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RECONCILING THE PATTERN OF TRADE WITH THE PATTERN OF MIGRATION

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ABSTRACT

Empirical studies have consistently found that skilled-labor abundant countries tend to export skilled-labor intensive manufactured goods. Yet these countries also have higher wages for skilled workers, causing them to be net importers through migration of skilled labor from unskilled-labor abundant countries (the "brain drain"). A new explanation is presented for this combination of comparative and absolute advantage in skilled-labor abundant countries: if only skilled (educated) individuals can become managers, then given the same underlying distribution of managerial talent the country that is more poorly endowed with skilled labor must use a less talented manager at the margin in order to fully employ its work force. This causes wages for unskilled workers and skilled individuals who choose to become employees to be lower in the unskilled-labor abundant country while incomes of skilled individuals talented enough to become managers are lower (for a given talent level) in the skilled-labor abundant country. The consequences of the resulting migration of unskilled and skilled employees to the skilled-labor abundant country and managers to the unskilled-labor abundant country are then examined. There are several surprises: for example, migration of unskilled labor to the skilled-labor abundant country leads to a fall in the wages of both unskilled and skilled workers there and a rise in the wages of both unskilled and skilled workers in the country of origin.

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1. Introduction

Many empirical studies (see Deardorff 1984 for a survey) have found that skilled-labor abundant countries tend to export skilled-labor intensive manufactured goods. Indeed, Maskus (1983) has found that the relation between net exports of various United States manufacturing industries and their use of skilled labor is getting stronger over time. Yet skilled-labor abundant countries (especially the United States) are net importers of skilled labor through migration. The net migration of PTK (professional, technical, and kindred) workers from less developed to more developed countries[1] is sufficiently well known to have been given a popular name: "the brain drain."[2] Presumably these PTK workers are attracted by skilled wage rates that are evidently higher in the more developed countries. It seems that the skilled-labor abundant countries have not only a comparative advantage in skilled-labor intensive goods but also an absolute advantage that allows them to pay all workers more and thus attract skilled and unskilled immigrants. The purpose of this paper is to develop a model where the comparative advantage and the absolute advantage of skilled-labor abundant countries are two sides of the same coin. In the process a number of new predictions concerning the pattern and effects of labor migration will be derived. The basic idea of the model is that if only skilled (educated) individuals can become managers, then given the same underlying distribution of managerial talent the country that is more poorly endowed with

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[1]I use "less developed" and "skilled-labor scarce" and "more developed" and "skilled-labor abundant" interchangeably. This is a bit of an oversimplification: Balassa (1979) computes a rank correlation coefficient of .754 between per capita GNP and the Harbison-Myers index of human resource development for 36 countries evenly divided between developed and less developed.

[2]Remarkably, immigrants 25 years old and over to the United States during the period 1970-1980 contained a greater proportion of highly skilled (educated) people than the U. S. population: 22.2 percent had four or more years of college compared to 16.2 percent of 1980 U. S. residents. Since 1975, however, skilled immigration to the U. S. has remained close to the levels of the early 1970s while less skilled immigration has grown dramatically (Greenwood and McDowell 1986, pp. 1742-1743). This compositional change appears to be due in part to lagged effects of 1965 amendments to the U. S. Immigration and Nationality Act that changed the emphasis in the allocation of visas toward family reunification and away from occupational preferences.

skilled labor must use a less talented manager at the margin in order to fully employ its work force. This causes wages for unskilled workers and skilled individuals who choose to become *employees* to be lower in the unskilled-labor abundant country while incomes of skilled individuals talented enough to become *managers* are lower (for a given talent level) in the skilled-labor abundant country.

In contrast with the present paper, it is typically supposed that skilled-labor abundance and high wages are correlated due to their common association with a third important economic characteristic. In this introduction I will call these explanations of skilled-labor abundant countries' absolute advantage into question. Nevertheless, the skilled wage gap between developed and less developed countries is wide enough[3] to make room for (and perhaps require) many explanations, and it will be clear that the relevance of this paper's explanation does not preclude the relevance of the others.

One explanation of the wage gap is that workers in developed countries have more physical capital to work with than workers in less developed countries. Doubt is cast on the importance of physical capital endowments, however, by the fact that physical capital intensity was found to have a negative or insignificant effect on export performance of skilled-labor abundant countries in all of the multiple regression analyses cited in Deardorff (1984). It is true that the explanatory performance of physical capital improves in cross-country studies, but even there its explanatory power relative to skilled labor was found by Bowen (1983) to weaken over time. Indeed, given the extremely high mobility of physical capital through foreign lending and direct investment, we should not expect a country's endowment of capital to be a very important determinant of its pattern of trade or the wage level of its workers. The fact that capital mobility was steadily increasing in the post-World War II period (at least until

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[3]Kravis, Heston, and Summers (1982) have collected internationally comparable data for 1975 for wages of government employees with post-secondary education. The average for eight countries with per capita GDP less than 15 percent of U. S. per capita GDP (six countries with per capita GDP between 15 and 30 percent of U. S.) is 18.7 (34.5) percent of the average for nine countries with per capita GDP between 60 and 90 percent of U. S. per capita GDP.

1982) may explain the findings of Bowen and Maskus mentioned above.

The most popular explanation in the current literature for higher wages in skilled-labor abundant countries is that their technology is superior to that of unskilled-labor abundant countries.[4] This explanation requires continual technological progress in the developed countries, since otherwise the less developed countries will eventually learn all of the available technology through channels such as direct foreign investment and reverse engineering. Thus the technological explanation leads quickly to the "technology gap" model (Posner (1961)), if the technological progress takes the form of process innovations, and the "product cycle" model (introduced by Vernon (1966) and formalized by Krugman (1979)), if the technological progress takes the form of product innovations. If one asks why technological progress should be concentrated in developed countries, the answer is almost always based on their relative abundance of skilled labor. (The exception is Vernon, who believes most product innovations are stimulated by the needs of high-income consumers and most process innovations are stimulated by the need to conserve on high-cost labor. Obviously this only begs the question we are addressing here.) The implicit assumption is that more abundant skilled labor is cheaper and thus the research and development needed for technological progress is cheaper in developed countries. Grossman and Helpman (1989) get around this difficulty by specifying a production technology for research and development and assuming that *this* technology is superior in developed countries.

An explanation that makes skilled labor abundance itself the source of absolute advantage has recently been presented in a growth-theoretical context by Lucas (1988), who shared the concern of this paper with "reconciling observed pressures for immigration with the absence of equivalent capital flows" (p. 38). He allows the average national level of human capital per worker to act as an externality that Hicks-neutrally shifts the aggregate production

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[4]The technological models of the pattern of trade to which I refer here all assume perfect capital mobility either explicitly or implicitly. For example, Posner states (p. 325) that "each country in our trading world, we would assume, has (initially) the same rate of profit".

function, so that workers in different countries with the same level of human capital (skill) will be paid differently, the worker in the human-capital abundant country receiving the higher wage (p. 25).[5] The microeconomic foundation of this external effect of human capital is the sharing of knowledge and skills between skilled workers that occurs through both formal and informal interaction. The "diffusion and growth of knowledge" that takes place as a result of that interaction is modelled in a paper by Jovanovic and Rob (1987). In their model individuals augment their knowledge through pairwise meetings at which they exchange ideas. In each time period each individual seeking to augment his knowledge meets an agent chosen randomly from a distribution of agents/ideas. It seems clear that the higher the average level of human capital (knowledge) of the agents, the more "luck" the agents will have with their meetings and the more rapid will be the growth of knowledge. Thus we have a microeconomic foundation not only for external effects of human capital, but also for making those external effects dependent on the average level of human capital as did Lucas.

While this approach is very promising, the microeconomic foundation for the external effect of human capital suggests that it may be more appropriate to model it as skilled-labor augmenting rather than Hicks-neutral as Lucas specifies it. In this case the externality may raise the wages of skilled workers more than the wages of unskilled workers. It is a common perception, however, that the scarcity of skilled workers in less developed countries does lead to a higher premium for their services relative to those of unskilled workers. We can check this using the internationally comparable wage data collected for 1975 by Kravis, Heston, and Summers (1982). These show that the average ratio of wages of government employees with post-secondary education to wages of government employees with less than ten years of schooling in the poorest (next-poorest) group of countries surveyed is 2.0 (1.9) times the

[5]Lucas's model cannot at present incorporate comparative advantage because workers with different levels of human capital are perfect substitutes for each other in production, making the notion of skilled-labor intensity undefined. Presumably this simplification was adopted to make tractable the aggregate growth model in which Lucas was interested.

average ratio in the richest group of countries surveyed.[6]

We come to the approach taken in the present paper, which relies on neither externalities nor differences in the cost of capital or technology. I look instead at the potential for differences between skilled-labor and unskilled-labor abundant countries in the quality of *management.* Gershenberg (1987) states that "perhaps the most serious manpower constraint in less developed countries is the general scarcity of entrepreneurial and managerial ability." This is especially true of countries that were decolonized relatively recently, where, as the World Bank (1981) states, "The scarcity of managerial and technical cadres at the time of independence had strong adverse effects on public administration, industrial development, wage levels, and costs." The problem is not that people in less developed countries lack the intelligence, leadership, or organizational abilities that a manager needs, but rather that relatively few of them (compared to developed countries) have the *education* necessary to put their abilities to use in successful management. Thus the problem is precisely that these countries are unskilled-labor abundant (skilled-labor scarce), where skilled and unskilled are identified, as in the trade model of Findlay and Kierzkowski (1983), with educated and uneducated.

This raises the question of how we model management. Here I turn to yet another paper of Lucas (1978), "On the Size Distribution of Business Firms." In this paper the size distribution of firms reflects the underlying distribution of managerial talent, with greater talent generating a larger firm size by Hicks-neutrally shifting a decreasing-returns-to-scale production function. Obviously not every individual can be a manager, so a cutoff level of managerial talent emerges at the level where managerial rent just equals the wage (the opportunity cost of the manager's time). In section 2 I incorporate Lucas's one sector model into the two-by-two Heckscher-Ohlin-Samuelson trade model (hereafter called the "standard" model) and allow the two industries to differ in the degree to which managerial talent can

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[6]The country groups are defined in footnote 3. I have omitted Malawi from the poorest group average ratio because its ratio is more than twice as large as that of any other country.

affect output. I demonstrate in section 3 that the cutoff level of managerial talent will be higher for the skilled-labor abundant country and thus wages for both skilled and unskilled workers will be higher, though managerial rent will be lower for a given talent level. In section 4 the effects of the resulting migration of skilled and unskilled workers to the skilled-labor abundant country and managers to the unskilled-labor abundant country are explored, as is what happens if age distribution affects the pool of potential managers. Section 5 suggests some directions for future research.

2. Managerial talent in a two-by-two model

Following the discussion in the introduction, I divide the population of a country into two classes: skilled and unskilled, or educated and uneducated. Everyone in the country works, but only skilled workers can become managers (entrepreneurs). The reason is that management is assumed to require reading, writing, and accounting skills that only skilled (educated) workers possess. I assume that every skilled agent in the economy is endowed with a managerial (or entrepreneurial) talent level x drawn from a fixed distribution D: $R^+ \rightarrow [0,1]$. Unskilled workers may also be endowed with managerial talent, but because of their lack of education they never have the opportunity to use it. There is a continuum of types of skilled agent so that the entire distribution D of talent is always fully represented, and moreover each talent level is represented by a continuum of skilled agents indexed on [0,1]. Under these assumptions D(x) equals the proportion of skilled agents with managerial talent less than or equal to x.

Consider an industry that uses skilled and unskilled labor to produce "raw" output y, using a constant returns technology with unit cost function c(v,w), where v and w are the wages of unskilled and skilled labor. Actual output q depends on raw output y and managerial talent x according to:[7]

$$q = kxy^{\eta}$$

where k is a scale parameter and η is a constant such that $0 < \eta < 1$. If output can be sold at price p then the rental to talent when raw output is y is:

$$pkxy^{\eta} - cy.$$

The first-order condition determining the raw output y chosen by a manager with talent x is:

$$pkx\eta y^{\eta-1} - c = 0.$$

Solving for y and substituting into the preceding equation, the rental to a manager with talent x when raw output is optimally chosen is:

$$pkx(pkx\eta/c)^{\eta/(1-\eta)} - c(pkx\eta/c)^{1/(1-\eta)} = [\eta^{\eta/(1-\eta)} - \eta^{1/(1-\eta)}](pkx)^{1/(1-\eta)}c^{-\eta/(1-\eta)}.$$

Without loss of generality, choose the scale parameter k so that:

$$1 = [\eta^{\eta/(1-\eta)} - \eta^{1/(1-\eta)}]k^{1/(1-\eta)}.$$

Under the implied choice of units, the rental to talent x is:

$$r = (px)^{a}c^{1-a} \tag{1}$$

where $a = 1/(1-\eta)$ is the elasticity of the rental with respect to talent. By the Envelope Theorem, the demands for skilled and unskilled labor are:

$$s(v,w,p,x) = -\partial r/\partial w = (a-1)er/w \tag{2}$$

$$u(v,w,p,x) = -\partial r/\partial v = (a-1)fr/v \tag{3}$$

where e and f are the elasticities of c with respect to w and v.

Consider a country with two industries i = 1, 2 facing prices p_i, possibly with different values η_1, η_2 of the parameter η. (Subscripts i indicate variables associated with industry i.) Sector 1 uses skilled labor more intensively than sector 2 in that at any wages v, w:

$$s_1/u_1 > s_2/u_2.$$

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[7]More generally, we could write $q = xg(y)$, where g is twice-differentiable, increasing, strictly concave and satisfies $g(0) = 0$. The constant elasticity form of g with elasticities differing across industries greatly simplifies our analysis by insuring that there is only a single intersection of the managerial rental functions in figure 1 below.

It follows that $e_1/f_1 > e_2/f_2$. Since c_i is homogeneous of degree 1, $e_i + f_i = 1$ so:

$$e_1 > e_2,\ f_1 < f_2 \text{ for all } w,\ v > 0. \tag{4}$$

Since $a_i = 1/(1-\eta_i)$ is the elasticity of rent with respect to managerial talent in sector i, if $a_1 > (<)\ a_2$ we say that there is greater (less) scope for managerial talent, or that managerial talent is more (less) important, in sector 1. Selection into the industry that allows greater scope for managerial talent then takes place in the manner described by Roy (1951) and illustrated in Figure 1 for the case $a_1 > a_2$.[8] This embodies the equations:

$$r_2(v,w,p_2,z_2) = w \tag{5}$$

$$r_2(v,w,p_2,z_1) = r_1(v,w,p_1,z_1). \tag{6}$$

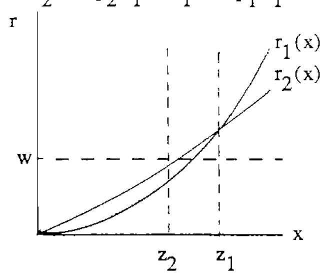

fig. 1

z_2 is the cutoff level of managerial talent, with all educated individuals having managerial talent below z_2 choosing to work for a wage. Among those who choose to become managers, those with managerial talent above z_1 choose to manage in industry 1, while the rest choose to manage in industry 2. Figure 1 applies to the case $a_1 < a_2$ if we interchange the subscripts 1 and 2. For this case, we have:

[8]I am not aware of any study relating compensation of top management to skilled-labor intensity of the industry in which they manage. However, I believe that $a_1 > a_2$ is more likely to be the case for the following reason. Empirical research in international trade (see Deardorff 1984) shows that skilled-labor intensity of an industry is closely associated with research and development intensity and with "youth" of the industry in the sense of the product cycle. It stands to reason that there is more scope for entrepreneurial success and failure in such industries than in well-established industries with "standardized" technologies.

$$r_1(v,w,p_1,z_1) = w \quad (5')$$

$$r_1(v,w,p_1,z_2) = r_2(v,w,p_2,z_2). \quad (6')$$

In equilibrium, the skilled workers employed in sector 2 (by managers with talent between z_1 and z_2) plus the skilled workers employed in sector 1 (by managers with talent exceeding z_1) must comprise a proportion of the skilled equal to those with talent less than z_2:

$$\int_{z_2}^{z_1} s_2(v,w,p_2,x)dD(x) + \int_{z_1}^{\infty} s_1(v,w,p_1,x)dD(x) = D(z_2). \quad (7)$$

Similarly, the unskilled workers employed in sector 2 plus the unskilled workers employed in sector 1 must equal the country's supply of unskilled workers U. Hence, if its supply of skilled workers is S, we have:

$$\int_{z_2}^{z_1} u_2(v,w,p_2,x)dD(x) + \int_{z_1}^{\infty} u_1(v,w,p_1,x)dD(x) = U/S. \quad (8)$$

For the case $a_1 < a_2$, the full employment equations are:

$$\int_{z_1}^{z_2} s_1(v,w,p_1,x)dD(x) + \int_{z_2}^{\infty} s_2(v,w,p_2,x)dD(x) = D(z_1) \quad (7')$$

$$\int_{z_1}^{z_2} u_1(v,w,p_1,x)dD(x) + \int_{z_2}^{\infty} u_2(v,w,p_2,x)dD(x) = U/S. \quad (8')$$

(5) and (6) are analogous to the industry equilibrium (price = unit cost) conditions in the standard model while (7) and (8) are analogous to the factor market equilibrium conditions. In contrast to the standard model, however, the first set of conditions cannot be solved independently of the second. As we see in the next section, this difference opens the door for factor endowments to influence factor prices under conditions that would yield factor-price equalization in the standard model.

3. Equal distributions of managerial talent and unequal wages

I now assume, in line with my introductory remarks, that technology and the distribution of managerial talent D are the same across countries. I also assume that there is free trade, so that $p_1 = p_1^*$, $p_2 = p_2^*$, where the asterisk denotes the skilled-labor scarce country. As stated in the introduction, the main objective of this section is to establish that in a free trade equilibrium the cutoff level of managerial talent will be higher in the skilled-labor abundant (S-abundant) country than in the unskilled-labor abundant (U-abundant) country, leading to higher wages in the S-abundant country. This objective implies some additional technical requirements. We see that in (5) and (6) or (5′) and (6′) only z_1, z_2, v and w are free to differ across countries. If (5) and (6) or (5′) and (6′) determine a *unique* solution for v and w given any z_1 and z_2, we can say that factor-price equalization holds in our model when managerial quality does *not* differ across countries. In this case we can attribute any cross-country differences in wages that emerge in a free trade equilibrium to cross-country differences in z_1 and z_2. We would then like it to be true that a higher z_2 implies higher wages in the case $a_1 > a_2$, while a higher z_1 implies higher wages in the case $a_1 < a_2$. Our objective is then met if in free trade equilibrium $\bar{z}_2 > \bar{z}_2^*$ in the former case and $\bar{z}_1 > \bar{z}_1^*$ in the latter case, where the overbar denotes equilibrium value.

Like the industry equilibrium conditions in the standard model, (5) and (6) ((5′) and (6′)) both describe curves in v, w space when we take the other variables in these equations as fixed. We can demonstrate uniqueness of the solution for v and w given z_1 and z_2 by showing that these curves can only intersect once. The curve described by (5) or (5′) is always downward-sloping:

$$dw/dv\Big|_{(5)} = (\partial r_2/\partial v)/(1 - \partial r_2/\partial w) = -\,[(a_2\text{-}1)f_2r_2/v]/[1 + (a_2\text{-}1)e_2r_2/w],$$

and $dw/dv\Big|_{(5')}$ is the same except the subscript 2 is replaced by a subscript 1. It is easily seen that this curve shifts out as the cutoff level of managerial talent z_2 (z_1) increases. It follows that the curve described by (6) or (6′) will have to slope *upwards* in v, w space if the cutoff level of managerial talent is to increase *all* wages. In this case uniqueness will of course hold as well. We have:

$$dw/dv\Big|_{(6)} = (\partial r_2/\partial v - \partial r_1/\partial v)/(\partial r_1/\partial w - \partial r_2/\partial w)$$
$$= [(a_2-1)f_2r_2/v - (a_1-1)f_1r_1/v]/[(a_1-1)e_1r_1/w - (a_2-1)e_2r_2/w], \text{ or}$$
$$\hat{w}/\hat{v}\Big|_{(6)} = [(a_2-1)f_2 - (a_1-1)f_1]/[(a_1-1)e_1 - (a_2-1)e_2], \tag{9}$$

where $\hat{y} = dy/y$. The right-hand side of (9) also applies to $\hat{w}/\hat{v}\big|_{(6')}$. (4) insures that the denominator of $\hat{w}/\hat{v}\big|_{(6)}$ and the numerator of $\hat{w}/\hat{v}\big|_{(6')}$ are positive. But the numerator of $\hat{w}/\hat{v}\big|_{(6)}$ (the denominator of $\hat{w}/\hat{v}\big|_{(6')}$) are positive if and only if $(a_2-1)f_2 > (a_1-1)f_1$ ($(a_1-1)e_1 > (a_2-1)e_2$), or:

$$f_2/f_1 > (a_1-1)/(a_2-1) \tag{10}$$
$$e_1/e_2 > (a_2-1)/(a_1-1) \tag{11}.$$

(10) implies $u_2(v,w,p_2,z_1) > u_1(v,w,p_1,z_1)$ in the case $a_1 > a_2$ and (11) implies $s_1(v,w,p_1,z_2) > s_2(v,w,p_2,z_2)$ in the case $a_1 < a_2$. In words, if the difference in scope for management between industries is small relative to the difference in factor intensities, v and w are uniquely determined given any z_1, z_2 and the cutoff level of managerial talent positively affects both v and w.

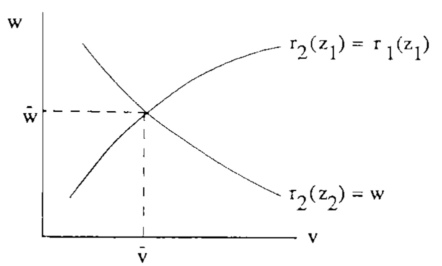

fig. 2

Figure 2 is drawn on the assumption that (10) holds for all v, w > 0. It applies, with the upward-sloping curve growing steeper rather than flatter, to the case $a_1 < a_2$ if we interchange the subscripts 1 and 2 and if (11) holds for all v, w > 0. In both cases an increase in the cutoff level of managerial talent shifts the downward-sloping curve right, but in the case $a_1 > a_2$ an increase in z_1 shifts the upward-sloping curve left while in the case $a_1 < a_2$ an increase in z_2 shifts the upward-sloping curve right. Changes in z_1 (z_2) therefore have

Stolper-Samuelson-type effects, which shrink to zero as $a_1 - a_2$ approaches zero. Note also that as $a_1 - a_2$ approaches zero the right-hand side of (9) approaches unity (recall that $e_i + f_i = 1$), so that movements along the upward-sloping curve leave the skilled-unskilled wage ratio unchanged. We can then see that for $a_2 - a_1 \neq 0$ we have $\hat{w}/\hat{v}|_{(6)} < 1$ and $\hat{w}/\hat{v}|_{(6')} > 1$, so increases in the cutoff level of managerial talent reduce the skilled-unskilled wage ratio when $a_1 > a_2$ but.increase it when $a_1 < a_2$.

We are now ready to derive the main results of this section. As in standard two-by-two Heckscher-Ohlin trade theory, we maintain the assumption that the factor-endowment ratios of the S-abundant and U-abundant countries lie within the "cone of diversification" so that both countries are incompletely specialized in production in any free trade equilibrium. We then follow a standard procedure (see, e. g., Bhagwati and Srinivasan 1983, Chapter 6) used to establish the Heckscher-Ohlin theorem that in free trade equilibrium the S-abundant country exports the skilled-labor intensive good and the U-abundant country exports the unskilled-labor intensive good. Along the way we will also establish our results on wage differences across countries. The procedure is to fix commodity prices, since they are the same for both countries, and then show that full employment of each country's two factors of production requires the S-abundant country to produce the skilled-labor intensive good 1 in a higher proportion to the unskilled-labor intensive good 2 than does the U-abundant country. If both countries consume 1 and 2 in the same proportion, as they will if we make the additional standard Heckscher-Ohlin assumption that preferences are identical and homothetic for all consumers in both countries, then the Heckscher-Ohlin theorem follows.

In our model an incompletely specialized equilibrium implies $0 < \bar{z}_2 < \bar{z}_1 < 1$ and $0 < \bar{z}_2^* < \bar{z}_1^* < 1$ in the case $a_1 > a_2$ and $0 < \bar{z}_1 < \bar{z}_2 < 1$ and $0 < \bar{z}_1^* < \bar{z}_2^* < 1$ in the case $a_1 < a_2$. This means that in figure 3 the relevant space in the case $a_1 > a_2$ lies above the 45° line, while in the case $a_1 < a_2$ the relevant space lies below the 45° line. We first consider the

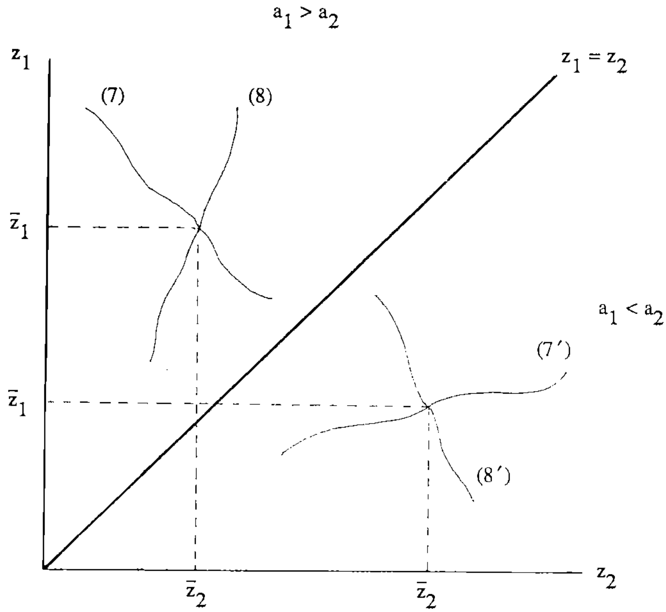

fig. 3

case $a_1 > a_2$, and begin with intuitive demonstrations that full employment of skilled labor (equation (7)) and full employment of unskilled labor (equation (8)) define downward-sloping and upward-sloping loci, respectively, in figure 3. As the cutoff level of managerial talent z_2 increases, the number of employers declines while the supply of skilled individuals seeking employment increases. To eliminate the excess supply of skilled labor, we need to shift managers from the unskilled-labor intensive industry to the skilled-labor intensive industry, which is accomplished by decreasing z_1. To restore the demand for unskilled labor we need to shift managers from the skilled-labor intensive industry to the unskilled-labor intensive industry, which is accomplished by increasing z_1.

These intuitive explanations ignore the indirect effects of z_2 and z_1 on employment through their effects on wages. These indirect effects are shown in the Appendix to reinforce the negative direct effects on demand for skilled labor of both z_2 and z_1, with the sole ambiguity coming from the fact that the sign of any changes in the elasticities e_i cannot be determined. It is also shown in the Appendix that, aside from the ambiguity due to possible changes in the elasticities f_i, the indirect effect of z_2 reinforces its negative direct effect on demand for unskilled labor, while the indirect effect of z_1 on u_2 reinforces its positive direct effect on demand for unskilled labor and its indirect effect on u_1 is ambiguous. In order to insure that propositions 1-5 below hold it is necessary that this ambiguity does not cause the full employment of unskilled labor locus to become downward-sloping *and flatter* than the full employment of skilled labor locus. A sufficient (but far from necessary) condition on the elasticities to get the slopes shown in figure 3 is that the e_i (and therefore the f_i as well) are constant, as they would be in the case of Cobb-Douglas cost functions c_i. These requirements are assumed to be met in the discussion below.

The full employment equations for the S-abundant and U-abundant countries are identical except for the right-hand side of (8), which by definition is greater for the U-abundant than for the S-abundant country. It follows that full employment of unskilled labor in the U-abundant country requires a smaller z_2 given any z_1 than in the S-abundant country. Therefore the upward-sloping locus in figure 3 for the U-abundant country lies to the left of that for the S-abundant country, while the downward-sloping locus is the same for both countries, yielding $\bar{z}_2^* < \bar{z}_2$ and $\bar{z}_1^* > \bar{z}_1$. We have thus proved

PROPOSITION 1: *The cutoff level of managerial talent is lower in the U-abundant than in the S-abundant country.*

The intuition behind this result is clear. Because a lower proportion of the population in the U-abundant country has the education necessary to become a manager, that country must draw on lower-quality managers to employ its entire population, despite having the same distribution of managerial talent as the S-abundant country.

We can establish three more important propositions:

PROPOSITION 2: *The unskilled wage rate is lower in the U-abundant than in the S-abundant country.*

We can see from figure 2 that $\bar{z}_2^* < \bar{z}_2$ and $\bar{z}_1^* > \bar{z}_1$ both act to reduce v^* relative to v.

PROPOSITION 3: *The skilled-unskilled wage ratio is higher in the U-abundant than in the S-abundant country.*

We can see from equation (9) and figure 2 that $\bar{z}_2^* < \bar{z}_2$ and $\bar{z}_1^* > \bar{z}_1$ both act to raise w^*/v^* relative to w/v.

PROPOSITION 4: *For a_1 - a_2 sufficiently small, the skilled wage rate is lower in the U-abundant than in the S-abundant country.*

We can see from figure 2 that $\bar{z}_2^* < \bar{z}_2$ acts to lower w^* relative to w while $\bar{z}_1^* > \bar{z}_1$ acts in the opposite direction. The smaller is $a_1 - a_2$, the stronger is the first effect and the weaker is the second. We cannot be more precise about how small is sufficient because we would need to know the size of $\bar{z}_2 - \bar{z}_2^*$ relative to $\bar{z}_1^* - \bar{z}_1$, which in turn depends on the steepness of the downward-sloping locus in figure 3, which finally depends in part on variations in the slope of the managerial talent distribution function D about which we can say nothing.

The last proposition we want to establish is the Heckscher-Ohlin theorem itself. We find the supply of any good at the firm level using the Envelope Theorem:

$$\partial r/\partial p = q(v,w,p,x) = ax^a p^{a-1} c^{1-a}.$$

The ratio of industry 1 to industry 2 production in free-trade equilibrium is then given by

$$\bar{Q}_1/\bar{Q}_2 = \int_{\bar{z}_1}^{\infty} a_1 x^{a_1} (\bar{p}_1)^{a_1-1} (\bar{c}_1)^{1-a_1} dD(x) / \int_{\bar{z}_2}^{\bar{z}_1} a_2 x^{a_2} (\bar{p}_2)^{a_2-1} (\bar{c}_2)^{1-a_2} dD(x)$$

$$= [a_1(\bar{p}_1)^{a_1-1}/a_2(\bar{p}_2)^{a_2-1}][(\bar{c}_1)^{1-a_1}/(\bar{c}_2)^{1-a_2}][\int_{\bar{z}_1}^{\infty} x^{a_1} dD(x) / \int_{\bar{z}_2}^{\bar{z}_1} x^{a_2} dD(x)].$$

We can substitute (6) into the last line to get[9]

$$\bar{Q}_1/\bar{Q}_2 = [a_1\bar{p}_2/a_2\bar{p}_1](\bar{z}_1)^{a_2-a_1}[\int_{\bar{z}_1}^{\infty} x^{a_1}dD(x)/\int_{\bar{z}_2}^{\bar{z}_1} x^{a_2}dD(x)]. \qquad (12)$$

We can now prove

PROPOSITION 5: *The Heckscher-Ohlin theorem holds.*

This follows from substitution of $\bar{z}_1 < \bar{z}_1^*$ and $\bar{z}_2 > \bar{z}_2^*$ into equation (12) and the standard Heckscher-Ohlin assumption on preferences mentioned above.

We can conclude that when scope for management is greater in the skilled-labor intensive industry than in the unskilled-labor intensive industry, as long as it is not *too* much greater our model is in accord with the stylized facts cited in the introduction to this paper: wages of both skilled and unskilled workers are lower in skilled-labor scarce than in skilled-labor abundant countries, relative wages of skilled workers are higher in skilled-labor scarce countries, and skilled-labor abundant countries tend to export skilled-labor intensive goods to skilled-labor scarce countries and import unskilled-labor intensive goods in return. When scope for management is greater in the unskilled-labor intensive industry, however, matters are less clear. The reader can show that the same intuitive demonstrations used in the case $a_1 > a_2$ lead in the case $a_1 < a_2$ to an upward-sloping full employment of skilled labor locus and a downward-sloping full employment of unskilled labor locus in the space below the 45° line in figure 3. Again setting aside possible changes in the elasticities e_i and f_i, in the Appendix it is shown that in both (7′) and (8′) the indirect effects of z_1 on employment through wages reinforce its negative effects on labor demand. The same is true of the indirect

[9]Equation (12) may give the misleading impression that our model yields a perverse supply function where relative commodity prices negatively affect relative outputs. In fact, by working through the entire supply-side equilibrium it can be shown that relative supply depends positively on relative prices, in part because relative prices have the same Stolper-Samuelson effect that (through the full employment conditions) generates the positive supply response in the standard two-by-two Heckscher-Ohlin model.

effects of z_2 in equation (8′). In equation (7′), however, the direct effect of z_2 is to increase demand for skilled labor while the indirect effect through wages works in the opposite direction. Moreover, the upward slope of the full employment of skilled labor locus is necessary in order to insure that propositions 1′-5′ below hold. This upward slope can be guaranteed by making $a_2 - a_1$ sufficiently small, since this increases the difference between $s_1(z_2)$ and $s_2(z_2)$ (see the discussion following (11)) and decreases the effects of z_2 on wages (see the discussion following figure 2). A sufficient (but far from necessary) condition on the elasticities to get the slopes shown in figure 3 is again that the e_i (and therefore the f_i as well) are constant. These requirements are assumed to be met in the discussion below.

Following the same reasoning as in the case $a_1 > a_2$, we see that full employment of unskilled labor in the U-abundant country requires a smaller z_1 given any z_2 than in the S-abundant country. Therefore the downward-sloping locus in figure 3 for the U-abundant country lies below that for the S-abundant country, while the upward-sloping locus is the same for both countries, yielding $\bar{z}_1^* < \bar{z}_1$ and $\bar{z}_2^* < \bar{z}_2$. We have thus proved for the case $a_2 > a_1$:

PROPOSITION 1′: *The cutoff level of managerial talent is lower in the U-abundant than in the S-abundant country.*

We can also prove propositions analogous to propositions 2 - 4:

PROPOSITION 2′: *The unskilled wage rate is lower in the U-abundant than in the S-abundant country.*

We can see from figure 2 that $\bar{z}_1^* < \bar{z}_1$ and $\bar{z}_2^* < \bar{z}_2$ both act to reduce v^* relative to v.

PROPOSITION 3′: *The skilled-unskilled wage ratio may be higher or lower in the U-abundant than in the S-abundant country.*

We can see from equation (9) that $\bar{z}_1^* < \bar{z}_1$ acts to lower w^*/v^* relative to w/v while figure 2 shows that $\bar{z}_2^* < \bar{z}_2$ acts to raise w^*/v^* relative to w/v. Reducing $a_2 - a_1$ cannot yield an unambiguous result because it shrinks towards zero *both* of the effects on w^*/v^* relative to w/v.

PROPOSITION 4′: *For a_2 - a_1 sufficiently small, the skilled wage rate is lower in the U-abundant than in the S-abundant country.*

We can see from figure 2 that $\bar{z}_1^* < \bar{z}_1$ acts to lower w^* relative to w while $\bar{z}_2^* < \bar{z}_2$ acts in the opposite direction. Reducing $a_2 - a_1$ shrinks both effects, but the second effect approaches zero while the first does not.

Finally, we turn to the Heckscher-Ohlin theorem for the case $a_2 > a_1$. The ratio of industry 1 to industry 2 production is now given by

$$\bar{Q}_1/\bar{Q}_2 = [a_1\bar{p}_2/a_2\bar{p}_1](\bar{z}_2)^{a_2-a_1}[\int_{\bar{z}_1}^{\bar{z}_2} x^{a_1}dD(x)/\int_{\bar{z}_2}^{\infty} x^{a_2}dD(x)]. \qquad (12')$$

Although $\bar{z}_2^* < \bar{z}_2$, since $\bar{z}_1^* < \bar{z}_1$ there is even some ambiguity as to whether the Heckscher-Ohlin theorem holds.

PROPOSITION 5′: *The Heckscher-Ohlin theorem holds unless $\bar{z}_1 - \bar{z}_1^*$ is much greater than $\bar{z}_2 - \bar{z}_2^*$.*

Of course the other side of lower wages for employees in the U-abundant country is higher rents for its managers, given their talent levels. In effect, managers benefit from weaker "competition" in the country where the cutoff level of managerial talent is lower. This will have important consequences when we discuss the effects of allowing skilled-labor migration in the next section.

4. Unskilled-labor migration, the brain drain, and the effects of age distribution

The international differences in wages that emerge from section 3 create incentives for migration of both unskilled and skilled individuals. Migration of unskilled individuals is easier to analyze because of their homogeneity. To keep matters simple and conserve on space I will discuss the effects of this migration on each country under the assumption that the country in question is too small to affect world commodity prices. These effects are easily seen by referring to figure 3. An increase (decrease) in a country's endowment of U as result of unskilled-labor immigration (emigration) causes the upward-sloping curve to shift left (right) in the case $a_1 > a_2$ and the downward-sloping curve to shift down (up) in the case $a_1 < a_2$. Provided that propositions 4 and 4′ hold, in both cases immigration (emigration) causes a decrease (increase) in the wages of both unskilled *and* skilled labor. Thus *all* employees in a small, skilled-labor abundant country should be opposed to immigration of unskilled labor, except for skilled employees whose managerial talent is very near the cutoff level, while all employees in a small, skilled-labor scarce country should favor emigration of unskilled labor. Managers in each country should take the opposite stands, with the exception of marginal or near-marginal managers in the skilled-labor scarce country who will have the opportunity to become more highly paid skilled employees.

In table 1, these results for the present model are compared to those for the standard model, which is divided into the case where both countries produce both goods and the case where both countries completely specialize in production of one good. We can see that the results for the model of sections 2 and 3 are dramatically different.

Table 1: Unskilled-labor migration under the small-country assumption

	Standard Heckscher-Ohlin-Samuelson Model		present model
	incomplete specialization(even)	complete specialization (odd)	
Effect on:			
v			
country of origin	0	+	+
country of destination	0	–	–
w			
country of origin	0	–	+
country of destination	0	+	–

It would be nice if we could treat skilled-labor migration symmetrically with unskilled-labor migration. However, we showed at the end of section 3 that if proposition 4 or 4′ holds (as we shall maintain throughout this section) a skilled individual's incentives to migrate are quite different depending on whether she is an employee or a manager, i.e., depending on her managerial talent level. In particular, skilled employees in the U-abundant country earn lower wages than in the S-abundant country but managers in the U-abundant country earn higher rents than managers with the same talent in the S-abundant country. This does not mean, however, that *all* managers in the U-abundant country are better off than they would be in the S-abundant country, because some of them would do better as *employees* in the S-abundant country. The break-even talent level t (for tie) is defined by $r_2(\overline{v}^*, \overline{w}^*, \overline{p}_2, t) = \overline{w}$ in the case $a_1 > a_2$ and by $r_1(\overline{v}^*, \overline{w}^*, \overline{p}_1, t') = \overline{w}$ in the case $a_1 < a_2$. Note that an increase in $\overline{w}$ increases t or t′, indicating that a greater proportion of skilled individuals would like to leave the U-abundant country or stay in the S-abundant country, while an increase in $\overline{w}^*$ (or $\overline{v}^*$) has (perhaps surprisingly) the same effect because it reduces profitability of management in the U-abundant country at the margin.

In the analysis of skilled-labor migration that follows we cover only the case $a_1 > a_2$ since (as the interested reader can show) in no instance does the case $a_1 < a_2$ yield qualitatively different results. We begin by observing that allowing skilled-labor migration will alter the distribution of managerial talent in both the country of origin and the country of destination[10] and thus have dramatically different effects than would migration of a random sample of skilled individuals. We will first work out the new distribution for the S-abundant country for the case where some of its skilled citizens with managerial talent greater than t

[10]For example, because managerial talent is more highly rewarded in the U-abundant than in the S-abundant country there is negative selection of skilled (educated) immigrants to the S-abundant country with respect to managerial talent. This result is similar to, but must be distinguished from, the argument of Borjas (1987) that immigrants to the United States from LDCs are negatively selected with regard to on-the-job ability because (it is claimed) that ability is more highly rewarded in LDCs than in the United States.

choose to manage in the U-abundant country.[11] I make two simplifying assumptions. First, not only is the S-abundant country small in terms of its ability to affect world prices, it is also small relative to the U-abundant country in the sense that its emigrants do not affect wages there, in which case changes in t can result only from changes in $\overline{w}$. (We can think of the S-abundant country in this case as being one of a continuum of identical S-abundant countries.) Second, the same proportion δ of individuals of each talent level x > t emigrates. The consequences of the more realistic assumption that δ increases with x will be brought out clearly in the discussion below.

Under these assumptions it is clear that the proportion of the skilled population that emigrates equals $\delta[1 - D(t)]$, leaving behind a total skilled population $S_m = S\{1 - \delta[1 - D(t)]\}$, where the subscript m denotes the post-migration situation. It follows that if $D_m(x)$ is to represent the proportion of skilled agents with managerial talent less than or equal to x in the post-migration situation (just as D(x) did in the pre-migration situation), we must have

$$D_m(x) = D(x)/\{1 - \delta[1 - D(t)]\},\ x \le t,$$

$$D_m(x) = \{D(t) + (1 - \delta)[D(x) - D(t)]\}/\{1 - \delta[1 - D(t)]\},\ x > t.$$

Thus $D_m(x)$ has a kink at t, where its slope becomes discontinuously flatter. What is important for our purposes is to realize that the density $dD_m(x)$ is greater than dD(x) for $0 < x \le t$ and less than dD(x) for $t < x < \infty$.

The other side of the coin from emigration from the S-abundant country is immigration to the U-abundant country. However, we now treat the U-abundant country as though it is the small country, and suppose that it experiences immigration of the same proportion ε of its skilled individuals of each talent level x > t, where changes in t will result only from changes

[11]A good example of this "cross-hauling" of skilled labor takes place between Taiwan and California. On the one hand, it is estimated that Taiwanese comprise as much as 20 percent of the engineers in California's Silicon Valley. On the other hand, many Taiwanese engineers have returned from California to Taiwan's equivalent of Silicon Valley, the Hsinchu Science-based Industrial Park, to found new firms or become top executives in existing firms. A group of them has formed the Overseas Chinese Entrepreneurs Advisory Network to "help returnees adjust to Taiwan, hammer out strong business plans and find the right partners" (Watanabe 1989).

in $\overline{w}^*$ and $\overline{v}^*$. The resulting new population of skilled individuals and new distribution of talent are shown in table 2, as are the new populations and distributions resulting from skilled-labor emigration from the U-abundant country and skilled-labor immigration to the S-abundant country, respectively. We would like to know, in each of these four cases, what the effect of skilled-labor migration is on $\overline{v}$ and $\overline{w}$ or $\overline{v}^*$ and $\overline{w}^*$. The answers are given by the shifts in the curves in figure 3. To compute these shifts we substitute S_m and D_m into equations (7) and (8) to get

$$\int_{z_2}^{z_1} s_2(v,w,p_2,x)dD_m(x) + \int_{z_1}^{\infty} s_1(v,w,p_1,x)dD_m(x) = D_m(z_2). \tag{7m}$$

$$\int_{z_2}^{z_1} u_2(v,w,p_2,x)dD_m(x) + \int_{z_1}^{\infty} u_1(v,w,p_1,x)dD_m(x) = U/S_m. \tag{8m}$$

We now continue to examine the case of emigration from the S-abundant country. Substituting from the first column of table 2 into equations (7m) and (8m), we have

$$\int_{z_2}^{z_1} s_2(v,w,p_2,x)(1 - \delta)dD(x) + \int_{z_1}^{\infty} s_1(v,w,p_1,x)(1 - \delta)dD(x) = D(t) + (1 - \delta)[D(z_2) - D(t)]$$

$$\int_{z_2}^{z_1} u_2(v,w,p_2,x)(1 - \delta)dD(x) + \int_{z_1}^{\infty} u_1(v,w,p_1,x)(1 - \delta)dD(x) = U/S,$$

where the term $1 - \delta[1 - D(t)]$ has cancelled out in both equations. As we saw in section 3, z_2 and z_1 both negatively affect the demand for skilled labor. They also both increase w and thus increase t on the right-hand side of equation (7m), creating an increased supply of skilled individuals seeking employment that reinforces their negative effects on labor demand. In short, the full employment of skilled labor locus remains downward-sloping in figure 3. Moreover, if we divide through equation (7m) by $1 - \delta$, we see that given z_2 and z_1 the supply of skilled individuals seeking employment has unambiguously increased relative to equation (7) while the demand is unchanged. The full employment of skilled labor locus must therefore shift left in figure 3 as a result of skilled-labor emigration. Turning to equation (8m), it is clear that given z_2 and z_1 the demand for unskilled labor has unambiguously decreased

TABLE 2

Skilled-labor migration under the small-country assumption

	Emigration from S-abundant country	Immigration to U-abundant country	Emigration from U-abundant country	Immigration to S-abundant country
S_m	$S\{1-\delta[1-D(t)]\}$	$S^*\{1+\varepsilon[1-D(t)]\}$	$S^*[1-\delta D(t)]$	$S[1+\varepsilon D(t)]$
D_m, $x \leq t$	$\frac{D(x)}{1-\delta[1-D(t)]}$	$\frac{D(x)}{1+\varepsilon[1-D(t)]}$	$\frac{(1-\delta)D(x)}{1-\delta D(t)}$	$\frac{(1+\varepsilon)D(x)}{1+\varepsilon D(t)}$
D_m, $x > t$	$\frac{D(t)+(1-\delta)[D(x)-D(t)]}{1-\delta[1-D(t)]}$	$\frac{D(t)+(1+\varepsilon)[D(x)-D(t)]}{1+\varepsilon[1-D(t)]}$	$\frac{D(x)-D(t)+(1-\delta)D(t)}{1-\delta D(t)}$	$\frac{D(x)-D(t)+(1+\varepsilon)D(t)}{1+\varepsilon D(t)}$
Effect on				
v	–	+	-	–
w	–	+	+	–

relative to equation (8) while the supply is unchanged. A lower z_2 given any z_1 is therefore necessary to maintain full employment of unskilled labor, so the upward-sloping locus also shifts left in figure 3. The net result of skilled-labor emigration from the S-abundant country is therefore a large reduction in the cutoff level of managerial talent $\bar{z}_2$ and an ambiguous change in $\bar{z}_1$, which yields a reduction in the wages of both skilled and unskilled workers under less restrictive conditions than required for proposition 4. This result is indicated at the bottom of the first column of table 2. Intuitively, skilled-labor emigration from the S-abundant country reduces the number of skilled individuals with managerial talent above the cutoff level. While it also reduces the number of skilled individuals with managerial talent below the cutoff level, the *proportion* of such individuals rises. It is therefore necessary to lower the quality of the marginal manager in order to find enough managers to fully employ the population.

The same computational procedure yields the other effects on wages shown at the bottom of table 2. The intuition for the positive effect on wages of skilled-labor immigration to the U-abundant country is obvious: the country acquires more managers without acquiring any more employees, allowing an improvement in the quality of the marginal manager.[12] We can reverse the reasoning in the case of skilled-labor immigration to the S-abundant country: the country acquires more skilled employees without acquiring any more managers. In this case equation (8m) does not shift at all relative to (8), while equation (7m) shifts left relative to (7), yielding an unambiguously lower $\bar{z}_2$ *and* $\bar{z}_1$. $\bar{w}$ is therefore reduced unambiguously, while $\bar{v}$ is reduced for $a_1 - a_2$ sufficiently small.

The case of skilled-labor emigration from the U-abundant country (the classic "brain drain" case) is the only one where the change in the cutoff level of managerial talent is

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[12]In the real world, sometimes highly talented manager-entrepreneurs move in the opposite direction from that predicted by our model for noneconomic reasons (e.g., from Hong Kong to the United States). We can analyze the consequences of this migration using the same computational procedure employed in the text. Clearly there will be an increase in wages in the country of immigration and a fall in wages in the country of emigration, with the opposite effects on managerial rents.

ambiguous. It is worth showing the computation explicitly. Substituting from the third column of table 2 into equations (7m) and (8m), we have

$$\int_{z_2^*}^{t} s_2^*(v,w,p_2,x)(1-\delta)dD(x) + \int_{t}^{z_1^*} s_2^*(v,w,p_2,x)dD(x) + \int_{z_1^*}^{\infty} s_1^*(v,w,p_1,x)dD(x) = (1-\delta)D(z_2^*)$$

$$\int_{z_2^*}^{t} u_2^*(v,w,p_2,x)(1-\delta)dD(x) + \int_{t}^{z_1^*} u_2^*(v,w,p_2,x)dD(x) + \int_{z_1^*}^{\infty} u_1^*(v,w,p_1,x)dD(x) = U^*/S^*,$$

where the term $1 - \delta D(t)$ has cancelled out in both equations. Since z_2^* increases both v^* and w^* it also increases t, reinforcing its negative effects on demand for both skilled and unskilled labor. z_1^* increases w^* but reduces v^*, and it can be shown that the latter effect on profitability at the margin dominates the former effect so that z_1^* reduces t. This reinforces the positive effect of z_1^* on demand for unskilled labor in equation (8m) but offsets its negative effect on demand for labor in equation (7m). Assuming that the total effect of z_1^* on demand for skilled labor is still negative, the full employment of skilled labor locus remains downward-sloping. Using by now familiar reasoning, we divide through equation (7m) by $1 - \delta$ and note that demand for skilled labor has increased relative to equation (7) while supply is unchanged, so the downward-sloping locus in figure 3 shifts right. On the other hand, the demand for unskilled labor in equation (8m) has decreased relative to equation (8) while the supply is unchanged, causing the upward-sloping locus in figure 3 to shift left. $\bar{z}_1^*$ increases unambiguously but the change in the cutoff level of managerial talent $\bar{z}_2^*$ is unclear. Intuitively, the ambiguity arises because on the one hand the proportion of skilled individuals with managerial talent less than the cutoff level has decreased, while on the other hand the number of managers has decreased. Table 2 assumes that the change in $\bar{z}_1^*$ dominates so that $\bar{v}^*$ falls and $\bar{w}^*$ increases.

Let us now examine the consequences of relaxing our second simplifying assumption above concerning the proportion of skilled individuals of any talent level that choose to immigrate or emigrate. In the case of emigration from the S-abundant country and immigration to the U-abundant country, it seems realistic to suppose that this proportion will depend positively on x since the financial incentive to migrate increases with x. Obviously this will only reinforce the negative effect on S-abundant country wages and positive effect on U-abundant country wages that we already derived. In the case of emigration from the U-abundant country and immigration to the S-abundant country, the financial incentive to migrate is identical for all skilled individuals with managerial talent $0 \leq x \leq \bar{z}_2^*$, decreasing with x only for those with managerial talent $\bar{z}_2^* < x < t$. If the proportion of the latter group that migrates decreases with x, it makes no difference for the effect of immigration to the S-abundant country on wages, since none of the immigrants will be managers anyway. However, for emigration from the U-abundant country the impact of the loss of managers will be somewhat weakened, making it more likely that the cutoff level of managerial talent will increase and less likely that $\bar{v}^*$ will decrease.

In concluding this section, I want to explore an issue that requires mathematical treatment similar to that given skilled-labor migration but is conceptually quite distinct. One often thinks of management as requiring a certain amount of maturity or "life experience", especially because of the leadership and organization of subordinates it involves. In the context of the model of section 2 this is most easily formalized by assuming that a skilled individual must reach a certain age before he is able to manage, and that this age is independent of his talent level. If we then compare two populations of skilled individuals with the same distribution D of managerial talent, the one with the "younger" age distribution has proportionately fewer potential managers.[13] This is important because a "younger" labor force age distribution is characteristic of less developed countries due to higher fertility and shorter

[13]Calvo and Wellisz (1980) work out a dynamic model where age and "ability" x interact over time to promote learning of "technical knowledge" which can then be applied to management. Rather than a cutoff level of managerial talent, their model generates a cutoff *curve* in x, age space which is convex to the origin and below which workers do not have enough technical knowledge to become managers. Use of their model rather than the one employed in the next paragraph also results in the country with the younger age distribution having proportionately fewer potential managers, and it can be shown to lead to the same effect on the difference in efficiency of the marginal manager between the two countries.

life expectancy.

Suppose, then, that for each country there exists a fixed age distribution A: $R^+ \to [0,1]$ and that every skilled agent has an "age of maturity" τ drawn from a fixed distribution E: $R^+ \to [0,1]$. Letting z_2 continue to denote the cutoff level of managerial talent, the proportion of nonmanagers is $D(z_2) + \int_0^\infty A(\tau)dE(\tau) - D(z_2)\int_0^\infty A(\tau)dE(\tau)$, since managerial talent is independent of both calendar age and age of maturity. ($\int_0^\infty A(\tau)dE(\tau)$ gives the probability that a skilled agent is younger than her age of maturity.) We can now alter equations (7m) and (8m) to incorporate the effects of age distribution rather than skilled-labor migration:

$$\int_0^\infty [1 - A(\tau)]dE(\tau)[\int_{z_2}^{z_1} s_2(v,w,p_2,x)dD(x) + \int_{z_1}^\infty s_1(v,w,p_1,x)dD(x)]$$

$$= D(z_2) + \int_0^\infty A(\tau)dE(\tau) - D(z_2)\int_0^\infty A(\tau)dE(\tau) \qquad (7a)$$

$$\int_0^\infty [1 - A(\tau)]dE(\tau)[\int_{z_2}^{z_1} u_2(v,w,p_2,x)dD(x) + \int_{z_1}^\infty u_1(v,w,p_1,x)dD(x)] = U/S. \qquad (8a)$$

Suppose now that the age distribution of the U-abundant country is "younger", i.e., $A^*(\tau) > A(\tau)$, $0 < \tau < \infty$. By looking at (7a) and (8a) we can see, using familiar reasoning, that in figure 3 both the downward-sloping locus and the upward-sloping locus will be shifted left for the U-abundant country relative to the S-abundant country. The result is that in free trade equilibrium the gap between $\bar{z}_2$ and $\bar{z}_2^*$ becomes even wider while the change in the gap between $\bar{z}_1$ and $\bar{z}_1^*$ is ambiguous, yielding a further reduction in the wages of both skilled and unskilled workers in the U-abundant relative to the S-abundant country under less restrictive conditions than required for proposition 4.

5. Conclusions

The approach this paper has taken to reconciling the pattern of trade with the pattern of migration has proved to be fruitful. It has generated new results on the effects of unskilled-labor migration. It predicts cross-hauling of skilled labor and yields new results for the effects of this skilled-labor migration. It has also provided an alternative to the capital-shallowing approach to explaining why more rapid population growth due to higher fertility might lower wages.

I have deliberately kept the approach taken here purely static or comparative static. It should therefore be easy to incorporate many natural extensions that involve a dynamic element. One such extension would be to endogenize the choice of whether or not to become skilled (educated), as in the aforementioned paper of Findlay and Kierzkowski (1983). Another extension would be to allow innate managerial talent to be augmented by on-the-job learning, as suggested at the end of Lucas (1978) and modelled explicitly by Calvo and Wellisz (1980). If this on-the-job learning benefits from skilled-labor externalities, then the approach of Lucas (1988) and Jovanovic and Rob (1987) discussed in the introduction could also be incorporated. This last extension is especially interesting because it may change the present model's results on the effects of skilled-labor migration, making it more likely that the brain drain from the unskilled-labor abundant country will lower all wages there. Bhagwati and Dellalfar (1976) state that a negative external effect on productivity is one reason for concern on the part of less developed countries about the brain drain.

APPENDIX: Determination of slopes of full employment loci in text figure 3

Each of the text equations (7), (8), (7′), and (8′) defines a full employment locus $\psi(z_2,z_1) = 0$ in figure 2. The slope of each locus is given by $dz_1/dz_2 = -(\partial\psi/\partial z_2)/(\partial\psi/\partial z_1)$. Holding p_1 and p_2 constant, we will find the sign of $\partial\psi/\partial z_2$ and $\partial\psi/dz_1$ for each locus in turn. In the process it will prove useful to know the proportional changes in wages in response to proportional changes in z_1 and z_2. We therefore begin by logarithmically differentiating the text equations (5) and (6) ((5′) and (6′)) in the case $a_1 > a_2$ (in the case $a_1 < a_2$). Arranging the results in matrix form yields:

$$\begin{bmatrix} (a_2-1)f_2 & (a_2-1)e_2 + 1 \\ (a_1-1)f_1 - (a_2-1)f_2 & (a_1-1)e_1 - (a_2-1)e_2 \end{bmatrix} \begin{bmatrix} \hat{v} \\ \hat{w} \end{bmatrix} = \begin{bmatrix} a_2 & 0 \\ 0 & a_1-a_2 \end{bmatrix} \begin{bmatrix} \hat{z}_2 \\ \hat{z}_1 \end{bmatrix} \quad \text{(A1)}$$

in the case $a_1 > a_2$, and

$$\begin{bmatrix} (a_1-1)e_1 + 1 & (a_1-1)f_1 \\ (a_2-1)e_2 - (a_1-1)e_1 & (a_2-1)f_2 - (a_1-1)f_1 \end{bmatrix} \begin{bmatrix} \hat{w} \\ \hat{v} \end{bmatrix} = \begin{bmatrix} a_1 & 0 \\ 0 & a_2-a_1 \end{bmatrix} \begin{bmatrix} \hat{z}_1 \\ \hat{z}_2 \end{bmatrix} \quad \text{(A1′)}$$

in the case $a_1 < a_2$. By applying Cramer's rule to the system (A1) ((A1′)), we obtain:

$$\hat{w} = \{a_2[(a_2-1)f_2 - (a_1-1)f_1]/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_2 \quad \text{(A2)}$$

$$\hat{v} = \{a_2[(a_1-1)e_1 - (a_2-1)e_2]/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_2 \quad \text{(A3)}$$

$$\hat{w} = \{(a_1 - a_2)(a_2-1)f_2/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_1 \quad \text{(A4)}$$

$$\hat{v} = \{-(a_1 - a_2)[(a_2-1)e_2 + 1]/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_1, \quad \text{(A5)}$$

for the case $a_1 > a_2$, while for the case $a_1 < a_2$ we have

$$\hat{w} = \{a_1[(a_2-1)f_2 - (a_1-1)f_1]/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_1 \quad \text{(A2′)}$$

$$\hat{v} = \{a_1[(a_1-1)e_1 - (a_2-1)e_2]/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_1 \quad \text{(A3′)}$$

$$\hat{w} = \{-(a_2 - a_1)(a_1-1)f_1/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_2 \quad \text{(A4′)}$$

$$\hat{v} = \{(a_2 - a_1)[(a_1-1)e_1 + 1]/[(a_1-1)(a_2-1)(e_1 - e_2) + (a_2-1)f_2 - (a_1-1)f_1]\}\hat{z}_2. \quad \text{(A5′)}$$

The denominators of these equations are found by simplifying the determinants using the facts $e_i + f_i = 1$.

We now turn to text equation (7). We have

$$\partial\psi/\partial z_2 = - s_2(z_2)dD(z_2) + \int_{z_2}^{z_1} [(\partial s_2/\partial w)(dw/dz_2) + (\partial s_2/\partial v)(dv/dz_2)]dD(x)$$

$$+ \int_{z_1}^{\infty} [(\partial s_1/\partial w)(dw/dz_2) + (\partial s_1/\partial v)(dv/dz_2)]dD(x) - dD(z_2)$$

$$\partial\psi/\partial z_1 = [s_2(z_1) - s_1(z_1)]dD(z_1) + \int_{z_2}^{z_1} [(\partial s_2/\partial w)(dw/dz_1) + (\partial s_2/\partial v)(dv/dz_1)]dD(x)$$

$$+ \int_{z_1}^{\infty} [(\partial s_1/\partial w)(dw/dz_1) + (\partial s_1/\partial v)(dv/dz_1)]dD(x).$$

From text equation (2) we can see that the terms $\partial s_i/\partial w$ and $\partial s_i/\partial v$ will involve changes in the elasticities e_i with respect to w and v. Since these changes cannot be signed in general, we will ignore them in the rest of this Appendix by holding the e_i constant (as they would be if the cost functions c_i were Cobb-Douglas), implying that the f_i are held constant as well. It is then clear from (2) and figure 2 that the terms $(\partial s_i/\partial w)(dw/dz_2)$ and $(\partial s_i/\partial v)(dv/dz_2)$ are all negative, so that $\partial\psi/\partial z_2 < 0$ unambiguously. Signing $\partial\psi/\partial z_1$ is more difficult because, as can be seen from (2) and figure 2, the terms $(\partial s_i/\partial w)(dw/dz_1)$ and $(\partial s_i/\partial v)(dv/dz_1)$ are of opposite sign.

Let us try to sign $(\partial s_2/\partial w)(dw/dz_1) + (\partial s_2/\partial v)(dv/dz_1)$. This equals

$$[(a_2-1)(\partial r_2/\partial w)(e_2/w) - (a_2-1)r_2e_2/w^2](dw/dz_1) + (a_2-1)(\partial r_2/\partial v)(e_2/w)(dv/dz_1)$$

$$= - (a_2-1)(e_2/w)[(s_2 + r_2/w)(dw/dz_1) + u_2(dv/dz_1)]$$

$$= - (a_2-1)(e_2/w)r_2\{\{[(a_2-1)e_2 + 1]/w\}(dw/dz_1) + [(a_2-1)f_2/v](dv/dz_1)\}$$

$$= - (a_2-1)(e_2/w)(r_2/z_1)\{[(a_2-1)e_2 + 1](\hat{w}/\hat{z}_1) + (a_2-1)f_2(\hat{v}/\hat{z}_1)\}.$$

Substituting from (A4) and (A5), the sign of the last expression is seen to depend on $[(a_2-1)e_2 + 1](a_2-1)f_2 - (a_2-1)f_2[(a_2-1)e_2 + 1] = 0$. Similar manipulations show that $(\partial s_1/\partial w)(dw/dz_1) + (\partial s_1/\partial v)(dv/dz_1) \lesseqgtr 0$ as $[(a_1-1)e_1 + 1](a_2-1)f_2 - (a_1-1)f_1[(a_2-1)e_2 + 1] \gtreqless 0$. But the last expression is clearly positive from text equations (4) and (10). We have thus shown that $\partial\psi/\partial z_1 < 0$ unambiguously and therefore the full employment locus defined by (7) slopes downwards unambiguously in figure 3.

Turning to text equation (8), following the same reasoning we did with (7) clearly shows that $\partial\psi/\partial z_2 < 0$. We then consider

$$\partial\psi/\partial z_1 = [u_2(z_1) - u_1(z_1)]dD(z_1) + \int_{z_2}^{z_1} [(\partial u_2/\partial w)(dw/dz_1) + (\partial u_2/\partial v)(dv/dz_1)]dD(x)$$
$$+ \int_{z_1}^{\infty} [(\partial u_1/\partial w)(dw/dz_1) + (\partial u_1/\partial v)(dv/dz_1)]dD(x).$$

We have $(\partial u_2/\partial w)(dw/dz_1) + (\partial u_2/\partial v)(dv/dz_1) =$

$$(a_2-1)(\partial r_2/\partial w)(f_2/v)(dw/dz_1) + [(a_2-1)(\partial r_2/\partial v)(f_2/v) - (a_2-1)r_2 f_2/v^2](dv/dz_1)$$
$$= -(a_2-1)(f_2/v)(r_2/z_1)\{(a_2-1)e_2(\hat{w}/\hat{z}_1) + [(a_2-1)f_2 + 1](\hat{v}/\hat{z}_1)\}.$$

This expression is positive or negative as $(a_2-1)e_2(a_2-1)f_2 - [(a_2-1)f_2 + 1][(a_2-1)e_2 + 1] \lesseqgtr 0$, so it is positive. Similarly, $(\partial u_1/\partial w)(dw/dz_1) + (\partial u_1/\partial v)(dv/dz_1) \gtrless 0$ as $(a_1-1)e_1(a_2-1)f_2 - [(a_1-1)f_1 + 1][(a_2-1)e_2 + 1] \lesseqgtr 0$. Unfortunately, the sign of the last expression is ambiguous. Except for this ambiguity, all factors contribute to making $\partial\psi/\partial z_1 > 0$, in which case the full employment locus defined by (8) slopes upwards in figure 3.

For text equations (7′) and (8′), we can show that $\partial\psi/\partial z_1 < 0$ for the same reasons that $\partial\psi/\partial z_2 < 0$ for (7) and (8). We then consider

$$\partial\psi/\partial z_2 = [s_1(z_2) - s_2(z_2)]dD(z_2) + \int_{z_1}^{z_2} [(\partial s_1/\partial w)(dw/dz_2) + (\partial s_1/\partial v)(dv/dz_2)]dD(x)$$
$$+ \int_{z_2}^{\infty} [(\partial s_2/\partial w)(dw/dz_2) + (\partial s_2/\partial v)(dv/dz_2)]dD(x).$$

We can show that $(\partial s_1/\partial w)(dw/dz_2) + (\partial s_1/\partial v)(dv/dz_2) =$

$$-(a_1-1)(e_1/w)(r_1/z_2)\{[(a_1-1)e_1 + 1](\hat{w}/\hat{z}_2) + (a_1-1)f_1(\hat{v}/\hat{z}_2)\}.$$

Substituting from (A4′) and (A5′), the sign of this expression is seen to depend on $[(a_1-1)e_1 + 1](a_1-1)f_1 - (a_1-1)f_1[(a_1-1)e_1 + 1] = 0$. Similarly, we can show that $(\partial s_2/\partial w)(dw/dz_2) + (\partial s_2/\partial v)(dv/dz_2) \gtrless 0$ as $[(a_2-1)e_2 + 1](a_1-1)f_1 - (a_2-1)f_2[(a_1-1)e_1 + 1] \gtrless 0$. But the last expression is clearly negative from text equation (4). The sign of $\partial\psi/\partial z_2$ is therefore ambiguous, making the slope of the full employment locus defined by (7′) ambiguous as well. The text gives conditions under which $\partial\psi/\partial z_2 > 0$ so that the full employment locus defined by (7′) slopes upwards in figure 3.

Turning to (8′), we consider

$$\partial\psi/\partial z_2 = [u_1(z_2) - u_2(z_2)]dD(z_2) + \int_{z_1}^{z_2} [(\partial u_1/\partial w)(dw/dz_2) + (\partial u_1/\partial v)(dv/dz_2)]dD(x)$$

$$+ \int_{z_2}^{\infty} [(\partial u_2/\partial w)(dw/dz_2) + (\partial u_2/\partial v)(dv/dz_2)]dD(x).$$

We have $(\partial u_1/\partial w)(dw/dz_2) + (\partial u_1/\partial v)(dv/dz_2)$

$$= - (a_1-1)(f_1/v)(r_1/z_2)\{(a_1-1)e_1(\hat{w}/\hat{z}_2) + [(a_1-1)f_1 + 1](\hat{v}/\hat{z}_2)\}.$$

This expression is positive or negative as $(a_1-1)e_1(a_1-1)f_1 - [(a_1-1)f_1 + 1][(a_1-1)e_1 + 1] \gtrless 0$, so it is negative. Similarly, $(\partial u_2/\partial w)(dw/dz_2) + (\partial u_2/\partial v)(dv/dz_2) \gtrless 0$ as $(a_2-1)e_2(a_1-1)f_1 - [(a_2-1)f_2 + 1][(a_1-1)e_1 + 1] \gtrless 0$, so it is also negative. We have thus shown that $\partial\psi/\partial z_2 < 0$ unambiguously and therefore the full employment locus defined by (8′) slopes downwards unambiguously in figure 3.

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