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A Model of World Supply, Demand, and Trade in Differentiated Products

Prepared by Daniel Gros*

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Abstract

The paper develops a two-country model of trade in differentiated products and contrasts the determinants of, and inter-relationships between, trade and competitiveness in the short run (when wage rates and the exchange rate are fixed), the intermediate run (when wages and the exchange rate are flexible, but the number of firms is fixed), and the long run (when all variables can adjust). The two-country general-equilibrium model yields predictions that differ considerably from those obtained from comparable small-country models and describes how and why the relationship between the trade balance and competitiveness might vary over time.

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*This paper was written while the author was a member of the Research Department. He is currently at the Universite Catholique de Louvain and the Centre for European Policy Studies in Belgium.

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Summary

This paper presents a model of world trade that distinguishes how trade and competitiveness are determined and interrelated over different time horizons. The features of the model--product differentiation, nonconstant returns to scale, and monopolistic competition--should make it useful in analyzing trade between industrial countries. The main contribution of the paper, however, is its use of a two-country general equilibrium approach. In contrast, most systems of international trade equations currently in use, including the World Trade Model of the Fund, rely on a partial equilibrium approach and the small country assumption.

For purposes of short-run analysis, the model developed in this paper supports the conclusions reached using the partial equilibrium approach and the small country assumption. In particular, under the short-run assumption of fixed or predetermined nominal wages and exchange rates, it is possible to determine world trade and relative prices using only assumptions about wages, exchange rates, and real expenditures in each country.

With regard to analysis over an intermediate horizon, this paper shows that if there is a world resource constraint in the form of a fixed level of employment, and if wages adjust to clear labor markets, then it is no longer possible to make arbitrary assumptions about real expenditures in each country. In this context, real expenditure in one country can rise only if expenditure in other countries falls, and the distribution of worldwide expenditure is a determinant of international trade flows and relative prices. Thus, real expenditure and relative prices cannot be regarded as two independent determinants of trade flows. From another perspective, the contrast between the results under short-run conditions of fixed exchange rates and wages with variable employment, and under the intermediate-run conditions of flexible prices and full employment suggests that the correlations between changes in trade flows and changes in the terms of trade may vary over time, depending on the relative degrees of slack in labor markets and the flexibility in wage rates and other prices.

An attractive feature of the model is that it yields simple results in elasticity or semi-elasticity form. This makes it possible to determine the influences on trade and competitiveness of such factors as demand and supply elasticities, openness, and country size. The transparency of its general equilibrium results should thus make the model useful in discussions of the determinants of world trade and relative prices--discussions that should take into account global equilibrium effects and not be limited to the simple summation of small country effects.

I. Introduction

This paper analyzes the determinants of, and inter-relationships between, trade and competitiveness in the context of a two-country model of trade in differentiated products. The analysis distinguishes between the determinants and interrelationship in the short run (i.e., under the assumption that wage rates and the exchange rate are fixed), in the intermediate run (i.e., under the assumption that the exchange rate is flexible and labor markets clear, but the number of firms in each sector is fixed), and in the long run (i.e., when everything can adjust). The two-country general equilibrium aspects of the model are shown to lead to results that differ considerably from the ones obtained for a comparable small-country model.

Although the model developed in this paper is simplified in many respects, it provides an appreciation for the limitations of analysis based on systems of international trade equations in isolation from a general equilibrium famework, including analysis based on the World Trade Model used at the International Monetary Fund in the World Economic Outlook (WEO) exercise. 1/ The two relationships that serve as the basic building blocks of such models--namely, the price and volume equations for exports and imports--are derived using a partial equilibrium approach and the small-country assumption, without taking into account any global general equilibrium effects. Somewhat surprisingly, however, the model developed in this paper, which does take general equilibrium effects into account, yields results that in some respects are quite similar to those of the World Trade Model when it is assumed that exchange rates and wages are fixed in the short run; see Appendix I. 2/ In this case, it is possible to determine world trade simply on the basis of assumptions about wages, exchange rates, and real expenditures in each country.

Taking into account general equilibrium effects also shows that the World Trade Model, as many other systems of international trade equations used in isolation from a general equilibrium model, does not adequately describe trade over a time horizon in which wages adjust to clear labor markets. The reason for this is that with clearing labor markets, global real demand is constrained by the available resource supply, and it is no longer possible to regard the levels of relative prices and real expenditures as independent determinants of trade.

1/ For descriptions of the World Trade Model, see Deppler and Ripley (1978), and Spencer (1984).

2/ Appendix I shows that the model used here yields a partial equilibrium price equation that is similar to the one used in the World Trade Model.

This paper uses specific functional forms for preferences and technology, which embody a demand for differentiated products 1/ and non-constant returns to scale in the production of each product. This allows one to derive all demand and supply functions from utility and profit maximization and to calculate income and price elasticities for exports and imports as functions of country size and various demand and supply parameters. The analysis shows that these elasticities are also functions of the time horizon under consideration. The paper distinguishes three time horizons, corresponding to different assumptions about the variables that can adjust within each time horizon.

In the first and shortest time horizon, it is assumed that nominal wages are fixed, that the authorities can set the nominal exchange rate, and that real expenditure levels are exogenous. Under these assumptions, relative prices are determined only by the exchange rate, and the exogenous factors determining trade are the levels of relative prices and real expenditures. In this case labor markets no longer clear, and employment is demand determined. The effects of changes in relative prices and real expenditure levels on trade are calculated in the form of elasticities (or semi-elasticities). These elasticities are, in general, a function of the size of the home country (relative to the rest of the world), the degree of openness of the home economy, and the elasticity of demand for tradable goods. In general, the bigger or the less open a country, the less it will be affected by external influences such as changes in competitiveness (i.e., relative prices) or changes in real expenditure abroad.

In the second and intermediate time horizon, it is assumed that labor markets clear. Employment is then equal to the labor supply, but the number of firms in each sector is taken as fixed. In this case competitiveness and real expenditure become interdependent and can no longer be interpreted as having independent effects on trade. Total

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1/ In the macroeconomic literature, it is often implicitly assumed that consumers differentiate among goods on the basis of the country of production, so that even a small country has some monopoly power. At the same time, it is also assumed that there are many producers in each country who produce the "national" good under perfectly competitive conditions, i.e., without using the monopoly power they would have if they acted collusively. This type of model has two serious drawbacks, although it leads to short-run results that are qualitatively similar to the results of this paper. The first drawback is that the rationale for product differentiation is not very convincing. Why should consumers distinguish only between goods produced in different countries, rather than between goods produced in different regions or different continents? A second drawback is that this type of model usually implies that no country can grow faster than its competitors without a continuous deterioration of its terms of trade, which is contrary to the experience of the fast growing East Asian countries.

world expenditure is given by the available resources and only its distribution across countries can change. The relationship between the trade balance and competitiveness is again a function of openness and size, but a given deterioration of competitiveness would be related to a stronger deterioration of the trade balance than in the first case.

In the third and longest time horizon, even the number of firms can adjust. The zero profit condition then determines the level of output of each firm. In this case, the supply function for each category of goods becomes horizontal because additional demand can be satisfied at a constant marginal cost by new firms that are identical to old firms. In this case, shifts in demand and trade balances can be accommodated without any change in the terms of trade or other relative prices.

The remainder of the paper is organized as follows. Section II contains a short description of a model that incorporates product differentiation, non-constant returns to scale, and monopolistic competition. Section III analyzes the global equilibrium and its determinants in the short run under the hypothesis that wage rates and the exchange rate are fixed. Section IV then analyzes the global equilibrium and its determinants in the intermediate run, under the hypothesis that the exchange rate is flexible and labor markets clear, but with a fixed number of firms in each sector. Section V analyzes the global equilibrium in the long run when everything can adjust. Section VI contains some concluding remarks.

II. The Model

One central feature of this model is the demand for differentiated products, which is derived from the utility function of consumers who are assumed to value diversity in the sense that they prefer one unit of two products over two units of one product. There are assumed to be two groups of products in the home country, h and T, where h consists of N varieties of nontradables and T consists of M_t varieties of tradables. The utility function of consumers in the home country is given by:

$$(1) \quad \ln U = (\alpha/\tau)\ln\left[\sum_{i=1}^{N} (h_i)^{\tau}\right] + ((1-\alpha)/\theta)\ln\left[\sum_{j=1}^{M_t} (T_j)^{\theta}\right]$$

where,

$$0 < \theta, \tau < 1, \quad 0 < \alpha < 1.$$

This specification treats all varieties of each product group symmetrically. The parameters θ and τ represent the degrees of substitutability among products in the same group. The parameter α represents the share

of income that is spent on nontradables. Products in the T group can be either exportables, x, or importables, y. Denoting the number of varieties of exportables produced at home by M_x, and the number of varieties of importables produced abroad by M_y, the utility function can be rewritten as:

$$(2) \quad \ln U = (\alpha/\tau)\ln\left[\sum_{i=1}^{N} (h_i)^{\tau}\right] + \left((1-\alpha)/\theta\right)\ln\left[\sum_{j=1}^{M_x} x_j^{\theta} + \sum_{j=M_x+1}^{M_t} y_j^{\theta}\right]$$

where $M_t = M_x + M_y$. Due to the symmetry inside each group it is sufficient to concentrate on one product in each of the groups; thus, the subscripts i and j will be omitted henceforth, and h, x, and y will indicate quantities consumed of each typical good in the respective groups. For nontradables, domestic consumption, h, is equal to domestic production, h_p, but this is not true for tradables.

Consumers in the foreign country value a different nontraded good, k, and the same tradable goods. For simplicity, however, the tradable goods produced in the two different countries are treated as different varieties. The utility function of consumers in the foreign country is thus given by:

$$(3) \quad \ln U^* = (\alpha/T)\ln\left[\sum_{i=1}^{N^*} (k_i)^{\tau}\right] + [(1-\alpha)/\theta]\ln\left[\sum_{j=1}^{M_x} x_j^{*\theta} + \sum_{j=M_x+1}^{M_t} y_j^{*\theta}\right]$$

where the x_j^* indicate foreign consumption of the tradable goods produced and exported by the home country, and the y_j^* indicate foreign consumption of the tradable goods produced in the foreign country. As in the case of the home country's nontradable good, the foreign country's nontradable good, k, is consumed only in the foreign country.

The other central feature of the model is the assumption that production requires a capital stock in excess of some minimal level, and given the sufficient capital stock, production exhibits decreasing returns to scale in labor. It is also assumed that the production processes for tradables and nontradables are the same in both countries and given by: 1/

$$(4) \quad h_p = \begin{cases} 0 \text{ for } K_h < \bar{K}_h \\ l_h^{1/\beta} \text{ for } K_h > \bar{K}_h \end{cases} \qquad k_p = \begin{cases} 0 \text{ for } K_k < \bar{K}_k \\ l_k^{1/\beta} \text{ for } K_k > \bar{K}_k \end{cases}$$

$$\beta > 1$$

and

$$(5)\quad x_p = \begin{cases} 0 \text{ for } K_x < \bar{K}_x \\ 1_x^{1/\gamma} \text{ for } K_x \geq \bar{K}_x \end{cases} \quad \Big| \quad y_p = \begin{cases} 0 \text{ for } K_y < \bar{K}_y \\ 1_y^{1/\gamma} \text{ for } K_y \geq \bar{K}_y \end{cases}$$

$$\gamma > 1$$

Here, 1_x and 1_h represent labor inputs for typical firms in the home country's nontradables and tradables (i.e., export) industries, respectively, while $\bar{K}_h$ and $\bar{K}_x$ represent the initial capital stocks that are necessary before labor in those industries can be productive. Similarly, 1_y and 1_k represent labor inputs for typical firms in the foreign country's nontradables and tradables industries, respectively, while $\bar{K}_k$ and $\bar{K}_y$ represent the initial capital stocks that are necessary before labor can be productive.

The pricing policies of producers can be determined by using the fact that the utility function (2) implies an elasticity of demand equal to $1/(1-\tau)$ for domestic nontradable goods and $1/(1-\Theta)$ for domestically-produced tradables. 2/ The condition that profit-maximizing firms equate marginal revenue to marginal cost therefore implies that:

$$(6)\quad p_h = \frac{\beta w}{\tau}\, h^{\beta-1}$$

$$(7)\quad p_k^* = \frac{\beta w^*}{\tau}\, k^{\beta-1}$$

$$(8)\quad p_x = \frac{\gamma w}{\Theta}\, x_p^{\gamma-1}$$

and

$$(9)\quad p_y^* = \frac{\gamma w^*}{\Theta}\, y_p^{\gamma-1}$$

1/ These production functions imply a U-shaped average cost curve with the minimum average cost achieved in the domestic nontradable goods sector at $K_h = \bar{K}_h$ and a level of production given by: $h(\text{min. AC}) = (rK_h/w(\beta-1))^{1/\beta}$ An equivalent description holds for the exportables sector.

2/ These are the elasticities of demand perceived by each individual firm operating in these two sectors.

where w represents the wage rate, while p_h and p_x denote the prices of nontradables and tradables produced in the home country expressed in the home country's currency. The corresponding prices of the goods produced in the foreign country are expressed in the foreign country's currency and are indicated with an asterisk superscript.

The model is closed by assuming that firms make zero profits in the long run. This implies that, in the long run, the outputs of the different products are constants given by:

$$(10) \quad \bar{x}_p = \left(\frac{r}{w}\frac{\bar{K}_x\theta}{\gamma-\theta}\right)^{\frac{1}{\gamma}} \quad \text{and} \quad \bar{y}_p = \left(\frac{r}{w^*}\frac{\bar{K}_x\theta}{\gamma-\theta}\right)^{\frac{1}{\gamma}}$$

and

$$(11) \quad h_p = \left(\frac{r}{w}\frac{\bar{K}_h\tau}{\beta-\tau}\right)^{\frac{1}{\beta}} \quad \text{and} \quad \bar{k}_p = \left(\frac{r}{w^*}\frac{\bar{K}_h\tau}{\beta-\tau}\right)^{\frac{1}{\beta}}$$

where r is the rental price of capital which is the same across countries, that is $r=r^*$ since capital is assumed to be mobile. 1/

Equilibrium in the labor markets implies that the labor supply in each country is equal to labor demand, i.e.:

$$(12) \quad \bar{L} = M_x l_x + N l_h = M_x x_p^{\gamma} + N h^{\beta}$$

$$(13) \quad \bar{L}^* = M_y l_y + N^* l_k = M_y y_p^{\gamma} + N^* k^{\beta}$$

where $\bar{L}$ is the home country's labor supply and $\bar{L}^*$ the foreign country's labor supply. But for analysis over the shortest time horizon, when it is assumed that wages are fixed and the exchange rate determined by the authorities, the labor market no longer clears. In these cases, employment is determined by labor demand alone.

On the demand side, the substitution between importables and exportables is characterized by:

1/ The rental price of capital is taken as exogenous here. It may be thought of as being determined by intertemporal preferences.

$$(14)\quad \frac{p_x}{p_y} = z = \left(\frac{x}{y}\right)^{\theta-1}$$

in the home country, and

$$(15)\quad \frac{p_x}{p^*s} = z = \left[\frac{(x_p - x)}{(y_p - y)}\right]^{\theta-1}$$

in the foreign country. It is assumed that there are no tariffs, so that the relative price of the two categories of tradables, z, is the same in the two countries. x and y represent the home country's consumptions of domestic and foreign tradables, respectively. Foreign consumptions of these goods are equal to x_p-x and y_p-y, respectively. s is the nominal exchange rate, the domestic currency price of one unit of foreign currency. The relative price, z, represents the inverse of the terms of trade for the home country, since it is the price of its exportables in terms of its importables. z can also be interpreted as a competitiveness indicator since it shows the outcome of the competition between domestic and foreign producers of tradables. According to this interpretation, competitiveness is high if the relative price of exportables of the home country is low, i.e., if the terms of trade are low. The substitution between the nontradable and tradable goods produced in the same countries are characterized by:

$$(16)\quad \frac{Ph}{p_x} = \frac{\alpha}{1-\alpha}\,\frac{[M_x + M_y z^{\left(\frac{-\theta}{\theta-1}\right)}]x}{Nh}$$

in the home country; and

$$(17)\quad \frac{p_k^*}{p_y^*} = \frac{\alpha}{1-\alpha}\,\frac{[M_x z^{\frac{\theta}{\theta-1}} + M_y]}{N^*k}(y_p - y)$$

in the foreign country.

The Cobb-Douglas specification of preferences implies that a proportion, α, of spending goes to nontraded goods. For the home country this implies that:

$$(18) \quad Nh = \alpha RE$$

where RE is real expenditure, i.e., total nominal expenditure deflated by the price of nontradables: $RE \equiv E/p_h \equiv (xp_xM_x + yp_yM_y + hp_hN)/p_h$. An equivalent relationship implies for the foreign country:

$$(19) \quad N^*k = \alpha RE^*.$$

Since only relative prices matter in this model, it is convenient to set the nominal wages equal to one in both countries, i.e., $w = w^* = 1$. The exchange rate then represents a relative price, i.e., the wage rate in the home country relative to that of the foreign country. The model can be described in terms of 15 variables: 6 quantities of goods (produced or consumed), four numbers of firms and five prices. The quantities are x_p, x, y_p, y, h, and k; the numbers of firms are N, N^*, M_x, M_y; the prices are p_x, p_h, s, p_y^*, and p_k^*.

The general equilibrium is analyzed under three different sets of assumptions, which correspond to different time horizons. In the first case considered, which corresponds to the short run, it is assumed that the nominal exchange rate and the number of firms in all sectors are fixed, so that only 10 variables (6 quantities, and 4 prices) have to be determined. In this case, it is not assumed that labor markets clear; instead, employment is determined by labor demand. Labor demand in turn is determined by the relative prices and the levels of real expenditure, which are taken as exogenous. The ten variables are therefore determined by the eight equations that describe the substitution in consumption and production plus two conditions that determine the shares of real expenditures that go towards nontradables in each country.

In the second case considered, which corresponds to the intermediate run, it is assumed that labor markets clear, but the number of firms is still fixed. The 11 variables are then determined by: the eight equations describing the substitution in consumption and production, equations (14) through (17) and equations (6) through (9); the two conditions describing equilibrium in the labor markets (12) and (13); and a trade balance condition which can be written as

$$(20) \quad TB = M_x(x_p - x)p_x - M_y(y_p - y)sp_y^*$$

In general, TB might be different from zero because agents in the two countries decide to consume different amounts than they produce. The reasons for the transfer, or for the differences between spending and production, are not analyzed here; the trade balance is simply taken as exogenous.

In the third case considered, which corresponds to the long run in which everything can adjust, labor markets clear and the number of firms in each sector adjusts until all firms earn zero profits. The long-run equilibrium is determined by a set of conditions similar to those for the intermediate run, the main difference being that in the long run the output of each good is determined by equations (10) and (11).

III. The Short Run, with Fixed Wages and Exchange Rates

In many projections of world trade, exchange rates, wages (or domestic price levels) and real expenditure are treated as exogenous. The purpose of this section is to follow that tradition and to analyze the effects of changes in those "exogenous" variables within the general equilibrium framework. It should therefore be interesting to see whether the model used here leads to similar conclusions about the effects of changes in exchange rates and real expenditure. 1/ This section therefore analyzes the effects of changes in the exchange rate on the competitiveness indicator, the production of tradables, and the trade balance; it also analyzes the effects of changes in real expenditure on the production of tradables and the trade balance.

To analyze the effects of changes in real expenditure on trade it is convenient to begin with the condition that a fraction $(1-\alpha)$ of world expenditure goes towards tradables. The value of world production of tradables, measured in domestic currency, therefore has to equal:

$$(21) \quad (1-\alpha)(E + sE^*) = p_y M_y y_p + p_x M_x x_p.$$

The expenditure and price terms in this equation can be substituted out by using the supply and demand functions, equations (6) through (9), (14), (19), and (20). Simplifying yields an expression for the production of tradables in the foreign country, y_p:

$$(22) \quad N^{-(\beta-1)} \left[\frac{RE^{\beta}\left(\frac{w}{sw^*}\right) + RE^{*\beta}\,(N^*/N)^{-(\beta-1)}}{M_y + M_x\left(\frac{w}{sw^*}\right)^{\frac{-\theta}{\gamma-\theta}}}\right] = y_p^{\gamma}$$

1/ The implicit assumptions behind this exercise are that nominal wages are fixed by long-term contracts but that the authorities can influence the nominal exchange rate through monetary policy and real expenditure through fiscal policy.

This equation implies that production of tradables in the foreign country (and thus also employment) is a function only of real demand in both countries (i.e., RE and RE*) and relative wages adjusted for the exchange rate (i.e., w/sw*). 1/ Equation (22) implies that an equiproportional increase in real demand in both countries would lead to a percentage increase in the production of tradables of β/γ times the percentage increase in demand. The symmetry between the two countries also implies that it is sufficient to switch the foreign and domestic variables in the LHS of equation (22) to obtain an equivalent expression for the production of tradables in the home country, x_p. Equation (22) thus shows that the general equilibrium elasticity of the output of tradables (in either country) with respect to world demand is equal to β/γ; this elasticity may be different from one, although the logarithmic form of the utility function implies that the (partial equilibrium) elasticity of demand for tradables with respect to expenditure (at given prices) is equal to one because if the production parameters are different, i.e., if $\beta \neq \gamma$, an equiproportional increase in expenditure on both tradables and nontradables will lead to a change in relative prices and thus different rates of increases in production and consumption of the two classes of goods. If, for example, the supply of tradables is less elastic with respect to labor inputs than that of nontradables, i.e., if $1/\gamma < 1/\beta$, a 1 percent increase in world demand with fixed wages and exchange rates will lead to a less than 1 percent increase in the production of tradables in each country.

Equation (26) also shows that the effect of an increase in expenditure in only one country depends on the relative size of the country. The proportional increase in the production of tradables in the foreign country that results from an increase in expenditure in the home country is thus equal to:

$$(23) \quad \frac{d\ \ln(yp)}{d\ \ln(RE)} = \frac{\beta}{\gamma}\left[\frac{L}{L + L^*}\right].$$

where the term $L/(L+L^*)$ indicates the fraction of the world's labor force that belongs to the home country, it is thus a measure of the relative size of the home country. 2/ As one would expect, equation (23) shows that the smaller the home country the less effect it has on the rest of

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1/ Strictly speaking, condition (22) indicates that total production of foreign tradables also depends on the numbers of firms.

2/ The elasticity in equation (27) has been calculated around the long-run equilibrium point where $L^*/L = N^*/N = M_y/M_x$ and $z = 1$. At this point the relative size of the home country is the same whether measured in terms of its labor force or in terms of the relative number of firms in either the nontradables or the tradables sectors.

the world. Since (as shown below, see equation (32) and (34)) the ratio of the output of tradables in the two countries, (x_p/y_p), is a constant as long as the exchange rate and wages are fixed, it can also be shown that if one considers only changes in real expenditure:

$$(24) \quad \frac{d\ \ln(x_p)}{d\ \ln(RE)} = \frac{d\ \ln(y_p)}{d\ \ln(RE)} = \frac{\beta}{\gamma}\left[\frac{L}{L + L^*}\right].$$

Thus, an increase in expenditure at home (or abroad) will lead to the same proportional increase in the production of tradables at home and abroad.

The results of equations (23) and (24) can be used to calculate the effects of an increase in real expenditure on the trade balance since the trade balance can be written as the difference between production and consumption of tradables:

$$(25) \quad TB = p_x M_x x_p - [p_x M_x x + p_y M_y y]$$

This is the trade balance of the home country in domestic currency terms; this expression can be transformed by using the equation describing the share of expenditure that goes towards nontradabables, (19), and its complement. Using also the equations describing the supply of tradables and nontradables it is possible to obtain an equation that gives the trade balance as a proportion of total expenditure:

$$\beta-1)\left(\frac{\gamma\tau}{\Theta\beta}\right)\left(\frac{M_x}{N}\right)\left(\frac{RE}{N}\right)^{-\beta} x_p^{\gamma} - (1-\alpha)$$

It is apparent from equation (26) that an increase in domestic real expenditure has a direct negative effect on the trade balance; but an increase in domestic real expenditure also stimulates the production of tradables at home, so that the net effect will thus be smaller than the direct expenditure effect. Using the result from equation (24), which gives the elasticity of domestic production of tradables with respect to an increase in domestic demand, it is possible to give the (absolute) change in the trade balance as a proportion of expenditure, $(\Delta TB/E)$, in terms of the proportional increase in real domestic demand, $(\Delta RE/RE)$. Around the equilibrium of a zero trade balance this semi-elasticity is equal to:

$$(27)\quad \Delta\left(\frac{TB}{E}\right) = \beta\left[\frac{L}{L+L^*} - 1\right](1-\alpha)\frac{\Delta RE}{RE}.$$

Since the term in square brackets, $[L/(L+L^*)-1]$, is negative, this implies that an increase in real demand, at given wages and exchange rates, leads to a deterioration of the trade balance. Equating expenditure with GNP, equation (27) implies that the deterioration of the trade balance measured in percentage points of GNP depends directly on the percentage increase in real GNP. Given an increase in real domestic expenditure the deterioration in the trade balance will be larger (in absolute terms) the smaller is the home country and the more open both countries are, i.e., the larger is the share of tradables in consumption, $(1-\alpha)$. The deterioration of the trade balance will also be stronger the lower is the elasticity of supply of nontradables with respect to labor inputs, i.e., the higher is β, since for a given increase in real expenditure, part of which falls on nontradables, the higher is β the more the price of nontradables has to rise and the larger is the part of the increase in real expenditure that is deflected towards tradables, part of which have to be imported.

The effects of changes in real expenditure on gross trade, as opposed to the production of tradables or the trade balance, can be found by analyzing the demand for tradables in the home country. The definition of domestic expenditure can be transformed by using the demand function of tradables to yield:

$$(28)\quad (1-\alpha)\, RE p_h = y p_y\left[M_y + M_x z^{\frac{\Theta}{\Theta-1}}\right].$$

This equation can be further transformed to yield an expression for the exports of the foreign country (the home country's imports), y, in terms of real expenditure and relative wages:

$$(29)\quad y = \frac{N^{\beta-1}\, RE^{\beta}\, (w/sw^*)}{M_y + M_x z^{\frac{\Theta}{\Theta-1}}}\, y_p^{-(\gamma-1)}.$$

This equation can be used to calculate the expenditure elasticity of imports for the home country:

$$(30)\quad \frac{d\ \ln(y)}{d\ \ln(RE)} = \frac{\beta}{\gamma}\left[\gamma - (\gamma-1)\ \frac{L}{L+L^*}\right].$$

This shows that the exenditure elasticity of imports is a decreasing function of the size of the country. This seems to accord well with the Keynesian notion that in a big country there are proportionately less leakages abroad so that an increase in domestic expenditure leads only to a proportionately small increase in imports. Equation (30) also implies that for the small country, with $L/(L+L^*) = 0$ in the extreme case, the expenditure elasticity of imports is equal to β, which may exceed one even though the expenditure elasticities of demand for all goods together is equal to one.

Equation (29), which determines the foreign country's exports and thus the home country's imports, also implies that both of these variables are affected by real expenditure in the foreign country. Indeed the elasticity of the home country's imports with respect to real expenditure abroad is equal to:

$$(31)\quad \frac{d\ \ln(y)}{d\ \ln(RE^*)} = -(\gamma-1)\ \frac{\beta}{\gamma}\left(1 - \frac{L}{L+L^*}\right).$$

Foreign real expenditure will have no effect on the home country's imports only if the supply of tradables is infinitely elastic with respect to price or unit elastic with respect to labor, i.e., if $\gamma = 1$. As long as the supply of tradables is not unit elastic with respect to labor, i.e., as long as $\gamma > 1$, an increase in foreign expenditure (at constant domestic expenditure) will affect the relative price of tradables in terms of nontradables in both countries, since as the relative price of tradables rises in the home country consumption will shift towards nontradables and thus imports will fall. This fall in imports occurs even though real domestic expenditure and relative prices do not change. This implies that equations in which imports are a function only of domestic expenditure and competitiveness (as defined in condition (14)) are missing an important explanatory variable.

The remainder of this section analyzes the effects of changes in the nominal exchange rate, at given wage rates, on relative prices and trade. To calculate the effects on competitiveness as defined here it is convenient to combine the two equations describing the substitution between domestic and foreign tradables (14) and (15) to obtain:

$$(32)\quad \left(\frac{x_p}{y_p}\right) = z^{\frac{1}{\theta-1}}$$

This equation implies that the ratio of total demand for these two goods is only a function of the terms of trade or competitiveness. But the supply functions (8) and (9) also imply that the ratio in which domestic and foreign tradables are produced is a function of the terms of trade and relative wages adjusted by the exchange rate. Dividing equation (8) by (9) yields:

$$(33) \quad z = \frac{w}{sw^*} \left(\frac{x_p}{y_p}\right)^{\gamma-1}.$$

Thus, combining equations (32) and (33) it is possible to write the terms of trade, z, as a function of only wages and the exchange rate: 1/

$$(34) \quad z = \left(\frac{w}{sw^*}\right)^{1/\phi}$$

where

$$(35) \quad \phi \equiv \frac{(\gamma-\theta)}{(1-\theta)} = 1 + (\gamma-1)/(1-\theta) > 1.$$

This implies that by fixing wages and the exchange rate, the terms of trade are also fixed. Moreover, it also implies that the effectiveness of a nominal devaluation, with fixed nominal wages, in changing the terms of trade or competitiveness depends only on the parameter ϕ and not on the size of the country. Equation (34) implies that the (absolute value of the) elasticity of the terms of trade, z, with respect to the exchange rate, s, is given by $1 < 1/\phi < 1$. If marginal costs in the production of tradables are independent of output, i.e., if $\gamma-1 = 0$, this elasticity is equal to one; in this case a 1 percent devaluation translates into a 1 percent gain in competitiveness or a 1 percent deterioration in the terms of trade. In general, the reaction of the terms of trade will be stronger the lower (the absolute value of) the elasiticy of demand $1/(1-\theta)$ and the less marginal cost in the production of tradables rises as output increases, i.e., the lower γ.

The effect of a devaluation on output can be found by using equation (22). If it is assumed that the starting point represents the long-run equilibrium, it is possible to write the elasticity of produc-

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1/ It is apparent from (32) and (33) that a change in the exchange rate at given wages is entirely equivalent to a change in wages at a given exchange rate.

tion of foreign tradables, y_p, with respect to the nominal exchange rate as: 1/

$$(36)\quad \frac{d\ \ln(y_p)}{d\ \ln(s)} = \frac{-1}{(\gamma-\theta)}\left[\frac{L}{L + L^*}\right] < 0.$$

The negative sign of this elasticity implies that an increase in s, a devaluation as seen from the home country, will lead to lower production abroad. It is apparent from equation (36) that the absolute value of this elasticity is an increasing function of the relative size of the home country. This implies that if the home country is small, a devaluation will not affect output strongly in the rest of the world. Given that this is a two-country world, a devaluation of the small home country is just the mirror image of an appreciation of the rest of the world, which implies that the output of tradables in a large country is less affected by changes in its exchange rate and thus its competitiveness.

Given the relationship between the exchange rate and the competitiveness indicator, z, equation (36) can be rewritten in terms of the elasticity of production with respect to a change in competitiveness:

$$(37)\quad \frac{d\ \ln(y_p)}{d\ \ln(z)} = \left[\frac{1}{(1-\theta)}\right]\left[\frac{L}{L + L^*}\right] > 0$$

Thus, a deterioration in competitiveness of the home country, or an increase in z, leads to an increase in the production of tradables in the rest of the world.

Since the ratio of the production of tradables in the home and foreign country is only a function of competitiveness, see equation (32), the elasticity of the domestic production of tradables with respect to competitiveness is equal to:

$$(38)\quad \frac{d\ \ln(x_p)}{d\ \ln(z)} = \left[\frac{1}{(1-\theta)}\right]\left[\frac{L}{L + L^*} - 1\right].$$

1/ More precisely, this is the elasticity of production of each foreign product specification with respect to changes in the nominal exchange rate at given wages.

This equation can be used together with the expression for the trade balance, (26), to give an expression for the effect of a change in competitiveness on the trade balance:

$$(39)\quad \Delta\left(\frac{TB}{E}\right) = \left[\frac{(1-\alpha)}{(1-\Theta)}\right]\gamma\left[\frac{L}{L+L^*} - 1\right]\frac{\Delta z}{z}.$$

This shows that a deterioration of competitiveness, an increase in z, leads to a deterioration in the trade balance. The absolute value of the deterioration in the trade balance is again an increasing function of the openness of the economy and a decreasing function of the size of the home country. For a given fall in competitiveness, the deterioration in the trade balance is also an increasing function of the elasticity of demand for (each specification of) tradables, $1/(1-\Theta)$, and the elasticity of supply of tradables $1/\gamma$.

Equation (29), in conjunction with the result from equation (37), can be used to calculate the elasticity of the foreign country's exports (the home country's imports) with respect to the terms of trade, z:

$$(40)\quad \frac{d\ \ln(y)}{d\ \ln(z)} = \left(\frac{1}{1-\Theta}\right)\left[(\gamma-\Theta)\left(1 - \frac{L}{L^*+L}\right) + \left(\frac{L}{L^*+L}\right)\right] > 1.$$

This result implies that the elasticity of the foreign country's exports with respect to changes in competitiveness has to be greater than one. This elasticity is an increasing function of the size of the home country only if $\gamma-1 < \Theta$. For a small country, $L/(L+L^*) = 0$, the price elasticity of imports would be equal to $(\gamma-\Theta)/(1-\Theta) = \phi > 1$, but for a big country, the price elasticity of imports would go towards $1/(1-\Theta) > 1$, i.e., the elasticity of demand for each variety of tradable goods.

IV. The Intermediate Run, Clearing Labor Markets

With full employment and a given labor supply, real expenditures in the two countries can no longer be regarded as exogenous variables since the world resource constraint puts a limit on total world expenditure. In this context, only the distribution of expenditure between the two countries can vary, and since this distribution determines and bears a one-to-one correspondence with the trade balance (there is only one trade balance in a two-country world), it can be described by the trade balance itself. The purpose of this section is therefore to analyze the interrelationships between the worldwide distribution of expenditure, competitiveness, and the trade balance. One way to interpret the results is to start with a country that wants to save and thus wants to make a

current transfer of tradable goods to the rest of the world. The equations below then describe the changes in expenditure and competitiveness that have to take place so that the transfer can be effected.

To analyze the relationship between the trade balance and expenditure it is convenient to write the trade balance in domestic currency terms as the difference between the production and consumption of tradables, as in equation (25). This equation can be simplified 1/ to yield an expression for the trade balance in terms of only domestic real expenditure:

$$(41) \quad \frac{TB}{E} = \frac{\gamma}{\theta} - \frac{N}{\bar{L}}\left(\frac{\alpha RE}{N}\right)^{\beta}\left(\frac{\gamma}{\theta} + \frac{1-\alpha}{\alpha}\frac{\beta}{\tau}\right).$$

This equation implies that a one percent increase in real domestic expenditure leads to a change in the trade balance as a proportion of total expenditure of more than one percentage point, since:

$$(42) \quad \Delta\left[\frac{TB}{E}\right] = -\frac{\beta\gamma}{\theta}\left(\frac{\Delta RE}{RE}\right).$$

The factor $\beta\gamma/\theta$ exceeds one since $\beta\gamma > 1$ and $\theta < 1$. The intuition behind this result is that part of any given increase in expenditure falls on tradables and thus has a direct impact on the trade balance at unchanged levels of production of tradables. But part of the increase in expenditure falls on nontradables whose production can increase only if resources move out of the tradables sector; so the production of tradables has to fall, which leads to a further negative effect on the trade balance. Equation (42) can also be read the other way around--it would then say that a given transfer, in terms of a given proportion of

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1/ Using the equation describing the substitution between tradables and nontradables in domestic consumption, equation (25) can be rewritten as:

$$w\left[M_x\, x_p^{\gamma}\left(\frac{\gamma}{\theta} + \frac{1-\alpha}{\alpha}\frac{\beta}{\tau}\right) - \frac{1-\alpha}{\alpha}\frac{\beta}{\tau}\bar{L}\right] = TB.$$

This can then be transformed into a relationship between real expenditure in the home country and the trade balance by using the expenditure shares condition (19), the resource constraint $\bar{L} = M_x \ell_x + N l_h$ and the zero profit condition at the long-run equilibrium, which together imply $E = w\bar{L}$.

expenditure of the home country, can be effected only by a reduction in expenditure that is smaller, in percentage terms, than the transfer itself.

It is not apparent from equation (42), but the worldwide resource constraint implies that an increase in expenditure in the home country is possible only if expenditure in the rest of the world decreases. The worldwide resource constraint thus implies that expenditure at home and in the rest of the world are linked (around the equilibrium of balanced trade and in percentage terms) by:

$$(43) \quad d\ \ln(RE^*) \;=\; -\frac{\bar{L}}{\bar{L}^*}\, d\ \ln(RE).$$

The effects of an increase in domestic expenditure (or more precisely a redistribution of world expenditure towards the home country or a transfer) on the terms of trade can be found by using the two trade balance equations and solving for the trade balance as a function of the terms of trade or competitiveness. 1/ Around the balanced trade position this yields:

$$(44) \quad \frac{TB}{E} \;=\; \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{\beta}{\tau}\right)\left(\frac{\bar{L}^*(z^{\frac{-\gamma}{1-\theta}} - 1)}{\bar{L}^* + \bar{L}z^{\frac{-\theta}{\theta-1}}}\right)$$

which uses the condition that, at the long-run equilibrium, $L/L^* = M_x/M_y$ and $E = w\bar{L}$. Equation (44) implies that the trade balance and the terms of trade, z, are related by:

$$(45) \quad \Delta\left(\frac{TB}{E}\right) \;=\; \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{\beta}{\tau}\right)\left(\frac{\gamma}{1-\theta}\right)\left[\frac{\bar{L}}{\bar{L}+\bar{L}^*} - 1\right]\frac{\Delta z}{z} \;<\; 0$$

1/ Combining the two trade balance equations for the home and the foreign country yields:

$$sw^*\left[M_y\, y_p^{\gamma}\left(\frac{\gamma}{\theta} + \frac{1-\alpha}{\alpha}\,\frac{\beta}{\tau}\right) - \frac{1-\alpha}{\alpha}\,\frac{\beta}{\tau}\,\bar{L}^*\right] \;=\; -TB.$$

This equation and (41) can be solved for z by using equation (14) which says that $(x_p/y_p) = z^{1/\theta-1}$. The result can be transformed to give the terms of trade, z, as a function of the trade balance as a proportion of domestic expenditure.

This result can be compared with equation (39) which gives the reaction of the trade balance to a change in z when prices are fixed and employment can deviate from $\bar{L}$. The comparison shows that a given proportional increase in z will be associated with a stronger deterioration in the trade balance if there is full employment since the reaction of the trade balance shown in equation (45) is the same as the one shown in equation (39) multiplied by the factor: $\beta/\tau\alpha > 1$. An important implication is that the correlation between the trade balance and the terms of trade might vary over time depending on whether the situation is characterized by fixed wages and exchange rates and thus variable employment, or by flexible prices and full employment.

Equations (42) and (45) describe the relationships between the trade balance and real expenditure, and between the trade balance and competitiveness. In this context, i.e., with a resource constraint, real expenditure and competitiveness cannot be regarded as two independent determinants of the trade balance. On the contrary, the resource constraint implies that a given transfer has to lead to a certain change in real expenditure and a change in competitiveness. This implies that real expenditure (in the home country) and competitiveness are linked. Equating expression (45) to (42) yields:

$$(46)\quad \frac{d\ \ln(z)}{d\ \ln(RE)} = \left[\frac{\bar{L} + \bar{L}^*}{\bar{L}^*}\right]\frac{\alpha\tau}{(1-\alpha)}\frac{(1-\theta)}{\theta}.$$

Equation (46) implies that a given percentage increase in real expenditure will have a stronger effect on the terms of trade in a big country than in a small country. A similar effect exists with respect to the real exchange rate, which is defined here as the ratio of the price of domestic nontradables to the price of foreign nontradables. Denoting this definition of the real exchange rate by q it can be shown that:

$$(47)\quad q = \frac{w}{w^*s}\left[\frac{RE/N}{RE^*/N^*}\right]^{\beta-1}.$$

Using the relationship between the exchange rate adjusted wages, w/w^*s, and z in equations (34), (43), and (46), the elasticity of the real exchange rate with respect to real domestic expenditure is equal to:

$$(48)\quad \frac{d\ \ln(q)}{d\ \ln(RE)} = \left[\frac{\bar{L} + \bar{L}^*}{\bar{L}^*}\right]\left[(\beta-1) + (\gamma-\theta)\left(\frac{\alpha}{1-\alpha}\right)\left(\frac{\tau}{\theta}\right)\right].$$

It is apparent that the elasticity of the real exchange rate with respect to an increase in domestic expenditure is an increasing function of the size of the home economy. This contrasts with the result that

would be obtained under the assumption of fixed wages and exchange rates. In the latter case, the elasticity of the real exchange rate with respect to an increase in domestic real expenditure is equal to $(\beta-1)$ as can be calculated directly from equation (47) since in this case w/w*s and RE* are constant.

V. The Long Run

In the long run, the size of each typical firm in each sector is determined by the zero profit condition because new firms will enter or exit any sector in which profits are not zero. Equations (10) and (11) show that in the long run the output of each firm is determined only by the wage rental ratio and the various parameters of the model. This implies that shifts in demand would lead not to a change in the output of the typical firm in any sector but rather to a change in the number of firms. However, the terms of trade are determined by the output of each specification of exportables and importables (as shown in equation (32) which is repeated below). With output of each firm fixed by the zero profit condition, at $\bar{x}_p$ and $\bar{y}_p$, respectively, the terms of trade, z, is not affected by shifts in expenditure in the long run. In contrast to the results obtained for the intermediate and short runs, the terms of trade is therefore constant in the long run.

The zero profit conditions, by fixing output per firm in the long run, also fix the other relative prices, such as the price of home nontradable goods in terms of importables. This implies that all shifts in expenditure, and thus any shifts in the trade balance, can be effected without any change in either the terms of trade or the real exchange rate. The only effect of a shift in real expenditure would be a change in the number of firms in the nontradables and tradables sectors of each country. Long-run shifts in expenditure, which would correspond to long-run shifts the trade balances, might be caused by the discovery of some natural resource; this was the case of the United Kingdom in the 1970s. Another case might be a change in the long-run real interest rate, which would affect the income the country receives from its net foreign asset position. This effect would be important for Switzerland now and might become important for the United States if the U.S. current account remains in deficit for long. The only effect of a shift in expenditure from the home to the foreign country (this would correspond to a shift in the home country's trade balance into surplus) would thus be that the number of firms in the nontradables sector goes up and the number of firms in the tradable (export) sector goes down. In the other country, exactly the opposite happens and the world-wide number of firms in the tradable and nontradable sector is, therefore, not affected by shifts in expenditure. The reason for this independence of relative prices from shifts in expenditure is that in this framework, in the long run, the supply curve of total production in each sector is horizontal because additional demand can be satisfied in the long run at a constant marginal cost by new firms.

VI. Concluding Remarks

This paper has presented a model of world trade in differentiated products. The main features of the model--product differentiation, nonconstant returns to scale, and monopolistic competition--should make it useful in analyzing trade between industrialized countries. The main contribution of the paper, however, is that it uses a two-country general equilibrium approach. In contrast, most systems of international trade equations currently in use, including the World Trade Model of the Fund, rely on a partial equilibrium approach and the small country assumption. Accordingly, the model developed in this paper provides insights into whether the conclusions reached using the small country assumption are robust. It is shown that for purposes of short-run analysis, that is, under the assumption of fixed or predetermined nominal wages and exchange rates, it is possible to determine world trade and relative prices using only assumptions about wages, exchange rates, and real expenditures in each country. This is the procedure followed in the World Trade Model of the Fund.

With regard to analysis over an intermediate horizon, this paper has shown that if there is a world resource constraint in the form of a fixed level of employment, and if wages adjust to clear labor markets, then it is no longer possible to make arbitrary assumptions about real expenditures in each country. In this context, real expenditure in one country can go up only if expenditure in other countries goes down, i.e., only the distribution of worldwide expenditure can vary, not the sum. The distribution of real expenditure then determines a set of real transfers in the form of international trade imbalances. These transfers also determine changes in the real exchange rate and the terms of trade. In this context, the worldwide distribution of real expenditure determines both world trade and relative prices; real expenditure and relative prices cannot be regarded as two independent determinants of trade flows. From another perspective, the contrast between the results under conditions of fixed exchange rates and wages with variable employment (which has been taken to describe the short run), and under conditions of flexible prices and full employment (which has been labeled the intermediate run), suggests that the correlations between changes in trade flows and changes in the terms of trade may vary over time, depending on the relative degrees of slack in labor markets and the flexibility in wage rates and other prices.

An attractive feature of the model is that it yields simple results in elasticity or semi-elasticity form. This makes it possible to determine the influences on trade and competitiveness of such factors as demand and supply elasticities, openness, and country size. The transparency of its general equilibrium results should thus make the model useful in discussions of the determinants of world trade and relative prices--discussions that should take into account global equilibrium effects and not be limited to the simple summation of small country effects.

A Digression on the Price Equation in the World Trade Model of the Fund

The World Trade Model, as presently used in the WEO exercise, assumes the existence of differentiated goods and non-constant returns to scale. Indeed, one of the central equations in the World Trade Model describes the pricing policy of a monopolistic firm and relates changes in the output price to changes in variable costs, competitor prices and a demand shift variable: 1/

$$(A.1) \quad \tilde{P} = \frac{1}{1 + \varepsilon\eta}[\tilde{V}C + \varepsilon\eta\tilde{C}P + \tilde{Y}]$$

where P is the output price, VC is variable cost (more exactly the rental price of the variable factor), CP is the competitor's price, and Y is a shift variable in the firm's demand function; a tilde (~) above a variable indicates that the variable is measured as a percent change. The parameter ε is the elasticity of the marginal cost function with respect to output and the parameter η is the absolute value of the price elasticity of the quantity demanded.

The model presented in this paper yields a comparable equation since it is also based on the assumption of monopolistic competition and non-constant returns to scale for individual firms. Indeed, the parameters ε and η have exact counterparts in this model. Marginal costs (of a firm in the tradables sector) are given by $w\gamma x_p^{\gamma-1}$; thus, the resulting elasticity of marginal cost with respect to output is equal to $\gamma-1$. The perceived elasticity of demand of each firm in the tradables sector is given by $1/(\theta-1)$. The product $\varepsilon\eta$ would then correspond to the term $(\gamma-1)/(1-\theta)$ in the present model.

Equation (21) in the text implies that each single firm can be taken to perceive an export demand function of the form: $x_p = y_p(p_x/p_y)^{1/(\theta-1)}$ where y_p is a shift factor from the firm's point of view. The profit-maximizing output price of such a firm can then be written as:

$$(A.2) \quad p_x = \left[w\left(\frac{\gamma}{\theta}\right) y_p^{\gamma-1} p_y^{\frac{-(\gamma-1)}{(\theta-1)}}\right]^{1 - \frac{(\gamma-1)}{(\theta-1)}}.$$

1/ See M.C. Deppler and D.M. Ripley, Staff Papers, 1978, p. 153, and Armington (1969).

This implies that percentage changes in the price of the domestic firm's output (whether exported or sold domestically), $\tilde{p}_x$, are given by:

$$(A.3) \quad \tilde{p}_x = \frac{1}{1 + \frac{(\gamma-1)}{(1-\theta)}}[\tilde{w} + \frac{(\gamma-1)}{(1-\theta)}\tilde{p}_y + (\gamma-1)\tilde{y}_p].$$

This equation is analogous to equation (A.1) since $(\gamma-1)/(1-\theta) = \varepsilon\eta$, the wage rate represents variable costs, and $\tilde{p}_y$ represents competitor prices. The only difference is that the demand shift factor y_p should be multiplied by $(\gamma-1)$ or η in the Deppler-Ripley terminology.

List of Symbols

Parameters:

α: Share of expenditure going to nontradable goods.

β, γ: Inverse of the elasticity of output with respect to input of labor in the nontradable goods and tradable goods sectors, respectively.

τ, θ: Inverse of the substitutability among different specifications of nontradable goods and tradable goods, respectively.

Variables:

h $(=h_p)$: Consumption (equals production) of each specification of nontradable goods in the home country. k $(= k_p)$ denotes the corresponding variable in the foreign country.

x, x_p: Respectively, consumption and production of each specification of exportable goods in the home country. y, y_p denote corresponding variables in the foreign country.

p_h, p_x, p_y: Nominal domestic currency prices of each specification of, respectively, nontradable goods, exportables, and importables in the home country.

p_k^*: Nominal foreign currency price of nontradable goods in the foreign country.

s: Exchange rate, domestic currency per unit of foreign currency.

w, w^*, r: Factor prices of, respectively, labor in home and foreign countries (= wage rates) and capital (= interest rate).

l_h, l_x: Labor used in each typical firm producing, respectively, nontradable goods and exportables in the home country. l_k and l_y denote corresponding variables in the foreign country.

$L, (L^*)$: Total labor supply of home (foreign) country.

K_h, K_x: Capital used in each typical firm in the home country producing, respectively, home goods and exportables. K_k and K_y denote the corresponding variables in the foreign country.

N, M_x: Number of firms in, respectively, the home goods and exportables sectors of the home country. N^* and M_y denote the corresponding variables in the foreign country.

E: Total nominal domestic expenditure.

RE: Total real domestic expenditure.

TB: Trade balance in terms of domestic currency.

q: Real exchange rate defined as the relative price of nontradable goods in terms of importables.

z: Competitiveness index, defined as the terms of trade, i.e., the relative price of exportables in terms of importables.

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