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Trade liberalization, wage inequality, and endogenously determined nontraded goods

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Abstract

We examine the boundary between traded and nontraded goods as a channel for trade to impact factor prices. In a two-country, two-factor, continuum-good model, tariffs generate a range of nontraded goods. A tariff reduction has a direct effect to expand a country's import set and an indirect effect through terms of trade to expand its export set. We show that the export expansion can dominate the import expansion, raising the relative demand for the factor intensively used in production. The result is useful in explaining observed rising wage inequality in developing countries following trade liberalization.

Keywords: Trade liberalization; Wage inequality; Nontraded goods

JEL classification: F11; F16

1. Introduction

In this paper we identify the boundary between traded and nontraded goods as a channel through which trade liberalization impacts relative factor prices. The idea that this boundary is endogenously determined has a long history in economic theory.[1] In particular, Dornbusch et al. (1977) show in a continuum Ricardian model that tariffs and transport costs generate a range of nontraded goods. In this

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[1] See Oppenheimer (1974) for a historical note.

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paper we investigate the implication of this boundary for the wage inequality between skilled and unskilled workers.

Empirically our paper is motivated by the observation that wage inequality rose in many developing countries after they implemented trade liberalization.[2] This observation is not explained by the simple 2×2 Heckscher–Ohlin (HO) model, which predicts that the skill-scarce country (South) will see a decrease in the relative wage of skilled workers after opening to trade. While several features of the simple HO model are potentially responsible for this failure, most of the recent studies of Southern wage inequality have chosen to abandon factor price equalization (FPE), one of the key characteristics of the conventional HO model.

A popular non-FPE framework is the continuum HO model of Dornbusch et al. (1980). In a widely cited paper, Feenstra and Hanson (1996) modify this two-factor model by adding a third factor, capital. They show that international capital movements, by shifting middle skill-intensive goods from the North to the South, increase relative skill demand and wage inequality in both countries. Adopting the DFS framework, Trefler and Zhu (2001) show that technology catch-up in the South can also cause this product-shifting effect. Notice that the sources of rising wage inequality in these two analyses are international capital movements and technical change. To argue that they reflect the effects of trade liberalization on wage inequality, one needs to establish trade liberalization as a cause for foreign investment and technical change. A recent literature on fragmentation of production processes and international input trade makes such an argument.[3]

One question remains: can Southern trade liberalization per se, without accompanied by increased foreign investment and induced technical change, cause Southern wage inequality to rise? This is a challenging question for a good reason: while rising foreign investment and technology capacity in the South increase its relative cost advantage in middle skill-intensive goods and hence shift them towards the South, a reduction in trade barriers in the South would decrease its relative cost advantage in such goods and hence shift them away from the South. A model discussed in Jones (1999) helps make this point clear. Jones considers a two-country, two-factor, three-good HO model with no FPE. In this model, a lowering of the tariff on the middle skill-intensive good, assumed to be produced by both countries, would result in a change in wage inequality in both countries in the same direction. However, which direction wage inequality moves depends on where trade liberalization occurs. Wage inequality would rise only if the tariff reduction is implemented by the North. If the South imports the middle skill-intensive good and reduces the tariff on it, then the model predicts wage inequality to *fall* in both countries. The reason for this falling wage inequality is precisely

[2] See Robbins (1996) for empirical evidence on wage inequality in nine developing countries between the late 1970s and early 1990s.

[3] For the literature on international fragmentation, see the list of papers in Jones (2000, p. 116).

that such a tariff reduction shifts production of the middle skill-intensive good from the South to the North.

In this paper we show that Southern trade liberalization per se can indeed cause Southern wage inequality to rise in the absence of international capital movements and technical change.[4] Key to our argument is the existence of nontraded goods whose range is endogenously determined by the level of trade barriers. Without such nontraded goods, an expansion of the range of exported goods in the North must imply a shrinkage of the range of exported goods in the South. With such nontraded goods, the range of exported goods can expand simultaneously in both countries as a result of trade liberalization.

To explain the intuition, we discuss a two-country, two-factor, four-good HO model in Section 2. In this model, a tariff by the South renders the two middle goods, one importable and one exportable under free trade for the South, to be nontraded. As we will explain in Section 2, the importable becomes nontraded because of the direct effect of the tariff, and the exportable becomes nontraded because of the indirect effect of the tariff through terms of trade. Both nontraded goods will eventually become tradable as the tariff decreases. The interesting case is: at certain tariff rate the exportable-turned nontraded good becomes tradable but the importable-turned nontraded good does not, and hence wage inequality *rises* in the South. This example identifies an export product-expansion effect induced by a country's own trade liberalization, which is what distinguishes our trade-wages mechanism from those in the literature.

It remains to formally establish that the export product-expansion effect can dominate other effects and cause wage inequality to rise in equilibrium. This is accomplished in Sections 3 and 4. In Section 3 we develop a continuum model that is a modified version of Dornbusch et al. (1977). Continuum models are more convenient than discrete models in capturing the endogenous boundary between traded and nontraded goods. In Section 4 we show that rising Southern wage inequality can indeed emerge as an equilibrium result of the South's own trade liberalization. We conclude the paper in Section 5.

2. The argument

In this section we use a 2×4 HO model to illustrate the logic of our argument. Consider a world of two countries (North and South), two factors (skilled and

[4]In a many-country, two-factor, many-good HO model with no FPE, Davis (1996) shows that wage inequality will rise after trade liberalization in a small Southern country that is unskilled-abundant relative to the North but skill-abundant relative to other Southern countries. The source of rising wage inequality in the Davis model is a lowering of trade barriers between Southern countries and the mechanism is the Stolper–Samuelson price-wage link. In contrast, the source in our model is a lowering of trade barriers between the South and the North, and the mechanism is product-mix changes implied by the endogenous change in the boundary between traded and nontraded goods.

unskilled labor), and four goods (1, 2, 3, and 4 in ascending order of skill intensity). Denote c_i and c_i^* as the unit cost of good i in the South and North, respectively. Suppose the two countries have sufficiently different factor abundance so that factor prices are not equalized under free trade. In the absence of trade barriers, $c_i < c_i^*$ for $i = 1,2$, and $c_i > c_i^*$ for $i = 3,4$. Thus the South completely specializes in goods 1 and 2 and the North in goods 3 and 4 in the free-trade equilibrium.

Let the South impose a uniform ad valorem tariff t. Suppose the size of t is large enough so that $c_3 < (1 + t)c_3^*$ but small enough so that $c_4 > (1 + t)c_4^*$. That is, the tariff protection reverses the cost advantage of the North in good 3 but not in good 4. As a result, both countries produce good 3 by themselves: good 3 becomes a nontraded good.

We argue that the tariff t not only causes the South's importable good 3 to be nontraded, but may also cause its exportable good 2 to be nontraded. The reason is a terms-of-trade effect: the introduction of t raises the average price of Southern goods relative to that of the North. With perfect competition, this implies a higher average unit cost of Southern goods relative to that of the North, thus a higher c_2/c_2^*. By assumption, the South has a cost advantage in good 2, that is, $c_2/c_2^* < 1$ under free trade. If this cost advantage is sufficiently small, then the increase in c_2/c_2^* due to the terms-of-trade effect can cause $c_2/c_2^* > 1$ in the tariff equilibrium, making the North produce good 2. However, the North will not be able to export good 2 as long as $c_2/[(1 + t)c_2^*] < 1$. This leads to a tariff equilibrium in which the South exports good 1, the North exports good 4, and both goods 2 and 3 are nontraded.

Now consider trade liberalization in the South that reduces the tariff from t to t'. This has a direct effect of reducing the South's tariff-driven cost advantage in good 3, and an indirect effect through the terms of trade that increases the South's cost advantage in good 2. Both goods are nontraded at tariff t, and both will eventually become tradable as the tariff falls. However, which good becomes the *first* to turn tradable depends on model parameters. Suppose at tariff t' good 2 becomes tradable and good 3 remains nontraded. In this case, the South adds a skill-intensive good to its export product mix, which increases the relative demand for skilled labor in the South and hence its wage inequality. This example shows the logic of our argument: trade liberalization in the South, by expanding the set of its exportable goods (the added exportable goods are relatively skill-intensive in the South's product mix), can raise its own wage inequality. In what follows, we establish the argument formally.

3. The model

The 2×4 HO model conveys the intuition of our argument but is less convenient than DFS-type continuum models in formalizing the argument. Ideally

we would show the argument in a continuum HO model, but that turns out to be complicated and uninformative.[5] Instead we show our argument in a modified version of Dornbusch et al. (1977). The Ricardian structure simplifies the analysis because it avoids the HO complication of tracing endogenous boundary and endogenous factor intensity simultaneously. In our model the Ricardian continuum serves to endogenize the boundary and the factor intensity ranking is modeled by assuming that the Ricardian goods are skill-intensive relative to a numeraire good.

Consider two countries, South and North. Both countries produce manufactured goods modeled as a continuum over the interval $z \in [0,1]$. The production of these goods uses skilled labor as input; one unit of good z requires $a(z)$units of skilled labor in the South and $a^*(z)$ in the North.[6] We assume $a(z) \neq a^*(z)$ for all z and define $A(z) \equiv a^*(z)/a(z)$ as the productivity of skilled workers in the South relative to that in the North. Ranking goods such that $A'(z) < 0$. Thus the South has a relative productivity advantage in low-index manufactures and the North in high-index manufactures. We assume that the South also produces food using unskilled labor.[7] The South is endowed with skilled labor H and unskilled labor L, and the North with skilled labor H^* and no unskilled labor. Factor supplies are inelastic by assumption.

3.1. Tariff-driven nontraded goods

Suppose the South imposes a uniform *ad valorem* tariff t on imports from the North, and the North imposes tariff t^* on imports from the South. Denote w_h and w_h^* as skilled wages of the South and North, respectively. With perfect competition, the price of good z in the South equals $a(z)w_h$ if domestically produced and $(1+t)a^*(z)w_h^*$ if imported. Thus, the South imports good z if and only if $a(z)w_h \geq (1+t)a^*(z)w_h^*$. The equality defines the South's borderline import good z^m, whose value satisfies

$$A(z^m) = \frac{\nu}{1+t}, \tag{1}$$

where $\nu \equiv w_h/w_h^*$ is the South–North skilled wage ratio. Using the same reasoning, the South exports good z if and only if $(1+t^*)a(z)w_h \leq a^*(z)w_h^*$. The equality defines the South's borderline export good z^x, whose value satisfies

$$A(z^x) = (1+t^*)\nu. \tag{2}$$

[5] We report the results from solving the continuum HO model of Dornbusch et al. (1980) in an unpublished appendix available from the author.

[6] Throughout the paper we use an asterisk to denote variables of the North.

[7] Since the only role for factor intensity ranking in our argument is to identify the effect of boundary change on the South's relative factor demand, adding an unskilled-intensive good in the South's product mix serves this purpose adequately.

Inspecting (1) and (2), we find that $z^m = z^x$ if and only if $t = t^* = 0$. If either tariff is positive, then $z^m > z^x$. Since the South produces goods in the range $[0, z^m]$ and the North produces goods in the range $[z^x, 1]$, the goods in the range $[z^x, z^m]$ are tariff-driven nontraded goods.

3.2. Factor market equilibrium

With inelastic factor supply, wages are determined by factor demand, which is derived from commodity demand. Let us assume that all consumers have identical Cobb–Douglas preferences, with λ being the expenditure share on the continuum of manufactures. For simplicity, we further assume that all manufactured goods receive an equal share in expenditure.

Denote E as total expenditure of the South. Southern consumers spend λE on good z at the price $p(z) = a(z)w_h$, so they consume $\lambda E/[a(z)w_h]$ units of the good. Given that the unit skill requirement is $a(z)$, this consumption implies a skill demand of $\lambda E/w_h$. The range of Southern goods consumed by domestic consumers is $[0, z^m]$, so domestic consumption generates a total demand for Southern skilled labor equal to $z^m\lambda E/w_h$. Let E^* denote total expenditure of the North. Northern consumers spend λE^* at the price $(1 + t^*)p(z)$ on good z exported by the South, which implies a skill demand of $\lambda E^*/[(1 + t^*)w_h]$. The range of Southern goods exported to the North is $[0, z^x]$, so the North's consumption generates a total demand for Southern skilled labor equal to $z^x\lambda E^*/[(1 + t^*)w_h]$. Adding the domestic and foreign components of skill demand, we obtain the full employment condition for skilled workers in the South:

$$\lambda[z^m E + z^x E^*/(1 + t^*)] = w_h H. \tag{3}$$

The demand for Southern unskilled labor is generated by food consumption. Denote w_l as the South's unskilled wage. We choose units so that one unit of food requires one unit of unskilled labor. Using food as the numeraire, we have $w_l = 1$. Southern consumers spend $(1 - \lambda)E$ on food at the price one and Northern consumers spend $(1 - \lambda)E^*$ on food at the price $(1 + t^*)$. Thus the full employment condition for unskilled workers in the South is given by

$$(1 - \lambda)[E + E^*/(1 + t^*)] = L. \tag{4}$$

Dividing (3) by (4) yields the following expression for w_h:

$$w_h = \{z^m\xi + z^x(1 - \xi)\}\frac{\lambda L}{(1 - \lambda)H}, \tag{5}$$

where

$$\xi \equiv \frac{E}{E + E^*/(1 + t^*)} \tag{6}$$

is the South's share of world income (measured at the South's prices). Note that

the South's wage inequality is given by w_h since $w_l = 1$. Eq. (5) shows that the South's wage inequality depends on its export range $[0, z^x]$, import range $[z^m, 1]$, and share of world income ξ.

Following the same procedure, we obtain the North's full employment condition:

$$\lambda[(1 - z^m)E/(1 + t) + (1 - z^x)E^*] = w_h^* H^*. \tag{7}$$

Dividing (7) by (4), using the definition of ξ, we obtain

$$w_h^* = \left\{ \frac{(1 - z^m)\xi}{1 + t} + (1 - z^x)(1 + t^*)(1 - \xi) \right\} \frac{\lambda L}{(1 - \lambda)H^*}. \tag{8}$$

Eq. (8) shows the determination of the North's skilled wage. The South's and North's skilled wages are linked by the South–North skilled wage ratio,

$$\nu = w_h / w_h^*. \tag{9}$$

3.3. Commodity market equilibrium

World commodity market equilibrium implies balanced trade. Measured at world prices, the South imports manufactures of value $(1 - z^m)\lambda E/(1 + t)$, and the North imports manufactures of value $z^x \lambda E^*/(1 + t^*)$ and food of value $(1 - \lambda)E^*/(1 + t^*)$. Trade balance requires

$$\frac{(1 - z^m)\lambda E}{1 + t} = \frac{(z^x \lambda + (1 - \lambda))E^*}{1 + t^*}. \tag{10}$$

Using the definition of ξ, we rewrite (10) as

$$\frac{\xi}{1 - \xi} = \frac{z^x \lambda + (1 - \lambda)}{(1 - z^m)\lambda/(1 + t)}. \tag{11}$$

3.4. General equilibrium

The general equilibrium is characterized by the borderline-good Eqs. (1) and (2), the skilled-wage Eqs. (5) and (8), the South–North wage-gap Eq. (9), and the trade-balance Eq. (11). The equilibrium contains six endogenous variables, z^m, z^x, w_h, w_h^*, ν, and ξ, which can be solved from the six equations.

It is worth noting that the effects of tariff revenues are fully considered in the model. The South's total expenditure equals its total income:

$$E = w_l L + w_h H + t\left(\frac{(1 - z^m)\lambda E}{1 + t} \right). \tag{12}$$

The last term in (12) is the South's tariff revenue. We can rewrite Eq. (12) as

$$E = \frac{(1+t)(w_l L + w_h H)}{1+(1-(1-z^m)\lambda)t}. \tag{13}$$

Similarly we obtain the North's total income as

$$E^* = \frac{(1+t^*)w_h^* H^*}{1+(1-z^x)\lambda t^*}. \tag{14}$$

We can verify that these two income-expenditure equations are implied by the full-employment and trade-balance equations and hence are redundant.[8]

4. Effects of trade liberalization

In this section we first simplify the general equilibrium into two equations and two unknowns, which allows a graphic illustration of the model, and then derive the effects of trade liberalization in the form of tariff reduction.

First we obtain from Eq. (1) z^m as a function of ν and t:

$$z^m = z^m(\nu, t), \quad \frac{\partial z^m}{\partial \nu} < 0, \quad \frac{\partial z^m}{\partial t} > 0. \tag{15}$$

Eq. (16) says that the South's import range $(1-z^m)$ increases with ν and decreases with t. Intuitively, an (endogenous) increase in the South–North skilled wage ratio ν, by shifting comparative advantage towards the North, widens the South's import range, and an increase in the South's tariff, by shifting comparative advantage towards the South, narrows the South's import range. Similarly we obtain from Eq. (2) z^x as a function of ν and t^*:[9]

$$z^x = z^x(\nu, t^*), \quad \frac{\partial z^x}{\partial \nu} < 0, \quad \frac{\partial z^x}{\partial t^*} < 0. \tag{16}$$

Eq. (15) says that the South's export range z^x decreases with both ν and t^*.

Next we derive an expression for the South's share of world income, ξ. Substituting (15) and (16) into the trade-balance Eq. (11) yields

$$\xi = \xi(\nu, t, t^*), \quad \frac{\partial \xi}{\partial \nu} < 0, \quad \frac{\partial \xi}{\partial t} > 0, \quad \frac{\partial \xi}{\partial t^*} < 0. \tag{17}$$

The partial derivatives in (17) can be understood as follows. First, an (endogenous) increase in ν, by shifting comparative advantage towards the North, widens the South's import range and narrows its export range. This causes the South to run a

[8] To check this, we substitute (3) and (4) into (13), which yields the trade-balance Eq. (11). Similarly we can substitute (7) into (14) to obtain (11).

[9] The equilibrium values of z^m and z^x are assumed to be between zero and one in all the cases we consider.

trade deficit, which is restored in equilibrium by a decrease in its share of world income. Second, an increase in the South's tariff t narrows the South's import range, implying a trade surplus; to restore trade balance, the South's share of world income must rise in equilibrium. Third, an increase in the North's tariff t^* narrows the South's export range, implying a trade deficit; to restore trade balance, the South's share of world income must fall in equilibrium.

By substituting (15), (16), and (17) into the South's skilled wage Eq. (5), we establish the following relationship between w_h and ν:

$$w_h = \{z^m(\nu, t)\xi(\nu, t, t^*) + z^x(\nu, t^*)(1 - \xi(\nu, t, t^*))\}\frac{\lambda L}{(1-\lambda)H}. \tag{18}$$

In Fig. 1 we depict this relationship as the AA curve.[10] The slope of the curve and its direction of shift are given by the following partial derivatives:

$$\left.\frac{\partial w_h}{\partial \nu}\right|_{AA} < 0, \quad \left.\frac{\partial w_h}{\partial t}\right|_{AA} > 0, \quad \left.\frac{\partial w_h}{\partial t^*}\right|_{AA} < 0.$$

To close the model, we need a second relationship between w_h and ν. By substituting (15), (16), and (17) into the North's skilled wage Eq. (8), we obtain

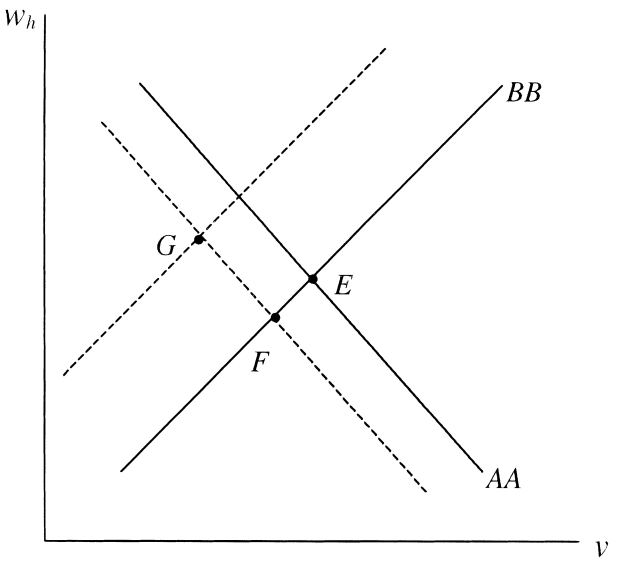

Fig. 1. Illustration of the equilibrium.

[10]The shape of the curve is not important to our analysis so we draw it as a straight line.

$$w_h^* = \left\{ \frac{(1 - z^m(\nu, t))\xi(\nu, t, t^*)}{1 + t} + (1 - z^x(\nu, t^*))(1 + t^*)(1 - \xi(\nu, t, t^*)) \right\} \frac{\lambda L}{(1 - \lambda)H^*}. \quad (19)$$

Substituting (19) into $\nu = w_h / w_h^*$ yields a second relationship between w_h and ν:

$$w_h = w_h^*(\nu, t, t^*)\nu. \quad (20)$$

In Fig. 1 we depict this relationship as the BB curve. The slope of the curve and its direction of shift are given by the following partial derivatives:

$$\frac{\partial w_h}{\partial \nu}\Big|_{BB} > 0, \quad \frac{\partial w_h}{\partial t}\Big|_{BB} < 0, \quad \frac{\partial w_h}{\partial t^*}|_{BB} > 0.$$

Fig. 1 shows the equilibrium at the intersection of the AA and BB curves where w_h and ν are simultaneously determined as functions of t and t^*.

4.1. Effects on terms of trade

Fig. 1 shows that a tariff has an unambiguous effect on the South–North skilled wage ratio, ν. According to (18), a decrease in t shifts down the AA curve and a decrease in t^* shifts it up. According to (20), a decrease in t shifts up the BB curve and a decrease in t^* shifts it down. These shifts establish:

Lemma 1. $d\nu/dt > 0$ *and* $d\nu/dt^* < 0$.

It is important to point out that a change in ν implies a change in the South's terms of trade. For any good z that the South exports, the change in its price (in response to a tariff change) is given by $\hat{p}(z) = \hat{w}_h$ using the hat notation for rate of change. For any good z' that the South imports, the change in its price is given by $\hat{p}^*(z') = \hat{w}_h^*$. So the ratio of the average price of the South's exported goods to the average price of its imported goods changes by $\hat{w}_h - \hat{w}_h^* = \hat{\nu}$. Thus the South's terms of trade moves in the same direction of ν. Lemma 1 states a result familiar from Dornbusch et al. (1977): ''an increase in the tariff improves the imposing country's relative wage and terms of trade'' (p. 831).

4.2. Effects on product mixes

Central to our analysis are responses of export and import product mixes to tariffs. Inspecting Eqs. (15) and (16), we find that a change in t or t^* has a direct effect and an indirect effect through ν. Consider a decrease in t, for example. The direct effect of this tariff reduction is that it reduces the South's competitiveness against imports from the North and hence increases its import range. The indirect

effect, as Lemma 1 indicates, is to lower the South's skilled wage relative to the North's (hence its terms of trade). This indirect effect enhances the South's competitiveness at both the export margin and import margin, thus increasing its export range and decreasing its import range. Adding up the direct and indirect effects, we find that a decrease in t will expand the South's export range but will have an ambiguous effect on its import range. Analogously, a decrease in t^* will reduce the South's import range but will have an ambiguous effect on its export range. These results are summarized in:

Lemma 2.

(i) $dz^x/dt < 0$, *and* dz^m/dt *is ambiguous*;
(ii) $dz^m/dt^* < 0$, *and* dz^x/dt^* *is ambiguous.*

4.3. Effects on wage inequality

Fig. 1 also shows the effects of trade liberalization on Southern wage inequality w_h. A tariff reduction in t or t^* always shifts the two curves in vertically opposite directions, and therefore the net effect depends on the relative magnitude of the two shifts.

Consider a decrease in t. As the South reduces the tariff, its import range expands, implying a smaller set of goods for domestic production and hence a smaller demand for skilled workers. Southern skilled wage falls and so does its terms of trade. This is illustrated in Fig. 1 by a movement from point E to point F. Point F is not an equilibrium point. As the South's import range expands, the demand for Northern skilled workers increases and hence w_h^* increases, which further worsens the South's terms of trade. The increase in the North's skilled labor cost leads the South to expand its export range, which raises the South's skill demand and wage inequality. This is illustrated in Fig. 1 by a movement from point F to point G.

We are interested in the possibility of rising wage inequality. Can the upward shift of the BB curve dominate the downward shift of the AA curve? The equations indicate that the relative magnitude of the shifts depends on the responsiveness of z^m to t and the responsiveness of z^x to t through ν. Intuitively the case of rising wage inequality is more likely to emerge if z^x is more responsive to t than z^m. While general conditions for this case are difficult to derive analytically, we can show it by solving the model numerically. For example, suppose $A(z) = 1 - z^2$ and $w_l = 1$, $L = 1$, $H = 0.5$, $H^* = 1$, $t^* = 0$, and $\lambda = 0.9$. We obtain the following results.[11]

[11]Mathematica 4.1 is used to solve the model. The program is available from the author upon request.

Table 1
Solutions to a numerical example

t	w_h	w_h^*	z^x	z^m	ν	ξ
0.6	5.601	5.633	0.075	0.615	0.994	0.437
0.3	5.598	5.764	0.170	0.503	0.971	0.424
0	5.600	6.200	0.311	0.311	0.903	0.380

Table 1 shows solutions to three possible equilibria. Suppose the South's initial tariff rate is 0.6. In this equilibrium, the South's skilled wage is 5.601 and the North's skilled wage is 5.633, both measured relative to the South's unskilled wage. The South produces manufactured goods in the range [0, 0.615] in addition to an agricultural good, and the North produces manufactured goods in the range [0.075, 1]. Because of the tariff, both countries export a narrower range of goods than they produce, rendering the goods in the range [0.075, 0.615] nontraded. The South's share of world income is 0.437 and the South–North skilled wage ratio is 0.994.

First we consider trade liberalization in the South that reduces its tariff rate from 0.6 to 0.3. Table 1 shows that this trade liberalization expands both the South's export range and its import range, making more goods tradable. In addition, it reduces the South's share of world income and its skilled wage relative to the North's. We find that this trade liberalization lowers the South's skilled wage and raises the North's skilled wage, a result that the Stolper–Samuelson theorem would predict in the conventional HO model.

Now suppose the South reduces its tariff rate further from 0.3 to zero. As before, the trade liberalization expands the South's export range and reduces the range of nontraded goods, and it lowers the South's share of world income and its skilled wage relative to the North's. In sharp contrast to the previous case, this further tariff reduction in the South increases both the South's skilled wage and the North's skilled wage. In fact we find in this numerical example a U-shaped relationship between the South's wage inequality w_h and its tariff rate t, with the threshold tariff rate at approximately 0.31. The U-shaped relationship says that when the South's tariff rate is above 0.31, a small reduction in t will lower its wage inequality. When the South's tariff rate is below 0.31, a small reduction in t will raise its wage inequality.

Further experiments show that the U-shaped relationship between wage inequality and tariff rate is not robust. For example, we have found the relationship to be of an inverted U-shape in one of our experiments. This is not surprising since the relative responsiveness of the export and import ranges does not depend systematically on the level of the tariff. However, our experiments indicate that rising wage inequality can easily emerge in equilibrium as a result of a tariff

reduction.[12] While falling wage inequality is equally possible, we focus on the possibility of rising wage inequality because it highlights the usefulness of our model in providing an account for the observed rising wage inequality in developing countries. We state our main result in:

Proposition 1. *In a North–South trading world with unequal factor prices and tariff-driven nontraded goods, a tariff reduction in the South, by changing the boundary between traded and nontraded goods, may increase its wage inequality.*

In Proposition 1 we emphasize that Southern trade liberalization per se can be a reason for rising wage inequality in the South. Throughout the presentation of the model we have included both t and t^*, so the effects of Northern tariff reductions and mutual tariff reductions can also be examined.[13] If the North also liberalizes trade, the effects on the terms of trade will be neutralized (Lemma 1). The decrease in t^*, however, adds a direct effect that expands the South's export range z^x. Thus, even if mutual tariff reductions make the terms of trade constant, there will still be an expansion in the South's export range, which increases the skill demand in the South. In this sense the consideration of Northern tariff reductions increases the likelihood that Southern wage inequality rises following trade liberalization.[14]

5. Conclusion

In this paper we investigated the boundary between traded and nontraded goods as a channel for international trade to impact factor prices. In contrast to conventional trade models which focus on the link between factor prices and commodity prices (Stolper–Samuelson), we emphasize the link between factor prices and product mixes. Trade liberalization affects not only commodity prices but also mixes of goods imported and exported. While some recent studies also examine product-mix changes, they model these changes as caused by foreign investment (Feenstra–Hanson) or technical progress (Trefler–Zhu). Our study

[12] We have numerical examples for both the current model and the model with a continuum of Heckscher–Ohlin goods.

[13] With minor modifications the model can be used to examine the effects of lowering global transport costs, i.e., a drop in t ($= t^*$), where t is reinterpreted as transport costs.

[14] Of course we need to compare the direct effect of Northern tariff reductions with the indirect terms-of-trade effect that makes the North export more products. The indirect effect implies a smaller set of goods in the South's production and hence decreases the South's skill demand.

examines trade liberalization per se as a source of product-mix changes and shows its implications for relative factor prices.

Like many recent studies of factor prices, our study was motivated by recent trends in wage inequality, in particular the observation of rising wage inequality in developing countries following trade liberalization. Our analysis provides a possible explanation for this observation. Trade protection makes some tradable goods nontraded. These goods are relatively skill-intensive in the South's production when factor prices are not equalized by trade. A tariff reduction in the South expands its import set, implying an inequality-reducing effect. Meanwhile it worsens the South's terms of trade and hence increases its export competitiveness, which expands its export set and implies an inequality-enhancing effect. We showed that the export expansion effect can dominate the import expansion effect and make the South's wage inequality rise in equilibrium. A distinctive feature of our trade-wages mechanism is the simultaneous expansion of export and import ranges accommodated by a shrinkage of nontraded goods.

Our theoretical exploration provides a new angle for empirical research of the relationship between trade and wages. Echoing Feenstra and Hanson (1996) in emphasizing the importance of examining shifts of traded goods between countries, our study points further to shifts between traded and nontraded goods as an equally important channel for empirical examination.

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