Comments welcome

Beggar My Neighbor?

Exchange-Rate Depreciation as a Profit-Shifting Trade Strategy

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Abstract:

In this paper I introduce a variant of the Dornbusch-Fischer-Samuelson (1977) trade model that incorporates not only differing productivity but also differing and endogenously determined profits and wage compensation to labor across industries. Depreciation of the nominal exchange rate is not welfare-neutral in this case, but is an agent for capturing for the home country the profits due to the existence of comparative advantage in international trade. Those profits, when reinvested, lead to improvement in home welfare relative to foreign welfare. The depreciation also can lead to a widening of the gap between the compensation of skilled and unskilled labor.

JEL classifications: F1, J6

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The nominal exchange rate plays a limited role in traditional theories of international trade. The relative price of importance in those theories is the terms of trade, or relative price of goods. Changes in the nominal exchange rate, as the relative price of currencies, alter the nominal prices of goods in the two countries while leaving the equilibrium terms of trade unchanged. The pattern of trade, the level of employment and the level of output in the countries are then unaffected.

Empirical investigations of the evolution of trade, wages and employment have recognized that this view is too simplistic. Recent empirical research raises the possibility that the gains to domestic welfare from an export expansion are accompanied by an increase in profits, productivity and capital intensity among the exporters.[1] As Campo and Goldberg (1998, p. 1) put it, "We know that exchange rates matter. The challenge is pinning down the exact channels for exchange rate effects and their range of specific implications for the real economy".[2] Meeting this challenge requires specification of a general-equilibrium trade model with both a steady-state (balanced-trade) equilibrium and a coherent description of dynamic adjustments in the neighborhood of that equilibrium. The model of this paper is a variant

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[1] Bernard and Jensen (1995) use the US Census Bureau's Annual Survey of Manufactures to create separate profiles of exporters and non-exporters. At any point in time, "Exporters are larger, more productive, and more capital intensive. In addition, exporting establishments pay wages that are more than 14 percent higher than hose paid by non-exporting plants; benefits at exporters are a third higher than at nonexporters." (p. 70). While these authors consider unobserved heterogeneity in firm management the causal factor, with both exporting and these other features stemming from it, the data are consistent as well with a dynamic that leads from exporting to the characteristics enumerated above.

[2] The importance of exchange rates is also suggested by the experience of the British economy in the aftermath of the speculative attack on the British pound in September 1992. The decision to exit the European Exchange-Rate Mechanism brought about a substantial nominal depreciation of the pound. In the period from the fourth quarter of 1992 to the end of 1996 the UK experienced a sharp real depreciation while Germany experienced a sharp real appreciation. At that time the unemployment rate in the United Kingdom (UK) was over 10 percent, but the UK experienced a sustained decline in unemployment rate that brought it down nearly to four percent by 1999. Germany's unemployment rate rose monotonically in the 1993-1997 period. These conclusions are drawn from data reported in OECD (2000).

of the classic Ricardian model introduced by Dornbusch, Fischer and Samuelson (1977, hereafter DFS). If the DFS paper is a Ricardian model, then the specification of this paper can be considered a Ricardo-Viner (RV) or specific-factor model.[3] Similarly to DFS there is a continuum of final goods produced and trade between two countries.[4] In contrast to DFS, exporting industries earn positive profits and these profits are shared with the workers in those industries through higher wages. The dynamics of the economy are specified in terms of investment of profits and relative-wage response to over- and unemployment.

These more realistic features have strong implications for the impact of exchange-rate changes on trade, employment and welfare. Nominal exchange-rate depreciation has a non-neutral and in most cases positive welfare and income effect on the depreciating economy. The non-neutrality flows from the profit-enhancing effect of depreciation in each production industry and the application of those profits to productivity-enhancing investment. Nominal depreciation is an economy-wide trade policy with profit-shifting impact in this case similar to the effect of commercial policy in Brander and Spencer (1981) and its successor papers.[5]

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[3] This is the terminology of, for example, Dixit and Norman (1980).

[4] Bernard, Eaton, Jensen and Kortum (1999) also convert the DFS model to imperfect competition through the assumption of Bertrand competition. That paper is more general than this one in its incorporation of arbitrary numbers of firms in each industry and in its inclusion (as in DFS) of "iceberg" transport costs between countries. It does not, however, consider the dynamic for investment implied by earning positive profit nor the potential for wage differentials based upon capturing mark-up gains through imperfect competition. The role of the exchange rate is also not considered there.

[5] I apologize for the short-hand use of "policy" to describe a nominal depreciation of the exchange rate. Movements of the exchange rate are market-driven, and governments have limited ability to "move the market" through foreign-exchange sales or purchases. The policy of nominal depreciation discussed here is perhaps most readily understood as the choice of macroeconomic policies that will induce such a depreciation. An example is the British decision in late 1992 to leave the European Exchange-Rate Mechanism (ERM); there, the policy was actually the decision to cease its macroeconomic policy defense of a more appreciated parity within the ERM.

This policy similarity of exchange rate depreciation to tariff protection is one forecast in Robinson (1947). Her arguments on the effects of devaluations of the currency for short-run employment gains at the expense of trading partners are validated in the static version of this model. These insights are compounded in the dynamics of the model, as depreciation leads to enhanced profits and induced investment in cost-reducing technology. Exchange-rate depreciation that touches off export expansion may through this dynamic channel have long-lasting positive effects on the productivity of firms and the well-being of domestic citizens.

This paper is complementary to a number of recent papers that have examined the comovement of exchange rate, trade and welfare within the "new open economy macroeconomics" paradigm.[6] The basic model for these analyses is the general-equilibrium dynamic macromodel of Obstfeld and Rogoff (1996, ch. 10). A number of authors (e.g., Devereux and Engel (1998, 1999) and Betts and Devereux (2000)) have amended the basic model with an assumption of pricing-to-market on the part of exporters, while Tille (2000) has extended it through introduction of a competitive fringe of firms providing export/import (e.g., transport) services. In these papers, expansionary home monetary policy will cause nominal depreciation of the home exchange rate and will lead to welfare improvements at home while welfare is reduced abroad – the phenomenon first described as "beggar my neighbor" policy by Robinson (1947). These macroeconomic analyses go beyond the present paper by integrating the demand for money and financial assets explicitly into the general-equilibrium model. It is thus possible to solve for the endogenous nominal exchange rate and the optimal exchange-rate regime – a step outside the scope of this paper. By contrast, the trade-theoretic structure of this paper provides for a continuum of products with differentiated costs of production, thus allowing explicit consideration of the linkage between a

[6] Lane (1999) is a useful survey of this literature.

country's comparative advantage and the gains possible from policies leading to nominal depreciation. I also consider the re-investment of profits into cost-reducing production improvements and thus can consider an investment-driven dynamic missing from these new open economy models.[7]

The logic of this paper begins with the steady-state equilibrium, and then introduces the dynamics of adjustment associated with wage rigidity and with re-investment of profits. Its conclusions can be summarized in three propositions.

- In the steady-state equilibrium, each country can improve its welfare through inducing a reduction in its wage relative to the foreign wage. This is possible through the profit-shifting effect of such relative-wage movements.

- With some degree of wage rigidity, nominal exchange-rate depreciation induces an adjustment that is welfare-increasing for the country whose exchange rate depreciates. This welfare improvement is enhanced when the effect of the exchange-rate depreciation on re-investment of profits is considered.

- With a Marshallian assumption on distribution of profits, nominal depreciation causes an immediate worsening of income inequality. In the new steady state, however, income equality is reduced.

After a short description of the model, the analysis is organized into sections devoted to each of these propositions.

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[7] There is some disagreement as well about the empirical validity of the pricing-to-market assumption. There is agreement that the law of one price does not hold in practice, and pricing-to-market assumptions are used to generate deviations from the law of one price. As Obstfeld and Rogoff (2000) note, however, this assumption also implies that (1) there are no exchange-switching effects of depreciation in a pricing-to-market model, and (2) the country's terms of trade improve when there is a depreciation. They provide evidence that the latter property does not hold in empirical data. In this paper the law of one price does hold, and the two anomalies noted by Obstfeld and Rogoff (2000) do not occur.

II. A Ricardo-Viner Trade Model with a Continuum of Labor.

The DFS model of international trade extends to a continuum of goods the simple constant-cost model attributed to Ricardo. There are many products, and firms both enter and leave production in each country in response to international pressures. This provides a natural framework for the investigation of hypotheses on the impact of exogenous shocks upon employment patterns. However, the model has one strongly counterfactual property: no industry earns positive profits.[8] In the first section that follows the DFS model is summarized. The second section summarizes the RV model. More detailed derivations are available in the appendix. Through a simple recasting of the industrial organization in each industry, positive profits and resulting investment are introduced.

Trade Equilibrium in the Classic DFS Model.

Comparative advantage can be defined in pairwise fashion on labor costs. DFS models these through consideration of fixed unit labor coefficients (a_i, a_i^*) in commodity i for the home and foreign country respectively. There is a chain rule on comparative advantage that holds in this instance.[9]

$$a_1^*/a_1 > a_2^*/a_2 > \ldots > a_n^*/a_n \tag{1}$$

These ratios are denoted $A_i = a_i^*/a_i$, with higher A_i for good i relative to A_k for good k indicating a home-

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[8] It has a second counterfactual property as well: all labor is paid the same wage. In the last section I consider an extension of the model to incorporate wage differences across industries due to a sharing of Marshallian rents.

[9] Home comparative advantage in good i for any two goods i and j is defined by $a_i^*/ a_j^* > a_i/a_j$ and can be rewritten in the above form.

country comparative advantage in i relative to k. There may be as well a commodity j for which both home and foreign producer are competitive. In that case, the zero profit condition applies for each firm. The domestic and foreign wages are w and w^*, respectively, while e is the home-currency price of one unit of the foreign currency. In DFS there is a continuum of commodities indexed by z on the interval [0 1] such that the function A(z) = {A_i for all i} sorted in descending order is continuous. For one commodity $\tilde{z}$ the zero-profit condition will hold. For commodity $\tilde{z}$ the relative wage (denoted $\omega = w/ew^*$) will just equal $A(\tilde{z})$ as in (2) below. Demand for each commodity is assumed to be Graham-Mill in nature. Labor receives all income, and has identical preferences over commodities. A constant fraction of income b(z) is spent on the consumption of each good. These fractions are assumed equal across countries. This demand behavior is summarized in the share of income $\theta(z_o)$ spent on commodities indexed below some arbitrary value z_o.

DFS assumes that the industrial organization is perfect competition. Perfect competition for labor within each country implies a constant wage across industries and pricing of the good according to labor cost. Goods-market equilibrium is assured where the exports of the home country are equal in value to the imports of the foreign country, as in (3) below. There is full employment in equilibrium at the labor endowments L and L^*, respectively. The ratio of labor endowments is defined $\lambda = L/L^*$. Steady-state equilibrium in DFS is defined by the simultaneous determination of $\tilde{z}$ and $\tilde{\omega}$ in (2) and (3).

$$A(\tilde{z}) = \tilde{\omega} \tag{2}$$

$$\tilde{\omega} = \theta(\tilde{z})/[\lambda(1-\theta(\tilde{z}))] = B^D(\tilde{z},\lambda) \qquad B^D{}_z > 0,\ B^D{}_\lambda < 0 \tag{3}$$

The shares of total labor $\beta(z) = b(z)/\theta(\tilde{z})$ and $\beta^*(z) = b(z)/(1-\theta(\tilde{z}))$ are used in production of home and foreign commodities z.[10] Employment shares are dependent upon the demand for the product, as indicated by the b(z). They are also dependent upon the range of products produced in-country in equilibrium. They do not depend directly, however, upon the relative productivity in the two countries due to the marginal-cost pricing assumption.

The welfare levels in equilibrium for the home and foreign countries are defined in terms of total home and foreign consumption $C_h(z)$ and $C_f(z)$ respectively. World welfare is defined in (4c) as the sum of welfare in the two countries.

$$u = \int_0^1 C_h(z)^{b(z)}\, dz \tag{4a}$$

$$u^* = \int_0^1 C_f(z)^{b(z)}\, dz \tag{4b}$$

$$U = \int_0^1 [C_h(z)+C_f(z)]^{b(z)}\, dz \tag{4c}$$

Trade Equilibrium in a Ricardo-Viner World

The technology and demand structure of the RV model are identical to that of DFS. The critical differences occur in the industrial organization of the market for each product. In each country, there is a specific factor for each industry z on the continuum. This specific factor has a single owner in each country for each z, and that owner establishes a firm to sell the industry's product. The world market is thus served by two firms for each industry z. The two owners compete with one another on the basis of price. Each owner practices limit pricing through setting a price just below that of the foreign competitor. If that price leads to negative profits the industry shuts down in that country.

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[10] If these employment shares are integrated for the range of goods produced at home, the resulting equalities return the trade balance condition. Full employment and trade balance are thus equivalent constraints in this model. This will be an important feature of the discussion of dynamics.

This leads to nominal prices p_i on the world market of:

$$p_i = \begin{cases} wa_i & \text{for foreign export good} \\ ew^* a_i^* & \text{for home export good} \end{cases} \qquad (5)$$

Each owner thus prices its good to gain the entire productivity differential.[11] Profits per unit of output in each industry can be defined for each z, with $\tilde{z}$ the good in which both countries have identical production cost.

$$\pi(z) = wa(z)\ [(A(z)/A(\tilde{z})) - 1\ ] \qquad \text{for } z \leq \tilde{z} \qquad (6a)$$
$$\text{and} \quad 0 \qquad \text{otherwise.}$$
$$\pi^*(z) = wa(z)\ [1 - (A(z)/A(\tilde{z}))] \qquad \text{for } z \geq \tilde{z} \qquad (6b)$$
$$\text{and} \quad 0 \qquad \text{otherwise.}$$

The terms in brackets indicates that the profit is simply the internalization by the firm of the relative productivity differential across countries. These profits are increasing for industries more distant on the continuum from the zero-profit industry $\tilde{z}$. Total profits per industry ($\Pi(\omega,z)$ or $\Pi^*(\omega,z)$) can be defined by use of the share of labor ($\beta(\omega,z)$ or $\beta^*(\omega,z)$) employed in that industry.

$$\Pi(\omega,z) = (ew^*L)\beta(\omega,z)\ [A(z) - \omega] \qquad \text{for } z \leq \tilde{z} \qquad (7a)$$
$$\text{and} \quad 0 \qquad \text{otherwise.}$$

[11] More precisely, the successful firm will capture the productivity differential minus an infinitesimal discount. For the crossover good $\tilde{z}$ both firms remain in business at zero accounting profit.

$$\Pi^*(\omega,z) = (ew^* L^*)\beta^*(\omega,z)\,[\omega - A(z)] \qquad \text{for } z \geq \bar{z} \qquad (7b)$$

$$\text{and} \quad 0 \qquad\qquad \text{otherwise.}$$

The $\beta(\omega,z)$ and $\beta^*(\omega,z)$ in this case are defined in terms of the sum of incomes in the two countries ($Y + Y^*$) and with p(z) defined by the limit pricing rule in (5). These shares are rising in the relative demand for the product b(z) and in total world income. The foreign share $\beta^*(\omega,z)$ is rising and the domestic share $\beta(\omega,z)$ is falling, other things equal, with an increase in A(z); such an increase indicates an improvement in the relative productivity advantage of the domestic economy.

Total incomes of the two countries ($Y(\bar{z})$, $Y^*(\bar{z})$) are defined as the sums of wages and profits in each country. One part of that income is the profit accruing to each country from producing inframarginal goods rather than the cross-over good. The share of world income accruing as profit in each country is denoted $\phi(\bar{z})$ and $\phi^*(\bar{z})$, respectively.[12]

$$Y(\bar{z}) = wL + (Y(\bar{z}) + Y^*(\bar{z}))\,\phi(\bar{z}) \qquad (8a)$$

$$Y^*(\bar{z}) = ew^*L^* + (Y(\bar{z}) + Y^*(\bar{z}))\,\phi^*(\bar{z}). \qquad (8b)$$

$\phi(\bar{z})$ is rising, and $\phi^*(\bar{z})$ is declining, in $\bar{z}$. The larger the "cumulative comparative advantage" as evidenced by the slope of the A(z) curve in the range of goods they produce, the larger will be both $\phi(\bar{z})$ and $\phi^*(\bar{z})$.[13]

The demand-side equilibrium (10) in the RV model is derived through substitution of Y and Y^*

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[12] Profits are properly functions of ω and $\bar{z}$, but in equilibrium $\bar{z}$ defines both. In the appendix, when non-equilibrium profits are considered, ϕ and ϕ^* are defined explicitly as functions of ω and $\bar{z}$.

[13] Tille (2000) identifies a similar component of income in his model, but in his case the profits accrue to an export/import firm separate from the producers.

into the balanced-trade condition. This becomes the DFS condition (3) when $\phi(\bar{z}) = \phi^*(\bar{z}) = 0$, but will in general be characterized by different equilibrium $\bar{z}$ and $\bar{\omega}$ due to the existence of these profit-taking terms.

$$\phi(\bar{z}) = \int_0^{\bar{z}} \left\{ b(z)\left(1 - \frac{\omega}{A(z)}\right)\right\} dz \tag{9a}$$

$$\phi^*(\bar{z}) = \int_{\bar{z}}^{1} \left\{ b(z)\left(1 - \frac{A(z)}{\omega}\right)\right\} dz \tag{9b}$$

$$\bar{\omega} = [(\theta(\bar{z}) - \phi(\bar{z}))/(1- \phi^*(\bar{z})-\theta(\bar{z}))]/\lambda = B^R(\bar{z};\lambda) \tag{10}$$

$$B^R_z > 0,\ B^R_\lambda < 0$$

The response of the newly defined $B^R(\bar{z};\lambda)$ to $\bar{z}$ will in general be positively sloped, as for $B^D(\bar{z};\lambda)$ in the DFS model. The $B^R(\bar{z};\lambda)$ schedule for a flat A(z) schedule is identical to that derived in the DFS model. As the A(z) schedule becomes steeper, the $B^R(\bar{z};\lambda)$ schedule has a larger positive gradient than $B^D(\bar{z};\lambda)$. The welfare levels in equilibrium for the home and foreign countries are again defined as in (4a)-(4c).

Steady-state equilibrium in the RV model is defined by the simultaneous determination of $\bar{z}$ and $\bar{\omega}$ in (2) and (10). This definition of equilibrium differs from that of DFS in two important ways. First, limit pricing makes home income dependent upon foreign wage, and vice versa. Second, each country captures as income the difference in relative productivity as measured by the ratio $[A(z)/A(\bar{z})]$ for the goods it produces. Supply-side characteristics of the market enter the profit-capture terms while characteristics of demand for goods enter through the value of the cross-over good $\bar{z}$.

A Numerical Comparison.

A normalization and three simplifications will make more transparent the comparison of DFS and RV equilibria. First, through choice of units, $a^*(z) = 1$ for all z. Second, a simplification of the demand side that retains the key features of the model is to set $b(z) = b$ for all z.[14] Third, the ratio of foreign to home unit labor coefficients is defined $A(z) = 2.65\ e^{-z}$. Fourth, the two countries have equal endowments of labor $L = L^*$.

The full-employment trading equilibrium for these economies in the DFS model is presented in Figure 1, with $\omega = 1.46$, $\bar{z} = .59$. The shares of labor in each country used in each variety are constant at $\beta(z) = 1/.59$, $\beta^*(z) = 1/.41$. Total consumption of goods for each variety is decreasing as z rises: $C(z)+C^*(z) = 5.3\ L\ e^{-z}$. Welfare in the two countries is $u = 1.78$ L and $u^* = 1.22$ L, with world utility U = 3.00 L.[15]

The RV model using the same technology and demand parameters generates a different equilibrium, also depicted in Figure 1. The value for $\omega = 1.43$, and for $\bar{z} = .61$. The values for $\phi(\bar{z})$ and $\phi^*(\bar{z})$ are .155 and .066, respectively. Utility levels in the two countries are respectively $u = 1.79$ L and $u^* = 1.13$ L with U = 2.92 L. The lower utility than in the DFS model is due to the inefficient allocation of labor, as the prices of almost all goods are not equal to the marginal costs of production. Figure 2 illustrates the varying allocations of labor across industries in the DFS and RV models for the home and foreign countries: the DFS allocation is constant across industries in each country, while the RV allocation is greater in industries with smaller productivity advantage.

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[14] It is further evident by the income constraint that a constant b over the continuum must be b=1.

[15] The autarkic equilibrium is characterized by $u = 1.67$ L and $u^* = L$.

III. **Proposition: the RV economy has incentive to expand the set of exported goods**.

Proposition 1: In the steady-state DFS equilibrium, each country will improve its welfare through inducing a contraction of the set of exported goods. In the steady-state RV equilibrium, each country will improve its welfare through inducing an expansion of the set of exported goods.

The locus A(z) defines a set of potential full-employment equilibria in (ω, z) space. Each country has preferences defined on the points in (ω,z) space that can be summarized by sets of iso-welfare loci. The proposition asserts that these isowelfare loci have fundamentally different properties in the RV and DFS models. In the appendix I provide a proof of the claims in the proposition.

The key elements of the proof are illustrated in the panels of Figure 3. The isowelfare loci of the DFS model for the home economy trace out convex sets above each locus, with the level of welfare rising for loci with intersections with A(z) at lower z. The isowelfare loci of the RV model, by contrast, trace out convex sets below each locus, with the level of home welfare rising for loci with intersections with A(z) at higher z. All isowelfare loci are horizontal at intersection with the A(z) curve. Once these preference sets are created, the proof of the proposition is immediate.

In the DFS model a shock that increases $\bar{z}$ for given A(z) leads to a reduction in the home country's relative wage.[16] This causes an unambiguous reduction in domestic real income and increase in foreign real income. That effect is also evident in the RV model, but is combined with the positive impact on home income of increasing the share of world income received through domestic profits $\phi(\bar{z})$ and in reducing the analogous foreign profits share $\phi^*(\bar{z})$. These latter effects are the profit-shifting effect of real depreciation analogous to the effect of production subsidy in Brander and Spencer (1981). The

[16] This comparative-static result follows, for example, if all else equal the value of L^* is reduced. This is the result derived in the appendix.

appendix demonstrates that for reasonable values of model parameters this combined effect leads to isowelfare curves with the characteristics illustrated in the first panel of Figure 3.

III. Proposition: nominal exchange-rate depreciation induces a welfare-improving dynamic in an RV economy with some degree of wage rigidity.

Proposition 1 indicates that an RV economy will reach a higher welfare level in the steady state by increasing its set of export goods. Left unanswered in that proposition is the question of the dynamic process that will move the economy from lower to higher welfare level. Proposition 2 asserts that an economy with some degree of wage rigidity will be able to achieve those higher welfare levels, if only momentarily, through inducing a depreciation of the nominal exchange rate.

Proposition 2: With some degree of wage rigidity, nominal exchange-rate depreciation in an RV economy induces an adjustment that is welfare-increasing for the country whose exchange rate depreciates. This welfare improvement is enhanced when the effect of the exchange-rate depreciation on re-investment of profits is considered.

This section provides a proof for the two parts of this proposition. The first is the real-wage response to over- and under-employment in the absence of investment: the DFS analysis (1977, section IV.D) can be interpreted as an application of this. The second is the impact of investment unique to the RV model.

The unemployment dynamic.

DFS considered unemployment equilibria for fixed money wage. There was not, however, an explicit discussion of the dynamic of adjustment in response to overemployment and/or unemployment. I abstract from the monetary aspects of this adjustment for simplicity, but capture the essence of the wage-rigidity argument through a simple differential equation for ω in (19). z^s_o and z^d_o are the z values of the A(z) and B(z;λ) curves, respectively, at relative wage ω_o.[17] As illustrated in Figure 4, the relative wage ω_o is not the equilibrium ω. Home-economy firms will find it profitable to produce and export all goods up to the index z^s_o, while balanced trade at full employment could only be sustained if the home economy produced and exported goods up to and including z^d_o. The observed outcome in this instance will be one of production at z^s_o with underemployment in the foreign economy and overemployment in the home economy, and with a trade surplus at home with a trade deficit overseas. The full-employment assumption is therefore relaxed in the short run while it remains a condition for steady-state equilibrium.

The technological differences across countries and across industries inherent in A(z) are divided into two parts in $\alpha(\omega_o,\kappa)$. The parameter κ represents the average productivity advantage of the home economy; as κ rises the A(z) curve shifts up everywhere. The comparative-advantage differentials in productivity by industry are indicated by the gradient $\alpha_\omega(\omega_o,\kappa)$. The change in ω per unit time is indicated by $\mathring{\omega}$.

$$z^s_o = \alpha(\omega_o,\kappa) \qquad \alpha_\omega < 0,\ \alpha_\kappa > 0$$

$$z^d_o = \gamma(\omega_o,\lambda) \qquad \gamma_\omega > 0,\ \gamma_\lambda > 0$$

$$\mathring{\omega}_o = \delta\{z^s_o - z^d_o\} = \delta\{\alpha(\omega_o,\kappa) - \gamma(\omega_o,\lambda)\} \qquad \delta > 0 \tag{11}$$

[17] The function $\alpha(\omega_o,\kappa)$ is created by inverting A(z) in equation (4). The function $\gamma(\omega_o,\lambda)$ is created by inverting equation (7). If the relative productivity of technologies can be summarized by $A(z) = \kappa\, e^{(-fz)}$, and if consumption shares are constant across industries, then $\alpha(\omega_o,\kappa)=(\ln(\kappa)-\ln(\omega_o))/f$ and $\gamma(\omega_o,\lambda) = (\lambda\omega)/(1+\lambda\omega)$. These functions have the derivatives noted above.

The difference (z_o^s - z_o^d) represents in terms of varieties of goods the trade imbalance observed at the relative wage ω_o. z_o^s also provides a measure of domestic employment for given world income, with increases in the difference (z_o^s - z_o^d) indicating a movement toward overemployment in the home economy and unemployment in the foreign economy.[18] Any shock that lowers ω_o below the equilibrium level – as, for example, a depreciation of the nominal exchange rate – causes an initial trade surplus, an increase in home employment and reduction in foreign employment, and eventual adjustment back to the equilibrium $\bar{\omega}$.[19] This adjustment is illustrated for the DFS model in Figure 5. On the horizontal axis, κ is the measure of the home country's industry-neutral technological advantage. The BB curve traces out the combinations of ω and κ that are consistent with balanced trade (i.e., with $\mathring{\omega}_o = 0$) in (11). Combinations of the two variables below the BB curve are consistent with trade surpluses, and those above the BB curve with trade deficits, for the home economy. The AA curve represents the combinations of ω and κ that are consistent with the relative productivity condition (4). This curve is vertical at the exogenously given κ in the DFS model. With nominal depreciation of the exchange rate the home economy slips into trade surplus and greater employment but converges back over time along the AA curve to the equilibrium $\bar{\omega}$ (and $\bar{z}$) according to (11). In the foreign country, this nominal

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[18] This is thus an illustration of the zero-sum game behind the Robinson (1947) "beggar-my-neighbor" behavior.

[19] This behavior out of equilibrium can be illustrated as follows. As noted above, (18) is the condition for consumption to equal production in the world economy. If the relative wage is set at ω_o, then the value of z that ensures the equality is z_0^d. If the relative wage is set at ω_o and the value of z set at z_0^s, then there is a ratio λ that will ensure the equality. This ratio will differ from the full-employment ratio, and will represent the degree of overemployment in the home economy and the unemployment in the foreign economy that this non-equilibrium relative wage implies. Note the isomorphic nature of unemployment and trade deficits in the foreign country: the difference in λ for given z_0^s defines the divergence from full employment, while the divergence of z_0^s from z_0^d for given λ defines the divergence from balanced trade.

depreciation of the home-economy exchange rate causes unemployment and a trade deficit but converges back to equilibrium.[20] Production shifts from $\tilde{z}$ to z_0^s in Figure 4 with the depreciation, and then converges back to $\tilde{z}$ over time with the evolution defined by (11).

In the DFS model, as indicated by Proposition 1, such a movement to overemployment will be welfare-reducing. In the RV model, by contrast, this movement to overemployment will be welfare-increasing.[21] The depreciation works precisely to beggar my neighbor in the short run; there is no long-run effect of the change. Welfare rises in the country with depreciating currency in the short run, and in the long run returns to its initial level.

The dynamic due to investment.

In the RV model, with profits accruing to the producer, there is a flow of resources that can be allocated to investment rather than consumption. If this investment is productivity-enhancing, the dynamic path of the two economies in response to nominal depreciation will become more complex. I consider two paths here; the first considers economies in which profits are reinvested equally over all industries in the home country, while the second considers economies in which profits are reinvested in the industry in which they are earned.

Investment in industry-neutral fashion. Total profits at home and abroad can be expressed, as in equations (9), as fractions ϕ and ϕ^* of total world income. Suppose that these profits were invested

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[20] As Robinson (1947, chapter 2) notes, this situation is tailor-made for retaliation by the foreign country through its own devaluation strategy.

[21] The utility function defined here values commodities alone. Once employment becomes variable, it is important to consider the disutility of labor in the welfare calculation. This disutility of employment reinforces the conclusion against depreciation in the DFS model. In the RV model it works against the income effect and could reverse the conclusions drawn here if it were to give the isowelfare loci a negative slope when crossing the A(z) curve larger in absolute value than the slope of the A(z) curve itself. The derivation in the appendix has the details of this.

in an industry-neutral fashion in the country in which they accrue. Then the industry-neutral component κ of relative productivity will be a function of the difference between these two fractions, as in (12).[22] The evolution of κ will depend upon the initial value κ_o. At any point in time, larger κ_o causes the home country to be relatively more productive in each industry and leads to a larger home profit share. As ω_o rises the domestic profit share falls relative to the foreign profit share and leads to a reduction, other things equal, in $\mathring{\kappa}$.

$$\mathring{\kappa} = \xi\{\phi(z_o^s) - \phi^*(z_o^s)\} = \xi\{\phi(\alpha(\omega_o,\kappa_o)) - \phi^*(\alpha(\omega_o,\kappa_o))\} \qquad \xi > 0 \qquad (12)$$

$$\mathring{\omega} = \delta\{\alpha(\omega_o,\kappa_o) - \gamma^R(\omega_o,\lambda)\} \qquad (13)$$

The complete dynamic system of the RV model becomes that of equations (12) and (13).[23]

Steady-state conditions for this system are defined by setting $\mathring{\kappa} = \mathring{\omega} = 0$ in (12) and (13). The steady state condition derived from (12) is denoted AA in Figure 6. For this to hold the profit shares in the two countries must be equalized, and this will only occur if ω is rising to offset increases in κ. The steady-state condition derived from (13) is denoted BB in Figure 6, and is the balanced-trade condition in the world economy. Here also as the relative productivity advantage of the home country rises, the relative wage of the home country must rise to ensure that there is sufficient demand for all the goods

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[22] The profit fractions may in general depend upon κ_o as well as z_o^s. In the case in which κ_o enters the A(z) curve multiplicatively and the dependence on z is exponential, its direct effect will drop out of the expression for $\phi(z^s{}_o;\kappa_o)$ and $\phi^*(z^s{}_o;\kappa_o)$. This is the case presented here for simplicity.

[23] The relative-wage equation has been amended to use the appropriate specification of z_0^d from (18) to generate $\gamma^R(\omega_o,\lambda)$. While the specific values of derivatives differ from the DFS case, the γ^R function has the same properties as the γ function of (18). The positive derivative with respect to ω is assured by the condition that $(d\theta(z)/dz > d\phi(z)/dz)$ when evaluated at the same z. This is always true, since revenue for a given industry will always exceed profit.

produced in equilibrium. The steady-state equilibrium at intersection of BB and AA will be characterized by constant values of κ, ω and $\bar{z}$.

Nominal depreciation of the home currency in this world economy will generate the dynamic pattern illustrated in Figure 6.[24] The steady state combination of κ and ω is never achieved because profit ratios diverge over time. Nominal depreciation causes the instantaneous movement from E to C, with the dynamic adjustment following the path CD as it converges to the BB curve. The nominal depreciation in this case generates relatively higher profits in the home economy and thus continuing growth in κ. International trade converges to balanced trade along the BB curve, but with the profit advantage accruing to and compounding in the home country's favor. Both ω and κ will be rising continuously. Employment at home will be increased so long as the trade balance is in surplus, and will converge to full employment as trade balance is achieved. The foreign country will experience initial unemployment and a trade deficit before converging to full employment and balanced trade, but with a steadily decreasing wage relative to the home country.

Welfare can only be completely characterized in this case with a specification of preferences of specific-factor owners across time. It is evident, however, that if the decision to invest along the lines described in the dynamic above were initially welfare-improving for the investor, then it will only grow more attractive over time. Further, there is an improvement in the base wage that improves labor welfare over time. Depreciation is initially attractive for its profit-capturing effect, but also triggers a divergent dynamic that favors the home country in every period thereafter.

Re-investing profits in the own industry. If the profits of an industry are invested in the productive technology of that industry, then an alternative adjustment process can be observed. If the

[24] The AA curve is always steeper than the BB curve, since $-\alpha_\kappa/\alpha_\omega > \alpha_\kappa/(\gamma_\omega - \alpha_\omega)$.

returns to owners are invested in productivity-enhancing investments in the same industry, then the change in relative productivity in each industry $\kappa(z)$ can be stated as an increasing function μ of the profits per worker. The change in $\kappa(z)$ can be expressed as

$$\mathring{\kappa}(z) = \mu(w[(A(z)/A(\tilde{z}))-1]) \qquad \text{for } z < \tilde{z} \qquad (14a)$$

$$\mathring{\kappa}(z) = -\mu(ew^{*}[(A(\tilde{z})/A(z))-1]) \qquad \text{for } z > \tilde{z} \qquad (14b)$$

For the variety $\tilde{z}$ there will be no investment, and thus no productivity improvement, due to the absence of profits. The change in A(z), whether toward greater home or foreign productivity, will be larger in absolute value for industries z more distant from $\tilde{z}$. This will, in turn, lead to still greater profits in those industries as well.

Nominal depreciation has a real impact in this world through the induced investment in inframarginal activities during the transition. The adjustment is illustrated in Figure 7. The nominal depreciation shifts the relative wage to ω_o and the cross-over good from $\tilde{z}$ to z_o^s. Profits accrue to all the inframarginal goods in the home country, and these profits are used in productivity-enhancing investments. The A curve pivots as a consequence, leading to a new equilibrium with higher relative wage ω_1 indicated by E_1. In the non-marginal industries, productivity improvements do not put upward pressure on the base wage. This increases the profits available to the owners and perpetuates the pivoting.[25] Welfare increases in the home country subsequent to depreciation, just as in the no-

[25] Note the difference from the conclusions in Lewis (1977). There he argued that investment in the common good (his "food") will have the highest payoffs for the economy as a whole. The reversal is due to the profit-capture effect -- the investors in non-marginal industries are able to capture the entire gains from trade through their pricing strategy.

investment case above. Contrary to that example, the existence of investment allows the home country to establish an advantage in marginal goods heretofore imported. This raises welfare through its effect in accentuating the profit-capture motive.

This depreciation/productivity linkage may also help to explain recent results reported by Bernard and Jensen (1998) on the growth in US export volumes over the period 1987-1994. They set up two competing hypotheses to explain export growth: real depreciation of the exchange rate and productivity improvements in the industry. They conclude that although both are important, the real depreciation was the dominant factor. This paper suggests that productivity may be a product of depreciation as well, with the correlation of the two leading to the relatively small independent effect reported.

Robinson (1947) discussed nominal exchange rate depreciation as a "beggar my neighbor" policy that shifted employment from the foreign to the home producers. This is evident in the discussion of dynamics in response to a devaluation in the current model. There is an important element added to the dynamics here as well in the reinvestment of captured profits. This investment provides an opportunity for the devaluing economy to lock in what seem to be temporary gains from the devaluation. Even a temporary capture of profits will have a long-term benefit in this instance. These benefits are not evenly distributed, however, as noted in the next section.

IV. Proposition: nominal depreciation will enlarge wage differentials across industries.

The DFS model has a simple, if counterfactual, discussion of wage differentials within each economy: they don't exist. Workers in each country are perfectly competitive and receive the common wage. The lack of international mobility does open one differential, as indicated by the value of ω, but the model does not admit others.

The RV model, with its industry-specific profits, is consistent with an explanation of wage differentials. This can be illustrated simply by the assumption that profits are distributed in Marshallian fashion among labor and the owner in a bargaining process. Aoki (1980) and Miyazaki (1984) were among the first to model this phenomenon, although the concept dates back to Alfred Marshall in his Principles of Economics. As Marshall states, "nearly the whole income of a business may be regarded as a ... composite quasi-rent divisible among different persons in the business by bargaining supplemented by custom and by notion of fairness".[26] In terms of a Nash cooperative game, for each owner the threat point is zero while for labor the threat point is the wage paid in the zero-profit industry.[27] As a result, the bargaining that occurs is over the profits of the firm as defined above. I assume for simplicity that there is a uniform bargaining coefficient τ $(0 \leq \tau \leq 1)$ such that the labor force receives τ of the profits and the owner of the firm receives $(1-\tau)$.[28] There is an analogous (but not necessarily equal) foreign bargaining coefficient τ^*.

Proposition 3: With a Marshallian assumption on distribution of profits, nominal depreciation causes an immediate worsening of income-inequality of labor. In the new steady state, however, income equality is reduced.

The compensation of labor per person will vary across firms. It is denoted $\eta(z)$ at home and $\eta^*(z)$

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[26] Marshall (1969, 8th edition), p. 520.

[27] Nash (1953).

[28] This parameterization has as extreme points the Ricardo-Viner version with profits accruing to the specific factor and a model in which the labor is the specific factor and receives all rents associated with production.

in the foreign market and can be written in terms of the zero-profit (or base) wage and the per-person profit share of the firm.[29]

$$\eta(z) = w + \tau\pi(z)/a(z) = w(1 + \tau[(A(z)/A(\bar{z})) - 1]) \tag{15a}$$

$$\eta^*(z) = ew^* + \tau^*\pi^*(z)/a^*(z) = ew^*(1+\tau^*[(A(\bar{z})/A(z))-1]) \tag{15b}$$

Note that in this instance the return to labor in industry z is increasing in the productivity of the home worker relative to that of the worker in that industry in the other country. Only for the zero-profit firm will labor compensation be equal to the base wage. The return to the owner per unit produced is denoted $\rho(z) = (1\text{-}\tau)\ \pi(z)$ and $\rho^*(z) = (1\text{-}\tau^*)\pi^*(z)$ for the home and foreign producers, respectively.

The first implication of the Marshallian bargaining assumption is that labor compensation will differ by industry. It will be increasing unambiguously in the relative profitability of the industry. The labor compensation curve can be illustrated in Figure 8 by the line DE for the workers in the domestic economy.

Additional implications of this assumption are found in considering the impact of a nominal exchange-rate depreciation on labor compensation.

• In the DFS model all relative wages fell with exchange-rate depreciation and then rose over time to return to the initial values. In the RV model the nominal depreciation brings about a worsening of inequality in labor compensation. Those workers at the margin receive the base wage, which is lower in purchasing-power terms. All labor in this construct suffers the same fall in the base wage, but for the most highly compensated workers the base wage is a smaller share of total labor compensation. The

[29] The second equality of each expression (15) employs equations (7).

profit-based share of that total compensation will be increasing with the devaluation, precisely because the zero-profit wage has fallen in relative terms. This can be derived from (15a). If $ew^* = 1$ is the numeraire, then $d\eta(z) = (1-\tau)d\omega$. Compensation falls by the same absolute value for all industries, but the percentage reduction is less for those with shares of greater absolute profits.

• The dynamic response to nominal depreciation through investment will have differing effects on wage inequality depending upon the type of investment undertaken. In the industry-neutral investment the effects of the investment accrue through movement in the base wage: as this rises over time the depreciation will have an equalizing effect on wage dispersion. If the investment is industry-specific, the pivoting of the A(z) curve due to investment will make the wage differential more unequal. The base wage will be little changed while the distribution of profits in labor compensation will increase greatly.[30]

• Job creation in response to a nominal depreciation occurs in the base-wage jobs: those in industries $z > \tilde{z}$ when the nominal depreciation is undertaken by the home economy. With full employment, jobs will be destroyed in the high-compensation export industries and will be created in the base-wage industries. Even if overemployment is allowed, the high-compensation jobs cannot be sustained because the nominal depreciation works through reduction of purchasing power – there will be less demand for the products of all industries. Only after investment occurs to raise the productivity of the base-wage worker will a rise in purchasing power be observed.

V. Conclusions.

Traditional trade theories suggest that nominal exchange-rate depreciation will be neutral in its

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[30] This is roughly consistent with the trends in real weekly wages in the US over the period 1967-1995 reported by Harrigan (1998). The base wage, taken as the wage paid to high-school dropouts, declined over that period while the real wage of other groups had increased.

effect on equilibrium. While the depreciation can elicit job creation and trade surpluses in the home economy, this job creation takes the "beggar my neighbor" form noted by Robinson (1947): jobs created at home are at the expense of jobs lost abroad. Further, these job gains will disappear as the economy moves back to the original equilibrium relative wage and pattern of trade.

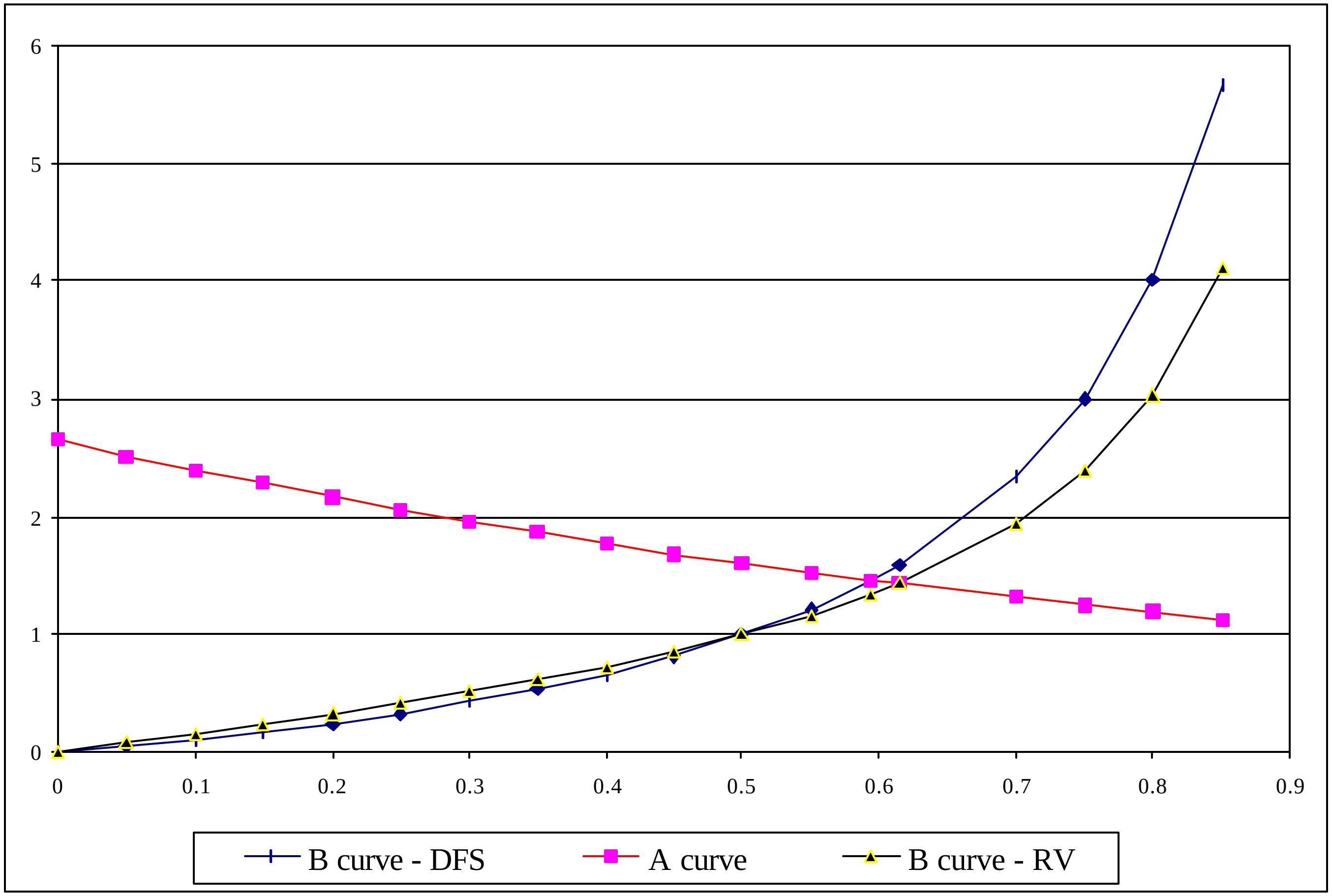
The analysis of this paper uses a slight modification to a traditional trade theory to demonstrate a "beggar my neighbor" property. Neutrality of exchange-rate depreciation no longer holds when firms are recognized to have some degree of monopoly power in their industries. Limit pricing by these firms leads to a fundamentally different trade equilibrium: one in which each country has an incentive to use policy tools to expand the range of goods exported. Exchange-rate depreciation in this world is welfare-improving for the depreciating country if there is some sluggishness in wage adjustment.

The welfare gains from this trade expansion are shown to be non-neutral even in the long run because they are captured in the form of profits. When these profits are reinvested, the underlying pattern of comparative advantage is altered. The country able to increase investment relative to the trading partner is able to raise steady-state welfare -- and in this model, exchange-rate depreciation causes the increase in investment. There is a negative impact of such expansions on income equality, as the gap in compensation between highly paid and marginal workers is enlarged as the adjustment dynamic begins. In the steady state equilibrium, however, the compensation gap can become narrower. This last conclusion depends upon the pattern of reinvestment of profits among firms in the home country.

These conclusions are dependent upon the model structure chosen. The assumption of a single profit-making firm in each industry runs counter to the assumptions underlying DFS, Lewis and Jones (1979); it provides in effect the opposite extreme to the perfect-competition outcomes of those papers. Also crucial to the results on the compensation gap is the assumption that profits of the firm are distributed as a Marshallian quasi-rent to both owner and labor. There is not a transferable human capital element to the compensation, as in models of skilled labor; this would be a different and interesting extension of the work here.

Trade equilibrium associated with unemployment in both countries provides an opportunity in this model for "beggar my neighbor" nominal devaluations of the exchange rate when the nominal wages are sticky. Home-country exchange rate depreciation will lead to an expansion of production; this expansion can be supported by an increase in labor use from the pool of unemployed. Clearly, however, such increases in employment at home will be paired by increases in unemployment overseas, leading as Robinson (1947) pointed out to competitive devaluations between monetary authorities. This competition is not modeled here.

Figure 1. General Equilibrium: Pattern of Trade and Double-Factoral Terms of Trade



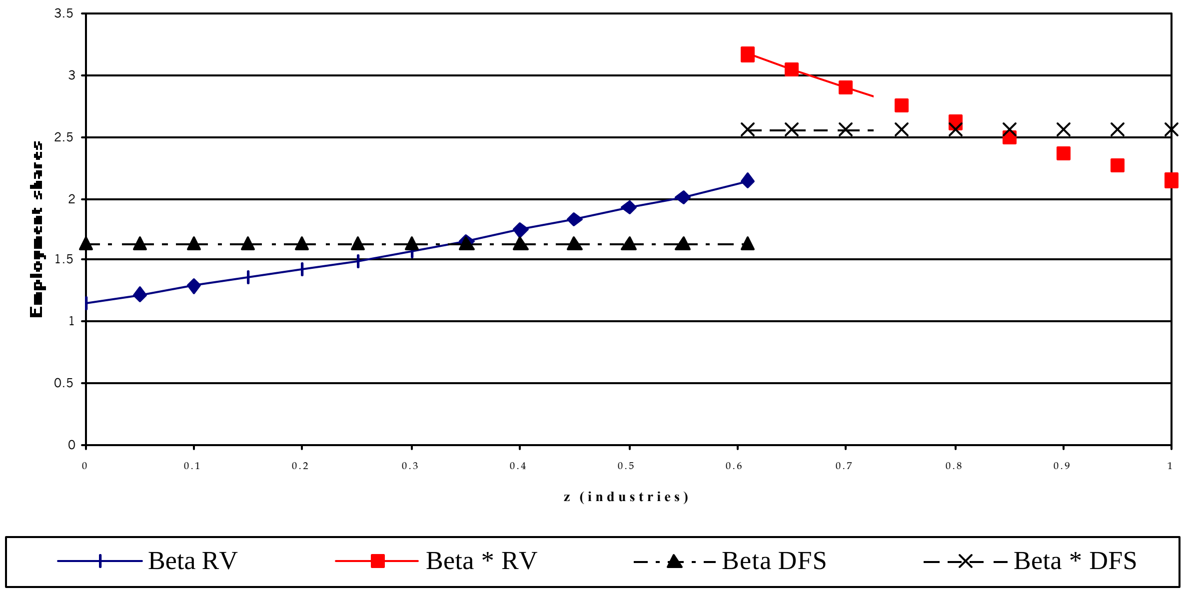


Figure 2. Employment Shares (β and β^*) by Industry

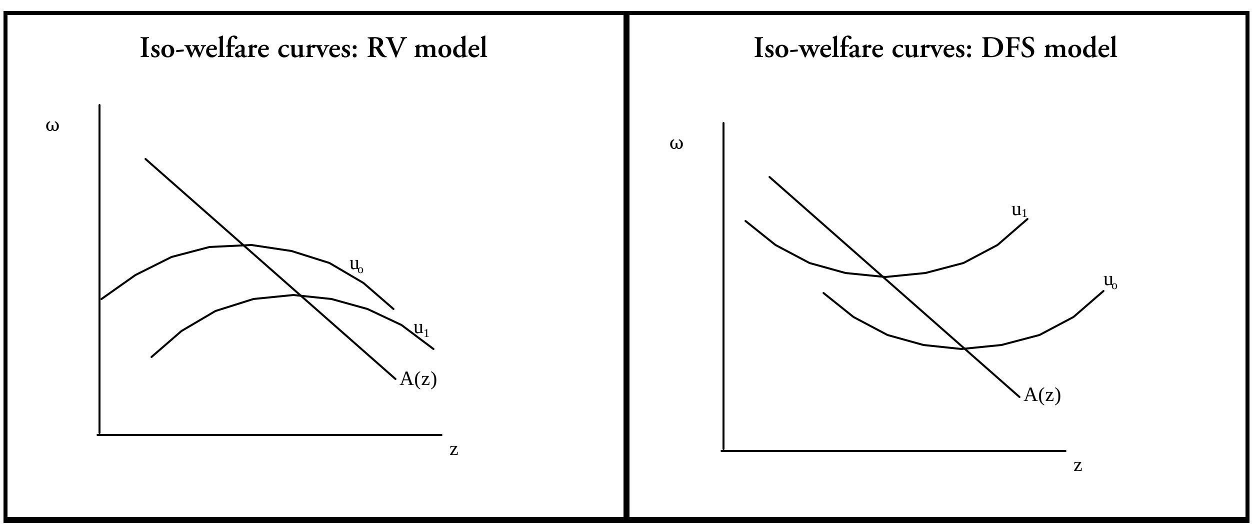


Figure 3. Iso-Welfare Loci in RV and DFS models

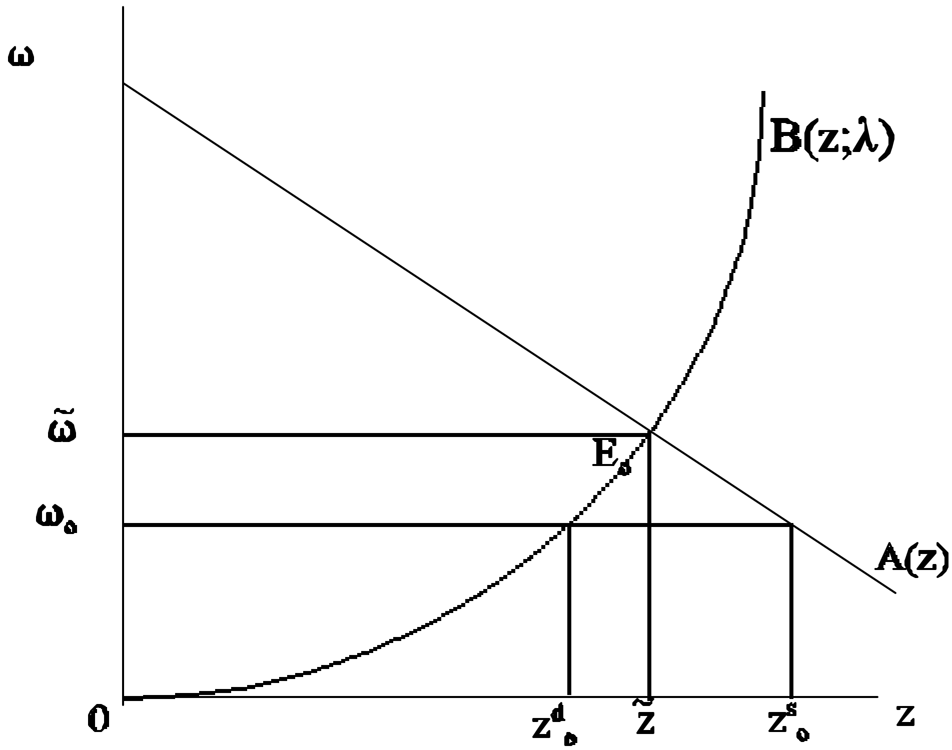


Figure 4. Relative Wage Out-of-equilibrium

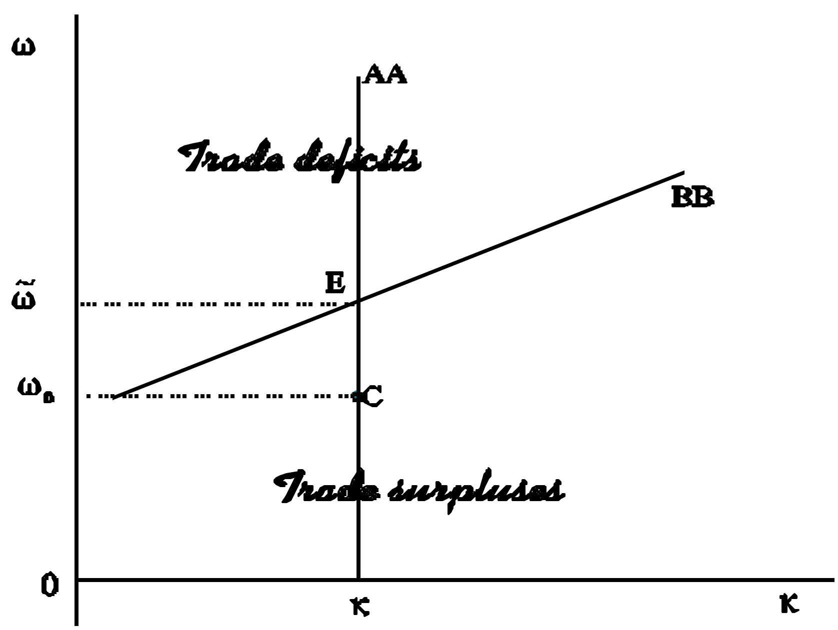


Figure 5. Dynamics of Adjustment in the DFS Model

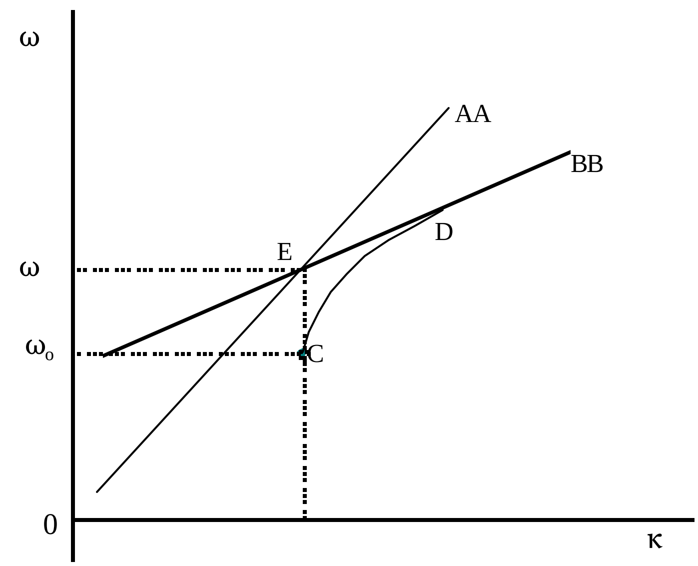


Figure 6. Dynamics of Adjustment in the RV Model: Proportional Investment

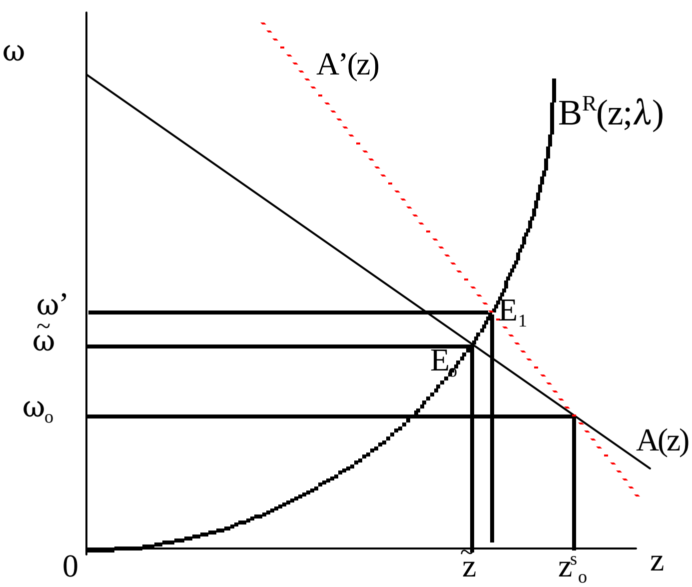


Figure 7. Dynamic of Adjustment: Industry-Specific Investment

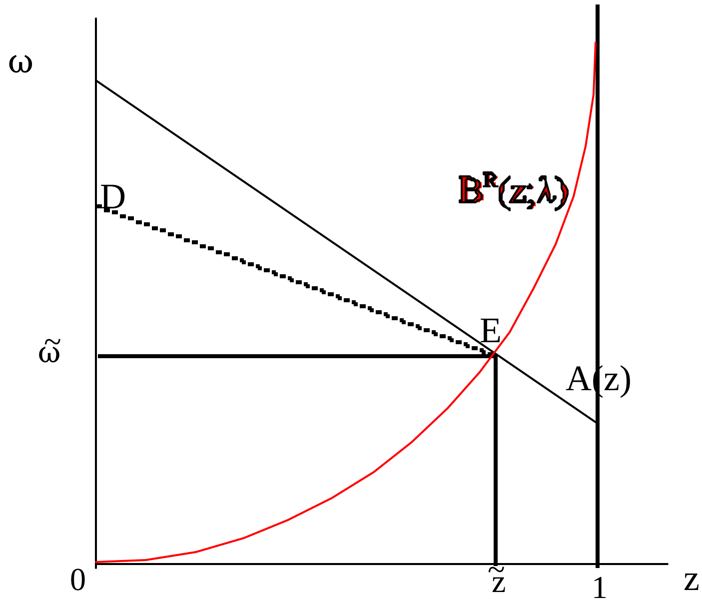


Figure 8. **Employment Compensation in the RV Model**

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Appendix: Derivation of the DFS and RV models.

The Classic DFS Model.

Comparative advantage can be defined in pairwise fashion on labor costs. DFS models these through consideration of fixed unit labor coefficients (a_i, a_i^*) in commodity i for the home and foreign country respectively. There is a chain rule on comparative advantage that holds in this instance.[31]

$$a_1^*/a_1 > a_2^*/a_2 > \ldots > a_n^*/a_n \tag{a1}$$

These ratios are denoted $A_i = a_i^*/a_i$, with higher A_i indicating a home-country comparative advantage relative to lower A_i . There may be as well a commodity j for which both home and foreign producer are competitive. In that case, the zero profit condition applies for each firm. The domestic and foreign wages are w and w^*, respectively, while e is the home-currency price of one unit of the foreign currency.

$$wa_j = ew^* a_j^* \tag{a2}$$

In DFS there is a continuum of commodities indexed by z on the interval [0 1] such that the function A(z) = {A_i for all i} sorted in descending order is continuous.

$$A(z) = a^*(z)/a(z) \qquad \text{with } A'(z) < 0 \tag{a3}$$

The zero-profit condition (a2) will hold for one commodity $\tilde{z}$. For that commodity the relative wage (or double-factoral terms of trade) denoted $\omega = w/ew^*$ will just equal $A(\tilde{z})$.

$$\tilde{\omega} = A(\tilde{z}) \tag{a4}$$

Demand for each commodity is assumed to be Graham-Mill in nature. Labor receives all income, and has identical preferences over commodities. A constant fraction of income is spent on the consumption of each good. These fractions are assumed equal across countries.

$$b(z) = p(z)C(z)/Y = b^*(z) = p(z)C^*(z)/Y^* \tag{a5}$$

$$\text{with } \int_0^1 b(z)\, dz = 1$$

This demand behavior is summarized in the share of income spent on commodities indexed below some arbitrary value $\tilde{z}$.

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[31] Home comparative advantage in good i for any two goods i and j is defined by $a_i^*/ a_j^* > a_i/a_j$ and can be rewritten in the above form.

$$\theta(\bar{z}) = \int_0^{\bar{z}} b(z)\, dz \quad \text{with } \theta'(\bar{z}) = b(\bar{z}) > 0 \tag{a6}$$

DFS assumes that the industrial organization is perfect competition. Perfect competition for labor within each country implies a constant wage across industries and pricing of the good according to labor cost. Goods-market equilibrium is assured where the exports of the home country are equal in value to the imports of the foreign country, as in (a7) below. The ratio of labor use is defined $\lambda = L/L^*$ in the second equality.

$$\begin{aligned} &(1-\theta(\bar{z}))\, wL = \theta(\bar{z})\, ew^*L^* \\ &\varpi = \theta(\bar{z})/[\lambda(1-\theta(\bar{z}))] = B^D(\bar{z},\lambda) \qquad B^D{}_z > 0,\ B^D{}_\lambda < 0 \end{aligned} \tag{a7}$$

The DFS equilibrium is characterized by simultaneous solutions of equations (a4) and (a7) for ϖ and $\bar{z}$. There is full employment in equilibrium at the labor quantities L and L^*, respectively.

Employment in each industry is closely related to total production (and consumption) of the good. Total consumption of home export goods is given by

$$C(z) = b(z)(wL + ew^*L^*)/p(z) \tag{a8}$$

The consumption of foreign products is defined analogously. The shares of total labor $\beta(z)$ and $\beta^*(z)$ used in production of home and foreign commodities z are:[32]

$$\beta(z) = L(z)/L = a(z)\, C(z) / L \tag{a9a}$$
$$= b(z)(1 + 1/\omega\lambda) = b(z)/\theta(\bar{z})$$
$$\beta^*(z) = b(z)(1 + \omega\lambda) = b(z)/(1-\theta(\bar{z})) \tag{a9b}$$

Employment shares are dependent upon the demand for the product, as indicated by the b(z). They are also dependent upon the range of products produced in-country in equilibrium. They do not depend directly, however, upon the relative productivity in the two countries due to the marginal-cost pricing assumption.

The welfare levels in equilibrium for the home and foreign countries are defined:

$$u = {}_o\!\int^1 C_h(z)^{b(z)}\, dz \tag{a10a}$$
$$u^* = {}_o\!\int^1 C_f(z)^{b(z)}\, dz \tag{a10b}$$

[32] If these employment shares are integrated for the range of goods produced at home, the resulting equalities return the trade balance condition. Full employment and trade balance are thus equivalent constraints in this model. This will be an important feature of the discussion of dynamics.

$$U = {}_o\int^1 [C_h(z)+C_f(z)]^{b(z)}\, dz \qquad \text{(a10c)}$$

Utility for the world economy is defined in terms of total consumption of goods in (a10c).

Trade Equilibrium in a Ricardo-Viner World

The structure of the RV model is identical to that of DFS. The technology is modeled in identical fashion, using equations (a1) through (a4). Demand is modeled in identical fashion as well, as defined in equations (a5) and (a6). The critical differences occur in the industrial organization of the market for each product.

In each country, there is a specific factor for each industry z on the continuum. This specific factor has a single owner in each country for each z, and that owner establishes a firm to sell the industry's product. The world market is thus served by two firms for each industry z. The two owners compete with one another on the basis of price. The limit-pricing policy maximizes profits through setting a price just below that of the foreign competitor. If that price leads to negative profits the industry shuts down in that country.

This leads to nominal prices p_i on the world market of:

$$p_i = \begin{cases} wa_i & \text{for foreign export good} \\ ew^* a_i^* & \text{for home export good} \end{cases} \qquad \text{(a11)}$$

Each owner thus prices its good to gain the entire productivity differential.[33] This profit can be defined per unit of commodity sold.

$$\pi_i = ew^*\, a_i^* - wa_i \qquad \text{for home export good} \qquad \text{(a12a)}$$
$$\pi_i^* = wa_i - ew^*\, a_i^* \qquad \text{for foreign export good} \qquad \text{(a12b)}$$

Profits per unit of output in each industry can be rewritten for the continuum of goods, with $\tilde{z}$ the good in which both countries have identical production cost.

$$\pi(z) = wa(z)\, [(A(z)/A(\tilde{z})) - 1\,] \qquad \text{for } z \leq \tilde{z} \qquad \text{(a13a)}$$
$$\text{and} \quad 0 \qquad \text{otherwise.}$$
$$\pi^*(z) = wa(z)\, [1 - (A(z)/A(\tilde{z}))] \qquad \text{for } z \geq \tilde{z} \qquad \text{(a13b)}$$
$$\text{and} \quad 0 \qquad \text{otherwise.}$$

The terms in brackets indicates that the profit is simply the internalization by the firm of the relative productivity differential across countries. These profits are increasing for industries more distant on

[33] More precisely, the successful firm will capture the productivity differential minus $\epsilon > 0$. I assume an owner operating at zero accounting profit will produce, but that an owner with ϵ loss will shut down.

the continuum from the zero-profit industry. Total profits per industry ($\Pi(z)$ or $\Pi^*(z)$) can be defined with the share of labor ($\beta(z)$ or $\beta^*(z)$) employed in that industry.

$$\Pi(z) = (wL)\beta(z)\,[(A(z)/A(\tilde{z})) - 1] \quad \text{for } z \le \tilde{z}; \quad \text{and } 0 \text{ otherwise.} \tag{a13c}$$

$$\Pi^*(z) = (ew^* L^*)\beta^*(z)\,[1-(A(z)/A(\tilde{z}))] \quad \text{for } z \ge \tilde{z}; \quad \text{and } 0 \text{ otherwise.} \tag{a13d}$$

The share of labor employed in each sector depends upon demand for products. Consumption of home goods derived from the consumer welfare function is as reported in (a8), but with ($wL + ew^*L^*$) replaced by the sum of incomes in the two countries ($Y + Y^*$) and with $p(z)$ defined by the limit pricing rule in (a11). The $\beta(z)$ and $\beta^*(z)$ in this case are

$$\beta(z) = b(z)(Y+Y^*)/(ew^*A(z)L) \quad \text{for } z \le \tilde{z}; \quad \text{and } 0 \text{ otherwise.} \tag{a14a}$$

$$\beta^*(z) = b(z)A(z)(Y+Y^*)/(wL^*) \quad \text{for } z \ge \tilde{z}; \quad \text{and } 0 \text{ otherwise.} \tag{a14b}$$

These shares are rising in the relative demand for the product $b(z)$ and in total world income. The foreign share $\beta^*(z)$ is rising and the domestic share $\beta(z)$ is falling, other things equal, with an increase in $A(z)$; such an increase indicates an improvement in the relative productivity advantage of the domestic economy.

Total incomes of the two countries (Y, Y^*) are defined as the sum of wages and profits.

$$Y = wL + \int_0^{\tilde{z}} \Pi(z)\,dz = wL\left(1 + \int_0^{\tilde{z}} \beta(z)\left(\frac{A(z)}{A(\tilde{z})} - 1\right)dz\right) \tag{a15a}$$

$$Y^* = ew^*L^* + \int_{\tilde{z}}^1 \Pi^*(z)\,dz = ew^*L^*\left(1 + \int_{\tilde{z}}^1 \beta^*(z)\left(\frac{A(\tilde{z})}{A(z)} - 1\right)dz\right) \tag{a15b}$$

I define the variables $\phi(\tilde{z})$ and $\phi^*(\tilde{z})$ in (a16a) and (a16b) to capture the profits accruing to each country from producing inframarginal goods rather than the cross-over good; these are declining in the productivity differential for each z relative to $\tilde{z}$. $\phi(\tilde{z})$ is rising with $\tilde{z}$ and $\phi^*(\tilde{z})$ is declining in $\tilde{z}$. The larger the "cumulative comparative advantage" as evidenced by the slope of the $A(z)$ curve in the range of goods they produce, the larger will be both $\phi(\tilde{z})$ and $\phi^*(\tilde{z})$.

$$\phi(\bar{z}) = \int_0^{\bar{z}} \left\{ b(z)\left(1 - \frac{\omega}{A(z)} \right) \right\} dz \qquad \text{(a16a)}$$

$$\phi^*(\bar{z}) = \int_{\bar{z}}^{1} \left\{ b(z)\left(1 - \frac{A(z)}{\omega} \right) \right\} dz \qquad \text{(a16b)}$$

Income in each country can be restated as:

$$Y = wL + (Y + Y^*)\,\phi(\bar{z})$$
$$Y(\bar{z}) = ew^*L^*[\omega\lambda(1-\phi^*(\bar{z})) + \phi(\bar{z})] \,/\, (1 - \phi(\bar{z}) - \phi^*(\bar{z}))) \qquad \text{(a17a)}$$
$$Y^* = ew^*L^* + (Y + Y^*)\,\phi^*(\bar{z})$$
$$Y^*(\bar{z}) = ew^*L^*[(1-\phi(\bar{z})) + \omega\lambda\phi^*(\bar{z}))] \,/\, (1 - \phi(\bar{z}) - \phi^*(\bar{z}))) \qquad \text{(a17b)}$$

In the DFS model an increase in $\bar{z}$ for given technological relation A(z) leads to an unambiguous reduction in domestic real income through a reduction in the relative wage. In the RV model, by contrast, that effect is combined with the impact of $\bar{z}$ in increasing domestic profitability $\phi(\bar{z})$ and reducing foreign profitability $\phi^*(\bar{z})$. The latter is the profit-shifting effect of real depreciation analogous to the effect of production subsidy in Brander and Spencer (1981).

The demand-side equilibrium (18) can be derived through substitution of Y and Y^* into the balanced-trade condition. This becomes the DFS condition (a7) when $\phi(\bar{z}) = \phi^*(\bar{z}) = 0$, but will in general be characterized by different equilibrium $\bar{z}$ and $\bar{\omega}$ due to the existence of these profit-taking terms.

$$(1-\theta(\bar{z}))\, Y(\bar{z}) = \theta(\bar{z})\, Y^*(\bar{z})$$
$$\bar{\omega} = [(\theta(\bar{z}) - \phi(\bar{z}))/(1- \phi^*(\bar{z})-\theta(\bar{z}))]/\lambda = B^R(\bar{z};\lambda) \qquad \text{(a18)}$$
$$B^R_z > 0,\ B^R_\lambda < 0$$

The response of the newly defined $B^R(\bar{z};\lambda)$ to $\bar{z}$ will in general be positively sloped, as for $B^D(\bar{z};\lambda)$ in the DFS model. The $B^R(\bar{z};\lambda)$ schedule for a flat A(z) schedule is identical to that derived in the DFS model. As the A(z) schedule becomes steeper, the $B^R(\bar{z};\lambda)$ schedule has a larger positive gradient than $B^D(\bar{z};\lambda)$.

This definition of equilibrium differs from that of DFS in two important ways. First, limit pricing makes home income dependent upon foreign wage, and vice versa. Second, each country captures as income the difference in relative productivity as measured by the ratio $[A(z)/A(\bar{z})]$ for the goods it produces. Supply-side characteristics of the market enter the profit-capture terms while characteristics of demand for goods enter through the value of the cross-over good $\bar{z}$.

The differences in equilibrium between DFS and RV models are illustrated by the comparison of the employment shares by industry in equilibrium in Box 1.

Box 1. Employment shares in Equilibrium

DFS Model	RV model
$\beta(z) = b(z)/\theta(\tilde{z})$	$\beta(z) = [b(z)/(A(z)\lambda)]/(1-\theta(\tilde{z})-\phi^*(\tilde{z}))$
$\beta^*(z) = b(z)/(1-\theta(\tilde{z}))$	$\beta^*(z) = [b(z)A(z)\lambda]/(\theta(\tilde{z})-\phi(\tilde{z}))$

In the DFS model, the employment shares by industry are determined by the demand for the product of that sector and the range of goods produced by that country in equilibrium. In the RV model the dependence on demand for the product is similar. There are three important differences. First, the relative productivity term A(z) enters in the expected way – the less relatively productive the industry, the more labor necessary to satisfy demand. Second, employment shares depend not on the own-country range of goods produced, but on the other country's range of goods produced. This is due to the limit pricing assumption. Third, the profit-taking terms $\phi(\bar{z})$ and $\phi^*(\bar{z})$ enter to magnify demand for the product in the trading partner: an increase in the home-country $\phi(\bar{z})$ leads to an increase in demand for labor in each industry in the foreign country.

The Impact on Utility of an Increase in L^*

The following results are derived using

simplification: b(z)=b for all z.
choice of units: $a^*(z) = 1$.
normalization: $ew^* = 1$.

First step: **identifying the effect of change in L^* on $\bar{z}$.**

DFS: $(d\bar{z}/dL^*) = (\theta(\bar{z})/[L^*\{\lambda(1-\theta(\bar{z}))^2A'(\bar{z}) - \theta'(\bar{z})\}] < 0$ from (a2) and (a3)

RV: $(d\bar{z}/dL^*) = \omega\lambda\ (1-\phi^*(\bar{z})-\theta(\bar{z}))/\ \{(1-\phi^*(\bar{z})-\theta(\bar{z}))A'(\bar{z})\lambda$
$- (1+\lambda\omega)(\phi^{*\prime}(\bar{z})+\theta'(\bar{z})) + (\phi'(\bar{z})+\phi^{*\prime}(\bar{z}))\}$ from (a2) and (a10)

The derivative in the DFS model is always negative. The derivative in the RV model is in general ambiguous but is assumed to be negative in what follows.

This condition holds, for example, for the class of $A(z)=\kappa\exp\{-f\tilde{z}\}$ for all positive κ and f. It is straightforward to show

- $\theta'(\tilde{z}) = b$
- $\phi^{*}(\tilde{z}) = b\,((1-\tilde{z})-(1/f)(1-(A(1)/A(\tilde{z}))))$
- $\phi^{*'}(\tilde{z}) = -b\,(1-(A(1)/A(\tilde{z})))$
- $\phi(\tilde{z}) = b\,(\tilde{z} - (1/f)(1-A(\tilde{z})))$
- $\phi'(\tilde{z}) = b\,(1-A(\tilde{z}))$.

With this, RV: $(d\tilde{z}/dL^{*}) = -(\lambda/f)(\omega-A(1))/(\omega(1+\lambda)) < 0$

Second step: **identifying the effect of a change in $\tilde{z}$ on u.**

This step is implemented by defining the set of iso-welfare curves for the home country in (ω,z) space. The text has as hypothesis that it will be in the interest of the home country to reduce $\tilde{z}$, other things equal, in the DFS model and to increase $\tilde{z}$, other things equal, in the RV model.

This step will be demonstrated for the home country for $b(z)=b$ for all z. $a^{*}(z) = 1$ for all z by choice of units. By normalization, $ew^{*} = 1$. The results for the foreign country and for the world as a whole are derived analogously.

Price deflator	$P = [\,{}_{o}\int^{z} (1/p(z))^{b}\,dz + {}_{z}\int^{1} (1/p(z))^{b}\,dz]$
Consumption:	$C_h(z) = bY/p(z)$
Home utility:	$u = {}_{o}\int^{1} C_h(z)^{b}\,dz$
	$u = P(bY)^{b}$

In the DFS model,

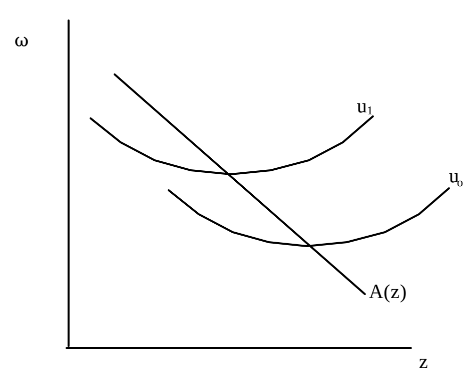
$$P_D = {}_{o}\int^{z} (A(z)/\omega)\,dz + (1-\tilde{z})$$
$$dP_D = -(1/\omega)d\omega[\,{}_{o}\int^{z} (A(z)/\omega)\,dz\,]$$

$$Y(\tilde{z}) = L^{*}(\omega\lambda)$$
$$dY = L^{*}\lambda\,d\omega$$

$$du = 0 = P_D dY + Y\,dP_D$$
or
$$d\omega/d\tilde{z} = (\omega - A(\tilde{z}))/(1-\tilde{z})$$

The isowelfare curve is downward-sloping for $z<\tilde{z}$, and upward-sloping for $z>\tilde{z}$. It is horizontal at $\omega = A(\tilde{z})$. Welfare is rising as ω rises for constant $\tilde{z}$.

Iso-welfare curves: DFS model



In the RV model:

$$P_R = \bar{z} + {}_z\int^1 (A(z)/\omega)\, dz$$
$$dP_R = -(1/\omega)d\omega[{}_z\int^1 (A(z)/\omega)\, dz\,]$$

$$Y(\omega,\bar{z}) = L^*[\omega\lambda(1-\phi^*(\bar{z})) + \phi(\bar{z})] \,/\, (1 - \phi(\bar{z}) - \phi^*(\bar{z})))$$

Creation of a welfare map requires that non-equilibrium combinations of ω and $\bar{z}$ be evaluated. In this instance, specifically, the values of ϕ and ϕ^* must be recognized to depend independently on ω and $\bar{z}$. (See equations a16a and a16b.) Derivations are simplified when it is recognized that the reciprocal of the price deflator is related to the profit share earned in the foreign country: $P_R = (1-\phi^*(\omega,\bar{z}))$.

$$P_RY = L^*[\omega\lambda(1-\phi^*(\omega,\bar{z}))^2 + (1-\phi^*(\omega,\bar{z}))\phi(\omega,\bar{z})] \,/\, (1 - \phi(\omega,\bar{z}) - \phi^*(\omega,\bar{z})))$$

$$d(P_RY) = [LP_R^2 d\omega - \{\omega LP_R - \phi(\omega,\bar{z})Y\}d\phi^* + (L^*+Y)P_R\, d\phi]/(1-\phi(\omega,\bar{z})-\phi^*(\omega,\bar{z}))$$

This is not a reduced-form expression, but illustrates the wage- and profit-channel impact on real income. The direct impact of an increase in relative wage, for given profit shares, is to increase real income. The impact of increased domestic profit share $\phi(\omega,\bar{z})$ for given ω is also positive. The impact of increased foreign profit share has an ambiguous effect, with a negative direct effect and a positive indirect effect through the price deflator.

Specific iso-welfare curves can be derived from this expression for the class of technologies $A(z) = \kappa e^{-fz}$. Then:

$$\phi(\omega,\bar{z}) = \bar{z} - [\omega/(fA(\bar{z})A(0))]\{A(0) - A(\bar{z})\}$$
$$d\phi(\omega,\bar{z}) = (1 - (\omega/A(\bar{z})))\, d\bar{z} - [1/(fA(\bar{z})A(0))]\{A(0) - A(\bar{z})\}d\omega$$
$$\phi^*(\omega,\bar{z}) = (1-\bar{z}) - [1/(f\omega)]\{A(\bar{z}) - A(1)\}$$
$$d\phi^*(\omega,\bar{z}) = ((A(\bar{z})/\omega) - 1)\, d\bar{z} + [1/(f\omega^2)]\{A(\bar{z}) - A(1)\}\, d\omega$$
$$(1 - \phi(\omega,\bar{z}) - \phi^*(\omega,\bar{z})) = (1/f)\{[\omega/(A(\bar{z})A(0))]\{A(0) - A(\bar{z})\} + (1/\omega)\{A(\bar{z}) - A(1)\}\}$$

Define $\Delta_0 = \{A(0) - A(\bar{z})\} > 0$ and $\Delta_1 = \{A(\bar{z})-A(1)\} > 0$. Then $d(P_RY) = 0$ implies

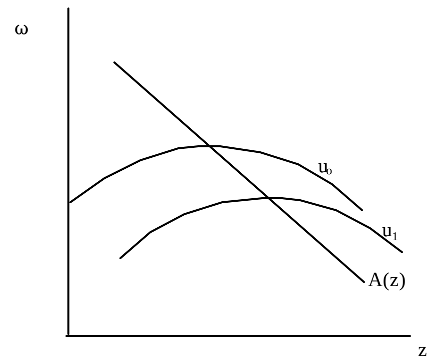
$$(A(\bar{z})-\omega)f\{Y(P_R-\phi(\omega,\bar{z})) + P_R(1+\omega\lambda)\}d\bar{z} -$$
$$\{Y\bar{z}((\Delta_0/A(0))-(A(\bar{z})/\omega)(\Delta_1/\omega)) + P_R\,((\Delta_0/A(0))- \lambda A(\bar{z})\bar{z}f\,\}d\omega = 0$$

The coefficient on $d\bar{z}$ has the expected properties: it takes on value of 0 at $A(\bar{z}) = \omega$, is positive when $A(\bar{z}) > \omega$ and is negative when $A(\bar{z}) < \omega$. The expression in brackets multiplying $d\omega$ would be negative in the DFS model, but in the RV model is more likely to be positive. If evaluated at $A(\bar{z}) = \omega$, this coefficient has the sign of

$$\{-P_R^2\,(\Delta_0/A(0)) + \phi(\Delta_1/\omega)(\phi + 2P_R\lambda\omega)\}$$

with the first term representing the direct impact of increased relative wage, and the second term representing the impact through the effects of profit-shifting. When the second term dominates, the indifference curves of the home country take the form shown in this figure, with welfare increasing with the lower indifference curves. The economy receives less of its income from the relative wage, but so much through its capture of the profits of production that welfare as a whole is rising.

Iso-welfare curves: RV model



Conclusion: **in the RV model, exogenous shocks that cause a fall in the relative wage along the A(z) curve will be welfare-improving to the home country.** By contrast, in the DFS model the exogenous shock that causes a fall in the relative wage along the A(z) curve will be welfare-reducing.