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NORTH–SOUTH TRADE AND EXPORTED-LED POLICIES*

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An earlier paper in this Journal [Chichilnisky (1981)] formulated a model of North–South trade where the South exports a labor-intensive commodity in exchange for industrial goods. The paper studied moves to new equilibria with higher levels of exports of the South and of industrial demand in the North. It was established that with abundant labor and technological dualism, such moves lead to more exports, but to lower terms of trade, consumption, and real wages in the South. This occurs within Walrasian stable and perfectly competitive markets. Sufficient conditions were also given for the South to improve its terms of trade, real wages, and consumption through an export expansion. This paper comments on several other papers written on these results, generalizes the earlier propositions, and extends them to a larger class of economies which export labor-intensive products, but need not have abundant labor. It gives a generalization of the earlier results on uniqueness and stability of the equilibria, and reports also on recent econometric tests for Sri-Lanka and the U.K., and numerical simulations of the model.

1. Introduction

In an earlier paper in this Journal [Chichilnisky (1981)], I formulated a model of North–South trade in order to evaluate the gains and losses from export-led policies. The aim was to explain why the international market works at times to concentrate rather than to diffuse the gains from trade. I followed the time-honored tradition of using a two region, two factor, and two commodity competitive equilibrium framework, with a unique and stable equilibrium. The results became the subject of several other papers in this issue of the Journal [Heal and McLeod (1984), Gunning (1984), Ranney (1984), Saavedra-Rivano (1984), Srinivasan–Bhagwati (1984)] and of articles elsewhere [Arrow (1981), Findlay (1983), Lim (1983), Mahran (1982), Motamen (1983), Podivinsky (1982), Sen (1981), Uriarte (1981)].

I welcome these authors' interest in an area that is growing in terms of theory and policy implications. This paper comments on their contributions,

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and extends the 1981 results to economies which export labor-intensive products, but may not have abundant labor. These include economies with fixed endowments of labor and capital. I give *necessary and sufficient conditions* for positive outcomes from an increase in exports; these conditions depend on the initial data, i.e., on technologies and factor endowments. A positive outcome means better terms of trade, and higher real wages and consumption in the South. Outside these conditions, the results from increased exports turn negative for the South: due to income effects the terms of trade and export revenues worsen, real wages and domestic consumption decrease. These results extend Propositions 1 and 2 in Chichilnisky (1981). Furthermore, I exhibit cases where exogenous increases in the North's industrial demand or the North's demand for basics, lead it to import more basics, and to consume simultaneously more of both goods. The South exports more but consumes less. An expansion of demand for either good in the North leads here to more trade and to gains for the North, but leads also to losses for the South. These results sharpen Proposition 3 of Chichilnisky (1981).

The propositions involve comparisons of nearby trade equilibria, rather than between autarchy and trade. The conditions are such that for the same economy different policies may be indicated at different levels of trade. In some cases, an optimum trade level can be reached. This depends upon domestic characteristics of the economy, such as technologies and factor markets, which may be influenced by policy. Finally, I extend the earlier results on uniqueness and stability of the solutions, and discuss also other adjustment processes suggested by some of the comments.

2. The North–South model

Each region is described by behavioral assumptions and by equilibrium conditions, making a total of 26 equations for the whole North–South model. However, in order to compute an equilibrium explicitly, it suffices to solve *a single equation* from which the solutions and all the comparative statics properties can be easily derived.[1]

Consider first the economy of the South. It supplies basic goods (B) and industrial goods (I) using labor (L) and capital (K): $B^S = \min(L^B/a_1, K^B/c_1)$, $I^S = \min(L^I/a_2, K^I/c_2)$. The corresponding price equations, under the assumption of competitive behavior on the part of the producers, are in equilibrium,

$$p_B = a_1 w + c_1 r, \qquad p_I = a_2 w + c_2 r.^2 \qquad (1), (2)$$

[1]Stiglitz pointed out that the existence of a single resolving equation does not depend on the particular production functions used, but would be true for any constant returns technology with or without intermediate goods.

[2]In Chichilnisky (1981) the cost of capital is rp_I, but since p_I is the numeraire, we obtain the same equation.

Labor and capital supplies in equilibrium depend on their rewards,

$$L^S = \alpha(w/p_B) + \bar{L}, \qquad \alpha > 0, \quad K^S = \beta r + \bar{K}, \qquad \beta > 0,^3 \tag{3), (4}$$

where w denotes wages, p_B the price of basics, and r the rate of return to capital. To these four behavioral equations we add equilibrium or market clearing conditions for factor and commodity markets,

$$L^S = L^D, \quad K^S = K^D, \quad L^D = B^S a_1 + K^S a_2, \tag{5), (6), (7}$$

$$K^D = B^S c_1 + K^S c_2, \quad B^S = B^D + X_B^S, \tag{8), (9}$$

where X_B^S denotes exports of B,

$$I^D = X_I^D + I^S, \tag{10}$$

where X_I^D denotes imports of I, and the balance of payments condition,

$$p_B X_B^S = p_I X_I^D. \tag{11}$$

In an equilibrium, the Walras law or national income identity is always satisfied in each region (NI): $p_B B^D + p_I I^D = wL + rK$.[4]

The North is specified by the same eqs. (1) to (11), except for possibly different parameters in the technology and in the supply of factors. In a *world equilibrium* the prices of traded goods are equal, and exports match imports. This yields four more equilibrium conditions,

$$p_I(\mathrm{S}) = p_I(\mathrm{N}), \qquad p_B(\mathrm{S}) = p_B(\mathrm{N}), \tag{12), (13}$$

$$X_B^S(\mathrm{S}) = X_B^D(\mathrm{N}), \qquad X_I^D(\mathrm{S}) = X_I^S(\mathrm{N}), \tag{14), (15}$$

where the letters S and N in brackets denote South and North, respectively. We add the normalization condition,

$$p_I = 1 \tag{16}$$

(I is the numeraire).

[3]In Chichilnisky (1981), $K^S = r/p_I + \bar{K}$, but since I is the numeraire (i.e., $p_I = 1$) the two equations are identical.

[4]This can be seen as follows:

$$p_B B^D + p_I I^D = p_B(B^S - X_B^S) + p_I(I^S + X_I^D) = p_B B^S + p_I I^S = (a_1 w + c_1 r)B^S + (a_2 w + c_2 r)I^S = wL + rK.$$

In view of this, and of its homogeneity properties, an equilibrium of this model is consistent with a standard Arrow–Debreu competitive general equilibrium for some set of underlying individual preferences.

In each region there are therefore eight exogenous parameters: a_1, c_1, a_2, c_2, α, $\bar{L}$, β, $\bar{K}$, and 14 endogenous variables: p_B, p_I, r, w, B^S, B^D, X_B^S, I^S, I^D, X_I^D, L^S, L^D, K^S, K^D. Therefore *for the two region model there are a total of 16 exogenous parameter and 28 endogenous variables.*

In the two regions there are so far 26 independent equations: 11 equations in each region [(1) to (11)], plus three international market clearing conditions [(12) to (14), since (15) is automatically satisfied when all others are], plus the normalization condition (16). To close the system, in Chichilnisky (1981) the level of industrial demand in an equilibrium of the South was exogenously given,

$$I^D(\mathrm{S}) = \bar{I}^D(\mathrm{S}). \tag{17}$$

Here we shall also substitute (17) by an equation which gives a *price-dependent demand for industrial goods* across equilibria of the South,

$$I^D(\mathrm{S}) = \lambda r \cdot K + \mu w L / p_B, \qquad 0 \leqq \lambda, \quad \mu \leqq 1, \tag{17'}$$

and either λ or μ different from zero. When $\mu = 0$, industrial demand equals capital income. This is equivalent by Walras law to $wL = p_B B^D$, i.e., equilibrium wage income is spent in basics. Where (17') substitutes (17) we call this the North–South model II. Adding (17) [or (17')] we have 27 equations in 28 variables, a system determined up to one variable. We parameterize the solutions by the *equilibrium level of demand for basics, B^D(N), or for industrial goods in the North, I^D(N)*: as one of the real numbers I^D(N) or B^D(N) varies, we obtain a one-parameter family of equilibria in the space of all endogenous parameters, which is R^{28}. Comparative static exercises consist of exploring the relationships between the endogenous variables across this path of equilibria. This parameterization by I^D(N) was used in Proposition 3 of Chichilnisky (1981). Alternatively, we may parameterize the equilibria by a real number indicating the equilibrium level of exports of the South $X_B^S(\mathrm{S}) = X_B^D(\mathrm{N})$.[5] This latter parameterization was used in Propositions 1 and 2 in Chichilnisky (1981); competitive equilibria with different levels of Southern exports will occur, for instance, with changes in Northern performances.

Proposition 1. The North–South model has at most one equilibrium for each level of industrial demand I^D(N) of the North. The model has also at most one equilibrium for each level of demand for basics B^D(N) in the North.[6]

[5]When X_B^D(N) is exogenously set, I^D(N) and B^D(N) are endogenously determined. Similarly, when B^D(N) is exogenously set, X_B^D(N) and I^D(N) are endogenously determined.

[6]*Existence* requires standard restrictions on the exogenous parameters to ensure that the equilibrium prices are all positive. Appendix 2, page 188 of Chichilnisky (1981) states: 'We therefore obtain at most two solutions in the relative price of B, p_B.' Since one solution could be negative or zero, this can be refined from 'at most two' to 'one', as in Proposition 1. Saavedra-Rivano (1984, sect. 1) also states that the model has *one* solution, but he reports, incorrectly the statement 'at most two' in Chichilnisky (1981) to be 'at least two', implying an error in the number of solutions which does not exist.

The set of equilibria described as the exports X_B^D vary, is identical to that obtained by parameterizing the solutions by the equilibrium level of industrial demand in the North. The comparative statics properties of the North–South model are the same when this is parameterized by the level of exports X_B^D, or by the industrial demand of the North, I^D(N), or by the demand for basics of the North, B^D(N).

Proof. Consider the international market clearing condition for industrial goods $X_I^D(\mathrm{S}) = X_I^S(\mathrm{N})$, i.e.,

$$I^D(\mathrm{S}) - I^S(\mathrm{S}) = I^S(\mathrm{N}) - I^D(\mathrm{N}), \tag{18}$$

where by (17) I^D(S) is a given constant, $\bar{I}^D$(S). Inverting eqs. (7) and (8), we obtain

$$B^S = (c_2 L - a_2 K)/D, \quad I^S = (a_1 K - c_1 L)/D, \qquad D = a_1 c_2 - a_2 c_1. \quad (19), (20)$$

Substituting (20) into (18), we obtain

$$\bar{I}^D(\mathrm{S}) - (a_1 K - c_1 L)/D = (a_1(\mathrm{N})K(\mathrm{N}) - c_1(\mathrm{N})L(\mathrm{N}))/D(\mathrm{N}) - I^D(\mathrm{N}).^7 \tag{21}$$

Inverting the price equations (1) and (2), one obtains

$$w = (p_B c_2 - c_1)/D, \quad r = (a_1 - p_B a_2)/D. \quad (22), (23)$$

Substituting (3) and (4) and then (22) and (23) into (21), we obtain a quadratic in p_B,

$$p_B^2(A + A(\mathrm{N})) + p_B(C + C(\mathrm{N}) + \bar{I}^D(\mathrm{S}) + I^D(\mathrm{N})) - (V + V(\mathrm{N})) = 0, \tag{24}$$

where $A = \beta a_1 a_2/D^2$, $V = \alpha c_1^2/D^2$, and $C = (1/D)(c_1 \bar{L} - a_1 \bar{K} + (\alpha c_1 c_2 - \beta a_1^2)/D)$.

Solving (24) gives an analytic expression for the equilibrium price p_B of the North–South model as a function of all the exogenous data and of the industrial demand of the North; (24) is thus a *resolving equation*. Since the constant and second order terms of (24) are positive and negative, respectively, there is at most one (strictly) positive root p_B^*, i.e., *at most one equilibrium price*, which is denoted $p_B^*(I^D(\mathrm{N}))$ to indicate its dependence on the parameter I^D(N). A similar resolving equation is obtained when B^D(N) is exogenous.

Each p_B^* defines unique equilibrium values of all the other 27 endogenous variables: From (22) and (23) we obtain w and r, from (3) and (4) K and L,

[7] All parameters and variables are for the South unless indicated, e.g., K is K(S).

from (19) and (20) B^S and I^S; $I^D(\mathrm{S})=\bar{I}^D(\mathrm{S})$ in the South, and $I^D(\mathrm{N})$ is given by our exogenous choice at the equilibrium. From the national income identity (NI), we may now compute B^D. The difference between supply and demand for each good at an equilibrium yields the volumes of exports and imports of each good in both regions. This completes the computation of the unique world equilibrium for each $I^D(\mathrm{N})$.

Consider now the second parameterization of the North–South model, by the equilibrium level of exports of the South $X_B^S(\mathrm{S})$. From (11),

$$X_B^D(\mathrm{N})=(\bar{I}^D(\mathrm{S})-I^S(\mathrm{S}))/p_B=\bar{I}^D(\mathrm{S})/p_B-(a_1K-c_1L)/p_BD \tag{25}$$

[by (20)], where $X_B^D(\mathrm{N})$ is now exogenously given. Substituting (3), (4), (22), and (23) into (25) we obtain a quadratic in p_B,

$$p_B^2(A-X_B^D(\mathrm{N}))+p_B(C+\bar{I}^D(\mathrm{S}))-V=0, \tag{26}$$

where A, V, and C are defined as in (24). This resolving equation (26) appears to be different from the first resolving equation (24) but it is in fact identical: From (20), (3), (4), (22), and (23) we obtain

$$p_BI^S(\mathrm{N})=-p_BC(\mathrm{N})-p_B^2A(N)+V(\mathrm{N}). \tag{27}$$

Therefore from (11) and (27), $p_B^2(X_B^D(\mathrm{N}))=-p_BI^D(\mathrm{N})-p_B^2A(\mathrm{N})-p_BC(\mathrm{N})+V(\mathrm{N})$, from which it is immediate that (24)=(26). This shows that the North–South model has the same equilibria or solutions when it is parameterized by industrial demand in the North $I^D(\mathrm{N})$, or by exports of the South $X_B^S(\mathrm{S})$. The comparative statics properties of the North–South model are also the same with both parameterizations. For instance, the change in p_B (an endogenous variable) as exports X_B^S vary is obtained by the implicit function theorem applied to an equilibrium expression $\psi(p,X_B^S)=0$: $\mathrm{d}p_B/\mathrm{d}X_B^S=(-\partial\psi/\partial X_B^S)/(\partial\psi/\partial p)$. The equilibrium expression $\psi=0$ used when the leading parameter is $I(\mathrm{N})$, is (24)=0; when the parameter is X_B^S, the expression is, instead, (26)=0. Since (24) and (26) are identical, it is equivalent to use either expression. A similar proof applies to the parameterization by $B^D(\mathrm{N})$. Q.E.D.

Comparative statics. The following extends and generalizes the results of Chichilnisky (1981) and comments on other papers written on the 1981 results. In view of the interest expressed in the comments on Propositions 1 to 3 of Chichilnisky (1981), it seems useful to state them and to provide alternative and straightforward proofs, based on the two resolving equations (24) and (26) for the North–South model. The appendix provides numerical simulations which reproduce several of the propositions below.

Proposition 2. Consider the North–South economy, where the South exports basic goods, has abundant labor (α large) and dual technologies (so that $c_2/D<2w/p_B$). Then a move to an equilibrium with a higher level of exports of basics leads to lower terms of trade, lower real wages, and decreased consumption in the South. [Proposition 1 in Chichilnisky (1981).] When labor is abundant, and real wages are sufficiently low, or else technologies are sufficiently homogenous that $c_2/D>2w/p_B$, then a move to an equilibrium with a higher level of exports X_B^S leads to better terms of trade, and higher real wages and consumption in the South. [Proposition 2 in Chichilnisky (1981).]

Remark. This comparative statics exercise consists of examining the sign of $dX_B^S/\mathrm{d}p_B$ as the exogenous parameter $\alpha(\mathrm{S})$ becomes very large, and when $c_2/D<2w/p_B$ is satisfied in the South. Note that all other exogenous parameters of the model (of which there are 15, see above) remain constant, including of course $\bar{L}(\mathrm{S})$. This comparative statics experiment thus ranges across *different* economies with different $\alpha(\mathrm{S})$'s, and thus different labor supply functions (3). All other exogenous parameters are fixed. The equilibria, of course, will vary with changes in the exogenous parameter α. The condition $c_2/D<2w/p_B$ can be expressed as a function of exogenous parameters only.[8]

Proof. Since (26) is identically satisfied across the equilibria, we have

$$\mathrm{d}p_B/\mathrm{d}X_B^S=p_B^2/(2p_B(A-X_B^S)+C+\bar{I}^D(\mathrm{S})). \tag{28}$$

With α large, the sign of (28) is determined by those terms containing α, so that (28) is negative whenever

$$2p_BX_B^S>\alpha c_1c_2/D^2. \tag{29}$$

Now,

$$X_B^S=(c_2L-a_2K)/D-(wL+rK-\bar{I}^D(\mathrm{S}))/p_B=(\alpha c_1/D^2p_B)(c_2-c_1/p_B)$$
$$+(\beta a_1/D^2)(a_2-a_1/p_B)+(c_1\bar{L}-a_1\bar{K})/Dp_B+\bar{I}^D(\mathrm{S})/p_B \tag{30}$$

[see Chichilnisky (1981, pp. 175–176)]. When α is large, the term that dominates X_B^S is $\alpha c_1(c_2-c_1/p_B)/D^2p_B$. Therefore, from (29) $\mathrm{d}p_B/\mathrm{d}X_B^S$ is negative when $2\alpha c_1(c_2-c_1/p_B)D^2p_B\alpha c_1\ c_2/D^2$, i.e., when $c_2>2c_1/p_B$, which is by (22) equivalent to $c_2/D<2w/p_B$ [Chichilnisky (1981, p. 177)]. A different

[8]From (22) $c_2/D<2w/p_B$ is equivalent to $p_B>2(c_1/c_2)$. Substituting p_B from (24), this yields an expression depending only on exogenous parameters. When α and D are large in the South, p_B is approximated by $c_1^2/(D/\alpha(c_1\bar{L}-a_1\bar{K})+c_1c_2)$, which exceeds $2(c_1/c_2)$ within an interval for the exogenous parameter D.

proof was given in Chichilnisky (1981): from (30) we have

$$dX^S_B/dp_B = (\alpha c_1/D^2 p_B^2)2c_1 p_B - c_2) + \beta a_1^2/D^2 p_B^2$$
$$+ (a_1 \bar{K} - c_1 L)/p_B^2 D - \bar{I}^D(\mathrm{S})/p_B^2. \tag{31}$$

When α is large, (31) implies that dX^S_B/dp_B is negative when $2c_1/p_B < c_2$, i.e., when $c_2/D < 2w/p_B$. The stated changes in real wages and domestic consumption are proved in Proposition 3 below. Finally, as the sign of dp_B/dX^S_B is that of $2c_1/p_B - c_2$, and $2c_1/p_B > c_2$ is equivalent to $c_2/D > 2w/p_B$, Proposition 2 of Chichilnisky (1981) is also proved. Q.E.D.

Proposition 3. Assume the South has abundant labor and dual technologies: α large and $c_2/D < 2w/p_B$. Then a move to a new equilibrium with a higher level of industrial demand in the North I^D(N), leads to a higher level of exports of basics from the South, but to lower terms of trade, real wages and domestic consumption in the South. This occurs in Walrasian stable markets [Proposition 3 in Chichilnisky (1981)],[9] and even if the expansion in exports follows from an expansion of the North's demand for basics.

Proof. From (24),

$$dp_B/dI^D(\mathrm{N}) = -p_B/(2p_B(A + A(\mathrm{N})) + (C + C(\mathrm{N})) + I^D(\mathrm{S}) + I^D(\mathrm{N})).$$

The term in α within $C + C(\mathrm{N})$ is $\alpha c_1 c_2/D^2 > 0$, and A and $A(\mathrm{N})$ are always positive; it follows that

$$dp_B/dI^D(\mathrm{N}) < 0 \tag{32}$$

when α in the South is large. Now, as seen in Proposition 2, $dX^S_B/dp_B < 0$ when $c_2/D < 2w/p_B$. Together with (32) and Proposition 1, this implies $dX^S_B/dI^D(\mathrm{N}) > 0$ across equilibria. By (22) across equilibria $d(w/p_B)/dp_B > 0$ Also $dB^D/dp_B > 0$ across equilibrium because $B^D = (wL + r\bar{K} - \bar{I}^D(\mathrm{S}))/p_B$, and when α is large this expression is dominated by the term in α [i.e., by $\alpha(w/p_B^2)$], which is an increasing function of p_B. Therefore, as p_B decreases, domestic consumption of basics drops in the South, while industrial demand remains at $\bar{I}^D$(S). Stability was established in the appendix of Chichilnisky (1981) and this and the expansion of the North's demand are discussed further in the following section. Q.E.D.

[9] Proposition 3 in Chichilnisky (1981) required in addition that labor supply in the North is relatively price inelastic, α(N) small. This condition is not required in the proof offered here; however, a small α(N) reappears in Proposition 5, when the welfare of the North is taken into consideration.

As pointed out in Chichilnisky (1981) and in Heal–McLeod (1984), the comparative statics results above are completely independent of any stability properties. They consist of altering exogenously one *real number*, e.g., the equilibrium volume of exports X_B^S or the number representing the equilibrium level of industrial demand I^D(N). This alters all the endogenous variables, as it leads to a new equilibrium of the model, and we have traced the changes in the endogenous variables as we move from one equilibrium to the next. This point seems worth emphasizing because other comments [e.g., Findlay (1983), Srinivasan–Bhagwati (1983) and Saavedra-Rivano (1983)] interpreted Proposition 3 in Chichilnisky (1981) as referring to a shift in a disequilibrium demand curve with everything else remaining constant, i.e., ceteris paribus. This is incorrect. Firstly, the industrial demand parameter I^D(N) is a *number*, the level of demand at the equilibrium, and not a curve relating prices and demand outside of an equilibrium as illustrated in figs. 2 and 3 of Srinivasan–Bhagwati (1983). Secondly, as I^D(N) varies, everything else does too, and therefore the *ceteris paribus* assumption is wrong here: e.g., the next section shows that as I^D(N) varies, the excess supply curve of the South shifts too. This error leads Findlay, Saavedra-Rivano and Srinivasan–Bhagwati to state that the drop in the price of basics following the increase in industrial demand I^D(N) 'can only be due to a decrease in the demand for basics, because the model is Walrasian stable'.[10] This is again erroneous, since *Walrasian stability does not predict any particular association between prices and demand increases, when both the supply and the demand curves are shifting simultaneously* as they do here with I^D(N). This point is also clearly explained in Arrow (1981) and in Heal–McLeod (1984).

The next proposition obtains results on total export revenues following an export expansion, without any assumptions on the international elasticities of demand.

Proposition 4. Assume that the South has abundant labor, α large, and dual technologies, $c_2/D < 2w/p_B$. Then a move to a new equilibrium with a higher

[10]Findlay (1983) states: 'Chichilnisky (1981) presents a North South model that apparently obtains some startling results. In particular, it is claimed that a shift in the composition of the North's demand in favor of the South's exports can worsen the terms of trade of the latter. This result is stated in Proposition 1 (p. 178 and footnote 11) which is actually self contradictory since it implies that a positive excess demand for a commodity can reduce its price even though the market is said to be stable in the Walrasian sense.' Saavedra-Rivano (1984) repeats this: 'Statement (*) Chichilnisky (1981) can be dismissed at once on the grounds of logical inconsistency, because two parts of it are mutually inconsistent. Namely, if the equilibrium is indeed Walras stable as the statement recognizes, then an upward shift in demand for the basic good must necessarily result in a higher relative price p_B.' Finally, Srinivasan-Bhagwati (1984) state the same point, 'one could not therefore get a stronger result: the equilibrium is unique and evidently Walras-stable... We get the orthodox conclusion that p_I/p_B must decrease with increased demand for the *B* good'. All these statements are incorrect since Walrasian stability does *not* predict that prices increase with demand when supply is also changing, as in our model. See Proposition 5, section 3 on stability, and the discussions in Arrow (1981) and Heal–McLeod (1984).

volume of exports leads not only to lower terms of trade but also to lower export revenues in the South. When $c_2/D > 2w/p_B$, prices and exports revenues increase.

Proof. Let $c_2/D < 2w/p_B$. By Proposition 2, the new equilibrium level of p_B drops as X_B^S expands, by (22) and (23) w/p_B decreases and r increases. Thus, from (3) and (4) K increases and L decreases. In the new equilibrium, by (20), industrial supply I^S increases. Since industrial demand is constant by (17), imports $X_I^D = I^D - I^S$ must *decrease*. Therefore, by (11), export revenues $p_B X_B^S$ decrease. When $c_2/D > 2w/p_B$, the results are reversed. Q.E.D.

The next proposition studies macro changes in *both regions.*

Proposition 5. Assume that α is large and $c_2/D < 2w/p_B$ in the South; labor supply in the North is unresponsive to the real wage [α(N) small; and industrial goods in the North use little labor (a_2 small). Then a move to a new equilibrium with a higher level of industrial demand in the North leads to higher consumption of basic goods in the North. The North consumes simultaneously more of both goods, and is therefore strictly better off.[11]

In the South, real wages and consumption decrease. The South exports more basics, at lower prices, and receives lower export revenues: it is strictly worse off at the new equilibrium. Identical results obtain when the move to a new equilibrium is due to an exogenous increase in the level of exports of the South X_B^S(S), or to an exogenous increase in the level of demand for basics B^D(N) in the North.

Proof. Consider first the case $\alpha(\mathrm{N}) = 0$ and $a_2(\mathrm{N}) = 0$. Then by (19) $B^S(\mathrm{N}) = c_2\bar{L}/D$, which is a constant. Therefore, since $B^D(\mathrm{N}) = B^S(\mathrm{N}) + X_B^D(\mathrm{N})$, B^D(N) must increase when X_B^D(N) increases. Proposition 3 shows that a higher I^D(N) leads to more imports X_B^D(N). It follows that I^D(N) and B^D(N) *increase simultaneously* in the North, and thus the North is strictly better off. By continuity, the same obtains when α(N) and a_2(N) are close to zero. The second paragraph is Propositions 3 and 4. The last sentence follows directly from Proposition 1 because $\mathrm{d}I^D(\mathrm{N})/\mathrm{d}B^D(\mathrm{N}) > 0$ and $\mathrm{d}I^D(\mathrm{N})/\mathrm{d}X_B^D(\mathrm{N}) > 0$. Q.E.D.

The North–South model II: Price dependent industrial demand. The following extension of the model was presented in Chichilnisky and Cole (1978), and discussed on page 179 of Chichilnisky (1981). The North–South model II consists of the same equations as the North–South model, but eq. (17′) with $\mu = 0$ replaces eq. (17), so that now $I^D = rK$ in the South. For equivalent results when $I^D = \lambda rk + \mu wL/p_B$, $\lambda > 0$, $\mu > 0$; see Chichilnisky (1984).

[11]Related results were obtained in Heal and McLeod (1984).

Proposition 6. Consider a North–South economy II, where capital stocks in the South are fixed ($K=\bar{K}$) *and* $L=\alpha w/p_B$ ($\bar{L}=0$). *Then: (A) A necessary and sufficient condition for an increase in exports to lower the South's terms of trade, real wages, and consumption is technological duality:* $c_2/D<2w/p_B$. *When the economy is more homogeneous, or wages are lower so that* $c_2/D>2w/p_B$, *the South's terms of trade improve as the South increases its exports; its real wages and consumption of basics increase. (When* $\bar{L}\neq 0$, *the necessary and sufficient condition is, instead,* $c_2/D<2w/p_B+\bar{L}$). *(B) An increase in the North's industrial demand leads to an increase in exports and to lower terms of trade, real wages, and consumption of basics in the South, if and only if the duality condition holds in the South,* $c_2/D<2w/p_B$. *(When* $\bar{L}\neq 0$ *the condition is* $c_2/D<2w/p_B+L$.) *When* $c_2/D>2w/p_B$, *terms of trade and real wages increase.*

The consumption of basics and of industrial goods increases simultaneously in the North provided industrial goods use little labor [a_2(N) *small] and labor is rather unresponsive to the real wage [*α(N) *small].*

Proof. (A) Substituting (19), (17′), (3), and (4) in $X_B^S=B^S(\mathrm{S})-B^D(\mathrm{S})$, we obtain $X_B^S=(c_2/D-w/p_B)(\alpha w/p_B+\bar{L})-(a_2/D)\bar{K}$, and $\mathrm{d}X_B^S/\mathrm{d}(w/p_B)=\alpha(c_2/D-2w/p_B)-\bar{L}$. By (22) $\mathrm{d}w/p_B/\mathrm{d}p_B=c_1/p_B^2D>0$. Thus when $\bar{L}=0$, $\mathrm{d}X_B^S/\mathrm{d}p_B$ is negative *iff* $c_2/D<2w/p_B$ (when $\bar{L}\neq 0$, iff $c_2/D<2w/p_B+\bar{L}$). Finally, $B^D=\alpha(w/p_B)^2+w/p_B\bar{L}$ by (3), so that $\mathrm{d}B^D/\mathrm{d}p_B>0$. This completes the proof of (A). (B) Since $I^D=rK=\beta r^2+r\bar{K}$,

$$\mathrm{d}r/\mathrm{d}I^D=1/(2r\beta+\bar{K})>0. \tag{33}$$

Furthermore, from (23), across equilibria,

$$\mathrm{d}r/\mathrm{d}p_B=-a_2/D<0. \tag{34}$$

(33) and (34) imply $\mathrm{d}p_B/\mathrm{d}I^D(\mathrm{N})<0$, which together with (A) implies: $\mathrm{d}X_B^S/\mathrm{d}I_N^D>0$, *iff* $c_2/D<2w/p_B$ when $\bar{L}=0$ (or *iff* $c_2/D<2w/p_B+\bar{L}$ when $\bar{L}\neq 0$). $B^D(\mathrm{N})$ increases by Proposition 5. Q.E.D.

2.1. Fixed endowments of labor and capital

Proposition 7. Consider a North–South model with fixed factor endowments $K=\bar{K}$, $L=\bar{L}$ ($\alpha=\beta=0$). *In this case, a move to a new equilibrium with higher levels of exports always lowers the terms of trade and export revenues of the South, and leads also to lower real wages and consumption of basics in the South.*

Proof

$$X_B^S=(c_2\bar{L}-a_2\bar{K})/D-(w\bar{L}+r\bar{K}-\bar{I}^D(\mathrm{S}))/p_B=(c_1\bar{L}-a_1\bar{K})Dp_B+\bar{I}^D(\mathrm{S})/p_B$$

from (22) and (23). Thus,

$$\mathrm{d}X_B^S/\mathrm{d}p_B = (a_1\bar{K} - c_1\bar{L})/Dp_B^2 - \bar{I}^D(\mathrm{S})/p_B^2,$$

which is always negative because when $\alpha = \beta = 0$, $a_1\bar{K} = c_1\bar{L}$ by (24). The rest follows from Propositions 2 and 3.

Proposition 8. Consider the North–South model II with fixed factor endowments. Then a move to an equilibrium with increased exports of the wage good leads always to a drop in the South's terms of trade, in its real wages, and in its consumption of the wage good. However, in the new equilibrium, the South imports more industrial goods.

Proof. In the North–South model II,

$$X_B^S = (c_2/D - w/p_B)\bar{L} - a_2\bar{K}/D = (c_1/p_B D)\bar{L} - a_2\bar{K}/D$$

[from (22)], so that $\mathrm{d}X_B^S/\mathrm{d}p_B = -c_1\bar{L}/p_B^2 D$, which is always negative. By Proposition 6, $B^D(\mathrm{S})$ and $w/p_B(\mathrm{S})$ fall. Since $I^D = rK$, by (23) $\mathrm{d}I^D/\mathrm{d}p_B < 0$, i.e., industrial demand increases in the South. However, since factor endowments are constant, industrial supply I^S does not change. Therefore, the higher level of industrial demand at the new equilibrium must be met by increased imports. Q.E.D.

3. Stability and applications

All the commentators agree that the North–South model is stable under the given conditions. Arrow points out that 'individual equilibria are stable in the usual sense of general equilibrium theory'.[12] Heal and McLeod extend and generalize the 1981 stability results to a family of adjustment processes that contains the process in Chichilnisky (1981). Findlay, Bhagwati, Srinivasan, Ranney, and Saavedra-Rivano propose an adjustment process quite different from that in Chichilnisky (1981), but again obtain stability of the model; see footnote 9. To clarify the discussion, it seems useful to define

[12] Arrow (1981, p. 2) states: 'Individual equilibria are stable in the usual sense of general equilibrium theory.' Gunning (1984) states in the paragraph after eq. (14): 'Hence equilibrium is stable in the Walrasian sense...' Heal and McLeod (1984, sect. 4) state: 'It will be shown that under either of these approaches Chichilnisky's model is stable under the conditions assumed in her paper.' Findlay (1983, last section) states: 'Examination of the structure of the model shows that it possesses a unique equilibrium that is Walras stable...' Ranney (1984) in the paragraph after eq. (6) states: 'thus an increase in p_B results in a decline in the production of I goods in both countries, and the model is Walrasian stable'. Saavedra-Rivano (1984) states in section 2: 'We know from the preceding section that Walrasian stability of equilibrium always holds in this model.' Finally, Srinivasan–Bhagwati (1984) state in their last page 'one could not therefore get a stronger result; the equilibrium is unique and evidently Walras-stable'.

the adjustment process in Chichilnisky (1981). This is necessary because all equations given so far are not relevant for stability analysis, as they are only *equilibrium* relations. For instance, all equations until now assumed that profits are identically zero, namely that commodity prices are linear combinations of factor prices [(1) and (2)], or equivalently that the factor/commodity price relations (22) and (23) hold.

Since the North–South model has constant returns to scale, at equilibrium profits must be zero. But during the adjustment from a disequilibrium position to an equilibrium profits are generally *not* zero. In classical studies of stability in constant returns to scale economies [Samuelson (1947), Arrow and Hurwicz (1963)], non-zero profits are a driving force in the adjustment process: in disequilibrium producers increase output when profits are positive, and vice versa. Similarly, more recent adjustment processes in Chichilinsky (1981), Mas Colell (1974) and in Heal and McLeod (1984) non-zero profits have a non-trivial role during the adjustment. In all of these processes, therefore, the commodity-factor price equations (1) and (2), or (22) and (23), do *not* hold outside of an equilibrium.[13] This point is worth noting because other commentators, e.g., Gunning, Findlay, Bhagwati, Srinivasan, Ranney and Saavedra use a process which is quite different from the one I defined in 1981; in their process profits are assumed to be identically zero at every disequilibrium point, even while commodity markets are adjusting. This follows from their universal use of the commodity-factor price equations [(22) and (23)], at every disequilibrium point. Since in their process commodity markets adjust and factor markets are always in equilibrium, their use of eqs. (22) and (23) is inappropriate for testing Walrasian stability. This is because eqs. (22) and (23) require that *factor prices* are continuously varying as functions of goods prices, even though factor markets remain with zero excess demand: *In a Walrasian adjustment process, there can be no price changes in markets which remains with zero excess demand.* Moreover, since the process used by these commentators assumes zero profits at every disequilibrium point, it rules out attractive and traditional approaches such as those in Samuelson, Arrow and Hurwicz, Mas Colell and Heal and McLeod. It also rules out my 1981 process so that these authors have actually *altered* the model they comment on. The fact that they do not make this alteration explicit leads to confusion, since they erroneously attribute their conclusions to my original model.

We now describe in detail the process in Chichilnisky (1981) for one region; the two-region process is in the appendix. There are four markets in each region: for K, L, B, and I, with prices $p=(r, w, p_B, p_I)$. A standard Walrasian adjustment requires that price changes be positively associated

[13]Arrow and Hahn (1971, ch. 12, p. 317) define an adjustment process where the price equations (1) and (2) always hold, but this is because they assumed that *commodity markets remain at an equilibrium throughout*, so that profits are naturally zero, and only factor markets adjust (lines 21–23).

with the excess demand in that market,

$$\dot{p}_B = DB(p) - SB(p), \quad \dot{p}_I = DI(p) - SI(p), \dot{w} = DL(p) - SL(p)$$

$$\dot{r} = DK(p) - SK(p), \tag{35}$$

where the letters D and S preceeding a variable indicate (disequilibrium) demand and supply, respectively, and the dot time derivatives.

In order to avoid the technicalities of a four dimensional dynamical system, we assumed as in Arrow and Hahn (1971, ch. 12), and in much of the trade literature, that some of the markets are always at an equilibrium and that the burden of adjustment lies on the other markets. Factor markets are therefore assumed always to clear, $DL = SL$ and $DK = SK$: (35) therefore implies $\dot{w} = \dot{r} = 0$. Also p_I is identically equal to 1, so that $\dot{p}_I = 0$. The market for basics is therefore the only one in which price and quantity adjustments take place, following the differential equation $\dot{p}_B = DB(p) - SB(p)$.

Next we define supply and demand functions $SB(p)$ and $DB(p)$, for all disequilibrium prices, including price vectors $p = (p_B, 1, w, r)$ where profits are not zero (i.e., where the commodity-factor price equations (22) and (23) *do not hold* simultaneously). Such a supply function has not been defined previously. Since the model has constant returns to scale, profit maximization conditions *do not* determine supply independently from demand, and (disequilibrium) supply functions are therefore not well defined [see Chichilnisky (1981, appendix), and Arrow and Hahn (1971, ch. 12, sect. 10)]. Several alternatives are possible, each of which defines a different adjustment process; see, e.g., Heal–McLeod (1984). We follow a reasonable one: for any given price vector $p = (p_B, 1, w, r)$ we use the factor supply equations $SL(p) = \alpha w/p_B + \bar{L}$ and $SK(p) = \beta r + \bar{K}$ to determine the level of factors supplied at p. Since factor markets always clear, $SL(p) = DL(p) = L(p)$ and $SK(p) = SK(p) = K(p)$, and we obtain the total level of capital and labor employed $L(p)$, $K(p)$. If firms use factors efficiently, the disequilibrium supply function for basics is then

$$SB(p) = (c_2 L(p) - a_2 K(p))/D = (c_2/D)(\alpha w/p_B + \bar{L}) - (a_2/D)(\beta r + \bar{K}). \tag{36}$$

Similarly, the (disequilibrium) supply function for industrial goods is

$$SI(p) = (a_1 K(p) - c_1 L(p))/D = (a_1/D)(\beta r + \bar{K}) - (c_1/D)(\alpha(w/p_B) + \bar{L}). \tag{37}$$

By Walras law at any (disequilibrium) price p, the value of expenditures must equal the value of income,

$$p_B DB(p) + DI(p) = wL(p) + rK(p) + \Pi(p), \tag{38}$$

where $\Pi(p)=SB(p_B-a_1w-c_1r)+SI(1-a_2w-c_2r)$ are total profits at p, and are *not zero* outside of an equilibrium.

The disequilibrium demand function for basics, $DB(p)$, was defined on page 190 of Chichilnisky (1981) [denoted $B^D(p)$] by

$$p_B DB(p)=wL(p)+rK(p)-\bar{I}^D(p),^{14} \tag{39}$$

where w and r are the equilibrium values, and $\bar{I}^D$ is the constant defined in eq. (17). By Walras law (38), this is *equivalent* to defining (disequilibrium) demand for industrial goods as

$$DI(p)=\bar{I}^D+\Pi(p), \tag{40}$$

implying that profits $\Pi(p)$ are always spent in the industrial sector. In particular, since profits $\Pi(p)$ are non-zero and an increasing function of p_B in disequilibrium, $DI(p)$ is *not* a constant out of equilibrium: $DI(p)$ is an increasing function of p_B, or equivalently *$DI(p)$ is downward sloping in the relative price of p_I*, as stated in Chichilnisky (1981). It is obvious from (39) and (40) that Walras law (38) is always satisfied.

To study stability in the neighborhood of one equilibrium, $p^*=(p_B^*, 1, w^*, r^*)$, one considers a shock to p^*. From (35), the factor prices w and r must remain at the equilibrium values during a Walrasian adjustment process, i.e., $\dot{w}=\dot{r}=0$, because factor markets have been assumed to clear at all times, so we assume that $w\equiv w^*$ and $r\equiv r^*$. Stability in a neighborhood of one equilibrium requires that the eigenvalues of the Jacobian of system (35) have negative real parts. This Jacobian is the 4×4 matrix of the *partial derivatives* of the four functions $DB(p)-SB(p)$, $DI(p)-SI(p)$, $DL(p)-SL(p)$, and $DK(p)-SK(p)$ with respect to the four variables p_B, p_I, w, and r. However, since $\dot{p}_I=\dot{w}=\dot{r}=0$, the matrix has only one non-zero term, which is the partial derivative of the excess demand for basics with respect to the price of basics, i.e., $\partial/\partial p_B(DB(p)-SB(p))$. For stability this *partial derivative* must be negative. From (36) and (39),

$$\begin{aligned}(DB(p)-SB(p))&=\alpha(w/p_B)^2+\beta(r^2/p_B)+(w/p_B)(\bar{L}-ac_2/D)\\&\quad+r(\beta a_2/D+\bar{K}/p_B)+(\bar{K}a_2-\bar{L}c_2)/D-\bar{I}^D/p_B,\end{aligned} \tag{41}$$

and its partial derivative with respect to p_B is

[14] In Chichilnisky (1981) this function is defined in the appendix, p. 190, where the last two terms rK and $\bar{I}$ ought to have been divided by p_B. However, since only the terms in α matter when α is large, and these two terms do not contain α, this typo has no consequence in the conclusions.

$$\partial/\partial p_B(DB(p)-SB(p)) = (\alpha w/p_B^2)(c_2/D - 2w/p_B) - (\beta r^2/p_B^2)$$
$$-((\bar{L}w + \bar{K}r)/p_B^2) + \bar{I}^D/p_B^2. \tag{42}$$

When α is sufficiently large the term $\alpha w/p_B^2(c_2/D - 2w/p_B)$ dominates expression (42). *Therefore the B market is stable when α is large and the duality condition $c_2/D < 2w/p_B$ is satisfied.* This is the stability condition on pages 190–191 of Chichilnisky (1981), and in Heal and McLeod (1984).

It is now immediate that *the market for industrial goods is also stable when α is large and $c_2/D < 2w/p_B$.* For this the *partial derivative* $\partial/\partial p_B(DI(p)-SI(p))$ must be positive, which follows from $(42)<0$ and Walras law.[15] We obtain:

Proposition 9. [*appendix 2 of Chichilnisky (1981)*]. *Under the Walrasian adjustment process $\dot{p} = DB(p) - SB(p)$ of Chichilnisky (1981), the economy of the South is stable when α is large and $c_2/D < 2w/p_B$.*

Heal and McLeod (1984) have studied more general adjustment processes for the North–South model, in particular, one where a proportion λ of profits is spent on basics and a proportion $(1-\lambda)$ of profits is spent on industrial goods. They prove that the most favorable case for stability is when all profits are allocated to the industrial sector [i.e., $(\lambda = 0)$], so that *the adjustment process in Chichilnisky* (1981) *is indeed the one most favorable to stable markets.* It was also stated in Chichilnisky (1981, p. 191) (but not proved) that the *world market* for basics was stable under the same conditions:

Proposition 10. Consider the Walrasian adjustment process for the world economy where the price of basics rises with the world excess demand for basics: $\dot{p}_B = WDB(p) - WDB(p)$. Then the world economy is stable when the economy of the South has abundant labor [α(S) large] and dual technologies ($c_2/D < \alpha w/p_B$). (For a proof, see the appendix.)

To summarize: the adjustment process in Chichilnisky (1981) was analyzed in detail, and was shown to yield Walrasian stability under the conditions in Chichilnisky (1981). This process has an element in common with the process defined in Arrow and Hahn (1971) for constant returns to scale economies: some of the markets (in our case, factor markets) are always in equilibrium. It also has an element in common with the processes defined in Samuelson (1947), Arrow and Hurwicz (1963), Mas Colell (1974) and Heal and McLeod

[15] By Walras law, the value of excess demand is zero, i.e., $p_B(DB(p)-SB(p)) = DI(p) - SI(p)$. It follows that $\partial/\partial p_B(DI(p)-SI(p)) = (DB(p)-SB(p)) - (\partial/\partial p_B(DB(p)-SB(p)))p_B$. Near an equilibrium, $DB(p)-SB(p)$ is close to zero, so that $\partial/\partial p_B(DI(p)-SI(p))$ is indeed positive when $\partial/\partial p_B(DB(p)-SB(p))<0$. Therefore *the market for industrial goods is also stable when α is large and $c_2/D < 2w/p_B$.*

(1984): there are non-zero profits outside of an equilibrium, and these have indeed a non-trivial role in determining the stability of the model. The stability results, Propositions 9 and 10, agree with the comments of Arrow (1981), those of Heal–McLeod (1984) and with Chichilnisky (1981).

A final task is to discuss the comments on stability of the North–South model by Gunning, Findlay, Ranney, Saavedra and Srinivasan–Bhagwati. These comments are based on one particular adjustment process proposed first by Findlay [as pointed out by Bhagwati and Srinivasan (1983)], and which is quite different from that in Chichilnisky (1981). Yet, these authors still obtain stability of the model; see footnote 12. Findlay et al. confuse my equilibrium equations with disequilibrium excess supply and demand curves, and therefore use the wrong excess supply and demand curves to generate an incorrect adjustment process which is at odds with my model. Figs. 2 and 3 of Bhagwati–Srinivasan [first proposed by Findlay (1983)] are typical examples. They state that my (disequilibrium) demand for industrial goods is a constant [i.e., $DI(p)=\bar{I}^D$] and therefore draw the (disequilibrium) demand function for industrial goods as a vertical line. Yet by Chichilnisky (1981) and (40) the disequilibrium demand for industrial goods must necessarily be $DI=\bar{I}^D+\Pi(p)$, for otherwise Walras law (38) would be violated. Clearly, $DI(p)$ is *not* a constant function, because profits $\Pi(p)$ are not zero outside of an equilibrium and indeed they vary with p. *The error of these authors is therefore to forget that profits are not zero outside of an equilibrium when commodity markets adjust, i.e., to confuse equilibrium properties with disequilibrium properties.*

A similar error appears in these comments' analysis of the market for basics. Here we choose fig. 1 of Gunning (1984) and fig. 1 of Ranney (1984) as typical examples: the downward sloping cross equilibria curve X_B^S is confused there with a disequilibrium excess supply curve in the usual sense, i.e., with the curve $SB(S)-DB(S)$, defined in (41) and in page 190 of Chichilnisky (1981). Yet the two curves X_B^S and $(SB(S)-DB(S))$ are very different objects. In fact, one is downward sloping precisely when the other is upward sloping: when $c_2/D<2w/p_B$, the slope of X_B^S is *negative* by Proposition 2, while $\partial/\partial p_B(SB-DB)$ is *positive*, as shown in (42). *Once again, the error of these authors is to forget that profits are not zero outside of an equilibrium when commodity markets adjust*: X_B^S is a curve across equilibria, constructed assuming that commodity/factor price relations (22) and (23) hold. *This means that profits are zero along X_B^S; therefore X_B^S cannot be a disequilibrium excess supply curve, because in disequilibrium profits are not zero.*

The extemporaneous assumption that profits are zero everywhere outside of equilibria leads obviously to an erroneous specification of the Walras law and to a number of other erroneous conclusions. In Chichilnisky (1981) a warning was repeated several times against confusing X_B^S with a supply curve, and Arrow (1981) warns against this error as well[16]: Nevertheless, it has been made. However, since in each equilibrium profits are necessarily zero, and the two approaches differ only in the value of profits, the two approaches give exactly the same equilibria. This explains why all these comments agree on the whole with the comparative statics results of Chichilnisky (1981): export volumes of the South are negatively associated to their price, and higher values of industrial demand in the North lead to lower prices and to higher volumes of exports of basic goods from the South (when α is large, and $c_2/D<2w/p_B$ in the South). They also agree that the model is stable, even though they define stability differently. Thus the differences that arise from this confusion are actually rather minor, although in some cases it takes a careful reading to disclose this fact.

The only point at stake is the disequilibrium interpretation of the comparative statics results which is only natural since the adjustment process has been changed. The difference of interpretation is most acute when these authors state rather emphatically that a drop in the South's terms of trade following an expansion of the industrial demand in the North, 'must follow from a decrease or downward shift in the North's demand for basics'.[17] This is actually false. Both Proposition 5 of section 2 and Theorem 1 in Heal and McLeod (1984) show that *the terms of trade of the South may drop even with an exogenous increase in* B^D(N) *or an upward shift in the international demand for basics in the North.* This point is also substantiated by the simulations in

[16]The difference between X_B^S and an excess supply curve valid for stability analysis was clearly pointed out in Chichilnisky (1981, fn. 10, p. 175 and p. 189, lines 15–31). Arrow (1981, pp. 1–2) states: 'Methodologically, the papers are exemplary applications of general equilibrium analysis. *A clear distinction is made between the downward sloping response of the economy as a whole and supply curves in the strict sense. The reaction curve* (X_B^S) *links alternative equilibria of the economy and is not a curve relevant to any one equilibrium.* It is shown, in fact, that the individual equilibria are stable in the usual sense of general equilibrium theory' (my italics).

[17]Findlay (1983) states: 'A shift in the demand of the North towards the South's exports in her model actually can only produce the completely standard result that it would improve the terms of trade of the latter.' Gunning, states in his Proposition 1: 'A positive shift in demand for basic goods by the North results for the South in an improvement of the terms of trade, higher real wages, and increased consumption.' And in the next paragraph: 'investment demand in the North is *increased*. This implies a shift in the composition of the North's demand away from the basic goods exported by the South...' Srinivasan–Bhagwati state on their last page: 'Now consider the North to have an increased demand for South's exportable good B, as in Chichilnisky. We then get the orthodox conclusion that p_I/p_B must *decrease* with *increased demand* for the B-good.' Saavedra-Rivano states in section 2: 'An increase in $(I^D)^N$ (demand for industrial goods of the North) is equivalent to a downward shift in the demand for basic goods by the North.' Ranney states in her last paragraph: 'An increase in the demand for basic goods by the North will never result in a worsening of the terms of trade for the South or a decrease in the purchasing power of wages within the South.' All these statements contradict the facts: industrial demand in the North may increase simultaneously with its demand for basics, as the price of basics is lower [see Proposition 5, the numerical simulations in the appendix, figs. 3 and 4, and Heal–McLeod (1984)]. In any case their disagreement must be seen in its proper context: in 1983 (JDE) Bhagwati–Srinivasan argued against my 1980 JDE results on international transfers, while Bhagwati and co-authors (AER, 1983) subsequently put their names to the same conclusions.

the appendix: *An increase in the demand for basics of the North DB*(N), *and a positive shift in the excess demand for basics of the North WD* (which intersects X_B^S from above)[18] *lead to a drop in the price of basics* p_B *and in the purchasing power of the South.* This occurs within a Walras stable market, *because both international demand and supply curves vary simultaneously when* I^D(N) *or* B^D(N) *increase.* Fig. 2b in Chichilnisky (1981) illustrated this fact; this figure is reproduced in the appendix (fig. 3) from a simulation of the model. In a Walras-stable market, a drop in the price of basics may follow an upward shift in demand for basics when the supply curve for basics shifts sufficiently. This is precisely what was shown in Chichilnisky (1981). When the equilibrium value of industrial demand in the North I^D(N) increases, both excess supply and demand curves for basics shift. At the new I^D(N), a new equilibrium set of prices emerges (p_B^*, 1, w^*, r^*), the only set of prices compatible with the new I^D(N). From the definitions of the excess supply and demand functions for basics (41) in each region, it is clear that both of these functions shift at the new equilibrium; see fig. 4. Obviously, when both demand and supply curves shift simultaneously, an increase or upward shift in demand may be accompanied by lower prices, within a Walras-stable market.

Gunning, Findlay, Saavedra, Ranney and Srinivasan–Bhagwati all make the same error: they invoke Walrasian stability to deduce erroneously that a drop in the price of basics can only derive from a decrease in the North's demand for basics (see footnote 17). But obviously, Walrasian stability can only yield a relation between demand and prices when everything else remains constant. This is a *ceteris paribus* partial equilibrium assumption which is certainly not satisfied in my model, so the argument is clearly flawed.

In view of the interest demonstrated in the comments in fig. 2b of Chichilnisky (1981), it may be helpful to repeat here what the curves in this figure are, and what they are not. The demand curve denoted *WD* in fig. 2b, is the North's excess demand function $WD = DB(\mathrm{N}) - SB(\mathrm{N})$, defined in (41). It is a properly defined disequilibrium curve, and is a curve useful for stability analysis. The curve X_B^S defined in (30) is a totally different object: it

[18]Some of the comments state that for Walrasian stability X_B^S must be met by the North's excess demand curve from below, which is an erroneous conclusion. This error leads them to question fig. 2b in Chichilnisky (1981): Gunning states: '...Hence the export supply curve X_B^S necessarily crosses the import demand curve from above as shown in fig. 1'. Ranney, footnote 11, states: 'Walrasian stability, shown from eq. (6) above, implies that excess demand of the North cannot cross X_B^S from above.' In two different versions of his paper, Saavedra-Rivano, Part II states: 'there is a confusion with the concept of stability, already noted in the preceeding part, which is highlighted in fig. 2 in Chichilnisky (1981). This diagram, presented as an illustration of Proposition 1, indeed depicts unstable equilibria both for the closed economy of the South and for the world economy'. These statements are all incorrect. Fig. 3 below shows that X_B^S is met by above by the excess demand of the North, as in fig. 2b of Chichilnisky (1981), and the equilibrium is indeed Walrasian stable, because the excess supply of the South is upward sloping and excess demand of the North downward sloping.

is a cross equilibrium locus of export volumes and export prices, and *not* a disequilibrium excess supply curve valid for testing Walrasian stability. This was pointed out clearly in Chichilnisky (1981) and in Arrow (1981); see footnote 16. The use of X_B^S as an excess supply curve is not appropriate for testing Walrasian stability because it requires that the price equations are satisfied at all times, so that factor prices are continuously varying as functions of goods prices, even though the factor markets are continuously at an equilibrium with excess demand zero. *In a Walrasian adjustment process, there can be no price changes in a market which remains with zero excess demand.* The disequilibrium excess supply of the South $SB(S)-DB(S)$ was defined in appendix 2 Chichilnisky (1981) and in (41) above, and is clearly very different from X_B^S.

A simulation of fig. 2b of Chichilnisky (1981) with the proper excess supply function of the South $WS=WB(S)-DB(S)$, is in figs. 3 and 4. It shows X_B^S as the locus of the intersections of two sets of curves: the (disequilibrium) excess demand curves of the North WD and the (disequilibrium) excess supply curves of the South WS, at different equilibria. How the North's excess demand curve WD meets X_B^S is totally irrelevant for stability; what matters for stability is only how the excess demand of the North WD crosses excess supply of the South, WS. Since excess demand WD is downward sloping and excess supply WS is upward sloping, the equilibrium is obviously stable; see figs. 3 and 4, appendix.

The cross equilibria curve X_B^S and the excess supply and demand curves were also analysed theoretically and simulated numerically in Heal and McLeod (1984). Another case in the literature where a downward sloping equilibrium supply price locus is met from above by a demand curve is in Neary (1978). His fig. 3 (p. 678) includes a downward sloping equilibrium locus, the analogue to X_B^S, and two supply and demand curves (which he calls 'short run'), the analogues to the North's excess demand and the South's excess supply. Neary carefully points out that his supply–price equilibrium locus is met *from above* by the demand curve, in a Walrasian stable market.

The mislabelling of X_B^S as a disequilibrium supply curve is therefore unhelpful for economic understanding: it has apparently led several authors to conclude that the price of basics can only drop with a decrease in the North's demand for basics, an erroneous conclusion. This mislabelling is also theoretically unsatisfactory, since X_B^S is defined by keeping zero profits everywhere, an assumption that runs counter to classical disequilibrium adjustment processes for constant return economies of Arrow, Hurwicz and Samuelson.

Stability analysis should be given its rightful role: to suggest plausible adjustment processes to an equilibrium. But it should not be allowed to confuse and obscure the only facts that economics owns: the comparative statics results that obtain from changes in exogenous parameters.

3.1. Applications

The model presented in my 1981 paper, and developed further above, shows that under certain conditions an expansion of labor intensive exports leads to disadvantageous outcomes for the South, even where this is associated to an expansion of the North's demand for basics. The critical conditions concern the domestic structure of the South's economy as reflected by the inequality $c_2/D \lesseqgtr 2w/p_B$, and the responsiveness of labor supplies to real wages. In order to evaluate the basic structure of the model, and to test its implications for particular cases, a sequence of econometric case studies has been undertaken. The first of these is reported in Chichilnisky, Heal and Podivinsky (1983). This deals with trade between Sri Lanka and the United Kingdom, which is characterized by the exchange of primary products (mainly tea) for industrial goods.

For this empirical implementation, the equilibrium equations (1) to (17) of section 2 above were treated (in reduced form) as describing the long-run steady state of a dynamical system. The system was then assumed to adjust towards this steady state configuration by a partial adjustment process, a standard way of developing a time-series implementation of an equilibrium model.

The resulting system of non-linear simultaneous equations was estimated, using a 25 year data series, by both non-linear FIML and 3-state least squares. Full details of the results are contained in Chichilnisky, Heal and Podivinsky (1983): these results confirmed that a dynamic adaptation of the model defined by eqs. (1) to (17) can provide a good statistical explanation of patterns of trade between Sri Lanka and the U.K. and their relationship to technologies and factor prices. The case study also established that in Sri Lanka, where labor is certainly abundant, the inequality $c_2/D < 2w/p_B$ held for every year but one in the same period 1952 to 1980. In view of Propositions 2 and 3 above, this implies that during the sample period a change in demand in the U.K. that led to an expansion of Sri Lanka's exports, would lead in statistical terms to a reduction in Sri Lanka's real wages and terms of trade. This case study thus confirms both the appropriateness of the general structure of the model and the potential importance of the domestic structural issues that it highlights. Other applications are: Mahran (1982) extended the North–South model to Cobb–Douglas technologies; Uriarte (1981) includes land as an input, in Chichilnisky (1983) one region is a monopolistic resource exporter; Chichilnisky and McLeod (1984) study increases in agricultural productivity; and Chichilnisky, Heal and McLeod (1983) study the North–South model with debt.

Appendix

This appendix contains the results of several computer runs which reproduce numerically comparative statics results of Chichilnisky (1981), propositions in section 2, and the stability results in section 3. These were produced by Eduardo-Jose Chichilnisky. A program in BASIC is available in Chichilnisky (1983): it is based on the resolving equation (24).

A.1. Data set: Initial parameters

	α	β	a_1	a_2	c_1	c_2	$\bar{L}$	$\bar{K}$	D
South	75	0.025	4.5	0.02	0.01	3	−2	2.7	13.5
North	6	9.7	2	0.15	1.3	1.7	0.5	12	3.13

$I^D(S) = 4.00$ *Run 1*: $I^D(N) = 6.00$ *Run 2*: $I^D(N) = 7.00$

The initial data shows that labor is abundant in the South [$\alpha(S) = 75$] and much less abundant in the North [$\alpha(N) = 6$]. The duality condition $c_2/D < 2w/p_B$ is satisfied in both runs of the South. The North has more abundant capital than the South [$\beta(N) = 9.7$ while $\beta(S) = 0.025$, and $\bar{K}(N) = 12$ while $\bar{K}(S) = 2.7$]. The level of duality is much higher in the South, $D(S) = 13.5$, while in the North $D(N) = 3.13$.

A.2. Solutions: Endogenous variables

	South		North	
	Run 1	Run 2	Run 1	Run 2
p_B	3.252	1.721	3.252	1.721
w	0.7232	0.3818	1.194	0.3598
w/p_B	0.2220	0.2218	0.3666	0.2090
r	0.3285	0.3308	0.4829	0.5565
L	14.65	14.63	2.700	1.754
K	2.70822	2.70826	16.683	17.398
B^S	3.252	3.248	0.6667	0.1190
B^D	2.297	1.443	1.621	1.925
X_B^S	0.9541	1.806	−0.9541	−1.806
I^S	0.89189	0.8913	9.108	10.108
I^D	4.00	4.00	6.00	7.00
X_I^D	3.10810	3.10807	−3.1081	−3.10807
$c_2/D - 2w/p_B$	−0.2218	−0.2214	−0.1901	0.1251

A.3. Simulation of comparative statics results

Runs 1 and 2 above reproduce numerically the results of Propositions 1 and 3 in Chichilnisky (1981), and Propositions 2, 3, and 4 in section 2. In both runs, the industrial demand in the South $I^D(S)$ is equal to 4.00. In the first run, the industrial demand in the North is 6.00, and is increased to 7.00 in the second run.

As proved in Proposition 3 of Chichilnisky (1981) and Proposition 3 of section 2, the increase in the value of $I^D(\mathrm{N})$ has the following general equilibrium effects: Exports of basic goods in the South, X_B, *increase*, the price of basics p_B *decreases*, wages in the South *decreases*, consumption of basics in the South *decrease*, and total export revenues of the South decrease (Proposition 4). Also, as stated in Proposition 5, the North's demand for basics $B^D(\mathrm{N})$ *increases*: the North consumes simultaneously more of both goods. In the South, $I^D(\mathrm{S})$ remains constant and $B^D(\mathrm{S})$ decreases. Hence, the welfare of the South *decreases*, the welfare of the North *increases*.

These runs confirm also Proposition 1 of Chichilnisky (1981) and Proposition 1 of section 2, since changing exogenously the export volume X_B^S from 0.9541 to 1.806, and leaving $I^D(\mathrm{N})$ to be determined endogenously, leads to the same solutions of runs 1 and 2.

A.4. Stability analysis: The two region model

There are six markets: two markets for commodities, basics, and industrial goods, and two different markets for factors (capital and labor) in each region, as factors are not traded internationally. A price vector is now $p=(p_B, p_I, w(\mathrm{S}), w(\mathrm{N}), r(\mathrm{S}), r(\mathrm{N}))$. A Walrasian adjustment process is described by prices increasing with the *world excess demand*,

$$\dot{p}_B = WEDB(p) = DB(\mathrm{S})(p) - SB(\mathrm{S})(p) + DB(\mathrm{N})(p) - SB(\mathrm{N})(p),$$

$$\dot{p}_I = WEDI(p) = DI(\mathrm{S})(p) - SI(\mathrm{S})(p) + DI(\mathrm{N})(p),$$

$$\dot{r}(N) = DK(N)(p) - SK(N)(p),$$

$$\dot{w}(S) = DL(\mathrm{S})(p) - SL(\mathrm{S})(p), \quad \dot{r}(\mathrm{S}) = DK(\mathrm{S})(p), \quad \text{and}$$

$$\dot{w}(\mathrm{N}) = DL(\mathrm{N})(p) - SL(\mathrm{N})(p).$$

As before, we assume that all factors markets clear, and that industrial goods are the numeraire, so that $\dot{p}_I = \dot{w}(\mathrm{S}) = \dot{w}(\mathrm{N}) = \dot{r}(\mathrm{S}) = \dot{r}(\mathrm{N}) = 0$. Therefore, wages and profits always remain at their equilibrium levels, and we only need to prove that the first differential equation $\dot{p}_B = WEDB(p)$ leads to stability.

The world's market for basics: Stability

The world's supply function of basics is the sum of the North's and the South's,

$$WSB(p) = SB(\mathrm{N})(p) + SB(\mathrm{S})(p) \tag{A.1}$$

from (36)

$$=(c_2(\mathrm{N})/D(\mathrm{N}))(\alpha(\mathrm{N})w(\mathrm{N})/p_B+\bar{L}(\mathrm{N}))+a_2(\mathrm{N})/D(\mathrm{N})(\beta(\mathrm{N})r(\mathrm{N})$$

$$+\bar{K}(\mathrm{N}))+c_2/D(\alpha w/p_B+\bar{L})-a_2/D(\beta r+\bar{K}),$$

where as usual all parameters and variables are from the South unless otherwise indicated.

Next we define the *world demand for basics* at any (disequilibrium) price p. In each region *Walras law* is now $p_B BD(p)+DI(p)=wL(p)+rK(p)+\Pi(p)+NX$, where NX denotes net export revenues at price p. This implies that at any price vector p the demand function for basics in each region is now $DB(p)=[wL(p)+rK(p)-\bar{I}^D(p)]/p_B+\mu(NX/p_B)$, where μ is the proportion of net export revenues allocated to the B sector. Here we have assumed as before that $DI(p)=\bar{I}^D+\Pi(p)$, so that profits are spent in the industrial goods. At an equilibrium net export revenues NX are, of course, zero: this is the balance of payments condition (11). Outside of an equilibrium, however, NX need not be zero. However, the *world's net export revenues*, which is the sum of the North's and the South's $NX(\mathrm{N})+NX(\mathrm{S})$, must be zero. In particular, when $\mu(\mathrm{S})=\mu(\mathrm{N})$, i.e., when the same proportion of export revenues goes to basics in both region, $\mu(NX(\mathrm{N})/p_B)+\mu(NX(\mathrm{S})/p_B)=0$. Therefore, the world excess demand for basics $WEDB$, which is the sum of the North's and the South's, does not contain any term in NX. We obtain from (40):

$$WEDB(p)=(DB(\mathrm{N})(p)+DB(\mathrm{S})(p))-(SB(\mathrm{N})(p)+SB(\mathrm{S})(p))$$

$$=\alpha(w/p_B)^2+\beta r^2/p_B+(w/p_B)(\bar{L}-\alpha c_2/D)+r(\beta a_2/D+\bar{K}/p_B)$$

$$+(\bar{K}a_2-\bar{L}c_2)/D-\bar{I}^D/p_B+\alpha(\mathrm{N})(w(\mathrm{N})/p_B)^2$$

$$+\beta(\mathrm{N})r(\mathrm{N})^2/p_B+(w(\mathrm{N})/p_B)(\bar{L}(\mathrm{N})$$

$$-\alpha(\mathrm{N})c_2(\mathrm{N})/D(\mathrm{N}))+r(\mathrm{N})(\beta(\mathrm{N})a_2(\mathrm{N})/D(\mathrm{N})+\bar{K}(\mathrm{N})/p_B)$$

$$+(\bar{K}(\mathrm{N})a_2(\mathrm{N})-(\bar{L}(\mathrm{N})c_2(\mathrm{N}))/(D(\mathrm{N}))-\bar{I}^D(\mathrm{N})/p_B, \qquad (\mathrm{A.2})$$

where all the parameters are for the South unless otherwise indicated.

We now study the stability of the world market for basics, i.e., the sign of the partial derivative of $WEDB(p)$ with respect to the price p_B. From (42),

$$(\partial/\partial p_B)(WEDB(p))=(\alpha w/p_B^2)(c_2/D-2w/p_B)-\beta r^2/p_B^2-((\bar{L}w+r\bar{K})/p_B^2)+\bar{I}/p_B^2$$

$$+(\alpha(\mathrm{N}))(w(\mathrm{N})/p_B^2)(c_2(\mathrm{N})/D(\mathrm{N})-2w(\mathrm{N})/p_B)-\beta(\mathrm{N})(r(\mathrm{N}))^2/p_B^2$$

$$-((\bar{L}(\mathrm{N})w(\mathrm{N})+r(\mathrm{N})\bar{K}(\mathrm{N}))/p_B^2)+\bar{I}(\mathrm{N})/p_B^2, \qquad (\mathrm{A.3})$$

where all parameters, unless otherwise indicated, are from the South. When $\alpha(S)$ is sufficiently large that the terms in $\alpha(S)$ dominate (A.3), $\partial/\partial p_B WEDB(p)$ has the sign of the expression $\alpha w/p_B(c_2/D-2w/p_B)$ in the South. Therefore, when $c_2/D<2w/p_B$ in the South, the world B-market is stable. As in the one region case, the world market for I is also stable, from Walras law. We have thus proved Proposition 10 in section 3.

The world's market for industrial goods: Stability

From eq. (37), the world's supply for industrial goods is

$$\begin{aligned} WSI(p) &= SI(S)(p)+SI(N)(p) \\ &= (a_1/D)(\beta r+\bar{K})-(c_1/D)(\alpha w/p_B+\bar{L}) \\ &\quad +(a_1(N)/D(N))(\beta(N)r(N)+\bar{K}(N))-(c_1(N)/D(N))(\alpha(N)w(N)/p_B+\bar{L}(N)), \end{aligned} \tag{A.4}$$

and the world's demand is

$$\begin{aligned} WDI(p) &= DI(N)(p)+DI(S)(p) \\ &= \bar{I}^D(S)+\bar{I}^D(N)+\Pi(S)(p)+\Pi(N)(p) \\ &= \bar{I}^D(S)+(p_B-a_1w-c_1r)[(c_2/D)(\alpha w/p_B+\bar{L})-a_2/D(\beta r+\bar{K})]+\bar{I}^D(N) \\ &\quad +(p_B-a_1(N)w(N)-c_1(N)r(N))[c_2(N)/D(N)(\alpha(N)w(N)/p_B+\bar{L}(N)) \\ &\quad -(a_2(N)/D(N)(\beta(N)r(N)+\bar{K}(N))]. \end{aligned} \tag{A.5}$$

As already mentioned, this I-market is stable when $\alpha(S)$ is large and $c_2/D<2w/p_B$ in the South (Proposition 10 and footnote 15).

A.5. Numerical simulations of stability

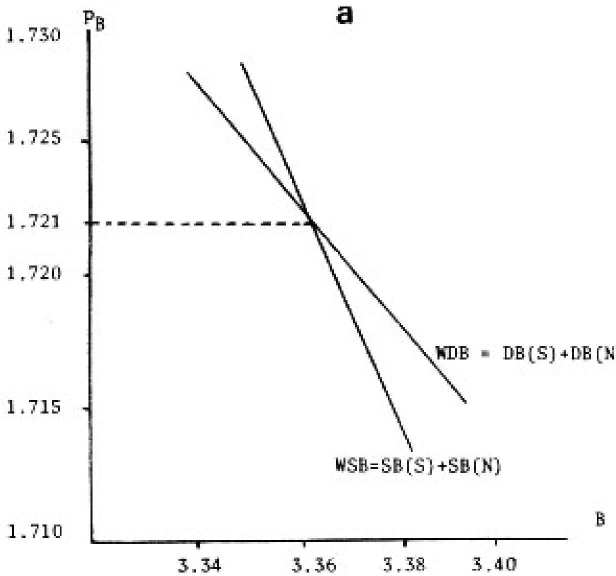
Using always the same data base, we compute numerically the world's (disequilibrium) supply and demand curves for basics and for industrial goods in fig. 1. Fig. 2 reproduces figure 2b in Chichilnisky (1981); as discussed in section 3, this figure depicts two curves: the cross equilibria relation X_B^S (30) relating the exports of the South and their price,

$$\begin{aligned} X_B^S &= (\alpha c_1/D^2p_B)(c_2-c_1/p_B)+(\beta a_1/D^2)(a_2-a_1/p_B) \\ &\quad +(c_1\bar{L}-a_1\bar{K})/Dp_B+\bar{I}^D(S)/p_B, \end{aligned}$$

where all parameters are for the South; and the North's disequilibrium excess demand for basics, denoted WD in Chichilnisky (1981). From (41),

$$WD = DB(\mathrm{N})(p) - SB(\mathrm{N})(p) = \alpha(w/p_B)^2 + \beta r^2/p_B + (w/p_B)(\bar{L} - \alpha c_2/D)$$
$$+ r(\beta a_2/D + \bar{K}/p_B) + (\bar{K}a_2 - \bar{L}c_2)/D - \bar{I}^D/p_B,$$

where all parameters and variables are for the North.



WSB = world disequilibrium supply of basics.
WDB = world disequilibrium demand for basics.

The world market for basics is stable when α(S) is large, and $c_2/D < 2w/p_B$ in the South (Proposition 10, section 3).

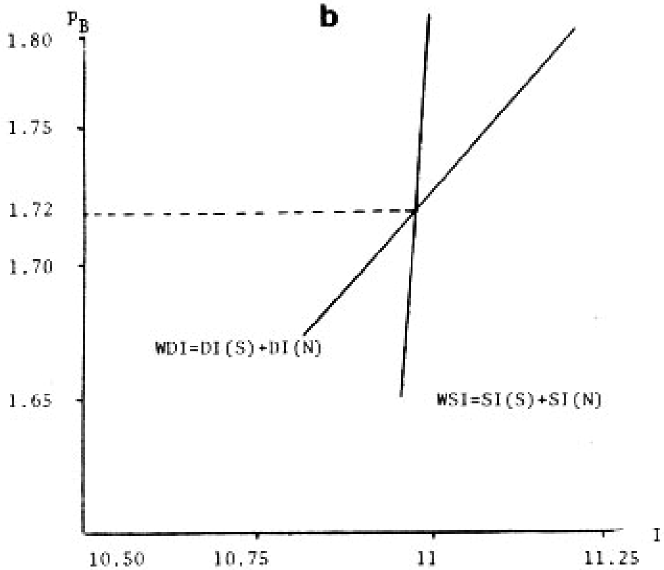
Numerical values.

p_B	WSB	WDB
1.6	3.6982	3.9433
1.65	3.5555	3.6894
1.7	3.4215	3.4582
1.75	3.2946	3.2470
1.8	3.1750	3.0536

Slope of WSB = =0.38
Slope of $WDB = -0.22$

Fig. 1a. Simulation of world's disequilibrium supply and demand curves per basics [at the equilibrium corresponding to $I^D(\mathrm{N}) = 7.0$].

Finally, fig. 3 exhibits the cross equilibria relation X_B^S as the intersection of world excess supply of the South and excess demand curves of the North, i.e., as the intersection of different *WD* and *WS* across different equilibria. Note that each *WD* meets X_B^S from above. The world market is Walras-stable because *WD* meets *WS* from below at each *B* equilibrium.



WSI = world disequalibrium supply of industrial goods.
WDI = world disequilibrium demand for industrial goods.

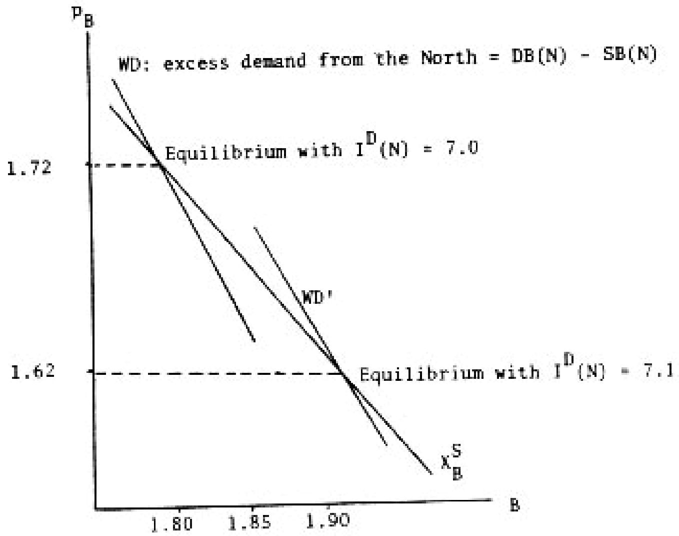
The world market for industrial goods is also stable, under the conditions of Proposition 10, section 3.

Numerical values.

p_B	*WSI*	*WDI*
1.6	10.944	10.553
1.65	10.968	10.748
1.7	10.991	10.928
1.75	11.012	11.096
1.8	11.032	11.250

Slope of *WSI* = 2.27
Slope of *WDI* = 0.29

Fig. 1b. Simulation of the world's disequilibrium supply and demand curves for industrial goods [at the equilibrium corresponding to I^D(N) = 7.0].



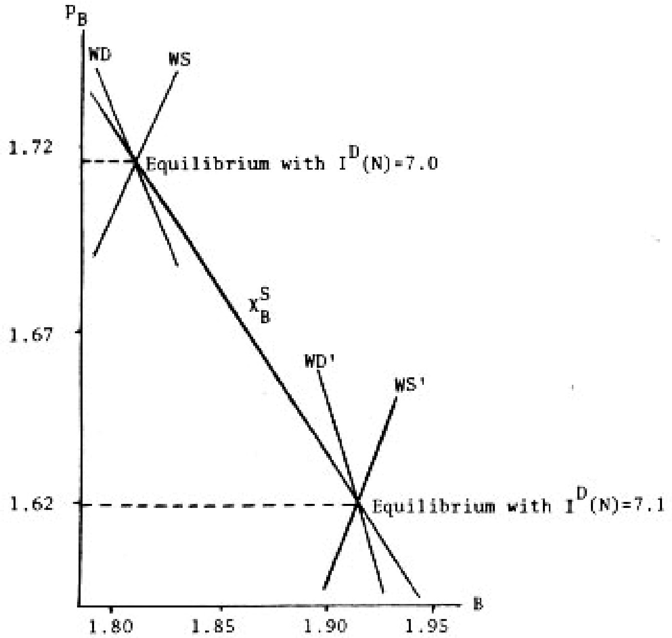
This figure reproduces fig. 2b in Chichilnisky (1981) where the curves have been computed numerically from the basic data set. For $I^D(N) = 7.0$ we obtain WD, and for $I^D(N) = 7.1$ we obtain WD'. Note that the cross equilibrium curve is met from above by both of the curves representing the North's disequilibrium excess demand (WD and WD'), and that by fig. 1a the world's market for basic goods is Walrasian stable. Note also that the curve WD' is a shift to the right of the excess demand for basics of the North WD, yet at the new equilibrium [when $I^D(N)$ has increased to 7.1] the price of basics is *lower*. This is as depicted in fig. 2b of Chichilnisky (1981), Proposition 3 of Chichilnisky (1981), and Proposition 5 of section 2 above. The drop in the price of basics following the positive shift in the North's excess demand for basics, is due to a simultaneous shift in the excess supply curve for basics of the South, $SB(S) - DB(S)$, a curve that appears in fig. 3.

Numerical values

P_B	X_B^S	WD at $I^D(N)=7.0$	WD' at $I^D(N)=7.1$
1.56	1.992	1.963	1.978
1.6	1.943	1.920	1.937
1.66	1.872	1.860	1.880
1.7	1.828	1.823	1.844
1.74	1.786	1.788	1.810
1.8	1.727	1.739	1.763

Slope of $X_B^S = -0.9$ Slope of $WD = -1.1$
Slope of $WD' = -1.1$

Fig. 2. Simulation of fig. 2b in Chichilnisky (1981). X_B^S and the excess demand function for basics of the North $WD = DB(N) - SB(N)$, in a neighborhood of the stable equilibria given by $I^D(N) = 7.0$ and $p_B^* = 1.721$ and of $I^D(N) = 7.1$ and $p_B^* = 1.62$.



The cross equilibria relation X_B^S is the locus of the intersection of the (disequilibrium) excess demand curve of the North WD with the (disequilibrium) excess supply of the South, WS. These curves are computed at nearby equilibria determined by varying exogenously I^D(N). Note that in the two equilibria, WD meets X_B^S from above. The market is Walrasian stable because world demand WD meets world supply WS from below.

$$WD = DB(\mathrm{N}) - SB(\mathrm{N}), \quad WS = SB(\mathrm{S}) - DB(\mathrm{S}).$$

WD and WS correspond to $I^D(\mathrm{N}) = 7.0$. WD' and WS' correspond to $I^D(\mathrm{N}) = 7.1$. The curve X_B^S is computed from a range of different values of I^D(N), which are of course associated to different equilibrium prices p_B. WD, WS and X_B^S meet at $p_B = 1.721$ and WD', WS', and X_B^S meet at $p_B = 1.62$.

Numerical values

p_B	WD	WS	X_B^S	WD'	WS'
1.56	1.963	1.619	1.992	1.978	1.858
1.6	1.920	1.677	1.943	1.937	1.897
1.66	1.860	1.748	1.872	1.880	1.944
1.7	1.823	1.788	1.828	1.844	1.969
1.74	1.788	1.821	1.786	1.810	1.989
1.8	1.739	1.862	1.727	1.763	2.011

Slope of $X_B^S = -0.91$, Slope of $WD = -1.1$, Slope of $WS = 1$, Slope of $WD' = -1.1$, Slope of $WS' = 1.6$

Fig. 3. Simulation of X_B^S as a locus of equilibria in the international market for basic goods.

References

Arrow, K., 1981, Evaluation of the UNITAR project on Technology, Domestic Distribution and North–South relations (UNITAR, New York) Aug.

Arrow, K. and F. Hahn, 1971, General competitive analysis (Holden–Day, San Francisco, CA).

Arrow, K. and L. Hurwicz, 1963, Decentralization and computation in resource allocation, in: R. Pfouts, ed., Essays in economics and econometrics in honor of Harold Hotelling (Universuty of North Carolina Press, Chapel Hill, NC).

Chichilnisky, G., 1981, Terms of trade and domestic distribution: Export-led growth with abundant labour, Journal of Development Economics 8, no. 2, 163–192.

Chichilnisky, G., 1983, North–South trade and basic needs, Working paper (International Institute for Applied Systems Analysis) Aug.

Chichilnisky, G., 1983, Oil prices, industrial prices and outputs, IIASA working paper.

Chichilnisky, G., 1984, A general equilibrium theory of North–South trade, in: W. Heller, D. Starrett and R. Starr, eds., Essays in honor of Kenneth J. Arrow, IMSSS working paper, Stanford University (Cambridge University Press, Cambridge, MA).

Chichilnisky, G. and S. Cole, 1978, Expansion of the North and exports of the South (Harvard Institute for International Development, Cambridge, MA). Revised version: Jan. 1981.

Chichilnisky, G. and D. McLeod, 1984, Agricultural productivity, development and trade, Working paper (The World Bank, Washington, DC).

Chichilnisky,G., G. Heal and D. McLeod, 1983, Resources, trade and debt, IIASA working paper.

Chichilnisky, G., G. Heal and J. Podivinsky, 1983, Sri-Lanka and the U.K.: A case study in North–South trade (Graduate School of Business, Columbia University, New York).

Findlay, R., 1983, Growth and development in trade models, in: P. Kenen and R. Jones, eds., Handbook of international economics, Vol. I, ch. 4 (North-Holland, Amsterdam).

Gunning, J.W., 1984, Export-led growth with abundant labour: A defense of orthodoxy, Journal of Development Economics, this issue.

Heal, G. and D. McLeod, 1984, Gains from trade, profits and stability: A comment on Chichilnisky's 'Terms of trade and domestic distribution: Export-led growth with abundant labour', Journal of Development Economics, this issue.

Lim, J., Simple theoretical models for the export-led industrialization in the Philippines (University of Pennsylvania, Philadelphia, PA).

Mahran, H.A., 1982, Export-drive growth with abundant labor supply (University of Essex, Colchester).

Mas Colell, A., 1974, Algunas observaciones sobre la teoria tatonement de Walras en economias productivas, Anales de Economia.

Moteman, S., 1983, Oil exports and industrial imports, North–South trade in the case of Iran, Doctoral dissertation (University of Essex, Colchester).

Neary, P., 1978, Dynamic stability and the theory of factor-market distortions, American Economic Review 68, no. 4.

Podivinsky, J., An application of the Chichilnisky terms of trade model to the Sri-Lanka–United Kingdom case, Working paper (London School of Economics, London).

Ranney, S., 1984, Terms of trade and domestic distribution: A comment, Journal of Development Economics, this issue.

Saavedra-Rivano, N., 1984, Terms of trade and domestic distribution: A comment, Journal of Development Economics, this issue.

Samuelson, P., 1947, Market mechanisms and maximization, in: J.E. Stiglitz, ed., Collected papers of Paul Samuelson (MIT Press, Cambridge, MA).

Sen, A., 1981, Evaluation of work carried out under the UNITAR Project on Technology, Domestic Distribution and North–South Relations, Aug. (UNITAR, New York).

Srinivasan, T.N. and J. Bhagwati, On transfer paradoxes and immiserizing growth: Part II, Journal of Development Economics, this issue.

Uriarte, R., 1981, An extension of Chichilnisky's terms of trade model to economies with land, Working paper (University of Essex, Colchester).