Globalization, Technology, and the Skill Premium*

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Abstract

We construct a model of international trade and offshoring to examine the impact of globalization on the skill premium in developed and developing countries. Our framework features two independent sources of comparative advantage (factor endowment differences and technological differences) and skill-biased technology (more efficient producers employ a relatively higher share of skilled workers). We show that a reduction in trade and/or offshoring costs induces a reallocation of resources both towards sectors that are intensive in a country's abundant factor (generating a Stolper-Samuelson effect that increases the skill premium in skill-abundant countries and reduces it in skill-scarce countries) and within sectors towards more efficient producers that are more skill intensive (generating a skill-biased technology effect that increases the skill premium in all countries). Larger dispersion in productivities across producers weakens the Stolper-Samuelson effect and strengthens the skill-biased technology effect, while offshoring strengthens both.

We then use a parameterized version of the model that matches salient features of U.S. data on trade and offshoring to study the impact on the skill premium of changes in the extent of globalization, i.e. the shares of trade and offshoring in output, and in the composition of globalization, i.e. the relative importance of skill-abundant and skill-scarce countries in the global economy. We find that the skill-biased technology effect is stronger than the Stolper-Samuelson effect. In response to the three-fold increase in the extent of globalization in the U.S. over the last 40 years, the model generates an increase in the skill premium of 4% to 6% in the U.S. (or 1/6 to 1/4 of the rise of the college wage premium during this period) and 5% in skill-scarce countries.

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1 Introduction

The nature of globalization has changed. The value of world trade as a share of world output, the sales of foreign affiliates as a share of world output, and the developing world's share of this global activity have grown tremendously over the last few decades. Over this period there was also a large increase in income inequality, both in developed and developing countries, as measured for example by the rise in the relative wage of skilled to unskilled workers—the *skill premium*. The changing nature of globalization and the increase in the skill premium raise a set of important questions. To what extent can the growth of trade and offshoring account for the rise in the skill premium in developed and developing countries? What are the different implications for the skill premium in developed countries of globalization with developing countries versus globalization with developed countries?

In this paper we construct a multi-country model of international trade and offshoring to address these and other questions. Our framework builds on Eaton and Kortum's (2002) Ricardian model of technology and international trade (henceforth EK), extending it in two key dimensions. First, our framework nests both a Ricardian model and a two-factor (skilled and unskilled labor) Heckscher-Ohlin (H-O) model of international trade. When productivity dispersion across producers is sufficiently low, factor endowment ratio differences across countries determine the allocation of resources across sectors as in the Heckscher-Ohlin model. When productivity dispersion across producers is sufficiently high, technological differences across countries determine the allocation of resources across sectors as in the Ricardian model. This feature of the model allows us to address the empirical evidence that differences in both technologies and factor endowment ratios play a significant role in shaping trade patterns; see e.g. Trefler (1993, 1995) and Davis and Weinstein (2001).[1] Second, our framework allows for an arbitrary factor bias of technology. When technology is skill biased, more efficient producers employ a higher share of skilled workers. This feature of the model enables us to address in a simple way the empirical evidence that exporters and large producers in manufacturing tend to be relatively skill intensive; see e.g. Bernard et. al. (2007) for U.S. firms, Verhoogen (2008) for Mexican firms, and Alcalá and Hernández (2009) for Spanish firms.

In Sections 3 and 4, we examine analytically the workings of a simplified version of our model. First, we prove that the interaction between Ricardian and Heckscher-Ohlin forces weakens the Stolper-Samuelson (S-S) effect.[2] For a fixed share of trade in output, increasing the relative importance of Ricardian comparative advantage mitigates the effect of relative factor costs on patterns

[1] See also, Davis (1995), Romalis (2004), Costinot (2005), Bernard, Redding, and Schott (2007), Chor (2008), and Morrow (2008).

[2] The Stolper-Samuelson theorem states that in a two-good, two-factor world, a rise in the relative price of a good will lead to a rise (fall) in the real return of the factor that is (is not) used intensively in the production of the good. Combined with additional assumptions, this implies that trade liberalization will increase the relative return of a country's abundant factor. It is this additional prediction that we refer to as the S-S effect.

of specialization; this decreases the impact of trade integration on relative factor demand and on the skill premium. While the implications of the interaction between H-O and Ricardian forces for the pattern trade of trade has been studied extensively, to our knowledge its implications for the skill premium have not yet been studied. This result suggests that if Ricardian forces are sufficiently strong, then: (*i*) It might not be surprising that other forces linked with globalization frequently dominate the S-S effect—see e.g. Goldberg and Pavcnik (2007) for a review of evidence that globalization tends to increase the skill premium in countries abundant in unskilled labor; and (*ii*) Under some circumstances the rising importance of trade with unskill-abundant countries such as China may not affect the skill premium in skill-abundant countries much differently than would trade with skill-abundant countries, in spite of fears to the contrary—see e.g. Krugman (2008). In our quantitative analysis, we assess the relative strength of Ricardian forces and address these two potential outcomes.

Next, we show that if technology is skill biased, then trade liberalization increases the skill premium in all countries through a Ricardian channel that we call the *skill-biased technology* (SBT) *effect*: as trade costs decline, the relative demand for skill increases because the most efficient producers, which have the highest skill intensities, expand. Hence, trade liberalization increases the relative demand for skill, analogous to the effect of skill-biased technological change. This prediction receives empirical support in Bloom et. al. (2009). We are not the first to observe the potentially important interaction between skill-biased technology, international trade, and inequality; see e.g. Acemoglu (2003) and Yeaple (2005).[3] Our paper contributes to this literature by including both trade and offshoring, nesting the SBT and S-S effects, and quantitatively assessing the strength of these effects.

In Section 4 we incorporate into our model offshoring, or multinational production, motivated by the fact that sales of U.S. foreign affiliates are larger than the value of U.S. exports. We follow Ramondo and Rodriguez-Clare (2009) in modelling offshoring as giving producers the ability to use their technologies to produce in foreign countries, at a cost. Offshoring reduces the technological gap across locations, i.e. it increases the relative importance of H-O relative to Ricardian forces, magnifying the effect of relative factor costs on patterns of specialization. With Hicks-neutral technology, this strengthens the S-S effect of globalization on the skill premium.

With offshoring and skill-biased technology, we show that a reduction in offshoring costs between two symmetric countries leads to an increase in the skill premium in both countries because producers that engage in offshoring tend to be the most productive (and, thus, the most skill intensive). Previous theoretical work that finds an impact of offshoring on inequality requires that countries differ in their factor-endowment ratios and/or their TFPs.[4] The contribution of our find-

[3] See also the work of Matsuyama (2007), Zeira (2007), Helpman et. al. (2008), Vannoorenberghe (2008), and Costinot and Vogel (2009).

[4] See e.g. Feenstra and Hanson (1996) and (1997), Zhu and Trefler (2005), Antras, Garicano and Rossi-Hansberg (2006), Grossman and Rossi-Hansberg (2008), and Costinot and Vogel (2009).

ing is that we obtain a positive effect on the skill premium of offshoring even between countries with similar endowment ratios and TFPs, which in the data account for the vast majority of offshoring.[5]

In establishing our analytic results, we make strong assumptions. In Sections 5-7, we use a parameterized version of our model that relaxes many of these assumptions to numerically confirm our analytic findings and to provide a quantitative analysis of the impact of globalization on the skill premium. We consider a three-country version of our model calibrated to match salient features of the extent and composition of U.S. trade and offshoring with skill-abundant and unskill-abundant countries. Although we account for shares of trade and offshoring in the entire economy, our parameterization strategy draws more heavily on detailed manufacturing data.

In our baseline parameterization, the SBT effect is relatively strong compared to the S-S effect. In particular, we find that increasing the extent of globalization raises the skill premium in both the skill-abundant and the unskill-abundant countries. For example, moving from autarky to the volumes of international trade and offshoring observed in 2006 increases the skill premium by almost 8% in the skill-abundant and the skill-scarce countries (throughout the paper we refer to changes in log points as percentage changes). We also consider a reduction in trade and offshoring costs to account for the three-fold increase in the U.S. trade share of output between 1963 and 2006. In this case, the rise in the skill premium ranges between 4.2% and 6.1% in the skill-abundant countries and between 5% and 5.9% in the skill-scarce country, depending on the growth of offshoring relative to trade. To put these numbers into perspective, the U.S. College-High School wage gap rose by 26% between 1963 and 2005; see e.g. Autor, Katz, and Kearney (2008).

We not only find in our parameterization that the S-S effect is weak relative to the SBT effect, but we also find that the S-S effect is weak in an absolute sense. To establish this result, we show that in a calibration of the model with Hicks-neutral technology, moving from autarky to 2006 levels of trade and offshoring increases the skill premium in the skill-abundant countries by only 1.1% and decreases the skill premium in the skill-scarce country by 2.5%. We also ask: What would happen to the skill premium in the skill-abundant countries if the skill-scarce country's factor endowment ratio rose to equal those in the skill-abundant countries? Our answer is: not much. In particular, the skill premium falls by only 0.6%.

We argue that it is quantitatively important to consider both trade and offshoring to assess the impact of globalization on the skill premium for at least two reasons. First, we show that the impact of the rise of trade and offshoring on the skill premium are of similar orders of magnitude. Second, we show that the S-S effect becomes more powerful as we reduce the costs of offshoring.

In Section 6, we discuss additional implications of our model. First, our model predicts that trade is more prevalent in skill-intensive sectors. We find support for this implication in the U.S. data. Second, our model can generate a simultaneous rise in the skill premium and a decline in the

[5] See e.g. Navaretti and Venables (2004) for evidence that most FDI flows take place between advanced countries, which typically have similar, high skill endowment ratios and TFPs.

relative price of skill-intensive sectors. Third, we show that our framework can generate a larger increase in the skill premium and less between-sector labor reallocation than than a model without Ricardian productivity differences. The second and third implications above address critiques of the standard Heckscher-Ohlin model; see e.g. Goldberg and Pavcnik (2007) for a discussion of the implications of the Heckscher-Ohlin model with regard to the data. Finally, we show that a standard procedure to estimate the factor content of trade (which is used to infer the impact of trade on inequality; see e.g. Katz and Murphy (1992)) is not very accurate in our model with skill-biased technology.

While our framework captures two important forces in the debate on globalization and the skill premium, the S-S and SBT effects, and incorporates both trade and offshoring, it abstracts from other interesting and potentially important considerations. For example, our model abstracts from additional factors of production (such as land, other natural resources, and capital) in order to focus on the impact of globalization on the skill premium. Including resources such as oil and rubber would make factor endowments more important for determining trade patterns (because the endowment ratio differences for these factors are more extreme); however, it is not clear what would be the impact on the relative strength of the S-S and SBT effects. Additionally, our framework does not incorporate the endogenous supply of skilled and unskilled labor, the endogenous bias of technology, or endogenous capital accumulation with capital-skill complementarity.[6] Our analysis also abstracts from unemployment and within-group inequality.[7] Finally, our model abstracts from non-homothetic preferences, which can lead to differences between changes in the nominal and the real skill premia.[8]

2 Basic Model of International Trade

Our model economy features I countries indexed by $i = 1, ..., I$. Aggregate quantities of inelastically supplied unskilled and skilled labor in country i are L_i and H_i, respectively. Each country produces a final non-tradeable good using a continuum of intermediate goods that can be traded subject to an iceberg cost. Intermediate goods are grouped into J sectors, indexed by j, in order of increasing skill intensity of production. Within each sector j there are a continuum of subsectors, indexed by $\omega(j) \in \Omega(j)$. Within each subsector, intermediate good producers from the same country share the same level of productivity. Productivity varies across subsectors, sectors, and countries. Goods markets and factor markets are perfectly competitive, and factors are perfectly mobile across sectors and subsectors but are immobile across countries. We assume that countries have balanced trade every period. Given that equilibrium allocations and prices are determined in a static fashion, we abstract from time subscripts.

[6] See e.g. Grossman and Helpman (1991), Acemoglu (2003), and Krusell et. al. (2000), respectively

[7] See e.g., Davidson et. al. (1988) and Helpman et. al. (2008), respectively.

[8] See e.g. Broda and Romalis (2009) for an empirical investigation of this issue.

The final non-tradeable good, denoted by Q_i, is produced in all countries by competitive firms that use an identical CES aggregator, which places equal weight on intermediate goods from all sectors and subsectors

$$Q_i = \left(\sum_{j=1}^{J} Q_i(j)^{(\eta-1)/\eta} \right)^{\eta/(\eta-1)}$$
$$Q_i(j) \equiv \left(\int_{\omega(j)\in\Omega(j)} q_i(\omega(j))^{(\eta-1)/\eta}\, d\omega \right)^{\eta/(\eta-1)}.$$

Here, $Q_i(j)$ and $q_i(\omega(j))$ denote country i's use of the sector j aggregate good and the subsector $\omega(j)$ good, respectively; and $\eta > 0$ is the elasticity of substitution across sectors and across subsectors.

Facing prices P_i, $P_i(j)$ and $p_i(\omega(j))$ for the final non-traded good, the aggregate sector j good, and the subsector $\omega(j)$ good, respectively, profit maximization by the final good producers gives rise to the following demands

$$Q_i(j) = \left(\frac{P_i(j)}{P_i} \right)^{-\eta} Q_i$$
$$q_i(\omega(j)) = \left(\frac{p_i(\omega(j))}{P_i(j)} \right)^{-\eta} Q_i(j).$$

The output of each subsector is produced by intermediate good producers. Goods within each subsector are perfect substitutes and potentially produced by every country. The final good producer purchases each intermediate good from the lowest cost source of that good in the world.

Our assumptions on the production of intermediate goods are as follows. A country i producer in subsector $\omega(j)$ with productivity z, hiring h units of skilled labor and l units of unskilled labor, produces output y according to a constant returns to scale production function

$$y = A_i \left[\alpha_j^{1/\rho} \left(z^{2\widetilde{\varphi}} h \right)^{(\rho-1)/\rho} + (1-\alpha_j)^{1/\rho} \left(z^{2(1-\widetilde{\varphi})} l \right)^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)}, \tag{1}$$

where $\rho > 0$ is the elasticity of substitution between skilled and unskilled workers at the level of an individual producer, $\alpha_j \in [0,1]$ determines the skill intensity of sector j, $\widetilde{\varphi} \in [0,1]$ determines the skill bias of technology (as described below), and $A_i \geq 0$ is country i's Hicks-neutral total-factor-productivity (TFP). We abstract from input/output linkages in the production of intermediate goods.[9]

[9] In our quantitative analysis, we have considered (but we do not report) a specification of our model in which production of intermediate goods requires the use of both labor and the final good aggregator. This does not substantially alter our quantitative results.

Note that if $\widetilde{\varphi} = 1/2$, then Equation (1) simplifies to a standard CES production function with skill-neutral productivity $A_i z$. If $\widetilde{\varphi} \neq 1/2$ and $\rho \neq 1$, then technology is not skill-neutral. In particular, facing wages of unskilled and skilled labor w and s respectively, a cost minimizing producer with productivity z in sector j chooses the following ratio of skilled-to-unskilled labor

$$\frac{h}{l} = \frac{\alpha_j}{1-\alpha_j}\left(\frac{w}{s}\right)^{\rho} z^{\varphi}, \tag{2}$$

where $\varphi \equiv 2\left(2\widetilde{\varphi}-1\right)\left(\rho-1\right)$ is the *skill-bias of technology*, which determines the effect of a producer's productivity on its relative demand for skill. Technology is Hicks-neutral if $\varphi = 0$ (i.e. if $\widetilde{\varphi} = 1/2$ or $\rho = 1$), so that h/l is independent of z. In contrast, technology is skill biased if $\varphi > 0$ (i.e. if $\widetilde{\varphi} > 1/2$ and $\rho > 1$ or if $\widetilde{\varphi} < 1/2$ and $\rho < 1$), so that h/l increases with z.

Each country i draws a subsector-specific productivity $z_i\left(\omega\left(j\right)\right) > 0$, henceforth denoted z when the dependence on i and $\omega\left(j\right)$ is clear. Within a given country, producers in each subsector have access to the country-specific common productivity z. We model productivity draws as in Eaton and Kortum (2002) and Alvarez and Lucas (2007). In an arbitrary subsector and country, productivity is equal to $z = u^{-\theta}$, where u is an *i.i.d.* random variable that is exponentially distributed with mean and variance 1 in all countries. The parameter $\theta > 0$ determines the dispersion of productivity across subsectors.[10] The assumption that productivity is *i.i.d.* across subsectors and sectors implies that a country i producer in sector j has an idiosyncratic productivity that is uncorrelated with (i) the factor intensity of its industry and (ii) the factor endowment of its country. This assumption receives empirical support in Morrow (2008). Nevertheless, for all of our qualitative predictions we only require an imperfect correlation between technology and factor endowment driven comparative advantage. We return to this issue in the quantitative analysis.

We introduce trade barriers using iceberg transportation costs: delivering a unit of intermediate good from country i to country n requires producing $\tau_{ni} \geq 1$ units in i, where $\tau_{ii} = 1$ for all i and $\tau_{ni} \leq \tau_{nk}\tau_{ki}$ for all $n, i, k \in I$. Denote by $c_{ni}\left(\omega\left(j\right)\right)$ the unit cost of intermediate good producers in subsector $\omega\left(j\right)$ producing in country i and selling in country n, given by

$$c_{ni}\left(\omega\left(j\right)\right) = \frac{\tau_{ni}}{A_i}\left[\alpha_j z^{\frac{\varphi}{2}+\rho-1} s_i^{1-\rho} + \left(1-\alpha_j\right) z^{\rho-1-\frac{\varphi}{2}} w_i^{1-\rho}\right]^{1/(1-\rho)}.$$

With $\widetilde{\varphi} = 1/2$ so that technology is Hicks-neutral, the unit cost of a given subsector $\omega\left(j\right)$ can be written as the cost of the factor bundle for all subsectors in sector j, $v_i\left(j\right)$, divided by the subsector-specific productivity. Namely, $c_{ni}\left(\omega\left(j\right)\right) = \tau_{ni} v_i\left(j\right)/z$, where $v_i\left(j\right)$ is defined as

$$v_i\left(j\right) = \frac{1}{A_i}\left[\alpha_j s_i^{1-\rho} + \left(1-\alpha_j\right) w_i^{1-\rho}\right]^{1/(1-\rho)}.$$

[10] As in EK, we must constrain η and θ to have a well-defined price index. In the skill-biased case, however, we cannot derive an analytic expression for this constraint. In all simulations, we check numerically that the price level is well defined.

This case corresponds to the EK setup with a factor bundle that combines skilled and unskilled labor.

With perfect competition, the price of the subsector $\omega(j)$ good in country i is

$$p_i(\omega(j)) = \min\{c_{ik}(\omega(j))\}_{k=1}^{I}$$

and the aggregate prices P_i and $P_i(j)$ are

$$\begin{aligned} P_i &= \left(\sum_{j=1}^{J} P_i(j)^{1-\eta}\, d\omega\right)^{\frac{1}{1-\eta}} \\ P_i(j) &= \left(\int_{\omega\in\Omega(j)} p_i(\omega(j))^{1-\eta}\, d\omega\right)^{\frac{1}{1-\eta}}. \end{aligned}$$

The total quantity produced of each intermediate good in country i must equalize its world demand

$$y_i(\omega(j)) = \sum_{n=1}^{I} \tau_{ni} q_n(\omega(j))\, \mathbb{I}_{ni}$$

where $\mathbb{I}_{ni}$ is an indicator function that equals one if country n imports subsector $\omega(j)$ goods from country i.

The amount of skilled and unskilled labor demanded by subsector $\omega(j)$ in country i are denoted by $h_i(\omega(j))$ and $l_i(\omega(j))$, respectively. Labor market clearing in each country requires

$$L_i = \sum_{j=1}^{J} \int_{\omega(j)\in\Omega(j)} l_i(\omega(j))\, d\omega \text{ , and} \tag{3}$$

$$H_i = \sum_{j=1}^{J} \int_{\omega(j)\in\Omega(j)} h_i(\omega(j))\, d\omega. \tag{4}$$

We assume that countries spend all of their income on the final non-traded good, which implies trade balance:

$$P_i Q_i = s_i H_i + w_i L_i. \tag{5}$$

An equilibrium of the world economy is a set of aggregate prices $\{P_i, w_i, s_i\}$, aggregate quantities Q_i, sector and subsector prices $P_i(j)$ and $\{p_i(\omega(j))\}$, sector and subsector quantities $Q_i(j)$ and $\{q_i(\omega(j)), y_i(\omega(j))\}$ demanded and produced, and factor demands $\{l_i(\omega(j)), h_i(\omega(j))\}$, that satisfy final and intermediate goods producers' optimality conditions, factor and goods market clearing conditions, and trade balance in each country.

3 International Trade and the Skill Premium

In this section, we conduct comparative statics on the skill premium in our basic model of international trade under different sets of simplifying assumptions. In our quantitative analysis, we relax all of these assumptions. Our goal is to provide intuition for the key mechanisms operating in our framework. We focus, in particular, on two central interactions: those between Ricardian and Heckscher-Ohlin forces in Subsection 3.1, and those between Ricardian forces and skill-biased technology in Subsection 3.2. In both subsections we focus on a two-country, two-sector, two-factor world, as in the standard Heckscher-Ohlin model. In particular, we maintain the following simplifying assumption.

A1 There are two countries, $I = \{1, 2\}$; trade costs are symmetric, $\tau \equiv \tau_{12} = \tau_{21}$; and there are two sectors, $J = \{x, y\}$ with sector x relatively skill intensive, $\alpha_y < \alpha_x$.

3.1 Hicks-Neutral Technologies and Endowment Differences

In this subsection, we conduct comparative statics exercises on the skill premium under Assumption A1 and the following assumption:

A2 Production functions are Cobb Douglas, $\rho = 1$ in Equation (1), and $\widetilde{\varphi} = 1/2$.

With Cobb-Douglas production functions, skilled labor's share of revenue in sector j is equal to α_j. With either $\rho = 1$ or $\widetilde{\varphi} = 1/2$, technology is Hicks-neutral, $\varphi = 0$. We assume that $\widetilde{\varphi} = 1/2$ so that the efficiency of a producer with productivity z is $A_i z$ as in standard models such as EK.

With Hicks-neutral technology, we obtain simple sector-level gravity equations, as in EK. The value of country i's production for country n in sector j is given by $\pi_{ni}(j) Q_n P_n / 2$, where $\pi_{ni}(j)$ denotes country i's revenue share of sector j in country n and $Q_n P_n / 2$ is country n's expenditure on sector j. With exponential productivity draws, $\pi_{ni}(j)$ is also the fraction of subsectors in sector j that country i provides in country n. Exploiting the convenient properties of the exponential distribution and Hicks-neutral technology, we obtain closed-form solutions for $\pi_{ni}(j)$ for all $n, i \in I$ given by

$$\pi_{ii}(j) = \frac{1}{1 + \left[\frac{v_i(j)}{v_{-i}(j)\tau}\right]^{1/\theta}} \quad \text{and} \quad \pi_{-ii}(j) = \frac{1}{1 + \left[\frac{v_i(j)\tau}{v_{-i}(j)}\right]^{1/\theta}}. \tag{6}$$

To derive most of our results in this specification of the model, we make the following additional assumption:

A3 Countries and sectors are mirror-images of each other: i.e. $H_1 = L_2$, $L_1 = H_2$, $A_1 = A_2$, and $\alpha_y = 1 - \alpha_x$.

This assumption, although unrealistic, features elsewhere in the literature; see e.g. Krugman (1980) and Matsuyama (2007). In this case, the impact of the interaction between factor endowments and technological differences in shaping the skill premium appears particularly clearly. In particular, the mirror-image assumption simplifies the system of equations by implying $w_1 = s_2$, $s_1 = w_2$, and $Q_1 P_1 = 1/2 = Q_2 P_2$.

The Appendix provides a characterization of the equilibrium under Assumptions A1 and A2, and also under Assumptions A1-A3, as well as proofs of all lemmas and propositions.

When technology is Hicks-neutral, our framework captures standard predictions from the Heckscher-Ohlin model. First, the relative price of a factor is relatively lower in the country abundant in that factor; i.e. the skill premium is relatively lower in the skill-abundant country. This implies a Heckscher-Ohlin-theorem-like result, that a country is a net exporter in the sector that is intensive in its abundant factor; e.g. the skill-abundant country will be a net exporter in the skill-intensive sector. Lemma 1 summarizes this result.

Lemma 1 *Suppose Assumptions A1 and A2 hold and that* $H_1/L_1 > H_2/L_2$. *Then (i)* $s_1/w_1 < s_2/w_2$, *and (ii)* $\pi_{n1}(x) > \pi_{n1}(y)$ *and* $\pi_{n2}(x) < \pi_{n2}(y)$ *for* $n = 1, 2$.

Second, reductions in trade costs increase the relative return of a country's abundant factor; e.g. the skill premium rises in the skill-abundant country. Lemma 2 summarizes this result.

Lemma 2 *Suppose Assumptions A1-A3 hold and that* $H_1/L_1 > H_2/L_2$. *Then* s_1/w_1 *is strictly decreasing in* τ *and* s_2/w_2 *is strictly increasing in* τ.

Lemma 2 captures a Stolper-Samuelson (S-S) -like result, one of the most empirically tested predictions in all of international trade. It states that, to the extent that factor endowment differences act as a source of comparative advantage, a decline in trade costs induces the skill-abundant (skill-scarce) country to specialize in the skill-intensive (unskill-intensive) sector, which increases (decreases) the relative demand for skilled labor and the relative skilled wage.

However, in our model a given subsector's location of production is determined not only by trade costs and relative factor costs, but also by technological differences. A higher dispersion of productivity, θ, increases the importance of technological differences relative to factor endowment ratio differences as a source of comparative advantage. In particular, according to Equation (6) we have $\frac{d}{d\theta}\pi_{-ii}(j) > 0$ if and only if $\tau v_i(j) > v_{-i}(j)$, so that as θ increases country i's exports to country $-i$ increase in i's comparative disadvantage sector and decrease in i's comparative advantage sector. Hence, the higher is θ the less a country specializes in its comparative advantage sector.

Because reductions in trade costs lead to less cross-sector specialization for higher values of θ, they also generate a smaller change in the skill premium. Proposition 1 summarizes this result.

Proposition 1 *Suppose Assumptions A1-A3 hold and that* $H_1/L_1 > H_2/L_2$*. The increase (decrease) in the skill premium in country 1 (country 2) caused by moving from autarky to any positive level of country 1 (country 2) exports in country 1 (country 2) output is declining in* θ*.*

The proof of this proposition consists of two parts. First, if trade costs are prohibitively high, then with Hicks-neutral technology θ has no impact on factor allocation and factor prices. Second, for a fixed share of world exports in world output,[11] a higher θ leads to less specialization of production across sectors and more specialization within sectors. With Hicks-neutral technology, within-sector specialization does not impact the relative demand for skill or the skill premium in either country. Combining these two parts of the proof, we obtain the result that going from autarky to a given volume of world trade, a higher θ leads to a smaller rise (decline) in the skill premium in skill-abundant (unskill-abundant) countries.[12] [13]

3.2 Skill-Biased Technologies and Symmetric Countries

In this subsection, we conduct comparative statics exercises on the skill premium under Assumption A1 and the following assumption.

A4 The sector-level aggregator is Cobb Douglas, $\eta = 1$; technology is skilled biased, $\varphi > 0$; and countries have equal endowments and TFPs, $H \equiv H_1 = H_2$, $L \equiv L_1 = L_2$, and $A_1 = A_2 = 1$.

With symmetric countries (i.e. equal factor endowments and TFPs), factor prices are equalized across countries, $s = s_1 = s_2$ and $w = w_1 = w_2$. The assumption that $\eta = 1$ simplifies the algebra, as discussed below. With skill-biased technology, we cannot solve explicitly for π_{ij}; however, we are able to obtain analytic results without this explicit solution. Because we do not require a closed-form solution for π_{ij}, our results in this subsection do not make use of the assumption that costs are distributed exponentially. We characterize equilibrium under Assumptions A1 and A4 in the Appendix.

If countries are symmetric and technology is Hicks-neutral, $\varphi = 0$, then reductions in the cost of trade do not affect the skill premium. On the other hand, if technology is skill biased, $\varphi > 0$,

[11] With balanced trade and under Assumption A3, if world exports as a share of world output are fixed at δ, then both country 1 exports as a share of country 1 output and country 2 exports as a share of country 2 output are also fixed at δ.

[12] This implication also applies under the assumption of Armington preferences or monopolistic competition, where θ in Equation (6) is replaced with $1/(\eta - 1)$; see e.g. Romalis (2004). A higher dispersion of productivities, θ, is analogous to a lower elasticity of substitution across goods, η, both of which reduce the impact of trade liberalization on relative factor prices.

[13] While we find that Ricardian differences across countries mitigate comparative advantage based on differences in factor endowment ratios, Bernard, Redding, and Schott (2007) find that introducing heterogeneous firms into a Helpman and Krugman (1985) model magnifies it. These are clearly different comparative statics exercises carried out in different frameworks. However, conducting comparative statics on the elasticity of substitution in their framework gives rise to our result.

then reductions in the cost of trade increase the skill premium. The intuition behind this result is as follows. As in standard Ricardian models, reductions in trade costs induce a reallocation of factors of production within sectors towards relatively productive producers. With skill-biased technology, relatively productive producers are also relatively skill intensive; see Equation (2). Hence, trade liberalization increases the relative demand for skill and the skill premium. This result is summarized in Proposition 2.

Proposition 2 *If Assumptions A1 and A4 hold, then s/w is strictly decreasing in τ.*

In Proposition 2, we have assumed that countries are symmetric. The results in Lemma 1 and Proposition 2 suggest that with asymmetric countries, the S-S effect and the SBT effect both lead to an increase in the skill premium in skill-abundant countries in response to a reduction in trade costs. On the other hand, they push in opposite directions in skill-scarce countries. According to Proposition 1, the stronger are Ricardian forces, the weaker is the S-S effect, and hence the more likely that the skill premium also rises in skill-scarce countries. Which force dominates and by how much is a quantitative question that we address in our quantitative analysis.

4 Offshoring and the Skill Premium

In this section, we extend our model by incorporating offshoring, or multinational production, and conduct comparative statics exercises on the skill premium. We model offshoring as enabling intermediate good producers to use their technologies in foreign countries. Producers choosing to engage in offshoring incur a per-unit cost. In particular, country k producers in subsector $\omega(j)$ that operate in country i incur a per-unit cost of offshoring given by $\mu_{ki} \times m_{ki}(\omega(j))$. The country-level per-unit cost of offshoring, $\mu_{ki} \geq 1$, is analogous to the per-unit cost of exporting; we assume $\mu_{ii} = 1$ and $\mu_{ki} \geq 1$ for all $k, i \in I$. We introduce a country/subsector-specific efficiency loss of offshoring, $m_{ki}(\omega(j)) \geq 1$ with $m_{ii}(\omega(j)) = 1$ for all $\omega(j)$ and all $k, i \in I$, in order to obtain an interior equilibrium for the subsectors that engage in offshoring versus exports; if we did not include this idiosyncratic offshoring cost, then either no producers in a sector would engage in offshoring or no producers in a sector would export. For simplicity, we consider the case with two countries in what follows; and we let $\mu_{ki} \equiv \mu$ if $k \neq i$ (we drop these assumptions in the quantitative analysis).

Goods in subsector $\omega(j)$ can be supplied to country n in four ways. Production can take place in either country 1 or country 2; and production can use productivity from either country 1 or country 2. We denote by $c_{ni}^{k}(\omega(j))$ the per-unit cost of supplying $\omega(j)$ to country n by producing in country i using country k's productivity

$$c_{ni}^{k}(\omega(j)) = \frac{\mu_{ki} m_{ki} \tau_{ni}}{A_k} \left[\alpha_j z_k^{\frac{\varphi}{2}+\rho-1} s_i^{1-\rho} + (1-\alpha_j) z_k^{\rho-1-\frac{\varphi}{2}} w_i^{1-\rho}\right]^{1/(1-\rho)}$$

where we omit the dependence of m_{ki} and z_k on $\omega(j)$. Note that if country k producers locate in country i, then they use their own productivity z_k and TFP A_k, but they use country i labor and hence incur country i's labor costs, s_i and w_i. Producers from country 1 may locate in country 2 either (i) to sell in country 2's domestic market—to avoid incurring trade costs and/or to exploit low factor prices in country 2—or (ii) to export the goods back to country 1—to exploit low factor prices in country 2.

As before, we conduct comparative statics exercises under two different sets of simplifying assumptions to obtain analytic solutions.

Hicks-neutral technology and endowment differences: We first consider the specification of our model with $\widetilde{\varphi} = 1/2$ so that technology is Hicks-neutral. In this case, the cost of the factor bundle can be disentangled from the productivity z, so that the cost $c_{ni}^{k}(\omega(j))$ can be expressed as

$$c_{ni}^{k}(\omega(j)) = \frac{v_i(j)}{z_k(\omega(j))}\frac{A_i}{A_k}\tau_{ni}\mu_{ki}m_{ki}(\omega(j))$$

The cost of supplying country 1 is (i) v_1/z_1 if production is carried-out in country 1 using country 1's productivity; (ii) $\tau v_2/z_2$ if production is carried-out in country 2 using country 2's productivity and output is exported to country 1; (iii) $\mu m_{21} v_1 A_1/A_2 z_2$ if production is carried-out in country 1 via offshoring (using country 2's productivity); and, (iv) $\tau\mu m_{12} v_2 A_2/A_1 z_1$ if production is carried-out in country 2 via offshoring and output is exported to country 1. Each good is supplied by the lowest cost of the four alternatives, which is determined by factor prices, productivity draws, trade costs, and offshoring costs.

We now derive analytic results on the impact of changes in offshoring costs on the skill premium under assumptions A1-A3. We solve for our model as in Subsection 3.1, where $\pi_{ni}(j)$ is now the fraction of subsectors in sector j that are supplied in country n by producers located in country i, defined as

$$\pi_{ni}(j) = \Pr\left[\min_{k=1,2}\left\{c_{ni}^{k}(j)\right\} \leq \min_{k=1,2}\left\{c_{n-i}^{k}(j)\right\}\right]. \tag{7}$$

With Hicks-neutral technology, offshoring does not affect the relative demand for skill within a sector at fixed factor costs; in this case it can only affect the between-sector allocation of factors. However, with no international trade, offshoring does not affect the between-sector allocation of factors because a reduction in μ has the same impact on $\pi_{ni}(x)$ as on $\pi_{ni}(y)$. This follows from the fact that $\pi_{ni}(x)$ and $\pi_{ni}(y)$ in (7) are both independent of factor prices when there is no trade. Combining these two implications, we obtain the result that the cost of offshoring has no impact on the skill premium in the absence of international trade.

With international trade, as the cost of offshoring decreases, the expected technological gap across locations decreases. This increases the importance of factor endowment differences in determining the pattern of specialization. Hence, as μ and m_{ki} decline, a country moves towards specializing in the sector that is intensive in its locally abundant factor, as in the model with no technological dispersion ($\theta \to 0$). In fact, under Assumptions A1-A3 the skill premium with costless offshoring is equivalent to the skill premium with no technological dispersion.

Proposition 3 summarizes these two results.

Proposition 3 *Suppose Assumptions A1-A3 hold and that $H_1/L_1 > H_2/L_2$. Then*

1. $\lim_{\tau\to\infty}(s_i/w_i) = 0$ *is independent of μ for $i = 1, 2$; and*
2. $\lim_{\mu m_{ki}(\omega(j))\to 1 \forall \omega(j),k,i} \frac{s_l}{w_l} = \lim_{\theta\to 0} \frac{s_l}{w_l}$ *for $l = 1, 2$.*

The central implication of Proposition 3 is that a lower offshoring cost strengthens the S-S effect by making factor endowment differences more important in determining patterns of specialization. That is, reductions in trade costs have a larger effect on the skill premium in both countries in the presence of costeless offshoring. We return to this in our quantitative analysis.[14]

Skill-biased technology and symmetric countries: We now consider the impact of offshoring on the skill-premium in the specification of our model with skill-biased technology and two symmetric countries. We consider the impact on the skill premium of both reductions in offshoring costs and asymmetric changes in TFPs.

A reduction in the cost of offshoring—from a level at which there is a positive volume of offshoring, $\mu < \tau$—increases the skill premium. If $\mu < \tau$, then a reduction in offshoring costs increases the fraction of subsectors in a country that produce using foreign productivity. If a domestic subsector produces using foreign productivity, producers in the foreign subsector must be more productive than those in the domestic one. Hence, a reduction in offshoring costs weakly increases the productivity of all subsectors and strictly increases the productivity of some subsectors. With skill-biased technology, relatively productive subsectors are also relatively skill intensive. Hence, reductions in the cost of offshoring increase the relative demand for skill and the relative skilled wage. Proposition 4 summarizes this result.

Proposition 4 *If Assumptions A1 and A4 hold and $\mu < \tau$, then s/w is strictly decreasing in μ.*

Note that Proposition 4 holds even in the absence of positive trade flows. This is in contrast to the case of Hicks-neutral technology, in which offshoring does not impact the skill premium in the absence of trade.[15]

[14] In our analytics we abstract from another mechanism studied in Feenstra and Hanson (1996), Zhu and Trefler (2005), and Costinot and Vogel (2009) by which offshoring transfers superior technology to the low-TFP and skill-scarce country, increasing the effective size of this country, and thereby strengthening (weakening) the S-S effect in skill-abundant (skill-scarce) countries. This increases the skill premium everywhere. This mechanism is also present in our framework, but here we turn it off by assuming $A_1 = A_2$.

[15] A similar logic applies to the implications of asymmetric changes in TFPs. For instance, if country 1 has a higher TFP than country 2 (e.g. $A_1 > A_2$), then a marginal increase in country 2's TFP leads to an increase in the skill premium in country 1. Hence, a country's offshoring partner's TFP plays a role in determining the impact of offshoring on the skill premium.

5 Quantitative Analysis: Baseline Parameterization

In this section, we study the quantitative implications of globalization on the skill premium in a parameterized version of our model that we cannot fully solve analytically. We first introduce additional assumptions that we use in our quantitative model. We then calibrate our model to match salient features of the data on U.S. trade and offshoring with other developed and developing countries, and present our baseline results on the implications of globalization on the skill premium. We also examine the role of our two central parameters, θ and φ, in our calibration.

5.1 Quantitative Model

Here we describe additional assumptions that we use in our quantitative analysis. First, to account for manufacturing's relatively small share of total output in many countries, we assume that the final good in country i is produced according to $(Q_i)^{\gamma}(N_i)^{1-\gamma}$, where Q_i denotes output of the final manufactured good, as modeled in Section 2, and N_i denotes output of the final non-manufactured good.[16] We model production of non-manufactured goods exactly as in Section 2, and we assume that labor is perfectly mobile between manufacturing and non-manufacturing. We denote the trade costs of manufactured and non-manufactured goods by τ_{ni}^{Q} and τ_{ni}^{N}, respectively, and impose symmetric trade costs between pairs of countries, $\tau_{ni}^{j} = \tau_{in}^{j}$ for $j = Q, N$.

Second, we assume that the country/subsector-specific efficiency loss of offshoring, $m_{ni}(\omega(j))$, is given by $1 + \widetilde{u}$, where $\widetilde{u} \geq 0$ is an *i.i.d.* random variable that is exponentially distributed with mean and standard deviation θ_m. We also assume that the country-level offshoring cost, μ_{ni}, is equal for manufactured and non-manufactured goods and is symmetric between pairs of countries, $\mu_{ni} = \mu_{in}$.

Third, throughout our quantitative analysis, we consider a world economy that is composed of three countries.[17] Countries 1 and 2 are skill-abundant countries that are ex-ante identical (i.e., in their labor endowments $H_1 = H_2$, $L_1 = L_2$, total factor productivities $A_1 = A_2$, trade costs $\tau_{31}^{j} = \tau_{32}^{j}$ for $j = Q, N$, and country-level offshoring costs $\mu_{32} = \mu_{31}$), but they differ in their ex-post realizations of country/subsector-specific productivity draws and idiosyncratic offshoring costs. Country 3 is an unskill-abundant country. This three-country setup allows us to consider the impact of globalization on the U.S., other skill-abundant countries, and skill-scarce countries, accounting for shares of trade and offshoring between these countries.

[16] In our sensitivity analysis, we allowed for a CES aggregator between manufactured and non-manufactured output. Our quantitative results are largely unaffected by varying this elasticity over a wide range of values.

[17] Adding more countries will make the model solution more computationally intensive. Recall that we do not obtain closed-form solutions for π_{ij} with skill-biased technology, so we cannot directly apply the partly analytic solution procedure in EK and Alvarez and Lucas (2007).

5.2 Baseline Calibration

The parameters that we must choose are the skill bias of technology, φ; the dispersion of productivities, θ; the dispersion of offshoring costs, θ_m; the elasticity of substitution across subsectors, η; the elasticity of substitution between skilled and unskilled labor at the level of an individual producer, ρ; the share of manufacturing in final output, γ; the two TFP levels, A_1 and A_3; the labor endowments, H_i, L_i for $i = 1, 3$; the sectoral skill intensities, α_j's; and the trade and offshoring costs, τ_{12}^j, τ_{13}^j, μ_{12}, and μ_{13} for $j = Q, N$. We normalize country 1's aggregate TFP and supply of unskilled labor, $A_1 = L_1 = 1$.

The parameters of the model are chosen to reproduce a number of salient features of the data on international trade and multinational production between the U.S. and its trading partners in 2006 (or the closest years with available information). Even though we account for shares of trade and offshoring in the entire economy, our parameterization strategy draws more heavily on detailed manufacturing data. We consider two baseline parameterizations, one with only trade and one with both trade and offshoring. Our preferred baseline parameterization includes both trade and offshoring. We will use the simpler specification with only trade to isolate the role of key parameters in our model in Subsection 5.3. Table 1 displays the parameter values under our two baseline parameterizations. Table 1 also reports the parameter values under two additional parameterizations in which we impose $\varphi = 0$, one with only trade and one with both trade and offshoring. We use these additional parameterizations in Section 7 to isolate the strength of the S-S effect and the role of skill-biased technology.

We first determine the set of skill-abundant and skill-scarce countries that we map to our three-country model economy. Using the educational attainment dataset described in Barro and Lee (2000), we rank countries by their most recent data on the average years of education for the population over age 25—denoted the country's education level. We consider a country to be skill abundant if its education level is greater than 6.9 years. According to this cutoff, Mexico is the most skilled of the skill-scarce countries and Italy is the least skilled of the skill-abundant countries. We list the set of skill-abundant and skill-scarce countries according to our cutoff in the Data Appendix.

The endowments of skilled and unskilled labor in each country are chosen as follows. We set the relative endowment of unskilled labor in country 3, $L_3/L_1 = 5.7$, so that $L_3/(2L_1)$ matches the relative population of the skill-scarce countries to the skill-abundant countries in 2006, as reported in the World Bank's World Development Indicators (WDI). We set the ratio of endowment ratios $(H_1/L_1)/(H_3/L_3) = 0.49$ to match the population-weighted average of education levels in the skill-abundant countries relative to the unskill-abundant countries.[18] Finally, we set $H_1/L_1 = 0.71$ as in Acemoglu (2002).

[18] Weights are determined by relative populations in 2006, obtained from the WDI.

We set the share of manufactured goods in final output, $\gamma = 0.219$, to match the share of manufacturing in U.S. total output in 2006, based on the Bureau of Economic Statistics' (BEA) input-output tables. We assume that there are 100 sectors in each manufacturing and non-manufacturing and that each sector contains 900 subsectors. The sectoral skill intensities, α, are uniformly distributed over the range 0.1 and 0.6 to roughly match the range of skill intensities of manufacturing sectors in the U.S.[19] We set the elasticity of substitution across sectors and subsectors, $\eta = 3$, to match the median sectoral elasticity in the U.S. estimated by Broda and Weinstein (2006).[20]

We choose the elasticity of substitution between skilled and unskilled labor at the level of an individual producer, $\rho = 1.2$, to match the aggregate elasticity of substitution of 1.41 between skilled and unskilled labor estimated by Katz and Murphy (1992), who control for skill-biased technological change using a time trend. In particular, we set ρ so that, given other parameter values, a change in the relative endowment of skilled labor results in a change in the skill premium that is consistent with that estimated by Katz and Murphy (1992). This procedure yields a value of ρ that is slightly lower than 1.41 because of inter- and intra-sectoral labor reallocation in response to a change in factor endowments.

We set the dispersion of subsector productivities, $\theta = 0.25$, to match the absolute difference between the U.S.'s share of imports in manufacturing from skill-abundant countries in the 50% most skill-intensive sectors and in the 50% least skill-intensive sectors.[21] We discuss the rationale for this procedure in greater depth in Subsection 5.3. Our value of θ falls within the range of θ's estimated by EK (2002) and Donaldson (2008), although the gravity equations that give rise to these estimates do not apply with skill-biased technology. EK estimate $\theta \in [0.08, 0.28]$ and EK's preferred value is $\theta = 0.12$; Donaldson (2008) estimates $\theta \in [0.14, 0.26]$ and Donaldson's preferred value is $\theta = 0.25$. We choose TFP in country 3 relative to country 1, A_3, to match the overall share of U.S. imports in manufacturing from skill-abundant countries.[22] Given that we have assumed that country 3 has a relatively large population, our calibration procedure results in a relatively low TFP for country 3.

We set the degree of skill bias in technology, $\varphi = 0.37$, so that the elasticity of skill intensity to sales at the producer level in country 3, controlling for the producer's sector, is equal to 0.1. This roughly matches the elasticity calculated by Verhoogen (2004) using matched employer-employee

[19] Our measure of sectoral skill intensity is the sectoral share of non-production worker employment, obtained from the NBER-CES Manufacturing Industry Database for 2002.

[20] Our choice of $\eta = 3$ falls between the median elasticities of substitution based on the HTS and SITC5 classifications for the period 1990-2001, reported in Broda and Weinstein (2006)

[21] In particular, we target a difference of 11%, corresponding to the difference in the U.S. in 2006. For this calculation, we created a second measure of skill intensity—the average worker wage in the sector—and dropped all SIC sectors that are in the top 20% of one measure of skill intensity and in the bottom 20% of the other measure. This is a conservative approach: without dropping these sectors the difference would have been much smaller (2%), our value of θ would have been larger, and globalization's impact on inequality would have been greater.

[22] The share of U.S. imports in manufacturing from skill-abundant countries was equal to 0.59 in 2006.

data for Mexico in 1998.[23] In our first parameterization, we set $\varphi = 0$ so that the elasticity of skill intensity to size is zero. We discuss the parameterization of φ in greater depth in Subsection 5.3. In this quantitative section, our model's producer-level statistics are constructed under the assumption that an individual subsector is matched to an individual producer. Of course, this is only one of many possible configurations, as the distribution of sales across producers within a subsector is not unique in our model.[24]

We choose the level of trade costs between the skill-abundant countries, τ_{12}^{Q} and τ_{12}^{N}, and the constant of proportionality that defines the level of trade costs between skill-abundant and unskill-abundant countries, $\varsigma = \left(\tau_{13}^{j} - 1\right) / \left(\tau_{12}^{j} - 1\right)$ for $j = Q$ and N, to match the three following observations on the volumes of international trade observed in 2006: (i) the average of manufactured exports and imports relative to manufactured output in country 1 (the U.S.) is 22.7%; (ii) the average of non-manufactured exports and imports relative to non-manufactured output in country 1 is 3.3%;[25] and (iii) the average of exports plus imports relative to output in country 3, combining manufacturing and non-manufacturing, is 12%.[26] The resulting share of trade in total output in country 1 is equal to $0.22 * 22.7\% + (1 - 0.22) * 3.3\% = 7.5\%$. Note that our parameterization abstracts from potentially important trade imbalances between skill-abundant and skill-scarce countries.

In our second baseline parameterization, which incorporates offshoring, we choose the country-level offshoring costs, μ_{12} and μ_{13}, to match the two following observations on U.S. multinational activity in 2006 obtained from the BEA: (i) the local sales of majority-owned non-bank U.S. foreign affiliates divided by total U.S. exports is equal to 1.72; (ii) the share of local sales of majority-owned non-bank U.S. foreign affiliates located in skill-abundant countries is equal to 0.82.[27] Finally, we set the parameter that governs the mean and standard deviation of country/subsector-specific off-

[23] The elasticity of the share of workers in Mexican firms with 9+, 12+, and 16+ years of education to firm sales is 0.08, 0.15, and 0.14 respectively. These figures are from unpublished results generated in connection with Verhoogen (2004) by INEGI personnel in Aguascalientes in compliance with legal confidentiality requirements.

[24] Individual subsectors would be matched to individual producers in a slightly modified model with Bertrand competition in undifferentiated goods in each subsector, as in Bernard et. al. (2003), if the efficiency-advantage of the most productive producer were arbitrarily small. In this case, there would be only one active producer in each subsector, and allocations and prices would coincide with those in our model.

[25] These two observations are obtained from the BEA's 2006 input-output tables, including only private industries. We match the share of trade in gross output as opposed to value added, because our model abstracts from intermediate inputs in production.

[26] This figure is obtained as the product of the two following numbers: (i) the average of exports and imports between the set of skill- and unskill-abundant countries relative to the latter's combined GDP, equal to 24% in 2006 based on information from the IMF's Direction of Trade Statistics and WDI; and (ii) the median share of value added in gross output, equal to 0.5, across the set of unskill-abundant countries with available input-output data as reported by the OECD. Due to a lack of detailed information, we do not separately target manufacturing and non-manufacturing trade shares; nor do we separate trade in mining and agriculture from trade in other commodities.

[27] Note in Table 1 that our calibration with trade and offshoring requires a very high μ_{13}. This is because country 3 has a very low relative TFP, so that producers from countries 1 and 2 have a large incentive to produce in country 3, which would generate a counterfactually high volume of offshoring towards country 3. An alternative strategy to match our targets would be to assume a lower location-specific TFP in country 3, as in Burstein and Monge-Naranjo (2008). This would not alter our baseline calibration.

shoring costs, $\theta_m = 0.1$. In our sensitivity analysis we consider alternative values of this parameter, $\theta_m = 0.2$ and $\theta_m = 1$, and show that the change in the skill premium is not largely affected.

Rows 1-9 in Table 2 report the implications of our two baseline parameterizations on the moments that we target in our calibration procedure. Note that in the first parameterization we abstract from offshoring and so we do not target the offshoring moments (displayed in rows 8 and 9). Rows 10-13 in Table 2 display four additional moments from our model that we do not target in our calibration. These four additional moments are (*i*) the fraction of exporting producers in country 1,[28] (*ii*) the sales of country 1 manufacturing exporters relative to non-exporters,[29] (*iii*) the median, across manufacturing sectors in country 1, of the average log-difference between the skill intensity of exporters and non-exporters,[30] and (*iv*) the median, across manufacturing sectors in country 3, of the average log-difference between the skill intensity of exporters and non-exporters.[31] Our baseline parameterizations are in line with the fraction of exporters and the size premium of exporters observed in U.S. data. Moreover, the skill-intensity premium of exporters is only slightly higher than the one documented by Bernard et. al. (2007b) for the U.S., and is in the range of estimates provided by Verhoogen (2004) for Mexico.

In what follows we use our parameterized model to conduct a series of counterfactuals. We first consider a reduction in trade and offshoring costs starting in autarky (i.e. $\tau_{ij}^k = \infty$ and $\mu_{ij} = \infty$) to the levels of trade and offshoring costs that generate the volumes of international trade and offshoring observed in 2006. One way to interpret these counterfactuals is that they answer the question: But for globalization, by how much would the skill premium change? Rows 14 and 15 in Table 2 report the log-percentage change in the skill premium, w/s, resulting from these experiments under our two baseline parameterizations and our two additional parameterizations in which we impose $\varphi = 0$. Here we discuss only the baseline parameterizations. In the first baseline parameterization (with only trade), countries 1 and 2 experience a 3.46% increase in the skill premium while country 3 experiences a 5.69% increase in the skill premium. In the second baseline parameterization (with both trade and offshoring), countries 1 and 2 experience a 7.62% increase in the skill premium while country 3 experiences a 7.54% increase in the skill premium.

We also consider an alternative set of counterfactuals. Instead of starting from autarky, we choose initial trade and offshoring costs so that after lowering trade and offshoring costs to their baseline level, the trade share of output in country 1 increases by a factor of 3. In particular, we

[28] Estimates of the fraction of manufacturing plants that export in the U.S. range from 20% to 30% over the years 1987-1997; see e.g. Bernard and Jensen (2004) and Bernard et. al. (2007b). Bernard et. al. (2007b) report that 18% of U.S. manufacturing firms exported in 2002.

[29] Bernard et. al. (2003) report that this ratio is 5.6 for U.S. manufacturing plants. Bernard et. al. (2007b) report that the ratio is 2.9 for U.S. manufacturing firms.

[30] Bernard et. al. (2007b) report that among U.S. manufacturing firms, log skill per worker—measured as non-production workers per total employment—is 0.11 points higher for exporters, controlling for industry fixed-effects.

[31] In unpublished results, Verhoogen (2004) reports that among Mexican manufacturing firms, log skill per worker—measured as the share of workers with 9+, 12+, and 16+ years of education—is 0.12, 0.16, and 0.21 points higher for exporters, respectively.

increase our baseline level of trade costs, τ_{12}^{j} and τ_{13}^{j} for $j = Q$ and N, by the same proportion so that at these higher trade costs, the average of exports and imports relative to total output in country 1 is roughly 2.5% instead of 7.5%. This three-fold increase in trade corresponds to the rise in the trade share of GDP in the U.S. between 1963 and 2006. We do not separately target the share of trade in manufacturing and non-manufacturing output in 1963 due to a lack of detailed information on U.S. sectoral gross output for this time period. Given that we do not have detailed information on the sales growth of U.S. foreign affiliates in this time period, we make two alternative assumptions regarding our target for the initial ratio of outward offshoring relative to exports in country 1: (i) we assume that it is equal to 1.72 as in our baseline parameterization, and (ii) we assume that is equal to 0. Presumably, the level of U.S. offshoring in 1963 lies somewhere between these two extremes.

We report the results from these counterfactuals in Rows 16-19 of Table 2. In the first baseline parameterization (with only trade), countries 1 and 2 experience a 2.1% increase in the skill premium while country 3 experiences a 3.1% increase in the skill premium. In the second baseline parameterization (with both trade and offshoring), countries 1 and 2 experience an increase in the skill premium ranging between 4.2% and 6.2%, while country 3 experiences an increase in the skill premium ranging between 5% and 5.9%.

To put these numbers into perspective, the U.S. College-High School wage gap rose by 26% between 1963 and 2005; see e.g. Autor, Katz, and Kearney (2008). Therefore, under our preferred baseline parameterization (with trade and offshoring), the increase in country 1's skill premium in response to the three-fold rise in globalization observed between 1963 and 2006 represents between 1/6 and 1/4 of the increase in the U.S. college premium during this period.

5.3 Understanding the Baseline Results

We now examine in greater detail the quantitative results of our baseline parameterizations. In order to do so, we focus in particular on the role of the model's two key parameters: θ and φ. We discuss how our calibration strategy disciplines our choice of these two parameters; we confirm the analytic results from Section 3, which were derived under stronger assumptions; and we explore the quantitative role of θ and φ in shaping the effects of globalization on the skill premium. For simplicity, we conduct these exercises in parameterizations with trade and no offshoring.

We first discuss how sectoral trade patterns shape our choice of θ in our calibration strategy. Figure 1 plots the share of imports in country 1 from country 2 by sector (similar to Figure 1 in Romalis (2004)) under two different values of θ: $\theta = 0.05$ and $\theta = 0.25$. In both cases, we set $\varphi = 0.37$ and choose the remaining parameter values as in the baseline parameterization with no offshoring. If θ is low, trade patterns are shaped mostly by factor endowment differences: the share of imports in country 1 from country 2 is small in unskill-intensive sectors and high in skill-intensive sectors. If θ is high, there is less sectoral specialization: the share of imports in country 1 from country 2 is relatively constant across sectors. These patterns of specialization can be summarized by the absolute difference between country 1's share of imports from skill-intensive countries in the 50% most skill-intensive sectors and in the 50% least skill-intensive sectors. Panel A of Table 3 reports this absolute difference for a wide range of θ's. The difference of 0.11 in the U.S. trade data leads us to our choice of $\theta = 0.25$.[32] By choosing the extent to which technological heterogeneity across countries determines trade patterns, our choice procedure for θ is related to Trefler (1993) and (1995) and Davis and Weinstein (2001), which add technological differences across countries to the H-O model to better match predicted and actual factor contents of trade.

We now explore the role that higher values of θ play in mitigating the Stolper-Samuelson effect, as detailed in Proposition 1 under a stricter set of assumptions. To isolate this effect of θ quantitatively, we assume that technology is Hicks-neutral, $\varphi = 0$, and abstract from offshoring, as in our first additional parameterization. Figure 2 depicts the percentage change in the skill premium of countries 1 and 3 as they move from autarky to the baseline shares of trade in output, for levels of θ ranging from 0.025 to 0.3. Figure 2 reveals that the strength of the S-S effect is significantly weakened as we raise θ. For example, increasing θ from 0.025 to 0.1 reduces the change in the skill premium in all countries by more than half.

At our choice $\theta = 0.25$, the S-S effect is weak. This explains the relatively small impact of a reduction in trade costs on the skill premium in all countries when technology is Hicks-neutral, in Column 3 of Table 2. We obtain this result in spite of the fact that the ratio of factor endowment ratios, $(H_3/L_3)/(H_1/L_1)$, is 0.49. In our parameterized model, Ricardian forces are sufficiently powerful to substantially mitigate the S-S effect.

We now explore the role of skill-biased technology. We discipline φ by targeting the elasticity of skill intensity to sales at the producer level that we measure in the data. As illustrated in Panel B of Table 3, this elasticity is increasing in φ. We set $\varphi = 0.37$ to match an elasticity equal to 0.1 in country 3.

In Proposition 2 we proved that with two symmetric countries, the change in the skill premium in response to a reduction in trade costs is positive when $\varphi > 0$. Figure 3 confirms this result in our asymmetric 3-country quantitative model. It also shows that higher values of φ strengthen the SBT effect. Intuitively, the difference in skill intensities of an efficient producer and a less efficient producer is strictly greater, the higher is φ. That is, $h/l\,(z,\varphi)$ is log-supermodular in z and φ so that within an industry $\frac{h/l(z,\varphi)}{h/l(z',\varphi)} > \frac{h/l(z,\varphi')}{h/l(z',\varphi')}$ for all $z > z'$ and $\varphi > \varphi'$. Hence, when a reduction in trade costs induces low$-z$ producers to contract and high$-z$ producers to expand, the increase in the relative demand for skill is strictly greater, the higher is φ.

[32] How would our calibration be affected if we assumed that productivity draws were not *i.i.d.* across subsectors and sectors? One might think that for a given θ, if productivity were relatively higher in the sector intensive in a country's abundant factor, then the S-S effect would be strengthened. However, our choice of θ would be different under this alternative assumption. In particular, matching the difference of 0.11 in the U.S. trade data would require a higher value of θ, which would weaken the S-S effect. Which effect dominates is a quantitative matter.

While a higher θ weakens the S-S effect, it strengthens the effect of skill-biased technology on the skill premium. We illustrate this point quantitatively in Figure 4. This figure depicts the percentage change in the skill premium of moving from autarky to our baseline trade shares, for different values of θ, when technology is skill biased ($\varphi > 0$ is at its level of our two baseline parameterizations). Intuitively, as θ rises, the relative difference in productivity between high- and low-productivity producers increases. Thus, reallocation across producers as a result of a decline in trade costs induces a greater increase in the relative demand for skill, the greater is θ. Hence, by strengthening the SBT effect and weakening the S-S effect, the percentage change in the skill premium in country 3 is increasing in θ. On the other hand, the change in the skill premium in country 1 is non-monotonic in θ because a higher θ strengthens the SBT effect and weakens the S-S effect, and these forces push the skill premium in opposite directions in a skill-abundant country. Note, however, that the SBT effect dominates for $\theta > 0.1$.

We are now equipped to understand the results of our baseline parameterizations with SBT. Without offshoring (Column 1 in Table 2), countries 1 and 2 experience a 3.46% increase in the skill premium, while country 3 experiences a 5.69% increase in the skill premium. The SBT effect is relatively strong compared to the S-S effect in all countries for two reasons. First, at $\theta = 0.25$, the S-S effect is weak (recall Figure 2 and Column 3 of Table 2). Second, at $\varphi = 0.368$ and $\theta = 0.25$, the SBT effect is strong (recall Figures 3 and 4).

The SBT effect is particularly strong in country 3 relative to countries 1 and 2 for two reasons. First, the fraction of producers that export from country 3, 14.5%, is relatively small compared to the fraction in countries 1 and 2, 19.6%, because country 3 is a small country and hence exports in fewer subsectors. Thus, the relative productivity—and therefore the relative skill intensity—of expanding producers to contracting producers is greater in country 3 than in countries 1 and 2. Second, the ratio of employment by (skill-intensive) exporters is higher in country 3 than in countries 1 and 2 because in our parameterization, the ratio of exports to output is relatively higher in country 3. Both of these forces imply that when factors reallocate across producers within a sector, the relative increase in the demand for skill is greater in country 3 than in countries 1 and 2.

When we reduce offshoring costs on top of the reduction in trade costs, in our second baseline parameterization (Column 2 in Table 2), the increase in the skill premium is larger: 7.62% in countries 1 and 2, and 7.54% in country 3. These results can be understood following the logic in Section 4. First, offshoring magnifies the SBT effect because subsectors that expand by adopting foreign technology become more skill intensive. Second, the S-S effect is strengthened when technologies can be internationally reallocated because relative factor rewards become more important in determining relative costs of production. This is apparent from comparing the relative changes in the skill premia across Columns 3 and 4 of Table 2, where technology is Hicks-neutral so that only the S-S effect is active. The strengthening of the S-S effect leads to an increase in the skill premium for skill-abundant countries, and a reduction for the unskill-abundant country. This partly explains why including offshoring increases the skill premium by a larger magnitude in country 1 than in country 3.

6 Quantitative Analysis: Additional Implications

In this section, we discuss additional implications of our model and link these to others' and our own empirical findings. We first show that our model with skill-biased technology implies that trade is more prevalent in skill-intensive sectors, and provide support for this implication using U.S. data. We then discuss the impact of globalization on sectoral price changes, on the reallocation of factors between sectors, and on the factor content of trade, all of which have received significant attention in the literature.

Trade and skill intensity: In our model with skill-biased technology, normalized trade (defined as the ratio of exports plus imports to output minus net exports) is greatest in skill-intensive sectors. This is illustrated in Figure 5, which depicts a positive relation in the model between country 1's normalized trade by sector and sectoral skill intensity for all manufacturing sectors, under our baseline parameterization with trade and offshoring.[33] Figure 5 also shows that this relation is essentially flat in our parameterization with Hicks-neutral technology.

We prove this result analytically, in Proposition 5 in the Appendix under Assumptions A1 and A4. The intuition is that Ricardian comparative advantage is relatively more important in skill-intensive sectors. Hence, a given productivity advantage, $z_i > z_{-i}$, provides country i producers in the skill-intensive sector a relatively larger cost advantage than in the unskill-intensive sector. This implies that the value of trade as a fraction of sectoral absorption (i.e. production minus net exports) is increasing in a sector's skill intensity.

This result is similar to that in Fieler (2007), which predicts that one sector is more traded than another, but unlike Fieler (2007) does not rely on an assumption that the distribution of productivities is more dispersed in one sector than in another.[34] Instead, in our model the interaction between skill intensity and productivity causes the same distribution of productivities in all sectors to yield a more dispersed distribution of unit costs in skill-intensive sectors. Our model, therefore, predicts that normalized world trade is greatest in the most skill-intensive sectors, even after controlling for the dispersion of productivities or the elasticity of substitution.

To evaluate this prediction of the model, we construct measures of U.S. normalized trade in manufacturing sectors using the BEA's detailed IO tables for the 2002 Benchmark.[35] We regress

[33] This pattern is very similar in the parameterization with trade only.

[34] Similarly, Epifani and Gancia (2006) assume that industries with a high degree of product differentiation are skill intensive.

[35] In the denominator of our measure of normalized trade, we use gross output plus imports minus exports, which differs from absorption. The latter is based on final demand instead of gross output.

these on (*i*) sectoral skill intensity measured by the share of non-production workers and (*ii*) a measure of the sector's elasticity of substitution as reported in Broda and Weinstein (2006). Table 4 reports the results. We run the regression without controlling for the elasticity of substitution—reported in Columns 1 and 2—and also controlling for the elasticity of substitution—reported in Columns 3 and 4. In Column 1 we use all available manufacturing IO-code sectors and in Column 2 we restrict the sample to the manufacturing IO-code sectors for which we have a measure of the elasticity of substitution. In Column 3 we control for the median and in Column 4 we control for the average Broda and Weinstein (2006) elasticity of substitution corresponding to each manufacturing IO-code sector. In all specifications, the coefficient on skill intensity is positive and significant at the 1% level. To our knowledge, we are the first to identify this relationship in the data. We acknowledge that there are alternative mechanisms that could also lead to this pattern in the data. For example, an alternative hypothesis that is also consistent with the results in Table 4 is that trade costs are lower in skill-intensive sectors.

Sectoral prices: In our model, globalization impacts sectoral prices, $P_i\left(j\right)$, through two channels. First, it increases the relative price of sectors intensive in the locally abundant factor, as in the Heckscher-Ohlin model. Second, in our parameterization with skill-biased technology, it leads to a greater increase in trade volumes in skill-intensive sectors.[36] This decreases the relative price of skill-intensive goods as in a standard model of skill-biased technological change. These two channels push relative sector-level prices in opposite directions in a skill-abundant country such as the U.S.

Figure 6 displays the percentage change in sectoral prices of manufactured goods in country 1 of moving from autarky to our baseline levels of trade and offshoring, with Hicks-neutral technology and skill-biased technology. With Hicks-neutral technology, the relative price of skill-intensive sectors increases, as in the H-O model (note that the slope of the curve is only slightly positive because the increase in the skill premium is small–recall Column 3 in Table 2). With skill-biased technology, the relative price of skill-intensive sectors falls because the SBT effect is more powerful than the S-S effect.

Hence, our model provides a quantitatively powerful mechanism that can counter the direct effect of the skill premium on the relative price of skill-intensive sectors. It has the potential to address the observation that large changes in the skill premium in the U.S. have been accompanied by relatively small changes in the relative price of skilled to unskilled goods (see e.g. Lawrence and Slaughter (1993)), which has been interpreted as evidence that globalization is not responsible for much of the rise in inequality. We do not attempt to assess the quantitative success of our model in matching sectoral price changes, because our model does not fully account for the rise in the skill premium over this period.

[36]That reductions in trade costs increase trade more in skill-intensive sectors is not an unambiguous prediction of the model. Indeed, one can show that the growth of trade in skill-intensive sectors is higher (lower) at high (low) trade costs.

Cross-sector factor reallocation: If the S-S effect is responsible for increasing the skill premium, we should observe an increase in the relative demand for skilled workers resulting from shifts in the sectoral distribution of employment towards skill-intensive sectors. At fixed factor supplies, this requires within-sector reductions in skill intensities. However, empirical studies document both within-industry increases in the share of skilled workers—see e.g. Berman, Bound, and Griliches (1994) for the U.S.—and relatively little between-sector labor reallocation—see e.g. Currie and Harrison (1997) for Morocco, Hanson and Harrison (1999) for Mexico, and Attanasio et. al. (2004) for Colombia.

In our model, as in any standard framework with constant and inelastically supplied labor endowments, simple accounting implies that it is impossible to obtain both between-sector reallocation towards skill-intensive sectors and within-sector increases in the ratio of skilled to unskilled workers. If one is positive, then the other must be negative. Hence, observed increases in both between- and within-sector reallocations provide evidence of growing skill endowments but do not provide evidence that globalization has not affected inequality.

Our framework, like the H-O model, predicts that a country's labor reallocates towards sectors that are intensive in its locally abundant factor. However, the magnitude of this reallocation is significantly smaller in our framework than in the H-O model because higher values of θ reduce inter-sectoral factor reallocation. For example, in our baseline parameterization with only trade, the increase in the share of manufacturing labor employed in the 50% most skill intensive sectors that results from moving from autarky to current levels of trade is 3.7%. However, when we reduce Ricardian productivity differences and set $\theta = 0.025$, the increase in the share rises to 9.3%. Hence, our framework can generate a larger increase in the skill premium and less between-sector labor reallocation than can our parameterization with weaker Ricardian forces.

Factor content of trade: According to Krugman (2000), "...many economists studying the impact of trade on wages have been reluctant to commit themselves to a specific CGE model. Instead, they have tried to use a shortcut, by estimating the 'factor content' of trade." A typical approach to calculating the factor content of trade is to estimate the factors of production used to produce exports and subtract from this an estimate of the factors of production that would have been used to produce imports. The factor content of trade is then subtracted from actual factor endowments. Dividing the percentage change in the effective ratio of skilled to unskilled endowments that is induced by trade by an estimate of the elasticity of substitution between skilled and unskilled workers gives an estimate of the impact of trade on the skill premium. We investigate to what extent this is a reasonable approach to determining the change in the skill premium from a reduction in trade costs. To do so we replicate this exercise on data generated by our model under our parameterizations with Hicks-neutral and skill-biased technology (with only trade and no offshoring) and compare the estimated changes in the skill premium with the actual changes in the skill premium that result from the full model.

In order to calculate the factor content of trade, we must estimate the factors of production (i) that are used to produce exports and (ii) that would have been used to produce imports. This is an extremely difficult task. Here, we follow the "equal allocation" procedure of Katz and Murphy (1992) and measure the factors of production used to produce County 1 exports and that would have been used to produce country 1 imports, using country 1 average unit labor requirements.

With Hicks-neutral technology (Column 3 in Table 2), the actual increase in the skill premium in country 1 according to the model is 0.4%. Using data generated by the model and the factor content of trade approach, the increase in the skill premium in country 1 is estimated to be 0.5%. In our baseline parameterization with skill-biased technology (Column 1 in Table 2), the actual increase in the skill premium in country 1 is 3.5%. Using data generated by the model and the factor content of trade approach, the increase in the skill premium in country 1 is estimated to be 0.2%.

The equal allocation approach to the factor content of trade does well in the first case with Hicks-neutral technology and poorly in the second case with skill-biased technology because the assumptions underlying the equal allocation counterfactual are reasonable in the prior case—in which all producers in a sector share the same skill intensity—but not the latter case—in which the skill intensity of a typical exporting producer is relatively high compared to the skill intensity of a typical producer that is replaced by imports. It remains an open research question whether one can find a simple back-of-the-envelope procedure to adequately measure the factor content of trade when technology is skill biased.

7 Quantitative Analysis: Sensitivity and Other Counterfactuals

In this section, we perform sensitivity analyses to better understand the role (both qualitative and quantitative) of various parameters in our model. We also perform additional counterfactual experiments to assess how the geographic composition of globalization (i.e. the overall share of country 1's trade and offshoring with skill-scarce countries), the extent of globalization (i.e. the size of trade and offshoring as a share of output), and the type of globalization (i.e. the relative importance of trade and offshoring) impact the skill premium in our model.

7.1 Sensitivity Analysis

In Section 5.3 we discussed the relationship between our model's two key parameters, θ and φ, and the impact of globalization on the skill premium. In this subsection, we provide additional sensitivity analyses with respect to other model parameters (holding θ and φ constant). In Columns 1-11 of Table 5, we report the change in the skill premium in countries 1 and 3 of going from autarky to the baseline trade shares under alternative parameterizations. We focus on counterfactuals in which we lower trade and offshoring costs from their autarky levels to those consistent with 2006 levels of trade and offshoring to ease the comparison of results across alternative parameterizations. Columns 1 and 2 report the change in the skill premium under our baseline parameterizations, with and without offshoring, respectively.

We first consider a calibration of our model, without offshoring, with a higher elasticity of substitution between skilled and unskilled labor while holding φ constant, reported in Columns 3-4 of Table 5. We consider $\rho = 1.4$ (here we are using Katz and Murphy's (1992) estimate without taking into account the intra- and inter-sectoral factor reallocation that is present in our model) and $\rho = 2$ (this is on the high side of the estimates by Borjas et. al. (1997), again without taking into account the intra- and inter-sectoral factor reallocation that is present in our model), instead of $\rho = 1.2$. The rise in country 1's (country 3's) skill premium is 2.5% (3.3%) when $\rho = 1.4$, and 1.5% (1.9%) when $\rho = 2$, instead of 3.5% (5.7%) when $\rho = 1.2$. Clearly, a higher elasticity ρ requires a smaller change in the equilibrium skill premium in response to an increase in the relative demand for skilled labor induced by trade integration.

Next, we report results using a lower and a higher elasticity of substitution between sectors and sub-sectors ($\eta = 2$ and $\eta = 3.5$, instead of $\eta = 3$) in our parameterization without offshoring, reported in Columns 5-6 of Table 5. The rise in country 1's (country 3's) skill premium is 2.95% (3.61%) when $\eta = 2$, and 3.39% (6.18%) when $\eta = 3.5$. A higher elasticity η magnifies the effects of skill-biased technology on the skill premium because it amplifies size differences across producers with different productivities (and hence skill intensities). However, a higher elasticity also mitigates the S-S effect because, even under autarky, countries specialize in sectors with comparative advantage, and hence the extent of sectoral reallocation induced by trade is weaker. All this implies that a higher η leads unambiguously to a larger increase in country 3's skill premium, but has an ambiguous effect on country 1's skill premium (in the cases we consider, the increase in country 1's skill premium is lower with both $\eta = 2$ and $\eta = 3.5$).

We then consider a calibration of our model in which we abstract from non-manufactured goods. That is, we increase the share of manufactured goods from $\gamma = 0.22$ to $\gamma = 1$, reported in Columns 7-8 of Table 5. We choose the level of trade costs to match the share of trade in manufacturing in our baseline parameterization. Given that manufactured goods are more heavily traded than non-manufactured goods, this alternative parameterization results in a much higher share of trade in the overall economy: the average of exports and imports relative to total output in country 1 increases from 7.5% when $\gamma = 0.22$ to 22.5% when $\gamma = 1$. The increase in the skill premium of going from autarky to these higher levels of trade is roughly three times larger than under our baseline parameterization without offshoring: 9.4% in country 1 and 13.8% in country 3. If we also incorporate offshoring (and target a ratio of outward offshoring sales to exports in country 1 equal to 1, roughly that observed in the U.S. manufacturing industries in 2006), the increase in the skill premium is 13.1% in country 1 and 13.3% in country 3. Note that the increase in the skill-premium is larger in country 1 than in country 3, relative to the parameterization without offshoring, because offshoring magnifies the S-S effect. These results reveal that it is important to take into consideration the share of globalization in the overall economy and not only in manufacturing in order to quantitatively assess the role of globalization on the skill premium.[37]

In the next two sensitivity analyses we change the level of trade and offshoring that we target in our calibration as follows. First, we increase country 1's share of trade over output in manufacturing from 22.7% to 40%. The latter corresponds to the share of trade in manufacturing for a skill-abundant country that is more open than the U.S., such as France in 2005. In this case, we abstract from offshoring. Second, starting from our baseline with offshoring, we increase the ratio of offshoring to exports in country 1, from 1.72 to 2.8. The latter value corresponds to total sales of majority-owned non-bank U.S. foreign affiliates relative to U.S. exports (in our baseline parameterization, we only included local sales to the host economy). Results are displayed in Columns 9 and 10 of Table 5. In the first case, the increase in country 1's skill premium starting from autarky is 4.7% (instead of 3.5%). In the second case, the increase in country 1's skill premium starting from autarky is 8.9% (instead of 7.6%).

We finally consider a version of our model with offshoring in which we increase the parameter θ_m that governs the mean and standard deviation of country/subsector-specific offshoring costs. As we increase θ_m we must reduce the level of country-level offshoring costs to match our target offshoring-to-export ratios. Column 11 of Table 5 shows that if we double θ_m from 0.1 to 0.2, the rise in the skill premium in countries 1 and 3 of going from autarky to the baseline levels of trade and offshoring is 7.6% and 8.4% (instead of 7.9% and 7.8%), respectively. We also consider an increase in θ_m of a factor of 10 from 0.1 to 1, and the rise in the skill premium in countries 1 and 3 is 6.9% and 9.2%, respectively (not reported in Table 5). We see that very large changes in θ_m have a relatively small effect on the rise in the skill premium from globalization.

We conclude that while the size of the change in the skill premium varies to some degree across these alternative parameterizations, in all cases the SBT effect is stronger than the S-S effect, so that the skill premium increases even in skill-scarce countries.

7.2 Changing the Extent, Composition, and Type of Globalization

Here we consider sensitivity analyses and counterfactuals regarding the geographic composition of globalization, i.e. the overall share of country 1's trade and offshoring with skill-scarce countries; the extent of globalization, i.e. the size of trade and offshoring as a share of output; and the type of globalization, i.e. the relative importance of trade and offshoring.

The geographical composition of globalization: Our discussion of the impact of globalization

[37] We can also view these results as roughly the increase in the manufacturing skill premium from globalization in an economy in which labor mobility between manufacturing and non-manufacturing is restricted. In this case, the increase in the manufacturing skill premium would be significantly larger than the increase in the non-manufacturing skill premium.

on the skill premium has already raised the question of the differential impact on a skill-abundant country, such as the U.S., of globalization with a skill-abundant or an unskill-abundant country. Clearly, the relative strength of the S-S and SBT effects plays a large role in determining the answer to this question.

The S-S effect is relatively weak compared to the SBT effect. This was already apparent from comparing the changes in the skill premia across Columns 2 and 4 of Table 2. These two parameterizations differ only in our choice of how to set the value of φ—which is zero in Column 4, so that only the S-S effect is active, and is set to match the elasticity of skill intensity to sales in Column 2, so that both the S-S and SBT effects are active. In countries 1 and 2, the change in the skill premium of moving from autarky to 2006 levels of trade and offshoring is 1.12% and 7.62% with Hicks-neutral and skill-biased technology, respectively. The relative weakness of the S-S effect is even more apparent when considering country 3, where the change is -2.53% and 7.54% with Hicks-neutral and skill-biased technology, respectively.

To address further the question of how the composition of globalization affects country 1's skill premium, we ask: What would happen to the skill premium in country 1 if country 3's share of skilled workers rose to equal to that in countries 1 and 2, $H_3/L_3 = H_1/L_1$, while all other parameters remain constant at the level in our preferred baseline calibration? The results are presented in Column 12 of Table 5. In spite of having eliminated the S-S effect, the skill premium falls by only 0.6% in country 1 relative to the skill-premium in our baseline parameterization, where $H_3/L_3 \approx \frac{1}{2}H_1/L_1$.

Perhaps one reason that we find that the composition of globalization is relatively unimportant in the two previous counterfactuals is because the share of country 1's trade and offshoring with country 3 is relatively small. To address this issue we calculate the change in the skill premium from increasing the shares of trade and offshoring between countries 1 and 3 from zero to one, for given fixed total shares of trade and offshoring in country 1. In the parameterization with trade only, the skill premium in country 1 increases by only 1% as the S-S effect becomes slightly stronger. In the parameterization with trade and offshoring, surprisingly, the skill premium in country 1 falls by 3.5%. This results from the fact that in this case country 1 receives almost no inward offshoring because country 3 producers are relatively unproductive. From these counterfactuals we conclude that country 3's very low TFP in our parameterization plays a larger role than its low skill abundance in determining the importance of country 1's geographic composition of globalization for its skill premium.

The extent of globalization: We now perform counterfactuals to study the implications of further reductions in trade and offshoring costs on the skill premium, starting at the level of trade and offshoring observed in 2006. In these exercises, we do not recalibrate the model as we reduce trade and offshoring costs.

First we reduce all trade costs proportionately and all country-specific offshoring costs proportionately to double the trade share of output from the level in 2006 while maintaining the same ratio of outward offshoring to exports in country 1. Country 1 experiences a 2.8% increase in its skill premium and country 3 experiences a 6.3% increase in its skill premium (reported in Column 13 in Table 5).

Second we ask: What is the upper bound on the increase in the skill premium from trade integration, with no offshoring, starting at the observed level of trade in 2006? In order to address this question, we move to a zero-gravity world by removing all trade costs (i.e. $\tau_{ij}^k = 1$ for all i, j, k), starting at our first baseline parameterization—without offshoring. Country 1 experiences a 10% increase in its skill premium and country 3 experiences a 9.7% increase in its skill premium (reported in Column 14 in Table 5). The skill premium increases in country 3 because the SBT effect dominates the S-S effect.

In our third counterfactual, we re-calculate the increase in the skill premium from moving to a zero-gravity world, but this time we incorporate offshoring. This is important because, from Proposition 3, falling offshoring costs strengthen the S-S effect. In particular, we remove all trade and offshoring costs (i.e. $\tau_{ij}^k = 1$, $\mu_{ij} = 1$ for all i, j, k, and $\theta_m = 0$) from our second baseline parameterization. Country 1 experiences a 34.7% increase in its skill premium and country 3 experiences a 15% decrease in its skill premium (reported in Column 15 in Table 5). The rise in country 1's skill premium of going from current levels of globalization to a zero-gravity world is more than three times as large with offshoring as without offshoring. Moreover, the skill premium actually falls in country 3 going from current levels of globalization to a zero-gravity world with offshoring.

These counterfactuals suggest that at our baseline shares of trade and offshoring the S-S effect is dormant, but not dead. That is, in spite of our finding that the S-S effect is weak—which accords well with empirical studies of the implications of globalization in the developing world—this need not remain the case as future trade and offshoring costs fall. Hence, further reductions in trade and offshoring costs may have large and divergent impacts on the skill premium in skill-abundant and unskill-abundant countries.

The type of globalization: What is the contribution of trade and what is the contribution of offshoring in determining the rise of the skill premium? To provide a simple answer to this question, we compare the rise in the skill-premium of moving from autarky to the levels of trade in 2006 with no offshoring (Column 1 in Table 2), to that of moving from autarky to the levels of trade and offshoring in 2006 (Column 2 in Table 2). The rise in the skill-premium with trade alone is 45% (75%) as large as the rise in the skill-premium with both trade and offshoring in country 1 (country 3). That trade is relatively more important in country 3 than in country 1 is not surprising: offshoring increases the S-S effect, as established in Proposition 3, which decreases the skill premium in country 3 and increases it in country 1.

This comparison, however, is imperfect because in recalibrating the model with trade and offshoring, we have changed not only trade and offshoring costs, but also country 3's TFP. We thus consider an additional counterfactual in which we calibrate the model with only trade assuming the same TFP in country 3 as in the parameterization with trade and offshoring (and we do not target the share of country 1 imports in manufacturing from country 2). This counterfactual gives very similar results to those above: the rise of the skill-premium starting in autarky, with trade alone, is 49% (66%) in country 1 (country 3) of the rise in the skill premium, with both trade and offshoring.

We conclude that both trade and offshoring are quantitatively important to assess the impact of globalization on the skill premium.

8 Conclusions

We have constructed a quantitative model of international trade and offshoring to study the impact of globalization on the skill premium in developed and developing countries. The key mechanisms in our framework arise from the interaction between three elements: Heckscher-Ohlin forces, Ricardian forces, and skill-biased technology. By combining these three elements, our model nests the Stolper-Samuelson and skill-biased technology effects of globalization on the skill premium. We use our framework to investigate, both theoretically and quantitatively, the impact on the skill premium of changes in the extent (the share of trade and offshoring in output), the geographical composition (the relative importance of skill-abundant and skill-scarce countries in the world economy), and the type (international trade and offshoring) of globalization.

When the model is parameterized to match salient features of the extent and composition of U.S. trade and offshoring with skill-abundant and skill-scarce countries, the SBT effect is significantly stronger than the S-S effect, so that a reduction in trade and offshoring costs increases the skill premium in both skill-abundant and skill-scarce countries. In response to the three-fold increase in the extent of globalization in the U.S. over the last 40 years, the model generates an increase in the U.S. skill premium in the range of 4% to 6%, or 1/6 to 1/4 of the rise of the college wage premium during this period. The rise of trade and offshoring have an impact of similar magnitude on the skill premium, suggesting that considerations of both trade and offshoring are important to assess the overall impact of globalization on the skill premium. The S-S effect is weak in our parameterization, implying that the skill-abundance of a country's trade and offshoring partners does not play a significant role in determining the impact of globalization on the country's skill premium.

While our framework captures two important forces in the debate on globalization and the skill premium, the S-S and SBT effects, and incorporates both trade and offshoring, it abstracts from other interesting and potentially important considerations. For example, our model abstracts from additional factors of production (such as land, other natural resources, and capital) and does not incorporate the endogenous supply of skilled and unskilled labor, the endogenous bias of technology, or endogenous capital accumulation with capital-skill complementarity. Our analysis also abstracts from considerations of unemployment and within-group inequality. Extensions of our model along these directions is a fruitful area for future research to fully assess the quantitative effects of globalization on inequality.

A Characterizing Equilibrium in Special Cases

A.1 Characterizing Equilibrium with Hicks-Neutral Technologies

Here we impose Assumptions A1 and A2. The equilibrium values of $\{w_1, w_2, s_1, s_2, Q_1P_1, Q_2P_2\}$ can be solved using: the balanced trade condition (5); our choice of world income as the numeraire, $Q_1P_1 + Q_2P_2 = 1$; and the labor market clearing conditions (3) and (4), which, together with cost minimization, can be expressed as

$$H_1 = \frac{1}{2s_1} \sum_{j=x,y} \alpha_j \left[\pi_{21}(j) Q_2P_2 + \pi_{11}(j) Q_1P_1\right] \tag{8}$$

$$L_1 = \frac{1}{2w_1} \sum_{j=x,y} (1-\alpha_j) \left[\pi_{21}(j) Q_2P_2 + \pi_{11}(j) Q_1P_1\right] \tag{9}$$

$$H_2 = \frac{1}{s_2} \left[\frac{1}{2} \sum_{j=x,y} \alpha_j - H_1 s_1\right] \tag{10}$$

$$L_2 = \frac{1}{w_2} \left[\frac{1}{2} \sum_{j=x,y} (1-\alpha_j) - L_1 w_1\right] \tag{11}$$

In what follows, we impose Assumption A3 in addition to Assumptions A1 and A2. Assumption A3 simplifies Equations (8)-(11) by implying $w_1 = s_2$, $s_1 = w_2$, and $Q_1P_1 = Q_2P_2 = 1/2$. Under Assumptions A1-A3, Equations (8) and (9) become

$$H_1 s_1 = \frac{1}{2}(1-\alpha_x) + \frac{1}{4}(2\alpha_x - 1)\left[\pi_{11}(x) + \pi_{21}(x)\right], \tag{12}$$

$$L_1 w_1 = \frac{1}{2} - H_1 s_1, \tag{13}$$

Equations (10) and (11) become redundant, and the relative cost of country 1's factor bundle in sector j simplifies to

$$\frac{v_1(j)}{v_2(j)} = \left(\frac{s_1}{w_1}\right)^{2\alpha_j - 1}.$$

Offshoring: To solve for the equilibrium of our model with offshoring under Assumptions A1 and A2 or under Assumptions A1, A2, and A3, we use Equations (8)-(11) or Equations (12) and (13), respectively, where $\pi_{ni}(j)$ is defined by Equation (7).

A.2 Characterizing Equilibrium with Skill-Biased Technology

Under Assumptions A1 and A4, we can write the factor market clearing conditions as

$$\begin{aligned} L &= \sum_{j=x,y} \left[\int_0^\infty l_{ii}(z,j)\, \chi_{ii}(z,j)\, dz + \int_0^\infty l_{-ii}(z,j)\, \chi_{-ii}(z,j)\, dz \right] \\ H &= \sum_{j=x,y} \left[\int_0^\infty h_{ii}(z,j)\, \chi_{ii}(z,j)\, dz + \int_0^\infty h_{-ii}(z,j)\, \chi_{-ii}(z,j)\, dz \right] \end{aligned}$$

Here, $l_{ii}(z,j)$ $(l_{-ii}(z,j))$ is the unskilled labor demanded by a country i subsector operating in sector j with productivity z in order to supply the domestic (export) market, conditional on supplying said market. We similarly define $h_{ii}(z,j)$ and $h_{-ii}(z,j)$ as the skilled labor demanded by a country i subsector operating in sector j with productivity z in order to supply the domestic (export) market, conditional on supplying said market. We define $\chi_{ii}(z,j) \big/ \int_0^\infty \chi_{ii}(z,j)\, dz$ as the density of productivities of subsectors in country i sector j that supply the domestic market. Finally, we similarly define $\chi_{-ii}(z,j) \big/ \int_0^\infty \chi_{-ii}(z,j)\, dz$ as the density of productivities of subsectors in country i sector j that supply the foreign market.

Equation (1), Equation (2), and the assumption that $\eta = 1$ yield

$$l_{ii}(z,j) = l_{-ii}(z,j) = \frac{1}{w} f\left(\frac{w}{s}, z, j\right) \tag{14}$$

$$h_{ii}(z,j) = h_{-ii}(z,j) = \frac{1}{s} g\left(\frac{w}{s}, z, j\right) \tag{15}$$

where

$$f\left(\frac{w}{s}, z, j\right) \equiv (1-\alpha_j)\left[\alpha_j z^{\varphi} \left(\frac{w}{s}\right)^{\rho-1} + 1 - \alpha_j\right]^{-1} \tag{16}$$

$$g\left(\frac{w}{s}, z, j\right) \equiv \alpha_j \left[(1-\alpha_j)\, z^{-\varphi} \left(\frac{w}{s}\right)^{1-\rho} + \alpha_j\right]^{-1} \tag{17}$$

Note that the labor use of a producer with productivity z is the same for domestic sales and for exports. This is a consequence of the assumption that $\eta = 1$, which implies that the direct effect of a reduction in trade costs—less labor is required to sell a given quantity of output in the foreign market—and the indirect effect—falling export prices increase the quantity sold in export markets—exactly offset each other. Substituting Equations (14) and (15) into the factor market clearing conditions yields

$$wL = \sum_{j=x,y} \int_0^\infty f\left(\frac{w}{s}, z, j\right) \left[\chi_{ii}(z,j) + \chi_{-ii}(z,j)\right] dz \quad (18)$$

$$sH = \sum_{j=x,y} \int_0^\infty g\left(\frac{w}{s}, z, j\right) \left[\chi_{ii}(z,j) + \chi_{-ii}(z,j)\right] dz$$

B Proofs

Proof of Lemma 1. The proof of Lemma 1 follows very closely the proof of the "Quasi-Heckscher-Ohlin Prediction" in Romalis (2004): To obtain a contradiction, suppose that $\frac{s_1}{w_1} \geq \frac{s_2}{w_2}$. Then $\frac{v_1(x)}{v_2(x)} \geq \frac{v_1(y)}{v_2(y)}$, which implies that country 1 (respectively 2) captures a larger fraction of unskill-intensive sectors (skill-intensive sectors); that is, $\pi_{n1}(x) \leq \pi_{n1}(y)$ and $\pi_{n2}(x) \geq \pi_{n2}(y)$ for $n = 1, 2$, according to Equation (6). Moreover, production is weakly less skill intensive in country 1 than in country 2 in each sector; that is Equation (2) becomes $\frac{h_i}{l_i}(j) = \frac{\alpha_j}{1-\alpha_j}\left(\frac{w_i}{s_i}\right)^\rho$, which implies $\frac{h_1}{l_1}(j) \leq \frac{h_2}{l_2}(j)$ for all j. Therefore, factor markets cannot simultaneously clear in countries 1 and 2, a contradiction that proves (i) $\frac{s_1}{w_1} < \frac{s_2}{w_2}$. Part (i) directly implies part (ii). **QED.** ■

Proof of Lemma 2. To obtain a contradiction, suppose that Lemma 2 is false; i.e. suppose that $\frac{d}{d\tau}\left(\frac{s_1}{w_1}\right) \geq 0$. Under Assumptions A1-A3, the condition $\frac{d}{d\tau}\left(\frac{s_1}{w_1}\right) \geq 0$ is equivalent to $\frac{d}{d\tau}s_1 \geq 0$ (since $\frac{d}{d\tau}s_1 \geq 0$ if and only if $\frac{d}{d\tau}w_1 \leq 0$). According to Equation (12), this is equivalent to $\frac{d}{d\tau}\left[\pi_{11}(y) + \pi_{21}(y)\right] \geq 0$, so that $\frac{d}{d\tau}s_1 \geq 0$ if and only if

$$\left[\pi_{21}^2(x)\,\tau^{2/\theta} + \pi_{11}^2(x)\right] \tau \frac{d}{d\tau}\left(\frac{v_1(x)}{v_2(x)}\right) + \left[\pi_{21}^2(x)\,\tau^{2/\theta} - \pi_{11}^2(x)\right] \frac{v_1(x)}{v_2(x)} \leq 0 \quad (19)$$

Given our assumption that $\frac{d}{d\tau}s_1 \geq 0$, Lemma 1 implies $\frac{d}{d\tau}\left(\frac{v_1(x)}{v_2(x)}\right) \geq 0$, so that the first term in Condition (19) is weakly positive. Moreover, the second term in Condition (19) is strictly positive, since $\pi_{21}^2(x)\,\tau^{2/\theta} > \pi_{11}^2(x)$. This yields a contradiction, implying the desired result that $\frac{d}{d\tau}\left(\frac{s_1}{w_1}\right) < 0$. **QED.** ■

Proof of Proposition 1. Our proof of Proposition 1 follows directly from the following two lemmas, Lemma 3 and Lemma 4, and the fact that under Assumptions A1-A3 if world exports in world output is fixed at δ then country 1 (country 2) exports in country 1 (country 2) output is fixed at δ.

Lemma 3 *Suppose Assumptions A1-A3 hold and that $H_1/L_1 > H_2/L_2$. Then if the trade cost τ is a function of θ such that world exports in world output is fixed at $\delta \in (0, 1/2)$, then $\frac{d}{d\theta}\left(\frac{s_1}{w_1}\right) < 0$ and $\frac{d}{d\theta}\left(\frac{s_2}{w_2}\right) > 0$.*

Proof of Lemma 3. We have

$$\begin{aligned}\frac{d}{d\theta}\left(\frac{s_1}{w_1}\right) &< 0 \iff \frac{d}{d\theta}\left[\pi_{11}(x)+\pi_{21}(x)\right]<0\\ &\iff \frac{d}{d\theta}\left[2\pi_{11}(x)+\delta-1\right]<0\\ &\iff \frac{d}{d\theta}\pi_{11}(x)<0.\end{aligned}$$

The first equivalence follows from Assumptions A1-A3, the second follows from

$$\delta \equiv 1-\pi_{11}(x)+\pi_{21}(x), \tag{20}$$

and the third follows from the fact that $\frac{d}{d\theta}\delta = 0$. In what follows, we first solve for $\frac{d\tau}{d\theta}\frac{1}{\tau}$ by differentiating Equation (20) with respect to θ. Second, we substitute this solution for $\frac{d\tau}{d\theta}\frac{1}{\tau}$ into $\frac{d}{d\theta}\pi_{11}(x)$ to prove Lemma 3.

Differentiating Equation (20) with respect to θ and imposing $\frac{d}{d\theta}\delta = 0$ yields the following solution for $\frac{d\tau}{d\theta}\frac{1}{\tau}$:

$$\frac{d\tau}{d\theta}\frac{1}{\tau} = \frac{\pi_{11}^2(x)\ln\left[\frac{v_1(x)}{\tau v_2(x)}\right]-\pi_{21}^2(x)\ln\left[\frac{\tau v_1(x)}{v_2(x)}\right]\tau^{2/\theta}}{\pi_{21}^2(x)\tau^{2/\theta}-\pi_{11}^2(x)}\frac{1}{\theta}+\frac{v_2(x)}{v_1(x)}\frac{d}{d\theta}\left(\frac{v_1(x)}{v_2(x)}\right) \tag{21}$$

Differentiating $\pi_{11}(x)$ with respect to θ and substituting in for $\frac{d\tau}{d\theta}\frac{1}{\tau}$ from Equation (21) yields

$$\frac{d\pi_{11}(x)}{d\theta} = \frac{\frac{1}{\theta^2}\left[\frac{\tau v_1(x)}{v_2(x)}\right]^{1/\theta}\left[\pi_{11}(x)\pi_{21}(x)\right]^2}{\pi_{21}^2(x)\tau^{2/\theta}-\pi_{11}^2(x)}(-2\ln\tau)<0.$$

This is negative because $\pi_{21}^2(x)\tau^{2/\theta} > \pi_{11}^2(x)$ and $\tau > 1$. Hence, $\frac{d}{d\theta}(s_1/w_1) < 0$, and therefore $\frac{d}{d\theta}(s_2/w_2) > 0$, for a fixed share $\delta > 0$ of world exports in world output. **QED.** ■

Lemma 4 *Suppose Assumptions A1 and A2 hold. Then* $\frac{d}{d\theta}\lim_{\tau\to\infty}(s_i/w_i) = 0$ *for* $i = 1, 2$.

Proof of Lemma 4. The proof follows directly from the fact that $\lim_{\tau\to\infty}\pi_{11}(j) = 1$ and $\lim_{\tau\to\infty}\pi_{21}(j) = 0$. **QED.** ■

Proof of Proposition 2. Here we prove that if $\tau < \tau'$, then $\frac{s(\tau')}{w(\tau')} < \frac{s(\tau)}{w(\tau)}$. After setting out the necessary notation we proceed in three steps: Steps 1 and 2 are preliminary while Step 3 completes the proof of Proposition 2. In what follows we impose Assumptions A1 and A4.

Notation: Denote by $\chi_{in}(z,j;\tau)\Big/\int_0^\infty \chi_{in}(z,j;\tau)\,dz$ the density of country n subsectors in sector j with productivity z supplying country i, written explicitly as a function of the trade cost τ. Define $\Delta\chi_{ii}(z,j) \equiv \chi_{ii}(z,j;\tau') - \chi_{ii}(z,j;\tau)$ and $\Delta\chi_{-ii}(z,j) \equiv \chi_{-ii}(z,j;\tau') - \chi_{-ii}(z,j;\tau)$.

Denote by $\Omega_{ii}(j,\tau)$ the set of subsectors in sector j in which country i producers supply their domestic market; similarly denote by $\Omega_{-ii}(j,\tau)$ the set of subsectors in which country i producers in sector j supply in the foreign country.

Step 1: *If* $\tau<\tau'$ *and* $\frac{w(\tau)}{s(\tau)}\geq\frac{w(\tau')}{s(\tau')}$, *then* $\omega\in\Omega_{ii}(j,\tau)$ *implies* $\omega\in\Omega_{ii}(j,\tau')$.

Let $\tau<\tau'$ and $\frac{w(\tau)}{s(\tau)}\geq\frac{w(\tau')}{s(\tau')}$ and suppose that $\omega\in\Omega_{ii}(j,\tau)$, which is equivalent to $\frac{c_{ii}(\omega(j);\tau)}{c_{i-i}(\omega(j);\tau)}\leq 1$. There are two possible cases to consider: (i) $z_{-i}(\omega(j))\geq z_i(\omega(j))$ and (ii) $z_{-i}(\omega(j))<z_i(\omega(j))$. In case (i) we have $\frac{c_{ii}(\omega(j);\tau')}{c_{i-i}(\omega(j);\tau')}<\frac{c_{ii}(\omega(j);\tau)}{c_{i-i}(\omega(j);\tau)}\leq 1$, since $\frac{c_{ii}(\omega(j);\tau)}{c_{i-i}(\omega(j);\tau)}$ is weakly increasing in w/s if $z_{-i}(\omega(j))\geq z_i(\omega(j))$ and is strictly decreasing in τ. Hence, in case (i) we have $\omega\in\Omega_{ii}(j,\tau')$. In case (ii), we have $\omega\in\Omega_{ii}(j,\tau'')$ for any $\tau''\geq 1$; and in particular, $\omega\in\Omega_{ii}(j,\tau')$. Thus, if $\tau<\tau'$ and $\frac{w(\tau)}{s(\tau)}\geq\frac{w(\tau')}{s(\tau')}$, then $\omega\in\Omega_{ii}(j,\tau)$ implies $\omega\in\Omega_{ii}(j,\tau')$, concluding the proof of Step 1.

Step 2: *If* $\tau<\tau'$ *and* $\frac{w(\tau)}{s(\tau)}\geq\frac{w(\tau')}{s(\tau')}$, *then* $-\int_0^z\Delta\chi_{-ii}(v,j)\,dv<\int_0^z\Delta\chi_{ii}(v,j)\,dv$ *for all* $z>0$, $j=x,y$, *and* $i=1,2$.

Let $\tau<\tau'$ and $\frac{w(\tau)}{s(\tau)}\geq\frac{w(\tau')}{s(\tau')}$ and suppose that $\omega\notin\Omega_{ii}(j,\tau)$. Then $\frac{c_{ii}(\omega(j);\tau)}{c_{i-i}(\omega(j);\tau)}>1$, which requires $z_{-i}(\omega(j))>z_i(\omega(j))$. Hence, $\frac{c_{ii}(\omega(j);\tau)}{c_{i-i}(\omega(j);\tau)}>\frac{c_{ii}(\omega(j);\tau')}{c_{i-i}(\omega(j);\tau')}$. Thus, there must exist a positive mass of ω for which $\omega\notin\Omega_{ii}(j,\tau)$ and $\omega\in\Omega_{ii}(j,\tau')$ for $i=1,2$.[38] Choose an arbitrary $\omega(j)$ such that $\omega\notin\Omega_{ii}(j,\tau)$ and $\omega\in\Omega_{ii}(j,\tau')$. Then $\omega\in\Omega_{i-i}(j,\tau)$, $\omega\notin\Omega_{i-i}(j,\tau')$, and $z_{-i}(\omega(j))>z_i(\omega(j))$. Moreover, for any $\omega(j)$ there is a positive probability that $\omega\notin\Omega_{ii}(j,\tau)$ and $\omega\in\Omega_{ii}(j,\tau')$ (so that $\omega\in\Omega_{i-i}(j,\tau)$ and $\omega\notin\Omega_{i-i}(j,\tau')$). Hence,

$$\Pr\left[z_{-i}(\omega(j))<z\mid\omega\in\Omega_{i-i}(j,\tau)\setminus\Omega_{i-i}\left(j,\tau'\right)\right]<\Pr\left[z_i(\omega(j))<z\mid\omega\in\Omega_{ii}\left(j,\tau'\right)\setminus\Omega_{ii}(j,\tau)\right]$$

or, equivalently,

$$\frac{\int_0^z\left[-\Delta\chi_{i-i}(v,j)\right]dv}{\int_0^\infty\left[-\Delta\chi_{i-i}(v,j)\right]dv}<\frac{\int_0^z\Delta\chi_{ii}(v,j)\,dv}{\int_0^\infty\Delta\chi_{ii}(v,j)\,dv},\text{ for all }z>0 \tag{22}$$

By symmetry: (i) $\chi_{i-i}(z,j)=\chi_{-ii}(z,j)$ for almost all z, and (ii) $\int_0^\infty-\Delta\chi_{i-i}(v,j)\,dv=\int_0^\infty\Delta\chi_{ii}(v,j)\,dv$. Thus, according to Equation (22), we have $\int_0^z\left[-\Delta\chi_{-ii}(v,j)\right]dv<\int_0^z\Delta\chi_{ii}(v,j)\,dv$ for all $z>0$, $j=x,y$, and $i=1,2$, concluding the proof of Step 2.

Step 3: *The skill premium* s/w *is strictly decreasing in* τ.

Consider an arbitrary pair of trade costs $1\leq\tau<\tau'$, and to obtain a contradiction, suppose that $\frac{w(\tau)}{s(\tau)}\geq\frac{w(\tau')}{s(\tau')}$. According to Equation (5), and our normalization $w(\tau)L+s(\tau)H=1$, this implies $w(\tau)\geq w(\tau')$ and $s(\tau)\leq s(\tau')$. Equation (18), the condition that $w(\tau)\geq w(\tau')$, and the fact that $\frac{d}{d(w/s)}f\left(\frac{w}{s},z,j\right)<0$ together imply

$$\int_0^\infty f\left(\frac{w(\tau)}{s(\tau)},z,j\right)\Delta\chi_{ii}(z,j)\,dz\leq\int_0^\infty f\left(\frac{w(\tau)}{s(\tau)},z,j\right)\left[-\Delta\chi_{-ii}(z,j)\right]dz \tag{23}$$

[38] This requires that the density of subsectors drawing a productivity z must be positive for all z, but is otherwise independent of our choice of exponential distribution.

Finally, (i) $\frac{d}{dz} f\left(\frac{w(\tau)}{s(\tau)}, z, j\right) < 0$ with $\varphi > 0$, (ii) and Step 2 imply[39]

$$\int_0^\infty f\left(\frac{w(\tau)}{s(\tau)}, z, j\right) \Delta\chi_{ii}(z,j)\, dz > \int_0^\infty f\left(\frac{w(\tau)}{s(\tau)}, z, j\right) \left[-\Delta\chi_{-ii}(z,j)\right] dz \tag{24}$$

Equation (23) contradicts Equation (24). Therefore, if $\tau < \tau'$, then $\frac{w(\tau)}{s(\tau)} < \frac{w(\tau')}{s(\tau')}$. **QED.** ■

Proof of Proposition 3. We prove Part 1 and Part 2 separately.

Part 1. From Equations (8) and (9), we have $\lim_{\tau\to\infty} H_1 s_1 = \frac{1}{2} Q_1 P_1 (\alpha_x + \alpha_y)$ and $\lim_{\tau\to\infty} L_1 w_1 = \frac{1}{2} Q_1 P_1 (2 - \alpha_x - \alpha_y)$, since $\lim_{\tau\to\infty} \pi_{11}(j) = 1$ and $\lim_{\tau\to\infty} \pi_{21}(j) = 0$ for $j = x, y$. Hence, $\lim_{\tau\to\infty} (s_1/w_1) = (\alpha_x + \alpha_y)/(2 - \alpha_x - \alpha_y)$, so that $\frac{d}{d\mu} \lim_{\tau\to\infty} (s_1/w_1) = 0$. Similarly, we have $\frac{d}{d\mu} \lim_{\tau\to\infty} (s_2/w_2) = 0$, concluding the proof of Part 1 of Proposition 3.

Part 2. To obtain a contradiction, suppose that $\lim_{\mu m_{ki}(\omega(j))\to 1 \forall \omega(j),k,i} \frac{s_l}{w_l} > \lim_{\theta\to 0} \frac{s_l}{w_l}$. Using $v_1(j)/v_2(j) = (s_1/w_1)^{2\alpha_j - 1}$ and $\alpha_x > 1/2$, this implies

$$\lim_{\mu m_{ki}(\omega(x))\to 1 \forall \omega,k,i} \frac{v_1(x)}{v_2(x)} > \lim_{\theta\to 0} \frac{v_1(x)}{v_2(x)};$$

which, by Equation (6), yields

$$\lim_{\mu m_{ki}(\omega(x))\to 1 \forall \omega,k,i} \left[\pi_{11}(x) + \pi_{21}(x)\right] \leq \lim_{\theta\to 0} \left[\pi_{11}(x) + \pi_{21}(x)\right]. \tag{25}$$

Condition (25) and Equation (12) give

$$\lim_{\mu m_{ki}(\omega(j))\to 1 \forall \omega(j),k,i} \frac{s_l}{w_l} \leq \lim_{\theta\to 0} \frac{s_l}{w_l},$$

a contradiction. We obtain a similar contradiction if we assume that $\lim\limits_{\mu m_{ki}(\omega(j))\to 1 \forall \omega(j),k,i} \frac{s_l}{w_l} < \lim_{\theta\to 0} \frac{s_l}{w_l}$, concluding the proof of Proposition 3. **QED.** ■

Proof of Proposition 4. The proof of Proposition 4 follows very closely the proof of Proposition 2: Under Assumptions A1 and A4, we can write the factor market clearing conditions as:

$$\begin{aligned} wL &= \sum_{j=x,y} \int_0^\infty f\left(\frac{w}{s}, z, j\right) \left[\chi_{ii}^i(z,j;\mu) + \chi_{-ii}^i(z,j;\mu) + \chi_{ii}^{-i}(z,j;\mu)\right] dz \qquad (26) \\ sH &= \sum_{j=x,y} \int_0^\infty g\left(\frac{w}{s}, z, j\right) \left[\chi_{ii}^i(z,j;\mu) + \chi_{-ii}^i(z,j;\mu) + \chi_{ii}^{-i}(z,j;\mu)\right] dz. \end{aligned}$$

[39] This follows from the fact that if $\int_0^z f(v)\, dv < \int_0^z g(v)\, dv$ for any $z > 0$, and $h'(z) < 0$, then $\int_0^\infty f(v)\, h(v)\, dv < \int_0^\infty g(v)\, h(v)\, dv$.

Here $\frac{1}{w}f\left(\frac{w}{s},z,j\right)$ $\left(\frac{1}{s}g\left(w/s,z,j\right)\right)$ is the unskilled labor (skilled labor) demanded by a subsector in sector j producing in country i with productivity z in order to supply either its domestic or the foreign market, conditional on supplying the market. We define $\chi_{in}^{k}\left(z,j;\mu\right)/\int_0^\infty \chi_{in}^{k}\left(z,j;\mu\right)dz$ as the density of productivities of sector j subsectors in country n that supply market i using productivity from country k, written explicitly as a function of the offshoring cost μ. Note that with symmetric countries we have $\chi_{-ii}^{-i}\left(z,j;\mu\right)=0$ because $c_{-ii}^{-i}\left(\omega\left(j\right)\right)>c_{-i-i}^{-i}\left(\omega\left(j\right)\right)$. We let $\Delta\chi_{in}^{k}\left(z,j\right)$ $\equiv\chi_{in}^{k}\left(z,j;\mu'\right)-\chi_{in}^{k}\left(z,j;\mu\right)$. Finally, we denote by $\Omega_{in}^{k}\left(j,\mu\right)$ the set of sector j subsectors in which country n producers supply country i using country k's productivity.

We proceed in two steps. The first step is a preliminary step and the second step concludes the proof of Proposition 4.

Step 1: *If* $1<\mu<\min\left\{\mu',\tau\right\}$, *and* $\frac{w(\mu)}{s(\mu)}\geq\frac{w(\mu')}{s(\mu')}$, *then*

$$-\int_0^z \Delta\chi_{ii}^{-i}\left(z,j\right)dv<\int_0^z\left[\Delta\chi_{ii}^{i}\left(z,j\right)+\Delta\chi_{-ii}^{i}\left(z,j\right)\right]dv$$

for all $z>0$, $j=x,y$, *and* $i=1,2$.

Let $1<\mu<\min\left\{\mu',\tau\right\}$ and $\frac{w(\mu)}{s(\mu)}\geq\frac{w(\mu')}{s(\mu')}$ and suppose that $\omega\in\Omega_{ii}^{i}\left(j,\mu\right)$. As in the proof of Proposition 2, it is easy to show that if $\mu<\min\left\{\mu',\tau\right\}$ and $\frac{w(\mu)}{s(\mu)}\geq\frac{w(\mu')}{s(\mu')}$, then (i) $\omega\in\Omega_{ii}^{i}\left(j,\mu\right)$ implies $\omega\in\Omega_{ii}^{i}\left(j,\mu'\right)$; (ii) $\omega\in\Omega_{-ii}^{i}\left(j,\mu\right)$ implies $\omega\in\Omega_{-ii}^{i}\left(j,\mu'\right)$; (iii) there exist a positive mass of ω for which $\omega\notin\Omega_{ii}^{i}\left(j,\mu\right)$ and $\omega\in\Omega_{ii}^{i}\left(j,\mu'\right)$; (iv) there exist a positive mass of ω for which $\omega\notin\Omega_{-ii}^{i}\left(j,\mu\right)$ and $\omega\in\Omega_{-ii}^{i}\left(j,\mu'\right)$; and (v) there exist a positive mass of $\omega\in\Omega_{ii}^{-i}\left(j,\mu\right)$ for which $\omega\notin\Omega_{ii}^{-i}\left(j,\mu\right)$.[40]

Choose an arbitrary $\omega\notin\Omega_{ii}^{i}\left(j,\mu\right)\cup\Omega_{i-i}^{-i}\left(j,\mu\right)$ and $\omega\in\Omega_{ii}^{i}\left(j,\mu'\right)\cup\Omega_{i-i}^{-i}\left(j,\mu'\right)$. Then $\omega\in\Omega_{ii}^{-i}\left(j,\mu\right)$, $\omega\notin\Omega_{ii}^{-i}\left(j,\mu'\right)$, and $z_{-i}\left(\omega\left(j\right)\right)>z_i\left(\omega\left(j\right)\right)$; we have $z_{-i}\left(\omega\left(j\right)\right)>z_i\left(\omega\left(j\right)\right)$, because, if $z_{-i}\left(\omega\left(j\right)\right)\leq z_i\left(\omega\left(j\right)\right)$ then no offshoring would take place for any $\mu>1$, contradicting $\omega\in\Omega_{ii}^{-i}\left(j,\mu\right)$. Of course, if $\omega\notin\Omega_{i-i}^{-i}\left(j,\mu\right)$ and $\omega\in\Omega_{i-i}^{-i}\left(j,\mu'\right)$, then the efficiency of production in subsector $\omega\left(j\right)$ is unaffected, since country $-i$'s productivity is used under either μ or μ'. Nevertheless, for any ω there is a positive probability that $\omega\notin\Omega_{ii}^{i}\left(j,\mu\right)$, $\omega\in\Omega_{ii}^{i}\left(j,\mu'\right)$, $\omega\notin\Omega_{i-i}^{-i}\left(j,\mu\right)$ and $\omega\in\Omega_{i-i}^{-i}\left(j,\mu'\right)$. Hence,

$$\begin{aligned}&\Pr\left[z_{-i}\left(\omega\left(j\right)\right)<z\mid\omega\in\Omega_{ii}^{-i}\left(j,\mu\right)-\Omega_{ii}^{-i}\left(j,\mu'\right)\right]<\\&\qquad\Pr\left[z_i\left(\omega\left(j\right)\right)<z\mid\omega\in\Omega_{ii}^{i}\left(j,\mu'\right)\cup\Omega_{i-i}^{-i}\left(j,\mu'\right)-\Omega_{ii}^{i}\left(,j\mu\right)\cup\Omega_{i-i}^{-i}\left(j,\mu\right)\right]\end{aligned}$$

or, equivalently,

$$\frac{\int_0^z\left[-\Delta\chi_{ii}^{-i}\left(v,j\right)\right]dv}{\int_0^\infty\left[-\Delta\chi_{ii}^{-i}\left(v,j\right)\right]dv}<\frac{\int_0^z\left[\Delta\chi_{ii}^{i}\left(v,j\right)+\Delta\chi_{i-i}^{-i}\left(v,j\right)\right]dv}{\int_0^\infty\left[\Delta\chi_{ii}^{i}\left(v,j\right)+\Delta\chi_{i-i}^{-i}\left(v,j\right)\right]dv},\text{ for all } z>0 \tag{27}$$

[40] If $\mu\geq\tau$, then no offshoring takes place, so that decreasing μ' to μ has no impact on the equilibrium.

By symmetry

$$\chi_{i-i}^{-i}(z,j) = \chi_{-ii}^{i}(z,j) \text{ for almost all } z,$$

and

$$\int_0^\infty \left[-\Delta\chi_{ii}^{-i}(v)\right] dv = \int_0^\infty \left[\Delta\chi_{ii}^{i}(v) + \Delta\chi_{i-i}^{-i}(v)\right] dv.$$

Thus, according to Equation (27), we have

$$\int_0^z \left[-\Delta\chi_{ii}^{-i}(v,j)\right] dv < \int_0^z \left[\Delta\chi_{ii}^{i}(v,j) + \Delta\chi_{-ii}^{i}(v,j)\right] dv, \forall z > 0,\ j = x, y,\ i = 1, 2$$

completing Step 1.

Step 2: Consider an arbitrary pair of offshoring costs satisfying $1 < \mu < \min\{\mu', \tau\}$. To obtain a contradiction, suppose that $\frac{w(\mu)}{s(\mu)} \geq \frac{w(\mu')}{s(\mu')}$. According to Condition (5), and our normalization $w(\mu)L + s(\mu)H = 1$, this implies $w(\mu) \geq w(\mu')$ and $s(\mu) \leq s(\mu')$. Equation (18), the condition that $w(\mu) \geq w(\mu')$, and the fact that $\frac{d}{dw/s} f(w/s, z, j) < 0$ together imply

$$\int_0^\infty f\left(\frac{w(\mu)}{s(\mu)}, z, j\right)\left[\Delta\chi_{ii}^{i}(z,j) + \Delta\chi_{-ii}^{i}(z,j)\right] dz \leq -\int_0^\infty f\left(\frac{w(\mu)}{s(\mu)}, z, j\right)\Delta\chi_{ii}^{-i}(z,j)\, dz \qquad (28)$$

Finally, $\frac{d}{dz} f\left(\frac{w(\mu)}{s(\mu)}, z, z\right) < 0$ and Step 1 imply

$$\int_0^\infty f\left(\frac{w(\mu)}{s(\mu)}, z, j\right)\left[\Delta\chi_{ii}^{i}(z,j) + \Delta\chi_{-ii}^{i}(z,j)\right] dz > -\int_0^\infty f\left(\frac{w(\mu)}{s(\mu)}, z, j\right)\Delta\chi_{ii}^{-i}(z,j)\, dz. \qquad (29)$$

Equation (28) contradicts Equation (29). Thus, if $\mu < \min\{\mu', \tau\}$, then $\frac{w(\mu)}{s(\mu)} < \frac{w(\mu')}{s(\mu')}$. **QED.** ∎

Proposition 5 *If Assumptions A1 and A4 hold, then normalized trade in each country is strictly greater in the skill-intensive sector.*

Proof of Proposition 5. The proof is in two steps. The first step is a preliminary step and the second step concludes the proof of Proposition 5.

Step 1: *Suppose Assumptions A1 and A4 hold and fix an arbitrary pair of productivities* $z_i \equiv z_i(\omega(y)) = z_i(\omega(x))$ *and* $z_{-i} \equiv z_{-i}(\omega(y)) = z_{-i}(\omega(x))$. *Then* $z_i > z_{-i}$ *implies* $\frac{c_{ni}[\omega(x)]}{c_{n-i}[\omega(x)]} < \frac{c_{ni}[\omega(y)]}{c_{n-i}[\omega(y)]}$ *for* $n = i, -i$.

To obtain a contradiction, suppose that $z_i > z_{-i}$ and

$$\frac{c_{ni}(\omega(y))}{c_{n-i}(\omega(y))} \leq \frac{c_{ni}(\omega(x))}{c_{n-i}(\omega(x))} \text{ for } n = i \text{ or } n = -i. \qquad (30)$$

Equation (30) is equivalent to

$$z_i^{\varphi} \leq z_{-i}^{\varphi}. \qquad (31)$$

With $\varphi > 0$ Condition (31) is equivalent to

$$z_i \leq z_{-i},$$

a contradiction that concludes the proof of Step 1.

Step 2: According to Step 1, the mass of subsectors that export from country i in the skill-intensive x sector is strictly greater than the mass that export from the unskill-intensive y sector, for all i. With $\eta = 1$, this implies that the value of a country's exports plus its imports is greater in the x sector than in the y sector. Finally, with $\eta = 1$, the value of a country's consumption is equal in the x and y sectors. Hence, normalized trade is strictly greater in the skill-intensive sector, concluding the proof of Proposition 5. **QED.** ■

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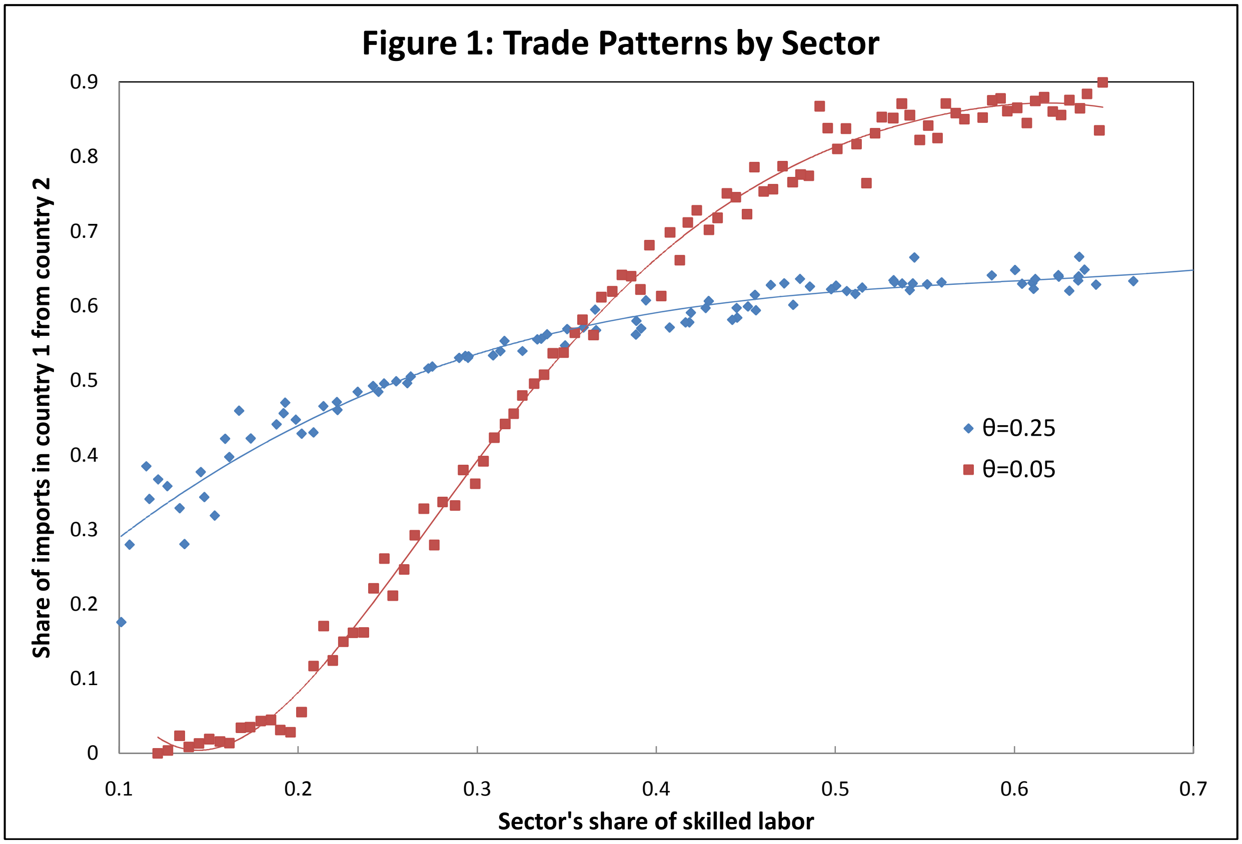
Figure 1: Trade Patterns by Sector
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Share of imports in country 1 from country 2
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sector's share of skilled labor
θ=0.25
θ=0.05

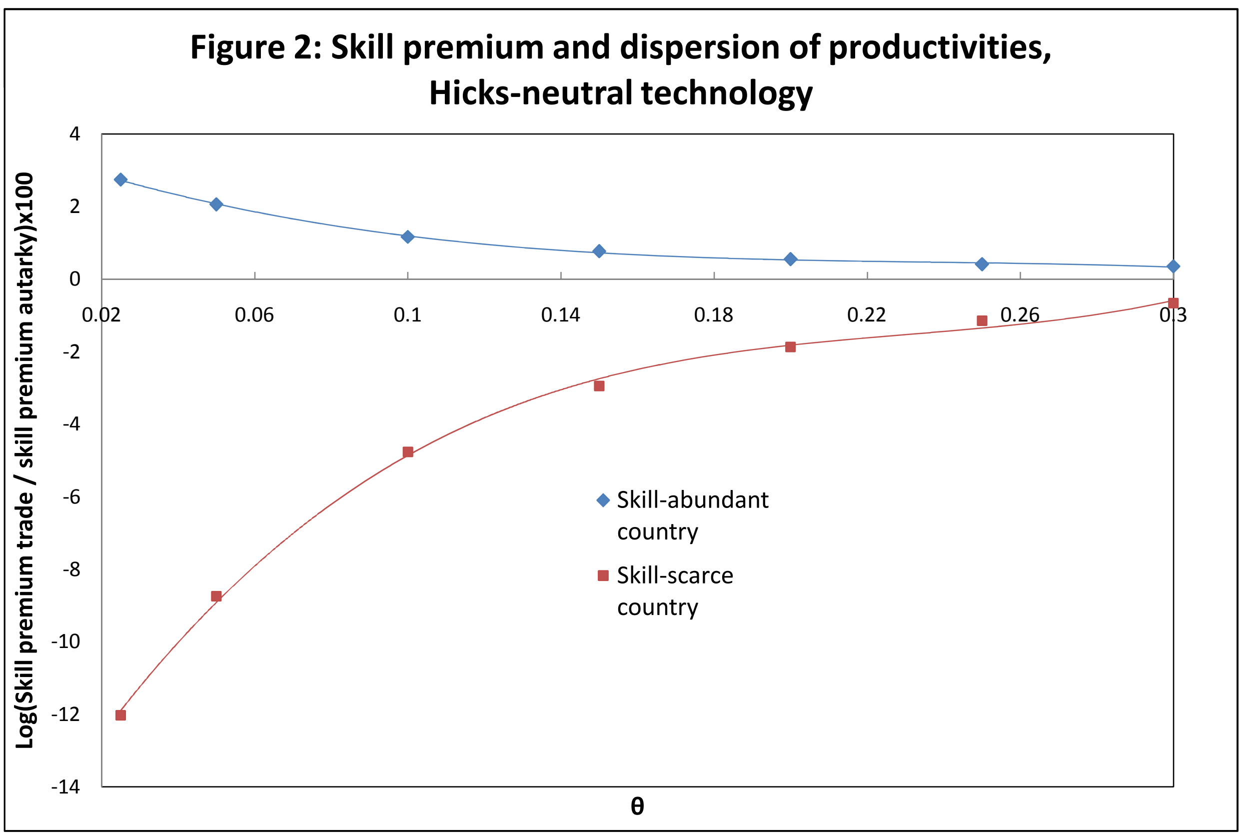
Figure 2: Skill premium and dispersion of productivities, Hicks-neutral technology
4
2
0
-2
-4
-6
-8
-10
-12
-14
Log(Skill premium trade / skill premium autarky)x100
0.02
0.06
0.1
0.14
0.18
0.22
0.26
0.3
θ
Skill-abundant country
Skill-scarce country

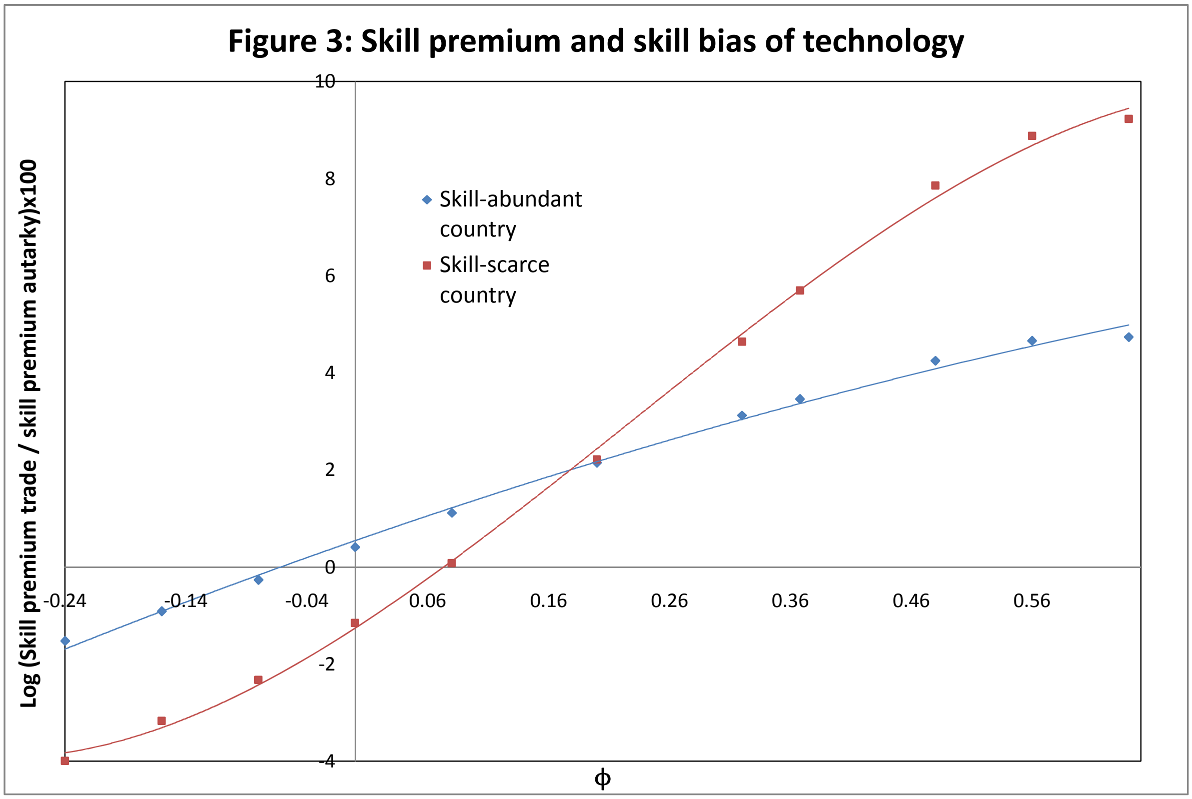
Figure 3: Skill premium and skill bias of technology
Log (Skill premium trade / skill premium autarky)x100
10
8
6
4
2
0
-2
-4
-0.24
-0.14
-0.04
0.06
0.16
0.26
0.36
0.46
0.56
ϕ
Skill-abundant country
Skill-scarce country

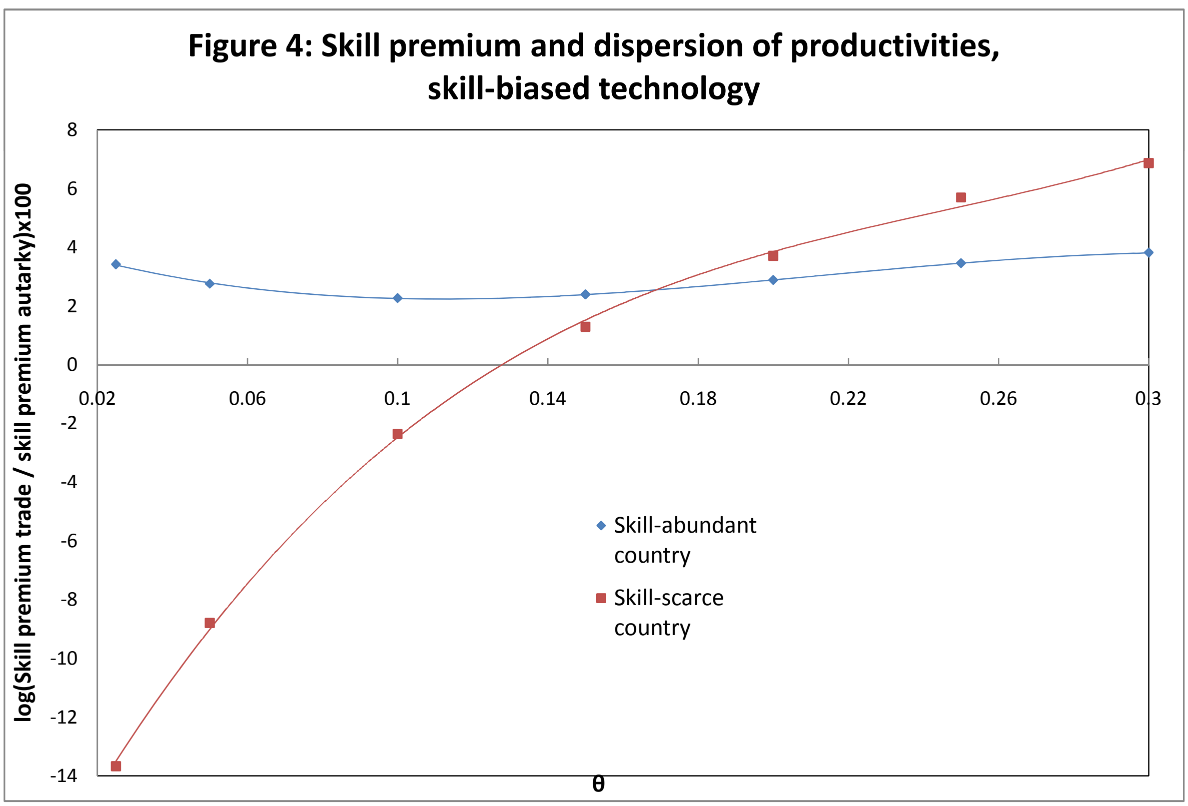
Figure 4: Skill premium and dispersion of productivities, skill-biased technology
log(Skill premium trade / skill premium autarky)x100
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
0.02
0.06
0.1
0.14
0.18
0.22
0.26
0.3
θ
Skill-abundant country
Skill-scarce country

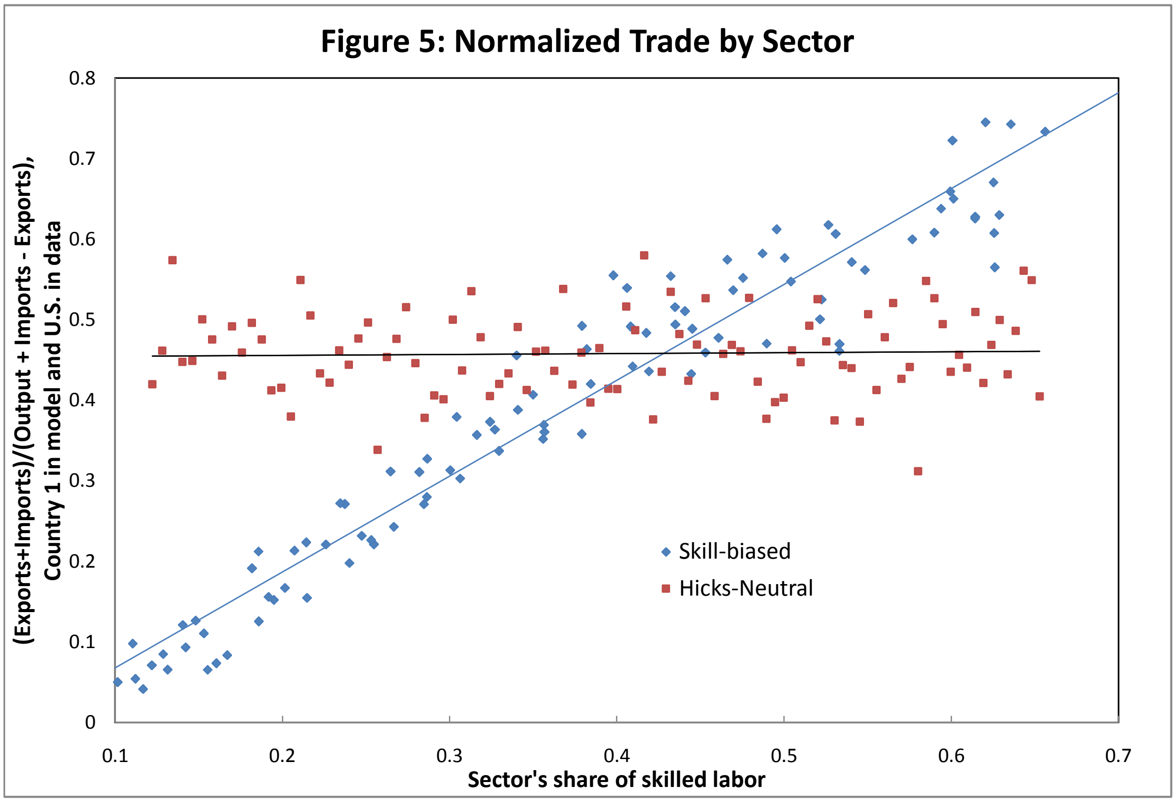
Figure 5: Normalized Trade by Sector
(Exports+Imports)/(Output + Imports - Exports),
Country 1 in model and U.S. in data
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sector's share of skilled labor
Skill-biased
Hicks-Neutral

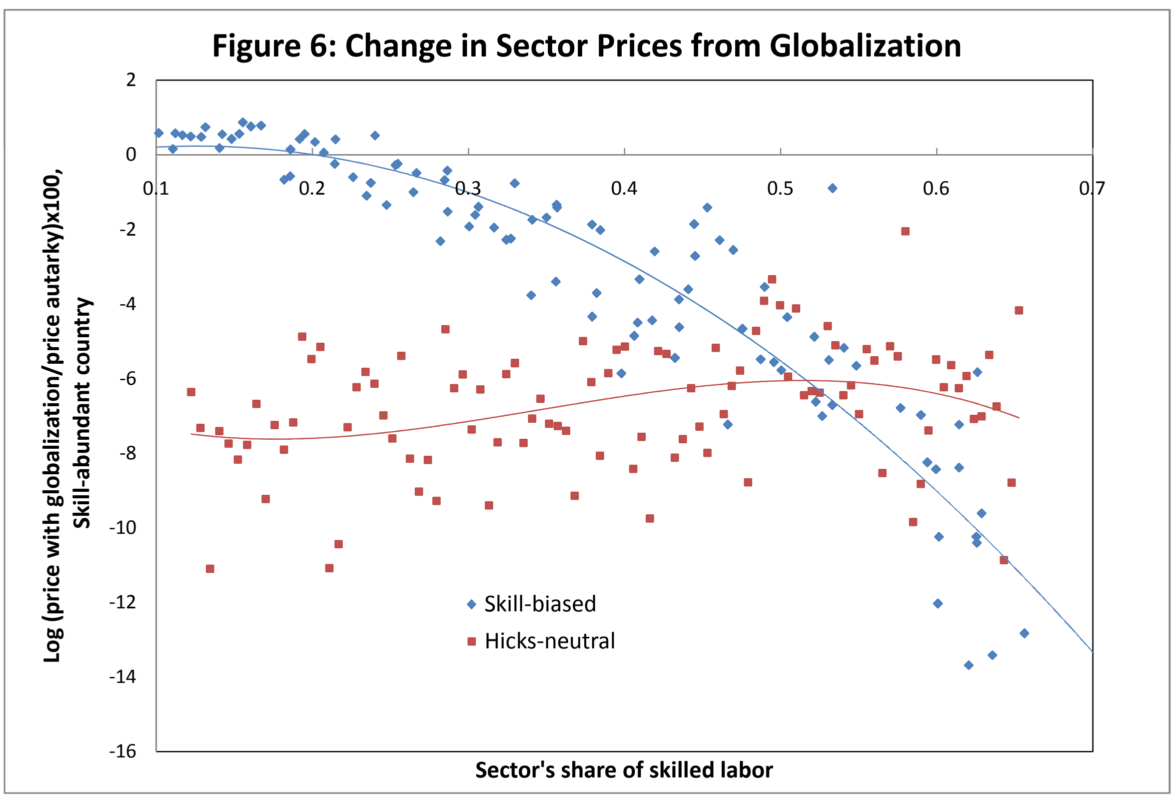
Figure 6: Change in Sector Prices from Globalization
Log (price with globalization/price autarky)x100,
Skill-abundant country
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sector's share of skilled labor
Skill-biased
Hicks-neutral

TABLE 1: BASELINE PARAMETERIZATIONS

		1	2	3	4
		BASELINE		**OTHER PARAMETERIZATIONS**	
		Skill-Biased Technology		**Hicks-neutral Technology**	
		Trade only	**Trade and offshoring**	**Trade only**	**Trade and offshoring**
Production parameters					
1	Skill-bias of technology, ϕ	0.368	0.368	0	0
2	Dispersion of productivities, θ	0.25	0.25	0.25	0.25
3	Demand elasticity, η	3	3	3	3
4	Elasticity of substitution skilled-unskilled labor, ρ	1.2	1.2	1.2	1.2
Endowments					
5	Skill-unskill endowment ratio country 1, H_1/L_1	0.71	0.71	0.71	0.71
6	Skill-unskill endowment ratio country 3, H_3/L_3	0.348	0.348	0.348	0.348
7	Total factor productivity country 3, A_3	0.105	0.165	0.105	0.165
Trade costs					
8	Manufacturing country 1, Dt_1	1.456	1.383	1.547	1.481
9	Non-manufacturing country 1, Dn_1	2.594	1.762	2.628	1.904
10	Trade cost country 3-country 1 ratio (Di3-1)/(Di1-1), i=n,t	0.94	1.15	1.02	1.23
Offshoring					
11	Dispersion of idisoyncratic offshoring costs, θ_m	0.1	0.1	0.1	0.1
12	Country-specific offshoring cost Country 1, Dm_1	1000	1.35	1000	1.45
13	Country-specific offshoring cost Country 3, Dm3	1000	9.18	1000	11.13
Other Parameters					
14	Share of manufacturing in total output, γ	0.219			
15	Sectoral skill intensities	α~U(0.1,0.6)			
16	Endowment of unskill labor country 1	1			
17	Endowment of unskill labor country 3	5.7			
18	Total factor productivity country 1, A_1	1			

TABLE 2: BASELINE RESULTS

		1	2	3	4	
		BASELINE		OTHER PARAMETERIZATIONS		
		Skill-Biased Technology		Hicks-neutral Technology		Target
		Trade only	Trade and offshoring	Trade only	Trade and offshoring	
Calibration Targets						
1	1/2*(Exports+Imports)/Output, Manufacturing, Country 1	0.227	0.229	0.227	0.226	0.227
2	1/2*(Exports+Imports)/Output, Non-Manufacturing, Country 1	0.033	0.033	0.035	0.033	0.033
3	1/2*(Exports+Imports)/Output, Manuf+Non-Manuf, Country 3	0.120	0.123	0.118	0.117	0.12
	Share of imports in country 1 from country 2, Manufacturing					
4	Level	0.60	0.58	0.60	0.58	0.59
5	Difference Top 1/2 Skilled - Bottom 1/2 Skilled Sectors	0.11	0.10	0.11	0.12	0.11
6	Elasticity of skill intensity to size, Country 3	0.10	0.10	0	0	0.075-0.147
7	Effective elasticity of substitution between skills, Country 1	1.42	1.43	1.38	1.38	1.4
8	Outward offshoring / Exports, Manuf+Non-Manuf, Country 1	-	1.75	-	1.70	1.72
9	Share of Country 1's outward offshoring to Country 2	-	0.82	-	0.85	0.82
Other Statistics						
10	Fraction of exporters, Manufacturing, Country 1	0.20	0.19	0.28	0.26	0.18-0.30
11	Ratio size exporters to non-exporters, Manuf, Country 1	4.26	4.18	4.69	4.69	3-5.6
12	Skill intensity exports minus non-exporters (logs), Country 1	0.13	0.13	0.00	0.00	0.11
13	Skill intensity exporters minus non-exporters (logs), Country 3	0.17	0.17	0.00	0.00	0.118-0.209
Counterfactuals						
Skill Premium, log baseline/autarky x 100						
14	Country 1 and Country 2	3.46	7.62	0.41	1.12	
15	Country 3	5.69	7.54	-1.15	-2.53	
Skill Premium, log baseline/(1/3 trade shares) x 100						
Offshoring/exports initial level = 1.7						
16	Country 1 and Country 2		4.18		0.88	
17	Country 3		5.02		-2.14	
Offshoring/exports initial level = 0						
18	Country 1 and Country 2	2.10	6.13	0.24	0.97	
19	Country 3	3.22	5.88	-0.72	-2.27	

TABLE 3: CALIBRATION OF TECHNOLOGY DISPERSION AND SKILL-BIAS OF TECHNOLOGY

	Panel A									
1	Technology Dispersion, θ	0.025	0.05	0.10	0.15	0.20	0.25	0.30		
2	Share of imports in country 1 from country 2, Manufacturing, Difference Top 1/2 Skilled - Bottom 1/2 Skilled Sectors	0.79	0.61	0.36	0.23	0.15	0.11	0.09		
	Panel B									
3	Skill-Bias of Technology, ϕ	-0.24	-0.16	-0.08	0.00	0.08	0.20	0.37	0.48	0.64
4	Elasticity of skill intensity to size, Country 3	-0.06	-0.04	-0.02	0.00	0.02	0.06	0.11	0.14	0.17

TABLE 4: SKILL INTENSITY AND NOMALIZED TRADE, U.S. 2002

		1	2	3	4
		Dependent Variable: Normalized Trade			
1	Skill Intensity	0.716***	0.885***	0.872***	0.895***
		(0.160)	(0.175)	(0.175)	(0.175)
2	Median Elasticity			-0.004	
				(0.003)	
3	Average Elasticity				0
					(0.000)
4	N	239	195	195	195
5	R^2	0.08	0.12	0.13	0.12

Standard errors are in parantheses. Skill intensity is defined as the share of non-production workers in employment. Normalized trade is defined as the ratio of sector exports plus imports to sector output plus imports minus exports. Median Elasticity and Average Elasticity are the median and average, respectively, SITC5 elasticity of substitution from Broda and Weinstein (2006) in the BEA IO-code sector. *p<0.10, **p<0.05, ***p<0.01

TABLE 5: SENSITIVITY ANALYSIS AND OTHER COUNTERFACTUALS

SENSITIVITY ANALYSIS	1	2	3	4	5	6
	BASELINE					
	Trade only	Trade and offshoring	ρ=1.4	ρ=2	η=2	η=3.5
Skill Premium, log baseline/autarky x 100						
1 Country 1 and Country 2	3.46	7.62	2.50	1.48	2.95	3.39
2 Country 3	5.69	7.54	3.32	1.94	3.61	6.18

	7	8	9	10	11
	Manuf. Only, γ=1 Trade only	Manuf. Only, γ=1 Trade + Offshoring	Manuf. Trade Country 1 = 40%	Offshoring / exports Country 1 = 2.8	θm = 0.2
Skill Premium, log baseline/autarky x 100					
3 Country 1 and Country 2	9.39	13.14	4.72	8.92	7.36
4 Country 3	13.79	13.25	3.74	8.93	8.05

COUNTERFACTUALS: Composition and Extent of Globalization	12	13	14	15
Skill Premium, log difference relative to baseline x 100	H3/L3 = H1/L1	Double Trade Country 1 Same Offshoring/Exports	Zero Gravity Only Trade	Zero Gravity Trade + Offshoring
5 Country 1	-0.58	2.82	10.33	34.66
6 Country 3	1.99	6.31	9.69	-15.00