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NORTH-SOUTH TRADE AND BASIC NEEDS*

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This paper examines the role of the international market in mediating North-South relations and analyzes how the market works in distributing the gains from trade. It is argued that the international market does not always provide an adequate engine of growth for the South if that region specializes in labor-intensive products. The South's export sector must be carefully balanced with other domestic sectors to avoid harming the economy as a whole. Any excessive expansion of labor-intensive exports or raw materials, even if accompanied by an expansion in international demand, may affect domestic markets and the distribution of income in the South in ways that conflict with sustainable development, especially when this is measured in terms of the satisfaction of basic needs for the majority of the population. The conditions under which this may occur are quite general. They are consistent with perfect market behavior but require that important features of the North-South relationship, including differential characteristics of technologies and factor markets in the two regions, be introduced into the analysis. The paper suggests alternatives to export-led policies, which balance domestic and international sectors of the South's economy and are conducive to sustained development and the satisfaction of basic needs. An appendix provides a model of North-South trade that has been econometrically tested for the trade between Sri Lanka and the UK. The appendix also includes a computer program for simulating the model and sample computer runs that reproduce, in practical terms, the model trade policies discussed in the paper.

1. Basic Needs and International Markets

The concept of basic needs has received widespread attention in the development literature over the last ten years, since its introduction in the early seventies in the Bariloche Model. This model was produced in the Fundacion Bariloche, Rio Negro, Argentina over the period 1972–76, under the auspices of the International Development Research Center of Canada; see e.g. Herrera et al. (1977) and Chichilnisky (1977b). The model was first presented at IIASA in 1975, at a conference chaired by Tjalling Koopmans. The model itself, and its introduction of the satisfac-

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tion of basic needs as a goal of development has been subsequently discussed by several authors; see e.g. Nordhaus (1975), Streeten (1978), and Hopkins et al. (1976). In 1976 the basic needs concept was brought to the attention of the wider international development community during the World Employment Conference of the International Labor Organization (ILO). A number of papers and books studying basic needs development strategies followed: see e.g. Richards and Leonor (1982). These refined and extended the ideas introduced in the Bariloche Model, which defined a basic needs development strategy as one aiming for minimum levels of per capita consumption of food, shelter, education and health. The Bariloche Model explored whether the goal of satisfying basic needs was within the reach of the developing countries, within their existing constraints on resources and population. The answer was positive but qualified: many reforms appeared to be needed for regions such as Africa to reach this goal. The model simulated these reforms, planning development paths to reach these goals under different scenarios and for different regions of the world. However, because of the model's large scale, these economic plans were highly aggregated and left large areas of economic behavior unexplained. For instance, little attention was paid to domestic or international *market* behavior.

Markets are powerful economic forces in developing and industrial countries alike. In particular, the *international market* has become an increasingly powerful force in the world economy, even affecting those countries with a certain degree of central planning, following the unprecedented growth of international trade from 1945 to the mid 1970s.[1] Large segments of the GDP of industrial and developing countries are now linked to international markets.

Yet in spite of the increasing degree of internationalization of our economies, the concept of basic needs has been essentially viewed in much of the literature as a domestic issue. The Bariloche model discussed basic needs in the international context, but did not analyze in detail the impact of international *markets* on the satisfaction of basic needs, since it was fundamentally a planning model. The studies on basic needs strategies that followed the Bariloche work have focused mostly on *domestic* policies, and little has been said about the connection between basic needs and the *international* policies of developing countries. However, the international policies of an economy play a significant role in determining the level to which basic needs can be satisfied domestically.

This paper examines the missing link between international policies and basic needs policies, by discussing alternative trade theories and exploring the policies that each suggests for encouraging the satisfaction of basic needs in a developing economy. The Appendix provides compu-

[1]See for example Project Reports I (1978) and II (1980) of the UNITAR Project on Technology Distribution and North-South Relations, UNITAR, New York 10017, USA.

ter simulations of a model of North-South trade and examines in practical terms the impacts of exports on domestic consumption, investment, employment, and wages. We find that in some cases the expansion of trade is favorable to the satisfaction of basic needs but in other cases it is not. We encounter results that may seem contrary to existing notions of gains from trade and advantages derived from international specialization We also question the effectiveness of the international market in transmitting growth from one region to another: we show that an industrial expansion of the North may lead to a new market equilibrium with a larger volume of exports from the South, but may at the same time reduce export revenues and the level of industrialization in the South. Moreover, this increase in exports may be associated with a worsening of the distribution of income within the south. Under such conditions, then, "export-led" development strategies are not favorable to the satisfaction of basic needs nor to wider development objectives. There is, therefore, a need for policy measures that correct such conditions before gains from trade can be assured, and we discuss alternatives to export-led policies that may be preferable until these conditions are corrected. These alternatives involve a more balanced view of development that relies on domestic markets as well as the international market and concentrates on raising domestic productivity in crucial sectors of the economy.

The rest of this paper is organized as follows. Section 2 summarizes the standard neoclassical development and trade literature, which provides the intellectual support for much of current development policy in the North and South, as well as in the major international financial institutions. It presents also a summary of criticisms of this body of thought, including some that accept the basic paradigm, but seek to cope with anomalies, and others that reject the basic paradigm altogether. Section 3 outlines a North-South model which we developed and tested econometrically in the context of a UNITAR project,[2] and which is presented formally in the Appendix. This model remains within the framework of perfectly competitive markets, though it introduces into this framework assumptions that could be considered more realistic, and that are in part suggested by some of the critical literature reviewed in the second section Section 4 discusses the main results. We conclude with some policy inferences and recommendations. An Appendix summarizes the theoretical structure of the model and discusses several empirical illustrations.

2. A Brief Survey of Trade Theory

The impact of international markets on the functioning of domestic economies is now generally acknowledged. However, recognition of this impact within the industrial economies is rather recent; it largely emerged due to the changes that took place during the seventies in the international

[2]See for example James and Pearce (1958) and Samuelson (1962).

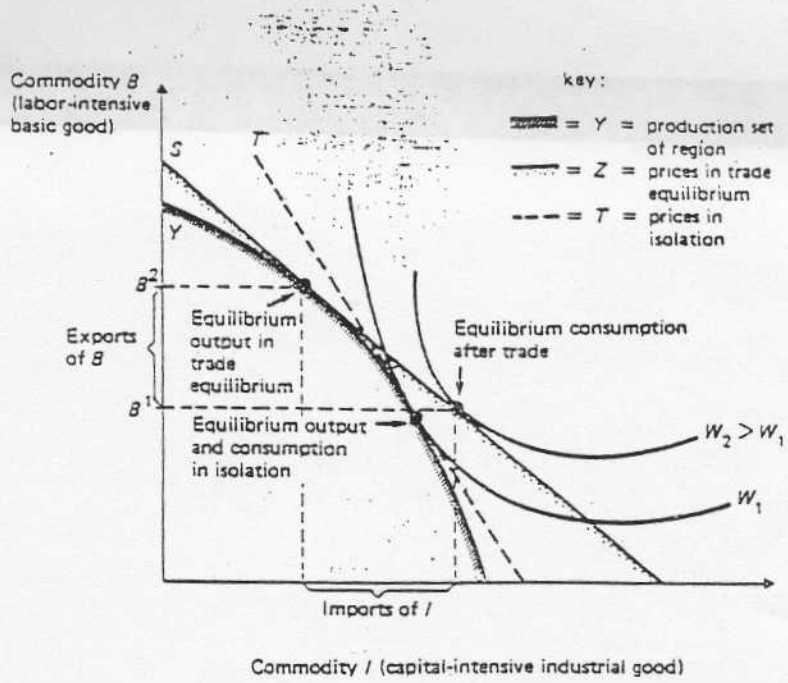

Figure 1. Gains from trade and specialization: output, prices, and welfare in isolation and with trade. In Figure 1 Y is the production possibility frontier of one region, the South: it represents the combination of basic goods B and industrial goods I that it could produce. In isolation, this region maximizes welfare on the production possibility set Y, reaching the level W_1. When trade is opened prices change and welfare can be maximized over all income available, which now includes export revenues. The new (after trade) budget set Z for the region is in general larger than Y; therefore a higher level of welfare W_2 can be achieved with free trade. The tangential intersection of the welfare surface W_1 with the production set Y determines the output of goods B and I in equilibrium before trade, and their relative price is given by the tangent line T. When international trade is opened, the price of the labor-intensive good B increases, and at the new prices S the budget for the country is given by the triangular set Z. Note that after trade basic goods are relatively more valuable than before, and more B is produced: the output of B increases from B^1 to B^2. More labor is employed at the new prices since B is labor-intensive. Wages can be shown to increase with an increase in the price of B (see the Appendix). The country specializes in and exports B, it imports I, and it is better off after trade since it consumes more of both. In any case, the welfare level after trade, W_2, is larger than that before trade, W_1.

which the labor-rich region specializes in labor-intensive goods, and the capital-rich region in capital-intensive goods. Note that, as wages in the South increase through free trade, the relative advantage of the South also decreases as trade proceeds. This theory, therefore, predicts that relative advantages tend to disappear with continued trade, and that the international division of labor is a temporary, even self-destructing, phenomenon. Whatever inequalities are introduced by it are predicted to be purely

temporary; in the long run the world economy is expected to move towards a more equal state. Figure 2 illustrates these points.

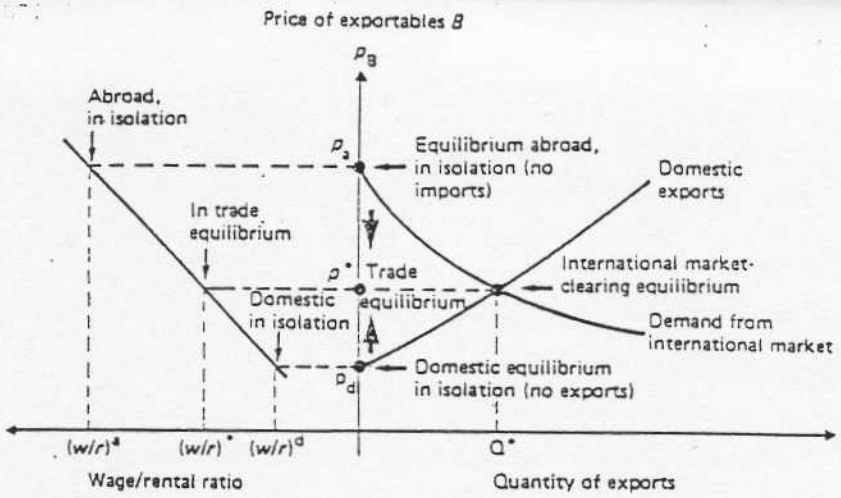

Figure 2. Factor price equalization effects of trade. In Figure 2, the left-hand diagram describes the relationship of the (relative) price of the exportable good B with the wage-rental ratios w/r. Since the exportable good is more labor intensive, as its price increases, so does the wage-rental ratio. The right-hand diagram shows the possible equilibrium values of exports and imports of the South and the North. In isolation, the equilibrium quantity of exports at home is zero, and the price is the domestic price p_d. Similarly, the equilibrium price abroad is p_a in isolation. When international trade opens, an international trade equilibrium price p^* is reached, and the quantity of exports equals Q^*. At price p^*, the new equilibrium wage rental ratio is $(w/r)^*$, which is larger than the isolation wage rental before trade at home $(w/r)^d$, and smaller than the wage rental before trade abroad $(w/r)^a$. Factor prices and prices of commodities equate in the trade equilibrium and improve the wage-rental ratio in the South to $(w/r)^*$.

The results on gains from trade and specialization and on factor-price equalization have been powerful enough to shape most formalized thinking on the theory of trade and international economic relations. They have also permeated policy thinking in a pervasive manner.

However, it is becoming increasingly clear that there are several factors that have not been considered in these theories, and which may have a striking effect on market behavior. Moreover, concerns have arisen about the general validity of policy thinking based only on Heckscher-Ohlin theory.

It is generally acknowledged that this theory has not provided an adequate explanation for a salient feature of the postwar period (1945–1970). During this period, the volume of international trade increased in an historically unprecedented fashion[3], while wealth differences and the

[3]For a discussion of the unprecedented postwar increase in international trade, see for example Chichilnisky (1982).

division of labor between the North and the South increased significantly.[4] Furthermore, the distribution of income within the South did not improve during this period.[5] Neither the results on gains from trade and specialization nor those on factor-price equalization seem consistent with these facts. Of course, exogenous historical explanations could be invoked, but this would amount to an implicit recognition of the limited explanatory powers of the theory.

A number of alternative explanations have been proposed for the striking developments in the world economy during the period 1945–1970. However, these have not produced a body of formalized theory with the rigor of the neoclassical theory. Therefore, they have lacked policy utility and have not carried as much conviction as the neoclassical theory.

The most significant representatives of these alternative theories can be grouped according to the weights that their analysis assigns to market vs. nonmarket factors. In general, those that assign more weight to markets tend to offer a higher degree of formalization or quantification.

Significant representatives of the analysis that focuses primarily on markets are R. Prebisch and W. A. Lewis. Both emphasize the dangers of overreliance on international markets as an "engine of growth" for the South.

Prebisch gave a variety of market-related explanations for North-South inequalities, perhaps the best known being his work on the deterioration of the secular terms of trade between products exported by the industrial countries and those exported by the "periphery" (Prebisch 1950, 1959). Prebisch's analysis is based on the premise that the demand for raw materials and labor-intensive products rises less than the demand for industrial products as incomes rise. Thus, over time, the relative prices of products exported by the South must decrease. Prebisch's work has led to the emergence of what are now widely known as import-substitution policies in Latin America. Lewis (1952, 1977) has contributed a wide range of powerful insights into the economic relationships between the North and the South, the most celebrated set of ideas emerging from his model of developing economies with unlimited supplies of labor and the determination of what he refers to as "factoral terms of trade" for North-South trade. Lewis assumes that labor supply in the South is infinitely elastic and thus that the level of employment is determined solely by demand. The real wage is pegged to the subsistence level, and terms of trade between the two regions are determined by their respective levels of labor productivity in agriculture. Lewis' analysis leads him to conclude that export-led policies may have a limited value for the South, that the growth of the North is not necessarily linked positively with the growth of South, and that there is a need for an endogenous "engine of growth" within the South.

[4]For a discussion of increases in North-South differentials during this period see Chichilnisky (1982).

[5]See Chichilnisky (1982).

The *dependencia* theory in Latin America, some of whose representatives are F. Cardoso, P. Baran, G. Frank, T. dos Santos, O. Sunkel, and M. C. Tavares, combined explanations of underdevelopment based on post-Marxist power relations with an analysis of markets. These theories had little or no formalization, and therefore could not be used for policy formulation.[6] A central theme in these studies is the impact of a "foreign industrialized sector" on the rest of the economy of a developing country. This foreign sector is associated with technologies, market demand structures, and distributions of income, i.e. with *patterns of development* which reinforce the dependence of the developing economies on the economies of the center. Finally, a number of other authors have largely disregarded the behavior of the market as having insignificant explanatory power, and have addressed themselves instead to the power structure of classes and to certain historical developments of capitalism, such as accumulation of capital within and between the industrial and developing regions. Among this last group, the most significant are the Marxist economists A. Emmanuel and S. Amin, neither of whom sought to formalize their assumptions or results.

Formalized economic theory allows for more accurate empirical testing, and also for the evaluation of alternative policies. Perhaps even more importantly, formalization allows for more consistent "thinking through" of ideas. Formalized theories can therefore grow, disperse, and frequently be applied better than nonformalized ones.

Another advantage of formalization is that it allows one to compare, in a precise manner, the assumptions of different theories, so that the discrepancies in their results can be explored with precision. This can improve the level of the analysis and help clarify the validity of the results. With this understanding we decided, within our UNITAR project,[7] to develop a body of formalized theory that could be helpful in analyzing some of the stylized facts of development and trade that appear to defy explanation by the existing formalized theories. Simplified versions of our model have been produced that are rather close to the general equilibrium trade models of the Heckscher-Ohlin type. Yet, under certain conditions our models yield results that appear strikingly different from the conventional results of gains from trade and factor-price equalization exercises. This is the subject of the next section.

3. A Model of North-South Trade

In this section we present a simplified version of the North-South model. The equations, main theoretical properties, and simulations are

[6] See for example Palma (1978).

[7] Project on Development and North-South Trade. This was sponsored by the UN, FUNDPAP, the Department of Economics and Social Affairs, New York, and the UN Institute for Training and Research (UNITAR), directed by S. Cole and G. Chichilnisky.

presented in the Appendix. This model differs from the Heckscher-Ohlin model in two main respects: the production system of the South is *different* from that of the North, and the labor and capital supplies of each region are responsive to real wages and profits. By contrast, in the Heckscher-Ohlin model, the two regions have the same production systems and total endowments of factors are fixed. This model was estimated with time series data for Sri Lanka and the United Kingdom trading with each other, and the estimation confirmed the results which we shall discuss next.[8] Sri Lanka and the United Kingdom were chosen to estimate the parameters of the model because as trading regions they correspond roughly to the stereotypical assumptions of the North-South model. Simulations of the model have also been performed with data for Argentina, Mexico, and the United States.[9]

We shall now describe those characteristics that the model has in common with that of Heckscher-Ohlin. There are two regions, denoted North and South. Two aggregate goods are produced, consumed, and traded by each region. These are denoted *B*, basic consumption goods, and *I*, industrial goods[10]. Neither region is completely specialized in production of one or the other good. There are two factors of production, capital and labor, in each region; the owners of these factors produce, consume, and trade the two goods. Goods are produced using constant-returns-to-scale technologies. The industrial good is more capital intensive and the basic good more labor intensive in both regions. The South exports basics and the North industrial goods.

In a trade equilibrium, the amounts produced, consumed, and traded within and between the regions are determined through the clearing of markets, i.e. supply equals demand. There are four domestic markets (two markets for factors, and two markets for goods) and two international markets (for goods). The international market equilibrium determines the prices of both goods and the returns to factors, i.e. wages and rates of profits in each region. Each trading region is constrained by its budget, so that export revenues and import costs are in balance. In equilibrium the relative price of each traded good is the same in the North and in the South.

We now discuss the differences between our North-South model and the Heckscher-Ohlin model. As already mentioned, the two regions have here different technologies for the production of goods, and the supplies of factors of production in the two regions, capital and labor, are responsive to their rewards, rates of profits and wages. Furthermore, we assume that the responsiveness of labor supply to real wages is rather large in the South, while less so in the North. The high responsiveness of labor

[8]See Podivinsky (1982).

[9]See Chichilnisky and McLeod (1983).

[10]For the precise conditions, see Proposition 1 of Chichilnisky (1981) and also Chichilnisky (1983a).

supply to real wages is a measure of the abundance of labor in the South. This could be interpreted as indicating a high level of migration from the subsistence part of the economy (such as rural areas) to the market economy. In a limiting case, when this responsiveness is infinitely large so that labor supplies never represent a constraint, this would be identical to Lewis' assumption of unlimited supplies of labor. However, Lewis' assumption implies that wages are always pegged at the subsistence level while in the North-South model, by contrast, wages do vary with supply and demand conditions. This is because despite the facts that labor supply is highly responsive to wages, it is not infinitely elastic in our model. The high responsiveness of the labor supply in the South is denoted *abundance of labor*. We should note here that the responsiveness of the supply of a factor to its price may depend not only on its relative scarcity but also, in some cases, on the degree of market control exercised by the group that supplies the factor (i.e. workers or capitalists). For instance, at present, labor in the South is clearly much less organized, and has less market power than in the North.

The behavior of factor markets is formalized as follows. We assume that labor supply increases with the real wages.

$$L = \alpha \frac{w}{p_B} + \bar{L}, \alpha > 0$$

where w/p_B is the real wage and α is the positive response of labor supply to real wage. Similarly, for capital supply,

$$K = \beta r + \bar{K}, \beta > 0$$

where r is the rate of profit and β is a positive response parameter. In the South the parameter α is large, i.e. labor supply is very responsive to real wages, and the parameter β is small, i.e. capital supply is not too responsive to the rate of return. The opposite is true of the parameters α and β in the North. Special cases of this model, where $K = \bar{K}$ and $L = \bar{L}$, have been studied (see Chichilnisky 1983a).

We now discuss the results on gains from trade and specialization and on factor-price equalization in the context of the North-South model and we shall explain how the characteristics of this model lead to the various results. We start by indicating, by means of Figure 3, how the geometric illustration of the gains from trade and specialization, given in Figure 1, *is no longer universally valid when factors are in variable supply*.

The second difference between the present model and the Heckscher-Ohlin model is that in the North-South model different regions have different technologies. This is formalized by assuming different production functions for the two regions.

In the Hecsckher-Ohlin model, production functions are assumed to show constant returns to scale, and to be identical in both countries. We also consider constant-returns production functions, though for analytical simplicity we use here fixed factor proportions. Extensions to Cobb-

Douglas or CES production functions are discussed in Mahran (1982). Let B denote a basic good, I an industrial good. If B^S and I^S denote outputs of the two goods, the two production functions are

$$B^S = \min (L^B/a_1, K^B/c_1)$$
$$I^S = \min (L^I/a_2, K^I/c_2)$$

where c_1 and c_2 are capital/output ratios and a_1 and a_2 are labor/output ratios in the two sectors, respectively. As is well known for such techno-

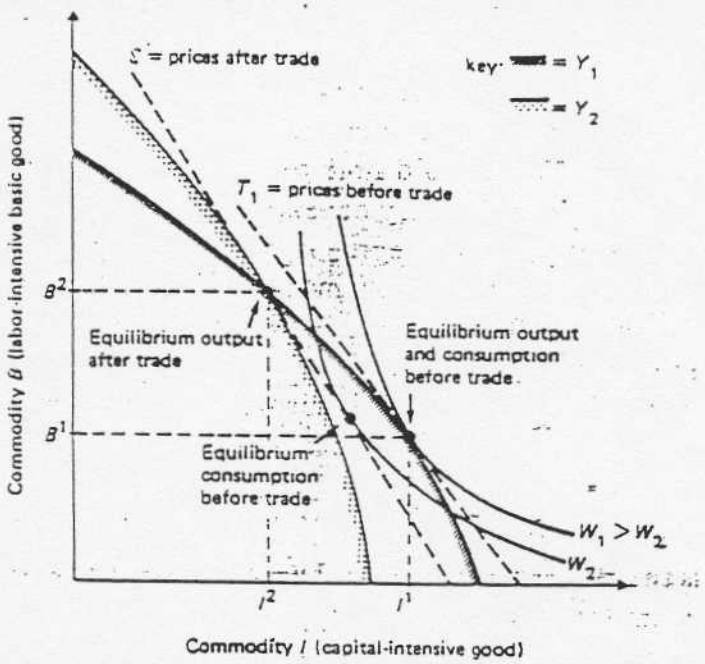

Figure 3. Gains from trade with price-responsive endowments. Figure 3 differs from Figure 1 in that initial endowments of capital and labor vary here with prices so that the production sets also vary with prices. The pre-trade production possibility set is Y_1. The equilibrium relative prices before trade are given by the line T_1, the equilibrium quantities of the two goods produced pre-trade are B_1 and I_1. After trade, the production possibility frontier has changed due to the response of the variable factor supplies; it is now Y_2. This could not occur in Figure 1 since factor supplies were fixed there. Labor supply has now increased with respect to capital goods supply, and therefore the new production possibility set Y_2 shows that the economy is now able to produce relatively more labor-intensive goods B. New prices S are achieved in equilibrium that reflect an increase in the price of the capital-intensive good I. The output of the labor-intensive good has increased with respect to that of the capital-intensive good (to B_2 and I_2) but total welfare levels achievable at the equilibrium (W_2) are now lower. The figure illustrates how a lower level of welfare is possible after trade, if factor endowments are price dependent.

logies, the difference in factor intensities in the two sectors is given by the expression $D = a_1c_2 - a_2c_1$. *We assume here that D is positive in both*

regions, but much larger in the South than in the North. This means that the good B is produced in a more labor-intensive way in both countries than the good I; but B is much more labor-intensive than I in the South.

Casual observation suggests that differences in capital/labor intensities between the technologies of the two sectors are indeed larger in the South than in the North. Empirical observations confirm this. Developing economies have significant differences between the production systems of different sectors, and we refer to this as "technological dualism". This fact has been pointed out in the theories of dual economies for many years, starting with the less formalized work of the Latin American economists already mentioned. However, a major difference between our work and previous studies of dual economies is that while those studies attempted to explain a division of the economy into a market and a subsistence sector, here we consider that markets operate throughout the economy and dualism appears here only in production. Otherwise, in our model, the economy is completely integrated and all its parts interact in a general equilibrium with each other. In particular, wages and prices are determined through the interaction of all markets. It should therefore be kept in mind that the terms "dual technologies" or "dualism in production" have rather different meanings here than elsewhere in the literature.

4. Basic Needs and North-South Trade

We now summarize the results obtained with the North-South model. When the economies of the South have very abundant labor and significant dualism in production, an increase in the exports of the labor-intensive basic consumption good will necessarily decrease the price of this good in relation to that of the industrial good; domestic employment and the purchasing power of wages will also decrease. The domestic consumption of basic goods decreases as well. This will occur quite independently of the cause of this increase in exports; for example, it may occur even with an expansion of the North's demand for exports from the South. In particular, the results do not depend on any assumptions of the elasticity of international demand for goods from the South. They depend instead on domestic conditions in the South. The specific condition is that α be large and that $c_2/D > 2w/p_B$, where w/p_B is the real wage. (Note that when D is large, technologies are dual and c_2/D is more likely to be smaller than, rather than twice, as great as the real wage.) This second condition is termed "dualism".

What these results show is that under conditions of dualism and abundant labor in the South, a higher volume of exports is necessarily associated with a lower (relative) price of the basic good, with lower wages and employment, and with lower domestic consumption of basic goods. In the following, we summarize the rationale for this sequence of events. However, before doing so it seems worth noting that the results

are *reversed* when the production system in the South is more homogeneous and when its labor supply is less abundant. In this latter case, following an expansion of exports, we obtain results in the spirit of "gains from trade and specialization": increasing exports leads to an improvement in the North-South terms of trade, and to increases in domestic employment, consumption of basics and real wages. From an economic viewpoint, therefore, the economic parameters of dualism and of labor abundance are rather important. Such parameters may have to be modified before embarking on an export-led policy. It should be noted that the crucial duality condition $c_2/D < 2w/p_B$ that determines whether or not an export expansion is desirable can be shown to depend itself on the level of exports already achieved by the economy. Therefore, different export policies are advisable at different export levels. The results may therefore be viewed as suggesting optimal export levels, or optimal balances between domestic sectors and the export sector. We shall discuss these and other alternative policy issues in the last section of the paper.

We now discuss how the negative impacts of increased exports emerge when the economy of the South has abundant labor and dual technologies. This requires that we analyze the changes in the domestic consumption of basic goods as their price increases.

If all prices other than those for basics remain constant, the economist's *ceteris paribus* assumption, an increase in the price of basic goods, will lead to lower demand and to lower consumption of basics. This is a standard partial equilibrium demand response to a price change. However, things are quite different when we remove the *ceteris paribus* assumption and let all markets adjust, i.e. when we move from one full market equilibrium to another. In this latter case, the demand for B may *increase* at a new equilibrium with a higher price of B. This will occur when, at a new price level, firms produce more of the labor-intensive commodity B and increase, therefore, the levels of employment and of wage income, thus leading to a higher demand for the basic good at the new equilibrium. Similarly, the supply of basic goods increases with a higher price of basics. What remains to be determined is whether supply has increased more than demand, or vice versa, at the new equilibrium. Since exports are the difference between domestic supplies and domestic demand, this determines whether exports increase or decrease at a higher price of basics. The sign of the expression $c_2/D - 2w/p_B$ compares precisely the strength of the supply (c_2/D) with the demand response $(2w/p_B)$.

Proposition 1 of Chichilnisky (1981) proves that with abundant labor and dual technologies, the increase in domestic demand *exceeds* the increase in supply at the new equilibrium. Therefore, as the price of basics increases, exports decrease. Equivalently, exports can increase only if prices and domestic consumption drop. For a proof, see the Appendix. A clear exposition and technical analysis of this result is offered in Arrow (1981), Sen (1981), and Heal and McLeod (1983). Figure 5 illustrates the

behavior of a reaction curve of the South, a curve that links the volume of exports with the price of these exports across different possible equilibria of this economy. This curve traces the intersections of domestic supply and demand curves. Note that since this reaction curve violates *ceteris paribus* assumptions (as all markets adjust in it) this curve is *not* a supply curve for the economy. It merely allows us to trace out hypothetical equilibria, and the relationship between the prices of basic goods and the volume of exports of basic goods, across each of these equilibria. For each level of international demand, only one equilibrium is possible, the one where the volume of exports equals the volume of imports demanded by the North. This volume of exports corresponds to one *price level* for basic goods. We can therefore analyze the changes in prices of basics as the volume of international exports varies across equilibria. However, at *any* equilibrium where labor is abundant and technologies are dual (α large, $c_2/D < 2w/p_B$), a move towards another nearby equilibrium with a *higher volume* of exports from the South is necessarily associated with a *lower price* of basic goods.

The price of the basic good is always positively associated with wages because the basic good is labor intensive (see the Appendix). It follows therefore that as exports increase and the price of the basic good decreases, so do wages. The purchasing power of wages in terms of the basic good is also shown to decrease when exports increase (see the Appendix). We therefore conclude that *under dualism and with abundant labor (α large, $c_2/D < 2w/p_B$), a move towards a new equilibrium with a higher volume of exports is necessarily associated with a lower price of these exports, a lower real wage, and decreased domestic consumption of basic goods in the South.* This is Proposition 1 in Chichilnisky (1981).

It is of interest to point out that should the economy's technologies be more homogeneous, and labor supply less responsive to wages, these results would be reversed. In this latter case, an increase in the volume of exports is associated with a higher level of prices of basic goods. This is because now, as the price of the basic good increases, domestic supply increases proportionately more than domestic demand in the new equilibrium. *With abundant labor and homogeneous technologies ($c_2/D > 2w/p_B$) an increase in exports leads to better terms of trade, to higher real wages and employment and also to higher levels of consumption of basic goods.* This is Proposition 2 in Chichilnisky (1981). It can also be shown that the volume of industrial goods imported also increases in the new equilibrium. This is discussed in the Appendix. Figure 4 illustrates the standard case in which, as exports of the basic good expand, the price of this good increases, and so do real wages and employment. Figure 5 illustrates the case of the dual economy with abundant labor: as exports of the basic good increase, the price of this good, the real wage and the employment all decrease in the South.

A few analogies and contrasts can be drawn here with the results of

the Heckscher-Ohlin theory presented in the previous section.

A first point is that, in the North-South model, the international division of labor is actually *reinforced* by the expansion of international trade when technologies are dual and labor abundant in the South. This is because more trade leads to lower wages in the South, therefore reinforcing the relative advantage of the South. In contrast to the conventional wisdom, inequality and the division of labor may perpetuate themselves.

A second point is that factor prices not only fail to equalize across regions in this model, but they also tend to drift further apart in the South as trade expands. This point is worth mentioning because it is only natural that with different technologies in the two regions, factor prices would never become fully equalized. As only goods are traded internationally in this case, only the prices of goods are equal in equilibrium. However, in a Heckscher-Ohlin model in which technologies are different, but duality is not significant and labor is not abundant, free trade would *tend* to equalize (even though it may never *fully* equalize) factor price. Thus in such a Heckscher-Ohlin model relative advantages tend to be blurred as trade takes place, and the division of labor appears again to be a temporary or

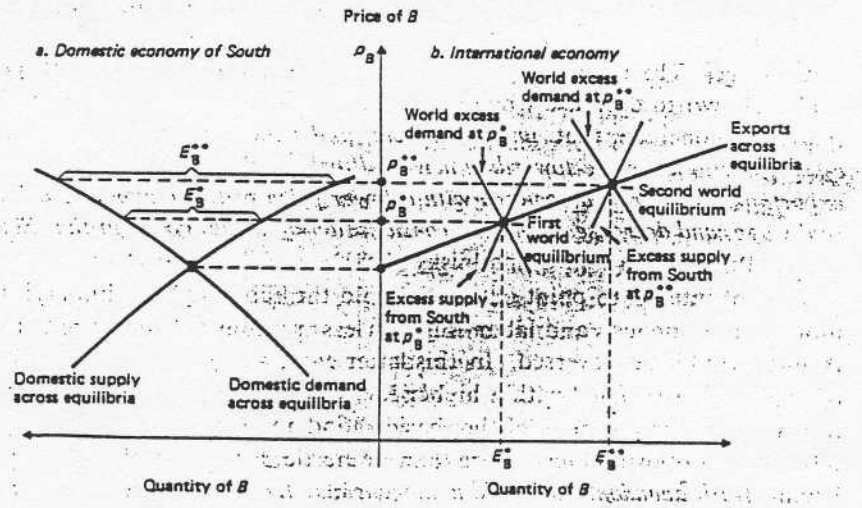

Figure 4. The standard case with homogeneous technologies: $c_3/D > 2w/p_B$. Figure 4a represents the domestic market, both supply and demand for the exportable at home; Figure 4b represents the international market. The difference between the equilibrium level of supply and the equilibrium level of demand is denoted E_B^*, the amount exported to the international market at equilibrium prices p_B^*. Domestically we have the corresponding equilibrium values of supply and demand that determine domestic consumption at the world equilibrium.

In the second equilibrium there are more exports E_B^{**}, at a higher price p_B^{**} and an increase in the equilibrium value of domestic supply, as well as a decrease in equilibrium demand. Therefore, as shown earlier in Figure 2 (left-hand side), the wages in the wage/rental ratio have increased in the South. More exports lead to a higher level of wages in the new equilibrium.

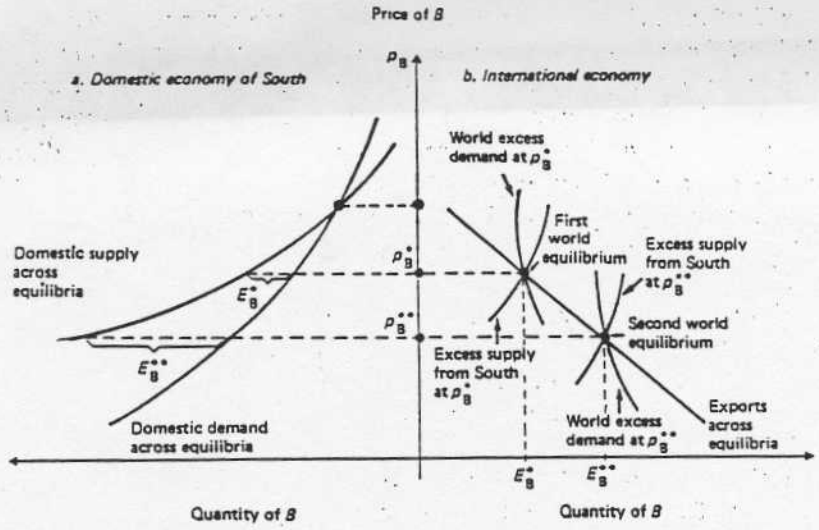

Figure 5. The dual economy with abundant labor: $c_1/D < 2w/p_s$. Figure 5 represents domestic and internal markets interacting with each other; the domestic market is represented in Figure 5a and the international market in Figure 5b. Here p_s^* represents first equilibrium prices, and E_s^* the equilibrium level of exports. p_s^{**} and E_s^{**} represent the second equilibrium prices and export volumes. The rest of the symbols correspond to those of Figure 4. As opposed to the neoclassical case in the dual economy the reaction curve that links export levels with equilibrium prices is downward sloping, reflecting the supply and demand effects across equilibria that were discussed in the text for both markets for goods and for services. This is proved in Proposition 1 of Chichilnisky (1981). With increased exports, the wage/rental ratio decreases, and there is also lower total output, and thus employment, domestically. Furthermore, the increase in demand from the North brings about lower equilibrium prices for the exportable.

self-destructive phenomenon. In the North-South model, by contrast, relative advantages are emphasized through free trade because wages in the South decrease. The international division of labor is thefore self-perpetuating.

It now remains to analyze the response of total export revenues of the South. This is relevant because if total revenues did increase, it would be possible to increase exports and to redistribute the proceeds adequately in order to compensate for the harmful effects of export-led policies on wages and consumption. In Chichilnisky (1983a) we examined how an increase in export affects export revenues of the South under different conditions, and showed that, with duality and abundant labor, the deterioration in the terms of trade of the South following an increase in exports leads also to lower export revenues. *In the new equilibrium the North imports more basic goods at a lower price, and exports a lower volume of industrial goods in exchange. In certain cases the North may actually increase its domestic consumption of both goods, basic and industrial, at the new equilibrium.*

In the South, the worsening of the terms of trade leads to fewer imports of industrial goods. The consumption of basic goods decreases in the South, and the volume of imported industrial goods available for investment decreases also. In this sense export-led growth under the conditions of technological duality and abundant labor may have a harmful impact on industrialization as well as on the satisfaction of basic needs. A continuation of export-led policies under these conditions does not seem propitious for sustained development. All these results occur in stable markets. They are proved in Chichilnisky (1981, 1983a).

With abundant labor and dual technologies, the international market appears, therefore, to concentrate rather than to diffuse the gains from trade. It is true that both regions are better off trading than they would be in isolation. But starting from one free trade position and moving to another with a higher volume of exports is not desirable for the South when there is abundant labor and dual technologies, $c_2/D < 2w/p_B$. An expansion of exports under these conditions may lower the welfare of the South and increase the welfare of the North in a sustained fashion. Obviously we cannot apply these results to compare autarky and free trade, since autarky is *not* a free trade equilibrium and here we are only comparing free trade equilibria with different trade levels. In cases where autarky is a limit of a sequence of free trade equilibria, it can be shown that the crucial condition $c_2/D - 2w/p_B$ becomes positive since the real wage w/p_B goes to zero. This means that in this particular case, more trade is initially beneficial but becomes more harmful as it expands. Note, however, that when there is a minimum wage w/p_B required for subsistence, there may be *no* export level at which c_2/D exceeds $2w/p_B$.

The above results seem more consistent than the standard Heckscher-Ohlin results with the overall international experience of the 1945–1970 period, a period in which there was an expansion of trade, accompanied by continued specialization and increasing wealth differentials between the industrial and the developing countries. It remains to evaluate the generality of the assumptions, both within the context of what is usually assumed in the body of economic theory and also in the context of the empirical data available, and this we shall discuss next.

The condition of duality in technologies of the South is rather general and has been tested for Sri Lanka, Mexico, and Argentina. However, the condition of labor abundance (α large) may be considered more stringent. For this reason we have also considered a version of the North-South model where labor is not necessarily very responsive to wages in the South, i.e., α may be small or even zero (see Chichilnisky 1983a). Here we make instead a different assumption, namely that the exported good is a "wage good", i.e. a good that constitutes the bulk of the consumption of wage earners ($wL = p_B B$ in equilibrium). This assumption acts as a substitute for the condition of labor abundance in producing the results. Therefore, an economy with dual technologies and which exports wage

goods is subject to the same harmful effects of export-led policies. Other extensions of the model were produced, leading to similar results, for cases where the country exports a labor-intensive good that is not consumed domestically (an export enclave), or where the country exports raw materials whose production is not labor intensive; see Chichilnisky (1981, 1982). It seems necessary, therefore, to correct the conditions that lead to negative outcomes before undertaking an export-led policy. If the conditions are intrinsically difficult to correct, it seems desirable to consider alternatives to export-led policies on labor-intensive products. This will be discussed in the last section.

We shall now discuss briefly the relationship of the assumptions and results of this model with the work of R. Prebisch and of W. A. Lewis mentioned earlier.

Prebisch (1950, 1959) developed a thesis that there is a systematic bias in the distribution of the gains from trade against developing countries, implied by a secular deterioration in the terms of trade of the South. While no formal model was presented, an economic basis for this process can be summarized as follows. Prebisch postulates that the income elasticity of international demand for exports from the South is low, while the demand for exports from the North is highly income elastic. Increases in income thus proportionately reduce the demand for exports from the South but increase the demand for exports from the North. This leads to a secular decrease in the price of exports of the South with respect to the exports of the North. Other arguments were also advanced about the role of noncompetitive agents, such as large corporations and unions in the North, in the decline in the relative price of exports from the South, and in the rise in income by the North. An important outcome of the Prebisch "terms-of-trade" thesis were the protectionist policies of import substitution in Latin America in the late fifties and the early sixties. These policies of imposed tariffs in order to protect certain domestic industrial sectors, such as manufactures and capital goods—the so-called infant industries.

Our approach is different from that of Prebisch both in assumptions and in results. In the first place, the North-South model makes no assumptions about the elasticities of international demands for the goods exported by the North and the South. Our assumptions are instead on *domestic structures*: technologies and factor markets within each region. Secondly, our model is consistent with perfectly competitive markets for goods and factors and, therefore, also differs from the assumption of Prebisch about noncompetitive agents in the North. Finally, with respect to policy, certainly the North-South model does not advocate the replacement of export-led growth by import substitution policies. This is because import substitution is a policy concerned only with the supply side of the economy, while in our work, instead, both supply *and* demand must be considered to evaluate the outcomes. Appropriate local demand structures

seem at least as important as changes in the supply side, to obtain beneficial outcomes.

We focus next on W. A. Lewis' celebrated model of economic development with unlimited supplies of labor (Lewis, 1952) and especially on his last section where he discusses development and trade. Lewis' model considers two regions trading with each other. One, the North, has the characteristics of a neoclassical economy. The other region, the South, is characterized by unlimited supplies of labor and a dual economy, a part of which is capitalistic and the other "traditional". Lewis' work, therefore, diverges from the neoclassical model as well as from our model, in that a rather different formalization is given to the economies of the North and of the South. The North is a perfect market economy, while the South has a rather different structure. In our model, instead, the behavior of both regions is consistent with perfect market behavior.

Clearly, the assumption of a high elasticity of labor supply in our model is linked with Lewis' assumption of unlimited supplies of labor. However, our assumption is substantially different; wages in the South *do* adjust with changes in market conditions. In Lewis' model, instead, wages are permanently pegged to the subsistence level. Another difference is that Lewis' model assumes that the economy is divided into a "capitalist" and a "traditional" sector. In the capitalist sector, the motive for employment is to generate profits, while in the traditional sector, labor is considered as essentially self-employed (as in the peasant family) or engaged in petty trade, or service occupations. The real wage in the capitalist sector is endogenously given, and it exceeds earnings available in the traditional sector, so that employment in the formal sector is constrained by demand only and not by supply. It is in this sense that Lewis speaks of "unlimited supplies of labor". Given the wage and technology, profit maximization determines the capital/labor ratio and the rate of profit and the size of the capital stock determines the level of employment in the capitalist sector. Each region produces three goods, one of which is common to both. The terms of trade between the two regions are determined purely by relative labor productivities in the common good, food, independently of demand conditions. Demand conditions are therefore not important in the Lewis' model. All these specifications contrast with the North-South model.

In the North-South model, instead, demand is rather important. It helps determine the variable level of real wages and it contributes to the understanding of the relationship between international market behavior (export levels) and domestic output and distribution of income. The international terms of trade are determined by supply and demand forces in both markets.

It is also of interest to contrast our model and the Heckscher-Ohlin model with that of Lewis. Lewis considers two different sectors, a capitalistic and a traditional one, each with different modes of behavior. Only

the capitalistic sector maximizes profits. Instead, in our economy, market behavior is consistent with the hypothesis of profit and utility maximization throughout. As in the Heckscher-Ohlin model, both economies produce, consume, and trade the same two goods, while Lewis considers three goods in each region, only one of which is shared by both regions (food). These features make Lewis' model difficult to compare directly with the two-region, two-good, and two-factor Heckscher-Ohlin model, and thus his results, while yielding different conclusions, do not necessarily contradict or support the standard results. By contrast, since our results are posed in a manner completely analogous to that of the Heckscher-Ohlin model, a more thorough comparison of assumptions and results is possible, and thus criticism can be formulated more precisely.

Finally, we compare the North-South model with the work of the Marxist economists and the *dependencia* theorists of Latin America. Both these groups give less importance to market behavior than we do. G. Frank concentrates on the secular trends in the international accumulation of capital as determining terms of trade, while our work does not produce results that predict any secular trends in this sense. However, if the labor market behavior that we study in our model could be related to the stages of the accumulation of capital of the South, then the deterioration in terms of trade that he predicts could be, in part, attributed to market forces. A. Emmanuel's unequal exchange work measures the terms of trade by the value of a unit of labor in the North relative to that of a unit of the South's labor. Trade between economies with different wage levels, in his conceptual scheme, must result in "exploitation" of the one with the lower wage. This view is, in certain cases, consistent with that of Lewis on factorial terms of trade. In Emmanuel's work (as in Lewis') the real wage is exogenously fixed in each country while, as explained above, in our model real wages adjust in relation to the international terms of trade and to all markets. This is a significant feature of our results.

Some points of contact exist between our work and that of the Latin American *dependencia* theorists. Firstly, as in Lewis' and in contrast to the Heckscher-Ohlin model, *dependencia* theory stresses certain asymmetries in the structures of the economies of the North and South. The existence of some asymmetries and of "the other region" having a large role in shaping the economies of each region is common to this work, although it is a matter of continued controversy within the *dependencia* school to what extent these asymmetries are *determinant* of the economic development patterns in the South. The Latin American economists also put some emphasis on duality in production. However, at the level of assumptions and structure, as pointed out earlier and also discussed by Palma (1978), neither formalization for consistency with competitive market behavior can be found in the *dependencia* theory literature. This is a major departure from our model.

At the level of results, or predictions, particular cases of differences

between the Latin American *dependencia* theory and our work are easily seen. For instance, as explained by Palma, *dependencia* theory never produced a clear answer to the problem of whether *dependencia* was favorable to growth or whether, instead, it leads inexorably to stagnation. In fact, opposing viewpoints on this matter have been proposed during the last 20 years within the *dependencia* school. (See the discussion in Tavares and Serra (1974).)

Our model, instead, can be utilized to resolve a related question; it can be used to examine those cases in which the growth of the North and its effects through trade, will be favorable and those in which it will be unfavorable to the growth of the South. This has been explored in Chichilnisky and Cole (1978) and Chichilnisky (1983).

5. Conclusions

The results discussed above pose doubts about the general reliance on export-led policies to satisfy basic needs in the South. When labor is very abundant and there is a significant level of duality in the production system of the South, an expansion of exports cannot be expected to improve consumption or real wages in the South. Nor can it be expected to increase total export revenues, so that redistributive policies would not provide a solution either. Furthermore, industrial imports decrease, so that these policies are not beneficial to industrialization either. A careful appraisal of each case, focusing especially on the parameters studied here, labor markets, technologies and domestic demand, seems to be in order before endorsing export-led strategies.

We may also view the results as supporting the need for a careful balance between domestic sectors and the export sector. The crucial duality condition that determines whether or not an expansion of exports is beneficial ($c_2/D < 2w/p_B$) depends on the level of real wages and this depends, in turn, on the current levels of exports. At different export levels, different policies will be recommended: when $c_2/D < 2w/p_B$, exports should contract; when $c_2/D > 2w/p_B$ they should expand. The conditions therefore aim to achieve optimum export levels, which depend on the domestic structure of the economy.

One conclusion is that the development of the South cannot, in general, be based on the relative advantage of cheap labor provided by extreme mass poverty. To the extent that such conditions are consistent with abundant and wage-responsive labor supply and with dual technologies, export-led policies may lead to serious deterioration of the terms of trade and to lower export revenues for the region.

If better income distributions are achieved that lead to larger and stronger domestic markets and these are accompanied by lower rates of population growth and thus less abundant labor, then the negative results of export-led policies may be reversed. *Basic needs policies may therefore improve the position of the developing country vis-a-vis international markets.*

It should be noted that the protection of local production, i.e. import substitution or infant industry protection, is neither a necessary nor a sufficient correction to the harmful effects of export-led policies. What is required is that local markets be strong in order to prevent deterioration of international terms of trade and of export revenues in the long run. The required "protection" must therefore be of the domestic market rather than of the infant industry alone and should lead to an improvement in the lot of the majority of people. In policy terms, since in a market or a semimarket economy the income of factors is related to their productivity, increases in productivity of the rural and other low-income groups in the economy seem necessary before reliance is put on export-led policies.

Increases in domestic labor productivity seem to be rather crucial towards this end. They lead to higher real wages, better domestic markets, and better terms of trade, as proved in Chichilnisky and McLeod (1983). This is consistent with Lewis' view that labor productivity in agriculture is an important determinant of the region's international terms of trade and the relative price of agriculture vs. industry. The experience of Japan, West Germany and South Korea, which were widely discussed in the seventies as having very successful export policies, seem to confirm our view. In all of these cases the domestic market was strong and the levels of wages, productivity, employment and consumption were all relatively high. The lack of success of Latin American export-led policies also confirms our views. Latin American policies have been based on cheap labor and poverty, both associated with low productivity, weak domestic markets and poor terms of trade for their products.

The results also indicate that a significant relationship exists between the North-South terms of trade and the distribution of income within the South. Better terms of trade with the North are linked with better distribution of income within the South. The international market is therefore an important factor in shaping domestic distributions within each region. The interaction of domestic and international factors should not be neglected, even with respect to variables that are often considered to be purely domestic, such as the distribution of income. *Basic needs are not only a domestic issue: they pertain to the international community as a whole.*

APPENDIX

This Appendix summarizes the North-South model of Chichilnisky 1981, 1983a) and computes the set of equilibria as a function of the initial data: production functions and supplies of factors. It also gives conditions for uniqueness of the solutions, and proves the main results quoted in the paper. A computer program for solving the model and the results of a number of simulations are also provided.

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*. This is a rather unusual and useful feature of the model: it allows one to derive in a simple algebraic fashion the solution and all of the comparative static properties of the model.

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:

$$p_B = a_1 w + c_1 r \tag{A.1}$$

$$p_I = a_2 w + c_2 r \tag{A.2}$$

Labor and capital supplies in equilibrium depend on their rewards:

$$L^S = \alpha\left(\frac{w}{p_B}\right) + \bar{L},\ \alpha \geqslant 0 \tag{A.3}$$

$$K^S = \beta r + \bar{K},\ \beta \geqslant 0 \tag{A.4}$$

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:

$$L^S = L^D \tag{A.5}$$

$$K^S = K^D \tag{A.6}$$

$$L^D = B^S a_1 + K^S a_2 \tag{A.7}$$

$$K^D = B^S c_1 + K^S c_2 \tag{A.8}$$

$$B^S = B^D + X_B^S, \text{ where } X_B^S \text{ denotes exports of } B \tag{A.9}$$

$$I^D = X_I^D + I^S, \text{ where } X_I^D \text{ denotes imports of } I \tag{A10}$$

and the balance of payments condition

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

where the superscripts S and D denote equilibrium supply and demand respectively. It is worth noticing that in an equilibrium, the Walras Law or National Income Identity is always satisfied in each region:

$$p_B B^D + p_I I^D = p_B(B^S - X_B^S) + p_I(I^S + X_I^D) = p_B B^S p_I I^S$$

$$= (a_1 w + c_1 r)B^S + (a_2 w + c_2 r)I^S = wL + rK \tag{W}$$

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

The North is specified by the same equations (A.1) to (A.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:

$$p_I(S) = p_I(N) \tag{A.12}$$

$$p_B(S) = p_B(N) \tag{A.13}$$

$$X_B^S(S) = X_B^D(N) \tag{A.14}$$

$$X_I^D(S) = X_I^S(N), \tag{A.15}$$

where the letters S and N in brackets denote South and North respectively.

In each region there are therefore *eight exogenous parameters*: a_1, c_1, a_2, c_2, α, $\bar{L}$, β, $\bar{K}$ and fourteen 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. There are eleven equations in each region (A.1 to A.11) plus four international market clearing equations (A.12 to A.15). Note that the balance of payments condition (A.11) for the North is automatically satisfied when (A.12) to (A.15) hold and then (A.11) is satisfied in the South. Therefore we have a total of twenty-five independent equations. To these we add a normalization condition

$$p_I = 1, \tag{A.16}$$

i.e. the industrial good is the numeraire, and thus obtain *a total of 26 independent equations for the North-South model.*

Since there are fourteen endogenous variables in each region, *we have 28 endogenous variables in total.* To fully determine the system we have to specify the values of two variables. This is not surprising since we have not so far defined the demand behavior at an equilibrium in either region. This can be done in several ways. One is to choose utility functions; another is to choose equilibrium levels of demand for one or the other good and a final alternative is to choose the demand for imports or for exports at an equilibrium. In Chichilnisky (1981) the equilibrium level of demand for industrial goods in the South is fixed exogenously:

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

thus leaving a system determined up to one variable. Alternatively, (A.17) can be substituted by the price dependent demand equation

$$p_B B^D = wL \tag{A.17'}$$

i.e. wage income is spent on the basic good. This is equivalent, in turn, to the assumption that capital income is spent on the industrial good, by the National Income Identity (W) given above

$$I^D = rK \tag{A.17''}$$

We parameterize the solutions in the first place by fixing the equilibrium level of *demand for industrial goods in the North.* Therefore, as the demand for industrial goods in the North $I^D(N)$ varies, we obtain a one-parameter family of equilibria. This family describes a path 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. For instance, Proposition 3 in Chichilnisky

$$r = \frac{a_1 - p_B a_2}{D} \tag{A.23}$$

In view of this we can rewrite (A.21) as a function of only one variable, namely the (relative) price of basics p_B, by substituting (A.3) and (A.4) and then (A.22) and (A.23) into (A.21). One obtains therefore a quadratic equation in the (relative) price of basic goods. This equation is parameterized by all the exogenous data, and by the industrial demand of the North $I^D(N)$:

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

where

$$A = \frac{\beta a_1 a_2}{D^2}, \quad V = \frac{\alpha c_1^2}{D^2},$$

and

$$C = \frac{1}{D}\left[c_1 \bar{L} - a_1 \bar{K} + \frac{\alpha c_1 c_2 - \beta a_1^2}{D}\right].$$

The parameters in expressions A, B and C are those of the South while $A(N)$, $B(N)$ and $C(N)$ are the same expressions but with parameters of the North.

Solving the quadratic equation (A.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. Therefore we call (A.24) a *resolving equation*. Since the constant and second order terms of this quadratic equation are positive and negative respectively, there is at most one (strictly) positive root which we denote $(p_B(I^D(N))$ to indicate its dependence on the parameter $I^D(N)$, the equilibrium level of industrial demand in the North.

PROPOSITION 1. *The North-South model has at most one equilibrium for each level of industrial demand $I^D(N)$ of the North.*

Proof. The proof is constructive. Equation (A.24) determines at most one (strictly) positive equilibrium price for basics, p_B^*, for each level of industrial demand in the North, $I^D(N)$.

We now indicate how each p_B^* defines unique equilibrium values of all the other 27 endogenous variables.

From the factor/commodity price equations (A.22) and (A.23) one obtains the equilibrium levels of wages and profits in the North and in the South. Note that these levels can be different in the two regions, since the parameters of their technologies are, in general, different. Factor prices determine the levels of employment of both factors in equilibrium, from (A.3) and A.4; this, in turn, yields output levels in equilibrium, from (A.19) and (A.20). We need only determine domestic demand for both goods in both regions. Demand for industrial goods in the South is an exogenous constant $I^D(S)$ (or else it equals $r \cdot K$, both of which are known by (A.23) and (A.4). In the North, I^D is fixed by our choice of $I^D(N)$.

From the National Income Identity (A.11), it is then simple to compute the demand for basic goods, since all other variables in this identity are already known in an equilibrium.

The difference between supply and demand for each good at an equilibrium yields exports, and imports of each good, in both regions. This completes the computation of the unique equilibria for the North-South model for each value of industrial demand in the North.

We consider now a different parameterization of the North-South model. The model is now defined by equations (A.1) to (A.11) in each region and (A.12) to (A.17), so we obtain as before a system of 27 equations in 28 variables. However, we now choose to parameterize the model by the equilibrium level of exports of the South $X_B^S(S)$, rather than by the industrial demand of the North. Since in equilibrium $X_B^S(S)$ equals the imports of the North $X_I^D(N)$, this parameter can be interpreted as an "import quota" of the North:

PROPOSITION 2. *The North-South model has at most one equilibrium for each level of exports of basics. This volume of exports may be set by an import quota in the North. As the import quota varies, a set of equilibria is described. This set 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 import quotas or by the industrial demand of the North.

Proof. Equation (A.24) ceases to be the most convenient way of finding an explicit solution, since now industrial demand in the North $I^D(N)$ is an endogenously determined variable.

An appropriate choice of equation to solve the North-South model parameterized by the level of exports $X_B^S(S)$, is the balance of payments condition (A.11).

$$X_I^D(S) = p_B X_B^S(S) + p_B X_B^D(N)$$

Since $X_I^D(S) = I^D(S) - I^S(S)$, we have:

$$\frac{I^D(S) - I^S(S)}{p_B} = X_B^D(N), \tag{A.25}$$

where the right-hand side variable is now exogenously given. We now reduce (A.25) to a quadratic expression in the price of basics, p_B.

As before, we express industrial supply as a function of employed factors:

$$\frac{I^D(S)}{p_B} = \frac{(a_1 K - c_1 L)}{p_B{}^D} = X_B^D(N). \tag{A.26}$$

Since by (A.3) and (A.4) the equilibrium levels of capital and labor employed are functions of wages and profits, and by (A.22) and (A.23) wages and profits are functions of the price of basics, by substitution into (A.26) we obtain:

$$p_B^2(A - X_B^D(N)) + p_B(C + I^D(S)) - V = 0 \qquad \text{(A.27)}$$

where A, V, and C are defined as in (A.24), all parameters for the South. Equation (A.27) is a quadratic expression in p_B which allows to solve the model analytically, and is therefore called a resolving equation. ($I^D(S)$ can be substituted as before for $I^D(S) = r(S) \cdot K(S)$, from eqn. (A.17)''.)

The resolving equation (A.27) appears to be different from the resolving equation (A.24) which was used to solve the model when this was parameterized, instead, by the equilibrium level of industrial demand in the North. However, it will now be shown that (A.27) is identical to (A.24); in particular, of course, they have the same solutions. To show this consider the difference between (A.24) and (A.27).

$$\text{(A.24)} - \text{(A.27)} = p_B^2(A(N)) + X_B^D(N)) + p_B(C(N) + I^D(N)) - V(N) \qquad \text{(A.28)}$$

We shall now show that this difference is identical to zero, by expanding the expression $p_B^2 X_B^D(N)$. In equilibrium,

$$X_B^D(N) = \frac{I^S(N) - I^D(N)}{p_B}, \text{ so that } p_B^2(X_B^D(N)) = p_B I^S(N) - p_B I^D(N). \qquad \text{(A.29)}$$

Substituting $I^S = (a_1 K - c_1 L)/D$ into (A.29), we obtain an expression for the value of industrial supply as a function of factors employed in the North:

$$p_B I^S(N) = \frac{p_B}{D(N)} (a_1(N)K(N) - c_1(N)L(N)). \qquad \text{(A.30)}$$

We may now substitute (A.3) and (A.4) and (A.22) and (A.23) into (A.30) to obtain an expression for $p_B I^S(N)$ depending only on the price of basics:

$$p_B I^S(N) = \frac{p_B}{D}\left[Ka_1 - Lc_1 - \frac{\alpha c_1 c_2 - \beta a_1^2}{D}\right] - p_B^2\left[\frac{a_1 a_2 \beta}{D^2}\right] + \frac{\alpha c_1^2}{D^2}, \qquad \text{(A.31)}$$

where all parameters are for the North. Thus,

$$p_B I^S(N) = - p_B C(N) - p_B^2 A(N) + V(N).$$

where $A(N)$, $C(N)$ and $V(N)$ were defined above. We may therefore rewrite $p_B^2 X_B^D(N)$ in (A.29) as:

$$p_B^2(X_B^D(N)) = - p_B I^D(N) - p_B^2 A(N) - p_B(C(N) + V(N)), \qquad \text{(A.32)}$$

from which it is immediately apparent upon inspection of (A.28) that the difference (A.24)−(A.27) is identically equal to zero. Therefore, the quadratic expressions (A.24) and (A.27) give exactly the same solutions to the North-South model. This shows that the model has the some solutions whether it is parameterized by industrial demand in the North or by exports of the South.

It is now necessary to show that the comparative statics properties of the North-South model are the same with both parameterizations. Com-

parative statics involves studying the signs of derivatives of one endogenous variable with respect to a parameter or to another enodogenous variable, across equilibria. For instance, we study the changes in the price of basics (an endogenous variable) as exports X_B^S vary, indicated by dp/dX_B^S. The tool used is the implicit function theorem, applied to an equilibrium expression $\psi(p, X_B^S) = 0$, which leads to $dp/dX_B^S = -d\psi/dX_B^S/d\psi/dp$. The equilibrium expression $\psi = 0$ used when industrial demand is the parameter is (A.24) = 0; when the parameter is the level of imports X_B^S the expression is instead (27) = 0. However, as we have just shown, (A.24) and (A.27) are identical, so it is equivalent to use either one or the other expression. Therefore, *parameterizing the model by the import quota $X_B^D(N)$, or by the industrial demand in the North $I^D(N)$, yields identical comparative statics properties.* This completes the proof.

We now prove two comparative statics results. Following these, a program in BASIC for the North-South model and also numerical simulations which reproduce the propositions below are given.

PROPOSITION 3. *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.* [This is Proposition 1 in Chichilnisky (1981).]

When labor is abundant and real wages are low, or else technologies are sufficiently homogeneous that $c_2/D > 2w/p_B$, than 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. [This is Proposition 2 in Chichilnisky (1981).]

Proof. It suffices to apply the implicit function theorem to the quadratic expression (A.27), $p_B^2(A - X_B^S(S)) + p_B(C + I^D(S)) - V = 0$, which is identically satisfied across the equilibria. We thus obtain:

$$\frac{dp_B}{dX_B^S} = \frac{p_B}{2p_B(A - X_B^S) + C + I^D(S)}, \tag{A.33}$$

where all parameters, unless otherwise indicated, are from the South. The sign of (A.33) is that of $2p_B(A - X_B^S) + C + I^D(S)$, where A and C were defined in (A.27). Since α is large, the sign of (A.33) will be determined by those terms containing α. In A there are no terms in α; in C, the term is $\alpha c_1 c_2/D^2$; therefore (A.33) is negative whenever

$$2p_B X_B^S > \frac{\alpha c_1 c_2}{D^2}. \tag{A.34}$$

From Chichilnisky (1981), pages 175 and 176, we obtain an expression for X_B^S, the volume of exports and the price of basics across equilibria:

$$X_B^S = \frac{c_2 L - a_2 K}{D} - \frac{wL + rK - I^D(S)}{p_B} \tag{A.35}$$

$$= \frac{\alpha c_1}{D^2 p_B}\left[c_2 - \frac{c_1}{p_B}\right] + \frac{\beta a_1}{D^2}\left[a_2 - \frac{a_1}{p_B}\right] + \frac{(c_1 L - a_1 K)}{D p_B} + \frac{I^D(S)}{p_B}.$$

When α is large, the term that dominates the expression for X_B^S is $\alpha c_1(c_2 - c_1/p_B)/D^2 p_B$. Therefore, from (A.34) dp_B/dX_B^S is negative when $2p_B X_B^S 2\alpha c_1(c_2 - c_1/p_B)/D^2 > \alpha c_1 c_2/D^2$, i.e., when $c_2 > 2c_1/p_B$, which is equivalent to $c_2/D < 2w/p_B$ (Chichilnisky (1981), p. 177). Note that Chichilnisky (1981) gave a different proof, using (A.35) rather than (A.33) to compute the derivative dX_B^S/dp. From (A.35) one obtains

$$\frac{dX_B^S}{dp_B} = \frac{\alpha c_1}{D^2 p_B^2}\left[\frac{2c_1}{p_B} - c_2\right] + \frac{\beta a_1^2}{D^2 p_B^2} + \frac{a_1 K - c_1 L}{p_B^2} - \frac{I^D(S)}{p_B^2} \qquad \text{(A.36)}$$

Therefore, when α is large (A.36) implies that dX_B^S/dp_B is negative when $2c_1/p_B < c_2$, i.e. when $c_1/D < 2w/p_B$, which is identical to the condition derived from eqn. (A.33). Thus, exports increase only when their price p_B drops, across equilibria. Therefore, the two proofs yield exactly the same results. This completes the proof of Proposition 1 of Chichilnisky (1981).

The proof of Proposition 2 of Chichilnisky (1981) now follows immediately. We saw that the sign of dp_B/dX_B^S is that of $2c_1/p_B - c_2$, or equivalently that of $c_2/D - 2\omega/p_B$. Since $2c_1/p_B > c_2$ is equivalent to $c_2/D > 2w/p_B$, the proposition is proved.

PROPOSITION 4. (Proposition 3 in Chichilnisky (1981)). *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 leads to a higher level of exports of basics from the South, and to lower terms of trade, real wages and domestic consumption in the South. This occurs in Walrasian stable markets.*

Proof. For this comparative statics result, we use the first resolving equation (A.24), which gives an implicit relation between the equilibrium price of basics p_B and the equilibrium level of industrials in the North, $I^D(N)$ and, contains all the parameters of the model. From equation (A.24), by the implicit function theorem we obtain:

$$\frac{\partial p_B}{\partial I^D(N)} = -\frac{p_B}{2p_B(A + A(N)) + (C + C(N)) + I^D(S) + I^D(N)}$$

where A and C are defined in (A.24).

When α is large in the South, the sign of the term in α determines the sign of $C + C(N)$. Since the term in α within $C + C(N)$ is $\alpha c_1 c_2/D^2$, a positive number, $C + C(N)$ is positive in this case. Furthermore, A and $A(N)$ are always positive. It follows that

$$dp_B/dI^D(N) < 0 \qquad \text{(A.37)}$$

when α in the South is large. Therefore when α is large *an increase in the equilibrium level of industrial demand in the* North *leads to a drop in the equilibrium price of basics.*

Now, consider the equilibrium equation (A.35) relating exports of basics with their price

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

where all parameters are from the South. When α is large, the terms in α dominate dX_B^S/dp_B. From (A.36) these are $(\alpha c_1(2c_1/p_B - c_2))/D^2p_B^2$. Now, $2c_1/p_B < c_2$ if and only if $c_2/D < 2w/p_B$ (Chichilnisky (1981), p. 177). therefore as seen above

$$dX_B^S/dp_B < 0 \text{ when } c_2/D < 2w/p_B.$$

Added to (A.37), this implies $dX_B^S/dI^D(N) > 0$. To summarize: *a move to an equilibrium with higher level of industrial demand in the North* (i.e. an increase in the parameter $I^D(N)$) *leads to a larger volume of imports of basic goods by the North* (*higher* X_B^S) *and to lower terms of trade for the South* (*lower* p_B).

To complete the comparative statics results, it suffices now to point out that real wages w/p_B are always positively associated with the price of basics (by (A.22)) and that the consumption of B is also positively associated with the price of basics in the South when α is large. This is because $B^D = (wL + rK - I^D(S))/p_B$, and 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. Stability was established in the appendix of Chichilnisky (1981) and is discussed further in Arrow (1982), Heal and McLeod (1983) and Chichilnisky (1983).

The next result explores the changes in *export revenues* that follow an increase in exports.

PROPOSITION 5. *In the North-South economy, 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 volume of exports leads not only to lower terms of trade but also to lower export revenues in the South.*

Proof. By Proposition 4, as the level of exports X_B^S increases, the South's terms of trade p_B drop at the new equilibrium. By (A.22) and (A.23), wages decrease and the rate of profit increases. This implies from (3) and (4) that total capital available increases, and labor employed decreases. Therefore, the domestic supply of industrial goods I^S increases, since by (A.20), $I^S = (a_1K - c_1L)/D$. Since the industrial demand in the South is constant by (17), and the supply I^S has increased, the volume of imports of industrial goods $X_I^D(S) = I^D(S) - I^S(S)$ must therefore decrease when the price of basics drops. Therefore, by the balance of payments condition $p_BX_B^S = X_I^D$, the total revenue from exports, $p_BX_B^S$, has decreased. This completes the proof.

The next proposition studies macro changes in *both* regions, following either an increase of exports X_B^S, or an industrial expansion in the North, i.e. an increase in $I^D(N)$. The results of this proposition are numerically simulated in the computer runs below.

PROPOSITION 6: *Assume the conditions of Proposition 5, that labor supply in the North is unresponsive to the real wage* ($\alpha(N)$ *small*) *and that indus-*

trial goods in the North use little labor (α_2 small). Then a move to a new equilibrium with a higher level of industrial demand in the North leads to a higher consumption of basic goods in the North. The North consumes simultaneously more of both goods and is therefore strictly better off.

In the South, real wages and consumption decrease. The South exports more basics, at lower prices; and receives lower export revenues. The South is strictly worse off at the new equilibrium.

Identical results obtain when the move to a new equilibrium is due to an increase in the level of exports of the South, $X_B^S(S)$, or in the export quotas of basics in the North, $X_B^D(N)$.

Proof. Consider first the case where in the North $\alpha(N) = 0$ and $\alpha_2(N) = 0$. The supply of basics in the North is then a constant, since

$$B^S = (c_2 L - a_2 K)/D = c_2 \bar{L}/D \text{ when } \alpha = a_2 = 0$$

Since the consumption of basics of the North is the sum of domestic supply plus imports $B^D(N) = B^S(N) + X_B^D(N)$ and $B^S(N)$ is a constant, when imports of basics $X_B^D(N)$ increase, the level of consumption of basics in the North increases as well.

Proposition 4 shows that, under the conditions specified, a move to an equilibrium with a higher level of industrial demand in the North $I^D(N)$ leads to more exports of basics $X_B^S(S) = X_B^D(N)$. Therefore, this leads here to an increase in the consumption of basics in the North. The demands for industrial goods $I^D(N)$ and for basics $B^D(N)$ have therefore increased simultaneously at the new equilibrium of the North: by any reasonable welfare measure, the North is strictly better off. By continuity, the same results obtain when $a_2(N)$ and $\alpha(N)$ are close to zero, proving the first part of the theorem.

In the South, export revenues decrease as shown in Proposition 5 above. As the terms of trade p_B decrease, real wages and the consumption of basics decrease in the South, as shown in Proposition 4. Since industrial demand remains constant in the South, the South is strictly worse off.

The last statement in the proposition follows from Proposition 2, which establishes that parameterizing either by the level of exports X_B^S or by the level of industrial demand in the North $I^D(N)$ leads to the same comparative statics results. This completes the proof.

We now turn to extensions of the model. These allow us to obtain similar results for economies that may not have abundant labor. The extensions proposed here were formulated in Chichilnisky and Cole (1978), and also discussed in Chichilnisky (1981, p. 179).

An Extension of the North-South Model

The North-South model presented earlier is now altered in a rather simple fashion. The change is in the specification of demand in the South. Rather than assuming that the equilibrium level of industrial demand in the South is a given constant, we assume instead that in equilibrium, wage

income in the South is spent on the basic good. This entails replacing eqn. (A.17), i.e., $I^D(S) = \bar{I}^D(S)$, by the equation

$$p_B B^D = wL \qquad \text{(A.17)'}$$

This "North-South model II" consists therefore of the same equations (A.1)–(A.11) for each country, (A.12)–(A.16) and eqn. (A.17)' replacing (A.17). This is a total of 27 equations in 28 variables. The model has therefore a unique solution when we determine *one* variable, such as the levels of exports of the South $X_B^S(S)$, or of industrial demand in the North $I^D(N)$.

PROPOSITION 7. *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 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,* $c_2/D < 2w/p_B + \bar{L}$.

Proof. Consider the equation for the equilibrium volume of exports $X_B^S(S) = B^S(S) - B^D(S)$. From (A.19), $B^S = (c_2 L - a_2 K)/D$ and by (A.17)' $B^D = wL/p_B$. We may therefore rewrite $X_B^S = B^S - B^D$, substituting for L and K from (A.3) and (A.4), and obtain

$$\frac{dX_B^S}{dw/p_B} = \alpha(c_2/D - 2w/p_B)\,\bar{L}$$

When $\bar{L}=0$, the necessary and sufficient condition for dX_B^S/dp_B to be negative is $c_2/D < 2w/p_B$. When $\bar{L} \neq 0$, we obtain, instead, $c_2/D < 2w/p_B + \bar{L}$.

To complete the proof, note that the real wage is an increasing function of the price of basics across equilibria. This derives from the equilibrium relation (A.22):

$$w/p_B = c_2/D - c_1/p_B D, \text{ which implies } d\left[\frac{w}{p_B}\right]/dp_B = c_1/p_B^2 D > 0$$

Finally, the consumption of basics is an increasing function of the real wage across equilibria, since $B^D = w/p_B L = \alpha(w/p_B)^2 + w/p_B \bar{L}$ by (A.3). This completes the proof.

The following proposition obtains results analogous to those of Proposition 4, but for the North-South model II: the model is now parameterized by the North's industrial demand $I^D(N)$ rather than the volume of exports of the South.

PROPOSITION 8. *Consider a North-South economy II, where the capital stock in the South is fixed* ($K = \bar{K}$) *and* $L = \alpha w/p_B$ ($\bar{L} = 0$). *Then an increase in the North's industrial demand leads to an increase in exports and to lower terms of trade, lower 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* $c_2/D < 2w/p_B + \bar{L}$. *Furthermore, if the rate of profit*

in the South is sufficiently low that $r < a_1/D$, *an increase in exports lowers also total export revenues of the South.*

The consumption of basics and of industrial goods increases simultaneously in the North provided industrial goods use little labor ($\alpha_2(N)$ *small*), *and labor is rather unresponsive to the real wage* ($\alpha(N)$ *small*).

Proof. Firstly we study the relationship between the equilibrium price of basics and the level of industrial demand of the North. Since Walras' Law is always satisfied in an equilibrium, $p_B B^D + I^D = wL + rK$ and by assumption $p_B B^D = wL$, it follows that

$$I^D = rK = \beta r^2 + r\bar{K} \tag{A.38}$$

Across equilibria, therefore,

$$\frac{dr}{dI^D} = \frac{1}{2r\beta + \bar{K}} > 0 \tag{A.39}$$

Furthermore, from (23), across equilibria

$$\frac{dr}{dp_B} = \frac{-a_2}{D} < 0 \tag{A.40}$$

Therefore, from (39) and (40), it follows that

$$\frac{dp_B}{dI^D(N)} < 0$$

i.e. an increase in the industrial demand in the North decreases the price of basics.

We have already proved in Proposition 7 that the necessary, and sufficient condition for a negative association of export levels and the price of basics is duality in the South: $c_2/D < 2w/p_B$ when $\bar{L} = 0$ or $c_2/D < 2w/p_B + \bar{L}$ when $\bar{L} \neq 0$. Therefore since p_B is negatively associated with $I^D(N)$, these two conditions are also necessary and sufficient for an *increase* in exports and for a simultaneous *decrease* in the terms of trade of the South, as the industrial demand in the North increases. Since Proposition 7 showed that real wages and consumption of basics in the South both decrease with the price of basics, this completes the first part of the proof.

Next consider the condition on profits, $r < a_1/D$. Imports of the South are given by

$$X_I^D(S) = I^D(S) - I^S(S) = rK - (a_1K - c_2L)/D = (r - a_1/D)K + (c_1/D)L$$

It follows that

$$dX_I^D(S)/dp_B = (r - a_1/D)dK/dp_B + (c_1/D)(dL/dp_B)$$

By assumption $r < a_1/D$; since $dK/dp_B < 0$ and $dL/dp_B > 0$, it follows that $dX_I^D(S)/dp_B > 0$, i.e. the imports of the South decrease as the price of basics drops, across equilibria. By the balance of payments condition, total export revenues $p_B X_B^S(S)$ equal the value of imports $X_I^D(S)$. Therefore we have proved that export revenues fall with a decrease in the price of basics, across equilibria.

Finally, under the specified conditions, the consumption of basics will increase in the North following an expansion in industrial demand whenever $a_2(N)$ is small and $\alpha(N)$ is small, as proved in Proposition 6. This completes the proof.

The North-South Model with Fixed Endowments

The last two propositions in this appendix consider economies with fixed endowments, i.e. $K = \bar{K}$ and $L = \bar{L}(\alpha = \beta = 0)$. These propositions were suggested by comments made by Ron Jones. Proposition 9 refers to the basic North-South model and Proposition 10 to version II of the model.

PROPOSITION 9: *Consider a North-South model, with fixed factor endowments and a large labor supply $\bar{L}$ in the South. 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 also leads to lower real wages and consumption of basics in the South*

Proof. When $\alpha = 0$ and $\beta = 0$, the cross-equilibria relation (A.35) between exports and their price p_B is

$$X_B^S = (c_2\bar{L} - a_2\bar{K})/D - \left[\frac{w\bar{L} + r\bar{K} - I^D(S)}{p_B}\right]$$

$$= (c_2/D - w/p_B)\bar{L} - (a_2/D + \tau/p_B)\bar{K} + I^D/p_B$$

Substituting w and r from (A.22) and (A.23), we obtain

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

so that

$$dX_B^S/dp_B = (a_1\bar{K} - c_1\bar{L})/Dp_B^2 - I^D(S)/p_B$$

which is always negative when $\bar{L}$ is large. Furthermore, as the price of basics drops, the real wage, by (A.22), drops as well. Also, the consumption of basic goods, $B^D = (w\bar{L} + r\bar{K} - I^D(S))/p_B$, also decreases when $\bar{L}$ is large, since the sign of dB^D/dp^B is dominated by the expression $\bar{L}(dw/p_B)/(dp_B)$, which is positive by (A.22). This completes the proof.

PROPOSITION 10. *Consider a North-South model II with fixed factor endowments in the South. 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. It also leads to a drop in real wages and in the consumption of the wage good in the South. However, in the new equilibrium, the South imports more industrial goods.*

Proof. In the North-South model II, we have

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

i.e.,

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

By substitution from (A.22) this equals

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

so that

$$dX_B^S/dp_B = -c_1\bar{L}/p_B^2D$$

which is always negative. Therefore, a move to an equilibrium with increased exports of the wage good leads *always* to a decrease in their price, p_B. By eqn. (A.22), $w/p_B = c_2/D - c_1/p_BD$, so that the real wage decreases and domestic demand for wage goods, being $B^D = w\bar{L}/p_B = (c_2/D - (c_1/p_BD))\bar{L}$ also decreases, as $dB^D/dp_B = c_1\bar{L}/p_B^2D > 0$. We show finally that imports of industrial goods increase. Consider the domestic demand for industrial goods in the South: in this case this is $I^D = r\bar{K}$. Since p_B decreases following the export expansion, the new equilibrium profits r are higher, by (A.23). Therefore industrial demand I^D increases in the South. However, since factor endowments are constant, industrial supply I^S has not changed. Therefore, the higher level demand of industrial goods at the new equilibrium must be due to increased imports of industrial goods. This completes the proof.

A Basic Program for Solving the North-South Model

We present here a program in BASIC for solving the North-South model and the results of several computer runs that numerically reproduce comparative statics propositions. These were produced by Eduardo-Jose Chichilnisky.

Computer Code Names for the Variables and Parameter

Variables and Parameters (North and South)	Computer Code	
	South	North
α	MS	MN
β	NS	NN
α_1	A1	A3
α_2	A2	A4
c_1	C1	C3
c_2	C2	C4
$\bar{L}$	LS	L (not LN)
$\bar{K}$	KS	KN
D	DS	DN
A	AS	AN
V	VS	VN
C	CS	CN
W	WS	WN
r	RS	RN

(contd.)

Variables and Parameters (North and South)	Computer Code	
	South	North
L	L1	L2
K_s	K1	K2
B_D	B3	B4
B_S	B1	B2
I_D	I3	I4
I_S	I1	I2
X_g^s	X1	−X1
X_I^D	X2	−X2

Computer runs:

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	1.8	1.7	0.5	12	3.13

$I^D(S) = 400$

RUN 1 $I^D(N) = 6.00$ *RUN* 2 $I^D(N) = 7.00$

SOLUTIONS: ENDOGENOUS VARIABLE

	SOUTH		NORTH	
	Run 1	Run 2	Run 1	Run 2
p_g	3.252	1.721	3.252	1.721
w	0.7232	0.3818	1.194	0.3598
w/p_g	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_s	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_g^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
$c_2/D - 2w/p_g$	−0.2218	−0.2214	−.1901	0.1251

Program Listing in BASIC;

```
1000 INPUT "SOUTH:ALPHA,BETA,A1,A2?";MS,NS,A1,A2
1010 INPUT "SOUTH:C1,C2,L*,K*?";C1,C2,LS,KS
1020 INPUT "NORTH:ALPHA,BETA,A1,A2?";MN,NN,A3,A4
1030 INPUT "NORTH:C1,C2;L*,K*?";C3,C4,L,KN
1040 LF2:TEXT:CSIZE1:LPRINT "PARAMETERS":LF1
1050 LPRINT "SOUTH:";MS;",";NS;",";A1;",";A2
1060 LPRINT TAB6;C1;",";C2;",";LS;",";KS:LF1
1070 LPRINT "NORTH:";NN;",",NN;",",A3;",";A4
1080 LPRINT TAB6;C3;",";C4;",";L;",";KN:LF1
1090 INPUT "ID(S)?";I1
1100 INPUT "ID(N)?;I2:LF2
1110 DS = A1*C2−A2*C1:DN=A3*C4−A4*C3
1115 IF DS = 0 THEN 1500:IF DN = 5 THEN 1500
1120 AS = NS*A1*A2/(DS*DS):AN = NN*A3*A4/(DN*DN)
1230 VS = MS*C1*CS/(DS*DS):VN = MN*C3*C3/(DN*DN)
1040 CS = (1/(DS*DS))*(DS*(C1*LS−A1*KS)+MS*C1*C2−NS*A1*A2)
1150 CN = (1/(DN*DN))*(DN*(C3*L−A3*KN)+MN*C3*C4−NN*A3*A3)
1160 J = CS*CN+I1+I2:K=J*J+4*(VS+VN)*(AS+AN)
1170 IF K < 0 THEN GOTO 1500
1180 PB = (−J+√K)/(2*(AS+AN))
1190 WS = (PB*C2−C1)/DS:WN = (PB*C4−C3)/DN
1200 RS = (A1−PB*A2)DN:RN = (A3−PB*A4)/DN
1210 L1 = MS*WS/PB+LS:L2 = MN*WN/PB*L
1220 K1 = NS*RS+KS:K2 =NN*RN+KN
1230 I3 = (A1*K1−C1*L1)DS:I4 = (A3*K2−C3*L2)/DN
1240 B1 = (WS*L1+RS*K1−I1)/PB:B2 = (WN*L2+RN*K2−I2)/PB
1250 B3 = (C2*L1−A2*K1)/DS:B4 = (C4*L2−A4*K2)/DN
1260 XI = B3−B1:X2 = PB*XI
1265 LPRINT TAB6;"PB=";PB:LF2
1270 LPRINT "SOUTH:";TAB18;"NORTH:"LF1
1272 LPRINT TAB16;"W":LF1
1274 LPRINT WS;TAB18;WN:LF1
1280 LPRINT TAB15;"W/PB":LF1
```

```
1290 LPRINT WS/PB;TAB18;WN/PB:LF1
1300 LPRINT TAB16;"R":LF1
1310 LPRINTRS; TAB18;RN:LF1
1320 LPRINT TAB16;"L";LF1
1330 LPRINTL1;PAB18;L2;LF1
1340 LPRINT TAB16;"K":LF1
1350 LPRINT K1;TAB18;K2:LF1
1360 LPRINT TAB16;"BS":LF1
1370 LPRINT B3;TAB18;B4:LF1
1380 LPRINT TAB16;"BD":LF1
1390 LPRINTB1;TAB18; B2:LF1
1400 LPRINT TAB16: "IS";LF1
1410 LPRINTI3;TAB18;I4:LF1
1420 LPRINT TAB16;"ID":LF1
1430 LPRINTI1;TAB18;I2:LF2
1440 LPRINT "XSB(S)=";X1:LF1
1450 LPRINT"XDI(S)=";X2
1460 GOTO 1100
1500 LPRINT "DETERMINANT IS ZERO"
1999 END
```

Simulation of Comparative Statics Results

Runs 1 and 2 above reproduce numerically the results of Propositions 3, 4, 5, and 6 of this appendix, and Propositions 1 and 3 of Chichilnisky (1981).

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 $D(N) = 3.13$.

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 it is increased to 7.00 in the second run.

As proved in Proposition 3 of Chichilnisky (1981) and Proposition 4 of this appendix, this increase in the value of $I^D(N)$ has the following general equilibrium effects: Exports of basic goods in the South, X_B^S, *increase* from 0.9541 to 1.806; the price of basics p_B *decreases* from 3.252 to 1.721;

wages in the South *decrease* from 0.7232 to 0.3818, and consumption of basics in the South *decrease* from 2.297 to 1.443. As proved in Proposition 4 of this appendix, total export revenues of the South *decrease* also (even though export volume has increased) from 3.10810 to 3.10807.

These runs confirm also Proposition 1 of Chichilnisky (1981) and Proposition 3 of this appendix, since changing exogenously the export volume X_B^S from 0.9541 to 1.806 and leaving $I^D(N)$ to be determined endogenously, leads to the same solutions of runs 1 and 2. Therefore, as proved in Proposition 1 of Chichilnisky (1981) when exports of the South *increase*, in a new equilibrium the price of basics, real wages and consumption of basics in the South all *decrease*.

Finally, these runs illustrate the results of Proposition 6 of this appendix: following an exogenous *increase* in industrial demand $I^D(N)$, the North's demand for basics *increases* as well, from 1.621 to 1.925. Thus, an industrial expansion in the North (a higher $I^D(N)$) leads it to consume more of both goods simultaneously, so that the North's welfare strictly increases. The South, instead, exports more basics, at lower prices, and consumes less basics at home. Real wages decrease in the South. Since $I^D(S)$ remains constant, the welfare of the South strictly *decreases*.

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