Title	FOREIGN INVESTMENT AND MIGRATION: ANALYTICS AND EXTENSIONS OF THE BASIC MODEL
Sub Title	
Author	JONES, Ronald W. EASTON, Stephen T.
Publisher	Keio Economic Society, Keio University
Publication year	1990
Jtitle	Keio economic studies Vol.27, No.1 (1990.) ,p.1- 20
JaLC DOI	
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Notes	
Genre	Journal Article
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=AA00260492-19900001-0001

FOREIGN INVESTMENT AND MIGRATION: ANALYTICS AND EXTENSIONS OF THE BASIC MODEL

Ronald W. JONES* and Stephen T. EASTON

Abstract: This paper provides a unified approach to the basic model of international factor mobility. The use of new graphical techniques complements the algebraic exposition to underscore the persistence of the Ramaswami effect which pushes an active, home country toward a near "buy-out" of the foreign country's internationally mobile factors of production. By generalizing the Ramaswami function, which identifies the gains associated with moving to near buy-out, we are able to explore the forces at work that mitigate such a strategy and lead to situations in which only a partial buy-out, or even no acquisition of foreign factors is optimal. These features are developed in a context in which (i) technologies differ between countries or (ii) there exists a third, immobile factor of production.

The seminal work by Ramaswami (1968), comparing the advantages of allowing international labor inflows with those of foreign investment, elicited an immediate response from Webb (1970) and subsequent elaborations by Bhagwati (1979), Calvo and Wellisz (1983), Bhagwati and Srinivasan (1983), and Ruffin (1984). This work served to confirm Ramaswami's suggestion that if international factor markets are in operation, it is preferable for a capital-rich country to admit foreign labor than to export some of its own capital to foreign countries if such labor could be obtained at the low wage rate prevailing abroad. The model developed in this literature was stripped down to such bare elements as to be dubbed the "basic model" in Jones, Coelho, and Easton (1986), an article which extended the reasoning employed by Ramaswami to analyze optimal policy when an active country can control jointly the international flows of labor and of capital.

Simple assumptions often lead to striking conclusions, and optimal policy in the "basic model" was shown to involve subsidizing capital inflows from the low-wage, high-rent country. Indeed, first-best policy on the part of the active, capital-rich country was shown to involve almost a total "buy-out" of the other country's factor supplies at their autarky wages and rentals. The key assumptions of the basic model supporting such a strong result include:

(i) The active home country can obtain cheap labor abroad at low foreign

* Support for this research comes, in part, from Jones' NSF grant #SES-8510697. Easton is grateful to the Social Sciences and Humanities Research Council of Canada, which provided a Sabbatical leave Fellowship. An earlier version of this paper was presented at the University of Konstanz and appeared as Discussion paper #39, of the SFB 178 "Internationale Wirtschaftsbeziehungen".

wage rates. The Ramaswami reasoning and the "buy-out" strategy break down if foreign workers on net receive the high wages prevailing at home.[1]

(ii) Technological knowledge and factor skills are the same in both countries. Both Ruffin (1984), and Calvo and Wellisz (1983) remark on the question of technological parity, but seem to disagree on the consequences of allowing differences in technology. This issue is explored further in Jones and Easton (1989).

(iii) All (both) factors are assumed to be internationally mobile. If the dimensions of the model were to be extended to allow the existence of some factor (say land) that was immobile, the complete "buy-out" strategy would obviously be thwarted. But would there nonetheless be a tendency for the active home country to attempt to obtain at least some quantities of those factors that are internationally mobile, even if this entails subsidies to get expensive factors to move? An analysis of this issue was presented by Jones and Coelho (1985) in the context of a model with many commodities and (even more numerous) factors. Kuhn and Wooton (1987), and Bond (1989) address this issue in the more simple context in which only one commodity is produced (as in the basic model), both labor and capital can flow between countries (subject to taxation or encouraged by subsidies), but a third factor (land) is immobile in each country.

In the present paper we provide an analytical framework to investigate the fate of the Ramaswami type of reasoning, which leads to a buy-out optimal strategy in the basic model, when technologies differ or when a third non-mobile factor is introduced.[2] As in the basic model, international factor flows affect welfare in the active country both by the changes they bring about in world output and by induced changes in the "terms of trade", the factor prices paid to internationally mobile labor and capital. If the terms of trade effect were absent, the active home country would capture all the gains in world output. Our analysis proceeds by considering separately a set of world-output contours in factor space, and a set of terms-of-trade contours. A contract curve of maximal points connects these two sets of contours, and the optimal point for the home country is located on such a contract curve. This graphical device is employed in section I to review the argument for the basic model, in section II to investigate the case in which technology is inferior in the active home country, and in section III to establish the sense in which the Ramaswami reasoning is still in evidence even with immobile land.

I. THE BASIC MODEL AND THE LOGIC OF THE "BUY-OUT" STRATEGY

Adopting the notation of Jones, Coelho, and Easton (1986), let x denote the

[1] This argument is developed in Jones, Coelho and Easton (1986). See also Bhagwati and Srinivasan (1983), and Ruffin (1984). The analysis of optimal factor flows when labor exporting and importing countries enter into a wage agreement that splits the wage gap is provided in Easton and Jones (1990).

[2] We retain Ramaswami's assumption that the active country can hire foreign labor at its (low) opportunity cost abroad.

exports of capital from the home country and z the imports of labor from abroad. Foreign workers on net receive w^*, the wage rate prevailing in their own country, although home producers must pay the higher wage (w) ruling at home. The difference is paid as tax to the home country. Home capitalists earn r^* on each unit of capital shipped abroad, which is assumed to exceed the home rate of return, r. Home taxes on capital exports capture the difference, and should foreign capital be solicited from abroad a subsidy would have to be paid foreigners since foreign capital would only earn r at home.

With only one good produced and consumed, home income is given by expression (1):

$$Y = \{wL + rK\} + \{r^*x - w^*z\}\,. \tag{1}$$

The quantities of labor and capital actually employed at home are denoted by L and K, and these exceed the bundle of factors owned at home by the flow vector, $(z, -x)$. Small changes in factor flows lead to basic expression (2) for the change in home retained income:

$$dY = \{(r^* - r)dx + (w - w^*)dz\} + \{xdr^* - zdw^*\}\,. \tag{2}$$

In deriving (2), use is made of the basic relationship whereby $\{Ldw + Kdr\}$ vanishes, since all factor returns are quoted in terms of the single output.[3] The first bracket refers to the change in world output associated with the movement of labor and/or capital between countries. (This change is captured by the home country as net tax revenue). The second bracketed term show the net terms of trade effects for the home country. Expression (2) is applicable in all the models considered in this paper.

A set of world-output contours is illustrated in Figure 1. Both countries produce the same commodity using the same constant-returns technology, so that the locus of optimal world factor allocations is shown by diagonal 00*. The key feature of these contours, which rise towards the ridge 00*, is that the slope always lies between the capital/labor ratios employed in the two countries. This reflects the assumption that technology is strictly convex in the sense captured by expressions (3) and Figure 2.

$$\begin{aligned} &(w - w^*)L^* + (r - r^*)K^* > 0 \\ &(w - w^*)L + (r - r^*)K < 0 \end{aligned} \tag{3}$$

Each inequality states that the labor and capital bundle used in that country earns a return that is smaller than it would make if the same input bundle could obtain any other pair of factor rewards supported by the technology. The frontier is bowed in towards the origin. And, in the limit, the slope of the frontier at any point reflects the labor/capital proportions that support that pair of factor returns.

[3] A factor price frontier has slope, dr/dw, equal to the negative of the labor/capital ratio used at home. The factor price frontier concept is utilized in the analysis of Jones and Easton (1989).

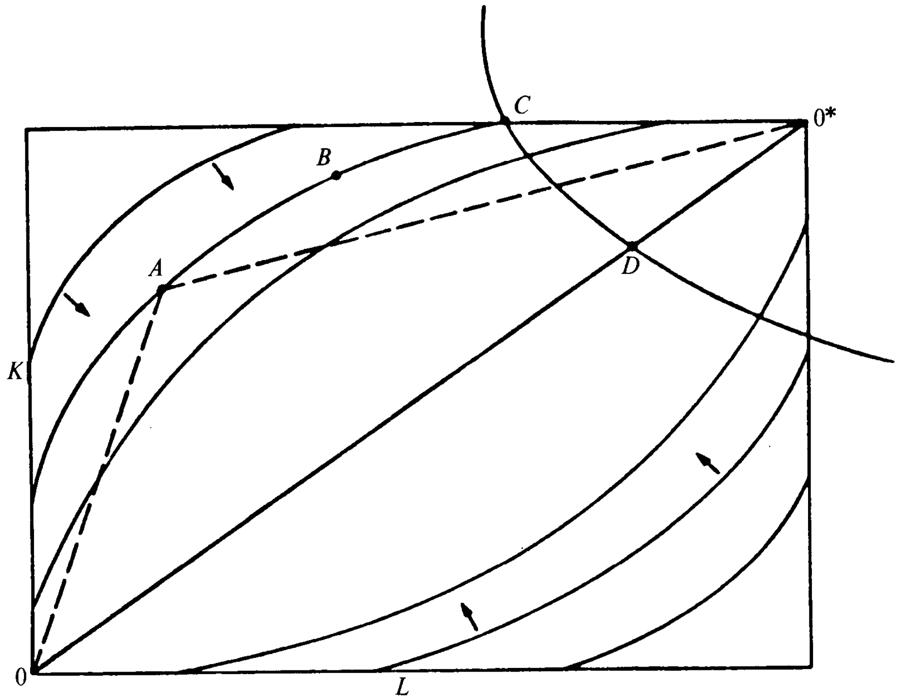

Fig. 1: World Output Contours, Basic Model

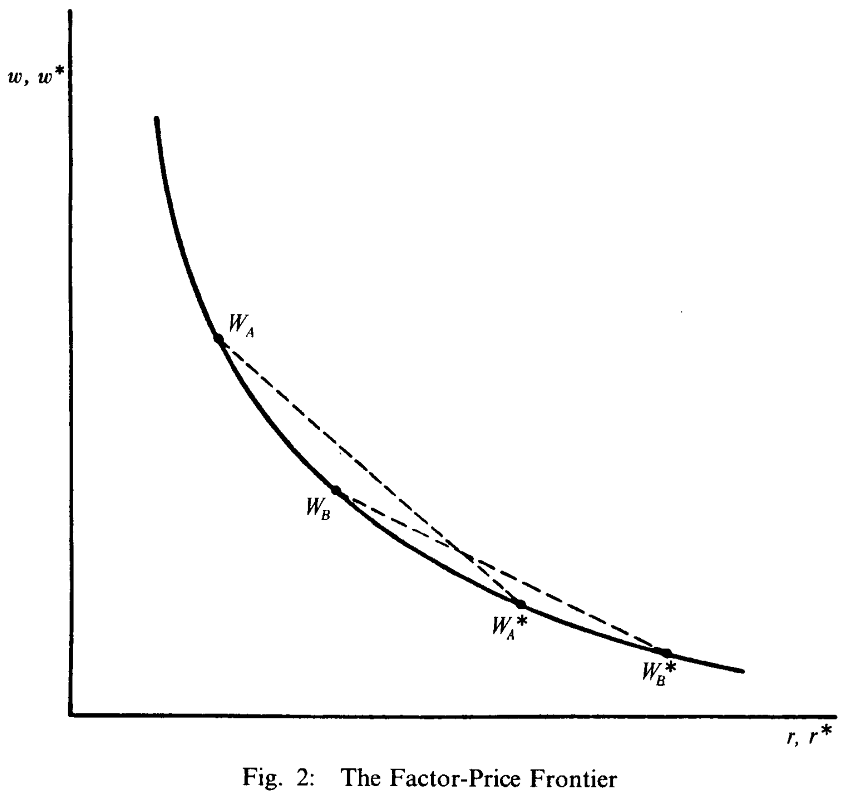

Fig. 2: The Factor-Price Frontier

Inequalities (3) imply

$$\frac{K}{L} > \frac{(w-w^*)}{(r^*-r)} > \frac{K^*}{L^*}$$

for production points above the diagonal (where the home country is capital-rich and thus r^* exceeds r).

The slope of the contours in Figure 1 is $(w-w^*)/(r^*-r)$, since world output remains constant only if the first bracketed expression in (2) vanishes. Turning to Figure 2, points W_A^* and W_A illustrate the factor returns in the two countries at point A in Figure 1, and the slope of the chord joining W_A^* and W_A is the slope of the contour at A in Figure 1. The chord connecting W_B with W_B^* in Figure 2 is flatter, as is the constant-world-output contour at B in Figure 1.[4]

These remarks support the following proposition: From any point off the diagonal of the world production box (such as A) a movement towards either origin must continually raise world output. Clearly a move from A southeastwards towards the diagonal must raise world output since it involves both labor and capital moving from low return to high return-areas. The move from A to 0^* also increases world output despite the fact that it entails the home country receiving both labor and capital from abroad in a situation in which capital earns less at home than it does abroad.

If the home country could hire a factor bundle from abroad without worsening the prices it must pay to obtain those factors, it would clearly gain by a "buy-out" strategy. Figure 3 illustrates the terms-of-trade contours for the home country. The endowment point is A, and a move from A to 0^* represents purchases of foreign factors at the returns earned in autarky. Foreign factor prices are each undisturbed. A move from endowment point A to point E reflects a pure outflow of capital from the home country to the foreign country. At each step the move from A to E lowers the return, r^*, which previous capital located abroad (x) can earn. It thus represents a worsening of the terms of trade. Similarly, a move from A to G reflects a pure inflow of foreign labor; the more labor that comes in, the higher is the wage that must be paid all foreign migrants. The terms of trade contours describe a ruled surface with maximal height given by any point on ridge $A0^*$, and descending on either side, with linear ridges always pointing towards 0^*.

Ramaswami argued that a policy of optimal labor inflow dominates a policy of optimal capital outflow. Suppose AE in Figure 3 represents the optimal outflow of capital, reflecting a balance between obtaining higher returns by shipping capital abroad and preserving the returns earned by capital already located abroad. A reallocation from E to G involves bringing AE amount of capital back home along

[4] Note that the contours in Figure 1 hit the axes. Thus, if amount $C0^*$ of the world's labor supply was left idle and the home country used the remaining labor supply and the entire supply of capital, its output would equal the world's output at an allocation between countries shown by A with all labor utilized. An isoquant passing through C would hit the diagonal at D. Ratio $0^*D/00^*$ would reflect the relative gain in world production in moving from A to some allocation on the diagonal.

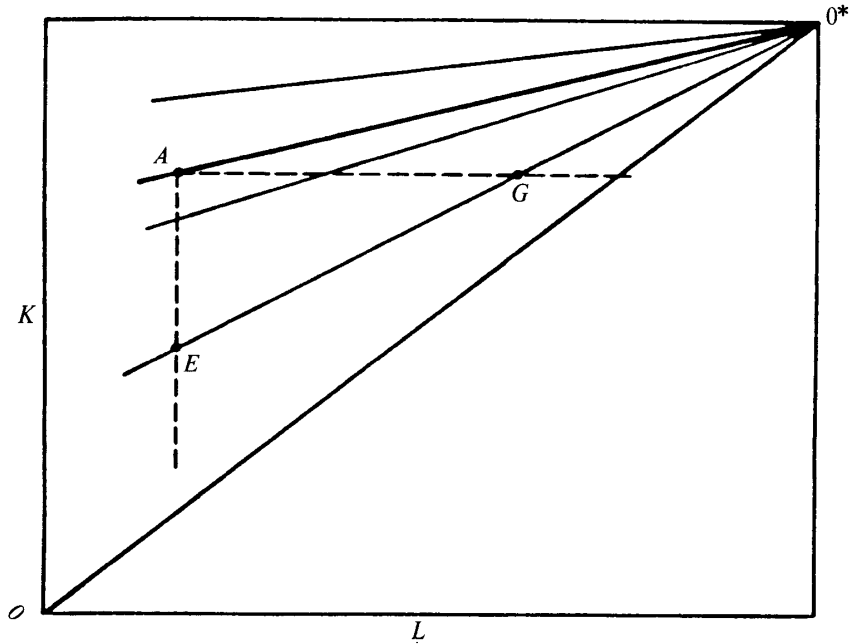

Fig. 3: Terms of Trade Contours, Basic Model

with AG units of foreign labor, which previously was employed with AE units of capital abroad. As Ramaswami argued, this move leaves factor prices unaltered and, by the convexity argument illustrated in Figure 1, raises world output. Thus for the home country allocation G clearly dominates E, and if a different pure-labor-inflow is better than G it must perforce dominate E as well. Thus, the Ramaswami reasoning entails a consideration of what a purchase of all mobile factors from abroad in the proportions employed abroad does to world output and the terms of trade. It was this reasoning which led to the "buy-out" argument in Jones, Coelho, and Easton (1986), whereby a move from A almost to 0^* optimized the returns to the home country.[5] And it is this reasoning which, in altered form, will still be relevant in the extensions to the basic model which we now consider.

II. DIFFERENT TECHNOLOGIES

If the active home country possesses a technology that is superior to that abroad, and can obtain capital and labor from abroad at factor prices which reflect their inferior technology (assuming the quality of factors is comparable between countries), a "buy-out" strategy is clearly appropriate. It is the reverse ranking

[5] Optimal strategy requires some factor bundle left in the foreign country in order to keep foreign factor prices at their autarky level. Note that although points closer to 0^* than G along ray $EG0^*$ (as seen in Figure 3) are superior to Ramaswami-point G, (since world output rises and the terms of trade do not change), the home country does even better buying at autarky prices along $A0^*$. The terms-of-trade surface has a "spike" at 0^*, as all contours merge there at different levels.

of technology that raises the interesting question: can it pay the active home country to purchase a bundle of factors from a region possessing a superior technology which supports a superior factor price frontier? More strongly, might the home country attempt an (almost) complete "buy-out"?

To examine the possibility that a "buy-out" strategy is optimal, we continue to pursue the logic described in the previous section but now ask: What is the effect on domestic income of moving one unit of labor and k^* units of capital from the foreign country to the home country? Using equation (2), this is expressed (per unit labor) by equation (4) since the terms of trade are left undisturbed:

$$\frac{dy}{dz}=\{(w-w^*)+(r-r^*)k^*\}\,. \tag{4}$$

Since technologies differ between countries, the income change can be decomposed into two portions: the income gain that would be associated with the factor inflow if countries shared in common the domestic technology, plus the income loss of the factor movement associated with the use of the inferior technology and the consequent necessity of hiring factors at prices shown along a superior frontier. Representing with a "†" the factor prices that would prevail abroad if foreigners shared the domestic technology, we rewrite equation (4) as equation (5):

$$\frac{dy}{dz}=[(w-w^\dagger)+(r-r^\dagger)k^*]-[(w^*-w^\dagger)+(r^*-r^\dagger)k^*] \tag{5}$$

On the right hand side, the first term in braces reflects what we have elsewhere termed the Ramaswami function, R:

$$R(k^*)\equiv(w-w^\dagger)+(r-r^\dagger)k^*\,, \tag{6}$$

which describes the change in domestic income from moving one unit of labor and k^* units of capital to the home country when the two share identical technologies. In general, the Ramaswami function depends both on the extent of the flow of factors from abroad (since this affects local wages and rents) and the disparities in the endowments between the two countries. It is to this latter point we turn to discover whether it remains optimal to engage in a "buy-out" of the foreign endowment.[6]

If technologies were common between the two countries in the neighborhood of the full "buy-out", domestic factor prices would approach $(\tilde{w},\tilde{r})$, the wages and rents associated with world factor proportions. Since factors were withdrawn from abroad in proportion, k^*, foreign factor prices remain at $\{w^\dagger(k^*), r^\dagger(k^*)\}$ which are functions of the original factor proportions abroad. This is the key to recognizing the effect of endowment changes on the Ramaswami function. An

[6] In Jones and Easton (1989) the relationship between the Ramaswami function and the proportion of the total foreign endowment transferred, a, is explored in some detail. Although $R>0$, $\partial R/\partial a<0$. In the context of the buy-out, we are considering $R(a,k^*)=R(1,k^*)$, and $\mathrm{w}R(1,k^*)/\partial k^*$.

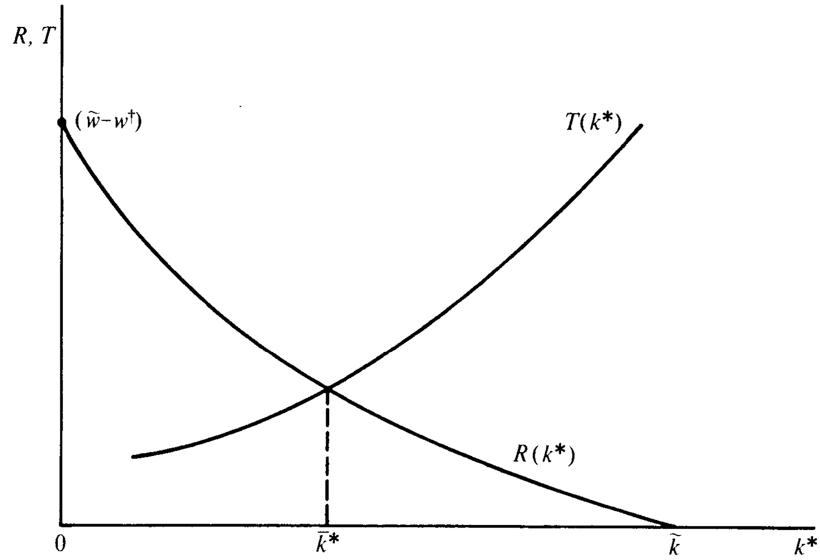

Fig. 4: The Ramaswami Function and Technology Difference in the Neighborhood of "Buy-Out"

increase in k^*, for a given world endowment of labor and capital (i.e. a fixed world production box), has the effect of making the original endowments less disparate since the foreign country is labor abundant. Although R remains non-negative, $R'(k^*) < 0$.[7]

Figure 4 provides a plot of the Ramaswami function. The negative slope indicates that the greater the difference between the two countries initial endowment ratios (i.e. the lower is k^*), the greater the gain to domestic income in the neighborhood of near "buy-out".[8] If $k^* = 0$, then R is maximized and $R(0) = (\tilde{w} - w^{\dagger})$ since only labor can flow. Similarly, if foreign factor proportions are identical to world proportions, ($k^* = \tilde{k}$), then $R(\tilde{k}) = 0$ as domestic and foreign endowments are similar.

The gains from the Ramaswami effect need to be weighed against the loss associated with the reallocation of factors from the superior foreign technology to the inferior home technology. This effect can be seen in the second bracketed expression in (5):

$$(7) \qquad T(k^*) \equiv (w^* - w^{\dagger}) + (r^* - r^{\dagger})k^* > 0\,.$$

That is, equation (5) for real income changes at home can be rewritten as (5a):

$$(5a) \qquad \frac{dy}{dz} = R(k^*) - T(k^*)\,.$$

[7] Since in the neighborhood of the buy-out point, $R(k^*) = (\tilde{w} - w^{\dagger}(k^*)) + (\tilde{r} - r^{\dagger}(k^*))k^*$, $R'(k^*) = -[w^{\dagger\prime} + k^* r^{\dagger\prime}] + [\tilde{r} - r^{\dagger}]$. The first term, $[w^{\dagger\prime} + k^* r^{\dagger\prime}]$ vanishes as k^* reflects the slope of the factor price frontier at the endowment point, and we assume throughout that $k > k^*$, so that $[\tilde{r} - r^{\dagger}] < 0$. (Since we are in the region in which domestic and world factor proportions coincide, $\tilde{w}$ is not a function of the initial allocation of factors.)

[8] Notice that $R''(k^*) = -(r^{\dagger})' > 0$.

A change in $T(k^*)$ arising from an increase in the initial endowment, k^*, describes the effect of a greater similarity of factor endowments for a given difference in technologies. Differentiating T with respect to k^* yields,

$$T'(k^*) = [w^{*\prime} + k^* r^{*\prime}] - [w^{\dagger\prime} + k^* r^{\dagger\prime}] + (r^* - r^\dagger). \tag{8}$$

In (8), the first two bracketed expressions are zero as each reflects the equality of the slope of the foreign country's factor price frontiers (the true frontier and the fictional (†) frontier) with the endowment ratio. We assume the technological difference is sufficiently unbiased so that r^* exceeds $r^\dagger$ and thus $T'(k^*)$ is positive.[9]

Plotting $T(k^*)$ in Figure 4 yields an upward sloping schedule which intersects the Ramaswami function at some value, $\bar{k}^*$.[10] If the initial endowment, k^*, lies to the right of $\bar{k}^*$, the losses $T(k^*)$, due to the movement of foreign factors which could be employed abroad with superior technology, outweigh the benefits arising from the Ramaswami argument, $R(k^*)$. A (near) complete buy-out will occur only if the endowments are sufficiently dissimilar so that the Ramaswami term, $R(k^*)$, exceeds the technology factor, $T(k^*)$.

If a complete "buy-out" proves not to be optimal (i.e. for $k^* > \bar{k}^*$) will the home country attempt to acquire *any* of the foreign factors of production? Is a *partial* buy-out now a possibility? To consider this issue we return to the world production box diagram illustrated in Figure 5. The diagonal of the box no longer represents allocations that equalize wages and rents. Assuming the difference in technology is not too large, wage rates could be equalized between countries if a higher capital/labor ratio is adopted at home than abroad; the $w = w^*$ locus above the diagonal in Figure 5 shows such allocations. Similarly, if the labor/capital ratio adopted at home exceeds that used abroad, rentals could be equated internationally; the $r = r^*$ locus lies below the diagonal. World output contours, three of which are illustrated, must be horizontal along the $w = w^*$ locus and vertical along the $r = r^*$ locus. These contours rise with a move towards the home "0" origin, reflecting superior foreign technology. The contours are negatively sloped in the region in which home wages and rentals are each lower than the returns which could be earned abroad.

The terms-of-trade contours in Figure 5 are the same form as in Figure 3: a purchase of foreign factors in proportions found abroad would not disturb their factor prices. These terms-of-trade loci are tangent to the equal-world-output contours along the "c.c." contract curve. If the initial endowment point should lie northwest of the contract curve, such as at point A, the Ramaswami reasoning remains intact for a *partial* "buy-out" of foreign factors. A move from A towards 0^* entails a gain for the home country until point B on the contract curve is reached. Thus despite inferior technology at home, if factor endowments are sufficiently different, gains to the home country accrue from obtaining factors

[9] Little can be said about the sign of $T''(k^*)$.

[10] If technologies are sufficiently dissimilar, the vertical intercept of the $T(k^*)$ curve lies above $(\tilde{w} - w^\dagger)$ so that no such k^* exists.

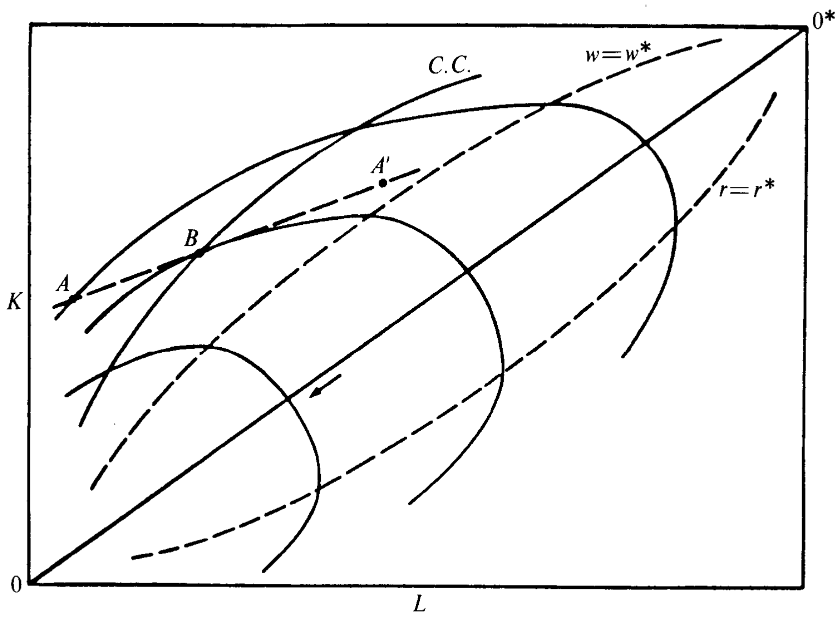

Fig. 5: Superior Foreign Technology

from abroad (without worsening the terms of trade along $A0^*$). However, if endowment proportions do not differ sufficiently (even with higher wages at home), such as at point A', our previous analysis reveals that the gains from convexity are overshadowed by the difference in technical knowledge. A flow of capital and of labor *out* of the home country (from A' to B) would raise incomes, even though home labor would require a subsidy to migrate. Along the contract curve a movement towards "0" entails raising world output but harming the home country's terms of trade in the process. Although optimal home strategy could easily involve a total "sell-out" of its factors, nonetheless for some initial endowments (such as A), a partial "buy-out" is still supported by a Ramaswmi-type reasoning combining the convexity of technology and the ability to obtain factors from abroad without worsening the terms of trade.

III. LABOR AND CAPITAL MOBILITY WITH IMMOBILE LAND

The preceding section's discussion of joint mobility of labor and capital when technologies differ by some given, arbitrary, amount serves as a useful introduction to a different extension of the basic model featured in the Kuhn and Wooton (1987) and Bond (1989) papers. Retaining the assumption of the basic model that labor and capital are jointly traded, they further assume that production requires a third factor, land, which is immobile between countries. Any complete "buy-out" strategy on the part of the active, home country is ruled out by assumption. The question remains whether there is any tendency for the Ramaswami-type of reasoning to prevail and encourage at least a partial "buy-out" of mobile labor and capital from abroad.

Kuhn and Wooton have usefully retained the basic model's world production box diagram in this expanded setting. In Figure 6 let point F divide the diagonal in the same proportion as home to foreign supplies of immobile land. As in the basic model, technological parity between countries is assumed, so that should the world's given supply of labor and capital be allocated in precisely the same proportions as land (i.e. at point F), all factor prices are equated. Whereas in the basic model full factor price equalization and optimal world outputs result from any allocation along the diagonal, in the present extension the immobility of land dictates a unique allocation of capital and labor that leads to the world optimum.

Allowing a third productive factor introduces a variety of possibilities for complementarity and substitutability not found in the two-factor basic model. Kuhn and Wooton assume that the inflow of any factor must serve to raise the marginal productivity of the other two factors, whereas Bond also analyses the case in which such a factor inflow would serve to reduce not only its own return, but as well that of one of the other factors.[11] Figure 6 illustrates a set of iso-world output contours, with a peak at free-trade point, F, corresponding to the case considered by Kuhn and Wooton. Three guiding loci are drawn through point F, each corresponding to capital and labor allocations which, in conjunction with the given allocation of land, keep the return to a particular factor in one country equal to its value in the other. These loci are derived from more primitive loci for each country (not drawn) along which the relevant factor price is kept at the same value as it attains at free-trade point, F.

Consider the home country and the values of capital and labor that would keep the wage rate constant, on the one hand, and the return to capital constant, on the other. Both such loci are positively sloped since from F an increase in L lowers the wage and (by assumption) raises the return to capital, requiring increases in K to raise the wage and lower the return to capital to the values at F. A movement from F radially out from the home origin to, say, point G is equivalent, in its effect on wages and returns to capital, to a shrinking of the supply of land for a given endowment of capital and labor. Such a shrinkage of land would, by assumption, lower the marginal productivity of both labor and capital. Original values of w and r could be retained, respectively, by a cut-back in the supply of

[11] There is some ambiguity in the use of the terms "complements" and "substitutes". Consider the present three-factor case. Bond follows the usage found in Rader (1968), and Hicks (1947), and calls labor and capital complements if an increase in the availability of labor raises capital's marginal product. In an alternative formulation, capital and labor are substitutes (instead of complements) if an increase in the wage rate causes capital to be used more intensively per unit of output. Only if labor and capital are highly substitutable in the latter sense will they be substitutes in the Rader-Hicks-Bond terminology. As established in Jones, Neary, and Ruane (1987), if E_k^i denotes the percentage effect of a one percent increase in factor i's return on the use of factor k (per given output level with all factor prices other than w_i held constant), capital and labor are substitutes in the sense used by Bond only if E_L^K exceeds E_T^K plus $(\theta_K/\theta_T)(E_L^T - E_T^T)$. (The θ's denote distributive shares). Since the latter term is assumed positive, capital and labor are substitutes in this sense only if capital is much more substitutable for labor than it is for land.

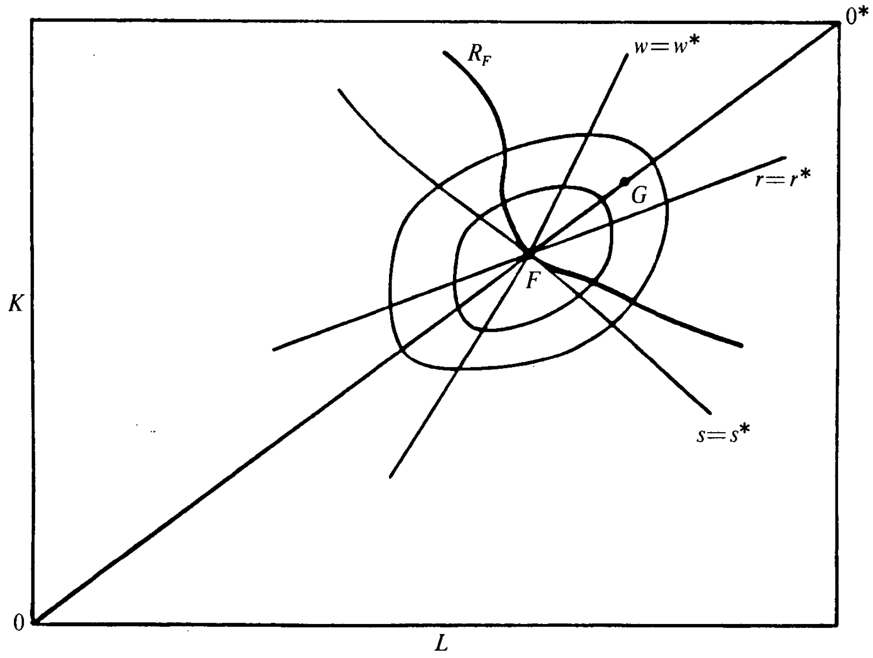

Fig. 6: World Output Contours and the Ramaswami Curve: Land Immobile

labor (to restore the wage rate), and of capital (to restore rentals). Thus, the positively sloped constant-wage locus is steeper than ray $0F$, while that for constant returns to capital is flatter. Comparable remarks can be made for foreign allocations of capital and labor with reference to the foreign origin, 0*. The locus along which $w=w^*$ is trapped between the locus $w=w_F$ and that of $w=w_F^*$, and similarly for the $r=r^*$ curve.[12]

[12] Figure 6 illustrates two general properties of constant $\bar{w}$ and $\bar{r}$ curves that hold regardless of substitutability or complementarity relationships: (i) The $\bar{w}$ and $\bar{r}$ curves have the same signed slope, positive if $\partial w/\partial K$ (equal to $\partial r/\partial L$) is positive. (Otherwise the $\bar{w}$ and $\bar{r}$ curves are negatively sloped, as described by Bond for the case of "substitutes"); (ii) The $\bar{w}$ curve is steeper than the $\bar{r}$ curve. To see this, pick any two points on the three-dimensional factor-price frontier: (L, K, T) and $(L^\dagger, K^\dagger, T^\dagger)$. The convexity of technology requires that

$$(w^\dagger - w)L + (r^\dagger - r)K + (s^\dagger - s)T > 0$$

and

$$(w^\dagger - w)L^\dagger + (r^\dagger - r)K^\dagger + (s^\dagger - s)T^\dagger < 0\,,$$

where s denotes the return to land. Subtraction reveals the general inverse correlation between physical factor abundance and factor returns:

$$(w^\dagger - w)(L^\dagger - L) + (r^\dagger - r)(K^\dagger - K) + (s^\dagger - s)(T^\dagger - T) < 0\,.$$

Now suppose the supply of land is given, so that $T^\dagger = T$, and that the two points selected lie on the same $\bar{w}$ curve so that $w^\dagger = w$. Then $(r^\dagger - r)(K^\dagger - K)$ must be negative. This, plus proposition (i), suffices to establish proposition (ii). For example, if the $\bar{w}$ curve is positively sloped and $L^\dagger$ exceeds L, $K^\dagger$ must exceed K (by proposition (i)) and $r^\dagger$ must be less than r. To raise $r^\dagger$ it would be necessary to lower K.

Two constant-world-output contours have been drawn in Figure 6. With reference to the first bracketed term in equation (2), these contours are horizontal when home and foreign wages are equal (so that a small relocation of labor does not disturb world output), and vertical everywhere along the $r = r^*$ line. A third supporting locus through F has been drawn, along which the returns to land in the two countries are equalized. This is, in the Kuhn-Wooton case illustrated in Figure 6, negatively sloped. (For example, for the home country an increase in K would raise land's marginal product, requiring a decrease in L to lower s to its initial value.) As we now demonstrate, the slope of the equal-world-output contours along the $s = s^*$ locus must lie between the capital/labor ratios in the two countries, precisely as was the case anywhere along an equal-world-output contour in Figure 1's illustration of the basic model.

To establish this result we choose, more generally, *any* point in the production box and consider the effect of relocating a small amount of capital and labor from the foreign country to the home country precisely in the proportions currently found abroad. That is, let dx equal $-\lambda K^*$ and dz equal λL^* for some small $\lambda > 0$. The effect of such a move on world output is

$$dY_w = (r^* - r)dx + (w - w^*)dz = \lambda[(r - r^*)K^* + (w - w^*)L^*] .$$

Convexity of the technology implies (9):

$$\{R\} \equiv \{(w - w^*)L^* + (r - r^*)K^* + (s - s^*)T^*\} > 0 \tag{9}$$

so that the change in world output corresponding to a small absorption at home of capital and labor from abroad in the proportions used there can be rewritten as

$$dY_w = \lambda[\{R\} - (s - s^*)T^*] . \tag{10}$$

In Figure 6 the curve R_F connects all the points for which dY_w is zero. That is, rays from 0* are tangent to equal-world-output loci along R_F, the "Ramaswami curve". Along R_F the relative scarcity of land at home is reflected in a value of land-rent, s, exceeding foreign s^*. Give that technology is identical between countries, a higher value for s means generally lower values for the returns to labor and capital at home. That is, northeast of the $s = s^*$ locus it is as if the foreign country had a superior "sub-technology" for inputs of capital and labor. Such a foreign superiority that is based on the presence of a third factor must eventually outweigh the "buy-out" strategy provided by the convexity of the technology so that further moves towards 0* lower world output.[13]

If there were no terms-of-trade considerations, the location of the R_F locus relative to the $s = s^*$ locus would reveal the relevance of the Ramaswami argument

[13] Two forces are working together to guarantee that a movement from any point on the $s = s^*$ locus towards 0* hits the R_F curve. Such a move brings the capital/labor ratio at home closer to its value abroad, thus diminishing the factor-endowment difference relative to any given degree of superiority in the foreign "sub-technology". Secondly, the degree of such superiority monotonically increases as a move is made from the $s = s^*$ locus towards 0* (foreign land rents fall and home land rents rise).

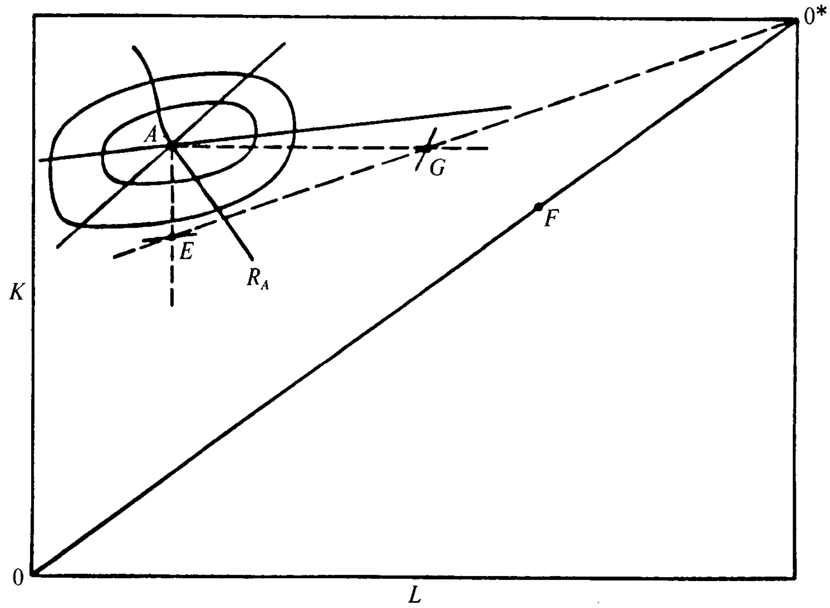

Fig. 7: Terms of Trade Contours: Land Immobile

to the case of fixed land supplies. If the supplies of land in the two countries were such that land rents were roughly equalized, it would *always* pay the home country to hire both labor and capital from abroad in the proportions found there, but only up to the limit shown by the R_F locus. There the gains from the convexity of the technology, which in the basic model called for almost a complete "buy-out", are just balanced by the greater amounts that must be paid in the aggregate for capital and labor abroad due to cheap foreign land.

Whereas in the basic model an absorption of foreign capital and labor in proportion to their supplies can leave foreign factor prices unchanged, the existence of immobile land in the present context invalidates such a procedure. Of special importance is the effect of international factor movements on the *net* terms of trade, as shown by the second bracketed term in (2), $\{xdr^* - zdw^*\}$. Figure 7 illustrates a set of contours showing the general terms-of-trade deterioration for the home country as it augments or runs down its endowment bundle represented by point A. Retaining the assumption underlying the illustration of the world output contours in Figure 6, namely that an increase in any factor raises the marginal product of the other two factors, the terms-of-trade loci are somewhat similar in shape to the world-output loci. In particular,

(i) When the terms-of-trade loci are locally horizontal or vertical, labor and capital must be flowing in the same direction. For example, when the slope is zero,

$$x\frac{\partial r^*}{\partial L^*} = z\frac{\partial w^*}{\partial L^*}.$$

Since $\partial w^*/\partial L^*$ is negative and $\partial r^*/\partial L^*$ is assumed positive, x and z must have opposite signs.[14]

(ii) A movement from autarky point A directly towards the foreign origin, 0^*, must worsen the terms of trade (any movement linearly away from A does that), and the terms-of-trade loci are negatively sloped along $A0^*$.

(iii) The locus of factor flows such that a slight inflow of capital and labor from the foreign country in the proportions found there does not affect the net terms of trade (the R_A curve) is negatively sloped.[15] This is readily seen by considering the net terms-of-trade effect of moving towards 0^* from an initial position of pure capital outflow (point E in Figure 7) and of moving towards 0^* from an initial position of pure labor inflow (point G in Figure 7). These effects are explicitly stated as (iv) and (v):

(iv) If the home country has some capital placed abroad but no immigration, a small purchase of capital and labor services in the proportions found abroad must, on net, improve the home country's terms of trade. From point E in Figure 7 a small move towards 0^* affects the foreign rate of return to capital in the same way as would an increase in the foreign endowment of land. By assumption this would raise r^*, and thus improve the home country's terms of trade. The constant net terms-of-trade contour at E is flatter then a ray to 0^*.

(v) If the home country initially admits some foreign migrants but does not allow international capital flows, a small purchase of foreign labor and capital services in the proportions found abroad must worsen the net terms of trade. From point G in Figure 7 a small move towards 0^* would increase the foreign wage just as would an increase in T^*. Therefore, the contour at G is steeper than a ray to 0^*.

These latter remarks ((iv) and (v)) show how Ramaswami's original comparison of a capital-export only policy with that of a labor-import-only policy is moderated because each country possesses fixed land. An expansionist proportional move from E, which in the basic model is encouraged because the terms of trade do not change, is now accompanied by an improvement in the terms of trade. However, the terms of trade start to deteriorate before the labor-inflow-only point is reached, so there are limits placed on the partial "buy-out" strategy. The R_A curve in Figure 7 shows factor flow combinations such that a small move towards 0^* on net does not alter the terms of trade. In the basic model such moves do not alter either the foreign wage rate or the foreign rate of return to capital, for finite as well as infinitessimal movements.

Figure 8 brings together the separate ingredients represented by the world-output contours of Figure 6 and the terms-of-trade contours in Figure 7 and illustrates

[14] A locus of points through A at which the foreign wage rate is constant (the $\bar{w}_A^*$ locus) has slope equal to $-(\partial w^*/\partial L^*)/(\partial w^*/\partial K^*)$. If this locus should happen to be linear, the slope would be $(-x/z)$ and, since $\partial w^*/\partial K^*$ equals $\partial r^*/\partial L^*$ by reciprocity, the constant terms-of-trade loci would all have zero slope along the $\bar{w}_A^*$ locus. If the $\bar{r}_A^*$ locus were linear, it would, by similar reasoning, be the locus along which constant terms-of-trade loci are vertical.

[15] If the negatively-sloped $\bar{s}_A^*$ locus is linear, it becomes the R_A locus as well.

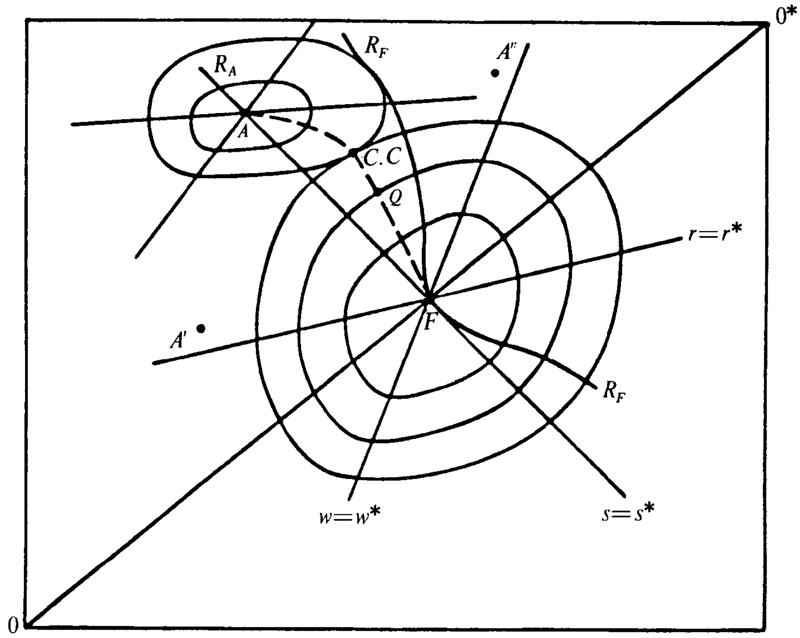

Fig. 8: The Contract Curve and Optimal Factor Flows

the special case in which at autarky point, A, the returns to land happen to match in the two countries. The dashed contract curve, c.c., connects points of tangency of the two sets of loci, and must run from endowment point, A, to the free-mobility point, F. The optimum point, Q, must lie on this curve.

Figure 9 explicitly portrays home country real income along the contract curve from A to F. It generalizes to the case of joint factor mobility the phenomena familiar when only one factor is mobile: A country can gain by the move from autarky to free trade, but can gain even more by controls on the movement of factors.

In Figure 8 the contract curve must be bounded by the R_A and R_F curves. If at autarky land rentals are equal, then at the point (Q) of optimal factor flows (and indeed anywhere on the contract curve) the Ramaswami reasoning is revealed in the fact that land rents at home are driven up beyond their levels abroad. In that sense there has been a "net" inflow of factors from abroad even though, in the case illustrated in Figure 8, a capital outflow accompanies the labor inflow.

Points A' and A'' depict in Figure 8 two alternative endowment points, each supporting new iso-terms-of-trade loci (centered on A' and A'' respectively) and contract curves (the world-output-contours are invariant to the change in capital and labor endowments, although the terms-of-trade loci are not). Relative to endowment point, A', the free trade point, F, lies northeast, as would the optimal point. That is, either at the optimum point or the free mobility point both capital and labor would flow into the home country, despite the fact that capital is relatively cheap at home in autarky. The attraction of labor inflows is strong when wages are sufficiently higher at home, and at A' it would not take much of an

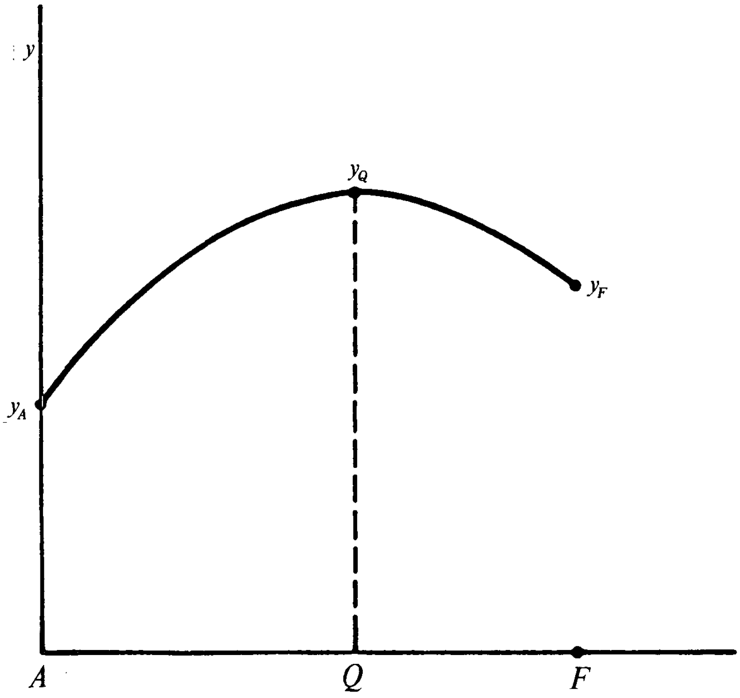

Fig. 9: The Optimum Point Along the Contract Curve

inflow of labor to raise r above r^*. By contrast, at endowment point A'' optimal factor flows (as well as free-trade flows) could require an exodus of labor as well as capital despite an initial high wage rate at home. Near the endowment point home wages are only slightly higher than foreign wages, and the pull of capital to the foreign country (where the returns are much higher) would quickly negate the wage differential.[16]

Throughout this discussion we have only considered explicitly the case in which any factor inflow raises the marginal productivity of the other two factors. But

[16] An explicit solution for optimal factor flows is easily derived by expressing dr^* and dw^* in (2) in terms of dx and dz, and then setting the coefficients of dx and dz in (2) each equal to zero. This yields formal solutions:

$$x = \frac{1}{\Delta}\left\{\left(-\frac{\partial w^*}{\partial L^*}\right)(r^* - r) - \frac{\partial w^*}{\partial K^*}(w - w^*)\right\}$$

$$z = \frac{1}{\Delta}\left\{\left(-\frac{\partial r^*}{\partial K^*}\right)(w - w^*) - \frac{\partial r^*}{\partial L^*}(r^* - r)\right\}$$

where Δ, the expression

$$\left\{\left(\frac{\partial w^*}{\partial L^*}\right)\left(\frac{\partial r^*}{\partial K^*}\right) - \left(\frac{\partial w^*}{\partial K^*}\right)\left(\frac{\partial r^*}{\partial L^*}\right)\right\},$$

must be positive by the convexity of the technology. A negative value for x reflects positioning of the optimal point near the $r = r^*$ locus in Figure 8, with the endowment point southwest of the optimum, such as point A'.

the same diagrammatic device can be used for other cases. These are discussed by Bond.[17] The contract curve always lies between the R_A locus of points such that a small inflow of capital and labor in "buy-out" proportions has no net influence on the terms of trade and the R_F locus of points such that a small inflow of capital and labor in "buy-out" proportions has no net influence on the terms of trade and the R_F locus of points such that a small "buy-out" move leaves world output undisturbed.

IV. CONCLUDING REMARKS

The original Ramaswami proposition entailed a bilateral superiority of a policy of allowing one factor to flow into a country (in a controlled, optimal, amount) as opposed to letting the cheap factor flow out. The two central properties of the "basic" model supporting this proposition are the convexity of a commonly-shared technology and the lack of disturbance to the terms of trade of factor inflows that are proportional to the factor supplies in use abroad. Going beyond the original bilateral proposition in order to consider joint mobility of capital and labor, the Ramaswami logic supports almost a complete "buy-out" of factors in the passive country by the active country. In this paper we have asked how robust this property of the basic model is to two alternative extensions whereby either technologies are not shared in common or there exists a third factor, land, which is internationally immobile, thus by assumption thwarting a complete "buy-out" strategy.

If factors located abroad earn higher returns than they would at home when used in the same proportions, because technology abroad is superior, there is clearly an argument for allowing home factors to emigrate to earn higher wages and rents. However, if factor endowment bundles in autarky are sufficiently skewed and home wages are relatively high (with returns to capital at home lower), it is possible that the Ramaswami-type reasoning based on the convexity of technology could outweigh the superiority of the foreign technology and support either a partial "buy-out" of foreign factors (the move from A to B in Figure 5) or indeed, even a complete "buy-out" (for $k^* < \bar{k}^*$ in Figure 4). Such a procedure would, as in the basic model, leave factor prices undisturbed abroad, although the optimal policy might call instead for a net exodus of both factors from the home country.

The case in which a factor such as land is immobile involves somewhat similar elements in that even with technologies equivalent the net returns available to mobile capital and labor as a group will be lower in the country with high land

[17] The following remarks help guide the construction of the world-output (and, by analogy, the terms-of-trade) loci: (i) If an inflow of labor lowers capital's marginal product (and vice-versa), the $r = r^*$ and $w = w^*$ loci are negatively sloped, trapping the $s = s^*$ locus between them; (ii) If $\partial w/\partial T$ is negative (land and labor especially good substitutes), the $w = w^*$ curve is positively sloped but flatter than ray $F0^*$, the $r = r^*$ curve, also positively sloped, is even flatter, and the $s = s^*$ curve is flatter yet (although still positively sloped); (iii) If $\partial r/\partial T$ is negative, all three equal-factor-return loci are positively sloped but steeper than $F0^*$, with the $s = s^*$ curve the steepest of the three (followed by the wage locus).

rentals and thus, considering only the mobile factors, it is as if technology differs between countries.[18] But even more is involved: an inflow of factors that is proportional to existing supplies in a country no longer keeps that country's factor returns unaltered. These complexities encourage a separation of the two elements that must be balanced when an active country seeks the optimal combination of international factor flows, *viz*, the effect of such flows on world output, on the one hand, and the net terms of trade for factors, on the other. A diagrammatic device was introduced, whereby a contract curve, containing the optimum point, was constructed. Such a contract curve was shown to be trapped between two loci which reflect properties in the original "basic" model. One of these was labelled the R_F curve, factor allocations such that a small proportional inflow of factors from abroad would not disturb world output. The other, the R_A curve, collects allocations such that a small proportional inflow of factors from abroad would not disturb the "net" factor terms of trade (although wages and capital rentals would not each remain unchanged).

Many combinations of optimal factor flows are possible in such a model, and we did not pursue a full taxonomy of these results. Instead, we indicated how a comparison of land rentals served as a proxy for a comparison of "sub-technologies" for labor and capital. Thus, if at autarky rents on land are comparable between countries, there always exists some joint inflow of factors from abroad that raises world output. Furthermore, there would initially (from autarky) be no net deterioration in the terms of trade. However, the optimal point would not entail a complete buy-out of labor and capital from abroad. Indeed, at the optimum a small further proportional inflow of foreign factors would still raise world output, but this gain would be lost to the active home country in a net deterioration of its terms of trade in factors.

If land rents are not comparable in autarky, the force of the convexity argument must be matched against the consequent difference in the net returns to capital and labor at home and abroad. Regardless of the initial asymmetries in endowments of all three factors, our analysis of the joint mobility of capital and labor has revealed how free mobility entails gains over autarky, but some restrictive policies are nonetheless optimal for the active country, so that it obtains better terms of trade than it would with completely free mobility. This was also the message of the basic model. The existence of fixed land moderates the "buy-out" strategy of the basic model but nonetheless preserves some key elements of the Ramaswami logic.

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[18] However, if one factor is immobile, a complete "buy-out" of the mobile factors is *never* optimal, unlike the possibilities when technologies differ but *all* factors are mobile.

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