Trade, Wages and "Superstars".

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Abstract

We study the effects "globalization" on wage inequality. Our "global" economy resembles Rosen (1981) "Superstars" economy, where a) innovations in production and communication technologies enable suppliers to reach a larger mass of consumers and to improve the (perceived) quality of their products and b) trade barriers fall.When transport costs fall, income is redistributed away from the non-exporting to the exporting sector of the economy. As the former turns out to employ workers of higher skill and pay, the effect is to raise wage inequality.

Whether the least skilled are stand to lose or gain from improved production or communication technologies, in contrast, depends on wether technology is skill-complement or substitute. The model gives an intuitive explanation for the empirical regularities that skill intensity, market size and wages tend to be positively associated to exporting activity, across sectors and plants.

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1. Introduction

"Globalization", "Internet economy", "Electronic trade" are the buzzwords of the day. The enthusiasm for the new technologies is often cooled down by worries concerning their possible consequences on income distribution. Will a globalized society be more or less "equal"? Who will be the winners and the losers? In spite of abundant empirical work, the distributive implications of globalization still seem poorly understood.

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"New" trade theory based on imperfect competition, while accounting for the failure of international convergence in factor prices, see Helpman and Krugman (1986), are in general silent about the implications of trade integration upon domestic inequality. A general prediction is that intra-industry trade has a small effect on income distribution, ad is likely to lead to higher welfare for all agents.

Traditional trade theory predicts that trade integration between developed and less developed countries will benefit skilled workers in the former, and manual workers in the latter (assuming these are the relatively abundant factors in the two areas).This view is generally refuted by the data. The actual changes in product prices generated by integration are hardly sufficient to explain the observed deterioration of the relative position of the unskilled.[1]. In addition, the Stolper-Samuelson theorem cannot account for the fact that inequality has risen dramatically within narrowly defined segments of the labor market (Juhn at al. (1993) [9]) i.e. between workers of similar occupations, education levels, and, in general, belonging to similar "skill" categories.

A number of recent studies conducted at firm or establishment level, have found empirical evidence on the link between *exporting activity and firms' performance*. This relationship seems to go both ways: better firms are more likely to export, and exporting firms are more likely to perform better in terms of profitability, productivity, growth prospect and so on.

For example, Bernard and Jensen (1997)[1] , in a study at plant and firm level, find that wages for particular occupations tend to be systematically higher in exporting firms/ plants, compared to wages in firms/plants that only sell in the domestic market. In a study on export decision of German firms in Saxony, Bernard and Wagner (1998)[3] find evidence that "successful plants, measured by size or productivity, are more likely to become exporters, as plants with greater shares of skilled labor*".* Interestingly, they also find that sunk costs play a crucial role in export entry/exit decisions by firms. On the other hand, exporting firms are found to do better than non exporters: "exporters... are larger, more productive, more capital intensive and pay higher wages*" (*Bernard and Jensen(1998)[2]).

In this paper we study the effects globalization on wage inequality. We present a model that accounts for the positive association between exporting, skill intensity, market size and wage premia.

Our description of a "global economy" is based on three crucial ingredients. The first is increasing returns in production. Market size matters. This is the basic tenets of "new" trade theory. The second is the role of technology in production and communication. Technology enables more talented suppliers to improve the

[1] See Freeman (1995)[?], Rodrik (1997)[10] and Slaughter and Swagel (1997)[12] among recent surveys on the empirical literature concerning the trade adn wages debate.

quality of their products, raises consumers' satisfaction and allows firms to reach a larger mass of consumers. The third ingredient is that barriers to trade that segment the international market tend to fall. We introduce transport costs and a fixed cost for entering foreign markets. Combining these ingredients into a simple trade model, we obtain a representation of the "global" economy that is reminiscent of Rosen's (1981)[11] "Economics of Superstar".

In his seminal paper, Rosen discussed the role that non-convexities in production may exert on income distribution. Some products are like non rival public goods: singing on a satellite-broadcast TV program or in a small cafe require approximately the same effort. For products where these non-convexities are particular important and where "talents" are particularly appreciated by consumers, even small differences in "skills" are associated with disproportionate differences in incomes (think of the show-biz, sport, science etc.).

Frank and Cook (1995)[4] recent best seller has popularized the idea of "winner-take-all" markets. To the extent that the earnings of executives and staff workers are increasingly tied to firm performance, tendency towards increasing earning differentials is likely to spread to from professionals and executives towards salaries and wages (as shown, for instance, in Hall and Liebman (1998)[6]).

In this paper, we take an admittedly extreme view of the labor market. Individuals derive their income from the *rents* associated with their specific skills. As in Rosen, the income distribution is shaped by the distribution of rents generated by individual abilities. To that we add a fully-fledged general equilibrium model, where the interaction between the distribution of wages, the size of firms and exporting decisions can be analyzed.

We consider a monopolistic competition trade model (Krugman (1980)[8]), where workers differ in their abilities. Firms supply different products varieties, and this generates demand "niches" and market power. However, employing better workers enables firms to produce goods of better quality, to capture larger market shares and enjoy higher profits. Due to the presence of a fixed cost to access foreign markets, only firms employing a "high-level" staff benefit from exporting. In such a setting, the decision to export on the part of each firm can only be determined after solving for the general equilibrium of the model: the distribution of income and the degree of openness of the market are interrelated.

As barriers to trade fall, more firms will benefit from exporting, and will have access to a larger market. Competition for skills will boost skill premia in exporting firms. Hence trade integration unambiguously leads to a redistribution of income from the workers employed in non-exporting firms to those employed in the export sector. Since the latter employs workers of greater skills, trade integration, while improving welfare, raises wage inequality. Even if aggregate welfare unambiguosly rises following a reduction in trade barriers, low-skilled workers may end up losing in nominal and even in real terms.

The introduction of new technologies allow firms to improve their products and/or enable them to market them more effectively. Hence, consumers everywhere start discriminating more and more among products, placing increasing weight on their (perceived) quality. As a result, consumers will concentrate their purchases on best-sellers products. The redistributive effects of technological progress, however, crucially depends upon the degree of complementarity of technology with workers' skills, and has ambiguous implications for the degree of openness of the economy. More importantly, wage inequality may be fostered even *within* firms belonging to the same sector

So, the effects on income distribution differ according as globalization comes from reduced trade barriers or technological change. This may help in disentangling empirically trade and technology shocks as alternative sources of rising income inequality.

The remainder of the paper is organized as follows. In section 2 the model is presented. Section 3 describes the solution of consumers' and firms' problems. In section 4 the solution of the model is characterized, while in section 5 comparative statics analysis is performed. The concluding remarks follow.

2. The Model

The world consists of two symmetric countries. We focus on the domestic country. Firms produce differentiated goods under imperfect competition and free-entry. Consumers like variety, according with the Dixit-Stiglitz formulation. Production requires two factors of production: skill ("talent"), whose total endowment is denoted by S, and a composite primary input, M (unskilled labor, raw materials). The market for production factors is competitive. In the economy there is a continuum of (of unit mass) households-workers, indexed by h, $h \in [0, H]$. Worker h is endowed with the amount raw inputs M^h, $\int_0^H M^h dh = M$. Skills are measured by an index s. More talented workers are characterized by higher s. Skills are distributed over the interval $[\underline{s}, \overline{s}]$, with density and cumulative function $\phi(s)$,and $\Phi(s)$, respectively, with $\int_{\underline{s}}^{\overline{s}} \phi(s)ds = S$. Production requires one skilled worker and an amount of composite input proportional to output. Raw inputs provide standardized services for production. Workers' skills improves the quality of the product. As a consequence, products are differentiated both along a horizontal dimension (variety) and a vertical one (quality). Output can either be sold in the domestic or foreign markets, or both. Shipping entails a iceberg transport cost *plus* a fixed market access cost (setting up a network of distributors abroad, covering legal expenses, etc.). Because of the fixed export costs, some firms prefer not to export their output at all. On the other hand, because of iceberg transport costs, no firms are willing to sell their production on the foreign market alone. As a result, firms may either sell only on the domestic market, or in both domestic and foreign markets.

2.1. Production Technology

There is one consumption good, X, which is suitable to be differentiated along a continuum of varieties i, $i \in R$. Each variety i is produced out of raw inputs, M, and skill, S. Each worker can employ her skills in the production of at most one variety of good X. The size of firms is normalized in such a way that one firm employs the skill of one worker. Each firm thus supplies only one variety. Raw inputs requirements are proportional to output. Let $w(s)$ and v denote, respectively, the return to skills of a worker endowed with "talent" s and that of raw inputs M. The cost of producing X units of variety i, when a type- s worker is involved is:

$$C(s(i), i) = w(s(i)) + v\,\beta X(s(i), i) + \delta^i v\gamma. \tag{2.1}$$

The parameter β represents the inverse of marginal productivity of raw inputs (units of inputs required for producing one unit of the variety i). The third term on the right hand side has the following interpretation. If the firm sell also in the foreign market it has to incur a fixed costs γ, which represents the extra units of composite inputs that are required to export [2] We denote the set of all different varieties supplied by N, and the subset of traded goods by N^e. If the variety i belongs to N^e, then $\delta^i = 1$ and the firms sells at home and abroad. If the variety is not exported, $i \notin N^e$, $\delta^i = 0$, and no cost is incurred.

Firms are atomistic profit-maximizers. They produce goods which are imperfect substitutes and set their price, taking as given other firms' choices (the "large group" Chamberlinian hypothesis holds). Consumers' utility increases with the extent of variety in consumption. As it is standard in monopolistic competition models, love for variety plus increasing returns in production insure that no firm is willing to supply the same variant offered by a rival. However, contrary to standard monopolistic competition models, the number of products here is given by the equilibrium condition on the skill market. Since each firm requires the skill of one worker, we have necessarily that $N = H$. In turn, the condition of free-entry ensures that skilled workers perceive all the operating profits realized

[2] Market access costs have been modelled as fixed costs in other papers. See, for instance, Smith and Venables (1991).

by firms. Workers' income is thus constituted by the sum of earnings from their endowment of raw input (sold on a competitive market) and skill rents[3] associated with firms' operating profits. This is a first analogy of our model with Rosen (1981)[11].

2.2. Preferences

Households have identical tastes, but different incomes, depending on their endowments of production factors. The income of household h, endowed with skills s, $I^h(s, M^h)$, is thus

$$I^h(s, M^h) = vM^h + w(s) \tag{2.2}$$

Consumers like variety, in the sense that their utility is increasing with the number of varieties consumed, according with the Dixit-Stigliz formulation. A distinguishing feature of our formulation is that more talented entrepreneurs produce better quality of each variety, and better quality is appreciated by consumers. Households derive utility from a combination of the quantity, X, and the "quality", indexed by $T(.)$, of each good. In this sense, a commodity is assimilated to a *bundle* of a physical good, X, and of an intangible good, $T(.)$ (the griffe of a fashionable tailor, the sound of a particular pop group, etc.), that is incorporated in the tangible commodity. For simplicity, we adopt a Cobb-Douglas specification to nest $T(.)$ and X^h, while we use the standard CES specification for different varieties:

$$U^h = \left[\int_{i=0}^{N} (T(s(i), a))^{1-\rho} \left(X^h(s(i), i) \right)^{\rho} di \right]^{\frac{1}{\rho}}. \tag{2.3}$$

As usual, the parameter $\rho \in (0, 1)$ is related to the elasticity of substitution between different varieties $\sigma = 1/(1-\rho) > 1$. This coincides with the price elasticity of the demand for each variety and therefore (inversely) measures the degree of market power of individual firms. $T(.)$ is a production function that matches the particular skill of the entrepreneur and the state-of-the-art technology, into the appreciated quality of the good. "Quality" depends on two factors: the skill of the entrepreneur producing the good, s, and the existing stock of technical knowledge a.[4] This may reflect both the accumulated stock of know-how in production and in communication. A technological break-through may enable firms either to improve their product quality or to market their products more effectively, raising the quality *perceived* by consumers. In our framework, a plays the

[3] In the remainder of the paper we will use indifferently the words wages, skill premia, or skill earnings, in referring to the rents accruing to workers' skills.

[4] So, quality is independent of variety i.

role of a shift parameter. We assume that $T(s,a)$ is a twice-differentiable continuous function satisfying some intuitive requirements. First, quality improves with technical progress, so that $T_a(s,a) > 0$ for all s, a. Second, more talented entrepreneurs produce "better" goods, so that $T_s(s,a)) > 0$, for all s and a. Finally, we add structure to this function assuming that the elasticity of $T(.)$ with respect to s, $\vartheta(s,a) \equiv T_s(s,a)s/T(s,a)$, is monotonic in a. According as $\vartheta_a(s,a)$ is equal, higher, or lower than zero, we say that technology is *skill-neutral*, *skill-complement* or *skill-substitute.*

Notice that our production and consumption technologies capture two important asymmetries between the role of primary inputs and skill in production. First, while costs related to primary inputs increase with output, the same expenditure for talent is required in serving a large or a small market. Second, even if both factors are required for production of a "standardized " variety, X (i.e., a good of quality $T(.) = 1$), only workers' ("entrepreneurial") talent can add "quality", according to the technology $T(s(i),a)$. These particular features of our model – namely, non-convexities in production and consumers valuing the characteristics associated with talented producers – give our model its Rosen-type flavor.

3. Firms' and households' equilibrium

3.1. Trade

The results of our model depart in some aspects from the standard monopolistic competition trade models (Helpman and Krugman (1986) [7]).As in the standard model, because of love for variety, consumers will try to spread their purchases across all available goods, produced either domestically or in the foreign country. However, not all firms will find it convenient to supply foreign consumers, because of the presence of fixed market access costs. In the standard model all firms sell abroad and their number is determined by the zero profit condition. Here, the total number of firms (entrepreneurs) is given, while the mass of exporting firms is endogenously determined.

We denote by an asterisk variables referring to the foreign country. Recall that, from the assumption of symmetry, all firms and workers abroad have access to the same technology as domestic workers and firms, defined by equation (2.1) and by the function $T(s(i),a)$. Let N and N^* denote, respectively, the mass of distinct varieties of the consumption good produced under free-trade at home and abroad. Now, let the subset $N^e \equiv \{i \in [N_{m^*}, N]\,,\ N_{m^*} \geq 0\}$ to be associated with goods that are sold both at home and abroad (domestic exports, foreign imports). By symmetry, the varieties $N^m \equiv \{i \in [N_m^*, N^*]\,, N_m^* \geq 0\}$ denote home imports of foreign goods.

In addition to the fixed market access costs γ (see (2.1)), there is another impediment to trade, namely transport costs of the iceberg type. For any unit shipped abroad, $1-\tau$ is lost in transit, and only a fraction $0<\tau<1$ arrives to foreign consumers. So, τ inversely measures the extent of transport costs.

Consider the home country. Household h maximizes utility (2.3) subject to the budget constraint (2.2). Domestic demand for home goods is given by

$$X(s(i),a,i,M) = T(s(i),a)\frac{I(M)}{P}\left(\frac{p(s(i),i)}{P}\right)^{-\sigma} \tag{3.1}$$

where I is total domestic income

$$I(M) = \nu M + \int_{s=\underline{s}}^{\overline{s}} \phi(s)w(s)ds \tag{3.2}$$

and P is the CES cost-of-living index that must also take into account imported goods

$$P = \left[\int_{i=0}^{N} T(s(i),a)\ p(s(i),i)^{1-\sigma}di + \right.$$

$$\left. + \int_{i*\ =\ N_m^*}^{N^*} T(s(i^*),a^*)\ \left(p(s(i^*),i^*)/\tau\right)^{1-\sigma} di^*\right]^{1/(1-\sigma)}. \tag{3.3}$$

Note from (3.1) that demand for variety i has unit elasticity with respect to quality and real households' income, and decreases with the relative price of good i with elasticity σ. Demand for imports, $X_m^*(s(i^*),i^*)$, is instead as follows

$$X_m^*(s(i^*),a^*,i^*,M) = T(s(i^*),a^*)\frac{I(M)}{P}\left(\frac{p(s(i^*),i^*)}{P}\right)^{-\sigma}\tau^{\sigma-1}. \tag{3.4}$$

The lower the transport cost, the lower the relative import price of foreign varieties, the higher imports. Moreover, as the domestic price index falls, real domestic income rises, so that domestic demand for imports rises both for a substitution and for an income effect.

We choose domestic raw inputs as a numeraire, so that $v=1$. Given the perfect symmetry of the model, it must also be $v^*=1$ at equilibrium.

The expression for the firm' s profits differ depending on whether the firm is selling on the domestic market only or also abroad. Denoting foreign demand for home goods (exports) by X_{m*}, we have

$$\pi(s(i),i) = p(.)X(.) + \delta^i p^*(.)X_{m*}(.) -$$

$$-\left[w(.) + \beta\left(X(.) + \delta^i X_{m*}(.)\right) + \delta^i\gamma\right]. \quad (3.5)$$

Profit maximization leads to mark-up pricing. Symmetry in production and tastes guarantees that all firms in both countries fix the same "free-on-board" price,

$$p(s(i), i) = p^*(s(i), i) = \frac{\sigma}{\sigma - 1}\beta \equiv p \quad \textit{for all } i, \ s(i). \quad (3.6)$$

Consistently, we can omit henceforth the index i. Using this condition of symmetric pricing (3.6), the demands for domestic goods, imports, and exports can be respectively expressed as follows:

$$X(s, a, M) = p^{-\sigma} Y(M)\, T(s, a) \quad (3.7)$$

$$X_m^*(s^*, a^*, M) = p^{-\sigma} Y(M)\, T(s^*, a^*)\, \tau^{\sigma-1} \quad (3.8)$$

$$X_{m^*}(s, a, M^*) = p^{-\sigma} Y^*(M^*)(T(s, a)\, \tau^{\sigma-1} \quad (3.9)$$

where

$$Y(M) \equiv I(M)\, P^{\sigma-1}, \quad Y^*(M^*) \equiv I^*(M^*) P^{*\sigma-1} \quad (3.10)$$

denote the demand for a home (foreign) good of unitary price and "standard" quality ($T(.) = 1$) by domestic (foreign) consumers. Because this variable enters as a multiplicative term in the demand for all goods, it can be interpreted as a measure of "firms' scale" in the domestic (foreign) market.

Two (endogenous) variables affect the magnitude of Y: aggregate income, I, and the price index, P. Given M, the distribution of skill earnings $w(s)$ univoquely determines aggregate income I. Other things being equal, higher households income raises the demand for a firm's product. Note that the real income elasticity of demand is unity, while the relative price elasticity is $\sigma > 1$. Therefore a higher P, resulting from higher the average price of competitors, raises the demand for each individual producer.

3.2. Income Distribution, Trade, and Technology

We now study the interaction between the distribution of wages and firms' choice to export. Suppose that a firm employing type-s worker decides not to export. Free entry entails that the earnings of the worker coincides with the firm's operating profits. From (3.5) and and (3.6) we see that :

$$w^i(s, a, M) = (p - \beta)X(s, a, M) = p^{1-\sigma} Y \frac{T(s, a)}{\sigma} \equiv w^n(s, a, M), \quad i \notin N^e \quad (3.11)$$

In the non-export sector, the earnings of a worker with skill s is positively related to the scale of the domestic market, Y, and to the firm's market power, measured by the mark-up $p-\beta$ (which is inversely related to the price elasticity of demand, σ). Notice that the wage rate increases linearly with quality, $T(s,a)$. The elasticity of the wage with respect to the level of skill, s, coincides with the elasticity of the quality index T, $\vartheta(s,a) \equiv T_s s/T$. Whenever the quality of the product rises more than proportionately with the skill of the producer, $\vartheta(s,a) > 1$, even small differences in skills may result in a large earnings premia and in a skewed income distribution, as in Rosen (1981)[11].

Assume now that a firm employing a type-s worker decides to export.. Recalling that an exporting firm must incur a fixed cost γ to access the foreign market, and imposing $a = a^*$, and $M = M^*$, the wage of type- s worker is

$$\begin{aligned} w^i(s,a,M) &= (p-\beta)(X(s,a,M) + X_{m*}(s,a,M^*)) - \gamma = \\ &= p^{1-\sigma}\frac{T(s,a)}{\sigma}Y\;(1+\frac{Y^*}{Y}\tau^{\sigma-1}) - \gamma \equiv w^e(s,a,M), \quad i \in N \end{aligned} \tag{3.12}$$

Comparing (3.11) and (3.12) we see that the wage premium increases even *more* with s if the firm is exporting, see figure 1.

Insert figure 1 here

The intuition is simple. Each additional unit of talent in exporting firms allows for larger sales in *both* home and foreign markets. This difference in market size, $\frac{Y^*}{Y}\tau^{\sigma-1}$, is translated in earnings differentials. As in Rosen (1981), "are the more talented that gain more from market size". Note that the elasticity of the wage premium with respect to skills is larger in the exporting sector, $(w^e(s)+\gamma)/w^e(s))\,\vartheta(s,a) > \vartheta(s,a)$. This feature of our model is consistent with recent empirical evidence concerning the wage premium paid by exporting firms (Bernard and Jensen (1997)[1]).

>From (3.11) and (3.12) it is clear that , for given market size Y, trade integration due to lower transport cost (higher τ) or lower access cost γ, raise the earnings of workers employed in the export sector, while leaving unaffected wages in non-exporting firms. Since, as we shall see, the export sector higher skills than the non-export sector, this tend to increase income concentration.

It is now easy to see under what conditions a firm employing a worker with skills s is willing to venture on the export market. It will do so provided this increases its operating profits, i.e. $w^e(s) \geq w^n(s)$. Since the access cost to foreign markets γ is independent of sales, while sales increase with talent, only firms employing sufficiently skilled workers will sell on the foreign market, from (3.11) and (3.12)

$$T(s,a) \geq \frac{\gamma p^{\sigma-1}\sigma}{Y * \tau^{\sigma-1}} \tag{3.13}$$

$$s \geq Z\left(\overset{+}{\frac{\gamma p^{\sigma-1}\sigma}{Y * \tau^{\sigma-1}}}, \bar{a}\right) \equiv z, \tag{3.14}$$

where $Z(.,a) \equiv T^{-1}(.,a)$[5]

Consistently with the evidence previously discussed, firms in the export sector tend to employ workers with higher skill and, as a consequence, to pay them higher wages.

The "degree of openness" of the economy is measured by the share of exporting firms, $\int_z^{\overline{s}} \phi(s)ds$. This is endogenously determined. Openness rises (z falls) with the scale of the foreign market, Y^*, since this raises the skill premium and induces more entrepreneurs to venture abroad. Also, notice that lower transport costs, i.e.e higher τ, boost demand, and therefore raise the proportion of exporting firms, *ceteris paribus.* Finally, the share of exporting firms is lower, the larger the sunk-cost of exporting, γ.

Clearly, the model generates trade provided

$$\underline{s} < z \leq \overline{s}. \tag{3.15}$$

In the following, we limit the analysis to this case.

Technological change, as measured by changes in a, affects both on the degree of openness and income distribution. As a increases, the cut-off skill level z is unambiguously reduced, because workers with lower skills start producing the threshold quality (check from (3.14), recalling that $Z_a = -1/T_a < 0$).) Hence more firms enter foreign markets.

The effect of technology on the wage distribution depends on the degree of substitutability between a and skills, and will be discussed later. Clearly, trade and technology shocks affect openness z and market size Y simultaneously, so that the implications for the wage distribution requires a joint solution for these variables..

[5] Hence, $Z_1 = 1/T_s > 0$; $Z_a = -1/T_a < 0$.

4. Model Solution

Invoking symmetry , we can set $Y = Y^*$, and $z = z^*$, and concentrate on the case of balanced trade.[6]. Next we exploit the fact that each worker/firm produces a single variety of the good. The space of goods can consistently be mapped into that of skills, and the CES price index (3.3) can be rewritten in terms of the s-distribution,

$$P = \left[p^{1-\sigma} \left(\int_{\underline{s}}^{\overline{s}} T(s,a)\ \phi(s)\ ds + \tau^{\sigma-1} \int_{z}^{\overline{s}} T(\ s,a)\ \phi(s) ds \right) \right]^{-1/(\sigma-1)} \tag{4.1}$$

Note that the price level P depends on openness , z. The price index falls whenever more firms decide to venture abroad (z falls). Due to "love for variety", a larger mass of varieties available through imports raises indirect utility, thus reducing the true price index (which is dual to it). In order to derive an expression for Y which only depends upon z, integrate across wages (3.11) and (3.12) and substitute the resulting expressions into aggregate income (3.2). This yields

$$Y = P^{\sigma-1} \left[M + \frac{p^{1-\sigma} Y}{\sigma} \left(\int_{\underline{s}}^{\overline{s}} \phi(s) s ds + \tau^{\sigma-1} \int_{z}^{\overline{s}} \phi(s) s ds \right) - \gamma \int_{z}^{\overline{s}} \phi(s) ds \right] \tag{4.2}$$

Substituting the expression for P (4.1) into (4.2), gives

$$Y = \frac{M - \gamma \int_{z}^{\overline{s}} \phi(s)\ ds}{(\frac{\sigma-1}{\sigma})^{\sigma} \beta^{1-\sigma} \left[\int_{\underline{s}}^{\overline{s}} T(s,a) \phi(s) ds + \tau^{\sigma-1} \int_{z}^{\overline{s}} T(s,a) \phi(s) ds \right]} = Y(z) \tag{4.3}$$

The numerator of expression (4.3) represents the total income of primary inputs employed in manufacturing, νM net of the income earned in export services. This term reflects the market size of a firm. Clearly, the more resources are "waisted " in market access services, the lower the market size facing each firm, Y. The denominator is inversely related to the price index. Since elasticity of demand to the firm relative price exceeds unity (compare with(3.1)), the substiitution effect prevails on the income effect. Hence when the general price index rises (the denominator falls), the individual producer becomes more competitive and her sales rise. It is immediate to check that this expression depends positively on z, $Y_z > 0$. Intuitively, there are two effects at work First, when the number of exporting firm falls (z rises) less resources are waisted for the access cost,

[6] By symmetry, $N = N^*$; $N_{m^*} = N_m^*$ is required for trade to balance.

and disposable income rises. Second, as imports fall, the true cost of living rises (compare with 4.1), and this makes domestic firm more competitive.

Equations (3.14) and (4.3) jointly determine the size of the export sector, z and the size of a firm in the domestic market, Y. The equilibrium can be represented on a simple diagram. Figure3 depicts equation (4.3), the YY curve, and equation (3.14), the ZZ curve, in the (z, Y) space.[7]

Insert Figure 2 here

The properties of the two curves imply that there exists an unique equilibrium, represented by the intersection of the two loci. This diagram will help the analysis of next sections, where we perform comparative statics on the system.

5. Trade Integration

Our aim is in this section is to assess the implications of trade integration on the wage distribution. From our diagram and from (3.14) we see that a reduction in transport costs (a rise in τ) shifts the ZZ curve down to the left (see figure 3). As transport costs fall, the price set abroad by domestic firms is reduced, foreign demand increases, and the mass of exporters rises (z falls). From (4.3) we see that the YY locus shifts up to the left. Lower transport costs increase competition from abroad, thus reducing demand for each firm, at given z. In the new equilibrium, Y unambiguously falls. Even if total sales are boosted by increased exports, each firm operates on a smaller *domestic* scale. The degree of openness is subject to two conflicting forces. One the one hand, lower transport costs boost the demand for exports through a direct price effect. This raises the mass of firms willing to export (see(3.14)), and z falls. On the other hand, lower transport costs have a negative effect on foreign demand through a scale effect (Y^* falls), and this reduces the mass of export-oriented firms (z rises). It can be shown (see the Appendix) that the price effect always dominates, so that the economy becomes more open when transport costs falls, $dz/d\tau < 0$, confirming partial equilibrium intuitions.

Insert figure 3 here

>From this result we can derive the effects on the distribution of wages. >From equation (3.11) we see that all skill premia in the non-exporting sector,

[7] Note that since we consider an equilibrium with trade, $\underline{s} < z \leq \overline{s}$ must hold. Consistently, the range of admissible values for market size must satisfy $\underline{Y} < Y \leq \overline{Y}$, where $\underline{Y} \equiv \sigma\gamma \left(\frac{\sigma\beta}{(\sigma-1)\tau}\right)^{\sigma-1} / T(\overline{s}, a)$ and $\overline{Y} \equiv \sigma\gamma \left(\frac{\sigma\beta}{(\sigma-1)\tau}\right)^{\sigma-1} / T(\underline{s}, a)$.

$w^n(s)$, must *fall* proportionately to the contraction the firm's scale, Y. Conversely, from (3.12) we see that wages in the export sector, $w^e(s)$ may *either fall,* because market scale Y shrinks, as before, *or rise,* because lower transport costs entail larger sales abroad.[8] Clearly, even if wages fall in the exporting sector, prevailing the first direct effect, they will fall by less than they do in the non export sector. More precisely, take any one entrepreneur in the non export sector, indexed by skill $s' \geq z$ and any one in the export sector, $s'' < z$. It is possible to show that their *relative* wage differential , $w^e(s')/w^n(s'')$, widens with trade integration (see the Appendix).

Given that lower transport cost tend to raise the share of the export sector $(dz/d\tau < 0)$, we conclude that a reduction in transport costs unambiguously implies a redistribution of income from the non-export to the export sector of the economy.

It is easy to work out the distributional effects between entrepreneurs,S on one hand, and owners of primary inputs, M. Denote aggregate profits by $\Delta \equiv \int_{\underline{s}}^{z} w^n(s)ds + \int_{z}^{\overline{s}} w^n(s)ds$.

>From (4.3) one can show that

$$\Delta = \frac{M}{\sigma - 1} - \frac{\gamma\sigma}{\sigma - 1} \int_{z}^{\overline{s}} \phi(s)\ ds. \tag{5.1}$$

Differentiating expression (5.1) yields

$$\frac{d\Delta}{d\tau} = \frac{\gamma\sigma}{\sigma - 1} \phi(s) \frac{dz}{d\tau} < 0, \tag{5.2}$$

since $dz/d\tau < 0$. A reduction in transport costs tilts the income distribution in favor of primary inputs. This result follows immediately by recalling that exporting requires a fixed access cost in term of these inputs. As more firms venture abroad more primary commodities are required in export services. Hence the share of profits must fall.

Finally, the effect of trade integration on total welfare can be assessed by looking at changes in the utilitarian indicator $W \equiv I/P = \Delta/P + M/P$ .First notice that a fall in transport costs reduces the price level. From (4.1), we see that this is due to two reasons. First, a direct positive effect via lower price of imported good. Second, an indirect effect through the reduction of the threshold z, which raises average quality. As a consequence, the "real" wage bill of primary inputs, M/P, unambiguously rises. As for aggregate real skill earnings, Δ/P, the effects are ambiguous, since Δ is reduced by higher τ. In the Appendix we show

[8] This second effect dominates provided demand is sufficiently elastic (σ high).

that the overall effect of lower transport is to increase total welfare, as measured by I/P.

In summary :

Lemma 1. *trade integration via lower transport (higher τ) has the following effects: i) openness rises (z falls) and the scale of each firm on the domestic market Y shrinks; ii) wages in non-exporting firms are reduced, wages in exporting firms may rise or fall, and their ratio, $w^e(s')/w^n(s'')$, rises iii) there is a redistribution from profits to raw inputs: Δ falls; iv) total welfare W rises.*

Two remarks are in order. First, whether "trade integration" is due to lower transport cost *or* to a reduction in the fixed cost of exporting,γ, does somewhat affects the results. In particular, trade integration via lower access cost can be shown to redistribute income towards the exporting sector (cf iii) above), to raise the share of traded goods in the economy (cf i), and to be welfare improving. However the effects on aggregate profits and upon the firms' scale become ambiguous.[9] Second,the fact that total welfare increases as transport costs are reduced, does not inply that welfare for each worker increases. It may well be the case that the nominal earnings of some workers are reduced to a sufficient extent to entail a reduction also in their real earnings (utility). So, depending on the initial distribution of M^h, *some agents may end up losing from reduced trade barriers.* To see this more formally, take the case of a worker employed in the non-exporting sector who is hit by a trade shock consisting of reduced transport costs. To simplify matters, assume that this worker has $M^h = 0$, so that he (she) is not endowed with raw inputs. His welfare is thus given by his wage, deflated by the CES price index

$$\omega^n(s) = p^{1-\sigma}\frac{T(s,a)}{\sigma}\frac{Y}{P}. \tag{5.3}$$

Applying the definition $Y \equiv IP^{(\sigma-1)}$ and totally differentiating $\omega^n(s)$ with respect to τ yields

$$\frac{\partial \omega^n(s)}{\partial \tau} = p^{1-\sigma}\frac{T(s)}{\sigma}\left[\frac{\partial I}{\partial \tau}P^{(\sigma-2)} + (\sigma-2)P^{(\sigma-3)}\frac{\partial P}{\partial \tau}\right], \tag{5.4}$$

Since $\partial P/\partial\tau < 0$ and $\partial I/\partial\tau = \partial\Delta/\partial\tau < 0$, $\sigma \geq 2$ is sufficient to imply $\partial\omega^n(s)/\partial\tau < 0$. Under such circumstances, all the workers employed in the non-exporting sector that are not sufficiently endowed with M will lose from a trade shock in *real* terms.

[9] These results can be obtained from the authors upon request.

6. Technological Progress

Now consider what happens when, as a result of a rise in technical knowledge, a,the quality of all products improves. Clearly, this means that a lower skill endowment is now required for achieving any *given* quality standard. Thus, from (3.14) the ZZ curve shifts down to the left in Figure 1 (recall that $Z_a = -1/T_a < 0.$). A higher fraction of entrepreneurs can benefit from exporting, at given scale Y. In turn, from (4.3), the YY curve shifts up to the left, since the price index falls when average quality improves. Hence, each firm's output becomes relatively more expensive compared with that of competitors, and demand falls. In the new equilibrium, a technology shock " reduces the firm's size, Y, but has an ambiguous effect on openness, z.

The implications for wages can be assessed as follows. Denote the elasticity of product quality and of firm scale with respect to $\dot{a}$,respectively, by $\eta(s,a) = T_a(s,a)a/T(s,a)$, and $\xi(a) = -(dY/da)a/Y > 0$. Differentiating the wage equations (3.11), (3.12) with respect to a we find

$$\frac{dw(s)}{da} \geq 0 \Leftrightarrow \frac{p^{1-\sigma}}{\sigma}\frac{T(s,a)Y}{a}\left[\eta(s,a) - \xi(a)\right] \geq 0 \tag{6.1}$$

in both the export and non export sector.

There are two contrasting forces on wages: a positive, firm-specific effect, η,and a common negative effect, ξ. The first effect is due to the fact that the firm's better quality raises demand for its variety, and thus boosts the firm's operating profits. The second effect works through price competition. As the general price level falls due to better average quality, each firm's product become relatively more expensive, and this lowers firms' size Y. As a consequence, the effects on skill earnings and on the income distribution are in general ambiguous.

It is useful to start with a benchmark case, and consider the a linear technology $T(s,a) = as$. Quality improvements are proportional to skills, so that change in a affects each firm quality and the average quality of competitors proportionately. From equations (4.3) and (3.14) Y and z can be written as

$$Y = \frac{M - \gamma\int_z^{\overline{s}}\phi(s)\,ds}{a(\frac{\sigma-1}{\sigma})^{\sigma}\beta^{1-\sigma}\left[\int_{\underline{s}}^{\overline{s}} s\phi(s)ds + \tau^{\sigma-1}\int_z^{\overline{s}} s\phi(s)ds\right]}, \quad z = \frac{\gamma\sigma p^{\sigma-1}}{aY\tau^{\sigma-1}} \tag{6.2}$$

Note that z is unaffected by technology (the term a at the denominator of z cancels out with the term a appearing at the denominator of Y). As a result, $\eta(s,a) = \xi(a) = 1$. The two effects cancel out, so that wages are unaffected by the shock. In this linear example aggregate profits, from (5.1), and thus the income distribution between entrepreneurs and primary inputs, do not change The only effect played by technological (neutral) improvements concerns the price index P. Higher average quality is translated into a lower price index, and therefore into higher welfare, W.

In order to generalize the analysis, remember that all firms are experience higher sales via the common effect, $\xi(a)$, the "quality" effect $\eta(s,a)$ generally varies across firms. For some s, the square bracket in (6.1) may be positive: these firms will benefit from technical progress. For some other s, the opposite may hold, $\eta(s,a) < \xi(a)$, implying a loss. Of course, results crucially depend on how $\eta(s,a)$ is changes with s. Suppose, for instance, that technology is skill-complement, that is $T_{as}(s,a)$ is "sufficiently" large, so that entrepreneurs with high skill can exploit the technical innovation much better than less talented entrepreneurs.[10] Then the "quality" effect will tend to dominate for more skilled workers, who will benefit from the innovation, while the "size" effect may dominate for the less skilled, who will lose. In the Appendix we show that there always exists a skill level $\widetilde{s} \in [\underline{s}, \overline{s}]$ such that the two effect cancel out $\eta(\widetilde{s},a) = \xi(a)$. Provided technology and skill are strong complements, a technological shock boosts the earnings a workers with skill is above $\widetilde{s}$ and reduces those of workers of type $s < \widetilde{s}$. Also, for reason discussed in the appendix, the effect on z has ambiguous sign.

Finally, technology shocks also have ambiguous implications on the aggregate income distribution between raw inputs and skilled workers. This can be understood by differentiating Δ in (5.1) with respect to a :

$$\frac{d\Delta}{da} = \frac{\gamma\sigma}{\sigma - 1}\phi(z)\frac{dz}{da} \tag{6.3}$$

and recalling that z may either fall or rise .As for trade shocks, technical progress always raises total welfare W, in spite of the ambiguous effect aggregate skill premia Δ (see the Appendix).

Summarizing,

Lemma 2. *technological progress (an increase in a) has the following effects i) openness (z) may rise or fall, while firms' scale Y falls; ii) if technology is skill-complement (skill-substitute), workers endowed with talent $s < \widetilde{s}$ experience a fall (rise) in their wage rate; iii) the aggregate skill premium, Δ, may rise or fall; iv) total welfare, W, increases.*

[10] A simple example of skill-complement technology is $T(s,a) = as + c, c > 0$. The product's quality depends on a common "state of the art" component, c, and on an idiosyncratic one, proportional to the level of skills.

Two are the main differences with respect to trade integration. Skill-biased technology shocks may redistribute earnings among *firms* belonging to the same *sector*, while trade shocks unambiguously redistributes income from the non-export to the export sector. While reduced trade barriers increase the extent of trade integration, technological shocks have an ambiguous effect on the share of exporting firms.

7. Conclusions

We have studied the effects "globalization" on wage inequality. Many different things are often meant by "global economy". In the spirit of the "Economics of Superstar", we have discussed two: trade integration in the form of lower transport cost , and technology innovations that enable suppliers to improve the (perceived) quality of their products and raise consumers' satisfaction.

If globalization takes place in terms of reduced trade barriers, then we find that income is redistributed away from the non tradable sector towards the traded sector of the economy. Since the former generally employs workers of lower skill and pay, the effect is to raise the extent of wage inequality, although welfare, as measured by real GDP, rises.

If globalization takes place in terms of improved production or communication technologies, then we find that the less skilled are stand to loose or gain, depending on whether technology is skill-complement or substitute.

The model gives an intuitive explanation for the empirical regularities that skill intensity, market size and wages tend to be positively associated to exporting, across sectors and plants.

These results can be of some use in the effort of disentangling empirically the distributive impact brought about by trade and technology: the former affecting sectors, and the latter firms within sectors.

Our conclusions deeply contrast with the general prediction of the new trade theory, where intra-industry trade is expected not to produce victims. In our setting, developments in trade or technology affect differently the opportunities of workers endowed with different abilities. Only those sellers that benefit more than the average competitor will end up with a net income gain.

Globalization, although welfare improving, is thus likely to raise inequality, and to foster demand for protection. As other analysis, ours shows that the government answer should rather be redistribution. However, the implications for redistributive intervention goes beyond the traditional skilled/unskilled distinction. Globalization entails income transfers even among those workers that appear to be skilled. The export status of firms and plants may guide policy action aimed at redistributing income.

8. Appendix

8.1. Lower transport costs

8.1.1. Effects on openness (z) and firm size (Y)

We show that $\partial z/\partial\tau < 0, \partial Y/\partial\tau < 0$
Proof. Total differentiation of the system formed by (3.14) and (4.3) yields

$$\frac{\partial z}{\partial \tau} = \frac{z_\tau + z_Y Y_\tau}{1 - z_Y Y_z} \tag{8.1}$$

$$\frac{\partial Y}{\partial \tau} = \frac{Y_\tau + Y_z z_\tau}{1 - z_Y Y_z}, \tag{8.2}$$

where subscripts denote partial derivatives. Recall that $z_Y < 0$ and $Y_z > 0$, so that the denominator of (8.1) and (8.2) is positive. In the second expression $Y_\tau < 0$ and $z_\tau < 0$, so that $\frac{\partial Y}{\partial \tau} < 0$.

As for z, the two terms in the numerator have conflicting sign, $z_\tau < 0$ and $z_Y Y_\tau > 0$. Therefore $\frac{\partial z}{\partial \tau} > 0$ if and only if $z_Y Y_\tau > -z_\tau$. Computing these expressions from (3.14) we have

$$z_Y = -\frac{1}{T_s(z)} Y^{-2} \frac{\gamma\sigma p^{\sigma-1}}{\tau^{\sigma-1}} = -T(z,a)/T_s(z)Y, \tag{8.3}$$

$$z_\tau = \frac{1}{T_s(z)} \frac{\gamma\sigma p^{\sigma-1}}{Y}(1-\sigma)\tau^{-\sigma} = -(\sigma-1)T(z,a)/T_s(z)\ Y\ \tau. \tag{8.4}$$

>From (4.3) we derive

$$Y_\tau = -Y\Lambda^{-1} p^{1-\sigma} \frac{(\sigma-1)^2}{\sigma} \tau^{\sigma-2} \int_z^{\overline{s}} \phi(s)T(s)ds,$$

where $\Omega > 0$ and $\Lambda > 0$ represent, respectively, the numerator and denominator of (4.3). Therefore, we can write

$$z_Y Y_\tau = \frac{1}{T_s(z)} \gamma Y^{-1} \Lambda^{-1} (\sigma-1)^2 \tau^{-1} \int_z^{\overline{s}} \phi(s)T(s)ds, \tag{8.5}$$

It appears that the condition $z_Y Y_\tau > -z_\tau$ which is necessary and sufficient for $\frac{\partial z}{\partial \tau} > 0$ can be satisfied if and only if

$$z_Y Y_\tau > -z_\tau \Leftrightarrow p^{1-\sigma}\left(\sigma-1\right)\Lambda^{-1}\int_z^{\overline{s}} \phi(s)T(s)ds > \sigma\tau^{1-\sigma}. \tag{8.6}$$

After developing the denominator Λ, we can rewrite

$$\frac{\sigma\int_z^{\overline{s}} \phi(s)T(s)ds}{\int_{\underline{s}}^{\overline{s}} \phi(s)T(s)ds + \tau^{\sigma-1}\int_z^{\overline{s}} \phi(s)T(s)ds} > \sigma\tau^{1-\sigma}, \tag{8.7}$$

which implies

$$\frac{\tau^{\sigma-1}\int_z^{\overline{s}} \phi(s)T(s)ds}{\int_{\underline{s}}^{\overline{s}} \phi(s)T(s)ds + \tau^{\sigma-1}\int_z^{\overline{s}} \phi(s)T(s)ds} > 1. \tag{8.8}$$

This inequality is never satisfied. So we find that $\frac{\partial z}{\partial \tau} < 0$ ■.

8.1.2. Effects on relative wages,

We show that $\partial(w^e(s')/w^n(s'')/\partial\tau > 0$ for $s' > z$, $s'' \leq z$.

Proof. First, remark that by definition of z, $w^e(z) = w^n(z)$, $\partial z/\partial\tau < 0$, implies

$$\frac{\partial(w^e(z))\,/w^n(z))}{\partial\tau} > 0. \tag{8.9}$$

So, following a reduction in trade barriers, relative wages computed at the threshold value z must rise. Take any relative wage rate in the non-export sector $w^n(s')/w^n(s'')$, $s' \geq z$, $s'' \geq z$. These are not affected by transport costs (check (3.11)). Note also that, given any pair of wages for skill levels $s' > z$, $s'' \leq z$ the following holds

$$\frac{\partial(w^e(s'))\,/w^n(s''))}{\partial\tau} > 0 \Longleftrightarrow \frac{\partial w^e(s')\,/\partial\tau}{w^e(s')} > \frac{\partial w^n(s'')\,/\partial\tau}{w^n(s'')} \tag{8.10}$$

Using (8.9) and (8.10) yields

$$\frac{\partial w^e(z)/\partial\tau}{w^e(z)} > \frac{\partial w^n(s)/\partial\tau}{w^n(s)} = 0, \quad s < z$$

Note that in the export sector

$$\frac{\partial w^e(s)/\partial\tau}{w^e(s)} = \frac{p^{1-\sigma}T(s,a)\left[\frac{\partial Y}{\partial\tau}(1+\tau^{\sigma-1}) + Y\left(\sigma-1\right)\tau^{\sigma-1}\right]}{p^{1-\sigma}YT(s,a)(1+\tau^{\sigma-1}) - \sigma\gamma}, \quad s \geq z$$

Since the previous expression is increasing in s, we can write

$$\frac{\partial w^e(s')/\partial\tau}{w^e(s')} > \frac{\partial w^e(z)/\partial\tau}{w^e(z)} > \frac{\partial w^n(s'')/\partial\tau}{w^n(s'')}, \quad \text{for any } s' > z,\ s'' \leq z$$

which trivially implies $\frac{\partial(w^e(s')/w^n(s'')}{\partial\tau} > 0$. ■

8.1.3. Effects on welfare

We show that $\frac{\partial W}{\partial \tau} > 0$

Proof. Our utilitarian welfare indicator, $W = \frac{I}{P}$ can be rewritten as $W = \left[\frac{\sigma}{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}} \Lambda^{\frac{1}{\sigma-1}}\Omega$. Therefore

$$\frac{\partial W}{\partial \tau} = \left[\frac{\sigma}{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}} \left[\frac{\partial \Omega}{\partial \tau}\Lambda^{\frac{1}{\sigma-1}} + \frac{1}{\sigma-1}\Omega\Lambda^{\frac{1}{\sigma-1}-1}\frac{\partial \Lambda}{\partial \tau}\right]. \tag{8.11}$$

After developing $\frac{\partial \Omega}{\partial \tau}$ and simplifying, we note that $\frac{\partial W}{\partial \tau} > 0$ is satisfied if and only if

$$-\gamma\phi(z)\frac{\partial z}{\partial \tau}\Lambda^{\frac{1}{\sigma-1}} < \Omega\frac{1}{\sigma-1}\Lambda^{\frac{1}{\sigma-1}-1}\frac{\partial \Lambda}{\partial \tau}, \tag{8.12}$$

a condition that can be rewritten as

$$-\gamma\phi(z)\frac{\partial z}{\partial \tau} < Y\frac{1}{\sigma-1}\frac{\partial \Lambda}{\partial \tau}. \tag{8.13}$$

Using expression (3.14) the above inequality can be written as

$$-\phi(z)\frac{\partial z}{\partial \tau}T(z)\frac{p^{1-\sigma}}{\sigma}\tau^{\sigma-1} < \frac{1}{\sigma-1}\frac{\partial \Lambda}{\partial \tau}. \tag{8.14}$$

Developing $\frac{\partial \Lambda}{\partial \tau}$ and simplifying (8.14) can be reduced to

$$(\sigma-1)\,\tau^{-1}\int_z^{\overline{s}} \phi(s)T(s)ds > 0, \tag{8.15}$$

an inequality which is always satisfied. ■

8.2. Technological progress

8.2.1. Effects on wages

We prove that there always exists one and only one value $\widetilde{s}$, $\widetilde{s} \in [\underline{s}, \overline{s}]$ such that $\eta(s,a) = \xi(a)$.

Proof. We first claim the following results.

Result 1. The term $\eta(s,a)$ is monotonically increasing (resp., decreasing) in s whenever technology is skill-complement (resp., skill substitute).

Proof. Consider the case of skill-complement technology, so that the elasticity $\vartheta(s,a) \equiv T_s(s,a)s/T(s,a)$, is increasing in a, $\vartheta_a(s,a) > 0$ for all s, a. Note that

$\vartheta_a(s,a) > 0$ if and only if $T_{as}(s,a) > \frac{T_a(s,a)T_s(s,a)}{T(s,a)}$. From the definition of $\eta(s,a)$, $\eta(s,a) = T_a(s,a)a/T(s,a)$, it emerges that this condition is also necessary and sufficient for $\eta_s(s,a) > 0$. Symmetrically, in the case of skill-substitute technology, $\vartheta_a(s,a) < 0$ implies $\eta_s(s,a) < 0$. ■

Result 2. $\eta(z,a) - \xi(a) \geq 0$ is a necessary and sufficient condition for $\partial z/\partial a \leq 0$

Proof. >From the definition of z, $w^e(z) = w^n(z)$, so that $\partial z/\partial a \leq 0$ requires

$$\frac{\partial w^e(z)}{\partial a} \geq \frac{\partial w^n(z)}{\partial a} \tag{8.16}$$

Using (3.12), (3.11), and (6.1), the above condition amounts to

$$[\eta(z,a) - \xi(a)]\,\tau^{\sigma-1} \geq 0. \tag{8.17}$$

■

Consider the case of skill-complement technology. Assume that a value for s satisfying $\eta(s,a) = \xi(a)$ does not exist. Then, by Result 1, either

$$i) \quad \eta(\underline{s},a) > \xi(a), \tag{8.18}$$

or

$$ii) \quad \eta(\overline{s},a) < \xi(a). \tag{8.19}$$

Assume that $i)$ holds. Then, by Result 1 and (6.1), following a rise in the stock of knowledge a, all wages must rise. Moreover, by Result 2, it must be $\partial z/\partial a < 0$. From (6.3), $\partial z/\partial a < 0$ implies $\partial \Delta/\partial a < 0$. But this contradicts Result 1, according to which $\partial \Delta/\partial a > 0$, because all wages must rise after the shock. Assume, conversely, that $ii)$ holds. Then, by Result 1 and (6.1), a rise in the stock of knowledge a, must reduce all wages. Furthermore, by Result 2, it must be $\partial z/\partial a > 0$. Again, $\partial z/\partial a > 0$ is in contradiction with Result 1, according to which $\partial \Delta/\partial a < 0$ because all wages must fall. A symmetric argument applies to the case of skill-substitute technology.

So, Result 1, Result 2, and (6.1) imply that a value $\widetilde{s}$, $\widetilde{s} \in [\underline{s}, \overline{s}]$ such that $\eta(s,a) = \xi(a)$ must exist. Uniqueness is insured by the fact that $\eta(s,a)$ is monotonic in s. ■

8.2.2. Effects on welfare

We show that $\partial W/\partial a > 0$
Proof. Note first that $\partial W/\partial a > 0$ if and only if

$$\frac{\partial I/\partial a}{I} > \frac{\partial P/\partial a}{P}. \tag{8.20}$$

Since $I = \frac{\sigma}{\sigma-1}\left(M - \gamma\int_z^{\overline{s}}\phi(s)ds\right) = \frac{\sigma}{\sigma-1}\Omega$, and $P = (\frac{\sigma}{\sigma-1}\Lambda)^{-1/(\sigma-1)}$, condition (8.20) rewrites as follows

$$\phi(z)\frac{\partial z}{\partial a}\left[\frac{\gamma}{\Omega} - \frac{T(z,a)\tau^{\sigma-1}}{\sigma\Lambda}\right] > -\frac{\partial\int_{\underline{s}}^{\overline{s}}\phi(s)T(s,a)ds/\partial a + \tau^{\sigma-1}\partial\int_z^{\overline{s}}\phi(s)T(s,a)ds/\partial a}{\sigma\Lambda} \tag{8.21}$$

Using the definition of $T(z,a)$ from (**??**) it is straightforward that the left hand side of (8.21) is identically equal to zero, so that the inequality holds. ■

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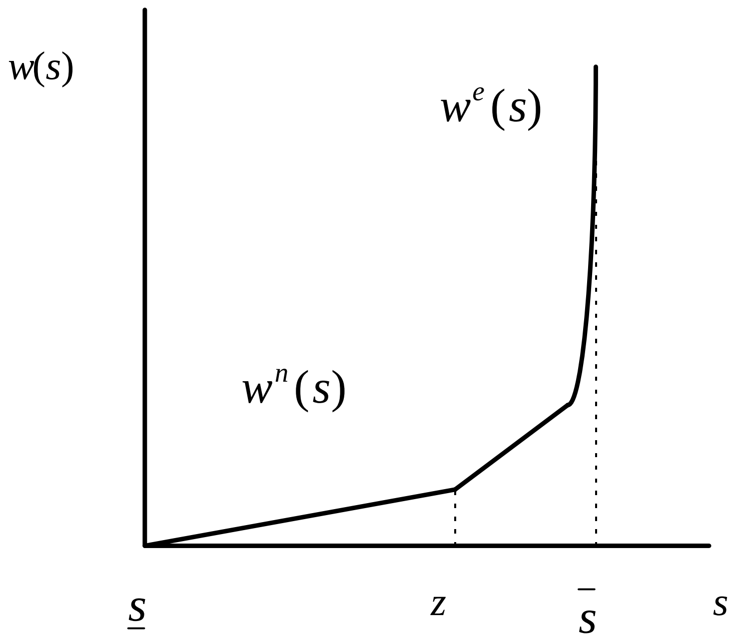

Figure 1

. Wage structure when technology is skill-complement

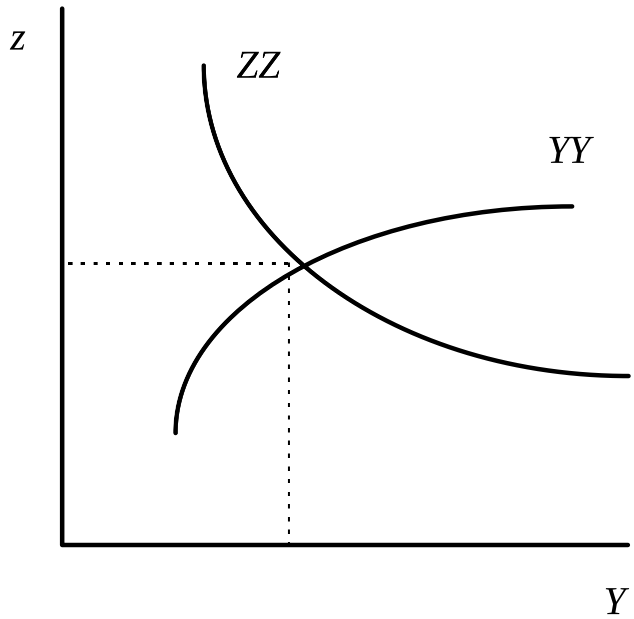

Figure 2

Equilibrium degree of openness (z) and firms' scale (Y)

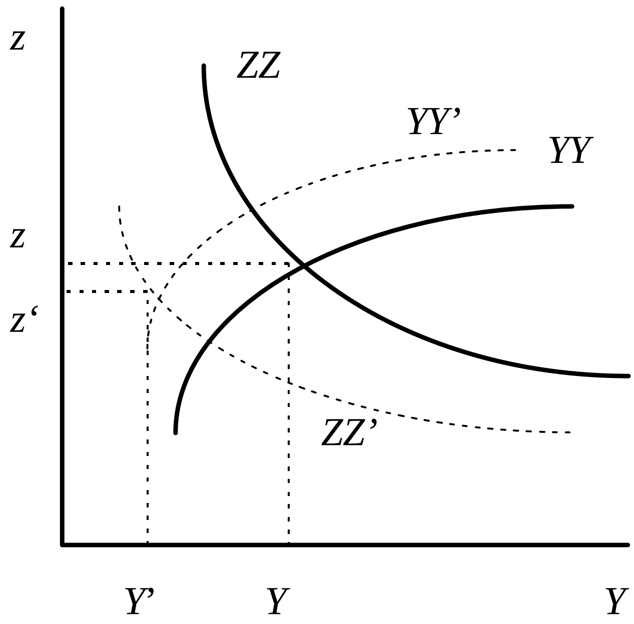

Figure 3

The effect of reduced trade barriers