk} = L_n(\lambda_n)^{-\sigma_k}\alpha_{2,k}(P_{nk})^{1-\sigma_k} \tag{5}$$

where λ_n is the Lagrange multiplier associated with the budget constraint:

$$L_n e_n = \sum_k D_{nk} \tag{6}$$

where e_n denotes per-capita income. Total demand X_{nk} for goods k in country n is the sum of the demand for final consumption D_{nk} and intermediate use:

$$X_{nk} = D_{nk} + \sum_h \gamma_{hk} Y_{nh} \tag{7}$$

where Y_{nh} refers to total production in sector h.

On the supply side, each industry mimics an Eaton and Kortum (2002) economy. In particular, given the Frechet distribution, we obtain a gravity equation for each industry. We follow Eaton and Kortum (2002) notation with the addition of industry subscripts. By denoting π_{nik} as import shares and X_{nik} as the value of trade *from* country i *to* country n, we obtain:

$$\pi_{nik} \equiv \frac{X_{nik}}{X_{nk}} = \frac{S_{ik}(d_{nik})^{-\theta_k}}{\Phi_{nk}} \tag{8}$$

where S_{ik} and Φ_{nk} are defined as follows. The "supplier effect", S_{ik}, is inversely related to the cost of production in country i and industry k. It depends on the factor productivity parameter z_{ik}, intermediate goods and factor prices:

$$S_{ik} = z_{ik}^{\theta_k}\,(c_{ikLab})^{-\theta_k\gamma_{kLab}} \prod_{f\notin Lab}(w_{if})^{-\theta_k\gamma_{kf}} \prod_h (P_{ih})^{-\theta_k\gamma_{kh}} \tag{9}$$

with the cost of labor $c_{ikLab} = \left[\mu_{ikL}\, w_{iL}^{1-\rho} + \mu_{ikH}\, w_{iH}^{1-\rho}\right]^{\frac{1}{1-\rho}}$ as in Equation (4).

In turn, we define Φ_{nk} as the sum of exporter fixed effects deflated by trade costs. Φ_{nk} plays the same role as the "inward multilateral trade resistance index" as in Anderson and van Wincoop (2003):

$$\Phi_{nk} = \sum_i S_{ik}(d_{nik})^{-\theta_k} \tag{10}$$

This Φ_{nk} is actually closely related to the price index, as in Eaton and Kortum (2002):

$$P_{nk} = \alpha_{3,k}(\Phi_{nk})^{-\frac{1}{\theta_k}} \tag{11}$$

with $\alpha_{3,k} = \left[\Gamma\left(\frac{\theta_k+1-\xi_k}{\theta_k}\right)\right]^{\frac{1}{\xi_k-1}}$ where Γ denotes the gamma function.[17]

Finally, two other market clearing conditions are required to determine factor prices and income in general equilibrium. Income for each factor equals the sum of total production weighted respectively by factor intensity. With factor supply V_{if} and factor price w_{if} for factor f in country i, market clearing for factors other than labor implies:

$$V_{if}w_{if} = \sum_k \gamma_{kf} Y_{ik} = \sum_{n,k} \gamma_{kf} X_{nik} \tag{12}$$

For each type of labor $l \in \{L, H\}$, factor intensity is given by:

$$\beta_{ikl} \ = \ \frac{\mu_{ikl}\, w_{il}^{1-\rho}}{\mu_{ikL}\, w_{iL}^{1-\rho} + \mu_{ikH}\, w_{iH}^{1-\rho}} \ = \ \mu_{kl}\, w_{il}^{1-\rho}\, c_{ikLab}^{\rho-1} \tag{13}$$

and labor market clearing imposes:

$$V_{il}w_{il} = \sum_k \beta_{ikl}\gamma_{kLab} Y_{ik} = \sum_{n,k} \beta_{ikl}\gamma_{kLab} X_{nik}. \tag{14}$$

In turn, per-capita income is determined by average income across all factors:

$$e_i = \frac{1}{L_i} \sum_f V_{if} w_{if} \tag{15}$$

By Walras' Law, trade is balanced at equilibrium.

2.3 Counterfactual equilibria

Following Dekle et al. (2007) and Caliendo and Parro (2014), the model lends itself naturally to counterfactual simulations in general equilibrium. By reformulating the above equilibrium conditions in terms of changes relative to the baseline observed equilibrium, counterfactuals can be obtained using a set of observed variables and only a few parameters to estimate. We do so with the help of hat notation, where $\widehat{Z} = Z'/Z$ denotes the relative change for variable Z (Z' referring to the value in the new equilibrium).

In our counterfactual simulations, we will examine the impact of the changes in productivity $\widehat{z_{ik}} = \frac{z'_{ik}}{z_{ik}}$ that explain recent changes in GDP per capita. Jointly or separately, we will also simulate changes in trade costs $\widehat{d_{nik}} = \frac{d'_{nik}}{d_{nik}}$ in order to match changes in openness to trade.

The model yields the following set of equilibrium conditions:

$$\widehat{D_{nk}} \ = \ \widehat{\lambda_n}^{-\sigma_k}\, \widehat{P_{nk}}^{1-\sigma_k} \tag{16}$$

[17] Alternatively, we can generalize this model and assume that the elasticity of substitution for intermediate use differs from the elasticity of substitution for final use, and depends on the parent industry. This does not affect the elasticity of the price index w.r.t. Φ_k. Differences in elasticities of substitution would be captured by the industry fixed effect that we include in our estimation strategy and would not affect our estimates.

$$\widehat{e_n} = \frac{\sum_k \widehat{D_{nk}}\, D_{nk}}{\sum_k D_{nk}} \tag{17}$$

$$\widehat{X_{nk}} = \frac{1}{X_{nk}}\left[D_{nk}\widehat{D_{nk}} + \sum_h \gamma_{hk} Y_{nh}\widehat{Y_{nh}}\right] \tag{18}$$

$$\widehat{X_{nik}} = \widehat{S_{ik}}\, \widehat{d_{nik}}^{\,-\theta_k}\, \widehat{P_{nk}}^{\,\theta_k}\, \widehat{X_{nk}} \tag{19}$$

$$\widehat{Y_{ik}} = \frac{\sum_n X_{nik}\widehat{X_{nik}}}{\sum_n X_{nik}} \tag{20}$$

$$\widehat{S_{ik}} = \widehat{z_{ik}}^{\,\theta_k}\, (\widehat{c_{ikLab}})^{-\theta_k\gamma_{kL}} \prod_{f\neq L} (\widehat{w_{if}})^{-\theta_k\gamma_{kf}} \prod_h (\widehat{P_{ih}})^{-\theta_k\gamma_{kh}} \tag{21}$$

$$\widehat{P_{nk}} = \left[\frac{1}{X_{nk}}\sum_i X_{nik}\widehat{S_{ik}}\, \widehat{d_{nik}}^{\,-\theta_k}\right]^{-\frac{1}{\theta_k}} \tag{22}$$

$$\widehat{c_{ikLab}} = \left[\beta_{ikL}\, \widehat{w_{iL}}^{\,1-\rho} + \beta_{ikH}\, \widehat{w_{iH}}^{\,1-\rho}\right]^{\frac{1}{1-\rho}} \tag{23}$$

$$\widehat{w_{if}} = \left[\sum_k sh_{ikf}\, \widehat{c_{ikLab}}^{\,\rho-1}\widehat{Y_{ik}}\right]^{\frac{1}{\rho}} \qquad \text{for } f \in \{L, H\} \tag{24}$$

$$\widehat{w_{if}} = \sum_k sh_{ikf}\, \widehat{Y_{ik}} \qquad \text{for } f \notin \{L, H\} \tag{25}$$

$$\widehat{e_i} = \frac{\sum_f V_{if} w_{if}\widehat{w_{if}}}{\sum_f V_{if} w_{if}} \tag{26}$$

where, in Equations (24) and (25), $sh_{ikf} = \frac{\beta_{ikf} Y_{ik}}{\sum_{k'} \beta_{ik'f} Y_{ik'}}$ is the share of sector k in the total returns to factor f, and β_{ikf} is factor intensity described in Equation (13) for labor and equal to γ_{kf} for other factors.

Knowing the values of variables D_{nk}, e_n, X_{nk}, X_{nik} and $V_{if} w_{if}$ in the baseline equilibrium as well as parameters σ_k, θ_k, γ_{kh} and β_{ikf}, we can solve for all changes $\widehat{D_{nk}}$, $\widehat{\lambda_n}$, $\widehat{e_n}$, $\widehat{P_{nk}}$, $\widehat{S_{nk}}$ and $\widehat{w_{nf}}$ driven by given changes in productivity $\widehat{z_{ik}}$ and/or trade costs $\widehat{d_{nik}}$.[18]

2.4 Implications for the skill premium

In this section, we illustrate how productivity growth and trade can affect the relative returns to factors if demand is non-homothetic and there is a systematic relationship between preference parameters and factor intensities.

2.4.1 Productivity growth and the skill premium

When skill intensity and income elasticity are correlated across industries, productivity (TFP) growth has a positive effect on the skill premium through the composition of consumption. The intuition is

[18] We solve this system in three iterative steps. In a first step, taking income and factor prices as given, we use Equations (21), (22) and (23) to solve for prices. Then, in a second step, given the change in prices from step 1, we use Equations (16) to (20) to solve for demand, trade and production. In a third step, we adjust for changes in factor prices and income using (24) to (26). We iterate these three steps until convergence is achieved.

simple. As productivity increases, people become richer and consume more goods from income-elastic industries which are, as we show, more intensive in skilled labor.[19] This increases the demand for skilled labor relative to less skilled labor and increases the relative wage of skilled workers. On the contrary, with homothetic preferences, uniform productivity growth is neutral for the skill premium.

To develop intuition, we derive first-order approximations of the response of the skill premium to changes in productivity, assuming uniform growth in all countries and all sectors. In the quantitative section, we will show how these approximations compare with estimates of changes in the skill premium obtained from general equilibrium simulations. The complete derivation of these approximations can be found in Appendix B.

Autarky without intermediate goods If countries are in autarky and intermediate goods are ignored, all changes in production can be traced back to changes in domestic consumer demand. Holding nominal GDP constant (normalization), a homogeneous productivity increase $\widehat{z}$ leads, as a first approximation, to a homogeneous change in prices $\widehat{P_{nk}} \approx \widehat{z}^{-1}$. Using Equations (16) and (26), we obtain that the changes in demand, and therefore production, in country n and sector k are simply given by the income elasticity η_{nk}: $\log \widehat{D_{nk}} \approx (\eta_{nk} - 1) \log \widehat{z}$. We can then obtain a simple expression for the elasticity of the skill premium, $\frac{w_{nH}}{w_{nL}}$, to a TFP increase $\widehat{z}$:

$$\log \left(\widehat{\frac{w_{nH}}{w_{nL}}} \right) \approx \frac{1}{\tilde{\rho}_n} \log \widehat{z} \sum_k (sh_{nk}^H - sh_{nk}^L) \, \eta_{nk} \tag{27}$$

where $sh_{nk}^H \equiv \frac{\beta_{nkH} Y_{nk}}{\sum_{k'} \beta_{nkH'} Y_{nk'}}$ is the share of sector k in the total skill labor employment in country n (and sh_{nk}^L refers to the share of unskilled workers in sector k), and η_{nk} is the income elasticity in sector k, country n. In this expression, the effect on the skill premium is deflated by an adjusted elasticity of substitution between labor types $\tilde{\rho}_i = \rho - (\rho - 1) \sum_k (sh_{ik}^H - sh_{ik}^L) \beta_{ikH}$, which is very close to ρ for most countries (and always smaller than ρ given the positive correlation between skill intensity and income elasticity).

We can see that this term is positive if income elasticity η_{nk} is correlated with the demand for high vs. low-skilled labor (the term in $sh_{nk}^H - sh_{nk}^L$) across sectors. In that case, growth in TFP generates an increase in the skill premium.

This first-order approximation neglects the feedback effect of the changes in the skill premium on relative prices across products. When the skill premium increases, the relative price of skill-intensive goods increases, decreasing the relative demand for these goods and thus the relative demand for skilled workers. Our general equilibrium simulations indicate that this feedback effect is small and can be neglected in a first-order approximation. This equation provides a good approximation of the skill premium increase even if labor is not the only factor of production—we also consider capital, land and other natural resources in our simulations to confirm this. Finally, let us also point out that this relationship would hold with income elasticities derived from any other type of preferences as a

[19] This assumes that the evolution of income is not driven by an accumulation of skills, which could of course mitigate the increase in the skill premium.

first-order approximation: the structure imposed on the model only matters for large changes and for the estimation of income elasticities.

Input-output linkages and trade can also affect the relationship between income elasticity and the demand for skills, and can be approximated as described just below.

With trade in final and intermediate goods: Under the assumption that the productivity increase $\widehat{z}$ augments all factors of production in all countries,[20] the change in price $\widehat{P_{nk}}$ still corresponds to $\widehat{z}^{-1}$ when we neglect the feedback effect of wages on prices.[21] Similarly, we obtain that $\widehat{S_{ik}} \approx \widehat{z}^{\theta_k}$ for each exporter i in industry k, which implies that trade shares $\pi_{nik} = \frac{X_{nik}}{X_{nk}}$ remain constant. Combining Equations (18), (19) and (20), we can now account for trade and international production chains. The changes in production and demand satisfy:

$$Y_{ik}\widehat{Y_{ik}} \ = \ \sum_n \pi_{nik} D_{nk} \widehat{D_{nk}} + \sum_h \sum_n \pi_{nik} \ \gamma_{hk} Y_{nh} \ \widehat{Y_{nh}} \tag{28}$$

Coefficients $\pi_{nik}\gamma_{hk}$ (direct requirement coefficients) reflect the value of inputs from industry k and country i required for the production of one unit of output in sector h and country n. The matrix containing these coefficients is a standard modeling tool to account for input-output linkages (Miller and Blair, 2009; Johnson, 2014). If we denote this matrix by G, the coefficients of the matrix $(I-G)^{-1}$, also called Leontief total requirement coefficients, can then be used to link changes in output to changes in final demand (see appendix for additional details):

$$\widehat{Y_{ik}} \ = \ \frac{1}{Y_{ik}} \sum_{n,h} \gamma_{nihk}^{tot} D_{nh} \widehat{D_{nh}} \tag{29}$$

where γ_{nihk}^{tot} is the value of inputs from i in sector k needed for each dollar of final good h consumed in country n. Using this result and $Y_{ik} = \sum_{n,h} \gamma_{nihk}^{tot} D_{nh}$, we can then express the difference in the changes in wages between skilled and unskilled workers as a function of the changes in final demand, and therefore as a function of income elasticities in downstream sectors, following the same first-order approximation as above:

$$\begin{aligned} \log \left(\widehat{\frac{w_{iH}}{w_{iL}}} \right) \ &\approx \ \frac{1}{\tilde{\rho}_i} \sum_{k,h,n} (sh_{ik}^H - sh_{ik}^L) \, \frac{\gamma_{nihk}^{tot} D_{nh}}{Y_{ik}} \ \log \widehat{D_{nh}} \\ &\approx \ \frac{1}{\tilde{\rho}_i} \log \widehat{z} \sum_{k,h,n} (sh_{ik}^H - sh_{ik}^L) \, \frac{\gamma_{nihk}^{tot} D_{nh}}{Y_{ik}} \ \eta_{nh} \end{aligned} \tag{30}$$

This generalizes Equation (27) to account for international trade and intermediate goods: a country's skill premium will increase if a sector's demand for high vs. low-skilled labor (the term in $sh_{nk}^H - sh_{nk}^L$) is correlated with the average income elasticity of all its downstream sectors, in all countries.

[20]Note that in our simulations, we will allow for productivity increase to vary across countries.

[21]Holding world nominal GDP constant as our normalization.

2.4.2 Trade cost reductions and the skill premium with non-homothetic preferences

How does a reduction in trade costs affect the skill premium? Standard models of trade such as the Heckscher-Ohlin model have focused on the supply side and ignored any role for the demand side in explaining the changes in the skill premium. Here we discuss how the structure of preferences may affect these results relative to a similar structure where we impose homothetic preferences.

In a similar fashion as above for productivity and the skill premium, we can provide a first-order approximation of the effect of trade cost reductions $\hat{d}$ on the skill premium (additional details are provided in the appendix) by neglecting second-order terms in $(\log \hat{d})^2$. The decomposition isolates the direct effect of changes in trade costs and the direct effect of changing consumption patterns from the remaining general equilibrium effects. Combining Equations (25) for factor prices, (20) for production and (19) for bilateral trade, we obtain:

$$\log\left(\widehat{\frac{w_{iH}}{w_{iL}}}\right) \approx -\frac{1}{\tilde{\rho}_i}\sum_k (sh_{ik}^H - sh_{ik}^L)\underbrace{\theta_k \frac{NX_{ik}}{Y_{ik}}\log \hat{d}}_{\text{Direct effects}} \tag{31}$$

$$+\frac{1}{\tilde{\rho}_i}\sum_k (sh_{ik}^H - sh_{ik}^L)\underbrace{\left[\sum_n \frac{\pi_{nik}D_{nk}}{Y_{ik}}\log\left(\widehat{\lambda_n}^{-\sigma_k}\widehat{P_{nk}}^{1-\sigma_k}\right)\right]}_{\text{Effects on final demand}} \tag{32}$$

$$+\frac{1}{\tilde{\rho}_i}\sum_k (sh_{ik}^H - sh_{ik}^L)\underbrace{\left[\sum_{n,h} \frac{\pi_{nik}\gamma_{hk}Y_{nh}}{Y_{ik}}\log\widehat{Y_{nh}}\right]}_{\text{IO linkage effects}} \tag{33}$$

$$+\frac{1}{\tilde{\rho}_i}\sum_k (sh_{ik}^H - sh_{ik}^L)\underbrace{\left[\sum_n \frac{X_{nk}\pi_{nik}}{Y_{ik}}\log(\widehat{S_{ik}}\widehat{P_{nk}}^{\theta_k}) - \sum_j \frac{X_{ik}\pi_{ijk}}{Y_{ik}}\log(\widehat{S_{jk}}\widehat{P_{ik}}^{\theta_k})\right]}_{\text{Effects on multilateral resistance}} \tag{34}$$

where NX_{ik} denotes net exports in sector k from country i, and where we recall that π_{nik} denotes the share of demand in country n in sector k that is imported from country i. In these expressions, X_{ik} and Y_{ik} are fitted expenditures and production that are constructed based on consumption patterns derived from either homothetic or non-homothetic preferences.

The decomposition described by Equations (31) through (34) can be used to illustrate several mechanisms through which consumption patterns and trade costs affect the demand for skills. The first term captures the direct incidence of trade costs on production, ignoring changes in consumption patterns and other general-equilibrium effects, while the remaining terms capture indirect effects. The second term captures the effect of changes in the composition of final demand caused by changes in income and prices. The third term captures the effect of changes in intermediate demand through input-output linkages. The fourth term captures changes in multilateral-resistance terms, e.g. adjustment in factor costs (in origin countries) and competition (in destination countries). As we will show, the quantification of all of these terms depends on preferences being homothetic or non-homothetic.

The first term, which we could call the Stolper-Samuelson effect, reflects the most direct effect of trade costs on production, and depends crucially on net export NX_{ik} relative to production. In particular, it reveals that trade cost reductions will lead to a larger increase in the skill premium in countries in which the sectors that employ the largest shares of skilled workers (with high $sh^H_{ik} - sh^L_{ik}$) have the highest net export ratios NX_{ik}/Y_{ik}. As we will illustrate, net export ratios, which depend on fitted export shares, depend not only on the supply side (comparative advantage) but also differ substantially across specifications on the demand side. With non-homothetic preferences, poor countries consume relatively less skill-intensive and income-elastic goods than other countries, and thus have higher net exports for these goods. Conversely, they have relatively lower net exports in income-inelastic and less skill-intensive goods. A consequence is that a reduction in trade leads to proportionally larger increases in the production of skill-intensive goods relative to the homothetic case in poor countries. In rich countries, the opposite should hold.

In the case where the trade elasticity $\theta_k = \theta$ is homogeneous across sectors, one can further rewrite the direct effect as a function of the net factor content in unskilled vs. skilled workers. The first term becomes:

$$\text{Direct effects } \approx -\frac{\theta}{\tilde{\rho}_i}\left(\frac{NCT_i^H}{V_{iH}} - \frac{NCT_i^L}{V_{iL}}\right)\log \hat{d} \tag{35}$$

where $\frac{NCT_i^f}{V_{if}}$ denotes the net factor content of trade of country i in factor $f \in \{H, L\}$ (skilled or unskilled labor) relative to its factor supply. As shown in Caron et al. (2014), non-homothetic preferences lead to a smaller content of trade in skilled labor for high-income countries and a smaller content of trade in unskilled labor in low-income countries. This implies that the Stolper-Samuelson effect is weaker.

Another direct impact of trade cost reductions on the skill premium can potentially stem from differences in tradability and trade elasticities across sectors. If skill-intensive sectors have higher elasticity of trade to trade costs θ_k or higher export shares, they would expand relatively more after a reduction in trade costs, and the demand for skills would increase with trade openness. Hence, we will later examine whether trade shares $1 - \pi_{iik}$ or θ_k are correlated with skill intensity and income elasticities (Section 3.4).

The remaining channels in the decomposition relate to different ways in which the model's endogenous variables react to the reduction in trade costs. The second channel identifies the role of trade-induced income and price effects in final demand described in (32), leading to changes in consumption patterns across industries. We use it to identify the role of changes in real income. As a country and its neighbors open to trade, their income increases, λ_n decreases, and consumption shifts towards income-elastic and skill-intensive goods. This mechanism is the same as was highlighted in the previous section on the effect of productivity growth. While price effects remain present under homothetic preferences, income effects disappear.

The third term in (33) captures the relationship between the skill premium and changes in the demand for intermediate goods. Skill-intensive sectors tend to require inputs that are skill-intensive as well (albeit less so, on average), so differences in demand patterns caused by non-homothetic preferences can potentially magnify both the direct effect and the final demand effect through input-output linkages.[22]

Finally, the fourth "multilateral-resistance" term (34) reflects changes in the supplier term S_{jk} (outward multilateral resistance index) and buyer term $P_{jk}^{\theta_k}$ (inward multilateral resistance index), and captures general-equilibrium feedback on wages and other prices (Anderson and van Wincoop, 2003). This feedback effect generally dampens the effect of trade. For instance, a higher skill premium leads to relatively higher costs in skill-intensive industries, as well as lower exports in these industries, which mitigate the skill premium increase.

3 Estimation

We now discuss the data and the estimation of the key parameters in the model. The estimation here closely follows Caron, Fally and Markusen (2014), although with different datasets and a number of additional robustness checks.

3.1 Data

Our empirical analysis is mostly based on Global Trade Analysis Project (GTAP) data. Unless otherwise indicated, model estimation and simulations rely on version 5 (GTAP 5) of the dataset (Dimaranan and McDougall, 2002), which describes 1997 data[23]. As noted earlier, we also test the robustness of our results by re-estimating all parameters using version 8 of the dataset (Narayanan et al., 2012), which is based on 2007.[24]

Both versions of the dataset contain consistent and harmonized production, consumption, endowment, trade and input-output tables for 57 sectors of the economy,[25] 5 production factors, and 66 countries (109 countries in version 8). The set of sectors covers both manufacturing and services and the set of countries covers a wide range of per-capita income levels. Demand systems are estimated over all available countries using final demand values based on the aggregation of private and public expenditures in each sector.

The GTAP dataset provides country-specific input requirement coefficients, including intermediate demand and demand for capital, high- and low-skilled labor, land and other natural resources. To limit cross-country variations in results, we use average input shares to calibrate our benchmark simulation

[22]Note that we assume Cobb-Douglas production functions, which implies constant input-output requirement coefficients. Additional effects on the skill premium can be obtained by assuming strong complementarity between manufacturing goods and services, as described in Cravino and Sotelo (2018).

[23]This is the earliest version of the dataset that includes a disaggregation of skilled and unskilled labor.

[24]The latest available iteration of GTAP data (version 9, 2011 data) includes a different (redefined) disaggregation of labor types, making it difficult to map onto skilled and unskilled labor to directly compare with previous datasets.

[25]Some sectors in GTAP are used primarily as intermediates and correspond to extremely low consumption shares of final demand. Six sectors for which less than 10% of output goes to final demand (coal, oil, gas, ferrous metals, metals n.e.c. and minerals n.e.c.) are assumed to be used exclusively as intermediates and are dropped from the final demand estimations. We also drop "dwellings" from our analysis, as this sector is associated with no trade and large measurement errors in consumption and factor intensities.

model (average weighted by each country's share of global factor demand), but our results are similar (slightly stronger) when we use country-specific input shares (see Section 4.6).

In addition to the GTAP trade data, estimating the gravity equations requires a set of bilateral variables describing physical distance, common language, access to sea, colonial link and contiguity, which we obtained from CEPII (www.cepii.fr).[26] Dummies for regional trade agreement and common currency are from de Sousa (2012).

Among other model parameters, all but one will be estimated. The elasticity of substitution between skilled and unskilled labor, ρ, is instead calibrated at a value of 1.4, as estimated by Katz and Murphy (1994). We discuss the role of this parameter and robustness of results in Section 4.6.

Finally, Section 4.5 compares our simulation results with observed changes in the skill premium. While a number of data sources and papers provide scattered estimates of these changes, a systematic comparison requires a harmonized dataset of skilled and unskilled wages across time and countries. We use the WIOD dataset (see Timmer et al., 2015 and Timmer et al., 2016), which, to our knowledge, provides the longest and widest consistent panel for this purpose. It comprises 40 countries, all of which are also in the GTAP5 dataset, allowing for an easy match with our simulated results.[27] These data have been used, for instance, by Costinot and Rodríguez-Clare (2014) and Cravino and Sotelo (2018).

3.2 Estimation strategy

The value of final demand in an industry is determined as in Equation (5) or equivalently Equation (1) for individual expenditures $x_{nk} = \frac{D_{nk}}{L_n}$. In log, the model provides:

$$\log x_{nk} = -\sigma_k . \log \lambda_n + \log \alpha_{2,k} + (1 - \sigma_k) . \log P_{nk} \tag{36}$$

where $\alpha_{2,k}$ is a preference parameter which varies across industries only. In addition, final demand should satisfy the budget constraint determining the Lagrange multiplier λ_n: a higher income per capita is associated with a smaller λ_n.

If there were no trade costs, the price index P_{nk} would be the same across countries and could not be distinguished from an industry fixed effect. If, in richer countries, consumption were larger in a particular sector relative to other sectors, the estimated $\hat{\sigma}_k$ would be larger for this sector. Since trade is not costless, estimated income elasticities would be biased if we did not control for the price index P_{nk} (to capture supply-side characteristics). As richer countries have a comparative advantage in skill-intensive industries, the price index is relatively lower in these industries. Conversely, poor countries have a comparative advantage in unskilled-labor-intensive industries and thus have a lower

[26] Distance between two countries is measured as the average distance between the 25 largest cities in each country weighted by population. Similarly, internal distance within a country is measured as the weighted average of distance across each combination of city pairs. See Mayer and Zignago (2011).

[27] Note that the GTAP5 dataset provides labor shares for skilled vs unskilled workers in terms of the total wage bill but does not provide average wages. WIOD provides disaggregated skilled and unskilled average labor wages up to 2009. Note also that WIOD provides three levels of skills. We aggregate medium and high-skill together in order to better match the definition of skilled labor in GTAP.

price index in these industries relative to other industries. When the elasticity of substitution between industries is larger than one, these differences in price indices affect the patterns of consumption. If we were not controlling for P_{nk}, we would overestimate the income elasticity in skill-intensive sectors.

We thus proceed in two steps. The main goal of the first step is to obtain a proxy for the price index $\log P_{nk}$. According to equilibrium condition (11), $\log P_{nk}$ depends linearly on $\log \Phi_{nk}$ which itself can be identified using gravity equations. Gravity equations by sector are derived from Equation (8). Specifying trade costs $\log d_{nik}$ as a linear combination of trade proxies, we obtain our first-step estimation equation:

$$X_{nik} = \exp\left[FX_{ik} + FM_{nk} - \sum_{var} \beta_{var,k} TC_{var,ni} - \beta_{border,ik}\delta_{n\neq i} + \varepsilon^G_{nik}\right] \tag{37}$$

where the set of variables $TC_{var,ni}$ refers to trade costs proxies: log physical distance between countries n and i, dummies for common language, colonial links, contiguity (equal to one if countries i and n share a common border), free-trade agreements, common currency and common legal origin (additional details are provided in appendix). Following Waugh (2010), we also include a dummy $\delta_{n\neq i}$ for international transactions allowing for an exporter-specific border effect denoted by $\beta_{border,ik}$.

Following the model structure and using our estimates, we can then construct:

$$\widehat{\Phi}_{nk} = \sum_i \exp\left(\widehat{FX}_{ik} - \sum_{var} \widehat{\beta}_{var,k} TC_{var,ni} - \widehat{\beta}_{border,ik}\delta_{n\neq i}\right) \tag{38}$$

Notice that, if country n is close to an exporter that has a comparative advantage in industry k, i.e. an exporter associated with a large exporter fixed effect FX_{ik} (large S_{ik}), our constructed $\widehat{\Phi}_{nk}$ will be relatively larger for this country, reflecting a lower price index of goods from industry k in country n.

In a second step, we estimate the final demand Equation (36) using $\widehat{\Phi}_{nk}$, which is rewritten as:

$$\log x_{nk} = -\sigma_k . \log \lambda_n + \alpha_{3,k} + \frac{(\sigma_k - 1)}{\theta_k} \log \widehat{\Phi}_{nk} + \varepsilon^D_{nk} \tag{39}$$

where $\alpha_{3,k}$ is an industry fixed effect and λ_n is the Lagrange multiplier associated with the budget constraint which must hold, i.e. such that $\sum_k x_{nk} = e_n$ (using observed per capita income e_n). While the coefficient for $\log \widehat{\Phi}_{nk}$ helps identify the ratio $\frac{(\sigma_k-1)}{\theta_k}$, the level of each term is not identified. We therefore allow θ_k to vary across sectors but we impose its average to equal 4, a standard calibration value in the trade literature (Simonovska and Waugh, 2014).[28] We estimate Equation (39) by constrained non-linear least squares.

[28] In our estimation, the coefficients for $\log \widehat{\Phi}_{nk}$ equal 0.4 on average. This implies that σ_k lies around 2 for most sectors. Note that the level of sigmas does not affect the computation of income elasticities, as described in Equation (40). Note that while CRIE preferences imply an explicit link between price and income elasticities, in Section 4.6 we examine the robustness of our results by using Comin et al. (2015) preferences, which results in an estimated elasticity of substitution of 0.76 across sectors.

Using our estimates of σ_k, income elasticities can then be retrieved as:

$$\widehat{\eta}_{nk} = \hat{\sigma}_k \cdot \frac{\sum_{k'} \hat{x}_{nk'}}{\sum_{k'} \hat{\sigma}_{k'} \hat{x}_{nk'}} \tag{40}$$

given that the weighted average of income elasticities must equal one (Engel aggregation).

We provide more detail regarding the estimation procedure in the appendix, along with alternative specifications to examine the robustness of our estimates. The first alternative specification disregards the budget constraint in our estimation, i.e. estimates Equation (39) without imposing the sum of fitted expenditures to equal the sum of actual expenditures. The second instruments $\log \widehat{\Phi}_{nk}$ by an alternative measure based only on foreign markets, i.e.: $\widehat{\Phi}^{IV}_{nk} = \sum_{i \neq n} \exp\left(\widehat{FX}_{ik} - \sum_{var} \widehat{\beta}_{var,k} TC_{var,ni} - \widehat{\beta}_{border,ik}\right)$ summing across $i \neq n$. This leaves out each country's own exporter fixed effect $\widehat{FX}_{nk}$, which may be endogenously related to final expenditures x_{nk}. The third alternative specification estimates income elasticity in reduced form, approximating the log of the Lagrange multiplier by a linear function of the log of income per capita: $\log \lambda_n \approx -\nu \log e_n$. This approach only allows us to identify $\widehat{\sigma_k \nu}$ up to a constant term ν, but one can see that this constant drops out of Equation (40): the implied income elasticities estimates are scale invariant. Finally, we have also re-estimated (39) by calibrating $\theta_k = 4$ across all sectors, thereby imposing an additional constraint on the coefficient of $\log \widehat{\Phi}_{nk}$ in Equation (39).

3.3 Parameter estimates

Gravity Parameters estimated from Equation 37 are in line with the gravity literature and described in Appendix C (Table A.1 presents summary statistics). Coefficients on distance and the other bilateral of trade determinants are of the expected sign and magnitude and significant in most industries. The estimates imply an important role for geography in explaining relative prices. Proximity to countries with a comparative advantage in certain industries leads to significantly lower relative prices in these industries. These effects are captured in the $\widehat{\Phi}_{nk}$ terms, which vary greatly across countries and sectors.[29]

Preferences Table 1 describes our income elasticity estimates by sector (evaluated at mean income), as well as differences in skill intensity across sectors. Estimates range from nearly zero for cereal and grains to 1.412 for insurance, with a clear dominance of agricultural sectors at the low end and service sectors at the high end. Half of the estimates are significantly different from unity (P-value < 0.05), with standard errors between 0.05 and 0.2 for most sectors.[30] We confirm the results from Caron, Fally and Markusen (2014): non-homotheticity is economically and statistically significant. It reduces by 24.2% the variance left unexplained with a homothetic preference specification with $\sigma_k = \sigma$, and the F-stats associated with imposing common σ_k's across industries clearly reject homotheticity (F-stat

[29] The standard deviation of demeaned $\log \widehat{\Phi}_{nk}$ is 1.22, taking the residual of a regression of $\log \widehat{\Phi}_{nk}$ on country and sector fixed effects.

[30] Two sectors have standard deviations between 0.2 and 0.3: gas and wheat.

equal to 11.74, all P-values < 0.001).[31]

We also examine several alternative specifications, all described in detail in Appendix D and illustrated in Figure A.1. We find our benchmark estimates to be robust to: removing the budget constraint as a constraint in our estimation (given the large variations in per capita income, introducing error terms in the budget constraint does not affect results); estimating demand in reduced-form, approximating $\log \lambda_n$ by a linear function of (log) per capita income (in our benchmark specification, Lagrange multipliers and per capita income are highly correlated); imposing $\theta_k = 4$ in all sectors, instead of treating it as parameter to be estimated. We also address potential endogeneity in $\log \widehat{\Phi}_{nk}$, instrumenting by an alternative measure based only on foreign markets, taking the sum of exporter fixed effects across all other countries but excluding its own market (Appendix Figure A.2).

Aside from these alternative estimations of Constant Relative Income Elasticities (CRIE) preferences, we have also estimated preferences as in Comin, Lashkari and Mestieri (2017), which impose a common price elasticity σ across sectors while allowing for different income elasticities of demand. Again, income elasticity estimates remain similar (see Figure A.3 in appendix). We also refer to Caron et al. (2014) for a comparison between CRIE, LES (Stone Geary) and AIDS (Deaton and Muellbauer, 1980) preferences. While LES yields much smaller differences in income elasticities across sectors, estimates based on AIDS are fairly similar to CRIE (the rank correlation is higher than 85% between any two of these specifications).

3.4 Empirical regularities

Correlation between income elasticity and skill intensity across sectors As discussed in the theory section, this correlation plays a crucial role in determining the impact of productivity growth and trade on the relative demand for skilled labor. The correlation is illustrated in Figure 1, with additional regression statistics reported in Appendix Table A.4.

Our measures of skill intensity correspond to the ratio of skilled labor to total labor input, excluding ('direct') or including ('total') labor required to produce intermediate inputs to each final good. As in Caron, Fally and Markusen (2014), we find a strong and significant correlation between income elasticity and 'direct' skill intensity of 77.9 % (p-value < 0.001). Tracking input-output linkages to compute 'total' skill intensity coefficients, which include 'indirect' factor usage, yields a similarly large correlation with income elasticity of 77.3%. This is consistent with the fact that skill-intensive final products tend to rely on intermediate goods that are skilled-labor intensive themselves, as also documented in Voigtländer (2014). However, the figure also reveals slightly less cross-sector variation in total skill intensity than in direct skill intensity (standard deviation of 0.13 instead of 0.17): intermediates upstream of skill-intensive sectors are indeed more skill-intensive than the average sector, but they tend to be relatively less skill-intensive than their downstream counterparts. This will explain why intermediate good linkages dampen the link between consumption patterns and factor demand.

Part of the large correlation between income elasticity and total skill intensity is explained by the

[31] The Akaike (AIC) and Bayesian (BIC) information criteria also favor the specification allowing for non-homotheticity.

composition of consumption into services vs. manufacturing industries, with services being generally associated with a larger income elasticity. However, the correlation remains high (72.3%) even after excluding service industries. The correlation also remains large and highly significant once we control for capital and natural resource intensity (see Appendix Table A.4). Finally, the correlation remains above 50% when using alternative specifications for the estimation of CRIE preferences (imposing $\theta_k = 4$, instrumenting $\log \Phi_{nk}$, using a reduced-form approximation, etc.) as well as when using alternative preferences such as AIDS, LES or implicitly-additive preferences as in Comin et al. (2017).

Correlation between income elasticity and other factor intensities It is interesting to note that capital intensity is positively correlated with income elasticity, as found by Reimer and Hertel (2010), but this correlation is much weaker than with skill intensity (less than 10% in most specifications) and not robust to controlling for skill intensity (see columns (2) and (4) of Table A.4). In our framework, this implies that growth should not greatly affect the returns to capital relative to wages. However, income elasticity tends to be negatively correlated with intensity in natural resources (including land), which supports the Prebisch-Singer hypothesis and implies that a growth in income per capita would lower the relative price of natural resources.

Correlation with trade shares Another potential determinant of the incidence of trade costs on the skill premium is the correlation between trade shares and skill intensity across sectors. A decrease in trade costs leads to an decrease in the relative price of traded products, and therefore a change in the relative employment share of sectors, depending on the elasticity of substitution among sectors. Here we examine the cross-sectoral correlations between skill intensity and average export shares $(1 - X_{iik}/Y_{ik})$ (averaged across countries).

Burstein and Vogel (2017) document that skill-intensive sectors tend to be more traded, but do not consider service sectors. In our data, we find that the correlation depends crucially on the inclusion of service sectors. If ignored, the correlation is positive at +30%. Once we include services, however, the correlation is considerably reduced, weakly negative (-6%) and no longer significantly different from zero (see Appendix Figure A.7).

Similar patterns are observed for the correlation between average trade shares and income elasticities. Looking across all sectors, the correlation is positive but not significant (15% correlation). When we exclude services, it jumps to 35%.

4 Quantitative implications for the skill premium

As argued in Section 2.4, non-homothetic preferences may help explain why the skill premium has been increasing for a large number of countries. In this section, we use our general equilibrium model to quantitatively estimate how historical changes in real per capita income and openness to trade may have affected the skill premium. Our primary objective is to explore the potential for non-homothetic preferences to affect this response. Separate counterfactuals then decompose results into the effect of growth and the effect of trade. In each case, we also use the approximations provided in the theory section 2.4 to further decompose the role of preferences, intermediate goods and trade patterns.

4.1 Calibration

Our main 'unified' counterfactual consists of adjusting total factor productivity (TFP) and trade costs simultaneously such that the model matches historical rates of real income growth and trade openness for the 1995-2010 period (a period which will allow us to compare our results with observed changes in the skill premium compiled from the WIOD dataset).

More specifically, we use the GTAP5 dataset to calibrate the model, then solve it[32] allowing all endogenous variables as well as two otherwise exogenous parameters, z_{ik} (TFP) and $\beta_{border,ik}$ (exporter-specific border effects) to adjust until the counterfactual equilibrium matches targeted (observed) changes in real per capita GDP and exports/GDP.[33] Changes in both variables are taken from the Penn World Table version 9 (Feenstra et al., 2015). The adjustments in both z_{ik} and $\beta_{border,ik}$ are allowed to vary across countries but not across sectors, in order to avoid changes in sectoral composition that are not directly driven by demand.

Appendix Table A.3 reports the targeted changes in per capita GDP and export/GDP ratios, the implied shocks to productivity and trade costs, and the resulting changes in the skill premium for all countries. On average, real per capita GDP (our proxy for real income) increased by 69% in the 66 countries of our sample, with growth ranging from 6% (Japan) to 175% growth (China). Growth was strongly biased in favor of low-income countries.[34] There also have been substantial but heterogeneous changes in export/GDP ratios (largest in low-income countries, 66% on average, and a standard deviation of 71%).[35] Note also that implied changes in productivity and reductions in trade costs are weakly correlated at 0.18 and are very similar when the model is calibrated with homothetic preferences instead (correlation of 0.99 and 0.97 respectively).

4.2 Combined effects of productivity growth and trade liberalization, 1995-2010

Figure 2 displays simulated general equilibrium changes in the skill premium as a function of each country's (log) per capita expenditures (which in most countries is very close to per capita income). A value of 0.1 in the figure implies that the ratio of skilled to unskilled wages increased by 10% during the 1995 to 2010 period because of simulated changes in real income and trade.

[32] The model is formulated in GAMS and solved by the non-linear PATH solver.

[33] We chose to target export/GDP ratios because trade affects the skill premium primarily through its changes in the relative supply of goods.

[34] Implied changes in TFP ($\widehat{z}$) are strongly correlated with these changes in real GDP per capita (0.87), but are slightly lower in level (average of 60%), as the observed increase in real income is partially caused by trade (i.e. generated by the reductions in trade costs).

[35] Implied reductions in trade costs (captured by the exporter-specific border effects $\widehat{\beta}_{border,ik}$) are also well correlated with changes in exports/GDP, at 81%. Trade cost reductions are smaller in magnitude than changes in trade flows, and average 30%, a difference driven by the estimated elasticity of trade to trade costs parameters, θ_k. They also vary substantially between countries (standard deviation of 62%), and 18 countries have increasing implied trade costs.

Focusing first on estimates obtained using non-homothetic preferences reveals an increase in the skill premium in almost all countries, but changes are very heterogeneous.[36] Low-income countries, including some of the largest countries in our dataset, see the largest increases in the skill premium: e.g. a 17.4% increase in China, 29.6% in India, 20.7% in Vietnam, and similarly high values for most African countries. Countries classified as low-income by the World Bank in 1997 (China and 10 other countries in our sample) see an average increase of 9.3%. Other countries see a much lower increase of 2.4% on average. Middle-income countries see moderate increases (e.g. 3.3% in Mexico, 1.7% Brazil, 3.6% in Russia) and estimates are lowest for developed countries (e.g. 0.8% for the USA and around 1-2% for European countries).

In some countries, our model also predicts non-negligible changes in the skill premium with homothetic preferences. Indeed, international trade can affect the relative wage of skilled workers if income growth rates vary across countries, and more generally the standard Stolper-Samuelson effects of trade do not require non-homothetic preferences. However, estimates are considerably closer to zero and their relationship with per capita income flatter. Allowing for non-homothetic preferences yields unambiguously higher estimates in all countries, but especially in developing countries.

Relative importance of income growth and openness to trade To decompose these results, we re-simulate the changes in the skill premium caused by productivity growth (estimated as described above), but not changes in trade costs. This 'growth-only' counterfactual is displayed in Figure 3(a). We then do the opposite and compute the effect of 1995-2010 changes in trade costs, holding productivity fixed. This 'trade-only' counterfactual is displayed in Figure 3(b).

Results indicate that the effect of productivity growth dominates as it tends to have a quantitatively larger influence on the skill premium than changes in trade, especially in low- and middle-income countries. We also find that adding the effect of productivity growth and trade costs to "recompose" the total effect on the skill premium leads to estimates which are very similar to those obtained by simulating both simultaneously as in our 'unified' counterfactual (see Figure A.8 in the appendix). This suggests only small interactions between the growth and trade channels, so we now discuss them individually.[37]

4.3 Productivity growth and the skill premium

We now focus on the 'growth-only' counterfactual, highlighting the mechanisms described in Section 2.4.1: when preferences are non-homothetic and the income elasticity of demand is positively correlated with the skill intensity of production, an increase in productivity makes consumers richer

[36] Zimbabwe, Uruguay and Malawi are the only three countries with a reduction among developing countries. Zimbabwe has followed a very unusual growth path over the time period. Its ratio of exports to GDP increased by a factor of 2.5, while its per capita real income decreased by 66%.

[37] Changes in the skill premium from simulations of simultaneous shocks actually tend to be slightly lower, especially for low-income countries. The effect of trade costs on the skill premium depends on per capita income (as will be seen) and is thus weaker when evaluated simultaneously with the effect of productivity growth which makes countries richer; on the other hand, the effect of productivity growth on skill premium depends on trade costs. Changes in domestic consumption patterns (caused by income growth) have a smaller impact on the skill premium as countries open to trade.

and raises the relative demand for skill intensive industries. On the contrary, uniform productivity growth has no effect on the skill premium when preferences are homothetic.

Comparing Figures 2 and 3(a) shows that the magnitude of the effect and its relationship with per capita income is similar to that obtained in the 'unified' growth and trade counterfactual: estimates vary considerably between countries but are again highest in low-income countries. Estimates can be large, including a 14.5% increase in the skill premium in China, 22.6% in India, 8.7% in Vietnam and in the 10-18% range for African countries. It is 9.6% on average for countries classified as low-income, and 2.4% for countries middle-income and above. As expected, the difference with estimates obtained with homothetic preferences is positive for all countries and again large for developing countries.

The role of trade and input-output linkages As discussed in Section 2.4.1, the main argument for the role of non-homothetic preferences does not involve trade and also applies to closed economies. To illustrate this point, we compute the closed-economy approximation described by Equation (27), inserting our estimates for income elasticities (η_{nk}) as well as labor shares (sh^H_{nk} and sh^L_{nk}, computed including demand for the labor embodied in intermediates). Figure 4 shows that this approximation of changes in the skill premium is a very good predictor of the simulated open-economy general equilibrium changes. In both cases, the figure plots the difference between non-homothetic and homothetic preferences to pinpoint the role of non-homotheticity (recall that in a closed economy, there is no change in the skill premium with homothetic preferences). The high (98%) correlation is partly due to production being mostly destined for local consumption, and partly because countries tend to trade with countries of similar per capita income, so that changes in the composition of consumption of their trading partners are similar to their own.

To investigate the importance of input-output linkages, Figure 4 also shows the closed-economy approximation implied by Equation (27), this time computed using labor shares that only account for final good production (without IO linkages). While these approximated changes in the skill premium again provide a fairly good approximation of the open-economy general equilibrium estimates, they are consistently larger.[38] This upward bias is explained by the lower variance in skill intensity between sectors when intermediate demand is accounted for (see Figure 1): input-output linkages mitigate the effect of changes in the composition of demand on the skill premium.

Why is the effect on the skill premium larger for low- and middle-income countries? The rates of income growth underlying the results vary considerably between countries. To better visualize the relative strength of the non-homothetic consumption effect across countries, Figure 5 compares the approximated changes in the skill premium described above to their equivalent computed with uniform growth rates. The latter can also be interpreted as *elasticities* to productivity growth: a value of 0.1 implies the skill premium increasing by 1% for every 10% increase in per capita income. The difference between rich and poor countries remains large, and is therefore not primarily driven

[38] Regressing the approximation without IO linkages on the approximation with IO linkages yields a coefficient of 1.62 with an R-squared of 92%.

by stronger productivity growth in developing countries observed over the 1995-2010 period.

As we have shown in Section 2.4.1, differences in skill premium changes across countries depend on differences in the income elasticity of demand and skilled/unskilled employment shares across countries and sectors. CRIE preferences generate income elasticities that decrease according to a country's income (within sectors), which could partially explain why the effect on the skill premium is smaller for richer countries. Second, a larger share of low-skilled employment in developing countries produces income-inelastic goods while skilled workers produce income-elastic goods. In rich countries, there are smaller differences in income elasticity between the goods that skilled and low-skilled workers produce. To disentangle these effects, we also show in Figure 5 that replacing country-specific income elasticities by their mean across countries per sector (such that all the variations across countries comes from differences in employment shares) still yields a strong negative relationship between skill premium changes and income. Hence, we conclude that the larger difference between homothetic and non-homothetic preferences in developing countries it is mostly due to the differences in employment shares.

4.4 Trade liberalization and the skill premium

We now examine the role of trade liberalization by focusing on the 'trade-only' counterfactual in which we simulate the 1995-2010 implied changes in trade costs, but hold productivity constant (Figure 3b).[39] With homothetic preferences, the effect of trade on the skill premium tends to be negative for developing countries and positive among the richest countries. This is in line with standard Stolper-Samuelson predictions: trade leads to a decrease in the relative demand for skilled labor in countries that are abundant in unskilled labor, and to an increase in the skill premium in more skilled-labor abundant countries.

This effect is mitigated, and often reversed, when we allow for non-homothetic preferences. Trade cost reductions lead to a larger increase (or a smaller reduction) in the skill premium in low-income countries (where simulated changes are on average 3.4% higher than with homothetic preferences). The difference is smaller at higher income levels, and even slightly negative in very high-income countries. The positive correlation between the effect of trade on the skill premium and a country's per capita income thus disappears (becoming slightly negative).

Decomposition Table 2 decomposes the effect of non-homothetic preferences into the channels described in Equations (31) through (34).

The "direct effects" of a trade cost reduction on the skill premium, also plotted on Figure 6(a), are derived from Equation (31) as an approximation holding trade and demand patterns constant (for each specification of preferences) and neglecting general-equilibrium feedback effects caused by changes in factor costs. As we described in Equations (31) and (35), this direct effect should be higher when countries have a higher net content of trade in skilled labor relative to unskilled labor. Our

[39] Nine countries saw reductions in export/GDP ratios over the period (implying increases in trade costs). These naturally have different implications for the skill premium and are dropped from the figure for clarity.

findings confirm this to be true for developing countries when the model is fitted with non-homothetic preferences (relative to homothetic preferences): they are indeed predicted to consume relatively more of the unskilled-intensive goods for which they have a comparative advantage in production while their trade partners, predominantly richer countries, have a relatively higher demand for income-elastic and skill-intensive goods. As discussed after Equation (31), this effect mitigates the standard Stolper-Samuelson effect found with homothetic demand. The reverse effect holds but is quantitatively much smaller for high-income countries.

Note that the "direct effect" of trade costs on the skill premium (Equation 31) could also be affected by a systematic correlation between skill intensity and average tradability across sectors. If, in turn, tradability were correlated with income elasticity, the strength of this effect could differ between non-homothetic and homothetic preferences. In Section 3.4, however, we find that both of these correlations are weak once services are included, and are not driving our results.[40]

The second term of the decomposition, "effects on final demand", plotted on Figure 6(b), captures changes in consumption patterns driven by changes in prices and income. With homothetic preferences, trade already generates changes in consumption patterns by changing relative prices, but the "effects on final demand" are larger with non-homothetic preferences:[41] trade liberalization generates an increase in real income which, as in the growth counterfactual, leads to a reallocation of consumption towards income-elastic and skill intensive goods, thereby increasing the skill premium. This "demand" channel is quantitatively strong and explains a substantial share of the average difference between non-homothetic and homothetic preferences (see Table 2), though in low-income countries the "direct" impact of trade on the skill premium dominates. In rich countries, the "direct" and "demand" channels go in opposite directions, partially explaining the smaller role of non-homothetic preferences on the skill premium in those countries.

Since trade-driven income growth leads to a larger expansion in skill-intensive sectors, it also leads to a larger demand for skill-intensive intermediate goods. While the "input-output" (IO) channel reinforces the final demand channel, the difference in the specifications is quantitatively smaller than what is explained by the first two channels. Finally, general equilibrium effects captured by changes in "multilateral-resistance" (MR) terms mitigate the direct effect of trade costs (e.g. adjustment in factor prices), but also remain quantitatively smaller than the first two channels.

To summarize, a combination of the composition effects in demand (which drive the second and third terms) and the substantially reduced Stolper-Samuelson effect (identified through the first term) explains why, in our general equilibrium simulations, non-homothetic preferences imply a higher effect of trade on the skill premium in low-income countries.

[40] To confirm that the differences between non-homothetic and homothetic preferences are indeed driven by patterns of specialization (net exports) rather than by differences in tradability across sectors, we have re-evaluated the direct effect using average export shares at the sector level. The difference between non-homothetic and homothetic preferences in this case is very small.

[41] With lower price elasticities, as in Cravino and Sotelo (2018), we find larger effects on the skill premium, but the effects remain large with non-homothetic preferences, as documented in our robustness checks in Section 4.6.

4.5 Explaining observed changes in the skill premium

Observed changes in the skill premium are caused by a number of confounding and possibly interacting mechanisms including skill-biased technical change and skill accumulation that are not captured in our model. We therefore cannot precisely quantify the relative importance of non-homothetic preferences and the skill intensity-income elasticity correlation in explaining historical changes. However, a simple correlation exercise and comparison suggest that our mechanisms may help explain historical changes.

Historical 1995-2010 changes in the skill premium in the 40 countries covered by WIOD vary greatly in sign and magnitude, with on average a larger increase in low-income countries (the correlation with log per capita income is -0.28), a pattern that is also evident in our simulation results. Figure 7 plots observed changes (from WIOD) against simulated changes from our unified growth and trade counterfactual: the relationship is noisy and observed changes are on average larger in magnitude, but the figure clearly shows that non-homothetic preferences significantly increase the correlation between model estimates and observed changes. Table A.5 in appendix summarizes coefficients from regressions of observed on simulated changes.[42] Note that the figure and regression coefficients may understate the mechanisms' importance: contrary to GTAP, WIOD includes only a small number of low-income countries (China, Mexico, Brazil, India, Indonesia and Turkey) and thus lacks many of the countries that have experienced the highest rates of income growth and have the highest predicted increases in the skill premium.

While this increase in correlation is mostly driven by the 'growth channel' (income-driven shifts in consumption patterns), we also find that non-homothetic preferences push our estimates of the effect of trade on the skill premium closer to observed changes (see Table A.5).

The magnitude of growth and trade effects relative to observed changes varies country-by-country, but is sometimes substantial. For China, our 17.4% simulated increase in the skill premium over the 1995-2010 period (14.5% increase due to productivity growth) suggests that our mechanism may have played an important role in the very large 51% increase reported in WIOD (Ge and Yang (2009) report a 40% increase between 1992 and 2006). For India, we obtain a 22% increase (mostly due to productivity growth). WIOD shows very little change over the period, but Azam (2009) documents a 11.9% increase between 1987 and 2004. A similar picture emerges for other Asian countries. In Latin America, the mechanisms explain smaller but still significant shares of observed increases: our simulations lead to a 2.5% increase in Peru, contrasted to an observed increase of 23.9% from 1994 to 2000 (Mazumdar and Quispe-Agnoli, 2004); a 3.3% increase in Mexico, contrasted to 12.5% from 1990 to 2001 (Verhoogen, 2008); and a 1.7% increase in Colombia, contrasted to 26.4% between 1990 and 2000 (Gutierrez, 2009). Note also that many of our highest estimates are in African countries, about which little is known regarding skill premia. Among developed countries, the predicted increase in skill premium is small, but so are observed changes: about 0.8% for the US (0.6% from growth-driven

[42] Once controlling for changes in skill endowments, as measured by 1995-2010 log changes in years of schooling (using cross-country data from Barro and Lee, 2013), we find that the correlation increases from a statistically insignificant 0.182 with homothetic preferences to 0.317 (p-value 0.07) with non-homothetic preferences. The difference between the non-homothetic to homothetic difference is also significantly correlated with observed changes (0.29; p-value 0.09), confirming that non-homothetic preferences improve the model's capacity to explain changes in the skill premium.

reallocation), contrasted to an observed 3.1% skill premium increase (Parro, 2013) (11% in WIOD); 1% in Great Britain (0.5% from growth), contrasted with an observed 2% increase for 1990-2005 (Parro, 2013) or a 4% reduction in WIOD.

4.6 Robustness

As made evident in the analytical approximations provided in Section 2.4, the effects of productivity and trade are inversely proportional to $\tilde{\rho}$ which is itself tightly linked to the elasticity of substitution between skilled and unskilled labor, ρ. A higher ρ naturally leads to smaller effects. While this elasticity is difficult to estimate in practice, most estimates lie between 1.4 and 1.7 (Acemoglu, 2007). Within this range, we find that the difference in simulated general equilibrium estimates is almost exactly proportional to differences in $\tilde{\rho}$. Appendix E provides additional details for this and the following four sets of robustness checks.

We also test the sensitivity of our results to differences in the θ_k parameter, which drives the response of trade flows to changes in trade costs. While this parameter affects our price index estimates and thus the estimation of income elasticities, we find similar results for the changes in the skill premium when θ_k is calibrated to the same constant in all sectors instead of estimated.

The CRIE preferences assumed in our benchmark specification are separable. Separability is a natural and common assumption but an important disadvantage is that it imposes a strong link between price elasticities and income elasticities in consumption. Our results are not dependent on this property: they remain qualitatively and quantitatively similar when we integrate "implicitly-additive" preferences (as in Comin et al, 2016 and Matsuyama, 2019) into our general equilibrium model. These preferences impose no link between price and income elasticities.

In our benchmark analysis, we use a cross-country average of each sector's input requirements, including in the computation of skilled and unskilled labor intensity. Using country-specific measures of input requirements, we find that the correlation of income elasticity with skill intensity is strong in most countries (and not just on average), so that our simulated skill premium estimates remain similar and indeed slightly stronger.

Finally, while our benchmark empirical and simulation results are obtained using GTAP5, which is based on 1997 (around the beginning of our 1995-2010 simulation period), we also find a strong correlation between income elasticity and skill intensity when using the more recent GTAP8 dataset based on 2007. Simulation results thus also remain very similar.

5 Summary and conclusions

Growing income inequality is a defining feature of our time, and many reasons for the increasing premium awarded to skilled workers have been identified and studied by the literature. We provide a quantitative assessment of a simple yet overlooked mechanism: when allowing for non-homothetic preferences, growth in income increasingly shifts consumption patterns towards goods and services that require relatively more skilled labor in their production.

We calibrate our model to match changes between 1995 and 2010, a period of moderate growth, increasing openness to trade, and increasing skill premium. Simulations suggest that productivity improvements underlying recent GDP growth had the potential to drive substantial increases in the skill premium, even under our assumption of uniform productivity growth across sectors. The predicted changes in the skill premium caused by the changing composition of consumption represent a sizable share of observed increases in many countries, particularly in the developing world.

We then show that income-driven changes in the composition of consumption can also be quantitatively important during an episode of trade liberalization. Like productivity, trade raises incomes and increases the return to skilled labor, once again with a strong effect in the developing world. The relationship between income and consumption patterns has further implications. The sector-level correlation between income elasticity and skill intensity implies a country-level correlation between relative specialization in consumption and relative specialization in production. This leads to a lower predicted net factor content of trade and therefore a weaker link between trade and relative wages. In many developing countries, this weakening of Stolper-Samuelson forces, combined with the effect of shifting consumption patterns, completely cancels out the decrease in the skill premium predicted by a standard homothetic-preference model.

We do not claim our demand-driven effects to be the main mechanisms behind increasing wage disparities. They are likely working alongside other forces, such as skill-biased technical change (Burstein and Vogel, 2017) and other sources of structural transformation (Cravino and Sotelo, 2018), with which they are not incompatible. Future research may want to integrate and contrast alternative mechanisms in a unified framework. We simply show that standard models ignoring non-homotheticity in demand would considerably underestimate effects on the skill premium, and that demand effects may be comparable in magnitude to other well-studied mechanisms in explaining why, despite the accumulation of skills, inequality has been increasing.

References

Acemoglu, Daron, "Equilibrium bias of technology," *Econometrica*, 2007, *75* (5), 1371–1409.

Anderson, James E. and Eric van Wincoop, "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, 2003, *93(1)*, 170–192.

Autor, David H, David Dorn, and Gordon Hanson, "Untangling trade and technology: Evidence from local labour markets," *The Economic Journal*, 2015, *125* (584), 621–646.

Autor, David H., Lawrence F. Katz, and Alan B. Krueger, "Computing Inequality: Have Computers Changed The Labor Market?," *The Quarterly Journal of Economics*, 1998, *113(4).*

Azam, Mehtabul, "India's Increasing Skill Premium: Role of Demand and Supply," 2009. IZA Discussion Paper No. 3968.

Barro, Robert J and Jong Wha Lee, "A new data set of educational attainment in the world, 1950–2010," *Journal of Development Economics*, 2013, *104*, 184–198.

Buera, Francisco J and Joseph Kaboski, "The rise of the service economy," *The American Economic Review*, 2012, *102* (6), 2540–2569.

Burstein, Ariel and Jonathan Vogel, "International Trade, Technology, and the Skill Premium," *Journal of Political Economy*, 2017, *125* (5), 1356–1412.

Bustos, Paula, "Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms," *The American Economic Review*, 2011, *101* (1), 304–340.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, 2014, *82(1)*, 1–44.

Card, David, Jörg Heining, and Patrick Kline, "Workplace Heterogeneity and the Rise of West German Wage Inequality," *The Quarterly Journal of Economics*, 2013, *128(3).*

Caron, Justin, Thibault Fally, and James R Markusen, "Skill premium and trade puzzles: A solution linking production and preferences," 2012. NBER working paper 18131, also issued as CEPR discussion paper 8999, May 2012.

_ , _ , and _ , "International trade puzzles: a solution linking production and preferences," *The Quarterly Journal of Economics*, 2014, *129* (3), 1501–1552.

Comin, Diego A, Danial Lashkari, and Martí Mestieri, "Structural change with long-run income and price effects," 2015. National Bureau of Economic Research w21595.

Costinot, Arnaud and Andrés Rodríguez-Clare, "Trade theory with numbers: Quantifying the consequences of globalization," in "Handbook of international economics," Vol. 4 2014, pp. 197–261.

_ and Jonathan Vogel, "Matching and inequality in the world economy," *Journal of Political Economy*, 2010, *118* (4), 747–786.

_ , Dave Donaldson, and Ivana Komunjer, "What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas," *Review of Economics Studies*, 2012, *79* (2), 581–608.

Cravino, Javier and Andrei A Levchenko, "The distributional consequences of large devaluations," 2016. Working Paper, University of Michigan.

_ and Sebastian Sotelo, "Trade Induced Structural Change and the Skill Premium," 2018. forthcoming in the *American Economic Journal: Macroeconomics.*

de Sousa, Jose, "The currency union effect on trade is decreasing over time," *Economics Letters*, 2012, *117* (3), 917–920.

Dekle, Robert, Jonathan Eaton, and Samuel Kortum, "Unbalanced Trade," *American Economic Review*, 2007, *97* (2), 351–355.

Dimaranan, Betina V. and Robert McDougall, "Global Trade, Assistance, and Production: The GTAP 5 Data Base," 2002.

Donaldson, Dave, "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure," *American Economic Review*, 2018, *108* (4-5), 899–934.

Eaton, Jonathan and Samuel Kortum, "Technology, Geography, and Trade," *Econometrica*, 2002, *79(5)*, 1453–1498.

_ , _ , **and Francis Kramarz**, "An Anatomy of International Trade: Evidence From French Firms," *Econometrica*, 2011, *79(5)*, 1453–1498.

Faber, Benjamin, "Trade liberalization, the price of quality, and inequality: Evidence from Mexican store prices," Technical Report, UC Berkeley Working Paper 2014.

_ **and Thibault Fally**, "Firm heterogeneity in consumption baskets: Evidence from home and store scanner data," Technical Report, National Bureau of Economic Research w23101, 2017.

Fajgelbaum, Pablo D and Amit K Khandelwal, "Measuring the unequal gains from trade," *The Quarterly Journal of Economics*, 2016, *113(3)*, 1113–1180.

Fally, Thibault, "Structural gravity and fixed effects," *Journal of International Economics*, 2015, *97* (1), 76–85.

Feenstra, Robert C and John Romalis, "International Prices and Endogenous Quality," *Quarterly Journal of Economics*, 2014, *129* (2), 477–527.

Feenstra, Robert, Robert Inklaar, and Marcel Timmer, "The Next Generation of the Penn World Table," *American Economic Review*, 2015, *105* (10), 3150–3182.

Fieler, Ana Cecilia, "Non-Homotheticity and Bilateral Trade: Evidence and a Quantitative Explanation," *Econometrica*, 2011, *79(4)*, 1069–1101.

_ **, Marcela Eslava, and Daniel Yi Xu**, "Trade, Quality Upgrading, and Input Linkages: Theory and Evidence from Colombia," *American Economic Review*, 2018, *108* (1).

Flam, Harry and Elhanan Helpman, "Vertical product differentiation and North-South trade," *The American Economic Review*, 1987, pp. 810–822.

Ge, Suqin and Dennis T Yang, "Accounting for rising wages in China," 2009. Manuscript, Virginia Tech and Chinese University of Hong Kong.

Goldberg, Pinelopi Koujianou and Nina Pavcnik, "Distributional Effects of Globalization in Developing Countries," *Journal of Economic Literature*, 2007, *45(1)*, 39–82.

Gonzaga, Gustavo, Naércio Menezes Filho, and Cristina Terra, "Trade liberalization and the evolution of skill earnings differentials in Brazil," *Journal of International Economics*, 2006, *68* (2).

Gutierrez, Catalina, "Trade and Technology: Decomposing the Rise of the Skill Premium," 2009. IZA manuscript.

Hallak, Juan Carlos, "A Product-Quality View of the Linder Hypothesis," *The Review of Economics and Statistics*, 2010, *92* (3), 453–466.

Hanoch, Giora, "Production and Demand Models with Direct or Indirect Implicit Additivity," *Econometrica*, 1975, *43(3)*, 395–419.

He, Zheli and Feiran Zhang, "Trade and Real Wages of the Rich and Poor: Cross Country Evidence," 2017. Columbia University working paper.

Helpman, Elhanan, Oleg Itskhoki, Marc-Andreas Muendler, and Stephen J Redding, "Trade and inequality: From theory to estimation," *The Review of Economic Studies*, 2017, *84(1).*

Hung-po, Sehun Kim Chao and Alan S. Manne, "Computation of Equilibria for Nonlinear Economies: Two Experimental Model," *Journal of Policy Modeling*, 1982, *4(1)*, 23–43.

Jaimovich, Nir, Sergio Rebelo, Arlene Wong, and Miao Ben Zhang, "Trading Up and the Skill Premium," *NBER Macroeconomics Annual*, 2019, *34*.

Johnson, Matthew and Michael P Keane, "A dynamic equilibrium model of the US wage structure, 1968–1996," *Journal of Labor Economics*, 2013, *31* (1), 1–49.

Johnson, Robert C, "Five facts about value-added exports and implications for macroeconomics and trade research," *The Journal of Economic Perspectives*, 2014, *28* (2), 119–142.

Katz, Lawrence F and Kevin M Murphy, "Changes in relative wages, 1963–1987: supply and demand factors," *The Quarterly Journal of Economics*, 1992, *107* (1), 35–78.

Krugman, Paul R, "Technology, trade and factor prices," *Journal of International Economics*, 2000, *50* (1), 51–71.

Ligon, Ethan, "All λ-separable demands and rationalizing utility functions," *Economics Letters*, 2016, *147*, 16–18.

Markusen, James R., "Explaining the Volume of Trade: An Eclectic Approach," *American Economic Review*, 1986, *76*, 1002–1011.

_ , "Putting per-capita income back into trade theory," *Journal of International Economics*, 2013, *90* (2), 255–265.

Matsuyama, Kiminori, "A Ricardian Model with a Continuum of Goods under Non-Homothetic Preferences: Demand Complementarities, Income Distribution, and North-South Trade," *Journal of Political Economy*, 2000, *108*, 1093–2000.

_ , "Engel's Law in the Global Economy: Demand-Induced Patterns of Structural Change, Innovation, and Trade," *Econometrica*, 2019, *87* (2), 497–528.

Mayer, Thierry and Soledad Zignago, "Notes on CEPII's distances measures: The GeoDist database," Working Papers 2011-25, CEPII Research Center Dec 2011.

Mazumdar, Joy and Myriam Quispe-Agnoli, "Can capital-skill complementarity explain the rising skill premium in developing countries? Evidence from Peru," 2004. Federal Reserve Bank of Atlanta working paper No 0411.

Miller, Ronald E and Peter D Blair, *Input-output analysis: foundations and extensions*, Cambridge University Press, 2009.

Narayanan, Badri, Angel Aguiar, and Robert McDougall, "Global Trade, Assistance, and Production: The GTAP 8 Data Base," 2012.

Nigai, Sergey, "On measuring the welfare gains from trade under consumer heterogeneity," *Economic Journal*, 2016, *216*, 1193–1237.

Parro, Fernando, "Capital-skill complementarity and the skill premium in a quantitative model of trade," *American Economic Journal: Macroeconomics*, 2013, *5* (2), 72–117.

Porto, Guido G, "Using survey data to assess the distributional effects of trade policy," *Journal of International Economics*, 2006, *70* (1), 140–160.

Reimer, Jeffery J. and Thomas W. Hertel, "Nonhomothetic Preferences and International Trade," *Review of International Economics*, 2010, *18*, 408–425.

Robertson, Raymond, "Relative prices and wage inequality: evidence from Mexico," *Journal of International Economics*, 2004, *64* (2), 387–409.

Silva, JMC Santos and Silvana Tenreyro, "The log of gravity," *The Review of Economics and statistics*, 2006, *88* (4), 641–658.

Simonovska, Ina, "Income differences and prices of tradables: Insights from an online retailer," *The Review of Economic Studies*, 2015, *82* (4), 1612–1656.

_ **and Michael E Waugh**, "The elasticity of trade: Estimates and evidence," *Journal of international Economics*, 2014, *92* (1), 34–50.

Timmer, Marcel, Bart Los, Robert Stehrer, and Gaaitzen de Vries, "An anatomy of the global trade slowdown based on the WIOD 2016 release," 2016. GGDC, University of Groningen.

Timmer, Marcel P, Erik Dietzenbacher, Bart Los, Robert Stehrer, and Gaaitzen J De Vries, "An illustrated user guide to the world input–output database: the case of global automotive production," *Review of International Economics*, 2015, *23* (3), 575–605.

Verhoogen, Eric A., "Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sector," *The Quarterly Journal of Economics*, 05 2008, *123* (2), 489–530.

Voigtländer, Nico, "Skill Bias Magnified: Intersectoral Linkages and White-Collar Labor Demand in U.S. Manufacturing," *The Review of Economics and Statistics*, July 2014, *96* (3), 495–513.

Tables and Figures

Table 1: Estimated income elasticity by sector (a star adjacent the sector code denotes service sectors).

GTAP code	Sector name	Skill intens.	Income elast.	Theta θ_k	Export share
pdr	Paddy rice	0.063	0.370	1.534	0.015
v_f	Vegetables, fruit, nuts	0.088	0.562	1.528	0.124
c_b	Sugar cane, sugar beet	0.088	0.620	10.029	0.002
wol	Wool, silk-worm cocoons	0.093	0.265	0.993	0.119
wht	Wheat	0.104	0.246	3.130	0.228
ocr	Crops nec	0.106	0.864	1.318	0.270
osd	Oil seeds	0.111	0.561	1.674	0.231
pcr	Processed rice	0.120	0.549	0.993	0.054
oap	Animal products nec	0.124	0.223	1.069	0.058
rmk	Raw milk	0.131	0.596	0.993	0.001
fsh	Fishing	0.135	0.683	1.770	0.078
for	Forestry	0.141	0.363	1.252	0.099
gro	Cereal grains nec	0.141	0.000	0.993	0.155
pfb	Plant-based fibers	0.150	0.426	14.355	0.241
ctl	Cattle, sheep, goats, horses	0.176	0.189	1.069	0.039
sgr	Sugar	0.195	0.502	2.275	0.145
lea	Leather products	0.198	1.016	2.491	0.408
omt	Meat products nec	0.214	1.054	2.039	0.126
vol	Vegetable oils and fats	0.219	0.584	1.801	0.233
cmt	Bovine meat products	0.223	1.069	3.571	0.106
wap	Wearing apparel	0.230	1.024	3.204	0.309
tex	Textiles	0.230	0.814	1.069	0.296
mil	Dairy products	0.236	1.023	2.762	0.131
lum	Wood products	0.248	1.074	2.628	0.209
ofd	Food products nec	0.263	0.831	1.943	0.127
omf	Manufactures nec	0.274	1.022	2.864	0.269
b_t	Beverages and tobacco	0.283	0.761	4.364	0.097
otp*	Transport nec	0.294	1.061	1.710	0.083
cns*	Construction	0.302	0.832	16.036	0.009
atp*	Air transport	0.302	1.059	3.966	0.380
trd	Trade	0.304	1.090	4.916	0.021
wtp*	Water transport	0.315	1.055	1.292	0.353
mvh	Motor vehicles and parts	0.335	1.093	5.758	0.297
ppp	Paper products, publishing	0.337	1.072	4.629	0.125
otn	Transport equipment nec	0.344	1.027	1.069	0.378
p_c	Petroleum, coal products	0.346	0.780	16.036	0.114
crp	Chemical, rubber, plastic	0.355	0.909	1.624	0.252
ely*	Electricity	0.366	0.943	16.036	0.020
wtr*	Water	0.368	0.968	5.519	0.006
gdt*	Gas manufacture, distribution	0.369	1.057	16.036	0.025
ome	Machinery and equipment nec	0.374	0.931	3.552	0.408
ele	Electronic equipment	0.378	1.205	14.364	0.463
ros*	Recreational and other srv	0.482	1.171	1.807	0.029
obs*	Business services nec	0.491	1.209	7.430	0.065
cmn*	Communication	0.495	1.174	4.794	0.034
osg*	Public spending	0.499	0.994	1.368	0.017
isr*	Insurance	0.522	1.412	1.276	0.052
ofi*	Financial services nec	0.534	1.132	5.063	0.019

Notes: Estimates of income elasticities and theta θ_k based on the benchmark specification; income elasticities evaluated using average country expenditure shares; skill intensity based on total requirements; export share is the sector average of the export share across countries.

Table 2: The effect of trade on the skill premium (in %): decomposition of the difference between non-homothetic and homothetic preferences. Average over countries which experienced a reduction in trade costs.

Channel:	Country groups (per capita income):		
	Low-income	Middle-income	High-income
Direct	4.10	0.10	-0.22
Demand	1.77	0.30	0.13
IO	0.08	0.08	-0.05
MR	-2.60	-0.03	0.07
Total	3.35	0.45	-0.06

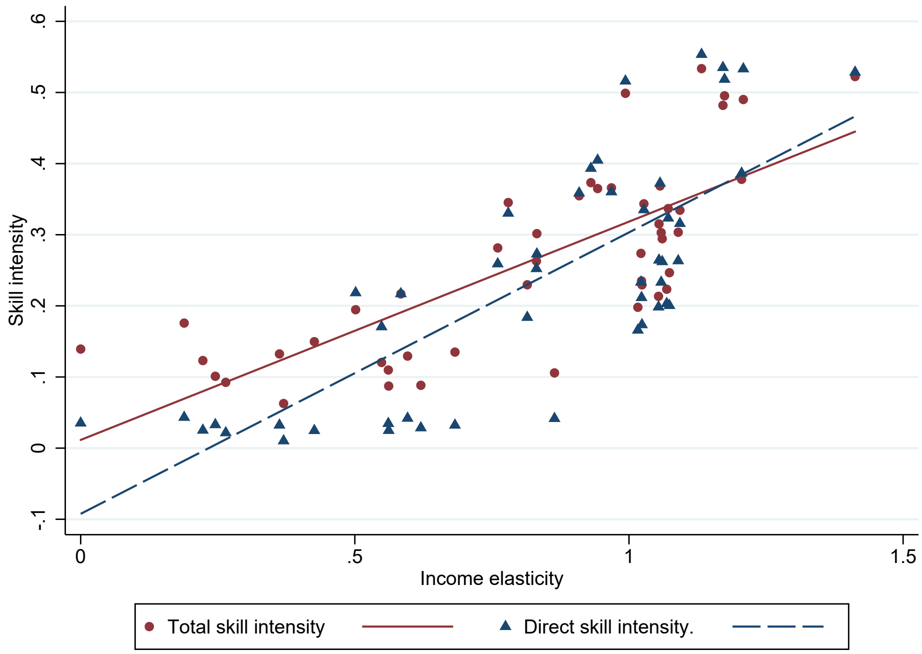


Figure 1: Correlation between income elasticity and skill intensity. Total skill intensity includes indirect demand for labor, direct does not. The standard deviation in total intensities is 0.13; the standard deviation in direct intensities is 0.17. The coefficient of correlation between income elasticity and total skill intensity is 0.773 with a robust standard error of 0.085 (p-value < 0.01, n $= 49$).

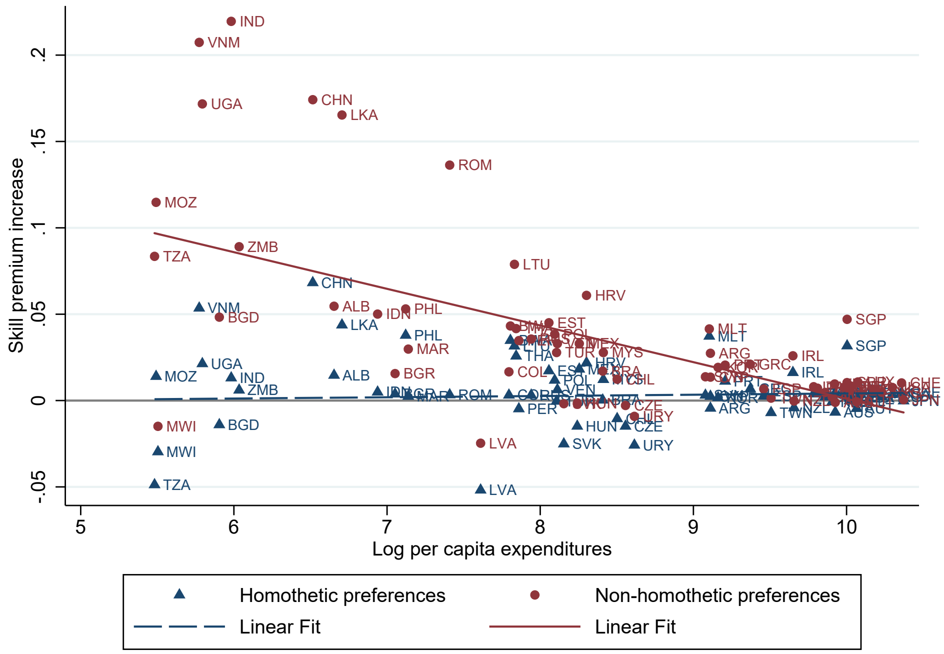
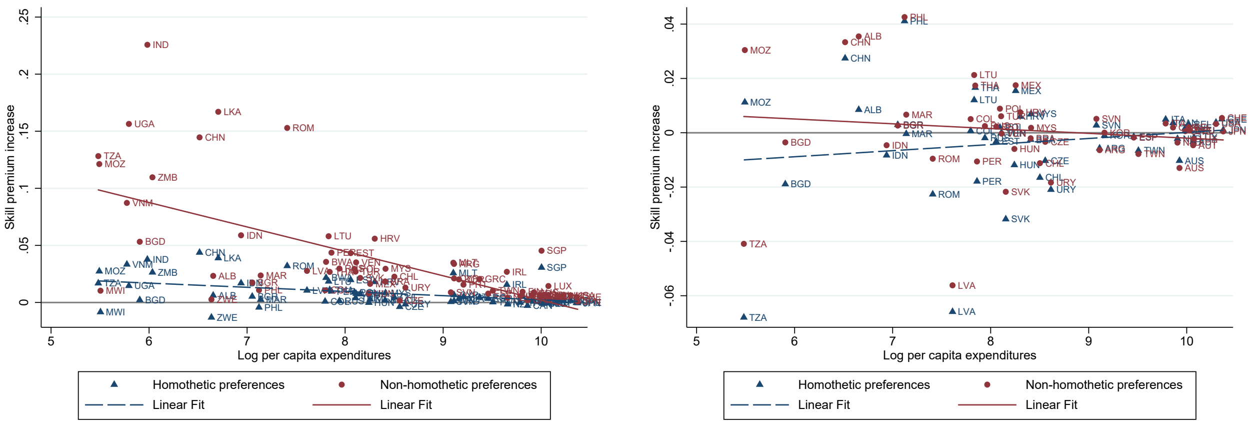


Figure 2: The effect of growth and trade on the skill premium. Simulated general equilibrium changes caused by 1995 to 2010 changes in real per capita income and openness to trade (unified counterfactual). Zimbabwe (ZWE) is dropped from the figure (values of -0.12 for non-homothetic preferences and -0.17 for homothetic preferences). See Appendix Table A.3 for the full set of estimates.



(a) Growth counterfactual

(b) Trade counterfactual

Figure 3: Decomposition into the growth and trade channels. Simulated general equilibrium changes in the skill premium caused by 1995 to 2010 changes in real per capita income (a) and openness to trade (b). For clarity, Figure b only displays countries which experienced a reduction in trade costs.

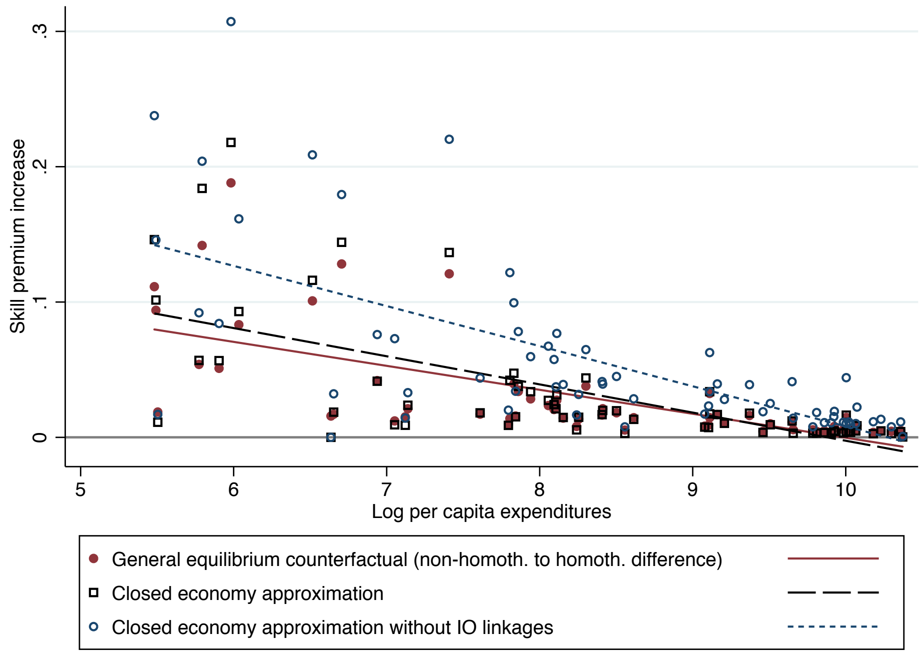


Figure 4: Growth channel. Closed-economy approximations with and without intermediate good (IO) linkages and comparison to general equilibrium estimates. The figure shows the non-homothetic to homothetic difference – in closed economy approximations, there is no change in the skill premium under homothetic preferences.

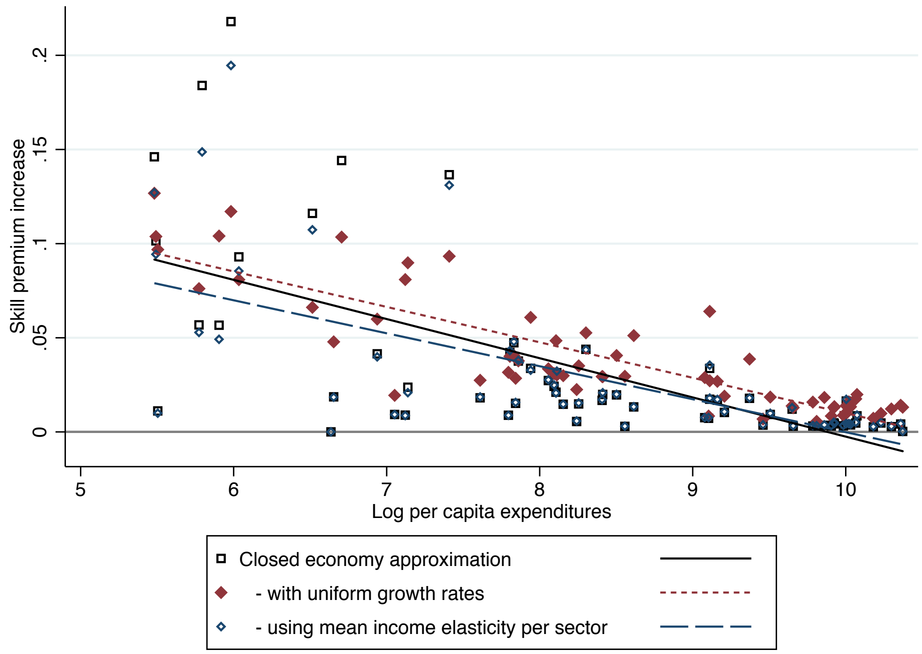
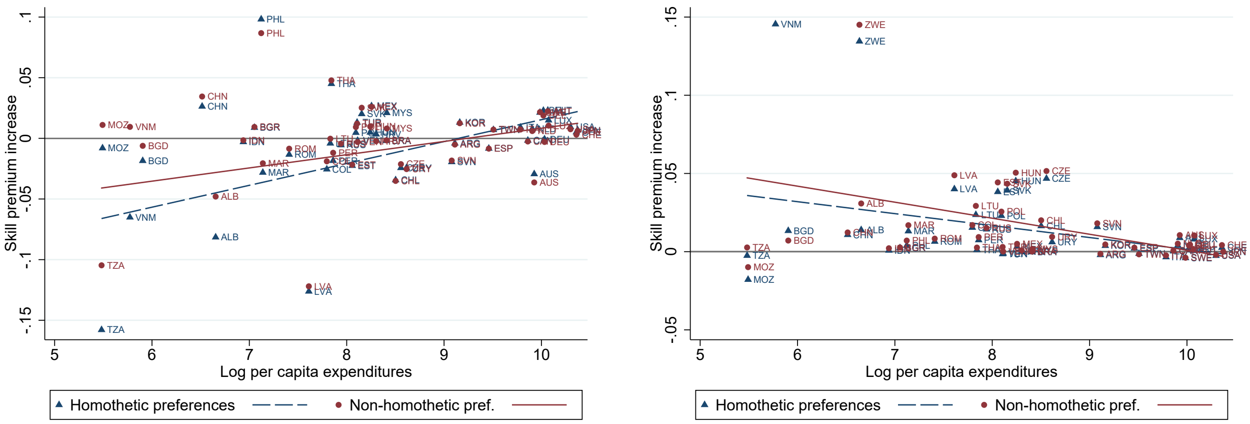


Figure 5: Growth channel. Closed-economy approximations. Effect of heterogenous growth rates and effect of cross-country variations in income elasticity within sectors.



(a) First term: Difference in direct effect

(b) Second term: Difference in final demand effects

Figure 6: Trade channel. Decomposition into the 'direct' and the 'demand' effects of trade cost reductions on the skill premium. For clarity, this figure only displays countries which experienced a reduction in trade costs.

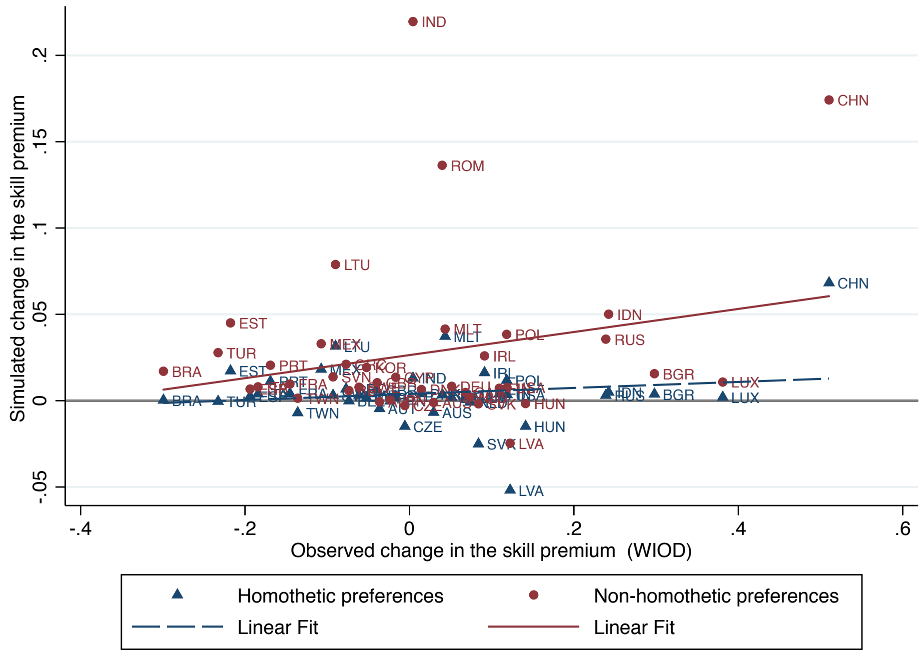


Figure 7: Comparison of observed 1995 to 2010 changes in the skill premium with simulated estimates. Observed changes are from the WIOD dataset. The general equilibrium simulated changes in the skill premium are from the unified counterfactual, i.e caused by observed changes in per capita income and openness to trade. See Table A.5 in appendix for the full set of regression statistics.

Appendix – For online publication

Notation: Summary list. Subscripts n and i refer to countries, k and h refer to industries, f refers to factors of production (in particular, H and L are the two labor inputs).

Endogenous variables (equilibrium outcomes):

D_{nk}	Final demand expenditures in country n, industry k
η_{nk}	Income elasticity of consumption, country n, industry k
X_{nik}	Value of trade from i to n
X_{nk}	Total expenditures in country n, $X_{nk} = \sum_i X_{nik}$
Y_{ik}	Production in country i, $Y_{ik} = \sum_n X_{nik}$
π_{nik}	Share of exporter i in country n's total expenditures, $\pi_{nik} = X_{nik}/X_{nk}$
e_n	per capita income in country n
λ_n	Budget constraint Lagrange multiplier
P_{nk}	CES Price index industry k, country n
Φ_{nk}	Inward multilateral-resistance term, industry k importer n
S_{ik}	Outward multilateral-resistance term, capturing supplier costs
w_{if}	Cost of factor f in country i
c_{ikLab}	Aggregate labor costs in industry k, country i
sh_{ikf}	Share of industry k in factor f employment
β_{ikf}	Share of labor type $f \in \{L, H\}$ in total labor costs

Parameters and exogenous variables:

σ_k	Parameter governing income elasticity
ξ_k	Elasticity of substitution within industry k
α_k	Taste shifters
z_{ik}	Productivity shifters
θ_k	Productivity dispersion and trade elasticity
d_{nik}	Iceberg trade cost from country i to n in industry k
γ_{kh}	Direct input-output coefficient, use of products h by industry k
γ_{kf}	Direct factor use, use of non-labor factor f by industry k
ρ	Elasticity of substitution between skilled and unskilled labor
μ_{kf}	Industry-specific productivity shifter for labor type f
L_i	Population in country i
V_{if}	Endowments of country i in factor f

A) Simulation equations: baseline equilibrium and changes

From the demand equation (5):

$$D_{nk} = L_n(\lambda_n)^{-\sigma_k}\alpha_{2,k}(P_{nk})^{1-\sigma_k}$$

It is easy to obtain the counterfactual change in demand as a function of the change in prices and Lagrange multiplier, which yields Equation (16) in the main text:

$$\widehat{D_{nk}} = \widehat{\lambda_n}^{-\sigma_k}\,\widehat{P_{nk}}^{1-\sigma_k}$$

The change in the Lagrange multiplier is such that total expenditures equal income (Equation 6). This yields Equation (26); the change in total expenditures also equals the change in income:

$$\widehat{e_n} = \frac{\sum_k \widehat{D_{nk}}\,D_{nk}}{\sum_k D_{nk}}$$

Total demand X_{nk} for goods k in country n is the sum of the demand for final consumption D_{nk} and intermediate use (Equation 7). This also holds in the counterfactual equilibrium, which yields:

$$X_{nk}\widehat{X_{nk}} = D_{nk}\widehat{D_{nk}} + \sum_h \gamma_{hk}Y_{nh}\widehat{Y_{nh}}$$

which can then be rewritten as in Equation (18).

Next, using gravity Equation (8) and (9), we directly obtain Equation (19) and Equation (21):

$$\begin{aligned}
\widehat{X_{nik}} &= \widehat{S_{ik}}\,\widehat{d_{nik}}^{-\theta_k}\,\widehat{P_{nk}}^{\theta_k}\,\widehat{X_{nk}} \\
\widehat{S_{ik}} &= \widehat{z_{ik}}^{\theta_k}\,(\widehat{c_{ikLab}})^{-\theta_k\gamma_{kL}}\prod_{f\neq L}(\widehat{w_{if}})^{-\theta_k\gamma_{kf}}\prod_h(\widehat{P_{ih}})^{-\theta_k\gamma_{kh}}
\end{aligned}$$

For the change in labor costs, we have:

$$c_{ikLab}^{1-\rho}\widehat{c_{ikLab}}^{1-\rho} = \mu_{ikL}\,\widehat{w_{iL}}^{1-\rho}w_{iL}^{1-\rho} + \mu_{ikH}\,\widehat{w_{iH}}^{1-\rho}w_{iH}^{1-\rho}$$

Hence:

$$\widehat{c_{ikLab}}^{1-\rho} = \beta_{ikL}\,\widehat{w_{iL}}^{1-\rho} + \beta_{ikH}\,\widehat{w_{iH}}^{1-\rho}$$

which gives Equation (23).

In turn, for price indices, we obtain from Equation (10):

$$\widehat{\Phi_{nk}}\Phi_{nk} = \sum_i \widehat{S_{ik}}S_{ik}(\widehat{d_{nik}})^{-\theta_k}(d_{nik})^{-\theta_k}$$

Hence:

$$\widehat{P_{nk}}^{-\theta_k} = \widehat{\Phi_{nk}} = \frac{\sum_i \widehat{S_{ik}} S_{ik} (\widehat{d_{nik}})^{-\theta_k} (d_{nik})^{-\theta_k}}{\Phi_{nk}} = \sum_i \pi_{nik} \widehat{S_{ik}}\, \widehat{d_{nik}}^{-\theta_k} \tag{A.1}$$

which yields Equation (22) in the text (π_{nik} are import shares).

Given the change in trade flows, Equation (20) then follows from the equality between production and total outward trade for country i sector k:

$$\widehat{Y_{ik}} = \frac{\sum_n X_{nik} \widehat{X_{nik}}}{\sum_n X_{nik}}$$

We can now examine the changes in income and factor prices. From $V_{if} w_{if} = \sum_k \gamma_{kf} Y_{ik}$ and thus $V_{if} w_{if} \widehat{w_{if}} = \sum_k \gamma_{kf} Y_{ik} \widehat{Y_{ik}}$, we obtain for factors other than labor:

$$\widehat{w_{if}} = \sum_k sh_{ifk} \widehat{Y_{ik}}$$

where $sh_{ifk} = \frac{\gamma_{kf} Y_{ik}}{\sum_k \gamma_{kf} Y_{ik}}$ is the share of factor f used in sector k.

Finally, for labor, we have (Equation 13):

$$\beta_{ikl} \;=\; \mu_{kl}\, w_{il}^{1-\rho}\, c_{ikLab}^{\rho-1}$$

and thus:

$$\widehat{\beta_{ikl}} \;=\; \widehat{w_{il}}^{1-\rho}\, \widehat{c_{ikLab}}^{\rho-1}$$

For each type of labor $f \in \{L, H\}$, labor market clearing imposes:

$$V_{if} w_{if} = \sum_k \beta_{ikf} \gamma_{kL} Y_{ik}$$

and thus:

$$\widehat{w_{if}} = \sum_k sh_{ikf} \widehat{\beta_{ikl}} \widehat{Y_{ik}} = \sum_k sh_{ikf} \widehat{w_{if}}^{1-\rho}\, \widehat{c_{ikLab}}^{\rho-1} \widehat{Y_{ik}}$$

where $sh_{ikf} = \frac{\beta_{ikf} \gamma_{kL} Y_{ik}}{V_{if} w_{if}}$ is the share of labor type f employed in sector k. Solving for $\widehat{w_{ikf}}$ as a function of $\widehat{c_{ikLab}}$ and $\widehat{Y_{ik}}$, we obtain Equation (24):

$$\widehat{w_{if}} = \left[\sum_k sh_{ikf}\, \widehat{c_{ikLab}}^{\rho-1} \widehat{Y_{ik}} \right]^{\frac{1}{\rho}}$$

This equation can also be combined with the change in labor costs $\widehat{c_{ikLab}}$, to yield:

$$\widehat{w_{if}}^{\rho} = \sum_k sh_{ikf}\, \widehat{Y_{ik}} \left[\beta_{ikL}\, \widehat{w_{iL}}^{1-\rho} + \beta_{ikH}\, \widehat{w_{iH}}^{1-\rho} \right]^{-1}$$

B) Implications for the skill premium

First, we examine how the skill premium depends on changes in production patterns. A first-order approximation in log, for each $f \in \{L, H\}$, yields:

$$\begin{aligned}
\log \widehat{c_{ikLab}} &\approx \beta_{ikL} \, \log \widehat{w_{iL}} + \beta_{ikH} \, \log \widehat{w_{iH}} \\
\rho \log \widehat{w_{if}} &\approx (\rho - 1) \sum_k sh_{ikf} \, \log \widehat{c_{ikLab}} + \sum_k sh_{ikf} \, \log \widehat{Y_{ik}} \\
&\approx (\rho - 1) \sum_k sh_{ikf} \left[\beta_{ikL} \, \log \widehat{w_{iL}} + \beta_{ikH} \, \log \widehat{w_{iH}}\right] + \sum_k sh_{ikf} \, \log \widehat{Y_{ik}}
\end{aligned}$$

Taking the difference between high- and low-skilled workers, we get the change in the skill premium:

$$\begin{aligned}
\rho \log \frac{\widehat{w_{iH}}}{\widehat{w_{iL}}} &\approx (\rho{-}1) \sum_k (sh_{ik}^H{-}sh_{ik}^L) \left[\beta_{ikL} \log \widehat{w_{iL}} + \beta_{ikH} \log \widehat{w_{iH}}\right] + \sum_k (sh_{ik}^H{-}sh_{ik}^L) \, \log \widehat{Y_{ik}} \\
&\approx (\rho{-}1) \sum_k (sh_{ik}^H{-}sh_{ik}^L) \left[\log \widehat{w_{iL}} + \beta_{ikH} \, \log \frac{\widehat{w_{iH}}}{\widehat{w_{iL}}}\right] + \sum_k (sh_{ik}^H{-}sh_{ik}^L) \, \log \widehat{Y_{ik}} \\
&\approx (\rho{-}1) \sum_k (sh_{ik}^H{-}sh_{ik}^L) \beta_{ikH} \, \log \frac{\widehat{w_{iH}}}{\widehat{w_{iL}}} \; + \sum_k (sh_{ikH}{-}sh_{ikL}) \, \log \widehat{Y_{ik}}
\end{aligned}$$

Hence:

$$\log \frac{\widehat{w_{iH}}}{\widehat{w_{iL}}} \approx \frac{1}{\tilde{\rho}_i} \sum_k (sh_{ik}^H{-}sh_{ik}^L) \, \log \widehat{Y_{ik}} \tag{A.2}$$

where $\tilde{\rho}_i = \rho{-}(\rho{-}1) \sum_k (sh_{ik}^H{-}sh_{ik}^L) \beta_{ikH}$. This relationship between the skill premium and production can then be used in each counterfactual to link the changes in production patterns to changes in the skill premium.

Effect of uniform productivity growth First, without intermediate goods and trade, $\widehat{P_{nk}} \approx \hat{z}^{-1}$ as a first approximation. Holding nominal income constant and using Equation (16), we obtain:

$$\log \widehat{D_{nk}} = -\sigma_k \log \widehat{\lambda_n} \; + \; (\sigma_k - 1) \log \hat{z}$$

Given the constraint on total expenditures provided by (26), we need:

$$0 = \log \widehat{e_n} \approx \frac{\sum_k D_{nk} \, \log \widehat{D_{nk}}}{\sum_k D_{nk}} = \frac{\sum_k D_{nk} \left(-\sigma_k \log \widehat{\lambda_n} \; + \; (\sigma_k - 1) \log \hat{z}\right)}{\sum_k D_{nk}}$$

Solving for $\log \widehat{\lambda_n}$ yields:

$$\log \widehat{\lambda_n} \approx \frac{\sum_k (\sigma_k - 1) D_{nk}}{\sum_k \sigma_k D_{nk}} \log \hat{z}$$

Re-incorporating the solution for $\log \widehat{\lambda_n}$ into the change in demand, we obtain the first-order approximation provided in the text:

$$\log \widehat{D_{nk}} \approx (\eta_{nk} - 1) \log \widehat{z}$$

$\eta_{nk} = \frac{\sigma_k \sum_{k'} D_{nk'}}{\sum_{k'} \sigma_{k'} D_{nk'}}$ is the income elasticity of demand in sector k, country n.

Using Equation (A.2) above, we can then obtain a simple expression for the response of the skill premium $\frac{w_{nH}}{w_{nL}}$ to a productivity increase $\widehat{z}$:

$$\log \frac{\widehat{w_{nH}}}{\widehat{w_{nL}}} \;\approx\; \frac{1}{\tilde{\rho}_i} \log \widehat{z} \;\sum_k (sh^H_{nk} - sh^L_{nk})\, \eta_{nk} \tag{A.3}$$

Next, consider the situation with trade in final and intermediate goods. Under the assumption that the productivity increase $\widehat{z}$ augments factors of production, the change in price $\widehat{P_{nk}}$ still corresponds to $\widehat{z}^{-1}$ when we neglect the feedback effect of wages on prices. One can check that $\widehat{P_{ik}} = \widehat{z}^{-1}$ and $\widehat{S_{ik}} = \widehat{z}^{\theta_k}$ are the solutions to the following system of equations:

$$\begin{aligned}
\widehat{S_{ik}} &= (\widehat{c_{ikLab}}/\widehat{z})^{-\theta_k \gamma_{kL}} \prod_{f \neq L} (\widehat{w_{if}}/\widehat{z})^{-\theta_k \gamma_{kf}} \prod_h (\widehat{P_{ih}})^{-\theta_k \gamma_{kh}} \\
\widehat{P_{nk}} &= \left[\frac{1}{X_{nk}} \sum_i X_{nik} \widehat{S_{ik}}\, \widehat{d_{nik}}^{\,-\theta_k} \right]^{-\frac{1}{\theta_k}}
\end{aligned}$$

Hence relative prices and import shares remain constant (as a first-order approximation).

Equation (19) yields:

$$\widehat{X_{nik}} = \widehat{S_{ik}}\, \widehat{P_{nk}}^{\,\theta_k}\, \widehat{X_{nk}} = \widehat{X_{nk}}$$

For production, we get:

$$Y_{ik} \widehat{Y_{ik}} = \sum_n X_{nik} \widehat{X_{nik}} = \sum_n X_{nik} \widehat{X_{nk}}$$

Finally, using Equation (18), we obtain that the changes in production and demand satisfy:

$$Y_{ik} \widehat{Y_{ik}} \;=\; \sum_n \pi_{nik} D_{nk} \widehat{D_{nk}} + \sum_h \sum_n \pi_{nik}\, \gamma_{hk} Y_{nh}\, \widehat{Y_{nh}}$$

If we denote by G the matrix with coefficients $\pi_{nik}\gamma_{hk}$, by Π the matrix with coefficients $\pi_{nik} 1_{k,h}$ (and where $1_{k,h}$ is a dummy equal to one if $h = k$), by $Y\widehat{Y}$ the vector of production and $D\widehat{D}$ the vector demand, we can write this equality as: $Y\widehat{Y} \;=\; \Pi \,.\, D\widehat{D} + G \,.\, Y\widehat{Y}$, which yields:

$$Y\widehat{Y} \;=\; (\mathrm{I} - G)^{-1} \,.\, \Pi \,.\, D\widehat{D}$$

Denoting by γ^{tot}_{inhh} the coefficients of the matrix $(\mathrm{I} - G)^{-1}\Pi$, we can link changes in output to changes in final demand:

$$\widehat{Y_{ik}} \;=\; \frac{1}{Y_{ik}} \sum_{n,h} \gamma^{tot}_{nihk} D_{nh} \widehat{D_{nh}}$$

Given that we have $Y_{ik} = \sum_{n,h} \gamma^{tot}_{nihk} D_{nh}$, we also have:

$$\widehat{Y_{ik}} - 1 \;=\; \frac{1}{Y_{ik}} \sum_{n,h} \gamma^{tot}_{nihk} D_{nh} (\widehat{D_{nh}} - 1)$$

Then, in log, a first-order approximation yields the two expressions in the text:

$$\begin{aligned} \log \widehat{w_{iH}} - \log \widehat{w_{iL}} &\approx \frac{1}{\tilde{\rho}_i} \sum_{k,h,n} (sh^H_{ik} - sh^L_{ik}) \frac{\gamma^{tot}_{nihk} D_{nh}}{Y_{ik}} \log \widehat{D_{nh}} \\ &\approx \frac{1}{\tilde{\rho}_i} \log \widehat{z} \sum_{k,h,n} (sh^H_{ik} - sh^L_{ik}) \frac{\gamma^{tot}_{nihk} D_{nh}}{Y_{ik}} \eta_{nh} \end{aligned}$$

Effect of a reduction in trade costs. Given Equation A.2, we need to examine how a reduction in trade costs leads to a change in production patterns. Using the following accounting equality (simply stating that production equals domestic demand plus exports minus imports):

$$Y_{ik} = X_{ik} + \Big(\sum_{n \neq i} X_{nk} \pi_{nik}\Big) \;-\; \Big(X_{ik} \sum_{j \neq i} \pi_{ijk}\Big)$$

we obtain, as a first-order approximation in terms of $\log \widehat{\pi}$ and $\log \widehat{X}$:

$$\log \widehat{Y_{ik}} \approx \left[\sum_{n \neq i} \frac{X_{nk} \pi_{nik}}{Y_{ik}} \log \widehat{\pi_{nik}} - \sum_{j \neq i} \frac{X_{ik} \pi_{ijk}}{Y_{ik}} \log \widehat{\pi_{ijk}} \right] + \left[\sum_{n} \frac{X_{nk} \pi_{nik}}{Y_{ik}} \log \widehat{X_{nk}} \right]$$

The first term in brackets captures changes in trade shares π while the second term in brackets captures changes in demand. We will now split each of these two terms in two: i) the changes in trade shares is split as a function of the changes in bilateral trade costs ("direct effect") and changes in multilateral-resistance terms ("MR effect"); ii) in turn, the changes in demand are split into changes in final demand and changes in demand for intermediate goods.

First, regarding trade shares, we can use Equation (19) for bilateral trade and obtain: $\log \widehat{\pi_{nik}} = -\theta_k \log \widehat{d} + \log \widehat{S_{ik}} \widehat{P_{nk}}^{\theta_k}$, assuming a uniform change in trade costs $\log \widehat{d}$. This provides the first two effects.

Second, regarding demand, we can combine Equations (16) and (18) to obtain:

$$\log \widehat{X_{nk}} \approx \frac{D_{nk}}{X_{nk}} \log(\widehat{\lambda_n}^{-\sigma_k} \widehat{P_{nk}}^{1-\sigma_k}) + \sum_h \frac{Y_{nh} \gamma_{hk}}{X_{nk}} \log \widehat{Y_{nh}}$$

These provide the last two terms of the decomposition. Combining all terms, we get:

$$\log \widehat{Y_{ik}} \approx \; - \left[\sum_{n \neq i} \frac{X_{nk} \pi_{nik}}{Y_{ik}} - \sum_{j \neq i} \frac{X_{ik} \pi_{ijk}}{Y_{ik}} \right] \theta_k \log \widehat{d} \; + \left[\sum_{n \neq i} \frac{X_{nk} \pi_{nik}}{Y_{ik}} \log \widehat{S_{ik}} \widehat{P_{nk}}^{\theta_k} - \sum_{j \neq i} \frac{X_{ik} \pi_{ijk}}{Y_{ik}} \log \widehat{S_{jk}} \widehat{P_{ik}}^{\theta_k} \right]$$

$$+\left[\sum_n \frac{D_{nk}\pi_{nik}}{Y_{ik}}\log(\widehat{\lambda_n}^{-\sigma_k}\,\widehat{P_{nk}}^{1-\sigma_k})\right]+\left[\sum_{n,h}\frac{Y_{nh}\gamma_{hk}\pi_{nik}}{Y_{ik}}\log\widehat{Y_{nh}}\right]$$

Note that the first term in brackets coincides with net exports relative to production:

$$\sum_{n\neq i}\frac{X_{nk}\pi_{nik}}{Y_{ik}}-\sum_{j\neq i}\frac{X_{ik}\pi_{ijk}}{Y_{ik}}=\frac{NX_{ik}}{Y_{ik}}$$

Reordering, and plugging this four-term decomposition of output into Equation (A.2), we obtain the four-term decomposition proposed in the main text, Equations (31) to (34):

$$\begin{aligned}
\log\left(\widehat{\frac{w_{iH}}{w_{iL}}}\right) \approx\ & -\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\,\theta_k\,\frac{NX_{ik}}{Y_{ik}}\,\log\hat{d}\\
& +\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\sum_n \frac{D_{nk}\pi_{nik}}{Y_{ik}}\,\log\left(\widehat{\lambda_n}^{-\sigma_k}\widehat{P_{nk}}^{1-\sigma_k}\right)\\
& +\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\sum_{n,h}\frac{Y_{nh}\gamma_{hk}\pi_{nik}}{Y_{ik}}\,\log\widehat{Y_{nh}}\\
& +\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\Big[\sum_n \frac{X_{nk}\pi_{nik}}{Y_{ik}}\log(\widehat{S_{ik}}\widehat{P_{nk}}^{\theta_k})-\sum_j\frac{X_{ik}\pi_{ijk}}{Y_{ik}}\log(\widehat{S_{jk}}\widehat{P_{ik}}^{\theta_k})\Big]
\end{aligned}$$

These four terms are respectively what we call the direct effect, the effect on final demand, the effect of input-output linkages, and the adjustment in multilateral-resistance terms.

To obtain equation (35) in the case where $\theta_k=\theta$ is homogeneous across industries, notice that the net content of trade NCT_f in labor type $f\in\{H,L\}$ relative to its supply is given by:

$$\frac{NCT_{if}}{V_{if}}=\frac{1}{w_{if}V_{if}}\sum_k \beta_{ikf}\gamma_{kLab}(Y_{ik}-X_{ik})=\sum_k sh_{ikf}\,\frac{NX_{ik}}{Y_{ik}}$$

Finally, consider a more general case where the change in bilateral trade cost is not uniform, but instead is given by the change in exporter-specific border effect $\widehat{B}_{ik}$ as we impose in our simulations, such that we now have $\log\widehat{\pi_{nik}}=\log\widehat{B_{ik}}+\log\widehat{S_{ik}}\widehat{P_{nk}}^{\theta_k}$. The change in the skill premium is then:

$$\begin{aligned}
\log\left(\widehat{\frac{w_{iH}}{w_{iL}}}\right) \approx\ & -\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\left[\sum_n \frac{X_{nk}\pi_{nik}}{Y_{ik}}\,\log\widehat{B_{ik}}-\sum_j\frac{X_{ik}\pi_{ijk}}{Y_{ik}}\,\log\widehat{B_{jk}}\right]\\
& +\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\sum_n \frac{D_{nk}\pi_{nik}}{Y_{ik}}\,\log\left(\widehat{\lambda_n}^{-\sigma_k}\widehat{P_{nk}}^{1-\sigma_k}\right)\\
& +\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\sum_{n,h}\frac{Y_{nh}\gamma_{hk}\pi_{nik}}{Y_{ik}}\,\log\ \widehat{Y_{nh}}\\
& +\frac{1}{\tilde{\rho}_i}\sum_k (sh^H_{ik}-sh^L_{ik})\Big[\sum_n \frac{X_{nk}\pi_{nik}}{Y_{ik}}\log(\widehat{S_{ik}}\widehat{P_{nk}}^{\theta_k})-\sum_j\frac{X_{ik}\pi_{ijk}}{Y_{ik}}\log(\widehat{S_{jk}}\widehat{P_{ik}}^{\theta_k})\Big]
\end{aligned}$$

C) Estimation strategy

Step 1: Gravity equation estimation and identification of Φ_{nk}

As described in the text, the model yields Equation (37):

$$X_{nik} = \exp\left[FX_{ik} \ + \ FM_{nk} \ - \ \sum_{var} \beta_{var,k} TC_{var,ni} \ - \ \beta_{border,ik}\delta_{n\neq i} \ + \ \varepsilon^{G}_{nik}\right] \tag{A.4}$$

In this equation, importer fixed effects correspond to $\log \frac{X_{nk}}{\Phi_{nk}}$ and exporter fixed effects correspond to $\log S_{ik}$. These terms are identified up to an industry constant (e.g. α_k in preferences). We normalize the exporter fixed effect $S_{US,k}$ to unity in each sector k.

$TC_{var,ni}$ refers to the variables (indexed by var) included in the gravity equation to capture trade costs between n and i. Following the literature on gravity, we include the log of physical distance (including internal distance when $i = n$), a common language dummy, a colonial link dummy, a border effect dummy (equal to one if $i \neq n$), a contiguity dummy (equal to one if countries i and n share a common border), a free-trade-agreement dummy (equal to one if there is an agreement between countries i and n), a common currency dummy and a common-legal-origin dummy (equal to one if i and n have the same legal origin: British, French, German, Scandinavian or socialist). Parameters $\delta_{var,k}$ capture the elasticity of trade costs to each trade cost variable var, which may differ across industries. Since all coefficients to be estimated are sector specific, we estimate this gravity equation separately for each sector. Following Silva and Tenreyro (2006) and Fally (2015), we estimate gravity using the Poisson pseudo-maximum likelihood estimator (Poisson PML).

Table A.1: Coefficients from the gravity equation estimations.

Trade cost variable:	Mean across sectors	Standard Deviation across sectors
Distance (log)	-0.802	0.731
Contiguity	0.124	1.511
Common language	0.022	0.791
Colonial link	-0.016	0.845
Both access to sea	0.244	1.185
RTA	0.430	2.117
Common currency	0.641	3.920
Common legal origin	0.400	1.723
Exporter border effects	Yes	
Exporter FE	Yes	
Importer FE	Yes	
Nb. of industries	55	
Pseudo-R2 (incl. domestic)	0.999	
Pseudo-R2 (excl. domestic)	0.973	

Notes: Poisson regressions; dependent variable: trade flows. The coefficients above are estimated separately for each industry. Pseudo-R2 equal the square of the correlation coefficient between fitted and observed trade flows, including or excluding domestic flows.

We then use Equation (10), $\Phi_{nk} = \sum_i S_{ik}(d_{nik})^{-\theta_k}$, to construct Φ_{nk}. The exporter fixed effects $\widehat{FX}_{ik}$) provide estimates for $\log S_{ik}$ while $\sum_{var} \widehat{\beta}_{var,k} TC_{var,ni}$ yields an estimate of trade cost d_{nik} multiplied by its elasticity for each sector and each country pair: $\theta_k \log d_{nik}$.

$$\widehat{\Phi}_{nk} \quad = \quad \sum_i \exp\left(\widehat{FX}_{ik} - \sum_{var} \widehat{\beta}_{var,k} TC_{var,ni} - \ \widehat{\beta}_{border,ik}\delta_{n\neq i}\right) \tag{A.5}$$

This constructed $\widehat{\Phi}_{nk}$ varies across industries and countries in an intuitive way. It is the sum of all potential exporters' fixed effects (reflecting unit costs of production) deflated by distance and other trade cost variables. If country n is close to an exporter that has a comparative advantage in industry k, i.e. an exporter associated with a large exporter fixed effect FX_{ik} (large S_{ik}), our constructed $\widehat{\Phi}_{nk}$ will be relatively larger for this country, reflecting a lower price index of goods from industry k in country n. Note that $\widehat{\Phi}_{nk}$ also accounts for domestic supply in each industry k (when $i = n$).

Step 2: Demand system estimation and identification of σ_k

The first step estimation gives us an estimate of Φ_{nk}. From Equation (11), we know that the price index P_{nk} is a log-linear function of Φ_{nk} which we can use as a proxy for P_{nk} on the right-hand side of Equation (36) describing final demand.[43]

As described in the text, we estimate Equation (39) for final demand:

$$\log x_{nk} = -\sigma_k. \log \lambda_n + \log \alpha_{3,k} + \frac{(\sigma_k - 1)}{\theta_k} \log \widehat{\Phi}_{nk} + \varepsilon^D_{nk} \tag{A.6}$$

where ε^D_{nk} denotes the error term. In each country n, we further impose the sum of fitted expenditures across sectors to equal observed total per capita expenditures e_n, which leads to the following constraint:

$$\sum_k \exp\left[-\sigma_k. \log \lambda_n + \log \alpha_{3,k} + \frac{(\sigma_k - 1)}{\theta_k} \log \widehat{\Phi}_{nk}\right] = e_n \tag{A.7}$$

We jointly estimate these equations using constrained non-linear least squares (we minimize the sum of squared errors $(\varepsilon^D_{nk})^2$ while imposing that both equations 39 and A.7 hold). Observed variables are: the price proxies $\widehat{\Phi}_{nk}$, individual expenditures x_{nk} per industry (net of intermediate goods) and total expenditures e_n. Free parameters to be estimated are the σ_k, θ_k, λ_n and $\alpha_{3,k}$. This estimation procedure can be seen as a non-linear least squares estimation of Equation (39) in which λ_n is the implicit solution of the budget constraint, Equation (A.7), and thus a function of fitted coefficients and observed per capita expenditures e_n.

At least one normalization is required. Given the inclusion of industry fixed effects, λ_n can be identified only up to a constant.[44] We normalize $\lambda_{USA} = 1$ for the US.

[43] In Caron et al. (2014), we show that this approach yields better and more conservative outcomes than using actual prices from the International Comparison Program. Using actual prices leads to a lower R-squared and a stronger correlation between income elasticity and skill intensity across sectors.

[44] To see this, we can multiply λ_n by a common multiplier λ' and multiply the industry fixed effect α_k by $(\lambda')^{\sigma_k}$. Using $\lambda_n\lambda'$ instead of λ_n and $\alpha_k(\lambda')^{\sigma_k}$ instead of α_k in the demand system generates the same expenditures by industry.

D) Alternative specifications in the estimation of income elasticities

We explore several alternative specifications to illustrate the robustness of our income elasticity estimates:

Specification without budget constraint In our baseline estimation, we constrain our fitted per capita expenditures to sum up to observed per capita total expenditures e_n for each country. In other words, we assume that e_n is observed without measurement errors. However, we obtain similar estimates without this constraint, as illustrated in Figure A.1 below.

Given our good fit for final demand at the country-by-sector level, the fit of total expenditures for each country is then also very good. The difference is negligible if we compare it to the very large variations in per capita income across countries. Hence, imposing a perfect fit for e_n does not generate substantial differences in our estimates.

Reduced-form estimation While our estimation procedure is consistent with general equilibrium conditions and our specification of preferences, we show that similar estimates are found when estimating Equation (39) with a reduced-form approximation in which $\log \lambda_n$ is replaced by a linear function of $\log e_n$. Assuming that $\log \lambda_n \approx \nu \log e_n$, we obtain:

$$\log x_{nk} = -\sigma_k \nu \log e_n + \log \alpha_{4,k} + \frac{1-\sigma_k}{\theta_k}. \log \Phi_{nk} + \epsilon_{nk} \tag{A.8}$$

where $\log \alpha_{4,k}$ and ν are constant terms. Even if ν is not separately identified from σ_k, we can obtain an estimate of income elasticities in each sector:

$$\eta_{nk} = \frac{\widehat{\sigma_k \nu} \sum_{k'} x_{nk'}}{\sum_{k'} \widehat{\sigma_k' \nu} x_{nk'}} \tag{A.9}$$

We report our estimates in Figure A.1.

Specification with $\theta_k = 4$ The benchmark specification described above identifies σ_k and income elasticities solely based on the coefficient associated with the Lagrange multiplier λ_n. The σ_k parameter also appears in the coefficient for Φ_{nk} in Equation (39) but the benchmark specification does not impose any constraint on the coefficient for Φ_{nk} since θ_k is a free parameter. In an alternative estimation, we jointly identify σ_k from the coefficients on λ_n and Φ_{nk} by constraining θ_k to equal 4 in all sectors. This choice of θ is close to the Simonovska and Waugh (2014) estimates of 4.12 and 4.03. Donaldson (2018), Eaton et al. (2011), Costinot et al. (2012) provide alternative estimates that range between 3.6 and 5.2. Figure A.1 reveals that the resulting income elasticity are well correlated (at 79.9%) with our benchmark estimates, though differences are significant for particular sectors. In the next section, we incorporate these estimates in the general equilibrium model to test the sensitivity of skill premium estimates.

Alternative values for θ (e.g. $\theta_k = 8$) yield similar results for income elasticities.

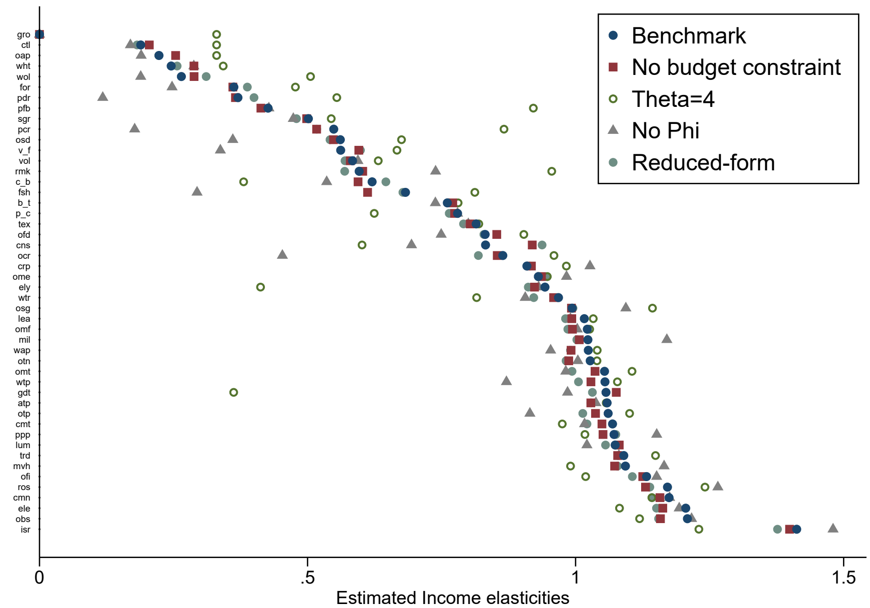


Figure A.1: Income elasticities across alternative specifications in the estimation of CRIE preferences.

Instrumenting or dropping $\log \widehat{\Phi}_{nk}$ Figure A.2 illustrates an alternative estimation of income elasticities where $\log \widehat{\Phi}_{nk}$ is instrumented by an alternative measure constructed using foreign exporter fixed effects only. Instead of taking the sum of fixed effects across all countries as in the text (including own market), we construct as an instrument $\widehat{\Phi}_{nk}^{IV}$ by taking the sum across foreign countries only:

$$\widehat{\Phi}_{nk}^{IV} = \sum_{i \neq n} \exp\left(\widehat{FX}_{ik} - \sum_{var} \widehat{\beta}_{var,k} TC_{var,ni} - \ \beta_{border,ik}\right)$$

Figure A.2 indicates that the two approaches yield very similar estimates with the exception of a few small sectors ("wol": wool, "c_b" cane and beet sugar, "pdr": rice).

To illustrate how controlling for trade costs matters, we also estimate final demand by dropping $\log \widehat{\Phi}_{nk}$ from the regression. This is equivalent to assuming that there are no trade costs and that all countries face the same prices. In this specification, we find even larger differences in estimated income elasticity, as illustrated in Figure A.1. These estimates are correlated at 94.6% with our baseline estimates.

Preferences as in Comin, Lashkari and Mestieri (2016). Following Comin et al. (2016), we examine a specification where utility U_n for consumers in country n is implicitly defined by:

$$\sum_k \alpha_k^{\frac{1}{\sigma}} U_n^{\frac{\epsilon_k - \sigma}{\sigma}} Q_{nk}^{\frac{\sigma-1}{\sigma}} = 1$$

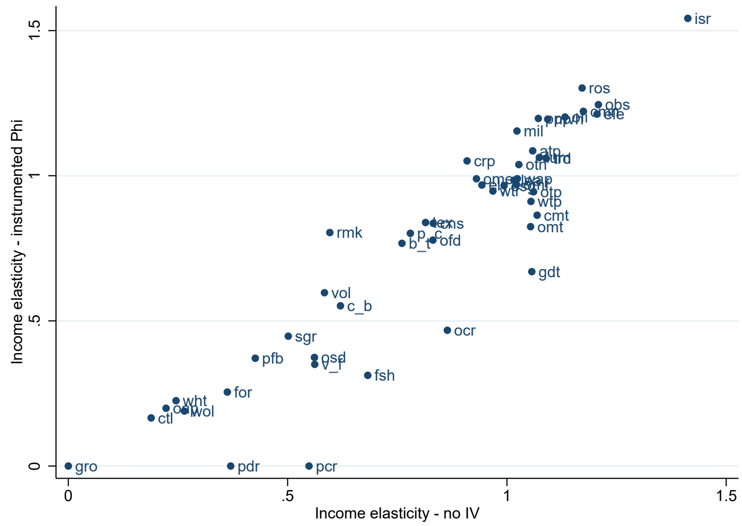


Figure A.2: Income elasticities estimated with and without instrumenting Φ (with Φ's constructed ignoring domestic supplier effects). Correlation is 0.923.

This leads to final demand:

$$x_{nk} = \alpha_k e_n^{\sigma} U_n^{\epsilon_k - \sigma} P_{nk}^{1-\sigma} \tag{A.10}$$

This implicit utility function does not impose any link between income elasticities (parameterized by ϵ_k) and price elasticities (σ), unlike separable utility functions where income elasticities are proportional to price elasticities across sectors for any country.

We estimate Equation (A.10) by letting U_n be a free parameter. An alternative (as in Comin et al 2016) would be to construct a proxy for U_n, which would be roughly equivalent to the reduced-form approach discussed above (estimation Equation A.8).[45] We impose a value $\theta_k = 4$ for this specification, and estimate the elasticity of substitution between sectors.

Using these estimates, the income elasticity can be retrieved as:

$$\eta_{nk} = 1 + (1-\sigma)\frac{\epsilon_k - \bar{\epsilon}_n}{\bar{\epsilon}_n - \sigma}$$

where $\bar{\epsilon}_n$ is an average of ϵ_k weighted by consumption shares to ensure that the weighted average of income elasticities equals one for each country n (Engel aggregation).

Figure A.3 compares these estimates to our baseline specification, using average expenditures to compute $\bar{\epsilon}_n$. The two sets of estimates are very close and correlated at 88.7%. Our estimated elasticity of substitution is equal to 0.85, which is in line with Comin et al's (2016) own estimates (0.8 and 0.6 with cross-section and panel data). Moreover, the income elasticities estimated with Comin et al (2016) preferences remain highly correlated with skill intensity in production (78.1% correlation).

[45] One can see from the definition of U above that we can rescale with any exponent $U' = U^a$, hence $(\epsilon_i - \sigma)$ is defined only up to a constant term. However, the income elasticity in CLM can still be identified as it is invariant to re-scaling utility by an exponent a.

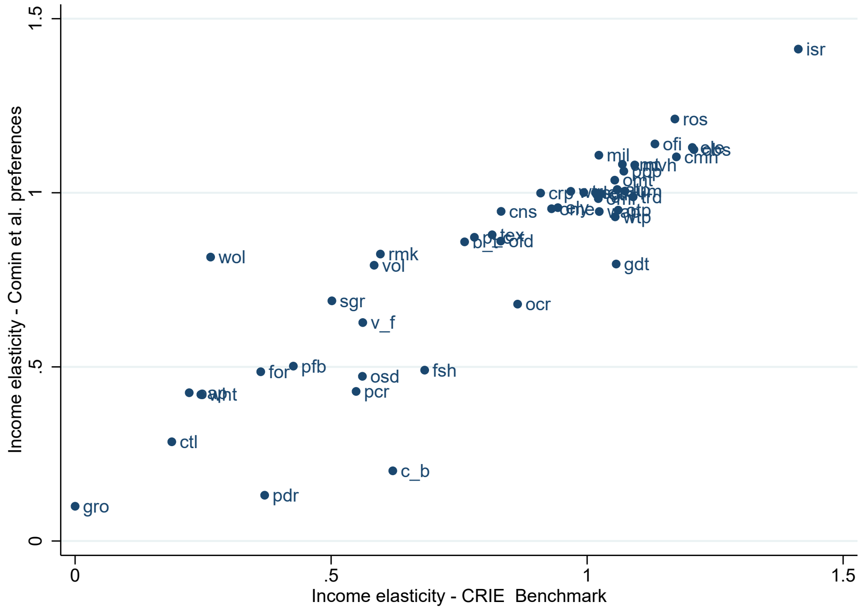


Figure A.3: Estimated income elasticities based Comin et al. (2016) preferences compared to benchmark CRIE preferences.

E) Robustness checks for the general equilibrium estimates

Elasticity of substitution between skilled and unskilled workers Using our analytical approximations, it is fairly straightforward to predict the role of alternative elasticities on the effect of productivity and trade. Relative to the Cobb-Douglas specification ($\rho = 1$), the change in the skill premium is scaled by a ratio of 1 over $\tilde{\rho}_i = \rho - (\rho - 1)\sum_k (sh^H_{ik} - sh^L_{ik})\beta_{ikH}$. We find that this adjustment provides a very good approximation of actual simulation results with higher elasticities as long as the changes are not too large. It can therefore be used to quickly identify the sensitivity of results to ρ.

For instance, for the baseline counterfactual, we compare results with $\rho = 1.4$ (as in our benchmark calibration) and $\rho = 1.7$, after multiplying the skill premium increase by $\tilde{\rho}_i = \rho - (\rho - 1)\sum_k (sh^H_{ik} - sh^L_{ik})\beta_{ikH}$. Elasticities of substitution between 1.4 and 1.7 imply values of $\tilde{\rho}_i$ between 1.3 and 1.6. We find there to be virtually no difference between simulations once we account for the $\tilde{\rho}_i$ adjustment (correlation of 0.999, mean difference 3.4%). Also, the effects of growth and trade remain sizeable across this range of elasticities.

Homogeneous trade elasticity $\theta_k = 4$ Our baseline simulations rely on sector-specific estimates of θ_k which we recover from the estimation of preferences of Equation (39). As documented in Appendix D above, imposing homogeneous trade elasticity $\theta_k = 4$ yields income elasticity estimates which are at 79% correlated with our benchmarks estimates and remain well correlated with skill intensity. Figure A.4 replicates our main simulation and finds similar results for the changes in the skill premium with these alternative preference estimates.

Note also that our estimated θ_k are slightly correlated with income elasticity (11% correlation), but this correlation is not crucial for our results.

Alternative measures of skill and unskilled labor intensity While the GTAP dataset provides skilled and unskilled labor usage for all countries, part of this information is extrapolated from a subset of European countries and six non-European countries (US, Canada, Australia, Japan, Taiwan and South Korea).[46] Also, skilled labor is defined on an occupational basis for a few of these countries (e.g. the US). In our baseline analysis, we thus use a cross-country average of skilled labor and unskilled labor intensity ($\bar{\beta}_{kL}$ and $\bar{\beta}_{kH}$) in Equation (23) to solve for the counterfactual change in wages. Our results are however not very sensitive to this choice. Figure A.4 displays results from the unified growth and trade counterfactual obtained using the country-specific shares of skilled labor provided by GTAP (β_{ikL} and β_{ikH}) in Equation 23. Resulting changes in the skill premium are higher in some low-income countries but overall similar. The robustness of results is due to the strong correlation of income elasticities with the country-specific measures of skill intensity of most countries, as documented in Caron et al. (2014).

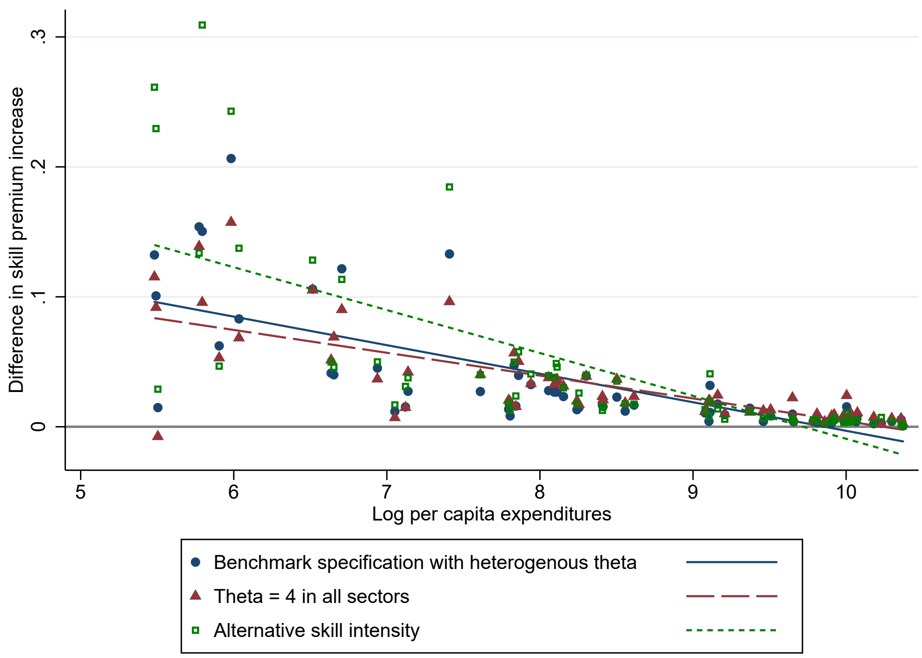


Figure A.4: Alternative specifications for the unified counterfactual (skill premium caused by 1995 to 2010 changes in real per capita income and openness to trade across); non-homothetic to homothetic difference. "Alternative skill intensity" corresponds to the use of country-specific skill intensity coefficients.

[46]See: https://www.gtap.agecon.purdue.edu/resources/download/4183.pdf

Price elasticity and Comin et al (2016) implicitly-additive preferences We integrate preferences as in Comin et al (2016) described above into the general equilibrium model. This yields the following counterfactual equilibrium conditions for final demand. Taking change ratios of final demand (Equation A.10), we obtain:

$$\widehat{D}_{nk} = \widehat{e_n}^{\sigma} \widehat{U_n}^{\epsilon_k - \sigma} \widehat{P}_{nk}^{1-\sigma}$$

Like the Lagrange multiplier with CREI preferences, the change $\widehat{U_n}$ is constrained by consumers' budget, which yields:

$$\widehat{e}_n = \frac{1}{L_n e_n} \sum_k D_{nk} \widehat{D}_{nk} = \frac{1}{L_n e_n} \sum_k D_{nk} \widehat{e}_n^{\sigma} \widehat{U_n}^{\epsilon_k - \sigma} \widehat{P}_{nk}^{1-\sigma}$$

These two equations allow us to determine $\widehat{D}_{nk}$ and $\widehat{U}_n$ depending on other outcome variables (changes in income $\widehat{e}_n$ and prices $\widehat{P}_{nk}$) and estimated parameters.

Simulation results for the unified counterfactual fitting changes in both productivity and trade are plotted in Figure A.5.

As argued by Cravino and Sotelo (2018), lower elasticity of substitution between sectors leads to larger skill premium increases with both types of preferences, yet the difference between non-homothetic and homothetic preferences remains large, if not larger with Comin et al's (2016) implicitly-additive specification.

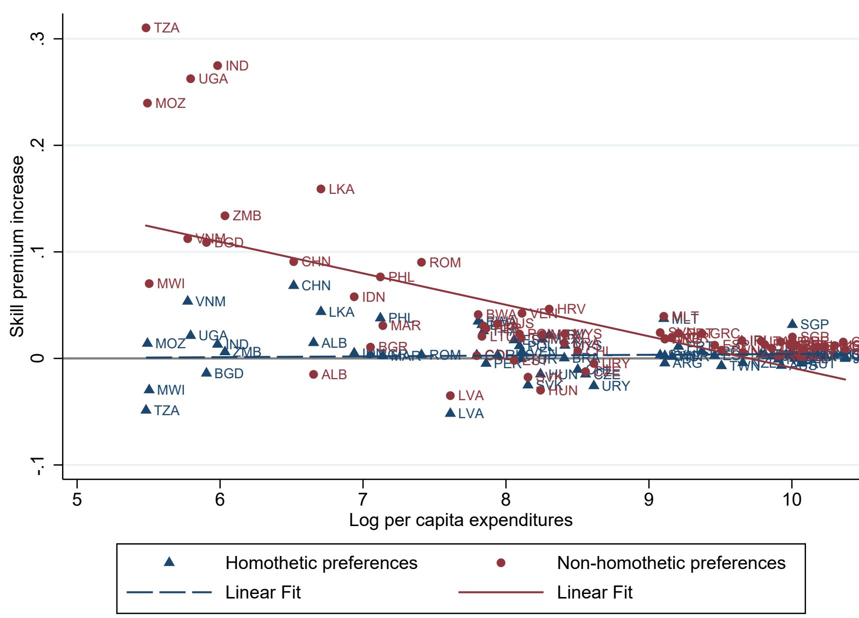


Figure A.5: Simulated estimates of changes in the skill premium caused by 1995 to 2010 changes in real per capita income and openness to trade – based on Comin et al (2016) preferences.

F) Using a more recent version of the GTAP data (version 8 based on year 2007)

While our benchmark empirical and simulation results are obtained using GTAP5, which is based on 1997 data from the beginning of our 1995-2010 simulation period, we would obtain very similar results if using the more recent GTAP8 dataset based on year 2007.[47] We indeed find that skill intensity is also very strongly correlated with income elasticity in the GTAP8 data, as described in Table A.2. The correlation is also above 50% even if we control for capital intensity and natural resource intensity or if we exclude services.

We also confirm that the simulated responses of the skill premium to productivity growth and changes in trade costs yield similar patterns. In particular, Figure A.6 displays the simulated elasticity of the skill premium to productivity growth, using the GTAP8 data to calibrate the model. For the set of countries also included in GTAP5, these results are close to what we obtained in Figure 5. On average, results appear stronger with GTAP8 data mainly because it includes more low-income countries, for which our demand-driven mechanisms are the strongest.

Table A.2: Correlation between income elasticity and skill intensity, using GTAP8 data (2007)

Dependent variable:	Income elasticity			
	(1)	(2)	(3)	(4)
	All sectors	All sectors	Excl. services	Excl. services
Skill intensity	0.583	0.546	0.613	0.660
	[0.108]**	[0.114]**	[0.126]**	[0.154]**
Capital intensity		0.177		-0.033
		[0.200]		[0.274]
Natural resource Intensity		-0.045*		0.138
		[0.021]		[0.255]
Observations (sectors)	55	55	43	43

Notes: Dependent variable: income elasticity by sector evaluated using average expenditures; beta coefficients; robust standard errors in brackets; * significant at 5%; ** significant at 1%.

[47] As noted earlier, comparisons to more recent GTAP version 9 data are difficult due to the change in labor types.

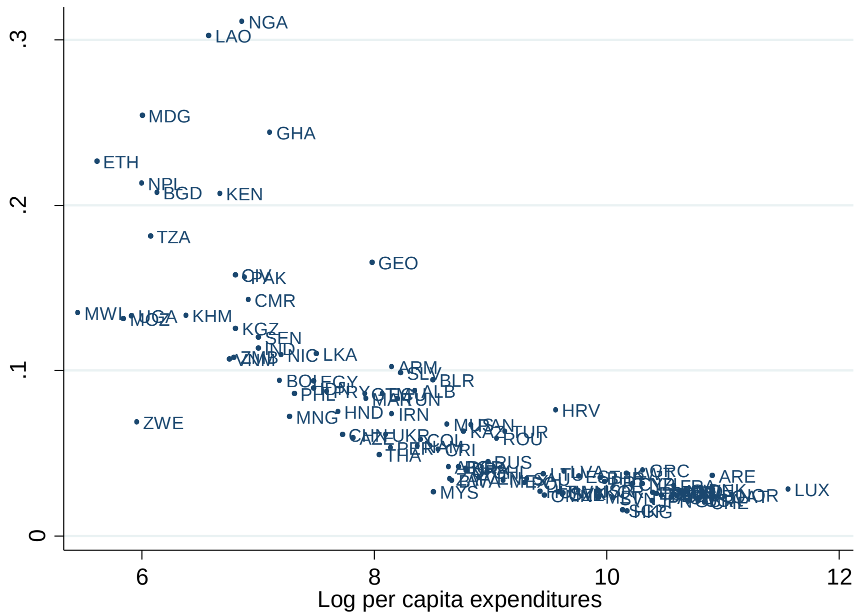


Figure A.6: Simulated elasticity of the skill premium to TFP, estimated using GTAP8 data (2007).

G) Additional tables and graphs

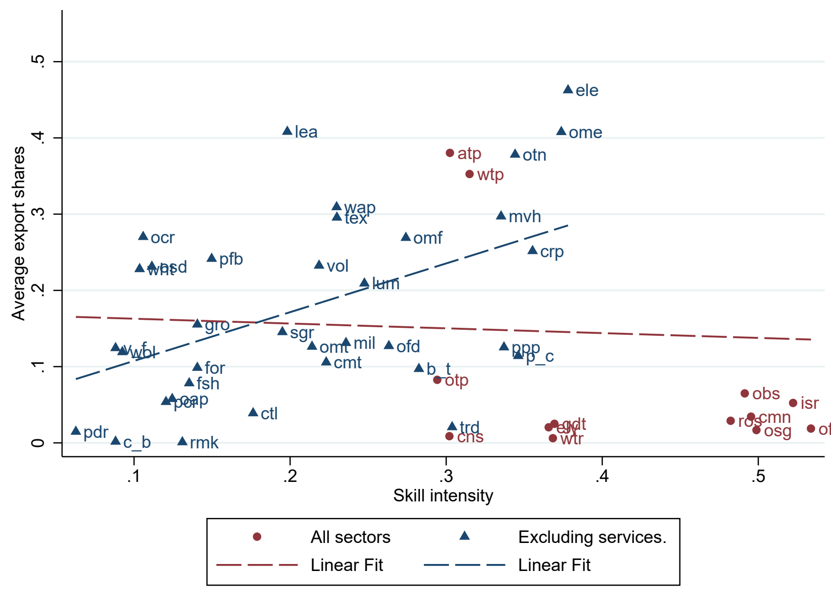


Figure A.7: Correlation between average export shares and skill intensity across sectors.

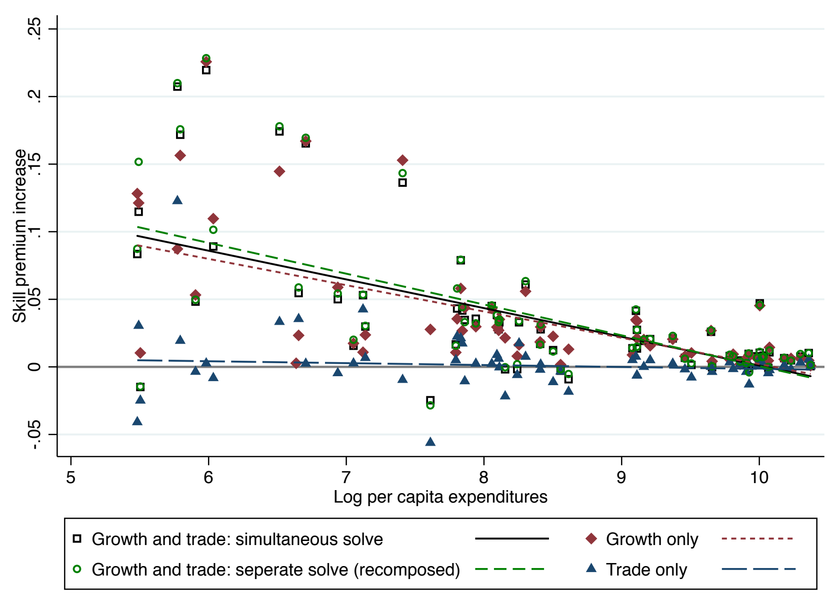


Figure A.8: 1995 to 2010 changes in the skill premium: simultaneous changes in productivity and trade, decomposition into growth and trade, comparison to recomposed growth + trade estimates. Results based on non-homothetic preferences. For clarity, Zimbabwe (ZWE) is dropped (values < -0.1).

Table A.3: 1995-2010 percentage changes in productivity, trade cost shocks and implied changes in the simulated skill premium. General equilibrium unified counterfactual.

	Targeted changes		Calibrated changes		Simulated skill premium		
	Real income	Export/GDP	Productivity	Trade costs	Growth & trade	Growth	Trade
ALB	113.0	200.7	38.9	-197.3	5.5	2.3	3.5
ARG	54.5	44.0	52.7	-10.3	2.7	3.4	-0.6
AUS	41.6	81.6	31.7	-67.0	-0.1	0.9	-1.3
AUT	37.6	53.6	26.8	-9.2	-0.1	0.5	-0.5
BEL	38.9	25.2	26.0	-11.7	0.6	0.5	0.2
BGD	58.7	103.1	54.5	-48.8	4.8	5.3	-0.4
BGR	51.9	189.9	47.7	-48.1	1.6	1.7	0.3
BRA	58.3	69.9	56.9	-31.1	1.7	1.8	-0.2
BWA	78.9	-24.8	105.0	195.2	4.3	3.6	2.2
CAN	24.3	20.9	19.0	-12.9	0.5	0.2	0.2
CHE	39.4	35.3	29.6	-19.5	1.0	0.5	0.5
CHL	70.3	85.5	48.4	-105.9	1.2	2.3	-1.1
CHN	175.1	149.8	175.5	-85.7	17.4	14.5	3.3
COL	37.8	92.9	28.0	-68.2	1.7	1.1	0.5
CYP	51.7	-49.7	63.8	54.5	1.4	2.1	-0.6
CZE	41.2	221.4	9.9	-94.4	-0.3	0.2	-0.3
DEU	36.1	67.1	27.5	-27.7	0.8	0.7	0.1
DNK	39.9	10.0	36.9	3.8	0.6	0.6	0.1
ESP	58.4	31.7	52.8	-19.6	0.7	0.8	-0.2
EST	117.5	85.6	81.4	-62.1	4.5	4.3	0.2
FIN	55.5	-3.8	55.5	15.6	0.7	0.9	-0.2
FRA	38.9	5.7	37.2	9.1	1.0	0.8	0.2
GBR	32.9	13.5	29.5	0.7	1.0	0.5	0.6
GRC	47.4	30.0	46.1	6.2	2.1	2.0	0.2
HKG	52.9	22.4	48.2	12.7	0.5	0.6	-0.2
HRV	84.7	17.3	83.4	-3.0	6.1	5.6	0.8
HUN	62.6	197.5	24.5	-98.2	-0.2	0.8	-0.6
IDN	70.5	33.7	69.2	-22.5	5.0	5.9	-0.5
IND	167.9	47.0	186.2	29.6	22.0	22.6	0.3
IRL	84.7	-6.6	87.7	0.2	2.6	2.7	0.0
ITA	24.1	29.7	19.7	-3.4	0.8	0.6	0.3
JPN	5.7	52.8	1.9	-1.2	0.0	0.1	0.0
KOR	70.3	78.7	62.6	-24.7	1.9	2.0	0.0
LKA	99.9	-26.1	139.3	66.9	16.5	16.7	0.2
LTU	149.0	256.4	116.8	-65.0	7.9	5.8	2.1
LUX	57.8	27.6	42.9	-21.4	1.1	1.4	-0.2
LVA	120.8	163.4	65.9	-131.9	-2.5	2.8	-5.6
MAR	37.0	78.5	26.4	-57.1	3.0	2.4	0.7
MEX	48.7	64.1	42.3	-43.1	3.3	1.6	1.7
MLT	71.6	-17.3	85.6	14.7	4.1	3.5	0.8
MOZ	122.8	148.9	97.8	-70.2	11.5	12.1	3.0
MWI	19.5	28.4	11.5	7.1	-1.5	1.0	-2.5
MYS	70.1	9.6	67.9	-2.1	2.8	3.0	0.2
NLD	51.7	43.1	36.8	-21.0	0.2	0.6	-0.4
NZL	28.4	20.5	23.5	3.5	0.0	0.4	-0.4
PER	106.5	110.0	99.7	-88.2	3.5	4.4	-1.1
PHL	25.9	51.8	11.0	-19.8	5.3	1.1	4.3
POL	94.5	154.9	78.2	-79.5	3.8	2.9	0.9
PRT	56.4	7.1	54.5	2.0	2.1	1.6	0.5
ROM	147.9	102.3	146.4	-53.0	13.6	15.3	-1.0
RUS	64.1	89.9	55.5	-52.3	3.6	3.0	0.2
SGP	145.3	-29.9	166.4	32.0	4.7	4.5	0.0
SVK	81.2	222.1	49.2	-88.0	-0.2	2.1	-2.2
SVN	43.4	71.7	26.1	-41.6	1.4	0.9	0.5
SWE	41.2	21.4	36.6	-1.4	0.8	0.6	0.1
THA	64.2	61.8	53.3	-34.6	4.2	2.7	1.7
TUR	56.4	107.2	43.5	-57.0	2.8	2.7	0.6
TWN	54.2	24.3	50.1	-0.3	0.1	1.0	-0.8
TZA	121.6	53.2	115.3	-40.0	8.3	12.8	-4.1
UGA	64.5	-18.0	89.3	93.9	17.2	15.6	1.9
URY	43.2	76.8	25.9	-57.9	-0.9	1.3	-1.8
USA	25.1	37.7	22.7	-1.0	0.8	0.6	0.3
VEN	105.5	-0.5	104.2	-8.9	3.3	3.5	0.0
VNM	162.3	156.2	74.7	-218.6	20.7	8.7	12.3
ZMB	116.1	17.9	115.0	12.3	8.9	11.0	-0.8
ZWE	44.2	251.1	0.0	-209.1	-12.4	0.3	-13.1

Table A.4: Correlation between income elasticity and total skill intensity

Dependent variable:	Income elasticity			
	(1) All sectors	(2) All sectors	(3) Excl. services	(4) Excl. services
Skill intensity	0.773	0.428	0.723	0.407
	[0.085]**	[0.133]**	[0.099]**	[0.172]*
Capital intensity		-0.015		-0.044
		[0.069]		[0.094]
Natural resource intensity		-0.461		-0.429
		[0.157]**		[0.207]*
Observations (sectors)	49	49	36	36

Notes: Dependent variable: income elasticity by sector evaluated using average expenditures; Factor intensities correspond to the ratio of each factor to total labor input including factors required to produce intermediate inputs to each final good; The table displays beta regression coefficients; Robust standard errors in brackets; * significant at 5%; ** significant at 1%; In Caron et al. (2014), we find that robust standard errors are very close to bootstrap standard errors constructed by resampling importers and sectors in all steps of the estimation in order to account for generated variable biases (income elasticities are estimated rather than observed).

Table A.5: Correlations between observed changes in the skill premium and simulated estimates

Dependent variable:	Observed change in skill premium				
	Preferences		Non-homothetic to homothetic difference		
	Homoth.	Non-homoth.			
Counterfactual:	Growth & trade	Growth & trade	Growth & trade	Growth only	Trade only
Simulated SP change	0.182	0.317	0.296	0.302	0.167
	[0.161]	[0.167]*	[0.170]*	[0.171]*	[0.165]
Log schooling years	-0.225	-0.130	-0.224	-0.229	-0.148
	[0.167]	[0.162]	[0.169]	[0.171]	[-0.165]

Notes: Dependent variable: Observed change in the skill premium over the 1995 to 2010 time period (WIOD); 40 observations, corresponding to the countries in the WIOD dataset; beta coefficients; robust standard errors in brackets; * denotes 10% significance level.