Globalization and Income Distribution: A Specific Factors Continuum Approach

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Abstract

Does globalization widen inequality or increase income risk? Globalization implies that sector specific investments are more exposed to idiosyncratic productivity shocks. But wider markets reduce the effect of economy-wide supply shocks on world prices. Both forces are at work in the specific factors continuum model of this paper. Equilibrium implies positive (negative) premia for export (import-competing) sector employment, and wider inequality in every country with globalization. Viewed ex ante, personal incomes are more risky in a globalizing world with pure idiosyncratic risk. With aggregate productivity risk globalization drives an offsetting force. Both forces have greatest impact for the poorest and least impact for the richest trading sectors, while the relative standing of the middle nontraded sectors is unaffected.

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Globalization is popularly supposed to have increased inequality and made personal incomes more risky. Lower trade costs imply that French wine makers are more exposed to supply innovations from Argentine and Australian makers. A contrasting economic intuition suggests that wider markets reduce the effect of national supply shocks on the variance of world prices and thus factor incomes. This paper shows that there is something right about both ideas simultaneously. The two offsetting forces are sorted out in a formal model that isolates the key elements while abstracting from inessential details.

The wine example suggests sectoral specificity of factors. The modeling strategy of this paper embeds the specific factors model in the infinitely many goods continuum setup pioneered by Dornbusch, Fischer and Samuelson, complementing their analyses (1977, 1980) of equilibrium in the Ricardian and Heckscher-Ohlin models. Along with its ability to rationalize large locational rents to otherwise observationally identical factors,[1] the specific factors model eliminates the excessive specialization imposed by general equilibrium in the Ricardian and Heckscher-Ohlin models. As with the original Dornbusch-Fischer-Samuelson Ricardian model, sharp implications are obtained for a special case that appears to have more general validity. The simplicity of the model suggests that it it is a good platform on which to build extensions.

The paper first provides a thorough characterization of equilibrium production and trade patterns. Some familiar comparative static results with respect to growth, transfers and trade costs are reviewed, echoing Dornbusch, Fischer and Samuelson. A more novel result shows that globalization reduces the variance of of the factoral terms of trade (hence the dispersion of national incomes) induced by aggregate supply shocks.

The model features sectoral factor specificity combined with idiosyncratic productivity shocks as a key determinant of internal income distribution. In the long run, for given productivities, the allocation of the sector specific factors should equalize returns. In the face of repeated productivity shocks, however, the best that can be done through efficient capital markets is to equalize ex ante expected returns, while the realized returns differ due to realized productivity shocks and the best ex post reallocation of the mobile factor to accommodate them.

[1] This regularity was given prominence by Katz and Summers (1989). Exporting sectors typically enjoy premia relative to import-competing sectors.

Based on this setup, a characterization of the equilibrium internal income distribution is developed. Equilibrium exhibits the well documented phenomenon of higher earnings for export sectors (those receiving high productivity realizations) than for import competing sectors (those receiving low productivity realizations). The model also makes the sharp prediction that globalization widens income inequality in every country, raising to top, lowering the bottom and narrowing the middle. Thus the model formalizes the popular sense that personal incomes are more risky in globalizing world.

Purely idiosyncratic productivity shocks suppress aggregate risk completely. When productivity shocks include an economy-wide component that shifts relative productivity between countries, then there is a tradeoff of two intuitive effects. On the one hand, globalization magnifies the effect of idiosyncratic shocks on the personal income distribution (better ability to capitalize on the opportunity to trade magnifies the effect of lucky or unlucky productivity draws), magnifying the ex ante dispersion of personal incomes. On the other hand, globalization reduces factoral terms of trade variance (wider markets damp the price effect of aggregate supply shocks), reducing the ex ante dispersion of personal incomes. The model reveals that both effects of globalization are largest for the poorest specific factors.

The effect of globalization on income distribution has previously been studied, but in models for which theory does not fit well with empirics. For example, the factor proportions model applications surveyed in Feenstra (2004) have income distributions of low dimension, in contrast to empirical distributions with high dimensionality characterized by factor earnings in export industries greater than earnings of similar factors in import competing industries. In the Heckscher-Ohlin continuum model (see for example Feenstra, 2004), adjustment is entirely on the extensive margin of production as some industries shut down and others open up. In contrast, the present paper has the property that globalization widens inequality here even though adjustment to shocks is on the intensive margin in production; no industry shuts down or opens up. These features appear to make the model a more realistic metaphor.

The closest related work is in new papers by Blanchard and Willman (2008) and Costinot and Vogel (2008) that feature continuuum income distributions with heterogeneous workers who sort into industries of varying skill intensity. These models cannot explain locational rents to otherwise observationally identical factors. Moreover, they imply that globalization widens inequality in one economy while reducing inequality in the other economy, which is apparently counterfactual.[2] Nevertheless, these two approaches should be viewed as complements in a fuller understanding of trade and income distribution.

The model is related to a wider literature. The specific factors model of production in small open economies has well-known sharp income distribution properties that are very useful in the political economy of trade policy (for example, Grossman and Helpman, 1994, and the succeeding literature). In contrast, the specific factors model's implications for the general equilibrium pattern of production, trade and income distribution have never been developed. Judiciously imposing further restrictions on technology and the distribution of productivity permits a characterization of the equilibrium reduced form pattern of production and trade. In this aspect, the present paper resembles Eaton and Kortum (2002), who derive the equilibrium implications of the Ricardian model. Eaton and Kortum solve the many country Ricardian continuum model by imposing a Frechet distribution on productivity shocks. I speculate that the two country specific factors continuum model of this paper can similarly be solved in the many country case.

1 The Basic Production Model

There is a continuum of goods, each with Cobb-Douglas production function in sector z given by

$$y(z) = [1/a(z)]L(z)^{\alpha}K(z)^{1-\alpha}, \tag{1}$$

where the index $z \in [0, 1]$. Here, $K(z)$ denotes the quantity of sector specific capital and $L(z)$ denotes the quantity of labor allocated to sector z. The sector specific capital includes human capital, and until Section 6 on heterogeneous firms it is simplest to think of it as human capital only. Prior to its allocation, the human capital is a unit of skilled labor that subsequently adapts to sectoral requirements. As for technical parameters, $1/a(z)$ gives the total factor productivity parameter in sector z while α is labor's share parameter.[3] The aggregate supply of labor is given by L, so the resource constraint is $\int_0^1 L(z)dz \leq L$. The economy achieves efficient allocation of labor

[2]The US rise in inequality is widely documented. For evidence on rising Mexican and Brazilian inequality see Calmon et al. (2002).

[3]The extremely strong restriction of identical shares across sectors serves to deliver clean results that characterize a somewhat wider class of models. While unrealistic, the assumption implies constancy of labor's share of GDP, a well know empirical regularity.

across sectors with price taking behavior by firms, compactly represented by the standard gross domestic product function.

Lemma 1 *The gross domestic product (GDP) function for this economy is given by $g = L^\alpha K^{1-\alpha} G$ where the GDP deflator G is given by*

$$G = [\int_0^1 \lambda(z)(p(z)/a(z))^{1/(1-\alpha)}]^{1-\alpha} dz, \tag{2}$$

$p(z)$ denotes the price of good z, $\lambda(z) = K(z)/K$ and $K = \int_0^1 K(z)dz$.

See Anderson (2008) for the derivation. The notation for specific capital anticipates a possible reallocation between sectors.[4] 'Real GDP' is given by $R \equiv L^\alpha K^{1-\alpha}$.

The GDP function for this economy has the standard specific factor properties, but in a very convenient constant elasticity of transformation (CET) form.[5] The GDP function is convex in prices, concave in $K, L, \{\lambda\}$ and homogeneity of degree one in p. Let p denote the price vector for goods, while a subscript with a variable name denotes partial differentiation with respect to that variable. Then by Hotelling's Lemma $g_p = y$, while $g_L = w$, where w denotes the wage rate. The GDP production shares[6] are given by

$$s(z) = \lambda(z)\left\{\frac{[p(z)/a(z)]}{G}\right\}^{1/(1-\alpha)}. \tag{3}$$

A country produces all goods for which it has a positive specific endowment because, due to the Cobb-Douglas assumption, the mobile factor has a very large marginal product in any sector where its level of employment is very small.

2 Global Equilibrium

There is a foreign economy with Cobb-Douglas production functions characterized by the same parametric labor share α but differing productivity

[4]As allocation of the specific capital grows more efficient, the model converges on the Ricardian model (since labor share parameters are constant over z). In the limit, $g = L^\alpha K^{1-\alpha} \max_z\{p(z)/a(z)\}$.

[5]The elasticity of transformation is equal to $\alpha/(1-\alpha)$.

[6]The word 'share' is used here and in the remainder of the paper for intuitive clarity at the cost of some violation of mathematical precision. Share is a discrete concept. $s(z)$ is strictly a share density, as is $\lambda(z)$, with the share of GDP due to production in the interval z_0, z_1 being given by $\int_{z_0}^{z_1} s(z)dz$.

parameters $1/a^*(z)$ and differing specific factor endowments $K^*(z)$ and labor endowment L^*. This yields the foreign GDP function as $g^* = (L^*)^\alpha (K^*)^{1-\alpha} G^*$ where

$$G^* = [\int_0^1 \lambda(z)(p^*(z)/a^*(z))^{1/(1-\alpha)}]^{1-\alpha}.$$

Tastes are identical across countries and characterized by a Cobb-Douglas utility function with parametric expenditure share for good z given by $\gamma(z)$. The cumulative share of expenditure on goods indexed in the interval $[0, \bar{z}]$ is given by $\Gamma(\bar{z})$.

Trade is costly, with parametric markup factor $t > 1$. For goods exported by the home country, $p^*(z) = p(z)t$. For goods exported by the foreign country, $p(z) = p^*(z)t$. International trade will occur in equilibrium for a range of goods where the productivity differences between countries are large enough to pay the trade cost. There is a range of nontraded goods in between the ranges of imported goods and exported goods due to differences too small to overcome trade costs.

Markets must clear for each good. As shown in the next section, this effectively determines the price in each sector as a function of the multi-factoral terms of trade, the relative real GDP deflator, G/G^*.[7] The multi-factoral terms of trade is determined by the trade balance condition. This structure nests the Dornbusch-Fischer-Samuelson Ricardian continuum model in which equilibrium boils down to determining the relative wage, converging to the Ricardian case when specific factor allocation is efficient.

2.1 Goods Market Equilibrium

First, the indexes z are assigned to industries. As in the Dornbusch-Fischer-Samuelson model, relative labor productivities can be ranked by industry to create intuitive ranges of products. In the specific factors model it is convenient to order the index of products according to the relative labor productivity shift parameters:

$$\Lambda(z) \equiv \frac{\lambda(z)/a(z)^{1/(1-\alpha)}}{\lambda^*(z)/a^*(z)^{1/(1-\alpha)}}, \tag{4}$$

[7] An older literature used an intuitive empirical concept called the 'double factoral terms of trade'. It was based on the 2 good Ricardian model equilibrium in which the price of home relative to foreign labor is equal to the relative price of home exports to imports times the relative productivity of home exports to foreign exports. In the special case of efficient allocation of specific factors, G/G^* is equal to the double factoral terms of trade.

where the indexes are assigned so that Λ is decreasing in z, $\Lambda_z < 0$. Thus the lowest indexed goods give the home country the greatest relative labor productivity and conversely for the foreign economy. Let $\bar{z}$ denote the upper end of the range of goods exported by the home country, those goods with index $z \in [0, \bar{z}]$. Let $\bar{z}^*$ denote the lower limit of the range of goods exported by the foreign country, those goods with index $z \in [\bar{z}^*, 1]$. The nontraded goods range is given by $z \in [\bar{z}, \bar{z}^*]$. $\bar{z}, \bar{z}^*$ are determined in equilibrium.

Equilibrium prices for any good z that is internationally traded are determined by market clearance:[8]

$$s(z)g + s^*(z)g^* = \gamma(z)(g + g^*).$$

For nontraded goods, $s(z) = \gamma(z) = s^*(z)$. It is convenient to normalize by the foreign GDP deflator ($G^* \equiv 1$), so in the solutions that follow, based on the preceding equations, G is the relative GDP deflator. It clarifies the properties of the model to refer to G as the (multi-)factoral terms of trade.

The equilibrium prices are determined in four ranges, one for home exports, one for foreign exports and one each for the nontraded goods of home and foreign. For home exports, the factory gate price is given by, $\forall z \in [0, \bar{z}]$,

$$p(z)^{1/(1-\alpha)} = \frac{1}{\lambda(z)a(z)^{-1/(1-\alpha)}} \frac{\gamma(z)(GR/R^* + 1)}{G^{-\alpha/(1-\alpha)}R/R^* + t^{1/(1-\alpha)}/\Lambda(z)}. \tag{5}$$

For foreign exports, the factory gate price is given by, $\forall z \in [\bar{z}^*, 1]$,

$$p^*(z)^{1/(1-\alpha)} = \frac{1}{\lambda^*(z)a^*(z)^{-1/(1-\alpha)}} \frac{\gamma(z)(GR/R^* + 1)}{\Lambda(z)G^{-\alpha/(1-\alpha)}t^{1/(1-\alpha)}R/R^* + 1}. \tag{6}$$

For home nontraded goods the price is given by, $\forall z \in [\bar{z}, \bar{z}^*]$,

$$p(z)^{1/(1-\alpha)} = \frac{\gamma(z)}{\lambda(z)a(z)^{-1/(1-\alpha)}} G^{1/(1-\alpha)}. \tag{7}$$

[8]The text expression for market clearance is built up from material balance using iceberg melting trade costs. For example, in the range $z \in [0, \bar{z}]$, market clearance is given by

$$y(z) - x(z) = t[x^*(z) - y^*(z)]$$

where $x(z), x^*(z)$ denote consumption of good z in the home and foreign countries. The equation implies that for each unit imported by the foreign economy, $t > 1$ units must be shipped from the home economy, $t - 1$ units melting away en route. Multiply both sides by $p(z)$, use $p^*(z) = p(z)t$ and utilize the GDP and expenditure share definitions to obtain the text expression.

For the foreign nontraded goods the price is given by , $\forall z \in [\bar{z}, \bar{z}^*]$,

$$p^*(z)^{1/(1-\alpha)} = \frac{\gamma(z)}{\lambda^*(z)a^*(z)^{-1/(1-\alpha)}}. \tag{8}$$

The equilibrium production shares, based on the equilibrium prices in (5)-(8), are as follows. For the range of goods exported by the home country, $\forall z \in [0, \bar{z}]$,

$$s(z) = \frac{\gamma(z)(GR/R^* + 1)}{GR/R^* + G^{1/(1-\alpha)}t^{1/(1-\alpha)}/\Lambda(z)} \tag{9}$$

$$s^*(z) = \frac{\gamma(z)(GR/R^* + 1)}{G^{-\alpha/(1-\alpha)}t^{-1/(1-\alpha)}\Lambda(z)R/R^* + 1}. \tag{10}$$

For the range of goods exported by the foreign country, $\forall z \in [\bar{z}^*, 1]$,

$$s(z) = \frac{\gamma(z)(GR/R^* + 1)}{GR/R^* + G^{1/(1-\alpha)}t^{-1/(1-\alpha)}/\Lambda(z)} \tag{11}$$

$$s^*(z) = \frac{\gamma(z)(GR/R^* + 1)}{G^{-\alpha/(1-\alpha)}t^{1/(1-\alpha)}\Lambda(z)R/R^* + 1}. \tag{12}$$

For nontraded goods, $s(z) = \gamma(z) = s^*(z) \forall z \in [\bar{z}, \bar{z}^*]$.

The margins of non-tradeability are determined by $s(\bar{z}) = \gamma(\bar{z})$ and $s^*(\bar{z}^*) = \gamma(\bar{z}^*)$. These solve for

$$G = \Lambda(\bar{z})^{1-\alpha}/t \tag{13}$$

and

$$G = \Lambda(\bar{z}^*)^{1-\alpha}t. \tag{14}$$

Thus the factoral terms of trade determines the dividing lines between imports and exports. $\bar{z}^*$ is implicitly a function $Z^*(\bar{z}, t)$ that is increasing in $\bar{z}$ and t in equilibrium, by (13)-(14).

2.2 Factoral Terms of Trade

It remains to determine the factoral terms of trade using the balanced trade condition, a special case of the international budget constraint. Home GDP is equal to the value of shipments to all destinations, valued at destination prices. This setup implies that home factor payments include the cost of shipment, iceberg trade costs imply a technology of distribution that utilizes factors proportionately to their production cost. Let $\Gamma(\bar{z}) \equiv \int_0^{\bar{z}} \gamma(z)dz$ and let $\Gamma^*(\bar{z}^*) \equiv \int_{\bar{z}^*}^1 \gamma(z)dz$. The expenditure share on nontraded goods is given by $1 - \Gamma - \Gamma^*$. The budget constraint is

$$\Gamma g + (1 - \Gamma - \Gamma^*)g + \Gamma^* g^* = g,$$

stating that expenditure on home produced goods is equal to home GDP. Solve for G to yield

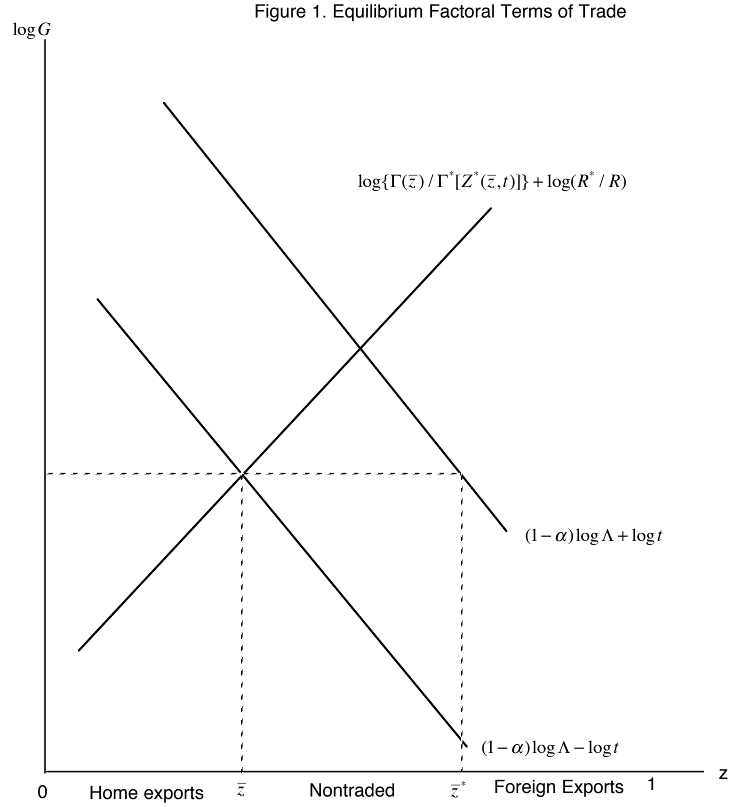
$$G = \frac{\Gamma(\bar{z})}{\Gamma^*[Z^*(\bar{z}, t)]} \frac{R^*}{R}. \tag{15}$$

(13), (14) and (15) are displayed in Figure 1. The intersection of (13) and (15) determines equilibrium $\bar{z}$.

Lemma 2 *Provided trade costs are not too high, a unique trading equilibrium exists on $z \in [0, 1]$.*

If equilibrium exists, it is unique because (15) is increasing in z while $\Lambda(z)$ is decreasing in z. Nonexistence arises when the absolute penalty of trade cost is too large relative to the absolute advantage schedule $\Lambda(z)$. There are two intuitive aspects. If t is too large for a given $\Lambda(z)$ schedule, the two downward sloping schedules in Figure 1 are too far apart and there is no value of $\ln G$ for which both $\bar{z}$ and $\bar{z}^*$ are in the unit interval. If $\Lambda(z)$ is too large relative to a given t, both the downward sloping schedules in Figure 1 are shifted upward and there is no trade because the foreign disadvantage is too large to overcome the trade cost.

Figure 1. Equilibrium Factoral Terms of Trade



3 Comparative Statics

Comprehension of the properties of the model is aided by reviewing its comparative static responses to changes in factor endowments, trade costs and international transfers. These are familiar from Dornbush, Fischer and Samuelson (1977, 1980). A more novel comparative static result deals with effect of globalization on the variance of the factoral terms of trade.

3.1 Growth

Neutral growth causes factoral terms of trade deterioration. A rise in R/R^* shifts the left hand side of (15) downward. Figure 1 reveals that the downward shift must lower the equilibrium value of the home country's factoral terms of trade G and raise $\bar{z}$, increasing the range of goods exported by the home country and reducing the range of goods exported by the foreign country. These effects are very similar to to those of the Ricardian continuum model.

Neutral growth raises average real income in the home country. Real income of a representative agent who receives a per capita share of national income is represented by $\ln u = \ln GR - \ln P$, where P is the price index. As to the first term on the left hand side, home nominal income in terms of foreign factor prices, GR, must rise, as can be illustrated by the effect of a rise in R on the budget constraint function in Figure 1. A fall in G that fully offset the rise in R would imply a constant $\bar{z}$, hence the rise in $\bar{z}$ induced in the new equilibrium must imply a higher GR.

As to the price index for the home economy, $\ln P$ can be shown to rise less than proportionally to GR. The Cobb-Douglas price index is given by $\int_0^1 \gamma(z) lnp(z)dz$. Using the general equilibrium solution for prices (5)-(7), the price index becomes

$$\frac{1}{1-\alpha}\ln P = k + \nu \ln GR + (1-\nu)\ln(GR/R^* + 1) - \Gamma\Pi - (1-\Gamma-\nu)(\Pi^* - \ln t), \tag{16}$$

where

$$\Pi \equiv \int_0^{\bar{z}} \frac{\gamma(z)}{\Gamma(\bar{z})} \ln[G^{-\alpha/(1-\alpha)}R/R^* + t^{1/(1-\alpha)}/\Lambda(z)]dz,$$

and

$$\Pi^* \equiv \int_{\bar{z}^*}^1 \frac{\gamma(z)}{\Gamma(\bar{z}^*)} \ln[G^{-\alpha/(1-\alpha)}t^{1/(1-\alpha)}\Lambda(z)R/R^* + 1]dz,$$

and $\nu \equiv \int_{\bar{z}}^{\bar{z}^*} \gamma(z)dz$. Here, k is a constant term not dependent on (G, t, R, R^*, Λ). Examining (16), it is clear that $\ln P$ rises with GR, but less than proportionately. For given $\bar{z}, \bar{z}^*$, real income in the average sense must increase. The effect of changes on the extensive margins on the price index is ordinarily small compared to the effect of change in GR, being proportional to the share densities $\gamma(\bar{z}), \gamma(\bar{z^*})$. Thus real income on average ordinarily rises with a rise in real GDP.

Non-neutral growth raises the relative price of the slow-growing factor. The Cobb-Douglas form imposes constancy on the income shares of the mobile factor labor, α, and the aggregate share paid to the specific factors, $1-\alpha$. The wage rate is given by

$$w = \alpha(K/L)^{1-\alpha}G.$$

The return to the group of specific factors (the value of marginal product of an equiproportionate increase in all specific factors) is given by

$$g_K = (1-\alpha)(L/K)^{\alpha}G.$$

g_K is shown below to be the average return to the specific factor. Taken together with the results of the preceding section, and interpreting the specific factor as specific human capital, the model implies that *the average skill premium*

$$g_K/w - 1 = \frac{1-\alpha}{\alpha}\frac{L}{K} - 1$$

is independent of international equilibrium forces. The skill premium depends only on the skill bias of technology (α) and own relative factor abundance (K/L).

The external price independence of the average skill premium in the model provides a very convenient benchmark that contrasts with the Stolper-Samuelson effect of external prices on relative factor prices that normally arises in the factor proportions model. Stolper-Samuelson effects imply that globalization should cause the skill premium to rise in the skill abundant country and fall in the skill scarce country, contrary to the observed coincidence of rising inequality in both rich and poor countries. External independence is basically due to the identical production functions assumption, leading to an effectively Ricardian structure in long run equal returns equilibrium. The identical Cobb-Douglas production function assumption serves to eliminate the effect of the distribution of relative productivities on the average skill premium in short run equilibrium.

3.2 Fall in Trade Costs

A one percent fall in symmetric trade costs evidently shifts $ln\Lambda - lnt$ up by one unit in Figure 1. The fall in t lowers $\bar{z}^*$ by $Z_t^* > 0$ and thus lowers the function $\Gamma R^*/\Gamma^* R$. *The net effect on the factoral terms of trade is ambiguous*, depending on the relative slopes of the two schedules on Figure 1 as well as the strength of the shift in $\Gamma R^*/\Gamma^* R$. Normally the equilibrium will imply a rise in $\bar{z}$, a fall in $\bar{z}^*$ and a change in G that is contained by (13) and (14) under these conditions.

Real income on average in the home country must rise with a fall in trade costs. This is because the rise in the price index induced by a possible rise in G does not offset fully the rise in nominal GDP, while the direct effect of lower trade costs on the price of imports isolated in (16) increases the gain. As with the analysis of real GDP shifts, these inferences suppress the small effect of changes in $\bar{z}, \bar{z}^*$ on price indexes for simplicity.

For the foreign country the real income effects essentially complement those of the home country, the foreign factoral terms of trade being the inverse of the home factoral terms of trade.

3.3 Transfers

Transfers affect the equilibrium factoral terms of trade in a standard way. Let B denote the transfer from the home country to the foreign country (in domestic price terms). The effect on equilibrium in any individual product market arises only through the factoral terms of trade, G. This property reflects the well known special case of the 2 good model with equal marginal propensities. The factoral terms of trade G is solved from (15) shifted to reflect the effect of the transfer on aggregate spending:

$$G = \frac{\Gamma}{\Gamma^*}\frac{R^*}{R} - \frac{1 - \Gamma - \Gamma^*}{\Gamma^*}\frac{B}{R}. \tag{17}$$

The effect of a transfer is to lower the factoral terms of trade of the transferor and to reduce the range of goods exported. This secondary burden of the transfer arises on the extensive margin only. In the absence of trade costs that create a range of nontraded goods, $1 - \Gamma = \Gamma^*$ and there is no secondary burden due to the identical Cobb-Douglas tastes assumption that implies identical marginal propensities to spend on the traded goods.

3.4 Income Risk and Globalization

Does a more open world economy experience greater income risk? There are two aspects of this question, the variation of national incomes across economies in the world system and the dispersion of personal incomes within an economy. This subsection deals with external variation while the next section deals with internal variation.

The variation of incomes across economies is driven by variation in relative country size due to differential growth rates, relative productivity shifts or transfers. Between countries, relative incomes are determined by the factoral terms of trade G.

Proposition 1 *Globalization reduces the variance in G induced by small shocks in relative productivity or relative country size.*

The rationale is simple — wider markets damp the effect of aggregate supply shocks on relative prices. Aggregate relative productivity risk enters the model as a multiplicative scalar random variable μ with unit mean, applied to the schedule of relative labor productivities. $\Lambda(z)$ is replaced in this section by $\mu\Lambda(z)$. The equilibrium comparative statics with respect to $\ln\mu$ are used to derive the variance of G in the neighborhood of $\mu = 1$. Then it is shown that the variance is decreased by reductions in t.

Equilibrium $\bar{z}$ is solved from combining the marginal export condition $G = \mu\Lambda(\bar{z})^{1-\alpha}t$ with the trade balance condition $G = \Gamma(\bar{z})R^*/\Gamma(\bar{z}^*)R$:

$$\mu\Lambda(\bar{z})^{1-\alpha}t = \frac{\Gamma(\bar{z})}{\Gamma(Z^*(\bar{z},t))}\frac{R^*}{R}. \tag{18}$$

Taking logs and differentiating (18) with respect to $\ln\mu$,

$$\frac{d\bar{z}}{d\ln\mu} = \frac{1}{\frac{\gamma(\bar{z})}{\Gamma(\bar{z})} + \frac{\gamma(\bar{z}^*)}{\Gamma(\bar{z}^*)}Z^*_{\bar{z}} - (1-\alpha)\frac{\Lambda_z(\bar{z})}{\Lambda(\bar{z})}} > 0.$$

Relative productivity risk μ affects G given by the expression on the right hand side of (18) via its effect on $\bar{z}$, thus

$$\frac{d\ln G}{d\ln\mu} = \left\{\frac{\gamma(\bar{z})}{\Gamma(\bar{z})} + \frac{\gamma(\bar{z}^*)}{\Gamma(\bar{z}^*)}Z^*_{\bar{z}}\right\}\frac{d\bar{z}}{d\ln\mu} > 0.$$

The variance of $\ln G$ in the neighborhood of the mean is given by

$$V(\ln G) = \left\{\frac{d\ln G}{d\ln\mu}\right\}^2 V(\ln\mu).$$

The effect of trade costs on the variance of G is given by

$$2V(\ln\mu)\frac{d\ln G}{d\ln\mu}\frac{\partial\frac{d\ln G}{d\ln\mu}}{\partial t},$$

where

$$\frac{\partial\frac{d\ln G}{d\ln\mu}}{\partial t}=\frac{\gamma(\bar{z}^*)}{\Gamma(\bar{z}^*)}\left\{\frac{d\ln G}{d\ln\mu}\right\}\frac{-(1-\alpha)\Lambda_z(\bar{z})/\Lambda(\bar{z})}{[\gamma(\bar{z})/\Gamma(\bar{z}+Z^*_{\bar{z}}\gamma(\bar{z}^*)/\Gamma(\bar{z}^*)]^2}Z^*_{\bar{z}t}>0.$$

Thus the variance of G is increasing in trade costs t.

A numerical example demonstrates the potential quantitative importance of the variance damping property of globalization. Assume a uniform distribution of tastes, hence $\gamma = 1$ and $\Gamma(z) = z$ and $\Gamma^*(z) = 1 - z^*$. Let $\Lambda(z) = \bar{\Lambda}/z$. The two export cutoff equations imply $Z^*(\bar{z}, t) = \bar{z}t^{2/(1-\alpha)}$.[9] Then

$$\frac{d\ln G}{d\ln\mu}=\frac{1/\bar{z}+t^{2/(1-\alpha)}/(1-\bar{z}^*)}{1/\bar{z}+t^{2/(1-\alpha)}/(1-\bar{z}^*)+(1-\alpha)/\bar{z}}.$$

Suppose that equilibrium implies symmetry, such that $\bar{z} = 1 - \bar{z}^*$. Then

$$\frac{d\ln G}{d\ln\mu}=\frac{1+t^{2/(1-\alpha)}}{1+t^{2/(1-\alpha)}+(1-\alpha)}.$$

Suppose $1 - \alpha = 0.33$, reflecting the roughly constant labor share of 0.67 that has long been a stylized fact of aggregate income accounting. Then for a frictionless equilibrium ($t = 1$), $d\ln G/d\ln\mu = 0.858$ and $V(\ln G) = 0.737V(\ln\mu)$. For $t = 1.74$, $d\ln G/d\ln\mu = 0.989$ and $V(\ln G) = 0.977V(\ln\mu)$. $t = 1.74$ is the benchmark value reported in Anderson and van Wincoop (2004) for OECD countries, with much larger values being appropriate for some developing countries. Evidently, as trade costs increase without bound, $d\ln G/d\ln\mu \to 1$. The effect of unequal country size or relative productivity is reflected in $(1 - \bar{z}^*)/\bar{z}$. Suppose for example that the home country (the South) exports one tenth as many products as the foreign country (the North). In frictionless equilibrium, $(d\ln G/d\ln\mu)^2 = 0.589$, hence

[9] A trading equilibrium always exists in this case. The equilibrium $\bar{z}$ is solved from

$$\frac{\bar{z}R^*/R}{1-\bar{z}t^{2/(1-\alpha)}}=\left\{\frac{\bar{\Lambda}}{\bar{z}}\right\}^{1-\alpha}\frac{1}{t}.$$

This equation always has a solution $\bar{z} \in [0, 1]$ for any positive $\bar{\Lambda}$ and $t > 1$.

$V(\ln G) = 0.589 V(\ln \mu)$. The example shows that there is scope in the model for globalization to decrease income variance by 1/3 or more.

The aggregate-risk-damping property of globalization due to market widening obtains much more generally than in the present model where market widening is on the extensive margin of trade. The Appendix provides an example where market widening acts exclusively on the intensive margin.[10]

4 Income Distribution

The main goal of this paper is derive equilibrium income distribution properties, in particular the comparative statics of income distribution with respect to trade costs, growth in endowments and transfers. A necessary component is the assignment of ownership patterns of specific factors. In this section, an arbitrary uniform assignment is eventually imposed to generate sharp comparative static results. The pattern of persistent positive (negative) premia for export (import competing) sectors obtains. In the next section the uniform assignment is rationalized as an efficient ex ante allocation of investments in rational expectational equilibrium.

The distribution of specific factor incomes has a rich relationship to international interdependence. The specific return in sector z is given by

$$r(z) = \frac{s(z)}{\lambda(z)} g_K, \tag{19}$$

where the equilibrium value of $s(z)$ is given by (9) and (11) for traded goods and $s(z) = \gamma(z)$ for nontraded goods. The average sector specific return is equal to g_K: $\int_0^{\bar{z}^*} r(z)\lambda(z)dz = g_K$.

(19) in combination with (9) and (11) implies that for given factoral terms of trade and trade costs, high returns are associated with good relative productivity draws, high demand and a relatively low amount of competing sector specific investment. Because the distribution of specific factor returns $r(z)$ is governed by $s(z)/\lambda(z)$, the distribution depends on the ex post inefficiency of allocation. In the limit of perfect efficiency, the factoral income distribution collapses onto g_K.

[10]The numerical example also implies that the variance of income is less for relatively smaller economies. This benefit of smallness implication is likely to hold in a wider class of models, but will be less robust than the market widening implication.

The share of specific factor payments in sector z is given by,

$$\rho(z) = s(z)(1-\alpha). \tag{20}$$

The return and the income share are related by (19)-(20). For the uniform allocation of specific capital, the distribution of $r(z)$ mimics that of $\rho(z)$. The richest specific factor owners are in the most advantaged sectors in the uniform benchmark case.

The connection from the factoral distribution of income to the personal distribution requires knowledge of ownership patterns. The most convenient interpretation of the specific factor is human capital, in which case the personal and factoral distributions are tightly linked. Let $H(\widetilde{z})$ denote the proportion of capital owners who own the residual returns to industries richer than $\widetilde{z}$. A common measure of income inequality is the share of total factor income received by some specific target for H such as the richest 10 per cent. This measure is implemented by solving the ownership distribution for $\widetilde{z} : H(\widetilde{z}) = 0.10$. Let

$$S(\widetilde{z}) \equiv \int_0^{\widetilde{z}} \rho(z)dz = (1-\alpha)\int_0^{\widetilde{z}} s(z)dz, \tag{21}$$

define the specific factor income share of the sectors with returns higher than $r(\widetilde{z})$, then solve for $S(\widetilde{z})$, an index of inequality focused on the upper tail.[11]

[11] Suppose for example that half the population owns no human capital. Then 20 per cent of the total capital will be owned by the richest 10 per cent in equilibrium. With the uniform allocation of capital, this means $\widetilde{z} = 0.20$. Then for the case where the export industries alone contain the richest owners S is evaluated as

$$S(\widetilde{z}, G, \cdot) = (1-\alpha)(GR/R^* + 1)\int_0^{\widetilde{z}} \gamma(z)[GR/R^* + (Gt)^{1/(1-\alpha)}A(z)]^{-1}dz$$

where $A(z) \equiv [a(z)/a^*(z)]^{1/(1-\alpha)}$.

The model is completed by specifying distributions for home and foreign productivities and for tastes. Suppose these are uniform with productivities being independent draws on $[a_{min}, a_{max}]$ and $[a^*_{min}, a^*_{max}]$ respectively. Then $A(z)$ is uniform on $[A_{min}, A_{max}] = [(a_{min}/a^*_{max})^{1/(1-\alpha)}, (a_{max}/a^*_{min})^{1/(1-\alpha)}]$. (21) has a closed form solution given G in this case, given by $S = (1-\alpha)(GR/R^* + 1)F$ where

$$F = \ln[(GR/R^* + (Gt)^{1/(1-\alpha)}((1-\widetilde{z})A_{min} + \widetilde{z}A_{max})] - \ln[(GR/R^* + (Gt)^{1/(1-\alpha)}A_{min})].$$

While the uniform distribution for tastes and productivities is convenient in yielding a closed form solution, the qualitative properties of the model are invariant to more general distributions of $\gamma(z)$ and $A(z)$.

The comparative static implications of the model for income distribution can now be drawn. Consider first the effect of improvements in the factoral terms of trade G. For example, two underlying drivers of such improvements are foreign relative growth and a transfer into the home country. Both ρ and r vary directly with s. Examining (9) and (11), s is decreasing in G for both exports and imports (a formal development follows below), while for nontraded goods s is independent of G. Increases in the factoral terms of trade G thus redistribute specific factor income from traded goods to nontraded goods. There is no effect on the relative shares of mobile vs. the average return to specific factors.

As to the distribution of specific factor returns $r(z)$ within the traded goods sectors, it is convenient to focus first on returns relative to the mean, $r(z)/g_K = s(z)/\lambda(z)$. Then

$$\frac{\partial \ln r(z)/g_K}{\partial \ln G} = \frac{\partial \ln s(z)}{\partial \ln G}.$$

For nontraded goods, $s(z) = \gamma(z)$, which is independent of G. For traded goods the term on the right is given by:

$$\frac{\partial \ln s(z)}{\partial \ln G} = -\frac{1}{1+GR/R^*} - \frac{\alpha}{1-\alpha}\frac{H(z)}{GR/R^* + H(z)}$$

where the export cutoff equations are used to simplify the derivatives of (9) and (11) to obtain $H(z) \equiv \Lambda(\bar{z})/\Lambda(z) \in [0,1], z \leq \bar{z}; H(z) \equiv \Lambda(\bar{z}^*)/\Lambda(z) \geq 1, z \geq \bar{z}^*$. The relative returns of trade-exposed specific factors fall with G everywhere, and most for the least productive sectors.

The specific factor returns respond to G according to

$$\frac{\partial \ln r(z)}{\partial \ln G} = \frac{GR/R^*}{1+GR/R^*} - \frac{\alpha}{1-\alpha}\frac{H(z)}{GR/R^* + H(z)}. \tag{22}$$

The right hand side of (22) is negative (positive) for

$$H(z) \geq (\leq) \frac{(GR/R^*)^2}{GR/R^* + \alpha/(1-\alpha)}.$$

The intuition for these results is that specific factor returns are run by the response of equilibrium goods prices to the demand and supply shifts arising from the change in G. In the nontraded goods sectors, a rise in G

raises both the willingness-to-pay and the short run unit cost function in proportion to G. Therefore the price rises in proportion to G and all sector specific factor returns rise in proportion to G. In tradable sectors, the rise in G results in price movements governed by (5) and t times (6). The uniform increase in willingness-to-pay is less than proportional to G, while the short run cost functions still rise in proportion to G. The equilibrium price scaled by G (and hence $r(z)/g_K$) falls relatively less in the most productive sectors because there the uniform demand rise interacts with the smallest general equilibrium supply elasticities.[12] Thus:

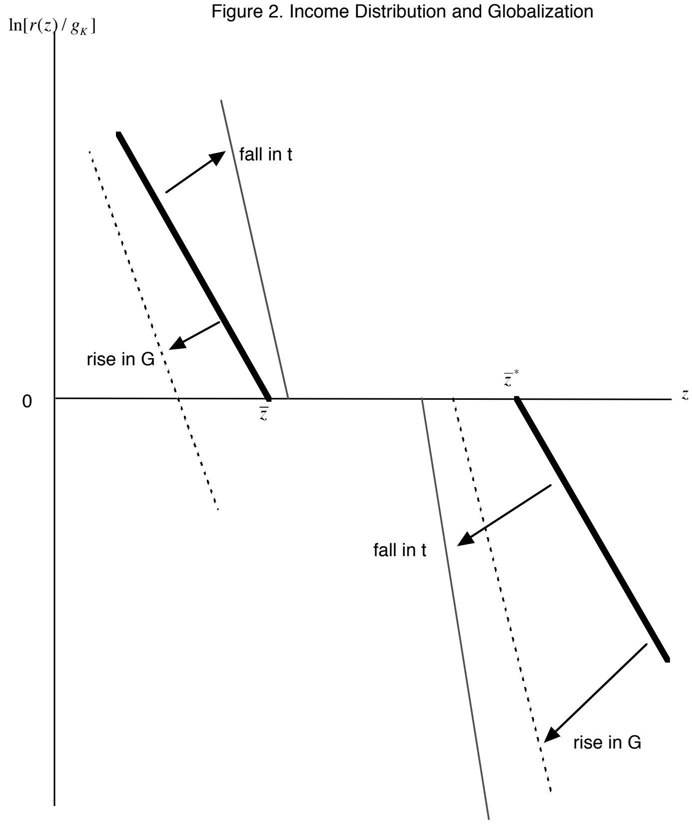
Proposition 2 *the redistributive effects of factoral terms of trade changes on trade exposed sectors are larger the less relatively productive the sector, while nontraded sectors are completely insulated from the factoral terms of trade.*

The intuition suggests that Proposition 2 is a property of specific factors models that holds more widely than in the special Cobb-Douglas structure that permits such sharp results. The more that the mobile factors crowd the sector specific factor, the closer that something like a capacity constraint approaches and the lower the sectoral supply elasticity will tend to be.

Figure 2 illustrates the effect of a rise in G and a fall in t (analyzed below) on the distribution of r for the benchmark case of uniform allocation. A 1 percent rise in G lowers the $\ln r(z)/g_K$ schedules for traded goods by $-1/[(1-\alpha)(GR/R^* + 1)]$. A 1 percent fall in t raises export relative incomes by the (absolute value of the) expression on the right hand side of (23) and lowers import sector relative incomes by the expression on the right hand side of (24). The figure is drawn assuming that $G < t$ so that a one percent fall in t has a bigger impact than a one percent rise in G for import competing sectors, but this ranking is arbitrary and without significance for the analysis. The complication of non-uniform λ's does not affect the elasticities of returns with respect to G, but it alters the one-to-one relationship between $r(z)$ and $s(z)$ imposed in Figure 2.

[12] The general equilibrium supply elasticity is given by $G_{pp}p/G = [1 - s(z)]\alpha/(1 - \alpha)$.

Figure 2. Income Distribution and Globalization



When aggregate productivity risk μ is present, the preceding result implies that personal income risk due to terms of trade risk is zero for the middle nontraded goods sectors and among traded goods it is greatest for the most disadvantaged sectors and least for the most advantaged sectors. μ has no direct effect on shares because $G^{1/(1-\alpha)}t^{d(z)/(1-\alpha)}/\Lambda(z) = \Lambda(\bar{z})/\Lambda(z)$ which is invariant to μ save through its effect on equilibrium $\bar{z}$. With the benchmark uniform allocation of specific capital, $r(z)$ is declining in z so aggregate risk hits the poorest sectors the hardest.

Globalization is modeled as decreases in symmetric trade costs. Globalization redistributes specific factor income to exports from both nontraded goods and imported goods for any given factoral terms of trade G. The effect of a change in t on the distribution of specific factor income relative to the mean is given by

$$\frac{\partial \ln r(z)/g_K}{\partial \ln t} = \frac{\partial \ln s(z)}{\partial \ln t} = -\frac{1}{G^{-\alpha/(1-\alpha)}t^{-1/(1-\alpha)}\Lambda(z)R/R^* + 1}\frac{1}{1-\alpha}, z \leq \bar{z}; \tag{23}$$

and

$$\frac{\partial \ln r(z)/g_K}{\partial \ln t} = \frac{1}{G^{-\alpha/(1-\alpha)}t^{1/(1-\alpha)}\Lambda(z)R/R^* + 1}\frac{1}{1-\alpha}, z \geq \bar{z}^*. \tag{24}$$

For nontraded goods, sector specific factor incomes are invariant to t. For exported goods, the relative income is increased by fall in t by more the more productive the sector while for imported goods the relative income is reduced by more the less productive the sector. The results are illustrated in Figure 2. Thus

Proposition 3 *Globalization at given factoral terms of trade reduces the specific factor income of import-competing sectors by more the less relatively productive the sector, increases the specific factor income of exporting sectors by more the more productive the sector, while nontraded sectors are completely insulated from globalization.*

Notice that inequality increases in both countries, and that this property does not require restricting the distributions of productivity draws. It is a feature of factor specificity and the assumed benchmark uniform allocation of factors. The effect of globalization on the factoral terms of trade is ambiguous, but any improvement due to the fall in trade costs will redistribute income to nontraded sector specific factors from traded sector specific factors. Globalization also narrows the range of nontraded goods $[\bar{z}, \bar{z}^*]$, but this has no independent effect on the income distribution.

In the presence of aggregate productivity risk, Proposition 1 showed that globalization reduces the induced variance of the factoral terms of trade, thus tending to offset the increased variance of ex post specific factor incomes in traded goods sectors. The size of the reduction in variance of relative income varies by sector in proportion to the square of

$$\frac{\partial \ln r(z)/g_K}{\partial \ln G}.$$

With the uniform benchmark allocation, Proposition 2, illustrated by Figure 2, shows that this offset in aggregate risk is most important for the poorest factors, least important for the richest factors and irrelevant for the middle nontraded sector factors. Proposition 3, also illustrated by Figure 2, shows that globalization increases idiosyncratic risk and is likewise most important for the poorest factors ex post, least important for the richest factors and irrelevant for the middle income nontraded sector specific factors.

The model implies that increases in the spread of the distribution of relative productivities serve to raise the dispersion of relative specific factor incomes because they raise the absolute value of the slope of $\Lambda(z)$ in the relevant range. Stretching the interpretation of the model, increases in the spread of the relative productivity distribution can be seen as an aspect of globalization reflecting the integration of much poorer countries into a world previously dominated by trade between rich countries.

5 Equilibrium Investment Allocation

Assume that specific factor investments are made through a perfect capital market that equalizes expected returns in all sectors for each country. A stock of wealth K is allocated among the sectors. The exact nature of the specific capital is not important at this point, but eventually it is useful to specify it as human capital created by the investment of K by individual workers electing to invest in their specific skill acquisition, in which case the distribution of the returns to capital is part of the earnings distribution.

Investments are made prior to receiving productivity draws. Productivity in each sector z is independently drawn from a common distribution $D(a)$ in the home country and $D^*(a^*)$ in the foreign country.[13]

The ex post return to the specific factor in sector z is given by

$$r(z) = \frac{p(z)}{a(z)}(1-\alpha)\left\{\frac{L(z)}{K(z)}\right\}^{\alpha}.$$

[13]In long run equilibrium with no productivity shocks or with complete mobility of capital, the model converges onto the Ricardian model due to the identical Cobb-Douglas production function restriction.

Using the value of marginal product condition for labor allocation to solve for $\{L(z)/K(z)\}^{\alpha}$ and substituting into the preceding expression, this becomes

$$r(z) = \lambda(z)K\frac{\alpha(1-\alpha)}{w}\frac{p(z)}{a(z)}. \tag{25}$$

In equilibrium, agents form expectations about the 'efficiency price' $p(z)/a(z)$. For price-taking agents, it is plausible that expectations converge to uniform efficiency prices: $E[p(z)/a(z)] = \pi$. In that case, a uniform allocation equalizes expected returns in (25).

Lemma 3 *The equilibrium allocation of specific capital* $\{\lambda(z)\}$ *is the uniform allocation.*

The comparative statics of income distribution are given in the preceding section. The elasticity of $r(z)/g_K$ with respect to G is negative for traded goods. This implies that a fall in G shifts income from the nontraded goods middle into the tails. Moreover, the shift is larger for the lower tail, the import-competing goods. By previous comparative static results on drivers of G, *an economy growing less fast than its partner thus experiences increasing inequality while the faster growing partner experiences decreasing inequality.* Also, *an economy borrowing from its partner will experience increasing inequality while its partner the transferor experiences decreasing inequality.*

Globalization represented by a fall in t increases inequality at constant G by reducing income in the lower tail and raising it in the upper tail. The amplification occurs through a second channel as well because the range of nontraded goods shrinks, more investments are trade sensitive. Improvements in factoral terms of trade, if they occur when driven by the fall in trade costs, will further increase inequality. Increases in the dispersion of relative productivities serve to increase the share of income earned by the richest, as in the preceding section.

Introducing relative productivity risk as in Section 3.4 introduces aggregate risk in the factoral terms of trade G. All the basic setup of this section remains valid, understanding that agents' expectations include expectations of G.

It might seem that better use of information about the economy could produce better investment returns. For example, the distribution of taste parameters $\{\gamma(z)\}$ is known ex ante and apparently could be exploited in the investment decision. The Appendix shows that attempts to exploit knowledge of the taste distribution using the general equilibrium structure result in the same average return to capital with greater variance. Nevertheless, the qualitative properties of income distribution with the two allocations are essentially the same, a property that suggests that the results of the model are robust to expectational assumptions and arise instead from the ex post sectoral specificity of investment in an environment with productivity shocks. Overturning the results appears to require extreme errors in expectations such that over-investment occurs in export industries while under-investment occurs in import-competing industries, inverting the empirically observed pattern of higher than average returns in export industries and lower than average returns in import competing industries. An interesting extension of the model is to limit the efficiency of the capital market in some way.[14]

6 Heterogeneous Firms

Recent research emphasizes that firms are very heterogeneous within sectors, identified with idiosyncratic productivity draws. Trade has a systematic impact tending to raise the average productivity of a sector by weeding out low productivity firms. In the Melitz (2003) model, a fixed cost of exports for each firm is combined with a variable cost of trade. A fall in the variable trade cost results in upward pressure on wages as more labor is devoted to entering exporting. The wage pressure causes low productivity firms to exit, raising the average productivity. The model of this paper can readily be extended to incorporate the endogenous productivity effect. More novel, however, the current setup implies a mechanism of endogenous productivity response to trade that amplifies productivity differences between export and import-competing industries even in the absence of fixed export costs. Trade does not *cause* average productivity changes, in contrast to the Melitz model, but exports are correlated with higher exit of the least productive firms and expansion of the most productive firms, with nontraded goods sectors having less churning and import-competing sectors the least churning.

A perfect capital market finances the startup of a mass of firms in each sector z.[15] The firms subsequently draw their productivities. The productiv-

[14]Other interesting extensions would allow a role for risk aversion and the magnitude of risk. One tack could take the line of Helpman and Razin (1978), who deploy the Diamond stock market model to analyze related issues.

[15]The description of equilibrium allocation is slightly more complicated than in preced-

ity draw has a sector specific component, so that the ex post distribution of firms' draws differs by sector. Some low productivity firms will exit in each sector z. The surviving firms in sector z have an average productivity that appears in the preceding sections as $1/a(z)$.

In each sector, the firms compete for the sector specific capital. That implies a harsher winnowing process in the sectors that have the better average draws; low productivity firms are faced with hiring more expensive capital. Thus the endogenous productivity effect acts to increase the average productivity of the exporting sectors relative to import competing sectors. In the import competing sectors, their relatively cheap specific capital softens the winnowing process, reducing the impact of the endogenous productivity effect. As in Melitz (2003), the Darwinian force comes through the factor market and acts to raise the average productivity of surviving firms in every sector, but least in the import competing sectors and most in the export sectors.

To preserve some heterogeneity of firms within sectors, assume (realistically) that the capital transfer is costly. For simplicity, assume that some portion of the transferred capital is used up in the transfer, so that one unit of original capital becomes $\phi < 1$ units of usable capital in the hiring firms. This loss could represent a firm specific component of skill that is lost when the worker moves. The (inverse) productivity draw of a firm is the sum of a sectoral component and an idiosyncratic component: $a(z,h) = a(z) + b(h)$ for firm h in sector z. Suppose that the firm level h dimension is ordered such that $b_h > 0$. In any sector z, the ex post value of marginal product of the specific factor is thus decreasing in h. When capital can be reallocated within the sector, the highest productivity firm hires specific capital away from low productivity firms in its sector. Provided that ϕ is not too small, this process drives the lowest productivity firms out of business.

In equilibrium, the least productive surviving firm, located at h^{max}, can

ing sections because the expected return is more complex. A full development is suppressed here because the equilibrium capital allocation remains uniform due to the complete *ex ante* symmetry of all firms in all sectors. 'The firm' can be thought of as owning the residual claim to operate the process it draws, employing skilled and unskilled labor for that purpose. The higher productivity processes earn rents. Ex ante, the potential firms bid for the right to receive a draw from the productivity distribution, in essence buying an option to operate. The expected profits from buying the option to operate are equal to zero, incorporating expectations of the equilibrium returns that include the winnowing process.

pay enough to offset the value of marginal product of the specific capital transferred to the most productive firm.[16] This implies

$$\phi = [a(z) + b(h^{max})]/[a(z) + b(0)]. \tag{26}$$

All draws of productivity $b(h) \geq b(h^{max})$ result in the capital being resold to the firm at the upper end of productivity. This results in an average productivity of surviving firms equal to

$$\bar{a}(z) = a(z) + D(h^{max})b(0) + [1 - D(h^{max})]E[b|h \leq h^{max}].$$

Here D is the probability of an idiosyncratic draw with worse productivity than the marginal firm.

To sort out the implications for endogenous productivity and trade, it helps to consider an additional ordering condition $a_z > 0$. $a_z > 0$ is met only in an average sense because the ordering of z in general equilibrium depends on domestic productivity relative to foreign productivity. Under $a_z > 0$, differentiating (26) yields

$$h_z^{max} = -\frac{a_z}{b_h}[1 - \frac{1}{a(z) + b(0)}] < 0, \forall z > 0.$$

Here the sign follows from the natural normalization $a(0) + b(0) = 1$. The implication is that the endogenous productivity effect is most powerful in the most productive sectors. On average, the Darwinian force is most strong in the export sectors, weakest in the import-competing sectors and in the middle for the nontraded goods sectors. Trade does not cause endogenous productivity changes in this model. But the endogenous productivity response is such that exports (imports) are correlated with high (low) exit of firms and high (low) expansion of the most productive firms.

Turning to the distributional implications, *the endogenous productivity effect amplifies the dispersion of productivity and therefore amplifies the dispersion of ex post factor incomes.* The effect of globalization, a fall in trade costs t, is to amplify the endogenous sectoral productivity response to intra-sectoral differences in productivity and thus to amplify the inter-sectoral

[16] More realistic but more complex reallocations from a set of low productivity to a set of high productivity firms follow when there are diminishing returns to the transfer due either to a fixed mangerial input for the firm or convex adjustment costs. Alternatively, more firms expand if there are heterogeneous adjustment costs (ϕ's) not perfectly negatively correlated with productivity.

dispersion of factor returns beyond what arises with exogenous average productivities in each sector.

A further twist on the model provides an explanation for the well documented *within sector* variation of returns to specific human capital. The highest productivity firms in each sector earn quasi-rents relative to the lowest productivity firm that remains in business. Suppose that the firms are subject to wage bargaining such that the rents are shared with the skilled workers of each firm. Then the highest productivity firms will pay the highest skilled wages within each sector. The dispersion of within sector wages will be least in the highest productivity sectors because the stronger Darwinian force compresses the productivity distribution of the surviving firms. Formalizing these points, the zero profit condition for the least productive firm in sector z implies that it can pay skilled workers

$$r^{min}(z) = \left(\frac{p(z)}{a(z) + b[h^{max}(z)]} \right)^{1/(1-\alpha)} w^{-\alpha/(1-\alpha)}.$$

The more productive firms share their profits with the skilled workers according to

$$r(z,h) = r^{min}(z) + \theta(z)[p(z) - (a(z) + b(h))w^{\alpha} r^{min}(z)^{1-\alpha}]; \theta(z) \in [0,1].$$

The higher is $r^{min}(z)$, smaller is the within-sector dispersion of skilled wages.

7 Toward Dynamics

The purely static analysis of this paper is a platform for interesting dynamics. The specificity of factors is transitory. Adjustment to a longer run equilibrium will have interesting and important economic drivers. An earlier literature (for example, Neary, 1978) provides a thorough analysis of adjustment to a one time shock. In the present setup it is natural to think of productivity draws arriving each period. Serial correlation in the draws would induce persistence in comparative advantage with potentially interesting implications for investment patterns and income distribution. Labor market evidence reveals that young workers are much more likely to relocate in response to locational rents, suggesting that overlapping generations models might usefully be deployed.

A significant extension of the model would focus on capital market imperfection. One approach would focus on the credit constraints that workers face in acquiring new specific human capital.

8 Conclusion

The specific factors continuum model developed in this paper provides a structural rationale for some well observed regularities in the factor income data. Earnings in export industries are systematically and persistently higher than those in import competing industries. The natural explanation in the model is that even an allocation that is efficient in the ex ante expectational sense will be unable to equalize returns ex post. The best productivity draws induce export industries and are associated with high returns while the worst productivity draws induce import competing industries and are associated with low returns.

The model provides a plausible mechanism through which globalization necessarily increases the ex post dispersion of factor incomes within economies. Viewed ex ante, specific factor incomes are more risky. In contrast, the model also provides a formalization of the intuition that globalization and wider markets damp aggregate supply side shocks. Both effects of globalization are largest for the poorest specific factors.

The results suggest that globalization reduces income risk for mobile factors while it may reduce or increase risk for specific factors. This insight may hold up in a much wider class of models than those examined here. The property of the model that the poorest specific factors are affected most by globalization is likely to be less robust but still appears plausible for a wider class of specific factor models.

The model is highly stylized but is rich with suggestions for empirical work. Most obviously, addressing whether globalization on balance increases or decreases income risk within the setup of this paper requires parameterizing the productivity distributions at home and abroad, as well as filling out the Cobb-Douglas parameters with reasonable values. The generality of the productivity distribution in the present model would be useful in replicating some dimensions of actual income distributions but this advantage may be illusory. Empirics would be more firmly grounded with an extension of the model to the many country case. The success of Eaton and Kortum (2002) in solving the many country Ricardian continuum model by imposing the Frechet distribution on the productivity draws suggests attempting something similar in the specific factors continuum model.

The complementary work of Blanchard and Willman (2008) and Costinot and Vogel (2008) on income distribution based on worker heterogeneity suggests that a combination of ex ante heterogeneity and ex post locational premia can go far toward fitting the extremely rich empirical regularities of actual income distributions. The analytic simplicity of their models and the specific factors continuum model suggests that analytic solutions may be feasible.

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10 Appendix

10.1 An Alternative Expectational Equilibrium

A sophisticated general equilibrium expectations allocation is based on the agents forming expectations about the actions of all players and their consequences for the general equilibrium factor returns. The ex post returns are given by substituting into (25) equations (5)-(8) to solve for the relevant ranges of $p(z)/a(z)$ and using the arbitrage conditions $p(z) = p^*(z)t$ for the foreign exports and similarly for the home exports to the foreign economy. For the ex ante investment decisions, impose an ex ante ordering on the z's, denoted by $Z \in [0,1]$. The ex post equilibrium expression for $p(z)/a(z)$ factors into a random component times $[\gamma(Z)^{1-\alpha}\lambda(Z)]^\alpha$. Then the ex ante allocation $\lambda(Z) = \gamma(Z)^{1-1/\alpha}$ satisfies the equal expected returns condition.

The efficient allocation results in the same equilibrium values of $G, \bar{z}, \bar{z}^*$ as does the price taking equilibrium expectations allocation. This property follows from (13),(14) and from solving (5)-(8) for $\lambda(z)[p(z)/a(z)]^{1/(1-\alpha)}$ and substituting the result into (2).

The long run equilibrium distribution of ex post specific factor returns in tradable sectors under the 'sophisticated expectations' allocation is given by:

$$r(z) = g_K \gamma(Z)^{1-1/\alpha}\gamma(z)\frac{GR/R^* + 1}{GR/R^* + G^{1/(1-\alpha)}t^{d(z)/(1-\alpha)}A(z)}$$

where $d(z) = 1$ for exports and $d(z) = -1$ for imports while for nontraded goods it is given by

$$r(z) = g_K \gamma(Z)^{1-1/\alpha}\gamma(z).$$

The average return on capital is g_K under any allocation, but the uniform allocation will have less dispersion of returns than the 'sophisticated' allocation because even though sophisticated agents can base allocations on taste parameters they do not know whether a particular ex ante location Z will be in the export, nontraded or import competing range.

10.2 Income Variance and Globalization on the Intensive Margin

As an example of market widening exclusively on the intensive margin, consider a generic two good two country general equilibrium trade model with symmetric iceberg trade costs. The home relative price of good 2 in terms of good 1 is p, the foreign relative price is p^* and arbitrage equilibrium implies $p^* = pt^2$ when the home country exports good 2. Suppose that $t^2 = \tau\epsilon$ where ϵ reflects a small random shock to the productivity of distribution with unit mean and τ is the mean value of t^2. The market clearance equilibrium condition is given by $X(p) = M^*(p^*)$ where X is the upward sloping export supply schedule of the home country and M^* is the downward sloping foreign import demand schedule. Then the variance of p is given by

$$\left\{\frac{M^*_{p^*}\tau}{X_p - M^*_{p^*}\tau}\right\}^2 Var(\epsilon).$$

This expression is decreasing in τ. The variance of p drives the variance of home factor incomes, so incomes are less risky as mean trade costs fall. The same setup can be reinterpreted as variance in incomes induced by random relative productivity differences represented by ϵ, using the concept of 'efficiency prices' set out in Section 1.