Intraindustry Trade and Wage-Income Inequality

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Abstract: This paper introduces a firm-specific Chamberlinian mechanism of income distribution, based on quasi-homothetic preferences, non-homothetic production, and factor-biased internal scale economies in the production of each product variety. We embed this mechanism in the standard two-country, one-sector model of intraindustry trade with two factors of production consisting of high and low-skilled labor. Under the empirically-relevant hypothesis of output-skill complementarity, our analysis reveals that a move from autarky to free trade raises (a) the relative wage of high-skilled workers, (b) the output of the representative firm, (c) and the level of total factor productivity within each firm. Interestingly, these changes occur across both trading partners.

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1. Introduction

An extensive and influential body of literature has documented the rise in global demand for high-skilled labor and the related increase in the skill premium during the 1980s and 1990s.[1] In contrast to the general consensus on the global increase in the skill premium, the search for its determinants and their implied policy remedies has generated an intense and spirited debate both in academia and policy circles. Initially, economists interpreted the evidence through the lenses of the traditional Heckscher-Ohlin-Samuelson model of trade and income distribution, which propelled them to reject a trade-based explanation for the global rise in the skill premium and argue in favor of demand shifts in the structure of wages due to exogenous skill-biased technological change.[2] Clearly identifying the primary cause of the rise in the skill premium is of paramount importance for prescribing an effective remedy to this prominent income distributional problem.

A small but growing literature has proposed several novel mechanisms linking economic openness to skill-biased technological change and the skill premium. For example, Feenstra and Hanson (1996, 1999) proposed international outsourcing (i.e., the endogenous relocation of component-production abroad) as a mechanism that may explain the global rise in the skill premium. Dinopoulos and Segerstrom (1999) and Sener (2001) developed a dynamic Schumpeterian version of the Stolper and Samuelson (1941) mechanism that relates the relative price of innovation to the skill premium. Neary (2002) advanced a mechanism that links trade to wages through strategic interactions among competing oligopolists. In an influential article, Acemoglu (2002) constructed yet another mechanism that relates an economy's market size to the profitability of new intermediate capital goods which in turn determine the relative efficiency of skilled labor and the skill premium. And, building on the insights of Acemoglu (2002), Epifani and Gancia (2007) and Unel (2008a) demonstrated how differences in external scale economies across sectors can link changes in the skill premium to changes in an economy's size.

In the spirit of the literature mentioned above, this paper proposes an alternative and hitherto unexplored mechanism of income distribution that operates in markets characterized by Chamberlinian (1933) monopolistic competition. The model of monopolistic competition is well-suited for analyzing markets containing a large number of firms with each firm producing a unique variety in the presence

[1] Katz and Murphy (1992), Berman et al. (1994), Johnson (1997), Berman et al. (1998), Krusell et al. (2000), Autor et al. (2007) among many others document the rise in the skill premium in several advanced and developing countries.

[2] Dinopoulos and Segerstrom (1999) and Neary (2002) offer more details on the trade versus technology debate as well as a summary of the central arguments. Bound and Johnson (2000) and Krusell et al. (2000) among numerous others provide empirical support for the skill-biased technological change explanation. See also Xu (2001) and Acemoglu (2002) for theoretical arguments on the role of technical change in the rise in the relative demand for high-skilled labor.

of internal scale economies and free entry and exit. This model generates trade in similar products (that is, intraindustry trade) and provides a theoretical rationale for the "gravity equation", which states that the volume of bilateral trade between two countries is directly proportional to the product of their GDPs. Interestingly and surprisingly, the existing literature has not given the nexus among internal scale economies, intraindustry trade and the skill premium the attention it deserves. [3]

The Chamberlinian mechanism we propose in this paper complements the existing literature on income distribution and derives its strength from two distinguishing ingredients. The first ingredient rests on an economy's consumption/demand side (described in Section 2.1) and relates the size of the market, measured by the number of consumers served, to the price elasticity of demand for a typical variety. Specifically, the model captures consumer tastes over varieties with a *translated CES utility function* (Pollak, 1971), which is quasi-homothetic in the quantities consumed, and gives rise to a price elasticity of demand for a typical variety that is decreasing in per capita consumption as in Krugman's (1979) seminal work. In this context, a move from autarky (closed-economy) to free intraindustry trade is isomorphic to an expansion in market size. As a consequence, the introduction of free trade causes the price elasticity of demand of the representative firm to rise and, owning to free entry, forces each firm to move down along its average-cost curve thereby causing both firm output and total factor productivity to increase.

The second ingredient of the Chamberlinian mechanism we propose lies on an economy's production/supply side (described in Section 2.2). In the spirit of Acemoglu's (2002) work on directed technical change, this link relates the degree of scale economies to the differential efficiency of high-skilled and low-skilled labor within each firm or plant. Borrowing from the literature on external variable returns to scale (Panagariya, 1981), we relate the intensity of *internal* scale economies to the efficiency of labor with the help of a non-homothetic CES production function, which allows the efficiency (quality) of high and low-skilled labor to differ. We model this difference by assuming that the elasticities of high and low-skilled labor efficiency with respect to output are constant but can take different values (perhaps due to differences in learning abilities). In this setting, the ratio of high to low-skilled labor demanded depends not only on the skill premium but also on output produced. We then propose a natural measure of scale-induced factor bias which is captured by the *output* (as opposed to the relative wage) elasticity of substitution: the percentage change in the ratio of high to low-skilled labor caused by one percent change in the firm's output. This elasticity is equal to the product of two

[3] For instance, Acemoglu (2002) assumes perfectly competitive product markets; Neary (2002) abstracts from free-entry considerations and highlights the role of "defensive" R&D investments in markets with few competitors; and Epifani and Gancia (2007) and Unel (2008a) concentrate on differences in external (as opposed to internal) scale economies across sectors but do not consider the possible role of non-homothetic tastes and production.

terms: the familiar (wage) elasticity of substitution minus one and the difference between the output elasticities of high and low-skilled labor efficiency. If the output elasticity of substitution is positive (negative), the production technology is non-homothetic and exhibits output-skill complementarity (output-skill substitutability). In contrast, if the output elasticity of substitution is zero, the production function is homothetic and exhibits output-skill neutrality (Definition 1). Drawing on the empirical literature on the determinants of the U.S. skill premium, we argue in Section 2.2 that the wage elasticity of substitution is greater than unity and that the output elasticity of high-skilled labor efficiency exceeds the corresponding output elasticity of low-skilled labor efficiency. In other words, the empirical literature provides evidence in favor of a positive output elasticity of substitution and thus supports the empirical relevance of output-skill complementarity.

Under the hypothesis of output-skill complementarity, the model generates several interesting predictions (presented in Sections 3 and 4). A move from autarky to free intraindustry trade increases the skill premium, the output of the representative firm, and the level of total factor productivity in both countries (Proposition 2). Moreover, if countries differ in skill abundance (measured by the ratio of high to low-skilled labor endowments), intraindustry trade does not equalize the skill premium across the two countries: the skill premium is lower (higher) and the output per variety is larger (smaller) in the high-skilled (low-skilled) abundant country (Proposition 3). Interestingly, these aforementioned changes do not require resource movements across sectors and/or within firms. Importantly, these predictions are consistent with the empirical literature on trade and the skill premium based on cross-country evidence (Epifani and Gancia, 2007) and establishment-based data (Bernard and Jensen 1997).

In Section 5 we explain the properties of the model under the hypotheses of output-skill substitutability and output-skill neutrality. If the output elasticity of substitution is negative (output-skill substitutability), then a move from autarky to free intraindustry trade increases the output per variety and the level of total factor productivity but reduces the skill premium in both countries (Proposition 4). We also discuss the implications of output-skill neutrality that may arise in the presence of homothetic tastes, homothetic production functions and identical output elasticities of labor efficiency. In these cases, the skill premium turns out to be independent of intraindustry trade. Section 6 contains several concluding remarks.

2. The Model

In this section, we present the key elements of the model regarding consumer preferences and production technology. The world we consider consists of two countries, Home and Foreign, which may differ in factor endowments but are otherwise structurally identical. In each economy there is a single sector producing similar products under increasing returns to scale and monopolistic competition. It is therefore sufficient to describe only Home's economy.

2.1 A Translated Additive Utility Function

The Home economy consists of N individuals (consumers/workers) who are partitioned into two groups: low-skilled workers L and high-skilled workers H. Every individual i has taste for variety as indicated by her additive utility function

$$U^i = \sum_{j=1}^{m} u(x_j^i), \tag{1}$$

where x_j^i denotes consumption of variety j and m the number of varieties that are available in the market. The sub-utility function $u(x_j^i)$ is assumed to take the form

$$u(x_j^i) = (x_j^i + \theta)^\rho, \ \ for\ x_j^i > 0 \ ; \qquad\qquad u(x_j^i) = 0, \ \ for\ x_j^i = 0; \tag{2}$$

where $\theta > 0$ and $\rho \in (0,1)$ .These preferences are "quasi-homothetic" and, following Pollak (1971), can be labeled "translated additive"(TA) preferences.[4] For some intuition, consider the case of two varieties. As in the case of homothetic preferences, the income consumption path is linear. The difference is that under TA preferences the income consumption path starts at point (θ,θ) instead of the origin $(0,0)$. Importantly though, aggregation is still possible; that is, the aggregate demand for each variety in the economy does not depend on the distribution of income among consumers.

The utility function in (2) is discontinuous (and thus non-differentiable) at $x_j^i = 0$. However, as long as all individuals demand positive quantities of the produced commodities—an assumption that we retain throughout the paper—this discontinuity poses no analytical problems. Thus, a sufficient condition for every individual to consume all varieties is that parameter θ is small relative to each consumer's income. We could interpret θ as the level of "luxury-based" or "status-based" quality derived from the consumption of a typical variety. For instance, buying organic food in Whole Foods Market increases the consumer's utility by an additional amount, which is probably independent from the quantity of each type of food bought compared to buying the same food in the local supermarket. The same holds true for many status-based products. This interpretation complements the standard interpretation of the familiar Stone-Geary utility function (where parameter θ is negative and captures the minimum consumption requirement).

[4] The term "translated" captures the property that the indifference map implied by (1) and (2) is a translation of the indifference map of homothetic additive preferences.

The interpretation of θ is of secondary importance compared to its implications for the properties of aggregate demand. The Appendix derives the following expression for the (absolute value of) price elasticity of *total market* demand x_j for a typical variety j:

$$\eta_j \equiv -\frac{p_j}{x_j}\frac{\partial x_j}{\partial p_j} = \varepsilon\left(1+\frac{\theta N}{x_j}\right) > 1 \qquad j = 1,2,...,m; \qquad (3)$$

where p_j and $x_j = \sum_{i=1}^{N} x_j^i$ are the price and total quantity of variety j, and $\varepsilon = 1/(1-\rho) > 1$.

The elasticity formula (3) reveals several interesting properties of the TA utility function. *First,* the parameter restrictions $\rho \in (0,1)$ and $\theta > 0$ ensure that the price elasticity of demand exceeds unity. This means that TA preferences generate elastic demand curves that can support imperfectly competitive market structures without any additional parameter restrictions. *Second,* the price elasticity of demand is decreasing in per-capita consumption $x_j^i = x_j / N$. The reason for this property is that the restriction $\theta > 0$ is tantamount to assuming that every consumer has a finite "reservation price" which is inversely related to θ.[5] Holding income and the prices of all other varieties constant, an increase in θ causes every consumer's reservation price for variety j to fall and the inverse demand function to become flatter, as in Krugman (1979). It is easy to verify that, if $\theta > 0$, TA preferences generate demand curves that are less convex than the constant elasticity demand curves (which emerge when $\theta = 0$). However, unlike Krugman's (1979) model, where η_j is *assumed* to be decreasing in per-capita consumption x_j^i, the TA utility function generates this property and therefore provides utility-based foundations for this important feature.[6]

Third, the partition of the population into high-skilled and low-skilled worker groups and the total consumer income, respectively, do not appear as arguments in the price elasticity of demand η_j. As we will see, this property simplifies the analysis and helps establish causal links between intraindustry trade and output per variety in a unified and direct manner. Therefore, one novel

[5] The first-order condition for consumer i's maximization problem is given by $p_j = (\rho/\mu^i)(x_j^i + \theta)^{\rho-1}$, where μ^i is consumer i's marginal utility of income. Consequently, the inverse demand curve yields the reservation price $p_j = (\rho/\mu^i)\theta^{\rho-1}$ which is inversely related to θ.

[6] This demand-based link is absent from models that use homothetic preferences based on CES utility functions and generate demand functions with constant price elasticity (Helpman and Krugman (1985) among many others). This standard case considered in the literature on intraindustry trade corresponds to setting the parameter θ equal to zero. If $\theta = 0$, then (3) implies that the price elasticity of demand $\eta_j = \varepsilon = 1/(1-\rho)$ is constant, identical across varieties and independent of per-capita consumption and market size.

contribution of the present paper is that it highlights the properties of TA preferences which appear to be ideal for addressing questions of functional income distribution in imperfectly competitive settings.

The property of $\theta > 0$ implies a positive relationship between the intensity of market competition and the price elasticity of demand. In monopolistically competitive markets, a typical firm j maximizes profits by following the optimal mark-up rule $(p_j - mc)/p_j = 1/\eta_j$, where mc is the firm's marginal cost and η_j is the price elasticity of its perceived demand curve.[7] As we can see from (3), for any given number of consumers N, if $\theta > 0$, then a reduction in per capita consumption of variety x_j due to an increase in the number of competitors or a reduction in their prices, raises the price elasticity of demand and thereby reduces the equilibrium mark-up. By contrast, if $\theta \le 0$, there would be a negative relationship between the intensity of market competition and the price elasticity of demand.

Empirical evidence supports a positive (negative) relationship between the intensity of market competition and the price elasticity of demand (price-cost mark-ups) in markets characterized by Cournot quantity competition. For example, domestic price-cost mark-ups are found to decline substantially after episodes of trade liberalization or exchange-rate appreciation in Turkey (Levinsohn, 1993), Cote d'Ivoire (Harrison, 1994), and India (Krishna and Mitra, 1998). Evidence from a field experiment by Barron et al. (2008) also provides support for an inverse relationship between the intensity of market competition and the price elasticity of demand. These authors used data from gas stations in Southern California to estimate price elasticities of demand for regular graded gasoline. They found that the price elasticity of demand is significantly higher in areas with higher seller density (measured by the number of gas stations within a two-mile area)[8] Markets with higher seller density are characterized by lower per capita demand per gas station, assuming that the number of consumers is roughly the same within a two-mile area. Thus the aforementioned evidence supports the assumed negative relationship between the price elasticity of demand and per-capita consumption which is consistent with the case of $\theta > 0$. We will therefore focus our analysis on this case.

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[7] This rule, which is derived from the first-order-condition for profit maximization, is captured by equation (10) below.

[8] The estimated price elasticity of demand for a typical gas station increases from 3.5 in markets with 14 stations within two miles to 7.5 in markets with 30 stations within two miles. The price elasticity facing an individual gas station is 4.5 in the San Diego area, where the density is 17.5 gas stations within 2 miles; 5.05 in San Francisco area, where the density is 18.2 gas stations; and 6.11 in the Los Angeles area, where the density is 22.4 gas stations.

2.2 Output-Skill Complementarity

The technology for each variety produced is non-homothetic, exhibits increasing returns to scale, and does not differ across varieties. The framework proposed here is inspired by both the theoretical and empirical literature on the capital-skill complementarity which has focused on the effects of capital accumulation on the efficiency of low and high-skilled labor (Krusell et al. (2000), Acemoglu and Zilibotti (2001), Acemoglu (2002), and Unel (2008b) among others). However, this literature focuses on perfectly competitive product markets and abstracts from formally exploring the effects of firm size on the skill premium in imperfectly competitive output markets. The idea of output-skill complementarity is similar to the notion of capital-skill complementarity since it relates output changes (instead of changes in capital services) to the demand for high-skilled labor in markets characterized by internal scale economies.

In our framework, all firms are symmetric and each firm supplies the same equilibrium quantity of each variety. Consequently, letting x denote the output of the representative firm it suffices to describe its technology with the following augmented CES production function which has been routinely used in the theoretical and empirical literature on capital-skill complementarity:

$$x = \left[(\Phi_H Z_H)^{\frac{\sigma-1}{\sigma}} + (\Phi_L Z_L)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{4}$$

where Z_H and Z_L are the amounts of high and low-skilled labor employed by the firm; $\sigma \in (0,\infty)$ is the constant (wage) elasticity of substitution; and Φ_H , Φ_L are two separate functions that capture the efficiency of high-skilled and low-skilled labor, respectively. According to (4) then, production of x depends on high-skilled and low-skilled labor measured in efficiency units $\Phi_H Z_H$ and $\Phi_L Z_L$, respectively.[9]

Analytical simplicity compels us to model the efficiency of labor as a function of market size measured by the representative firm's output. The idea that a larger market leads to increased efficiency through specialization of labor goes back to Adam Smith's famous statement that "The division of labor is limited by the extent of the market" and constitutes one of the main sources of scale economies.[10] Following Panagariya's (1981) seminal contribution to modeling variable returns to scale, we assume that the dependence of high-skilled and low-skilled labor efficiency on the representative firm's output takes the following simple form

[9] Empirical studies on capital-skill complementarity use a capital-augmented version of equation (4). See, for instance, Krusell et al. (2000) and Unel (2008b).

[10] There are other sources of internal scale economies: fixed inputs associated with human or physical capital, and research and development; and engineering principles such as the "cube-square rule". The research question of how different sources of scale economies affect the skill premium is beyond the scope of the present paper.

$$\Phi_H(x) = x^{\gamma_H}\ ; \qquad\qquad \Phi_L(x) = x^{\gamma_L}\ ; \tag{5}$$

where parameters $\gamma_H \in (0,1)$ and $\gamma_L \in (0,1)$ are the constant output elasticities of high-skilled and low-skilled labor efficiency defined as $\gamma_i \equiv (\partial \log \Phi_i)/(\partial \log x)$ for $i = H, L$. The case of homothetic production technology corresponds to $\gamma = \gamma_H = \gamma_L \in (0,1)$, whereas unequal positive output elasticities of labor efficiency imply non-homothetic production technology.

Next, we explore the analytical properties of the proposed technology by deriving the corresponding unit-cost function. Let w_H and w_L denote the wages of high-skilled and low-skilled labor and $c(w_H, w_L, x)$ the representative firm's unit-cost function. Following Varian (1984, pp 30-33), one can readily derive the cost function by minimizing $w_H Z_H + w_L Z_L$ subject to equation (4). The solution to this minimization problem yields the total cost function $C(w_H, w_L, x) \equiv c(w_H, w_L, x)x$, where

$$c(w_H, w_L, x) = \left[\left(\frac{w_H}{\Phi_H}\right)^{1-\sigma} + \left(\frac{w_L}{\Phi_L}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} = \left[\left(x^{-\gamma_H} w_H\right)^{1-\sigma} + \left(x^{-\gamma_L} w_L\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{6}$$

is the corresponding unit-cost function. It can be seen from (6) that, when $\gamma_H > 0$ and $\gamma_L > 0$, the unit-cost function is decreasing in the firm's output ($c_x \equiv \partial c(w_H, w_L, x)/\partial x < 0$) and the production function exhibits increasing returns to scale. If $\gamma_H = \gamma_L = 0$, the unit-cost function is independent of the firm's output and the production technology exhibits constant returns to scale. Finally, if $\gamma_H < 0$, $\gamma_L < 0$, then the unit-cost function increases in the firm's output and the production function exhibits decreasing returns to scale. The reader can also verify that if both of these parameters exceed unity, then both the unit and total-cost functions decline in output.

Differentiating (6) with respect to each wage yields the unit-output requirements for high and low-skilled labor

$$\alpha_H(\omega, x) \equiv \frac{\partial c(w_H, w_L, x)}{\partial w_H} = \left[\left(x^{-\gamma_H}\omega\right)^{1-\sigma} + \left(x^{-\gamma_L}\right)^{1-\sigma}\right]^{\frac{\sigma}{1-\sigma}} \omega^{-\sigma} x^{(\sigma-1)\gamma_H} \tag{7}$$

$$\alpha_L(\omega, x) \equiv \frac{\partial c(w_H, w_L, x)}{\partial w_L} = \left[\left(x^{-\gamma_H}\omega\right)^{1-\sigma} + \left(x^{-\gamma_L}\right)^{1-\sigma}\right]^{\frac{\sigma}{1-\sigma}} x^{(\sigma-1)\gamma_L} \tag{8}$$

where $\omega \equiv w_H / w_L$ is the relative wage of high-skilled labor and is identified with the skill premium.[11] Dividing (7) by (8) yields the following expression for the representative firm's relative demand for high-skilled labor (the skill-intensity of production):

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[11] These conditional input demand functions are derived from Shephard's lemma. In general, linear homogeneity of the unit-cost function in factor prices also implies that the marginal unit cost function $c_x(w_H, w_L, x)$ is

$$\frac{\alpha_H(\omega,x)}{\alpha_L(\omega,x)} = \omega^{-\sigma} x^{(\sigma-1)(\gamma_H-\gamma_L)}. \qquad (9)$$

Equation (9) plays a central role in Acemoglu's (2002) work on the dynamic determinants of directed technical change.[12] Equation (9) complements his work by relating the relative demand of high-skilled labor within a firm to the skill premium and the firm's output. Taking logs and differentiating (9) yields the standard *wage* elasticity of substitution $\sigma \equiv -\partial \log(\alpha_H/\alpha_L)/\partial \log \omega$. In addition, thanks to the assumed non-homotheticity in production, equation (9) generates the non-standard *output* elasticity of substitution $\lambda \equiv \partial \log(\alpha_H/\alpha_L)/\partial \log x = (\sigma-1)(\gamma_H-\gamma_L)$. The economic interpretation of these two elasticities is simple. If the constant (wage) elasticity of substitution is positive ($\sigma > 0$), then an increase in the relative wage of high-skilled labor decreases the skill intensity of production for any given output level as firms substitute low for high-skilled labor. If $\sigma > 1$, then an increase in ω reduces both the skill intensity of production and the share of high-skilled labor in the total costs of production, so the two factors are called gross substitutes (Acemoglu, 2002). The output elasticity of substitution is a new concept. It captures the effects of output changes on the skill intensity of production and offers the following natural definition.

Definition 1: *The output elasticity of substitution $\lambda \equiv \partial \log(\alpha_H/\alpha_L)/\partial \log x = (\sigma-1)(\gamma_H-\gamma_L)$ is defined as the percentage change in the ratio of high to low-skilled labor resulting from one percent change in output. The production function exhibits output-skill complementarity, output-skill substitutability, or output-skill neutrality if and only if the constant output elasticity of substitution λ is positive, negative or zero, respectively.*

The economic intuition behind the output elasticity of substitution can be described by considering the case of output-skill complementarity. Inspection of the unit-cost function (6) reveals that, in the presence of increasing returns, per unit costs depend on the "effective" wages of high-skilled and low-skilled labor w_H/x^{γ_H} and w_L/x^{γ_L} respectively, where the term "effective" denotes the wage per efficiency unit. Thus, for any given nominal wages w_H and w_L, an increase in output reduces the effective wage of high-skilled labor more than the effective wage of low-skilled labor (and reduces the effective skill premium) if and only if $\gamma_H > \gamma_L$. The decline in the effective skill premium increases the

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homogeneous of degree one and that $\alpha_H(w_H, w_L, x)$ and $\alpha_L(w_H, w_L, x)$ are homogeneous of degree zero in factor prices. See Varian (1984, Chapter 1) for further details on the properties of cost functions.

[12] Solving (9) for the relative wage and substituting (5) yields $\omega = (\Phi_H/\Phi_L)^{\frac{\sigma-1}{\sigma}} (\alpha_H/\alpha_L)^{-\frac{1}{\sigma}}$, which is the same (with the exception of a unimportant constant) as equation (1) in Acemoglu (2002).

relative demand for high-skilled labor α_H / α_L if and only if the two factors of production are gross substitutes ($\sigma > 1$) as firms aim at substituting high-skilled for low-skilled labor. The opposite holds if the two factors of production are gross complements ($\sigma < 1$). In the special case where $\sigma = 1$ (i.e., the production function is Cobb-Douglas and factor-cost shares are constant), the skill-intensity of production is independent of the effective relative wage. If the production function is homothetic ($\gamma_H = \gamma_L$) a change in output does not have any impact on the relative effective wage and does not change the relative demand for high-skilled labor. In both of these cases ($\sigma = 1$ and/or $\gamma_H = \gamma_L$) the production function exhibits output-skill neutrality.

Several studies on the U.S. skill premium provide convincing evidence in support of output-skill complementarity. First, consider the wage elasticity of substitution between high-skilled and low-skilled labor, σ. Katz and Murphy (1992) report an estimate of this elasticity of about 1.4, Krusell et al. (2000) report that σ is 1.67, and more recently Autor et al. (2007) find this elasticity to be about 1.6. Therefore, in what follows, we assume that high-skilled and low-skilled labor are gross substitutes ($\sigma > 1$).

Next, consider the second component of the output elasticity of substitution $\gamma_H - \gamma_L$ which captures the difference between the output elasticities of labor efficiency of high-skilled and low-skilled labor. If "learning-by-doing" is the underlying dominant source of scale economies, then it is reasonable to interpret $\gamma_H - \gamma_L$ as the difference between the learning rates of high and low-skilled workers. One could argue, then, that high-skilled (high-ability) workers learn faster and become more productive than low-skilled (low-ability) workers as the firm's output expands and higher degree of specialization is required.

This argument, which implies that $\gamma_H - \gamma_L > 0$, is consistent with cross-section and time series evidence. For instance, Newhouse et al. (1982) have documented the division of labor in medical markets and reported a disproportional higher percentage of general practitioners in smaller markets and a concentration of specialists in larger markets. This geographic pattern is consistent with the hypothesis that specialists face steeper average cost curves than general practitioners because they incur higher training costs and have higher levels of human capital. In other words, specialists (who possess more human capital) have a higher learning rate than general practitioners. This difference in learning rates leads to steeper average cost curves and allows specialists to do better in larger markets.[13]. Based on the Katz and Murphy (1992) estimates, Krusell et al (2000, p. 1047) calculate the implied growth rates (annual percentage changes) of high and low-skilled labor efficiency (quality) that can be used to

[13] Besanko et al. (2007, pp 83-84) provide more details on this argument.

derive proxies for γ_H and γ_L. Using the present model's notation, Krusell et al. (2000) assume that the labor efficiency of high and low-skilled labor is given by $\Phi_H = \Phi_0 e^{g_H t}$ and $\Phi_L = \Phi_0 e^{g_L t}$ in (5) which imply $g_H - g_L = 11\%$. In addition, Unel (2008b) reports estimates of the average annual growth rates for the efficiency of high and low-skilled labor using U.S. annual data over the period 1950-2005, and reports that $g_H - g_L$ is positive and lies between 9.5% and 4.5%. Furthermore, the evolution of labor efficiency over the sample period suggests that the difference $\Phi_H - \Phi_L$ is positive and increases over time. This evidence suggests that the efficiency of high-skilled labor is higher and increases more than the efficiency of low-skilled labor, which is consistent with the assumption that $\gamma_H - \gamma_L > 0$ and supports the hypothesis that the implied output elasticity of substitution λ is positive.[14]

The above-mentioned empirical studies lend support to the empirical relevance of a positive output elasticity of substitution and the hypothesis of output-skill complementarity. We will therefore present the main results of our analysis for this case. The implications of output-skill substitutability and output-skill neutrality are considered in Section 5.

3. Closed-Economy Equilibrium

The presence of increasing returns and horizontal product differentiation induces every firm to specialize in the production of a unique variety. Thus, by the structural symmetry of the model, we may concentrate on the behavior of the representative firm. Since each firm has monopoly power over its

[14] Katz and Murphy (1992) use annual U.S. time series data for the period 1963-87 to estimate the following equation ln($\omega(t)$) = constant -0709ln[$\alpha_H(t)/\alpha_L(t)$]+0.033(time), where the time trend captures the demand forces that might affect the skill premium. Under the following two (but perhaps restrictive) assumptions, one can obtain estimates of the output elasticity of substitution λ. First, expressing equation (5) as $\Phi_H(t) = (\overline{x}t)^{\gamma_H}$ and $\Phi_L(t) = (\overline{x}t)^{\gamma_L}$ where $\overline{x}$ is the firm's annual output capacity which is invariant over time. In other words, each year the firm's output can increase by a fixed amount $\overline{x}$, and therefore $x(t) = \overline{x}t$. The static version of the model corresponds to the long-run, where each firm can choose its profit-maximizing output without facing any capacity constraints. Our assumption implies that the second term in Katz and Murphy equation is given by $[(\sigma-1)(\gamma_H-\gamma_L)/\sigma]$ ln (time). Second, under a linear approximation of (time) ≈ ln(time), one can calculate the implied values of $\gamma_H - \gamma_L$ and λ. For example, the regression equation in Katz and Murphy (1992) implies an output elasticity of substitution $\lambda = 4.4\%$ based on $\sigma = 1.41$ and $\gamma_H - \gamma_L = g_H - g_L = 11\%$. Similarly, Unel's (2008) study implies an output elasticity of substitution $\lambda = 3.8\%$ which is based on $\sigma = 1.4$ and $\gamma_H - \gamma_L = g_H - g_L = 9.5\%$

Although these estimates seem reasonable, there are a few caveats regarding this interpretation of time series data. In addition to output growth, several other factors can affect the efficiency of labor over time including physical capital accumulation, human capital accumulation, government policies, and technological progress. Therefore, although we are confident about the positive sign of the output elasticity of substitution, we are less confident about its magnitude.

variety, the typical firm maximizes profits by choosing the level of output such that its marginal revenue is equal to its marginal cost, i.e.,

$$p\left[1-\frac{1}{\eta(x,N)}\right]=c(w_H,w_L,x)+xc_x(w_H,w_L,x)\,, \tag{10}$$

where p denotes the price of the representative variety and the price elasticity of demand $\eta(x,N)$ is given by (3). The left-hand side (LHS) of (10) is the firm's marginal revenue; and the right-hand side (RHS) is its marginal cost. Treating the number of firms m as a continuous variable and assuming this number to be large (or, more precisely, assuming that the model's parameters generate a large number of firms in the equilibrium), unrestricted free entry and exit drives economic profits down to zero, where the price of a typical variety equals its average production costs

$$p=c(w_H,w_L,x)\,. \tag{11}$$

Turning to factor markets, we assume that workers are perfectly mobile across firms and that wages are flexible, so demand for each of the two factors of production equals its supply and full employment prevails. The following two full-employment conditions ensure that factor markets clear and complete the description of the model:

$$\alpha_H(\omega,x)xm=H \tag{12}$$

$$\alpha_L(\omega,x)xm=L\,. \tag{13}$$

The RHS of (12) is the economy's endowment (fixed aggregate supply) of high-skilled labor. The LHS of (12) is the aggregate demand for high-skilled labor: each of the m identical firms employs $\alpha_H x$ high-skilled workers. A similar interpretation applies to the full-employment condition of low-skilled labor (13).

We may now investigate the properties of Home's autarkic (closed-economy) equilibrium. Substituting the zero-profit condition (11) into (10) and simplifying yields

$$\eta(x,N)=s(x,\omega)\,, \qquad (\textit{Pricing Condition}) \tag{14}$$

where

$$s(x,\omega)\equiv-\frac{c(x,w_H,w_L)}{xc_x(x,w_H,w_L)}=\frac{1+x^{\lambda}\omega^{(1-\sigma)}}{\gamma_L+\gamma_H x^{\lambda}\omega^{(1-\sigma)}}>1 \tag{15}$$

is the elasticity of output with respect to unit-cost of production. We refer to (14) as the "Pricing Condition" for obvious reasons. Equation (14) simply states that the slope of the inverse demand curve must equal the slope of the average cost curve (i.e., $dp/dx=dc/dx$). The requirement that γ_H and γ_L lie in the unit interval assures that the representative firm operates on the elastic segment of its perceived demand curve.

Totally differentiating (14) yields the slope of the *Pricing Condition* $dx/d\omega = s_\omega / (\eta_x - s_x)$ in the skill-premium and output space. In the Appendix we show that, under output-skill complementarity, $s(x,\omega)$ is an increasing function of the skill premium ω (i.e., $s_\omega > 0$). Moreover, inspection of (3) establishes that the price elasticity of demand is a decreasing function of output x (i.e., $\eta_x < 0$). We also show in the Appendix that the second-order condition for profit maximization requires the perceived inverse demand curve to be steeper than the unit-cost curve at the equilibrium (or, equivalently, the firm's marginal revenue curve to be steeper than its marginal cost curve): thus, $\eta_x - s_x < 0$.These properties mean that, for given N, the *Pricing Condition* defines an inverse relationship between ω and x, as illustrated by the negatively-sloped curve labeled PP in Fig. 1.

Ceteris paribus, an increase in the economy's size, measured by the number of consumers N (or an increase in θ or ε), shifts the PP curve in Fig.1 to the right. This is so because an increase in N renders the demand for each variety more elastic and thus increases the price elasticity of demand $\eta(x,N)$ for each output level x. An increase in the relative wage is needed to raise $s(x,\omega)$ to restore the initial equilibrium, thus requiring the PP curve to shift to the right.

The second general-equilibrium condition is obtained by dividing (12) by (13) and substituting (9)

$$\frac{\alpha_H(\omega,x)}{\alpha_L(\omega,x)} = \omega^{-\sigma} x^{\lambda} = \frac{H}{L}. \qquad (\textit{Market-Clearing Condition}) \qquad (16)$$

We refer to this equation as the "Market-Clearing Condition". The LHS of (16) equals the economy's (and, by symmetry, the firm's) relative demand for high-skilled labor and the RHS equals its relative supply (skill abundance). In this single-sector economy, the *Market-Clearing Condition* states that each firm's skill intensity is fixed and equal to the economy's skill abundance.[15]

Under the hypothesis of output-skill complementarity ($\lambda > 0$) and the assumption that high and low-skilled labor are gross substitutes ($\sigma > 1$), equation (16) defines a positively-sloped curve starting at the origin and labeled FF in Fig. 1. To see this consider an increase in output x. Ceteris paribus, this change in x raises the relative efficiency and demand for high-skilled labor by reducing its effective relative wage. An increase in the skill premium ω is needed to reduce the excess demand for high-skilled workers, thus establishing the positive slope of FF curve. In addition, an increase in skill abundance H/L reduces ω for any given level of x and rotates the FF curve counter-clockwise.

[15] If we allowed the economy's skill abundance $H(\omega)/L(\omega)$ to be an increasing function of the skill premium ω, an increase in the equilibrium skill premium would generate both firm-specific and economy-wide skill upgrading. To keep the analysis as simple as possible, we abstract from incorporating this supply-based skill upgrading mechanism in the model, which, in any event, represents a straightforward extension of our model.

The unique intersection of FF and PP curves at point A in Fig. 1 determines the closed-economy equilibrium values of the representative firm's output x_A and the skill premium ω_A. Once these variables are determined, the equilibrium values of the remaining variables can be readily obtained. Fig. 1 can also be used to analyze the model's comparative-statics properties. For instance, consider the effects of an equi-proportional increase in both H and L that raises the size of the economy N, but leaves its skill abundance unchanged. This increase in N leaves the FF curve intact, but shifts the PP curve upward for reasons explained earlier. At the initial equilibrium, both incumbent firms and potential entrants reason that positive profits can be obtained, so that at constant wages an increase in output produced x is beneficial. Under output-skill complementarity, the output increase induces each firm to demand more high-skilled labor which leads to a rise in the skill premium ω, since the skill intensity of production equals the fixed skill abundance (i.e., $\alpha_H / \alpha_L = H / L$). In other words, the model predicts that larger economies of equal skill abundance are populated by larger firms and offer *higher* skill premia.

Consider, now, the effects of an increase in H coupled with a corresponding equal decrease in L so that the economy's supply of skill abundance H / L rises without affecting its size N. It is obvious then that the PP curve remains intact but the FF curve shifts leftward bringing about an increase in the representative firm's output x and a decrease in the skill premium ω. According to the model, skill abundant economies of equal size are populated by larger firms and offer *lower* skill premia. The following proposition summarizes the main comparative-static properties of the closed-economy equilibrium.

Proposition 1: *If the output elasticity of substitution λ is positive, then:*

(a) an increase in market size N raises the skill premium ω and output per firm x;

(b) an increase in skill abundance H / L lowers the skill premium ω and increases output per firm x.

The negative effect of skill abundance on the skill premium operates through the economy's supply side, and it is consistent with the empirical findings of Katz and Murphy (1992, p.69) among others.

4. Effects of Intraindustry Trade

In this section we analyze the effects of intraindustry trade on two economies that may differ in their relative endowments of high-skilled labor and possibly in their relative size. We consider the extreme scenario whereby these economies move from autarky to free trade. This approach encompasses a variety of factors that may promote intraindustry trade, including reductions in trade barriers through the establishment of trade agreements, improvements in transportation and communication technologies, etc.

Denote with a star "*" Foreign's variables and for clarity, but no loss of generality, assume that Home is skill abundant ($H/L > H^*/L^*$) and also the largest country ($N > N^*$). In the absence of transportation costs or other obstacles to trade, the opening of national borders enables the two countries to engage in intraindustry trade. From the perspective of each individual country, the effect of trade is analytically equivalent to the effect of market-size expansion analyzed in the previous section.

Fig. 2 illustrates the impact of trade on the skill premium and on the size of the representative firm in each of the two countries. The PP curve lies to the right of the P^*P^* curve because by assumption Home is larger than Foreign. The F^*F^* curve is located to the right of the FF curve (except at the origin) because Home is the skill-abundant country (see Proposition 1). The coordinates of point A determine the closed-economy equilibrium pair (ω_A, x_A) of skill premium and firm size for Home. Similarly, the coordinates of point A^* identify the corresponding equilibrium pair (ω_A^*, x_A^*) for Foreign. Although at the autarkic equilibrium Home is populated by larger firms, the ranking of skill premia between the two countries is in general ambiguous. Fig. 2 illustrates the case where the equilibrium skill premium is lower at Home.

The move from autarky to free trade does not affect the location of FF and F^*F^* curves because the *Market-Clearing Condition* (16) does not depend on trade-related parameters. With the opening of trade, every active Home and Foreign firm now serves $N + N^*$ consumers, so the new *Pricing Condition* is given by (14) and evaluated at $N + N^*$.[16] Since firms in both countries face identical technologies and serve the same number of consumers, the P^TP^T curve in Fig. 2 describes the common *Pricing Condition.* A move from autarky to free trade expands the size of the market for the representative firm in each country, thereby raising the price elasticity of demand for each variety η and shifting the PP (P^*P^*) curve of Home (Foreign) to P^TP^T .

The free trade equilibrium for Home (Foreign) is depicted at point T (T^*), the intersection of curves P^TP^T and FF (F^*F^*) in Fig. 2. It is thus obvious that, under skill-output complementarity, the introduction of free trade causes the skill premium and the output of the representative firm to rise in both countries. It is also worth mentioning that under free trade, as compared to autarky, the output of

[16] More precisely, there exists a corresponding *Pricing Condition* for Foreign that is functionally identical to (14) but with variables ω^* and x^* appearing in the two sides of the equation.

every active firm is larger in both trading partners. Further, because of the presence of increasing returns and free entry and exit, the increase in output per variety forces producers to rationalize production which increases the efficiency of both types of labor, and thus raises the level of total factor productivity everywhere as the typical firm moves down along its negatively-sloped average cost curve.

In principle, a move from autarky to free trade does not reveal directly the direction of change in each country's terms of trade. It is obvious though from Fig. 2 that our main results hold for any move from less to more intraindustry trade caused by changes in country size and/or skill abundance. In this case, each country's terms of trade defined as the price of exports relative to the price of imports remains equal to unity due the assumption of structural symmetry across varieties

Lastly, comparison of the coordinates at points T and T^* in Fig. 2 reveals that the skill premium is lower at Home (the high-skilled labor abundant country) and that the size of the representative firm is lower at Foreign (the low-skilled labor abundant country). In other words, intraindustry trade will not equalize factor prices across the two countries if these countries differ in factor abundance. These are novel and intriguing findings that cannot arise in the context of the traditional Heckscher-Ohlin trade model. For clarity, we summarize these findings in the following two propositions

Proposition 2: *If the output elasticity of substitution λ is positive and consumers in both countries consume positive quantities of all available varieties under free trade, then a move from autarky to free intraindustry trade:*

(a) raises the skill premium ω;

(b) increases the output of a typical firm x; and

(c) raises the total factor productivity by lowering the unit production costs.

These changes occur in both trading countries.

Proposition 3: *If the output elasticity of substitution λ is positive and consumers in both countries consume positive quantities of all available varieties under free trade, then at the free intraindustry trade equilibrium the skill premium ω is lower (higher) and the output per variety x is larger (smaller) in the high-skilled (low-skilled) labor abundant country.*

Consider now the case of two identical countries ($H = H^*$ and $L = L^*$) which has been routinely used to analyze the effects of intraindustry trade among advanced countries. The autarky equilibrium in both countries is identical and determined by the intersection of the common PP and FF curves in Fig. 2 (say point A).In this case, a move from autarky to free trade does not affect the location of FF curve, but shifts the common PP curve to the right and the equilibrium from point A to point T . Therefore, Proposition 2 applies to the case of two identical countries as well, although Proposition 3 does not because, by assumption, the skill premium and the output of the representative firm are identical in both countries. Finally, consider the special case of two countries with equal-size ($N = N^*$) but unequal skill abundance (say, $H/L > H^*/L^*$). In this case, both countries share the same *Pricing Condition* (say PP curve in Fig. 2) but have distinct *Market Clearing Conditions* (say the FF and F^*F^* curves in Fig 2). It is obvious then that Propositions 2 and 3 apply to this case. Consequently, as long as countries differ in skill abundance, free trade does not lead to factor price equalization.

Proposition 2 predicts that the skill premium is positively related to the degree of economic openness and negatively related to an economy's skill abundance; and Proposition 3 predicts that free intraindustry trade does not necessarily bring equalization of skill premia across countries.[17] In other words, even in the presence of free intraindustry trade an increase in a country's skill abundance reduces its skill premium. These predictions are consistent with the empirical analysis of Epifani and Gancia (2007, Table 1). Using a panel of 35 countries for the years 1980 and 1990 they use regression analysis to identify the determinants of the skill premium, measured by the ratio of non-production wage to production wage. They regress the skill premium on market size (measured by the total labor force) on skill abundance (measured by the share of workers with secondary education) and on economic openness (measured by the ratio of exports and imports to GDP). They find that the skill premium is positively correlated to market size and economic openness and negatively correlated to skill abundance. All three variables are highly significant. According to their analysis, ceteris paribus, doubling of market size is associated with a 9% increase in the skill premium, doubling of economic openness is related to a 41% increase in the skill-premium, and doubling a country's skill abundance is associated with a 21% reduction in the skill premium.

Although our model provides a theoretical rationale for a correlation between the volume (as opposed to terms) of trade and the skill premium, it is also consistent with the findings of firm-level studies on trade and the skill premium. In our model, a move from autarky to free intraindustry trade reduces the number of firms in each country. The remaining firms become more efficient and produce more output to serve the domestic and foreign markets. Since the equilibrium ratio of high-skilled to low-skilled labor equals to the fixed economy-wide ratio H/L, there are no labor movements within

[17] Although the model analyzes the effects of a move from autarky to free intraindustry trade, Proposition 2 can be derived from a more general version of the model that incorporates trade barriers and/or transport costs, where a reduction in trade barriers (as opposed to a move from autarky to trade) increases the degree of intraindustry trade.

each firm (plant), but instead all movements occur between firms.[18] Therefore the model predicts a positive correlation between the skill premium, the degree of labor movements across firms, and each firm's output demanded, measured by either domestic and/or foreign shipments. These predictions are consistent with the seminal work of Bernard and Jensen (1997). Using plant-level data from the Census Bureau's Annual Survey of Manufacturers for the period 1976 to 1987, they analyze the relationship between exporting and labor market outcomes. They report on Table 8 a positive and significant correlation between changes in the skill premium and output per plant shipped to domestic and foreign consumers after controlling for several other variables including changes in the capital to labor ratio and the export status of an establishment. They state (Bernard and Jensen 1997, p. 26) "The determinants of increased wage inequality at the plant level are almost entirely driven by between plant shifts, as shown in Table 1 and Table 3. These increases are much more strongly linked to the demand variables, especially foreign sales, than technology or investment variables".

In summary, under output-skill complementarity, the model's predictions are consistent with the evidence on a simultaneous rise in the skill premium in several countries; with the evidence on a rise in total factor productivity; and with the evidence on no changes in the terms of trade (the price of exports relative to the price of imports equals unity due to structural symmetry).[19] This evidence has been used to argue against the Heckscher-Ohlin based trade and, therefore, in favor of the (exogenous) technology explanation for the global rise in skill premia.[20] In short, then, the model of monopolistic competition and intraindustry trade we developed in this paper strengthens the role of trade as an explanation for the rise in the global demand for high-skilled labor independently of differences in skill abundance. As such, it also contributes to the literature that analyzes the link between international trade and rising wage inequality in both North (advanced countries) and South (developing countries).[21]

5. Beyond Output-Skill Complementarity

The empirically relevant hypothesis of output-skill complementarity is but one component of the Chamberlinian mechanism of income distribution. This section analyzes the implications of output-skill

[18] Notice that the within-firm effect is zero if the equilibrium share of high-skilled labor in total firm employment $\alpha_H/(\alpha_H+\alpha_L)=1/[1+(\alpha_H/\alpha_L)]$ is exogenous; this is true in our model due to (16), which states that $\alpha_H/\alpha_L=H/L$. As we mentioned, one could readily generate within-firm skill upgrading and within-firm employment effects by assuming that the economy's skill abundance is a positive function of the skill premium.
[19] The study by Berman et al. (1998) provides evidence of a rise in total factor productivity with a simultaneous rise in the skill premium in several countries; and Feenstra (2004, Ch. 4) offers an overview of the stylized facts on the rise in the skill premium including the movement of domestic and import prices.
[20] Neary (2002) offers an excellent review on the debate on trade and wages.
[21] See, for instance, Beaulieu et al. (2004), Sayek and Sener (2006), Zhu (2005), and Zhu and Trefler (2005).

substitutability and neutrality in order to highlight the properties of this novel income-distribution mechanism.

The hypothesis of output-skill substitutability, which is based on the assumption that the output elasticity of substitution λ is negative, reverses the slopes of PP and FF curves in Fig. 1 and Fig. 2 (see the Appendix for details). In this case, an increase in skill abundance shifts the downward-sloped FF curve closer to the origin, which means that skill-abundant countries offer lower skill-premia and have smaller firms. In addition, the introduction of intraindustry trade shifts PP and P^*P^* curves to the left increasing the size of the representative firm and reducing the skill premium in both countries. The following proposition summarizes these results.

Proposition 4: *If the output elasticity of substitution λ is negative and consumers in both countries consume positive quantities of all available varieties under free trade, then a move from autarky to free intraindustry trade:*

(a) reduces the skill premium ω;

(b) increases the output of a typical firm x; and

(c) raises the total factor productivity by lowering the unit production costs.

These changes occur in both trading countries.

We conclude this section by mentioning briefly the conditions that disable the link between intraindustry trade and the skill premium. Consider first the case of homothetic tastes, where the price elasticity of demand is constant ($\theta = 0$) and renders the *Pricing Condition* independent of the number of consumers N. In this case, trade does not affect the skill premium nor does it affect the output of the representative firm. Consider next the case of a Cobb-Douglas production function which corresponds to setting $\sigma = 1$. In this case, the *Pricing Condition* does not depend on the skill premium and determines the firm's output; and the-*Market-Clearing Condition* does not depend on output and determines the skill premium. Consequently, in the case of a Cobb-Douglas production function trade affects only the output of the representative firm but not the skill premium. Finally, consider the case of homothetic production where $\gamma_H = \gamma_L$ which implies that $\lambda = 0$. Here the *Market-Clearing Condition* is independent of output and pins down the skill premium. More intraindustry trade increases the output of the representative firm but does not affect the skill premium. These special cases raise a word of caution concerning the use of functional forms in theoretical and empirical studies on trade and wages. The use of homothetic utility and production functions disables the firm-specific Chamberlinian mechanism and excludes, by assumption, the sector-specific effects of trade on wages in monopolistically competitive environments.

6. Conclusions

We modified the standard model of intraindustry trade based on monopolistic competition by introducing quasi-homothetic preferences and non-homothetic technology in the production of each variety. These two modifications generated the Chamberlinian mechanism of income distribution which operates in markets with internal economies of scale, product differentiation and free entry and exit.

Under the empirically relevant hypothesis of output-skill complementarity, which is equivalent to assuming a positive output elasticity of substitution, intraindustry trade expands the output of the representative firm, intensifies the competition among firms producing differentiated products, and generates a flatter inverse demand curve for a typical variety. Because the free-entry equilibrium is given by the tangency of the inverse demand curve and the downward-sloped average-cost curve, intraindustry trade causes an increase in the output of each firm. This endogenous scale expansion generates a rise in total factor productivity, thanks to internal scale economies, and an increase in the relative demand for high-skilled labor. The latter causes the skill premium, measured by the relative wage of high-skilled labor, to increase. And, since the Chamberlinian mechanism operates through changes in each firm's output, the above-mentioned changes occur in both trading countries.

The traditional view on intraindustry trade assumes that this type of trade is regional and occurs only among advanced countries. Contrary to this view, recent empirical studies on "extensive margins" (variety exports) have documented the global character of intraindustry trade. For instance, Hummels and Klenow (2005) use data on exports from 126 countries to 59 countries in 5000 product categories to study the contribution of variety exports to the overall pattern of trade. They find that variety exports account for about 60 percent of the greater exports for larger economies. The extensive margin is 70 percent for China, 56 percent for Hong Kong, 44 percent for India, 74 percent for Mexico, 47 percent for Russia, and 64 percent for South Korea (Hummels and Klenow, 2005, Table A1). This evidence suggests that the income distributional effects triggered by the Chamberlinian mechanism could be present in any set of advanced or developing countries that trade varieties. These effects could also be present in situations where the gravity equation (whose theoretical underpinnings rely on the theory of monopolistic competition) is a main determinant of bilateral trade flows among advanced and developing countries.

Several extensions constitute useful avenues for further research and could yield a more realistic model of monopolistic competition and the skill premium. For instance, it is straightforward to generate firm-specific and industry-specific skill upgrading by assuming that skill abundance is an increasing function of the skill premium. It is also feasible to develop a two-sector model of monopolistic competition in order to study the interactions between the Stolper-Samuelson (1941) and Chamberlinian (1933) mechanisms of income distribution. Finally, one can introduce firm heterogeneity and trade costs to analyze the effects of intraindustry trade on the skill premium in a more complex and realistic model of monopolistic competition where only a fraction of firms engage in exporting.

References

Acemoglu, Daron, (2002), "Directed Technical Change", *The Review of Economic Studies* 69, 4, 781-809.

Acemoglu, Daron and Fabrizio Zilibotti, (2001), "Productivity Differences", *The Quarterly Journal of Economics* 116, 2, 563-606.

Autor, David H., Lawrence F. Katz and Melissa S. Kearney, (2007), "Trends in U.S. Wage Inequality: Revising the Revisionists", *Review of Economics and Statistics,* forthcoming.

Barron, John M., John R. Umbeck and Glen R. Waddell, (2008), "Consumer and Competitor Reactions: Evidence From a Field Experiment", *International Journal of Industrial Organization* 26, 517-531.

Beaulieu, Eugene, Michael Benarroch, and James Gainsford, (2004), "Trade Barriers and Wage Inequality in a North-South Model with Technology-Driven Intra Industry Trade", *Journal of Development Economics* 75, 113-136.

Berman, Eli, John Bound and Zvi Griliches, (1994), "Changes in the Demand for Skilled Labor Within U.S. Manufacturing Industries: Evidence from the Annual Survey of Manufacturing", *The Quarterly Journal of Economics* 109, 367-98.

Berman, Eli, John Bound and Stephen Machin, (1998), "Implications of Skill-Biased Technological Change: International Evidence", *The Quarterly Journal of Economics* 113, 1245-80.

Bernard, Andrew B.and J. Bradford Jensen, (1997), "Exporters, Skill Upgrading, and the Wage Gap", *Journal of International Economics* 42, 3-31.

Besanko, David, David Dranove, Mark Shanley, Scott Schaefer, (2007), *Economics of Strategy*, John Wiley and Sons.

Bound, John and George Johnson, (2000), Changes in the Structure of Wages in the 1980's: An Evaluation of Alternative Explanations", *American Economic Review* 82, 371-92.

Chamberlin, Edward, (1933), *The Theory of Monopolistic Competition: A Re-Orientation of the Theory of Value*, Cambridge, Mass.: Harvard University Press.

Dinopoulos, Elias and Paul Segerstrom, (1999), "A Schumpeterian Model of Protection and Relative Wages", *American Economic Review* 89 (3), June, 450-473.

Epifani, Paolo and Gino A. Gancia, (2007), "The Skill Bias of World Trade", *Economic Journal*, forthcoming.

Feenstra, Robert C. (2004), *Advanced International Trade: Theory and Evidence*, Princeton University Press.

Feenstra, Robert C. and Gordon Hanson, (1996), "Globalization, Outsourcing, and Wage Inequality", *American Economic Review Papers and Proceedings* 85, 240-45.

Feenstra, Robert C. and Gordon Hanson, (1999), "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States 1979-1990," *The Quarterly Journal of Economics* 114, 907-40.

Harrison, Ann, (1994), "Productivity, Imperfect Competition and Trade Reform: Theory and Evidence", *Journal of International Economics* 36, 53-73.

Helpman, Elhanan and Paul R. Krugman, (1985), *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*, Cambridge: MIT Press.

Hummels, David and Peter Klenow, (2005), "The Variety and Quality of a Nation's Exports", *American Economic Review* 95, 3, 704-723.

Johnson, George E., (1997), "Changes in Earnings Inequality: The Role of Demand Shifts", *Journal of Economic Perspectives*, 11,2, 41-54.

Katz, Lawrence F. and Kevin M. Murphy, (1992), "Changes in Relative Wages, 1963-1987: Supply and Demand Factors", *The Quarterly Journal of Economics,* 107, 35-78.

Krishna, Pravin and Devashish Mitra, (1998), "Trade Liberalization, Market Discipline, and Productivity Growth: New Evidence from India", *Journal of Development Economics* 46, 447-52.

Krugman, Paul R., (1979), "Increasing Returns, Monopolistic Competition, and International Trade", *Journal of International Economics* 9, 469-480.

Krusell, Per, Lee E. Ohanian, Jose-Victor-Rull, and Giovanni L. Violante, (2000), "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis", *Econometrica* 68, 1029-53.

Levinshon, James, (1993), "Testing the Imports-as-Market-Discipline Hypothesis", *Journal of International Economics* 35, 1-12.

Neary, Peter, (2002), "Foreign Competition and Wage Inequality", *Review of International Economics* 10, 4, 680-93.

Newhouse, Joseph P, Albert P. Williams, Bruce W. Bennett, William B. Schwartz, (1982), "Does the Geographical Distribution of Physicians Reflect Market Failure?", *The Bell Journal of Economics* 13, 2, 493-505.

Panagariya, Arvind, (1981), "Variable Returns to Scale in Production and Patterns of Specialization", *American Economic Review* 71, 1, 221-30.

Pollak, Robert A., (1971), "Additive Utility Functions and Linear Engel Curves", *Review of Economic Studies* 38, 116, 401-14.

Sayek, Selin, and Fuat Sener, (2006), "Outsourcing and Wage Inequality in a Dynamic Product Cycle Model", *Review of Development Economics* 10, 1-19.

Sener, Fuat, (2001), "Schumpeterian Unemployment, Trade and Wages", *Journal of International Economics* 54, 119-48.

Stolper, Wolfgang F. and Paul A. Samuelson (1941) "Protection and Real Wages", *Review of Economic Studies*, 9, 1, 58-73.

Unel, Bulent, (2008a), "Firm Heterogeneity, Trade, and Wage Inequality", Louisiana State University, Department of Economics, *mimeo.*

Unel, Bulent, (2008b), "Analyzing Skilled and Unskilled Labor Efficiencies in the U.S.", Louisiana State University, Department of Economics, *mimeo.*

Varian, Hal, (1984), *Microeconomic Analysis*, Second Edition, Norton.

Xu, Bin, (2001), "Factor Bias, Sector Bias, and the Effects of Technical Progress on Relative Factor Prices", *Journal of International Economics* 54, 1, 5-25.

Zhu, Susan Chun, (2005), "Can Product Cycles Explain Skill Upgrading?", *Journal of International Economic*s 66, 131-55.

Zhu, Susan Chun and Daniel Trefler, (2005), "Trade and Inequality in Developing Countries: A General Equilibrium Analysis", *Journal of International Economics* 65, 21-48.

Appendix

A.1 Price Elasticity of Demand

Owing to increasing returns, each firm j produces a unique variety j. Let $\eta_j \equiv -(p_j / x_j)(\partial x_j / \partial p_j)$ be the (absolute) value of the price elasticity of firm $j's$ perceived demand for its good, where $x_j = \sum_{i=1}^{N} x_j^i$ and p_j is the market price of variety j. The first-order condition (FOC) for the consumer maximization problem is $p_j \mu^i = \partial u(x_j^i) / \partial x_j^i = \rho (x_j^i + \theta)^{\rho - 1}$ ($j = 1, 2, ...m$), where μ^i is consumer $i's$ marginal utility of income. As in Krugman (1979), suppose further that each firm believes that changes in its output x_j do not affect the μ^i's.

Differentiating consumer $i's$ FOC appropriately yields the following expression for her price elasticity of demand for variety j: $\eta_j^i = -(p_j / x_j^i)(\partial x_j^i / \partial p_j) = \varepsilon(x_j^i + \theta) / x_j^i$, where $\varepsilon = 1/(1-\rho) > 1$. The price elasticity of total demand for good j can now be calculated as

$$\eta_j \equiv -\frac{p_j}{x_j}\frac{\partial x_j}{\partial p_j} = -\frac{1}{x_j}\sum_{i=1}^{N} p_j \frac{\partial x_j^i}{\partial p_j} = \frac{1}{x_j}\sum_{i=1}^{N} x_j^i \eta_j^i = \frac{1}{x_j}\sum_{i=1}^{N} \varepsilon(x_j^i + \theta) = \frac{\varepsilon}{x_j}(x_j + \theta N) = \varepsilon(1 + \frac{\theta N}{x_j}).$$

A.2 Pricing and Market-Clearing Conditions

First we explore the properties of the *Pricing Condition* (14). Differentiating (15) with respect to the skill premium ω and the firm size x yields

$$s_\omega = \frac{\partial s(x,\omega)}{\partial \omega} = \frac{\lambda x^\lambda \omega^{-\sigma}}{\left(\gamma_L + \gamma_H x^\lambda \omega^{1-\sigma}\right)^2}, \tag{A1}$$

$$s_x = \frac{\partial s(x,\omega)}{\partial x} = -\frac{(\sigma-1)(\gamma_H - \gamma_L)^2 x^{\lambda-1} \omega^{1-\sigma}}{\left(\gamma_L + \gamma_H x^\lambda \omega^{1-\sigma}\right)^2} \tag{A2}$$

It is obvious from (A1) that $s_\omega > 0$ if and only if the output elasticity of substitution is positive ($\lambda > 0$). In addition, (A2) implies that $s_x < 0$ if the high-skilled and low-skilled labor are gross substitutes ($\sigma > 1$) and the production function is non-homothetic ($\gamma_H \neq \gamma_L$).

Differentiating the price elasticity of demand $\eta(x,N)$ defined in (3) generates

$$\eta_x = \frac{\partial \eta}{\partial x} = -\frac{\varepsilon \theta N}{x^2} < 0, \tag{A3}$$

$$\eta_N = \frac{\partial \eta}{\partial N} = \frac{\varepsilon \theta}{x} > 0. \tag{A4}$$

The slope of curve PP in Fig. 1 and Fig. 2 depends on the sign of $\eta_x - s_x$. This sign is in general ambiguous in the empirically relevant case $\sigma > 1$, since both elasticities are decreasing in output. However, the second-order condition for profit maximization implies that $\eta_x - s_x < 0$ in the neighborhood of equilibrium where $\eta(x) = s(x,\omega)$ and $p(x) = c(x,\omega)$. The two equilibrium conditions imply that the inverse demand curve is tangent to the average cost curve, that is, $p_x(x) = c_x(x,\omega)$ at the equilibrium output. To see this write the firm's profit function as $\pi(x) = R(x) - C(x)$, where $R(x)$ is total revenue, and notice that local concavity of $\pi(x)$ requires that $\pi_{xx} = R_{xx} - C_{xx} < 0$. This means that, in the neighborhood of equilibrium, the marginal revenue curve $R_x = p[1-\eta^{-1}]$ (given by the LHS of (10)) must be steeper than the marginal cost curve $C_x = c + xc_x$ (given by the RHS of (10)).

Differentiating the marginal revenue with respect to output yields $R_{xx} = p_x[1-\eta^{-1}] + p\eta_x / \eta^2$. Similarly, using the definition of $s(x,\omega)$, write the marginal cost as $C_x = c[1-s^{-1}]$ and differentiate C_x with respect to output to obtain $C_{xx} = c_x[1-s^{-1}] + cs_x / s^2$. Evaluating R_{xx} at the equilibrium output yields $R_{xx} = c_x[1-s^{-1}] + c\eta_x / s^2$, and therefore $\pi_{xx} = R_{xx} - C_{xx} = (\eta_x - s_x)c / s^2 < 0$, which holds if and only if $\eta_x - s_x < 0$. This condition, which means that the inverse demand curve must be less convex than the average cost curve, holds for sufficiently large values of N.

The slope of the *Pricing Condition* is obtained by totally differentiating (14)

$$\frac{dx}{d\omega} = \frac{s_\omega}{\eta_x - s_x}. \tag{A5}$$

The denominator of (A5) is negative and the numerator is given by (A1) and is positive if and only if the output elasticity of substitution λ is positive. Therefore, output-skill complementarity (substitutability) implies that curve PP in Fig. 1 is negatively (positively) sloped. Output-skill neutrality ($\lambda = 0$) implies that curve PP is vertical.

Consider, now, the properties of the *Market-Clearing Condition* (16), which can be written as

$$x = \left(\frac{H}{L}\right)^{\frac{1}{\lambda}} \omega^{\frac{\sigma}{\lambda}}. \tag{A6}$$

The graph of (A6) corresponds to FF curve in Fig. 1. Equation (A6) reveals that, if $\lambda > 0$, then the FF curve upward-sloped and convex starting at the origin. An increase in the economy's skill abundance H/L rotates the FF curve clockwise. In contrast, if $\lambda < 0$, then (A6) defines a downward-sloped convex FF curve, which shifts towards the origin when the economy's skill abundance increases.

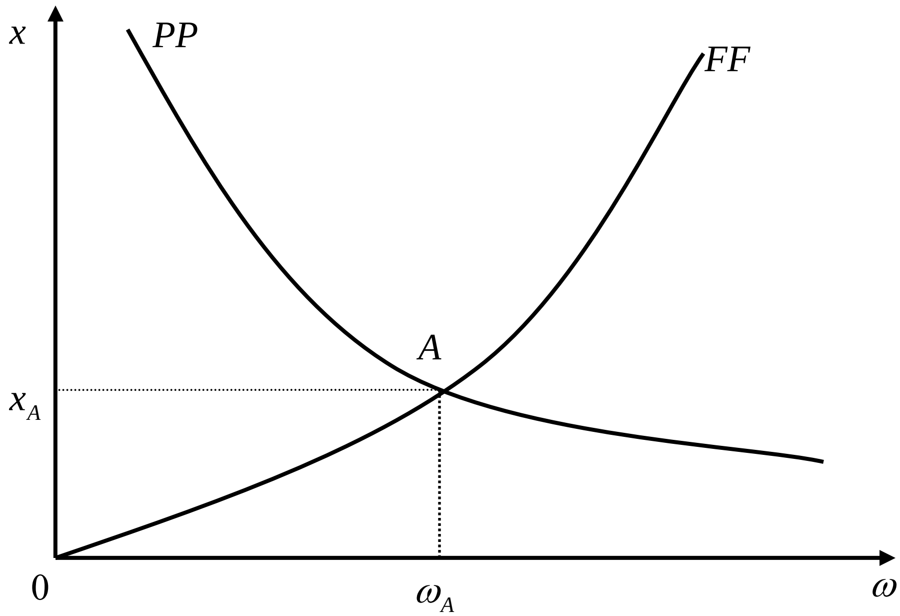

Fig.1: Closed-Economy Equilibrium

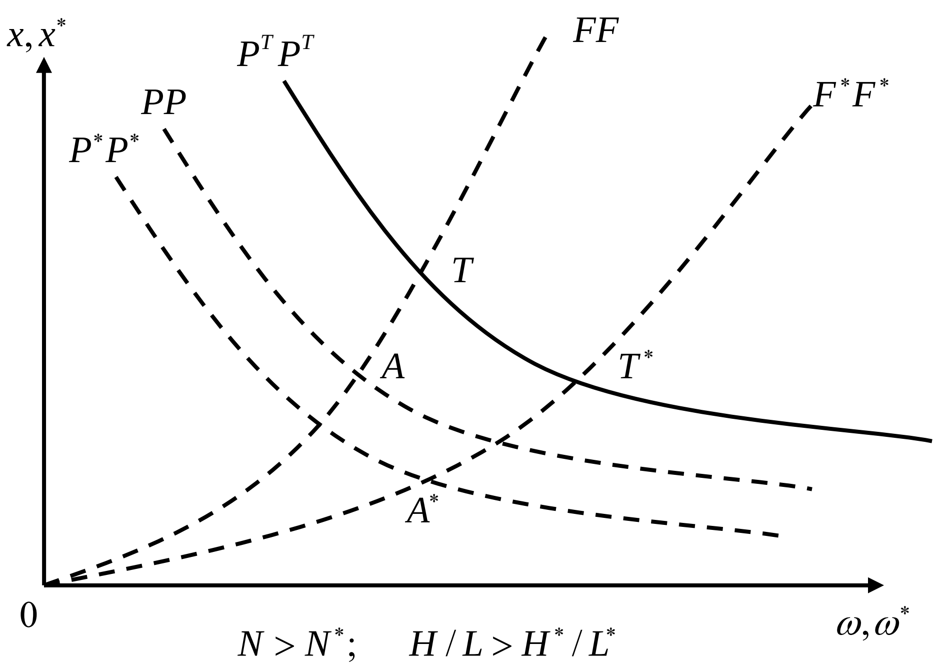

Fig. 2: Effects of Intraindustry Trade