ELSEVIER
Journal of International Economics xx (2006) xxx–xxx
Journal of INTERNATIONAL ECONOMICS
www.elsevier.com/locate/econbase

New goods and the skill premium ☆

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Received 27 January 2003; received in revised form 28 July 2005; accepted 14 March 2006

Abstract

In a two-cone Heckscher–Ohlin model with CES preferences and a continuum of goods, new northern goods increase the northern skill premium if they are skilled-labor intensive, and may increase the premium if they are unskilled-labor intensive. Thus, the introduction of new goods into US technology could have done more to increase the US skill premium than a closed-economy model would predict. I also explore how new northern goods affect the southern skill premium and what happens if they generate preference-induced reversals across existing goods. I develop a two-step solution method that simplifies comparative static analyses in the two-cone Heckscher–Ohlin model.

Keywords: New goods; Skill premium; Two-cone Heckscher–Ohlin model; Preference-induced reversals; Two-step solution method

JEL classification: F1

1. Introduction

It is well documented that the US skill premium (i.e. the wage of skilled workers relative to that of unskilled workers) increased in the 1980s (e.g. Bound and Johnson, 1982). Meanwhile, many new products also emerged in this period (e.g. Xiang, 2005). Is there a causal link? This paper focuses on

☆ This research was supported by a fellowship from the Social Science Research Council (SSRC) Program in Applied Economics with funds provided by the John D. and Catherine T. MacArthur Foundation while I was an SSRC Program in Applied Economics Fellow. I have benefited tremendously from the advice of Alan V. Deardorff and Gordon H. Hanson. I have also benefited from the comments of John Bound, Jonathan Eaton, Miles Kimball, Steve Martin, Katherine Terrell, two anonymous referees, and seminar participants at Michigan, Princeton, Rochester, Syracuse, UCLA, UCSD, Dartmouth, Indiana, Georgia, Clemson, Purdue, Wisconsin and Georgetown.
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doi:10.1016/j.jinteco.2006.03.002

how new northern goods affect the northern and southern skill premia using a two-cone Heckscher–Ohlin (HO) model in which the North is relatively abundant in skilled labor, the South is relatively abundant in unskilled labor and preferences are CES (Constant Elasticity of Substitution).

When new northern goods do not change the preferences for the old goods, the new northern goods necessarily increase the northern skill premium if they are skilled-labor intensive, and may even increase the premium if they are unskilled-labor intensive. The latter is because of what I call the "international factor market effect" of new northern goods: they increase the relative demand for the North's products and thus for the North's factor services. As the North's factors become more expensive, this country stops producing the least skilled-labor intensive products. This tends to increase the North's relative skilled labor demand and thus the northern skill premium.

Therefore, compared with the closed-economy model in which new northern goods decrease the northern skill premium if they are unskilled-labor intensive, new northern goods make a larger contribution to the northern skill premium in the two-cone open-economy model.

On the other hand, new northern goods necessarily increase the southern skill premium if they are unskilled-labor intensive, and may even increase the premium if they are skilled-labor intensive. Again, the latter is because of their international factor market effect. Following the introduction of new northern goods, the South takes over the production of the least skilled-labor intensive northern goods from the North. Since these goods are the most skilled-labor intensive in the South, the South's relative skilled labor demand tends to increase and so does the southern skill premium.

New northern goods may also change the preferences for the old goods, and such induced preference changes could counter and dominate the direct effects of new goods, leading to preference-induced reversals (the PIR). For example, if new northern goods that are skilled-labor intensive shift preferences away from skilled-labor intensive old northern goods, they may decrease the North's relative skilled labor demand and thus the northern skill premium. However, the PIR does not occur if the changes in the preferences for the old goods are uncorrelated with the skilled-labor intensities of the old goods and unrelated to where the old goods are produced.

To streamline the analysis of the ways new goods affect skill premia, I develop the following two-step solution method. Step 1 derives how new goods change relative factor demand. Step 2 then takes the changes in relative factor demand as given and derives the changes in skill premia.

Zhu (2001) shows that new northern goods increase the northern skill premium when the preferences are Cobb–Douglas and the new goods are more skilled-labor intensive than every old good. This paper differs from Zhu (2001) in three ways. First, I show that even unskilled-labor intensive new northern goods could increase the northern skill premium. Second, I explore whether new northern goods still increase the northern skill premium when preferences are CES (so that the demand for every good responds to relative goods prices) and preference-induced reversals may occur. Finally, the two-step solution method developed in this paper simplifies the analyses of many other comparative static exercises in the two-cone HO model.

In what follows, Section 2 sets up the model. Section 3 derives the results assuming that new goods do not change the preferences for the old goods. Section 4 develops the two-step solution method to tackle induced preference changes and the PIR. Section 5 concludes.

2. The model

Consider a Heckscher–Ohlin model with a continuum of goods (Dornbusch et al., 1980). The goods are indexed by $z \in [0, 1]$ and each good is produced by a constant-returns-to-scale technology using two factors, skilled labor and unskilled labor. The wages of skilled and unskilled

labor are w_s and w_u, and $\omega \equiv w_u/w_s$ is the relative wage of *unskilled* labor, or the inverse of the skill premium. For good z, $a_s(z)$ and $a_u(z)$ are the unit factor requirements, $\theta_s(z)$ and $\theta_u(z)$ are the income shares of skilled and unskilled labor in production, and $\beta(z) \equiv a_s(z)/a_u(z)$ is the skilled-labor intensity. In general, $a_s(z)$, $a_u(z)$, $\theta_s(z)$, $\theta_u(z)$ and $\beta(z)$ may all depend on factor prices. Assume that factor intensity reversal is absent and $\beta(z)$ increases with z; i.e. skilled-labor intensive goods have larger indices. To facilitate explaining the intuition of the results, assume that the preferences are Cobb–Douglas with expenditure shares $b(z)$ such that $\int_0^1 b(z)\mathrm{d}z = 1$. Appendix 1 shows that all the results hold under the more general CES preferences.

There are two countries, the North and the South, and they are identical except that the North is relatively abundant in skilled labor. The North's skilled and unskilled labor endowments are L_s and L_u, and $\gamma \equiv L_s/L_u$ is the North's relative supply of skilled labor. All the variables pertaining to the South have the superscript "*". Without loss of generality, let $L_u = L_u^*$. Assume that all goods markets are perfectly competitive, international trade is barrier-free and factors are perfectly mobile domestically but immobile internationally. Assume also that the North and the South have sufficiently different skilled-labor endowments so that the equilibrium involves complete specialization (i.e. there are two diversification cones): the North produces the skilled-labor intensive goods $[g, 1]$ and the South produces the unskilled-labor intensive goods $[0, g]$. In other words, except for the common good g produced in both countries, every northern good is more skilled-labor intensive than every southern good.

For the good z, its price $P(z)$ equals its marginal cost $\mathrm{MC}(z)$:

$$P(z) = \mathrm{MC}(z) = w_s A_s(z); A_s(z) \equiv a_u(z)[\omega + \beta(z)] \qquad \forall z \in [0, 1] \tag{1}$$

Let $h(z) \equiv \ln \frac{\mathrm{MC}(z)}{\mathrm{MC}^*(z)}$ denote the log of the marginal cost of good z in the North relative to the marginal cost of good z in the South. Since both the North and the South produce good g, $\mathrm{MC}(g) = \mathrm{MC}^*(g)$ so that:

$$h(g) = 0; h(g) = \ln \frac{\mathrm{MC}(g)}{\mathrm{MC}^*(g)} = \ln \frac{w_s}{w_s^*} + \ln \frac{a_u(g)[\omega + \beta(g)]}{a_u^*(g)[\omega^* + \beta^*(g)]} \tag{2}$$

where the last equality substitutes for $\mathrm{MC}(g)$ and $\mathrm{MC}^*(g)$ using Eq. (1).

Moving on to the market for skilled labor in the North, the demand for skilled labor by good z is $a_s(z)Q(z)$, where $Q(z)$ is good z's output. When the market for skilled labor clears, the aggregate demand equals the aggregate supply: $\int_g^1 a_s(z)Q(z)\mathrm{d}z = L_s$. On the other hand, by definition, $b(z) = P(z)Q(z)/y$, where y is the aggregate northern expenditure and $\theta_s(z) = w_s a_s(z)/P(z)$. Substitute the expressions for $b(z)$ and $\theta_s(z)$ into the market clearing condition for skilled labor and rearrange: $\int_g^1 b(z)\theta_s(z)\mathrm{d}z = w_s L_s/y$. Likewise, when the market for unskilled labor clears in the North, $\int_g^1 b(z)\theta_u(z)\mathrm{d}z = w_u L_u/y$. Take the ratio of these two market clearing conditions and re-arrange:

$$\frac{1}{\omega} = \frac{\mu(\omega, g)}{\gamma}, \mu(\omega, g) = \frac{\int_g^1 b(z)\theta_s(z)\mathrm{d}z}{\int_g^1 b(z)\theta_u(z)\mathrm{d}z} \tag{3}$$

Eq. (3) says that the skill premium $1/\omega$ is inversely proportional to the relative skilled-labor supply, γ, and proportional to the relative skilled labor demand, $\mu(.)$. Since $\mu(.)$ is the ratio of the average income share of skilled labor to the average income share of unskilled labor, both

weighted by the goods' expenditure shares, it can be thought of as the average skilled-labor intensity, based on factor income shares, across all sectors of the northern economy.

Similarly for the South:

$$\frac{1}{\omega^*} = \frac{\mu^*(\omega^*, g)}{\gamma^*}, \mu^*(\omega^*, g) = \frac{\int_0^g b(z)\theta_s^*(z)\mathrm{d}z}{\int_0^g b(z)\theta_u^*(z)\mathrm{d}z} \tag{4}$$

Finally, for every southern good z, the North's expenditure on it is $yb(z)$, and so the North's aggregate expenditure on the southern goods, or the value of the North's imports, is $\int_0^g yb(z)\mathrm{d}z$. Likewise, the value of the North's exports is $\int_g^1 y^* b(z)\mathrm{d}z$. As international payments are balanced, $\int_g^1 y^* b(z)\mathrm{d}z = \int_0^g yb(z)\mathrm{d}z$. Since aggregate expenditure equals aggregate factor income, $y = w_s L_s + w_u L_u$ and $y^* = w_s^* L_s^* + w_u^* L_u^*$. Substitute the expressions for y and y^* into the balance-of-payments condition and re-arrange, using the assumption that $L_u = L_u^*$:

$$\frac{w_s}{w_s^*} = \Lambda(g)\frac{\omega^* + \gamma^*}{\omega + \gamma}, \Lambda(g) = \frac{\int_g^1 b(z)\mathrm{d}z}{\int_0^g b(z)\mathrm{d}z} \tag{5}$$

Since international trade in goods can be viewed as the exchange of factor services, intuitively, we can think of Eq. (5) as the equilibrium condition of the international market for equivalent skilled labor, a hypothetical factor that always has the same price as skilled labor. $\Lambda(g)$ is the ratio of the aggregate expenditure share of northern goods to southern goods and can be interpreted as the relative demand for the North's equivalent skilled labor. Its relative supply is $(\omega+\gamma)/(\omega^*+\gamma^*)$ because one unit of skilled and unskilled labor is converted to 1 and ω unit(s) of equivalent skilled labor. Thus, the relative price of the North's equivalent skilled labor, w_s/w_s^*, is inversely proportional to its relative supply and proportional to its relative demand.

The equilibrium is fully characterized by Eqs. (2)–(5), which jointly determine three relative factor prices, ω, ω^*, and w_s/w_s^*, as well as the index of the common good, g.

3. Preference-neutral new goods

Assume that new goods appear only in the North.[1] To model them, imagine a small hole $[z_n, z_n + \mathrm{d}z_n]$ in the range of northern goods $[g, 1]$; as new goods appear, this hole is filled up. Since the hole is small, the original equilibrium is well approximated by Eqs. (2)–(5).[2]

Let x denote the value of any variable x after the introduction of new goods. The Cobb–Douglas preferences necessitate specifying how the expenditure shares of the old goods change:

Definition 1. New goods are *preference-neutral* if, for every old good z, $b'(z) = \rho b(z)$, where ρ is 1 minus the aggregate expenditure share of the new goods.

In other words, the new goods are preference-neutral if the expenditure share of every old good decreases by the same proportion. The case of the new goods that are not preference-neutral is taken up in Section 4.

[1] New Southern goods are discussed in the working paper version of this paper; they offer the same insights as new northern goods.

[2] This setup has Zhu (2001) as a special case with $z_n = 1$.

3.1. Effects on the northern skill premium

How new goods affect the northern skill premium depends on their skilled-labor intensity.

Definition 2. New goods are *skilled-labor intensive within the North* if $b_\psi>0$, *unskilled-labor intensive within the North* if $b_\psi<0$ and *skilled-labor neutral within the North* if $b_\psi=0$, where b_ψ

$$= \left[\frac{b(z_n)\theta_s(z_n)}{\int_g^1 b(z)\theta_s(z)dz} - \frac{b(z_n)\theta_u(z_n)}{\int_g^1 b(z)\theta_u(z)dz}\right]dz_n.$$

b_ψ is the marginal increase in the log of the North's relative skilled labor demand, $\mu(.)$, following the creation of the new goods. To better understand how the sign of b_ψ is determined, note that

$$b_\psi<0 \Leftrightarrow \frac{\theta_s(z_n)b(z_n)}{\theta_u(z_n)b(z_n)} < \frac{\int_g^1 b(z)\theta_s(z)dz}{\int_g^1 b(z)\theta_u(z)dz} = \mu(\omega, g) \tag{6}$$

Since Eq. (3) can be re-written as $\gamma=\omega\mu(.)$, in equilibrium, γ equals the North's average skilled-labor intensity based on factor quantities (i.e. physical units). Substituting for $\mu(.)$ in Eq. (6) using this expression yields:

$$b_\psi<0 \Leftrightarrow \beta(z_n)<\gamma \tag{7}$$

i.e. $b_\psi<0$ if the new goods are less skilled-labor intensive than average, and vice versa.

To solve for the change in the northern skill premium, totally differentiate Eq. (2) and the logs of Eqs. (3), (4), and (5) and then solve the resulting system of linear equations. As shown in the Mathematical Appendix (this appendix is available upon request from the author):[3]

$$\operatorname{sgn}\left(d\frac{w_s}{w_u}\right) = -\operatorname{sgn}(\omega) = \operatorname{sgn}(b_\psi + c_1 b)$$

$$b = \frac{b(z_n)}{\int_g^1 b(z)dz}dz_n>0, c_1 = -\frac{a_{21}a_{33}}{a_{13}a_{31}-a_{11}a_{33}}>0, a_{33} = \frac{\partial \ln[\omega^*\mu^*(\omega^*, g)]}{\partial \omega^*}>0,$$

$$a_{21} = \frac{b(g)\theta_u(g)}{\int_g^1 b(z)\theta_u(z)dz} - \frac{b(g)\theta_s(g)}{\int_g^1 b(z)\theta_s(z)dz}>0, a_{13} = \frac{1}{\omega^*+\beta^*(g)} - \frac{1}{\omega^*+\gamma^*}<0,$$

$$a_{31} = \frac{b(g)\theta_s^*(g)}{\int_0^g b(z)\theta_s^*(z)dz} - \frac{b(g)\theta_u^*(g)}{\int_0^g b(z)\theta_u^*(z)dz}>0, a_{11} = \frac{b(g)}{\int_0^g b(z)dz} + \frac{b(g)}{\int_g^1 b(z)dz} - \frac{\partial h(g)}{\partial g}>0 \tag{8}$$

Therefore:

Proposition 1. *Under Cobb–Douglas preferences new northern goods that are preference-neutral raise the northern skill premium if they are skilled-labor intensive or skilled-labor neutral within the North while the effect is ambiguous if they are unskilled-labor intensive within the North.*

[3] The meanings of the a's are discussed in the Mathematical Appendix.

To understand the intuition of Proposition 1, consider Eq. (8). The first term in Eq. (8) is b_ψ, and it measures what I call the "domestic factor market effect" of the new northern goods. When they are created, consumers shift demand away from the old goods towards them. The existing sectors contract and release both skilled and unskilled labor. When the new goods are unskilled-labor intensive within the North ($b_\psi, <0$), they demand a higher proportion of unskilled labor compared with the factors released by the existing sectors, creating excess demand for unskilled labor and putting downward pressure on the northern skill premium. On the other hand, b_ψ increases with $\beta(z_n)$ because as $\beta(z_n)$ increases, $\theta_s(z_n)$ increases and $\theta_u(z_n)$ decreases since $\theta_s(z_n)+\theta_u(z_n)=1$. Thus, the more the skilled-labor intensity of the new goods differs from the northern average, the larger the magnitude of the domestic factor market effect. Fig. 1 graphs b_ψ against the skilled-labor intensity of the new goods, $\beta(z_n)$. Since b_ψ increases with $\beta(z_n)$ and $b_\psi<0$ if and only if $\beta(z_n)<\gamma$, we get the upward-sloping dashed line $D_N D_N$ that intersects the horizontal axis at $\beta(z_n)=\gamma$. This line represents the domestic factor market effect.

The second term in Eq. (8) is $c_1 b$. b measures the marginal increase in the log of the relative demand for the North's equivalent skilled labor, $\Lambda(g)$, following the introduction of the new goods, and $b>0$ regardless of the skilled-labor intensity of the new goods. This is because the new goods appear in the North and consumers shift demand towards the North's products, which increases the relative demand for the North's factor services. Then the North's factors become more expensive, and the most unskilled labor-intensive sectors shut down in this country, releasing a mix of factors with lower-than-average skilled labor content. This creates excess supply of unskilled labor and so tends to increase the skill premium. This is what I call the "international factor market effect" of the new northern goods and it is measured by $c_1 b$, which does not depend on the skilled-labor intensity of the new goods. When $c_1 b$ is graphed against $\beta(z_n)$ in Fig. 1, we get the horizontal dashed line $I_N I_N$ above the horizontal axis. This line represents the international factor market effect.

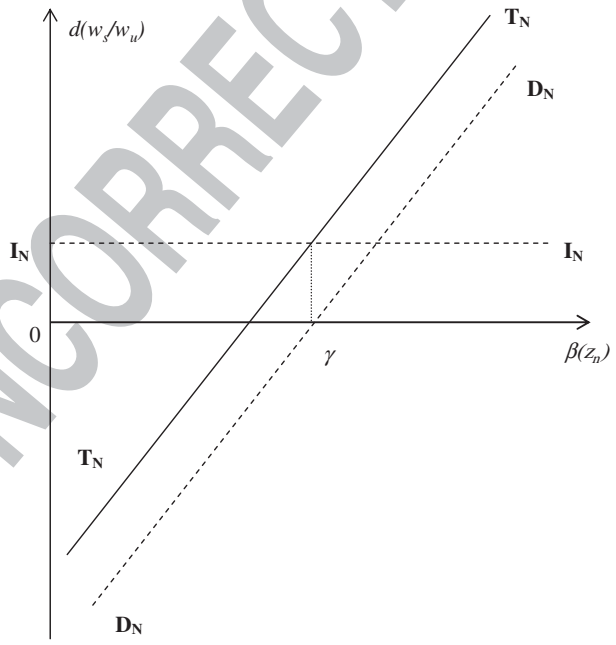

Fig. 1. Effects on the northern skill premium.

To determine the sign of $d(w_s/w_u)$ in Fig. 1, shift D_ND_N up to the solid line T_NT_N by the distance between I_NI_N and the horizontal axis. T_NT_N represents the sum of the domestic and international factor market effects. If it is above the horizontal axis, new goods increase the northern skill premium, and vice versa.

Suppose the new goods are slightly unskilled-labor intensive within the North; i.e. $\beta(z_n)$ is slightly smaller than γ. In Fig. 1, imagine drawing a vertical line that intersects the horizontal axis slightly to the left of γ. Then this imaginary line intersects D_ND_N slightly below the horizontal axis: the domestic factor market effect is slightly less than 0. However, this imaginary line intersects I_NI_N way above the horizontal axis: independent of $\beta(z_n)$, the international factor market effect is considerably larger than 0. Thus, the international factor market effect dominates, the imaginary line intersects T_NT_N above the horizontal axis in Fig. 1 and $d(w_s/w_u)>0$. The northern skill premium has increased even though the new goods are unskilled-labor intensive within the North and reduce the North's relative skilled labor demand, ceteris paribus.

On the other hand, when the new goods are skilled-labor intensive within the North, imagine drawing a vertical line that intersects the horizontal axis to the right of γ in Fig. 1. Since the imaginary line intersects both I_NI_N and D_ND_N above the horizontal axis, the domestic and international factor market effects work in the same direction and the northern skill premium increases. This is consistent with the finding of Zhu (2001), who considers the case of $z_n=1$.

Finally, consider introducing the same new goods, $[z_n, z_n+dz_n]$, in a closed economy that produces the goods $[g, 1]$. Then the international factor market effect is shut off, and in Fig. 1, the change in the skill premium is determined by D_ND_N alone. Thus, in a closed-economy model, new goods decrease the northern skill premium if they are unskilled-labor intensive within the North.

Therefore, due to the international factor market effect, new northern goods make a larger contribution to the northern skill premium in the two-cone open-economy model than in the closedeconomy model. Xiang (2005) shows that in the 1980s, the new goods that emerged in the US manufacturing sector were over 40% more skilled-labor intensive than the old goods, and using a closed-economy model, he shows that these new goods could account for about 30% of the increase in the relative skilled labor demand in US manufacturing. Then in light of Proposition 1, the new US manufacturing goods may be shown to have done more to increase the US skill premium in a two-cone open-economy model that takes into account the US trade with developing countries.

3.2. Effects on the southern skill premium

As shown in the Mathematical Appendix, the change in the southern skill premium is:[4]

$$\operatorname{sgn}\left(\mathrm{d}\frac{w_s^*}{w_u^*}\right) = -\operatorname{sgn}(\omega^*) = \operatorname{sgn}(-b_\psi + c_2 b)$$

$$c_2 = -\frac{a_{21}}{a_{12}} > 0, a_{12} = \frac{1}{\omega+\gamma} - \frac{1}{\omega+\beta(g)} < 0. \tag{9}$$

Therefore:

Proposition 2. *Under Cobb–Douglas preferences new northern goods that are preference-neutral raise the southern skill premium if they are unskilled-labor intensive or skilled-labor*

[4] b_ψ, b and a_{21} are the same as in Eq. (8) and the meaning of a_{12} is discussed in the Mathematical Appendix.

neutral within the North while the effect is ambiguous if they are skilled-labor intensive within the North.

To understand the intuition of Proposition 2, consider Eq. (9). The second term in Eq. (9), $c_2 b$, measures the international factor market effect. As the new goods appear in the North and increase the relative demand for the North's equivalent skilled labor, the North's factors become more expensive and the production of the most unskilled-labor intensive northern goods switches from the North to the South. Since these goods are the most skilled-labor intensive southern goods, the switching creates excess demand for the South's skilled labor and tends to increase the southern skill premium. As in Section 3.1, the magnitude of the international factor market effect does not depend on the skilled-labor intensity of the new northern goods, and so when $c_2 b$ is graphed against $\beta(z_n)$ in Fig. 2, we get the horizontal dashed line $I_S I_S$ above the horizontal axis. This line represents the international factor market effect.

The first term in Eq. (9), $-b_\psi$, measures the domestic factor market effect that the new northern goods have on the southern skill premium. Suppose the new northern goods are unskilled labor intensive within the North ($b_\psi < 0$). Then the North's relative skilled labor demand tends to decrease so that in this country, unskilled labor becomes more expensive relative to skilled labor. This increases the marginal cost of northern production for the most unskilled-labor intensive northern goods. As a result, the production of these goods switches to the South. Since they are the most skilled-labor intensive southern goods, the South's relative skilled labor demand increases and so does the southern skill premium. As in Section 3.1, the more the skilled-labor intensity of the new northern goods differs from the northern average, the larger the magnitude of the domestic factor market effect. But unlike in Section 3.1, the domestic factor market effect is $-b_\psi$ and decreases with $\beta(z_n)$. When $-b_\psi$ is graphed against $\beta(z_n)$ in Fig. 2, we get the downward-sloping dashed line $D_S D_S$ that intersects the horizontal axis at $\beta(z_n) = \gamma$. This line represents the domestic factor market effect.

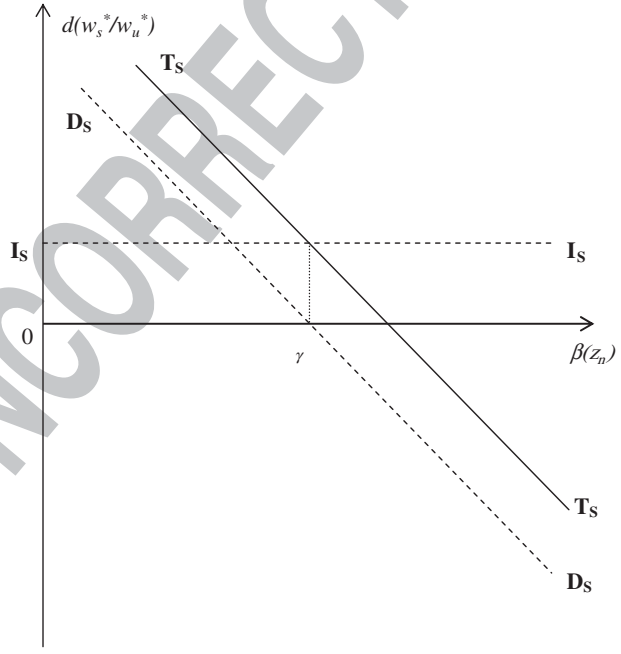

Fig. 2. Effects on the southern skill premium.

To determine the sign of $d(w_s^*/w_u^*)$ in Fig. 2, shift D_SD_S up to the solid line T_ST_S by the distance between I_SI_S and the horizontal axis. T_ST_S represents the sum of the domestic and international factor market effects. If it is above the horizontal axis, the new northern goods increase the southern skill premium, and vice versa.

When the new northern goods are skilled-labor intensive within the North, we are to the right of γ in Fig. 2. The domestic and international factor market effects work in opposite directions and the southern skill premium may increase or decrease. On the other hand, if the new northern goods are unskilled-labor intensive within the North, we are to the left of γ in Fig. 2. The domestic and international factor market effects work in the same direction, and the southern skill premium necessarily increases.

The results concerning the changes in g are discussed in the Mathematical Appendix.

4. Induced preference changes and preference-induced reversals (the PIR)

When new goods are preference neutral, skilled-labor intensive new goods always increase the relative skilled labor demand. What if the expenditure shares of some old goods change proportionately more than those of the others? For example, personal computers may have decreased the expenditure share of type-writers by proportionately more than, say, beef. Such induced preference changes provide an additional channel through which new goods affect relative factor demand and may counter and dominate the direct effects of the new goods, leading to preference-induced reversals (the PIR henceforth).

When the PIR occurs, new northern goods that are skilled-labor intensive within the North decrease the North's relative skilled labor demand. For a concrete example, consider an economy producing goods 1, 2 and 3, whose skilled-labor intensities increase with the index numbers. A new good, 4, appears, and it is as skilled-labor intensive as good 3. Through induced preference changes, good 4 replaces good 3 in consumption, increases the expenditure share of good 1 and decreases that of good 2. Then the average skilled-labor intensity, $\mu(.)$, which is also the relative skilled labor demand, decreases. On the other hand, when the PIR occurs, new northern goods decrease the relative demand for the North's factors because the new goods decrease the expenditure shares of the old northern goods by proportionately more than the old southern goods.

One way to tackle the PIR is to add induced preference changes into the comparative static exercises and crank out the results. However, this risks making the results messy and complex and losing the intuition. Instead, consider the following two-step solution method. Step 1 shows how new northern goods change relative factor demand. Step 2 then takes the changes in relative factor demand as given and derives the changes of the skill premia (and the other endogenous variables). The results from step 2 have the same intuition as those in Section 3. There, the results depend on b_ψ, the change in the North's relative skilled labor demand, plus b_Γ, the change in the relative demand for the North's factors. To draw a *loose* comparison, step 2 is *like* asking, what are the results if we know the signs of b_ψ and b_Γ? Likewise, step 1 is *like* asking, how do new goods determine the signs of b_ψ and b_Γ?

The two-step solution method streamlines the process of tackling the PIR. Since the PIR changes the way new goods affect relative factor demand, it affects step 1, and only step 1: step 2 starts from the given changes in relative factor demand and so is not affected by the PIR at all. Furthermore, the two-step solution method simplifies the analyses of many other comparative static exercises in the two-cone Heckscher-Ohlin model because even if the exogenous change is not the introduction of new goods, step 2 remains the same and so the results of step 2 derived below, shown in Table 1, can be used. Appendix 1 contains two examples of such applications.

Table 1
Results for given changes in relative factor demand

	$\psi>0$	$\psi=0$	$\psi<0$
$\Gamma>0$			
$\psi^*>0$	–	$(w_s^*/w_u^*)\uparrow$	$(w_s^*/w_u^*)\uparrow$
$\psi^*=0$	$(w_s/w_u)\uparrow$	$(w_s^*/w_u^*)\uparrow$, $g\uparrow$, $(w_s/w_u)\uparrow$	$(w_s^*/w_u^*)\uparrow$, $g\uparrow$
$\psi^*<0$	$(w_s/w_u)\uparrow$	$(w_s/w_u)\uparrow$, $g\uparrow$	$g\uparrow$
$\Gamma=0$			
$\psi^*>0$	$g\downarrow$	$g\downarrow$, $(w_s/w_u)\downarrow$, $(w_s^*/w_u^*)\uparrow$	$(w_s/w_u)\downarrow$, $(w_s^*/w_u^*)\uparrow$
$\psi^*=0$	$g\downarrow$, $(w_s/w_u)\uparrow$, $(w_s^*/w_u^*)\downarrow$	No effect	$(w_s/w_u)\downarrow$, $(w_s^*/w_u^*)\uparrow$, $g\uparrow$
$\psi^*<0$	$(w_s/w_u)\uparrow$, $(w_s^*/w_u^*)\downarrow$	$(w_s/w_u)\uparrow$, $(w_s^*/w_u^*)\downarrow$, $g\uparrow$	$g\uparrow$
$\Gamma<0$			
$\psi^*>0$	$g\downarrow$	$g\downarrow$, $(w_s/w_u)\downarrow$	$(w_s/w_u)\downarrow$
$\psi^*=0$	$g\downarrow$, $(w_s^*/w_u^*)\downarrow$	$g\downarrow$, $(w_s/w_u)\downarrow$, $(w_s^*/w_u^*)\downarrow$	$(w_s/w_u)\downarrow$
$\psi^*<0$	$(w_s^*/w_u^*)\downarrow$	$(w_s^*/w_u^*)\downarrow$	–

Notes: By Proposition A1, the results in this table hold under CES preferences. Γ is the country friendliness of new goods and $\Gamma>0$ if new goods increase the relative demand for the North's factors. ψ^* is the factor friendliness of new goods in the South and $\psi^*>0$ if new goods increase the South's relative skilled labor demand. ψ is the factor friendliness of new goods in the North and $\psi>0$ if new goods increase the North's relative skilled labor demand. w_s/w_u and w_s^*/w_u^* are the northern and the southern skill premia. g is the common good both the North and the South produce; when g increases, the North produces a narrower range of goods and the South produces a wider range of goods. When w_s/w_u, w_s^*/w_u^* or g does not appear in a cell, this variable may increase or decrease. A "–" indicates that all the 3 variables, w_s/w_u, w_s^*/w_u^* and g, may increase or decrease.

Since the two-cone HO model is widely used in the literature (e.g. Deardorff, 1998; Feenstra and Hanson, 1997; Xu, 1993) and consistent with a few empirical studies (e.g. Debaere and Demiroglu, 2003; Schott, 2003), the two-step solution method may be useful for future research.

4.1. Step 2: the results for given changes in relative factor demand

The change in the North's relative skilled labor demand is ψ:

Definition 3. New goods are *skilled-labor friendly within the North* if $\psi>0$, *unskilled-labor friendly within the North* if $\psi<0$ and *factor neutral within the North* if $\psi=0$, where $\psi\equiv\mu'(\omega, g)-\mu(\omega, g)$.

ψ is evaluated at the constant factor price ω. By Definition 3, if the new goods are skilled-labor friendly within the North, they increase the North's relative skilled labor demand. This definition circumvents the demand responses to new goods before they become skilled-labor friendly; i.e. we start from the knowledge that the relative skilled labor demand has increased at original factor prices.

For example, new goods can be unskilled-labor friendly within the North either because they are unskilled-labor intensive within the North and preference-neutral, or because they are skilled-labor intensive within the North but the PIR occurs. How new goods affect the relative skilled labor demand is discussed in Section 4.2. The change in the relative demand for the North's factors is Γ:

Definition 4. New goods are *friendly to the North* if $\Gamma>0$, *friendly to the South* if $\Gamma<0$ and *country-neutral* if $\Gamma=0$, where $\Gamma\equiv\Lambda'(g)-\Lambda(g)$.

In addition, since induced preference changes may happen to the old southern goods, new northern goods could change the South's relative skilled labor demand, $\mu^*(\omega^*, g)$. Let ψ^* denote the change of $\mu^*(.)$:

Definition 5. New goods are *skilled-labor friendly within the South* if $\psi^*>0$, *unskilled-labor friendly within the South* if $\psi^*<0$ and *factor-neutral within the South* if $\psi^*=0$, where $\psi^* \equiv \mu^{*\prime}(\omega^*, g)-\mu^*(\omega^*, g)$.

ψ^* is evaluated at the constant factor price ω^*.

As shown in the Mathematical Appendix:

Proposition 3. *Under Cobb–Douglas preferences, new northern goods raise the northern skill premium if they are skilled-labor friendly or factor neutral within the North, unskilled-labor friendly or factor neutral within the South and friendly to the North or country-neutral; they lower the premium if their factor friendliness and country friendliness are reversed while the effect is ambiguous in all other cases.*

Proposition 4. *Under Cobb–Douglas preferences, new northern goods raise the southern skill premium if they are unskilled-labor friendly or factor neutral within the North, skilled-labor friendly or factor neutral within the South and friendly to the North or country-neutral; they lower the premium if their factor friendliness and country friendliness are reversed while the effect is ambiguous in all other cases.*

The intuition of Propositions 3 and 4 is similar to that of Propositions 1 and 2. To facilitate using Propositions 3 and 4, they are presented in Table 1.[5] Table 1 also shows the results concerning the change in g.

4.2. Step 1: how do new goods change relative factor demand?

Suppose that new northern goods are skilled-labor intensive within the North, and consider their effect on the North's relative skilled labor demand. Since the PIR might occur, let us first explore its cause. Intuitively, the PIR might occur if the new goods decrease the expenditure shares of skilled-labor intensive old northern goods proportionately more than those of unskilled-labor intensive old northern goods. In some sense, the new goods are more "complementary" with unskilled-labor intensive old northern goods. To clarify the meaning of being "complementary," consider the aggregate expenditure share of all the old goods: before the new goods appear, it is 1; after that, it becomes 1 minus the aggregate expenditure share of the new goods, or the parameter ρ in the definition of preference neutrality (Definition 1). For an old good z, let $\varepsilon(z) \equiv b'(z)-\rho b(z)$. Since by construction $\int_0^1 \varepsilon(z)\mathrm{d}z = 0$, if $\varepsilon(z)>0$, the expenditure share of good z falls by less than the average of all the old goods and so is a "complement" of the new goods. In this new terminology, the PIR might occur if the "complements" of the new goods are also unskilled-labor intensive.

To be rigorous, totally differentiate the log of $\mu(.)$ at constant factor prices:

$$\mathrm{sgn}(\psi) = \mathrm{sgn}[\mathrm{dln}\mu(.)] = \mathrm{sgn}(b_\psi + \pi), \pi = \frac{\int_g^1 \varepsilon(z)\theta_s(z)\mathrm{d}z}{\int_g^1 b(z)\theta_s(z)\mathrm{d}z} - \frac{\int_g^1 \varepsilon(z)\theta_u(z)\mathrm{d}z}{\int_g^1 b(z)\theta_u(z)\mathrm{d}z} \tag{10}$$

The term b_ψ is the same as in Eq. (8) and measures the direct effects of the new goods; e.g. if the new goods are skilled-labor intensive within the North, $b_\psi>0$. The term π is the effect of induced preference changes. When the "complements" in the North of the new goods are also unskilled-labor intensive, $\int_g^1 \varepsilon(z)\theta_u(z)\mathrm{d}z>0, \int_g^1 \varepsilon(z)\theta_s(z)\mathrm{d}z<0$ and $\pi<0$. If the induced preference changes dominate, $b_\psi+\pi<0$ and the PIR occurs.

[5] Since step 2 starts from the given changes in relative factor demand, Table 1 can still be used when two or more exogenous changes take place (e.g. when new goods appear in both the North and the South).

Likewise, differentiate the logs of $\mu^*(.)$ and $\Lambda(.)$ at constant factor prices:

$$\mathrm{sgn}(\psi^*) = \mathrm{sgn}[\mathrm{d}\ln\mu^*(.)] = \mathrm{sgn}(\pi^*), \pi^* = \frac{\int_0^g \varepsilon(z)\theta_s^*(z)\mathrm{d}z}{\int_0^g b(z)\theta_s^*(z)\mathrm{d}z} - \frac{\int_0^g \varepsilon(z)\theta_u^*(z)\mathrm{d}z}{\int_0^g b(z)\theta_u^*(z)\mathrm{d}z} \tag{11}$$

$$\mathrm{sgn}(\Gamma) = \mathrm{sgn}[\mathrm{d}\ln\Lambda(.)] = \mathrm{sgn}(b_\Gamma + \pi_\Lambda), \pi_\Lambda = \frac{\int_g^1 \varepsilon(z)\mathrm{d}z}{\int_g^1 b(z)\mathrm{d}z} - \frac{\int_0^g \varepsilon(z)\mathrm{d}z}{\int_0^g b(z)\mathrm{d}z} \tag{12}$$

b_Γ is the same as in Eq. (8) and measures the direct effect of the new goods. π^* and π_Λ measure the effects of induced preference changes. Since new northern goods have no direct effect on the South's relative skilled labor demand, the sign of ψ^* depends solely on π^*.

Now we can analyze the effects of new goods when induced preference changes are present. For example, consider the scenario of Section 3: new northern goods are skilled-labor intensive within the North. Apply the two-step solution method. Step 1: how do new goods change relative factor demand at constant factor prices? Suppose the "complements" of the new goods are unskilled-labor intensive northern goods and skilled-labor intensive southern goods, and that most of them are southern goods. Suppose also that induced preference changes always dominate. Then in the North, the direct effect of the new goods is to increase the relative skilled labor demand but induced preference changes tend to reduce it. Due to the PIR, the new goods are unskilled-labor friendly within the North and $\psi<0$. In the South, the induced preference changes of new northern goods increase the relative skilled labor demand and so the new goods are skilled-labor friendly within the South and $\psi^*>0$. Finally, even though the introduction of the new northern goods tends to increase the aggregate expenditure share of the northern products, the induced preference changes tend to reduce it. Due to the PIR, the new goods are friendly to the South and $\Gamma<0$. Step 2: given these changes in relative factor demand, how do new goods change the northern skill premium? Consult Table 1: the skill premium decreases, in contrast to Section 3.

Thus, the PIR breaks the link between the skilled-labor intensity of the new goods and their factor friendliness, and the link between where they are produced and their country friendliness. However, Eqs. (10)–(12) suggest a way to remove the PIR and restore those links.

Definition 6. The induced preference changes are *PIR-free* if (a) $\int_g^1 \varepsilon(z)\theta_x(z)\mathrm{d}z = 0$, $x=s, u$; (b) $\int_0^g \varepsilon(z)\theta_x(z)\mathrm{d}z = 0$, $x=s, u$ and (c) $\int_g^1 \varepsilon(z)\mathrm{d}z = 0$ and $\int_0^g \varepsilon(z)\mathrm{d}z = 0$.

In other words, the induced preference changes are PIR-free if the "complementarities" between the old goods and the new goods are uncorrelated with the factor income shares of the old goods in both the North and the South ((a) and (b)) and unrelated to where the old goods are produced ((c)). Definition 6 has the definition of preference neutrality (Definition 1) as a special case because the latter has $\varepsilon(z)=0$ for every old good.

When the induced preference changes are PIR-free, $\pi=\pi^*=\pi_\Lambda=0$ in Eqs. (10)–(12).

Thus:

Proposition 5. *Under Cobb–Douglas preferences, when the preference changes induced by new northern goods are PIR-free: (1) the new northern goods are skilled-labor friendly within the North if and only if they are skilled-labor intensive within the North; (2) the new northern goods are factor neutral within the South; (3) the new northern goods are friendly to the North.*

By Proposition 5, Propositions 1 and 2 can be used when induced preference changes are present, provided that these changes are PIR-free.

Finally, as shown in Appendix 1, when the preferences are CES, Propositions 1–5 still hold and Table 1 can still be used.

5. Conclusion and discussion

This paper studies how new northern goods affect the northern and southern skill premia using a two-cone HO model with CES preferences. When new goods are added to the North's technology, they necessarily increase the northern skill premium if they are skilled-labor intensive, and may even increase the premium if they are unskilled-labor intensive. This implies that the introduction of skilled-labor intensive new manufacturing goods in the U.S. during the 1980s (Xiang, 2005) could have done more to increase the US skill premium than a closed economy model would predict.

What if new goods also appear in the South? In the working paper version of this paper, I show that the implication stated above still holds if there are more new northern goods than new southern goods and if the new southern goods are unskilled-labor intensive. Do these two conditions hold in the real world? It is likely that most product innovations take place in the North, and following the directed-technological-change argument of Acemoglu (1998), the relative abundance of unskilled labor in the South would induce southern product innovations to be unskilled-labor intensive. A definitive answer, however, must wait for future research. On the other hand, new northern goods necessarily increase the southern skill premium if they are unskilled-labor intensive, and may even increase the premium if they are skilled-labor intensive. This implies that the new US manufacturing goods that were introduced during the 1980s might have contributed to the increase in the skill premia in the developing countries, which is documented in Berman et al. (1998). The two-step solution method that I develop simplifies the analyses of many other comparative static exercises in the two-cone HO model because the results of step 2, shown in Table 1, can be used in these exercises even if the exogenous changes are not the introduction of new goods. Given the importance of the two-cone HO model in the literature, the two-step solution method may be useful for future research.

Appendix A

A.1. CES preferences

When the preferences are CES, the goods' expenditure shares are endogenous: they depend on the goods' prices and only on the goods' prices. Since the goods' prices equal their marginal costs, which are determined by the factor prices, the goods' expenditure shares are determined by factor prices. Thus, at constant factor prices, the equilibrium conditions (Eqs. (2)–(5)) and the definitions of factor friendliness and country friendliness still hold, and so do the definitions of preference neutrality and being PIR-free. Therefore:

Proposition A1. Propositions 1–5 *and Table 1 are valid under CES preferences.*

The formal proof of Proposition A1 is in the Mathematical appendix. The Mathematical Appendix also shows that Proposition A1 holds when the number of goods in the model is finite and/or when new goods are not infinitesimal changes.

A.2. A2 Applying the two-step solution method to other comparative static exercises

The two-step solution method simplifies the analyses of many other comparative static exercises in the two-cone HO model because the results derived for step 2, Table 1, can be used

even if the exogenous changes are unrelated to new goods. The following two examples illustrate this point.

A.2.1. Sector-biased technological progress

Consider the technological progress that is biased towards unskilled-labor intensive sectors and has no factor bias (Xu, 2001). Let z_0 be an unskilled-labor intensive northern good. Suppose that sector z_0 becomes more productive while the productivities of all the other sectors remain unchanged. Assume that the elasticity of substitution in consumption, σ, exceeds 1. Apply the two-step solution method. First, at constant factor prices, the factors' income shares do not change. Since sector z_0 becomes more productive, the price of good z_0 tends to fall. This increases the expenditure share of good z_0 and so decreases the North's relative skilled labor demand. Thus, the technological progress is unskilled-labor friendly within the North ($\psi<0$). Since the technological progress does not affect the South's relative skilled labor demand, it is factor-neutral within the South ($\psi^*=0$). Since z_0 is a northern good and its expenditure share increases, the relative demand for northern goods increases and so the technological progress is friendly to the North ($\Gamma>0$). Next, consult Table 1: the northern skill premium may increase, in contrast to Xu (2001), who uses the one-cone HO model.

A.2.2. Southern technological catch-up

Now consider southern technological catch-up (Zhu and Trefler, 2005). Suppose that the productivities of all the southern goods increase by the same proportion and the productivities of the northern goods remain unchanged. Assume that $\sigma>1$. Apply the two-step solution method. First, at constant factor prices, as the productivities of all the southern goods increase by the same proportion, the prices of these goods tend to fall by the same proportion. Thus, southern technological catch-up does not affect the relative skilled labor demand in either country and is factor neutral in both countries ($\psi=\psi^*=0$). On the other hand, since the prices of the southern goods decline and the prices of the northern goods remain unchanged, the relative demand for the northern goods, $\Lambda(g)$, tends to decline. In addition, southern technological catch-up has a supply-side effect: it lowers the marginal costs of southern production relative to the marginal costs of northern production. This supply-side effect is equivalent to the effect of an increase in $\Lambda(g)$ (i.e. it has the same effects on the equilibrium conditions, Eqs. (2)–(5), as an increase in $\Lambda(g)$). Thus, the country friendliness of southern technological catch-up is ambiguous, and when the supply-side effect is weak, it is friendly to the South ($\Gamma<0$). Next, consult Table 1: the skill premia decrease in both countries and the South produces a narrower range of goods. This is opposite to the results in Zhu and Trefler (2005), who consider the case of $\sigma=1$.

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