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On the Measurement of Probable Patterns of Comparative Advantage Under Trade Liberalization

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On the Measurement of Probable Patterns of Comparative Advantage Under Trade Liberalization (1)

1. Introduction

There seems to be a growing consciousness in many developing Latin American (and other) countries that the ideology of protectionist policies they have followed since before World War II may have outlived their usefulness. This doctrine is currently preached mainly by young economists, and to date has not really been acted on. However, as the youngsters age and take power, doctrine is bound to harden into dogma, and tariff reductions will occur. As this happens, economists will be well advised to know something about the probable shifts in industrial output, labor force use, profitability, and so on before the advent of reduced protection. There are bound to be sectors hurt by trade liberalization, and perhaps some unexpected expansions will occur. Further, these differential effects will vary, depending on the pattern of liberalization which undoubtedly will be contorted to fit the interests of such diverse groups as inefficient local industries with momentary political power and the international corporations which occasionally have a minor influence on capital inflows and the policy decisions of the local government.

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(1) The model set out in this paper was worked out after conversations with Marcelo Selowsky (who proposed the multisectoral approach) and Edmar Bacha (who originally proposed the aggregate model of the Bacha-Taylor paper which is generalized here.) Neither of these two gentlemen is responsible for errors which appear herein.

The international trade literature gives two methods for estimating the relative comparative advantages within a group of industries: Bruno-Kreuger exchange rates and rates of effective protection. Both of these measures are well-described in the literature (see / / and references there) and both can in principle be used to predict which industries would expand (and which contract) under trade liberalization. However, both measures also suffer from certain limitations:

Bruno-Kreuger rates do not take into account possible reductions of cost of intermediate inputs through importation. Further, although they do take specific factor costs into account, they do not investigate how these costs would change as tariffs decline.

Rates of effective protection, however calculated, are over-optimistic in their assumption that all importable intermediates will actually be imported at world prices, and completely sweep the problem of factor price changes under the rug by considering protection of value added.

In practice one would like to take both factor price changes and complex patterns of protection of intermediates into account. For example, it is plausible that Chile may choose to protect its petrochemical complex when it enters the Andean group free trade area, but let its beet sugar industry be gradually replaced by Peruvian cane. Brazil, on the other hand, may stop protecting chemicals and subsidize automobile exports instead. Policies of this nature are bound to have complex effects on the costs of intermediate inputs. Moreover,

if enough changes are undertaken, they will influence wages, interest rates, and the exchange rate in such a way as to make analyses which hold these factor prices constant (either separately or in a value added aggregate) misleading.

These problems point to the following exercise: the construction of a simple general equilibrium model of a trading economy, and its use to answer questions like the following:

(a) What sectors would expand or contract under a determinate policy of trade liberalization? The amounts of probable expansion and contraction would provide a ranking in terms of comparative advantage of domestic industries.

(b) What would be the changes in production patterns of non-tradable goods induced by the general equilibrium effects of tariff reduction?

(c) What would be the probable sectoral shifts of labor use (in the short run) and labor and capital use (in the long run)?

(d) How would the exchange rate respond to trade liberalization? What would be its equilibium (without protection) value?

(e) What would be the relative price relationships under free trade? How would these be dependent on monetary policy? Are free trade prices insensitive enough to monetary or other variations to allow their use in investment project analysis, as has been suggested by Little and Mirrlees / /?

The purpose of this paper is to set out a model in which questions like these can be answered, and illustrate its use with

at least a semi-realistic test case.

2. On General Equilibrium Models

There are at least two ways to undertake the exercise described above. On is to write out the general equilibrium equations of the economy with all trade restrictions (here we will concentrate solely on tariffs and subsidies) as parameters One would then change the levels of the parameters in certain ways, and use an alogrithm like Scarf's / / to find the new general equilibrium solution. (2)

The other approach is to assume that the economy is in equilibrium with its current structure of tariffs, and to investigate differential changes in quantities and prices which would result from differential tariff changes. This of course is an easy modification of the Johansen growth model / / which should finally give the Scarf solution after the resulting large system of (non-linear) differential equations for endogenous variables in terms of parameters is integrated.

However, the Johansen approach also has the advantage that it provides the differential effects of differential tariff reductions at only the cost of a matrix inversion. For practical analysis, knowledge of differential effects may be sufficient. Furthermore, if the data for a general equilibrium model can be assembled (no mean task in itself) at least the calculations can be made fairly painlessly. The same cannot be

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(2) Linear programming would do the same thing under its particular assumptions about production functions. However, these are less approporiate than neo-classicism to the problem at hand.

said for the first alternative: computer adepts of the Scarf algorithm are as yet few and far between.

For these reasons, we follow the Johansen approach here by writing out a simple general equilibrium system, totally differentiating it, and watching how the endogenous variables change in response to "small" changes in the exogenous parameters such as tariff rates.

The particular model considered is meant to be at least somewhat practical. For that reason, a number of not-so-general functional specifications are used. This is not done out of disrespect for the pure beauty of the general theory, but rather in an attempt to tailor the model to fit the data which might reasonably be available in a semi-industralized country. In particular we will assume that

(a) Use of intermediate inputs is determined by fixed coefficients. This would be a nice assumption to relax for a variety of reasons (see Tan / / for some of them) but in the general case it is empirically impossible to do so. Obvious extensions of the present model could be used to examine the substitution possibilities between, say, different types of fuel, but this and similar additions would be in the nature of special cases and are not considered here.

(b) The spirit of modern theoretical discussions of the balance of payments is followed by considering explicitly consumer demand for monetary stocks. Moreover, producers' demands for money are also considered, although in a very crude way.

(c) Cobb-Douglas production functions for value added are used

in this paper. These could easily be replaced by other simple indices such as the C.E.S., but this would eliminate one basic advantage of Cobb-Douglas functions: they can be "estimated" with only a single observation of factor shares. This is no small advantage in analysis of a large sample of disaggregated industries. Furthermore, the Cobb-Douglas approximation may not be so bad in the analysis of differential changes, as Nelson / / shows. (For large changes, any neoclassical approximation is likely to have its problems. On the theory of this, see Fisher / /; Chenery and Raduchel provide computed examples / /.)

(d) Demand functions are assumed to be determined by the additive utility function of a representative man (who uses money), so an extension of the Frisch scheme for determining all price elasticities of demand can be used. (See Appendix I) This is computationally manageable, and avoids the problem of explicit specification of an aggregate utility function.

(e) A very summary treatment is given government. It collects indirect taxes and plays a role in generating exogenous final demands. Thus, no importance is given to the government's budget constraint, nor to the effects on resource allocation of taxes other than tariffs (and export subsidies) and indirect production taxes. The model could be extended in fairly obvious ways to include direct taxes, allowing analysis of such problems as the design of tax packages to sustain government revenues when tariffs are reduced. Such analysis (omitted here for lack of space and data) would be important in small countries where

tariff proceeds make up a substantial portion of fiscal revenue.

3. The Equilibrium System of Equations

Within the limits of the above specifications, it is easy to write out a general equilibrium model of a trading economy. We assume that there are one non-competitive import good (sector 0) q_1 competitively imported good (sectors 1 through m), q_2 exported goods (sectors m+1 through n), and q_3 non-tradable goods (sectors n+1 through q). In matrix form, the flow balance equations for all these products are:

$$\begin{bmatrix} 0 \\ X_1 \\ \vdots \\ X_m \\ X_{m+1} \\ \vdots \\ X_n \\ X_{n+1} \\ \vdots \\ X_q \end{bmatrix} + \begin{bmatrix} M_0 \\ M_1 \\ \vdots \\ M_m \\ 0 \\ \vdots \\ 0 \end{bmatrix} - \begin{bmatrix} 0 & a_{01} \cdots\cdots a_{0q} \\ 0 & a_{11} \cdots\cdots a_{1q} \\ \cdot & \cdot \qquad \vdots \\ \cdot & \cdot \qquad \vdots \\ \cdot & \cdot \qquad \vdots \\ \cdot & \cdot \qquad \vdots \\ 0 & a_{q1} \cdots\cdots a_{qq} \end{bmatrix} \begin{bmatrix} 0 \\ X_1 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ X_q \end{bmatrix}$$

$$\begin{bmatrix} C_0 \\ C_1 \\ \vdots \\ C_q \end{bmatrix} + \begin{bmatrix} 0 \\ \vdots \\ 0 \\ E_{m+1} \\ \vdots \\ E_n \\ 0 \\ \vdots \\ 0 \end{bmatrix} + \begin{bmatrix} Z_0 \\ \vdots \\ Z_q \end{bmatrix} \qquad (3.1)$$

where the X_i are levels of domestic production of the q goods,

the M_i are levels of imports (M_0 is non-competitive), the a_{ij} are input-output coefficients, the C_i are levels of domestic consumption, the E_i are exports, and Z_i are exogenous domestic final demands for government, stock changes, etc.

The domestic prices of traded goods are assumed to be determined by tariffs and subsidies,

$$p_i=\tau_i \pi_i r \qquad i=0,1,\ldots.m$$
$$p_i=\phi_i \pi_i r \qquad i=m+1,\ldots.m \tag{3.2}$$

where τ_i is one plus the ad valorem tariff on imports into sector i (the "force" of the tariff), and ϕ is the corresponding force of an export subsidy. The exchange rate is r, and world prices are the π's. In the case of exports, these are related to export levels, on the assumption that the country may have some monopoly power in the goods it already sells abroad:

$$\pi_i=b_i E_i^{\beta_i} \qquad i=m+1,\ldots n. \tag{3.3}$$

When the production functions for the q domestically produced goods are of the Cobb-Douglas form,

$$X_i= A_i \; L_i^{\alpha_i} \; K_i^{1-\alpha_i} \qquad i=1,2,\ldots.q \tag{3.3}$$

(where A_i and α_i are constants, and L_i and K_i are labor and homogeneous, malleable capital used in sector i), then the production cost minimization equations take the form

$$\alpha_i p_i^* X_i=w_i L_i \qquad i=1,2,\ldots.,q \tag{3.4}$$
$$(1-\alpha_i)p_i^* X_i=s_i K_i \qquad i=1,2,\ldots.,q \tag{3.5}$$

where w_i is the wage and s_i is the rate of return to capital in the sector, and p_i^* is the "net price" of output in sector i.

This is defined by the equation

$$p_i^* = p_i - \Sigma_j a_{ji} p_j - \theta_i - a_{Di} v \qquad i=1,2,\ldots,q \qquad (3.6)$$

where the notation is as above, with the additions of θ_i, the rate of indirect taxation in sector i, a_{Di}, a coefficient of proportionality between the stock of money (D) which producers in sector i hold for transactions purposes and the output level X_i, and v, the money rate of interest.

We assume that wages in each sector are proportional to some overall wage level,

$$w_i = \xi_i w \qquad i=1,2,\ldots,q \qquad (3.7)$$

while the rate of return s_i is determined by the overall rate of return to capital and depreciation rates:

$$s_i = \sigma_i s + \delta_i \qquad i=1,2,\ldots,q \qquad (3.8)$$

The coefficients σ_i and ξ_i allow for the influence of risk, different skill levels, etc., in causing sectoral differences in returns to capital and wages, respectively. The δ_i are coefficients of radioactive depreciation.

It is assumed that the stocks of capital and labor K and L are fully employed

$$\Sigma_i \; L_i = L \qquad (3.9)$$

$$\Sigma_i \; K_i = K \qquad (3.10)$$

although these stocks can be varied parametrically to analyze the effects on prices and outputs of, say, "creating" employment by raising L. (3)

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(3) See Nelson / / for analysis of this type in an aggregate model whose structure is similar to the one presented here.

Levels of consumption are assumed to depend on prices, the alternative cost, v, of holding monetary stocks, and income,

$$C_i=C_i(p_0,p_1,\ldots p_q,v,y) \quad i=o,1,\ldots,q \tag{3.11}$$

$$D^c=D^c(p_0,p_1,\ldots p_q,v,y) \tag{3.12}$$

where

$$y=u+vD^{cs} \tag{3.13}$$

i.e., total consumer income is the sum u of incomes coming from the production sector and the supply of money used by consumers D^{cs}. Naturally, the equilibrium condition

$$D^c=D^{cs} \tag{3.14}$$

must also hold (although a "representative consumer" does not know it--see Samuelson / /.)

To close remaining demand-supply gaps, we add two more balance equations. These are the balance of payments in world prices:

$$\sum_{i=m+1}^{n} \pi_i E_i+\Delta=\sum_{i=0}^{m} \pi_i M_i \tag{3.15}$$

(where Δ represents capital inflows) and the demand-and-supply balance for money

$$\Sigma_i \; a_{Di}X_i+D^c=D \tag{3.16}$$

where D is the exogenous supply of domestic currency. (we assume that neither producers nor consumers wish to hold stocks of foreign currency.)

Finally, we assume that the economy-wide return to capital and the money interest rate are proportional:

$$v=\gamma s \tag{3.17}$$

This relates the alternative cost of holding cash balances to developments in the production sector of the economy.

4. Analyzing Differential Changes

As indicated above, we assume that the economy is in a state of equilibrium, as described by the above equations, and undertake a first year graduate theory analysis of the displacements to the equilibrium induced by changes in tariffs and other parameters. This section is devoted to a rapid derivation of the relevant differential equations. Succeeding sections attempt an empirical application.

Substitution from (3.11) and differentiation of the balance equation of (3.1) for non-competitive imports gives the relation

$$M_0M'_0-\Sigma_i\ a_{0i}X_iX'_i-C_0\left[g_{00}p'_0+\ldots+g_{0q}p'_q+g_{0v}\ v'+g_{0y}\ y'\right]-Z_0Z'_0=0 \qquad (4.1)$$

where the prime denotes a log-change ($M'_0=dM_0/M_0$, etc.) and the g s are elasticities of consumption with respect to prices (g_{0i}, $i=0,i,\ldots,q$), the interest rate (g_{0v}) and the income (g_{0y}).

Similar equations hold for the q_1 goods which are imported competitively,

$$M_iM'_i+X_iX'_i-\Sigma_j\ a_{ij}X_jX'_j-C_i\left[\Sigma_j\ g_{ij}\ p'_j+g_{iv}\ v'+g_{iy}y'\right]-Z_iZ'_i=0 \qquad i=1,\ldots.m \qquad (4.2)$$

the q_2 export goods,

$$X_1X'_i-\Sigma_j\ a_{ij}X_jX'_j-C_i\left[\Sigma_j\ g_{ij}p'_j+g_{iv}v'+g_{iy}y'\right]-Z_iZ'_i=0 \qquad i=m+1,\ldots.n \qquad (4.3)$$

and the q_3 non-tradable goods

$$X_iX'_i-\Sigma_j\ a_{ij}X_jX'_j-C_i\left[\Sigma_jg_{ij}p'_j+g_{iv}v'+g_{iy}y'\right]-Z_iZ'_i=0 \quad i=n+1,\ldots q \qquad (4.4)$$

Also, to complete the consumption specification, we have one equation (which follows from (3.12) and (3.14)

$$D^c(D^c)' - D^c\left[\Sigma_i\, g_{Di}\, p_i' + g_{Dv}\, v' + g_{Dy}\, y'\right] = 0 \qquad (4.5)$$

where g_{Dj} are elasticities of consumers' demand for money stocks with respect to prices, the rate of interest and income. (4)

Price changes for the tradable goods are determined by differentiating (3.2):

$$p_i' - \tau_i' - r' = 0 \qquad i=0,1,\ldots m \qquad (4.6)$$

and

$$p_i' - \phi_i' - \pi_i' - r' = 0 \qquad i=m+1,\ldots,n \qquad (4.7)$$

As (4.6) indicates, world import prices are assumed to remain constant. However, world export prices may in some cases be related to the country's export volume, as in (3.3). Differentiation gives

$$\pi_i' - \beta_i\, E_i' = 0 \qquad i=m+1,\ldots n \qquad (4.8)$$

Turning to the production specification, the Cobb-Douglas assumption gives us the following familiar equations:

$$X_i' - \alpha_i L_i' - (1-\alpha_i)\, K_i' = 0 \qquad i=1,2,\ldots,q \qquad (4.9)$$

Differentiating the labor demand equations (3.4) gives the equations

$$(p_i^*)' + X_i' - w_i' - L_i' = 0 \qquad i=1,\ldots,q$$

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(4) In all of these equations, the consumption specification is assumed to be based on some complete system of demand equations. If one makes the usual assumption of empirical studies that the underlying utility function is additive in its arguments C_0, C_1, ...,C_q and D^c/y, then an application of Frisch's method /0/ allows one to deduce all corss-price elasticities from income and some own-price elasticities (including these elasticities for money demand). The relevant equations are presented in Appendix 1.

By (3.7) we note that

$$w_i'=w'.$$

Also, if we assume that all goods prices $p_0,\ldots p_q$ are equal to one in the intial period, then we may write p_i^* as

$$p_i^*=1-\Sigma_j\ a_{ji}-\theta-a_{Di}v, \qquad i=1,\ldots,q$$

When all of these expressions are substituted into the differential of the labor demand equation, we derive

$$(p_i^*)^{-1}\left[p_i'-\Sigma_j\ a_{ji}\ p_j'-\theta_i\ \theta_i'-a_{Di}v'\right]+X_i'-w'-L_i'=0 \quad i=1,\ldots,q \qquad (4.10)$$

as the final specification of changes in labor use.

Differentiation of the capital demand equations (3.5) gives

$$(p_i^*)'+X_i'-s_i'-K_i'=0 \qquad i=1,\ldots.q.$$

From (3.8) and the assumption that s is initially equal to one, we find that

$$s_i'=\sigma_i s'/(\sigma_i+\delta_i).$$

Using this expression and making a substitution from the labor demand equations to remove the complex expression for $(p_i^*)'$, we derive the following equations for changes in capital use:

$$w'+L_i'-K_i'-\sigma_i s'/(\sigma_i+\delta_i)=0 \qquad i=1,\ldots.q \qquad (4.11)$$

Changes in both labor and capital use are constrained to add up to the change in total availibility of these factors:

$$\Sigma_i\ L_iL_i'-L\ L'=0, \qquad (4.12)$$

and

$$\Sigma_i\ K_iK_i'-K\ K'=0 \qquad (4.13)$$

Also the balance of payments and the demand-supply balance for money must continue to hold:

$$\sum_{i=m+1}^{n} \pi_i Ei\ (\pi_i'+E_i')\ +\Delta\Delta'-\sum_{i=0}^{m} \pi_i M_i M_i'=0 \qquad (4.14)$$

and

$$-D^c\ (D^c)'-\Sigma_i\ a_{Di}\ X_i\ X_i'\ +D\ D'=0 \tag{4.15}$$

The definitional equation (3.13) for y is also respected,

$$y\ y'-vD^c v'-vD^c\ (D^c)'-uu'=0 \tag{4.16}$$

And finally, the differential form of relation (3.17) holds:

$$v'-s'=0. \tag{4.17}$$

The set of equations (4.1)-(4.17) is the complete catalog of relationships between log-changes of the variables describing the state of our simple general equilibrium economy.

5. Analysis of the Equation System

Before continuing with an empirical application, a few remarks may clarify the interpretation of the system of equations we have derived.

First--It is inelegant but nontheless reassuring to count up equations and variables whenever one is working with a large sysgem. For the present model, this is done in Tables 1 and 2. Table 1 reveals that there are $15+8q_i+9q_2+6q_3$ variables whose log-changes appear in equations (4.1)-(4.17). Table 2 indicates that there are $9+5q_1+6q_2+4q_3$ equations in this system. Subtraction informs us that $6+3q_1+3q_2+2q_3$ log-changes "should" be specified exogenously to determine the remaining variables. Do this many naturally exogenous variables exist?

Perusal of the second column of Table 1 indicates that this question can indeed be answered in the affirmative. Here the following variables are tagged as exogenous: the final demands Z_i, the forces of tariffs τ_i, the forces of export subsidies ϕ_i,

Table 1

Number of Variables Whose Log-Changes Appear in the Model

Name	Type	Numbers			
		1	q_1	q_2	q_3
M_i'	Endg	x	x		
X_i'	Endg		x	x	x
Z_i'	Exg	x	x	x	x
E_i'	Endg			x	
$(D^c)'$	Endg	x			
v'	Endg	x			
y'	Endg	x			
p_i'	Endg	x	x	x	x
τ_i'	Exg	x	x		
ϕ_i'	Exg			x	
π_i'	Endg			x	
r'	Endg	x			
L_i'	Endg		x	x	x
L'	Exg	x			
K_i'	Endg		x	x	x
K'	Exg	x			
θ'	Exg		x	x	x
w'	Endg	x			
s'	Endg	x			
D'	Exg	x			
Δ'	Exg	x			
u'	?	x			
Totals		15	8	9	6

Table 2

Number of Equations Relating Log-Changes of the Variables

Name and Formula Number		Number			
		1	q_1	q_2	q_3
Non-competitive import balance	(4.1)	x			
Imported goods balances	(4.2)		x		
Exported goods balances	(4.3)			x	
Non-traded goods balances	(4.4)				x
Consumers' use of cash balances	(4.5)	x			
Imported goods' price changes	(4.6)	x	x		
Exported goods' price-changes	(4.7)			x	
Export price-volume equations	(4.8)			x	
Production functions	(4.9)		x	x	x
Labor use changes	(4.10)		x	x	x
Capital use changes	(4.11)		x	x	x
Total labor use	(4.12)	x			
Total Capital use	(4.13)	x			
Balance of payments	(4.14)	x			
Monetary supply-demand balance	(4.15)	x			
Definition of y'	(4.16)	x			
Equal log changes in interest rate of return to capital	(4.17)	x			
Totals		9	5	6	4

the total supplies of labor and capital L and K, the indirect tax rates θ_i, the money supply D and the capital inflow Δ. There are exactly $6+3q_1+3q_2+2q_3$ variables in this set, and all of them may be assumed to be under the control of either the government or the Gods.

Second--Suppose we group all the endogenous log-changes in a vector a and the exogenous changes in vector b. Then the system (4.1)-(4.17) can be written in a general matrix form as

$$M\ a+Nb=0$$

where M and N are matrices of order $(9+5q_1+6q_2+4q_3) \times (9+5q_1+6q_2+4q_3)$ and $(9+5q_1+6q_2+4q_3) \times (6+3q_1+3q_2+2q_3)$ respectively.

Formally, this system can be solved in the following form:

$$a=-M^{-1}Nb.$$

Can the system in fact be solved in practice? A little calculation indicates that the answer is "yes." For a typical application, one might be working with, say, 20 import sectors, 5 export sectors, and 10 non-traded sectors. In this case, the matrix M would be of order 179x179. It is by no means trivial to invert a matrix of this size, but the task still would require only a few minutes of time on the types of computers which now exist in many developing countries.