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DESTABILIZATION AND ADJUSTMENT IN A SMALL OPEN DEVELOPING COUNTRY: A FRAMEWORK FOR ANALYSIS

B. ESSAMA NSSAH

Cornell University Policy Reform Project
Ministry of Plan, Niamey, Niger

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1. INTRODUCTION

The 1980's have been a decade of a deepening economic crisis in developing countries. The comfortable growth that these countries enjoyed in the 1970's has been reversed. The World Bank reports that the average growth rate in developing countries dropped from 5.4 percent a year for the 1973-1980 period to 3.9 percent for the period 1980-1987 (World Development Report 1988).

This crisis can be traced back, at least in part, to developments in the world commodity and financial markets. Most developing countries are primary commodity exporters with small domestic markets. This makes them heavily dependent on trade, and their foreign exchange earnings quite volatile. Depending on the economic conditions and the policy environment in the industrial countries, commodity world markets may experience a boom or a bust. In either case, policy makers in developing countries are confronted with a tremendous challenge.

The economic crisis of the 1980's has led to a significant decline in real per capita GDP and levels of investment, particularly in some African countries where it is estimated that, on average, real per capita GDP declined by 3 percent per annum during 1980-1987 (World Development Report 1988).

The two oil price shocks of 1973 and 1979 have provoked an unprecedented income transfer between consuming and producing countries and have overshadowed any other terms of trade movement in the post war era (Gelb et. al. 1988). For oil exporting developing countries, the windfall presented an opportunity to relax some fundamental constraints impinging upon economic growth namely : foreign exchange, domestic savings and fiscal revenue. Oil exporters reacted differently to the windfall, their reaction ranging from euphoria to caution. The most optimistic countries increased spending by more than the windfall by taking advantage of easy money on international financial markets to finance consumption or dubious investment projects. After the boom, necessary economic and financial adjustments were not made and as a result, the economies were left with unsustainable external and internal imbalances in terms of current account deficits, capital flight, excessive debts, fiscal deficits, currency overvaluation, inflation and distorted incentives facing critical sectors such as agriculture and industry. Other countries such as Botswana, Cameroon, and Indonesia adopted a cautious stance by opting for relatively sound economic policies and thus sparing their economies most of the negative impact of the boom and bust cycles.

Developments in the non-oil commodity market are similar to the ones described above. Real prices of those commodities declined sharply between 1980 and 1987, due, in particular, to a fall in demand by industrial countries and to their policy of substitution and protection. The price fall was further amplified by a supply increase in developing countries reacting positively to the commodity boom of the 1970's. Again the response to this slump varied significantly across developing countries. East Asian countries stepped up the volume of their primary commodity exports in an effort to keep the purchasing power of these exports constant. In contrast, in Africa, purchasing power fell sharply as export volume stagnated.

The fact that, faced practically with the same trading environment, developing countries responded differently to external shocks clearly demonstrates that the part played by the socioeconomic structure and the domestic policy environment is not negligible.

Despite the observable differences in socioeconomic structure, the policy responses to the crisis have shown little variation across countries. These responses were aimed at restoring external and internal balance,

and improving the efficiency of the economy by shifting resources to tradeable sectors. The following instruments have been recommended and implemented: (1) devaluation; (2) getting prices right; (3) government spending cuts; (4) reduction in the rate of growth of money supply; (5) privatization of state-owned enterprises; and (6) creation of capital markets. However, the impact of these measures has been limited, because they are ill adapted to the economic structures of developing countries. These measures imply an economic structure which is more consistent with a distortion-free system best described by the Walrasian paradigm. A blind application of these rules outside of the Walrasian framework may lead to serious biases in the estimates of both the extent and the direction of the impact of policy reforms (Devarajan and Lewis 1989). This raises the fundamental issue of optimum policy response to shocks. Following the principles of optimum tax policy, the optimum response can be considered as a deployment of feasible policy instruments such that welfare is maximized subject to the structure of the economy.

In light of the issues described above, the purpose of this document is to present, in a coherent framework, the fundamental concepts and techniques for the specification and simulation of economy-wide models of shock or policy impact analysis. The analysis is essentially based on the dual, general equilibrium approach presented by Dixit and Norman (1980) and represents a step in the formulation of a CGE model for Niger.

In the next section, we present the Salter-Swan model which has inspired most models for structural adjustment analysis. Section three consists of a discussion of possible extensions to the basic model. Commercial policy is discussed in section four. Section five is a review of issues related to empirical implementation of such models. The main conclusions are presented in section six.

2. THE CORE MODEL

The Salter-Swan model of international trade has provided the fundamental framework for the study of the impact of macroeconomic imbalances and adjustment policies on the real sector of a small open economy. The model is a single-country model as opposed to a multi-country trade model. It represents an improvement on the standard neoclassical trade model which empirically often leads to implausible results due to the assumptions of tradeability of all goods and perfect substitutability between foreign and domestic goods. These two assumptions imply the law of one price which basically states that domestic prices of tradeable goods and services are determined by the world market.

Crucial within the Salter-Swan framework is the distinction between tradeable and non-tradeable goods and services. Non-tradeables are goods and services whose prices are determined by supply and demand conditions within domestic markets. The fact that a good is non-tradeable may be due to its nature (i.e public services or construction) or to prohibitive transport costs that keep the good off the world market. Prices for tradeable goods and services are determined by the world market. Thus, some policy changes can cause some goods to switch categories.

The Salter-Swan model is a two-sector, general equilibrium model dealing with three types of goods: a non-tradeable, an exportable and an importable good. The country is assumed small vis-à-vis international trade, and therefore faces a perfectly elastic excess supply from the rest of the world. In other words, it cannot affect the terms at which it is trading with the rest of the world. Exportables and importables can therefore be aggregated into a single class of good: tradeables. In the aggregation, world prices would be used as weights. The institutional framework replicates a purely competitive economy with three representative agents: a producer

who maximizes revenue subject to technical feasibility and primary factor endowment: the consumer who maximizes utility subject to an overall budget constraint: and the rest of the world. The equilibrium is a full employment equilibrium and wages and commodity prices are sufficiently flexible to maintain this status. Therefore, there is no need to explicitly model factor markets.

For ease of exposition, we model production decisions through a revenue function and consumption via an expenditure function. The formal expression of the model is presented in table 2.1.

Table 2.1 : The Salter-Swan Model[1]

(1) $e(p,q,u) = r(p,q,v)+\epsilon F$	(4) $b = p.m$
(2) $D_q e = D_q r$	(5) $p = \epsilon.\pi$
(3) $m(p,q,u,v) = D_p e - D_p r$	

Endogenous Variables:

u : Utility or Welfare index
q : Domestic price of the non-tradeable good
p : Domestic price of the tradeable good

Exogenous Variables:

F : Foreign capital inflow
ϵ : Nominal exchange rate
π : World Price of the tradeable.
v : Fixed factor supplies.

Equation 1 represents an overall budget constraint facing the consumer. It states that total absorption equals national income plus net foreign capital inflow. The optimizing behavior of the two domestic agents is summarized by the expenditure and revenue function respectively. The former is the minimum level of expenditure necessary to achieve utility level u at prices (p,q) while the latter represents the maximum attainable revenue given output prices and factor endowments. Both $e(p,q,u)$ and $r(p,q,v)$ are known to be linearly homogeneous in prices. The revenue function is convex in prices while the expenditure function is concave in those arguments.

Equation 2 describes equilibrium in the market for the home good (non-traded). Equation 3 represents the excess demand for the tradeable good. By definition it is homogeneous of degree zero. Equation 4 defines the balance of payments. Given the above homogeneity property and by virtue of Euler's theorem, it should be

[1] Throughout the document, $D_x f$ stands for the first order derivative of the function f with respect to argument x.

noted that equation 4. can be derived from equation 1 and is equivalent to $b = \varepsilon.F$. Equation 5 links the domestic price of the tradeable good to its World price via a fixed exchange rate.

The system described in table 2.1. is homogeneous of degree zero in (ε,q). Since the exchange rate (the domestic price of foreign currency) is assumed fixed, it may be chosen as the numeraire. Movements in q would therefore be interpreted as movements in the real exchange rate, usually defined as the relative price of tradeables to non-tradeables.

The country experiences a situation of internal and external balance when equation 2 holds and $F = 0$. Let's suppose that there is a sudden inflow of foreign exchange ceteris paribus. This would result in the relaxation of the budget constraint in equation 1 of table 2.1.. This may be written as:

$$D_u e du = \varepsilon.dF \tag{2.1}$$

Implying that:

$$du = \left(\frac{e}{D_u e}\right)dF \tag{2.2}$$

In order to trace the impact of this sudden inflow of foreign exchange on the domestic market for the non-traded good, we totally differentiate the equilibrium condition in equation 2 of table 2.1.; substituting for du we get the following expression:

$$D_q^2(e-r)dq = -\frac{D_{qu}^2 e}{D_u e}.\varepsilon.dF \tag{2.3}$$

Let the coefficient of dq be s. This is the own price derivative of the excess demand of the non-traded good. Normally, this is a negative scalar as it is a measure of own price substitution. The consistency imposed by the budget constraint in equation 1 of table 2.1. implies that $(D^2_{qu}\, e/D_u\, e)$ measures the pure income effect. Call this γ. It will be positive if the traded good is not an inferior good. We take that to be the case. Hence

$$dq = (-\gamma/s).\varepsilon.dF \geq 0 \tag{2.4}$$

Under our maintained hypotheses, a sudden foreign capital inflow would lead to a real exchange rate appreciation if the non-tradeable is a normal good.

Another interesting issue worth analyzing within this framework is the effect of a change in world prices. Let's suppose that, starting from a position of both internal and external balance, the world price of the tradeable changes by $d\pi$. Then the corresponding change in its domestic price is $dp = \varepsilon.d\pi$. In order to determine the real exchange rate as measured by changes in the domestic price of the non-tradeable good, we proceed as in the case of the foreign capital inflow, by totally differentiating the budget constraint and the

equilibrium condition in the non-tradeable market. This yields:

$$D_p e dp + D_q e dq + D_u e du = D_p r dp + D_q r dq \tag{2.5}$$

$$D^2_{qp} e dp + D^2_q e dq + D^2_{qu} e du = D^2_{qp} r dp + D^2_q r dq \tag{2.6}$$

Using (2.3), and recalling that :

$$D^2_{qu} e du = \gamma D_u e \tag{2.7}$$

Furthermore, let

$$(D_q e - D_q r) = n(p,q,u) \tag{2.8}$$

be the net compensated domestic demand for the non tradeable, then the above system reduces to :

$$m dp + n dq + D_u e du = 0 \tag{2.9}$$

$$D_p n dp + D_q n dq + D_u n du = 0 \tag{2.10}$$

Solving simultaneously for dq and du in terms of dp, and normalizing in such a way that $D_u e = 1$, we get the following expression of the change in the domestic price of the non-tradeable.

$$dq = -\frac{(D_p n - \gamma m)}{s} dp \tag{2.11}$$

It is a function of the exogenous change in the world price of the tradeable good and based on the assumption that the market for the non-tradeable is back in equilibrium.

The denominator in the above expression is clearly negative as it is a measure of the own price substitution effect for the non-tradeable. We have maintained all along that γ is positive. Therefore the sign of dq depends crucially on $D_p n$, the compensated cross price derivative between the tradeable and the non-tradeable (a measure of the substitutability between the two goods). For specificity, let us assume that the two goods are substitutes, the country is net importer $(m>0)$, the world price of the tradeable increases and the associated income effect is weak in the sense that : $\gamma m < D_p n$. Under those circumstances, there will be real exchange appreciation which will lead to structural adjustment in both consumption and production, resulting in the contraction of the tradeable sector. Conversely, if the income effect dominates the substitution effect as

would be the case where $D_p n = 0$, then there will be real exchange depreciation. If the two effects do cancel each other, there is no change in either the real exchange rate or the structure of the economy. When the country is a net exporter, the domestic price of the non-tradeable good is positively correlated with the price of the tradeable . One important lesson to be learned from this analysis is that free adjustment of an economy to an external shock depends crucially on its structure as defined by the key parameters such as income and price elasticities, and the volume of net trade.

The above comparative statics results may be used in the analysis of problems associated with maintaining internal and external balance. They also clearly reveal the policy implications of the core model. Table 2.2. below depicts a situation of internal and external balance in a small open economy.

Table 2.2.: Internal and external balance in a small open economy

(1) $e(p,q,u_o) = r(p,q,v)$	(3) $D_q e(p,q,u_o) = D_q r(p,q,v)$
(2) $D_p e(p,q,u_o) = D_p r(p,q,v)$	

This situation is characterized by the equality between total expenditure and full employment income (equation 1) and zero excess demand for both the tradeable and non-tradeable good. It should be noted that by the homogeneity property of the expenditure and revenue functions, equations 2 and 3 imply simultaneously equation 1.

Now, let ψ represent an excess demand resulting from a tax cut or an increase in government expenditure. Part of the additional expenditure will fall on traded and part on non-traded goods, creating excess demands m and n respectively for both goods. The overall disequilibrium is depicted in table 2.3.

Table 2.3.: Internal and external disequilibrium in a small open economy

(1) $e(p,q,u_1) = r(p,q,v) + \psi$	(3) $n = D_q e(p,q,u_1) - D_q r(p,q,v)$
(2) $m = D_p e(p,q,u_1) - D_p r(p,q,v)$	

In both tables 2.2. and 2.3., prices are the same; the only difference is in utility levels. The utility level associated with the situation of internal and external balance has been labelled u_o while u_1 represents the utility level corresponding to the excess demand. Taking a linear approximation to the excess expenditure $[e(p,q,u_1)-e(p,q,u_o)]$, we find that, under our normalization rule:

$$du = \psi \tag{2.12}$$

Proceeding similarly for the excess demand functions, we get:

$$m = D^2_{pu}e.\psi \quad = D_y m.\psi \tag{2.13}$$

Where:

$$D_y m = D^2_{pu}e \tag{2.14}$$

stands for the marginal propensity to spend on the traded good. Furthermore

$$n = D_y n.\psi \tag{2.15}$$

The results in (2.13) and (2.15) assume that the excess demand originates from the private sector e.g. response to a tax cut. A simplifying assumption concerning government spending is that the public sector's marginal propensity to spend on traded goods is not significantly different from the private sector's. In Salter's terminology, equations 2.12, 2.13 and 2.15 depict the expenditure effects associated with the excess demand. If the situation persists, the price effects would follow. Given the small country assumption and considering that the nominal exchange rate is fixed, the price effects will be measured by changes in the price of the non-traded good as reflected in equation 2.16.

$$dq = -\frac{D_y n}{s}.\psi \tag{2.16}$$

Thus, if the home good is normal,its price will increase as a result of the excess demand which is equivalent to a real exchange rate appreciation. This will, in turn, lead to an increase in the production of the non-tradeable good as the demand for it decreases. It can also offset the original expenditure effect and restore equilibrium in the home good market. However, despite this internal equilibrium, these factors can also lead to external imbalance which will be refleted by a trade deficit.

A major issue to be addressed is how to restore external balance. At first one would be inclined to cut expenditure in order to reduce excess demand. Unfortunately such a cut will create a situation of excess supply in the home good market. Assuming that prices are flexible and resources are homogeneous and can move freely and costlessly between sectors, an automatic adjustment process will be set in motion, causing the price of non-tradeables to fall. Given that the price of tradeables is constant, this fall in domestic prices will change the structure of incentives in favor of the traded goods by shifting resources from the non-tradeable to the tradeable sector. Excess demand in the tradeable market will thus be eliminated through the combined action of

expenditure cut and increase supply resulting from the change in incentives. The home goods market returns to equilibrium following the decrease in the price of the non-tradeable.

If we assume that the price of the home good is inflexible, then there can be no change in the structure of incentives. The excess supply in the non-tradeable sector can only be eliminated through unemployment in that sector.

Clearly there is a tradeoff between the two policy objectives of internal and external balance. This tradeoff necessitates the simultaneous use of an absorption and a switching instrument to counteract the expenditure and the price effects associated with a situation of excess demand.

A switching policy raises the domestic price of tradeables relative to non-tradeables and thus induces a change in the pattern of consumption and production. It is important to emphasize that this policy alone cannot eliminate excess demand in the tradeable market, as an increase in the domestic price of tradeables will discourage their domestic consumption and lead to an increase in their supply. At the same time the resulting resource movement out of the home goods market combined with the change in the pattern of consumption of these goods will create excess demand in the market for non-tradeables. The only way this could be eliminated is to let the domestic price of the home goods increase. Equilibrium will be restored in the market for non-tradeables but the external imbalance will not be resolved.

The core model may also be used in optimum policy analysis to determine the optimal response to external shocks. In that context, it is cast in a framework that explicitly accounts for the optimizing behavior of the sole consumer, as presented in table 2.4.

Table 2.4.: The Core Model in an optimization framework

Maximize $u(c_1, c_2)$ with respect to : c_1, c_2, x, d subject to:	(2) $c_1 - x = m$ (*balance of trade*)
(1) $g(x,d) = 0$ (*technology*)	(3) $c_2 = d$ (*non-tradeable market equilibrium*)

Where c_1 and c_2 represent consumption levels of the tradeable and non-tradeable good respectively; x and d represent the levels of domestic production of the two commodities. The constraint equation 1 in the above table describes the technological feasibility of the production plan (x,d). The last two equations are material balances for the two goods. They can be substituted in the objective function. The resulting Lagrangean is :

$$L = u(x+m,d) - \lambda g(x,d) \tag{2.17}$$

The associated first order conditions are :

$$D_x\mu - \lambda D_x g = 0 \tag{2.18}$$

$$D_d\mu - \lambda D_d g = 0 \tag{2.19}$$

$D_x\mu$ and $D_x g$ are interpreted as consumer and producer prices respectively. Thus efficient allocation of domestic resources requires that domestic consumer prices be proportional to domestic producer prices for both goods. In other terms, the marginal rate of substitution must equal the marginal rate of transformation.

Following Dixit and Norman (1980), we note that the envelope function of the problem depends parametrically on m and may be written as $\phi(m)$. This is the maximum utility achievable by the consumer given the level of net imports m. By the envelope theorem, the derivative of this function with respect to m is equal to the marginal utility of the tradeable good (i.e. consumer price), as follows:

$$D_m\phi = D_x\mu \tag{2.20}$$

This must equal the producer price for efficient allocation of resources. Let,

$$\hat{p} = D_m\phi \tag{2.21}$$

The question now is to determine the relationship between domestic prices and the World price π. In the case of a small country with no domestic distortions, this relationship is found by maximizing $\phi(m)$ with respect to m, subject to the balance of trade constraint $\pi.m = 0$. The answer is :

$$\hat{p} = a\pi \tag{2.22}$$

Where a is a factor of proportionality (nominal exchange rate). This forms the basis of the policy advice given developing countries to get the prices right. That is, let consumers and producers be subjected to the same prices domestically for non-traded goods; and the world prices for tradeables. Note that this result assumes the absence of distortions. Under these circumstances, the outcome is consistent with a free trade competitive equilibrium which may not necessary apply to the context of developing countries. This is one indication of the limited application of the core Salter-Swan model. Some extensions to the basic model are therefore warranted.

3. EXTENDING THE BASIC MODEL

The standard Salter-Swan model focuses on the effects of external shocks on the real exchange rate which ultimately directs resource allocation within the economy. The underlying assumptions describe the best of all worlds: perfect competition at home and free trade abroad. Thus, if the country is small, all tradeables can be aggregated into a single good. The trade balance is exogenous. Factor homogeneity combined with price flexibility ensures that all markets clear. Finally domestic and foreign goods are considered perfect substitutes

in consumption.

As specified above it is evident that this basic model, though a useful analytical tool, does not reflect the structure of a typical developing country nor does it cover the whole range of issues of critical interest to the developing world. First of all, by aggregating exportables and importables in a single class, the model precludes any discussion of trade policy. Developing countries are subject to frequent external shocks which render structural adjustment programs necessary. A major component of these programs entail changes in trade policy. Such changes alter the domestic relative price of exportables to importables (Bevan et al., 1990). Thus disaggregating the tradeable sector along with the non-tradeable leads to two relative prices which change independently from each other even if world prices are given. Second, the real exchange rate upon which the analysis focuses does not constitute a policy instrument directly accessible to the government; the basic model therefore does not explicitly include policy instruments such as taxes nor does it permit consideration of macroeconomic effects (Devarajan, Lewis and Robinson, 1990). Finally, the magnitude of the fundamental parameters (elasticities of substitution and transformation) necessary to secure the standard results may not materialize in developing countries which are typically characterized by many rigidities and/or distortions. Thus the basic model could be extended either by relaxing some of the fundamental assumptions deemed too restrictive or by adding actors and/or markets depending on the issues one wishes to focus upon.

Imperfect Substitution

As noted earlier, in the basic Salter-Swan model, goods are either tradeable or not. Domestically produced tradeables are perfect substitutes for foreign-produced goods. When coupled with the assumption of price-taking behavior, this specification may lead to specialization in production, in response to a change in commercial policy or in foreign prices. This is the case because domestic prices of tradeables are entirely determined by their world prices. However, some empirical evidence casts doubt on the validity of this conclusion. Furthermore, significant cross-hauling is observed in trade statistics even at a fairly high level of commodity disaggregation. These two reasons make the perfect substitution assumption quite inappropriate within the Salter-Swan framework, at least when it comes to applying it to developing countries.

To better understand what is structurally involved in the relaxation of the perfect substitution assumption, we reinterpret the framework within a one-sector model based on specific functional forms (see de Melo and Robinson, 1989). Consider then the case of a small open economy that produces one commodity. The output, X, which is fixed in the short run, is either consumed domestically or exported. The ratio of exports E to domestic sales D is determined by revenue maximization conditions consistent with a constant elasticity of transformation (CET) function for exports. If

$$\bar{X} = A(\alpha E^{h} + (1-\alpha)D^{h})^{\frac{1}{h}} \tag{3.1}$$

Then:

$$\frac{E}{D} = \left[\left(\frac{1-\alpha}{\alpha}\right)\frac{P_1}{q}\right]^{\Omega} \tag{3.2}$$

Where $\Omega = 1/(h-1)$, p_1 and q are the domestic price of exports and of domestic sales respectively[2]. Similarly, the consumer minimizes the cost of a composite good which is a constant elasticity of substitution (*CES*) aggregation of imports and domestic sales. Let Z stand for that good. Then:

$$Z = B(\beta M^{-\varrho} + (1-\beta)D^{-\varrho})^{-\frac{1}{\varrho}} \tag{3.3}$$

The above equation implies that:

$$\frac{M}{D} = \left[\frac{\beta q}{(1-\beta)p_2}\right]^{\sigma} \tag{3.4}$$

Where $\sigma = 1 / (1+\varrho)$ and p_2 the domestic price of imports. In the above expressions, α and β are share parameters while σ and Ω are the elasticities of substitution and transformation respectively. The overall budget constraint may be written as

$$p_z Z = p_x \bar{X} + \varepsilon F \tag{3.5}$$

also

$$p_z Z = p_2 M + qD \tag{3.6}$$

Given the prevailing equilibrium in the domestic market, equations 3.5 and 3.6 imply:

$$\varepsilon F = p_2 M - p_1 E \tag{3.7}$$

Where $p_i = \varepsilon\, \pi_i$ and π_i is the fixed world market price of exports or imports.

Now, to see how trade elasticities determine the impact of an external shock on the economy, we consider the log-differential of equations 3.2, 3.4, and 3.7 assuming an exogenous change in the world price of imports π_2. We get the following[3]:

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2 The result is obtained by maximizing $P_x X = p\,E + qD$, subject to $X = CET\,(E, D, \alpha, \Omega)$ see appendix 3.

3 see Devarajan, Lewis and Robinson (1990) p.15

$$\hat{E}-\hat{D} = -\Omega\hat{q} \tag{3.8}$$

$$\hat{M}-\hat{D} = \sigma(\hat{q}-\hat{\pi}_2) \tag{3.9}$$

$$\hat{M}+\hat{\pi}_2 = \hat{E} \tag{3.10}$$

Substituting (3.10) into (3.8) we get:

$$\hat{M}-\hat{D} = -\Omega\hat{q}-\hat{\pi}_2 \tag{3.11}$$

Using (3.9) we find that:

$$\hat{q} = \frac{\sigma-1}{\sigma+\Omega}\hat{\pi}_2 \tag{3.12}$$

A "hat" above a variable denote its log-differential so that

$$\hat{q} = d\ln(q) = \frac{dq}{q} \tag{3.13}$$

Whether or not there is real exchange appreciation (an increase in q) as a result of this unfavorable terms of trade shock depends on the sign of (σ - 1), which in turn, depends on the relative strength of the income and substitution effects, as mentioned in section 2. When $\sigma < 1$, the income effect dominates the substitution effect and the decrease in the consumer's real income (as a result of an increase in the world price of imports) leads to a real exchange depreciation (a decrease in q). Based on equation 3.8, exports should increase relative to domestic consumption in order to pay for the now more expensive imports. This lends support to the common policy advice given developing countries where it is believed that elasticity of substitution is less than unity. The recommendation is to depreciate the real exchange rate in response to an adverse terms of trade shock. When the substitution effect dominates, $\sigma > 1$ and real exchange rate will appreciate leading to a contraction of the tradeable sector. The reversal of the impact of a terms of trade shock according to the value of the elasticity of substitution also suggests the long-run effect may differ from the short-run effect since substitution elasticities are expected to be higher in the long-run.

The introduction of product differentiation on both export and import sides effectively solves the specialization problem associated with the perfect substitution assumption. However, this improvement upon the basic Salter-Swan framework comes with a cost, at least when one is interested in welfare analysis. It is known that the costs of protection may be severely understated when calculations are performed under product differentiation. This is an important point to keep in mind as we consider other possible extensions of the basic model.

The Public Sector

The public sector is a very important actor in the economic life of most developing countries. Most governments have in place control measures which grant them a monopoly over external trade, thus allowing them to import and export at world prices, while letting the private agents face different prices domestically. Furthermore, government spending is not necessarily distributionally neutral. Such neutrality would be achieved if the government returned its tax revenue as lump sum transfer to the private sector or at the very least if the distribution of public expenditures between tradeables and non-tradeables were the same as the private sector's allocation. In developing countries, government controls also extend to the money supply, the exchange rate, interest rate and the price of non-tradeables. Thus the behavior of the government imposes certain restrictions upon the private sector within those economies.

Adding the government to the core framework implies that policy instruments such as trade and domestic taxes, the budget and money supply have to be explicitly accounted for. The inclusion of the policy instruments along with the macroeconomic aggregates affected by them raises the issues of the macroeconomic properties of the resulting model and the compatibility or optimality of various policies.

The macroeconomic properties of a model hinge on the macro closure rule chosen. Three basic macro balances are considered: balance of trade, savings-investment balance and the government budget balance. The inclusion of these macro balances alongside policy, quantity and price variables usually leads to an undetermined system. One must therefore specify how the system is driven to equilibrium. In general, this would involve certain variables being determined exogenously or made dependent on others within the system. This is in essence, the closure rule.

In the case of neoclassical closure, both the balance of trade and real government expenditure are fixed. Thus, the government budget deficit is determined residually. There is no separate investment function, aggregate investment is determined by the level of aggregate savings. Aggregate savings include three components : private, public and foreign. Alternatively, one could fix real aggregate investment as well as real government expenditure and let the balance of trade become the equilibrating variable. This closure rule, which makes the system investment-driven rather than savings-driven was used by Devarajan and de Melo (1987) in a two sector general equilibrium model of CFA - Zone economies. As Sarris (1990) puts it, closure goes beyond the savings-investment adjustment. It is really a question of how various commodity and factor markets adjust to achieve equilibrium or material balance. This adjustment could be through prices or through quantities. The real nature of the process is determined by the structure and behavior of the markets under consideration.

As stated earlier, the explicit inclusion of the government in the core model also raises the issue of the compatibility of the various controls deployed. A control regime is said to be compatible if various policy instruments are set at levels consistent with a sustainable equilibrium (Bevan et. al., 1990). Note that compatible regimes are not necessarily optimal in terms of resource allocation. As Salter (1959) has observed, a state of internal and external balance is rare and precarious. In fact the macroeconomic imbalances experienced by many developing countries in the 1980's are partially explained by inappropriate domestic policies such as expansionary aggregate demand policy. For the purpose of this analysis, let us consider the case of an expansive monetary policy. To simplify matters, we assume that (1) money is the only asset in the economy held by the consumer rather than the producer, (2) the government controls the money supply, money is not held for its own sake but for transactions purposes, i.e the demand for money by the consumer is proportional to total expenditure on goods and services (Bevan et al. 1990 p.11). The basic framework is therefore modified as in table 3.1.

monetary policy. To simplify matters, we assume that (1) money is the only asset in the economy held by the consumer rather than the producer, (2) the government controls the money supply, money is not held for its own sake but for transactions purposes, i.e the demand for money by the consumer is proportional to total expenditure on goods and services (Bevan et al. 1990 p.11). The basic framework is therefore modified as in table 3.1.

Table 3.1. : Extending the Core Model to include monetary aspects

(1) $(1+\theta)e(p,q,u) = r(p,q,v)+k$	(4) $\theta e(p,q,u) = k$
(2) $m = D_p e - D_p r$	(5) $p = \varepsilon\pi$
(3) $n = D_q e - D_q r$	

Where k is the opening money supply and θ the coefficient of proportionality between private expenditure and private sector's transaction demand for money.

To determine the relation between the money supply and the balance of payments, we consider the financial expression of the latter. Invoking the homogeneity of the expenditure and the revenue function and using the equilibrium condition for the home good market, it follows from equation 1 that:

$$b = k - \theta e \tag{3.14}$$

and

$$D_k b = 1 - \theta \geq 0 \tag{3.15}$$

Therefore an excess supply of money leads to a balance of payment deficit, ceteris paribus.

Applying the derivation used in equation 2.16 we find that:

$$dq = -\frac{D_y n}{s(1+\theta)} dk \tag{3.16}$$

Thus, expansive monetary policy will lead to a real exchange rate appreciation in the context of a small economy with fixed nominal exchange rate. In fact, an important principle in macroeconomics is that, in a open economy, monetary and fiscal policies must be consistent with the chosen nominal exchange rate regime in order to achieve a sustainable macroeconomic equilibrium. In other terms, the selection of an exchange rate system imposes restrictions on the conduct of macroeconomic policy. Severe imbalances may result if these restrictions are violated. Expansive fiscal policies can be analyzed in a similar fashion except that an additional equation

must be added to reflect the government budget constraint. Furthermore, the overall budget constraint of the private sector must be modified accordingly to account for the distributional impact of government spending. One simplifying assumption in that context is that government fiscal policies are distributionally neutral.

Wage Rigidity

So far, the analysis has been conducted in the ideal context of perfect price flexibility in all markets. This assumption implies that notional demand and supply are equal to effective ones. Notional demand and supply are based on prevailing prices and income or production possibilities, while the effective ones take into consideration any quantitative restriction encountered by the agents in other markets. Therefore assuming economy-wide wage rigidity raises the possibility of spill-over into other markets. For instance, if unemployment prevails, household decisions in goods or asset markets are bound to be affected.

In section 2 the issue of external and internal balance was discussed in terms of the balance of trade and the market for non-tradeables. The model can be extended through the inclusion of an equation depicting the labor market in order to analyze the problems associated with maintaining full employment and balanced trade within a small, open economy. To do so requires the following steps:

Let v stand for actual employment and labor supply fixed at v^*. The level of employment is therefore given by:

$$w = D_v r(p,q,v) \tag{3.17}$$

Where it is assumed that the wage rate is fixed at w. The price-wage configuration may be such that $v > v^*$. In that case, there will be labor rationing among firms. We assume that this is done efficiently so that the revenue function, evaluated at v^* retains its optimal properties. To determine how the exchange rate affects employment, we write the labor demand function in trems of the world price of the tradeable, i.e

$$\frac{w}{\varepsilon} = D_v r(\pi, \frac{q}{\varepsilon}, v) \tag{3.18}$$

This shows clearly that the exchange rate will affect employment. In fact, totally differentiating this equation yields:

$$D_\varepsilon v = \frac{D^2_{vq} r - w}{\varepsilon^2 D^2_v r} \tag{3.19}$$

The denominator is negative because the revenue function is concave in v. The numerator of the expression is negative at least in the case where the price of the home good does not change. Thus, a devaluation would have a positive effect on employment in the case of a flexible exchange rate.

To show that an increase in the wage rate will worsen the trade balance, let us consider the following

financial expression of the balance of trade:

$$b = k - \theta e(p,q,u) \tag{3.20}$$

Substituting in the money metric utility derived from the overall budget constraint:

$$u^* = r(p,q,v) + k \tag{3.21}$$

We get:

$$b^* = k - \theta e(p,q,u^*) \tag{3.22}$$

In terms of foreign currency we have:

$$b^* = k/\varepsilon - \theta e(\pi, q/\varepsilon, u^*) \tag{3.23}$$

Therefore:

$$D_w b^* = -\theta D_u e . D_v r . D_w v \tag{3.24}$$

Where $\theta D_u e$ is the marginal propensity to demand money for transaction purposes (taken to be positive) and $D_w v$ is negative on account of the concavity of r in v. Hence $D_w b^* > 0$.

4. COMMERCIAL POLICY

In general, commercial or trade policy means a specific departure from free trade. The question then is why would a country want to depart systematically from free trade despite its celebrated qualities with respect to efficiency and welfare. The motives may be related to the external or internal sector of the economy. The country may seek to improve its terms of trade. The objectives pursued domestically may include:

i) Some exogenously fixed targets for production or consumption.
ii) The removal of some distortions resulting from market failure, and
iii) a modification of income distribution.

The most common instruments are trade taxes (a negative tax is a subsidy) and quantitative restrictions. A well known result in general equilibrium analysis is that there is always a shadow tax associated with a quantitative restriction. Furthermore, a uniform export tax is equivalent to a uniform import tariff. Thus, we can safely limit ourselves to the consideration of the effects of an import tariff. In so doing, it is important to keep in mind that such a tariff does not act in isolation as domestic taxes may be levied as well.

As stated earlier, a country may impose a tariff on imports in the hope to improve its terms of trade.

This is possible only for a large country. In that case the net purchases of the country will affect world prices. In other terms, the country faces a less than perfectly elastic excess supply function from the rest of the world. In the case of a small economy, which is the focus of this paper world prices are given, therefore tariffs present an interest mostly in connection with domestic equilibrium or in the context of a fixed exchange rate regime where an equiproportionate tariff on all imports and subsidies to exports could replicate the effect of a devaluation. The effects of a tariff may be desirable on the grounds of protection or income distribution.

We begin with the price effects of a tariff. Since a small country cannot affect world prices, the issue of interest here is the effect of tariff on domestic prices. To simplify the analysis, let us consider the case of a small country producing and consuming two goods: an importable, the domestic price of which is p, and a home good whose price is q. Let a tariff t be imposed on the importable and the proceeds rebated to the consumers in a efficient manner. Now the overall budget constraint is given by:

$$e(p,q,u) = r(p,q,v) + t.m \tag{4.1}$$

Where m is the amount of imports.

The equilibrium in the home good market is:

$$n = D_q(e-r) = 0 \tag{4.2}$$

The domestic price of imports is:

$$p = \pi + t \tag{4.3}$$

Where π is the world price of imports. For a small change in tariff we have the following change in the domestic price of the importable:

$$dp = dt \tag{4.4}$$

Since $d\pi = 0$ by the small country assumption, this implies the following changes in the budget constraint and in the equilibrium of the home good market:

$$D_u e du = t.dm \tag{4.5}$$

$$s dq + \gamma D_u e du = -D_p n dt \tag{4.6}$$

Solving for dq, we get an expression which is analogous to (2.11):

(4.7)

$$dq = -\frac{(D_p n dt + t\gamma dm)}{s} \tag{4.7}$$

Starting from a free trade equilibrium, the expression reduces to:

$$dq = -\frac{1}{s} D_p n \, dt \tag{4.8}$$

Thus, whether or not a tariff on the importable raises the price of the home good depends on whether the two are substitutes in both consumption and production. If the degree of substitutability in use dominates that in production, the price of the home good would rise as a consequence of a tariff on the importable, other wise it may fall or stay unchanged. Note that the general expression in (4.7) also includes an income effect and this has to be taken into account in the final reckoning.

The fact that a tariff raises the domestic price of the importable (assuming that cross-substitution both in use and in production and income elasticities are in the proper range for a relatively moderate increase in the price of the home good), would lead one to conclude that a tariff has a protective effect and accordingly, to expect domestic production of the importable to expand at the expense of that of the home good. This brings us to the issue of effective protection,and more specifically,to the effect of a tariff on net outputs. The effect can be decomposed into a change in gross output and intermediate inputs. There is also associated with it a movement of primary factors across productive activities.

To look at this more closely, we consider the case of a small country with a fixed endowment of primary factors v. The domestic and world prices of goods are given by the vectors p and π respectively so that tariffs are $(p - \pi)$. Let A be the matrix of technical coefficients a_{ij}. Such coefficients describe Leontief technology and represent the quantity of good i necessary for the production of a unit of gross output j. These are assumed constant. If x and x^* are vectors of gross and net output respectively, then:

$$x_i^* = x_i - \Sigma_j a_{ij} x_j \tag{4.9}$$

for all i. In matrix notation, we have:

$$x^* = (I - A)x \tag{4.10}$$

Where I is the identity matrix. If optimal behavior is assumed on the part of the producer, then the optimal production plan will maximize the value of net output subject to feasibility constraints. These constraints pertain to technology and primary factor endowments. The technological constraint may be represented by a transformation function such as:

$$g(x,v) = 0 \tag{4.11}$$

The value of net output may be calculated either on the basis of gross prices applied to net output or net prices applied to gross output. Hence:

$$\zeta = px^* = p^*x \tag{4.12}$$

Where

$$p_i^* = p_i - \Sigma_j p_j a_{ij} \tag{4.13}$$

is the value added per unit of activity level in sector i.

The envelope function resulting from this optimization problem may be written as $r^*(p^*, v)$; it is a genuine revenue function. Convex and homogeneous of degree one in p^*. Hence:

$$x = D_{p^*} r^* \tag{4.14}$$

$$D_{p^*} x = D^2_{p^*} r^* \tag{4.15}$$

Which is a positive semi-definite matrix. This means that the activity level in a sector will rise following an increase in the unit value added in that sector. In our context, a tariff will provide effective protection to a sector (the importable for instance) only if the unit value added in the sector is raised by the tariff.

Furthermore, in this specific context, a tariff has redistribution implications through the associated change of domestic price ratio and the use of the revenue it generates. In connection to the issue of effective protection discussed above, the net value revenue function can also be used to study the response of factor prices to effective protection. The formula is:

$$D_{p^*} w = D^2_{vp^*} r^* \tag{4.16}$$

Where w is the vector of factor rewards. So, depending on factor intensity and mobility, the response of factor prices to changes in unit value added may or may not be magnified. In the context of the Hecksher-Ohlin two-good, two-factor (long run) trade model, and in accordance with the Stolper-Samuelson theorem, the price of the factor which is more intensively used in an activity will increase by a greater proportion and that of the other factor will fall when unit value added increases in that sector. This magnification effect disappears for some factors as soon as factor mobility is limited as in the case of the **Ricardo-Viner** model. In the simplest, two-good, three factor version, only one factor is assumed mobile across sectors while the others are specific to each

sector. In this case, it can be shown (Dixit and Norman, 1980) that an increase in the unit value in one sector will lead to a smaller increase in the price of the mobile factor. However the price of the specific factor to that sector will rise by a greater proportion while that of the other specific factor will fall. This model is most suited for the analysis of short run issues.

To illustrate what is involved in the redistributive consequences of the proceeds from the tariff, we reduce the world trade model presented by **Dixit and Norman**[2] to its small, single-country expression. We, consider a small open economy producing two goods with two primary factors. For specificity, we consider good 1 the importable upon which a tariff t is levied. We also assume that the importable is factor 1 intensive relative to the other good which we use as numeraire. There are two households owning respectively the two factors. All the tariff revenue is returned to the second household, owner of factor 2.

The production side of this economy is modeled with the revenue function where use is made of the duality between the revenue and the cost function (revenue maximization is consistent with cost minimization). In particular, we have:

$$r(p,q,v) = \min \{ w_1v_1+w_2v_2;\ c_1(w_1,w_2)\geq p;\ c_2(w_1,w_2)\geq q \} \tag{4.17}$$

Where p is the domestic price of the importable and $q = i$ is the numeraire. The demand side for the two households is given by the next three equations.

$$e_1(p,q,u) = w_1v_1 \tag{4.18}$$

$$e_2(p,q,u) = w_2v_2 + t.m \tag{4.19}$$

$$m = D_pe_1 + D_pe_2 - D_pr \tag{4.20}$$

Equation 4.20 represents the perfectly elastic excess supply of imports by the rest of the world. If the other good is non-tradeable, its price is determined by domestic supply and demand conditions.

In order to measure the efffect of an increase of the tariff by ***dt, on the domestic equilibrium***, we must totally differentiate the defining equations and make use of our maintained assumptions. It is also assumed that we start from a free trade equilibrium. Thus, the demand block yields:

$$D_pe_1dp + D_ue_1du_1 = v_1dw_1 \tag{4.21}$$

$$D_pe_2dp + D_ue_2du_2 = v_2dw_2 + m.dt \tag{4.22}$$

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[2] **Dixit and Norman (1980), pp.155-159**

$$D_p^2 e_1 dp + D_{pu}^2 e_1 du_1 + D_p^2 e_2 dp + D_{pu}^2 e_2 du_2 - D_p^2 r dp = dm \tag{4.23}$$

From the production side, we have:

$$dw_1 = (D_p w_1).dp \tag{4.24}$$

By the Stolper-Samuelson theorem and given the assumed factor intensity, we get:

$$D_p w_1 > \frac{w_1}{p} \tag{4.25}$$

Let z_{ih} be the consumption of good i by household h. Then inequality 26 implies that:

$$v_1 D_p w_1 - z_{11} > \frac{v_1 w_1}{p} - z_{11} > 0 \tag{4.26}$$

Since

$$\frac{v_1 w_1}{p} = z_{11}^{\max} \tag{4.27}$$

is the maximum affordable consumption level of good 1 by household 1 and letting $\delta_1 = (v_1 D_p w_1 - z_{11})$, equation 4.21 reduces to:

$$D_u e_1 du_1 = \delta_1 dp \tag{4.28}$$

By analogy, equation 4.22 yields

$$D_u e_2 du_2 = \delta_2 dp + m dt \tag{4.29}$$

Where δ_2 is negative by the **Stolper-Samuelson** result.

The overall change in welfare is given by adding equations 4.28 and 4.29. Thus:

$$du = (\delta_1 + \delta_2) dp + m\, dt \tag{4.30}$$

By definition, we have:

$$\delta_1+\delta_2 = v_1D_pw_1 - z_{11} + v_2D_pw_2 - z_{12} \tag{4.31}$$

$$= (v_1D_pw_1 + v_2D_pw_2) - (z_{11} + z_{12})$$

Based on equation 4.17 we conclude that:

$$\delta_1 + \delta_2 = D_pr - (z_{11} + z_{12}) = - m \tag{4.32}$$

given that for a small open economy $dp = dt$, we get:

$$du = 0 \tag{4.33}$$

Therefore a tariff cannot improve welfare in a price-taking open economy. In other terms, free trade is Pareto efficient for a small open economy. Whether or not the second household, owner of the second factor of production, benefits from the redistribution of the proceeds depends on the greatest of the two opposing forces: the negative **Stolper-Samuelson** price effect δ_2 or the income effect of the tariff revenue.

Equation 4.23 may be rewritten as:

$$dm = sdp + [\gamma_1\delta_1 + \gamma_2(\delta_2 + m)]dt \tag{4.34}$$

Where dp and dt are interchangeable. The coefficient of dp measures the substitution effect while that of dt measures the income effect including the redistributive effect associated with the use of the tariff revenue.

Bearing in mind that the fundamental issue is the optimal formulation of commercial policy,we have observed as a general proposition that the best policy depends on the objective and on the applicable constraints. The general objective involves the pursuit of efficient allocation of resources and an equitable distribution of income. General constraints pertain to the socioeconomic structure (resource endowment, technology and institutions). There may also be constraints related to the magnitude of some economic variable or to existing policy instruments . Therefore, the formulation of trade policy must be considered not in isolation, but in conjunction with available domestic taxes and with relevant structural and/or other constraints. The optimal trade policy maximizes the social welfare function subject to technological and any other constraint related to the trading environment and the set of domestic taxes that can be deployed. It is therefore evident that,in a large country facing a less than perfectly elastic excess supply from the rest of the world,trade taxes can only secure an improvement in the terms of trade.Even in the presence of domestic distortions and constraints trade taxes should still be used only if trade is the source of the problem.

As for lump sum transfers ,they should be used to modify income distribution. Even if lump sum taxation were not feasible, indirect domestic taxes would still be the second best alternative with respect to income distribution.

As stated earlier, tariffs are often viewed in the context of macroeconomic adjustment as an alternative to devaluation for countries that cannot manipulate the nominal exchange rate to effect real exchange depreciation to reduce unemployment and their trade deficit. This is the case of member countries of the Communauté Financière Africaine (CFA Zone)[3] whose currency is pegged to the French Franc at a fixed rate of 1 FF = 50 CFA. To understand what is involved,we revert to the model defined in equations 3 - 5 to which we add an equation describing the labor market:

$$w = D_v r(p,q,v) \tag{4.35}$$

Where w is a fixed wage and v is a variable supply of a single factor such as, labor. A total differentiation of (3) leads to:

$$D_{uu} edu = D_v r dv \tag{4.36}$$

By assuming that we start from an initial free trade and that $dp = dt$ (small country assumption). Equation 4.35 implies that:

$$dv = (-\frac{1}{D_v^2 r}).D_{vp}^2 r dp \tag{4.37}$$

Since the revenue function is concave in vl the expression in parentheses is positive. Furthermore:

$$D_{vp}^2 = D_p w \tag{4.38}$$

This is the Stolper-Samuelson derivative of the demand price of labor with respect to the price of the importable. In the factor specific model where labor is the mobile factor, this derivative is positive and a tariff has a positive effect on employment and on welfare as well. In the context of **Hecksher-Ohlin** model, the sign of 38 hinges on relative factor intensity. If the importable uses relatively more labor, then the derivative is positive and the tariff will have a positive effect on employment.

The effect of a tariff on the trade deficit is determined by totally differentiating:

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[3]. Devarajan and de Melo (1987)

$$b = p.m \tag{4.39}$$

We get:

$$db = pdm + mdp \tag{4.40}$$

Where:

$$m = D_p e - D_p r \tag{4.41}$$

and

$$dm = D_p^2 edp + D_{pu}^2 edu - D_p^2 rdp - D_{pv}^2 rdv \tag{4.42}$$

$$= d_p mdp + D_{pu}^2 edu - D_{pv}^2 rdv$$

The above expression decomposes into a price effect, an income and an employment effects.

5. APPICATION OF THE MODEL

The core model and its extensions discussed in the previous sections represent a stylized view of a small open developing economy. As such, they are useful for qualitative analysis and for ease of interpretation of results based on more complex empirical models which are structurally and institutionally more specific. The purpose of this section is to describe, with the help a very simple model, the fundamental steps involved in the empirical analysis of the magnitude of the response of economic variables to various shocks and policy initiatives. Essentially, the process involves fitting a mathematical model of the economy to a data set reflecting the state of the economy in a given year known as the base year. The impact analysis is conducted through a series of simulations whereby shocks are fed to the system via exogenous variables. Eventually, sensitivity analysis is conducted by changing the value of structural parameters underlying the observed results.

Data Base

As demonstrated by the preceding discussion, general equilibrium is the appropriate framework within which issues of real exchange appreciation and structural adjustment ought to be analyzed. Therefore the necessary data for an empirical economy-wide model must, be organized in a frame that reflects the circular flow of economic activity for the chosen year. The Social Accounting Matrix (SAM) offers such a framework. It provides an analytically integrated data set which reflects various aspects of the economic process such as production, consumption, accumulation, trade, income distribution and redistribution. A SAM is a square matrix, the dimension of which is determined by the selected number of accounts. Each account is represented by a combination of one row and one column with the same label. Each entry represents a payment to a row-account by a column-account. Thus, all receipts to an account are read along the corresponding row while payments by the same account are found in the corresponding column. Even though all entries are nominal flows (i.e they

are denominated in currency units), they may be grouped in two categories. Some have real counterparts (i.e. have movements of goods and services or of factors of production across markets associated with them). others have no real counterparts and are called transfers. One further distinguishes pure transfers from financial transactions associated with the sale of assets. The latter reflect the functioning of the financial system and are an important determinant of the macroeconomic structure of an economy. In accordance with principles of double-entry bookkeeping, the whole construct obeys a consistency restriction in the sense that the column sums equal the corresponding row sums. The consistency restriction also means that the SAM obeys Walras' Law i.e. for an n-dimensional SAM, if *(n-1)* accounts balance, so must the last account.

Figure 5.1. shows the basic structure of a SAM. There is no standard SAM. The structure of a SAM depends on the socioeconomic structure of the country under consideration, the issues at hand and data availability and reliability. The socioeconomic structure is determined by classes of economic actors, their behavior and the institutional framework within which they interact. Eight accounts are included : activity, commodity, factor, enterprise, household, government, accumulation and world. These represent either economic actors, markets or other processes.

The activity account represents the producer who sells his output both to the commodity account and as exports to the rest of the world. He may receive export subsidies from the government. The activity account makes payments to the commodity and factor accounts in return for intermediate inputs and primary factors of production. It also pays indirect taxes to the government.

The commodity account represents the domestic goods market. This account sells goods and services to the production process (intermediate demand), to the household and government (final demand) and to the accumulation account (investment). In a sense, the commodity account keeps track of the absorption of goods and services (column sum). It gathers supplies from activities and the rest of the world and pays tariffs to the government. The inclusion of a commodity account separate from the activity account is justified on the ground that production processes which are technologically different may offer equivalent goods to the household sector. The commodities would be considered equivalent if they are viewed as perfect substitutes by consumers. The two classes of accounts need not, therefore, have the same sectoral definition in a more disaggregated SAM.

The factor account receives payments for primary inputs from the activity account and distributes them to those institutions which have claims on them by way of ownership. Factor taxes are paid to the government.

These first three accounts describe nominal flows with real counterpart. The remaining accounts describe mostly transfers among various institutions. The enterprise account distributes gross profits to the household and the government. The retained earnings from the enterprise account are recorded in the accumulation account. The incomings into the househod account are composed of wages (factor), dividend (enterprise), transfers (government) and foreign remittances. This income is spent on final consumption, direct taxes paid to government and savings paid to the accumulation account. Going into government account are direct and indirect taxes. This government revenue is spent on government consumption, subsidies and various transfers to economic agents. The difference between revenue and expenditure goes into the accumulation account. All the savings recorded in the accumulation account are used to procure investment goods. Note that the total savings include net capital inflow from the rest of the world, the difference between the *c.i.f* value of imports and the total foreign exchange earnings.

Table 5.1. provides a symbolic expression of the structure contained in figure 5.1.

FIGURE 1: STRUCTURE OF A SOCIAL ACCOUNTING MATRIX (SAM)

Receipts:	Expenditures: 1 Activities	2 Commodities	3 Factors	4 Enterprises	5 Households	6 Government	7 Capital acct.	8 World	9 Total
1 Activities		domestic sales				export subsidies		exports	total sales
2 Commodities	intermediate demand				household consumption	government consumption	investment		total demand
3 Factors	factor payments								value added
4 Enterprises			gross profits			transfers			enterprise income
5 Households			wages	distributed profits		transfers		foreign remittances	household income
6 Government	indirect taxes	tariffs	factor taxes	enterprise taxes	direct taxes				government receipts
7 Capital acct.				retained earnings	household savings	government savings		net capital inflow	total saving
8 Rest of world		imports							imports
9 Total	total payments	total absorption	value added	enterprise expenditure	household expenditure	government expenditure	total investment	foreign exchange	

SOURCE: ROBINSON. 1989. MULTISECTORAL MODELS in HOLLIS CHENERY and T.N. SRINIVASAN HANDBOOK OF DEVELOPMENT ECONOMICS VOL. 2 p. 897

TABLE 5.1 A Symbolic SAM

Receipts:	Expenditures: Activity	Commodity	Factors: Labor	Capital	Household	Government	Capital account	World	Total
Activity		$P^d \cdot D^S$						$p^e \cdot E$	$P^x \cdot X$
Commodity	$P^q \cdot V^D$				$P^q \cdot C^D$	$P^q \cdot G^D$	$P^q \cdot Z^D$		$P^q \cdot Q^D$
Factors:									
Labor	$W \cdot L^D$								$W \cdot L^D$
Capital	$R \cdot K^D$								$R \cdot K^D$
Household			$\bar{Y}^L$	$\bar{Y}^K$					$\bar{Y}^L + \bar{Y}^K$
Government			$\bar{T}^L \cdot W \cdot L^S$	$\bar{T}^K \cdot R \cdot \bar{K}^S$					$\bar{Y}^G$
Capital acct.					$\bar{S}^P$	$\bar{S}^G$		$r \cdot \bar{B}$	saving
Rest of world		$P^m \cdot M$							$P^m \cdot M$
Total	$P^x \cdot X$	supply	$W \cdot L^S$	$R \cdot \bar{K}^S$	$\bar{Y}^K + \bar{Y}^L$	$\bar{Y}^G$	$\bar{Z}$	foreign exchange	

Where:

P^d = domestic price of domestic sales, D^S
p^e = domestic price of exports, E
P^m = domestic price of imports, M
P^q = domestic price of composite consumer good, Q
P^x = domestic price of composite output, X
V^D = composite intermediate demand
C^D = composite demand for final consumption
G^D = composite government consumption
Z^D = composite investment good
W = wage rate
R = return to capital
L^D = demand for labor
K^D = demand for capital
Y = income
$\bar{T}^L$ = tax rate on labor income
$\bar{T}^K$ = tax rate on capital income
S^P = private sector savings
$\bar{S}^G$ = government savings
r = exchange rate
$\bar{B}$ = balance of trade

SOURCE: Robinson (1989); p. 918

TABLE 5.2 A Symbolic Expression of a Macroeconomic SAM

Receipts:	Expenditures: Activity	Commodity	Household	Government	Capital account	World	Total
Activity		X					GDP
Commodity			C	G	Z	E	demand
Household	Y						income
Government			T^h				taxes
Capital acct.			S^h	S^g		B	savings
Rest of world		M					imports
Total	domestic income	supply	←	expenditure	→	foreign exchange	

Variables:

X = output (GDP)
C = household consumption
G = government consumption
Z = investment
E = exports
Y = income (value added)
T^h = taxes
S^h = household savings
S^g = government savings
B = balance of trade
M = imports

Macroeconomic identities:

$X = Y$	Domestic income = domestic product
$X + M = C + G + Z + E$	Aggregate supply = aggregate demand
$Y = C + S^h + T^h$	Household income = expenditure
$S^g = T^h + G$	Government savings = taxes minus expenditures
$Z = S^h + S^g + B$	Investment = savings
$B = M + E$	Balance of trade (= foreign savings)

SOURCE: Robinson (1989); p. 900

The basic structure of the SAM described above may be further aggregated to yield a macroeconomic SAM as represented. Tables 5.2. In this context, the factor, household and enterprise accounts are aggregated into a single household account. All intermediate flows are netted. The activity account sells all of its output to the commodity and rest of the world account and pays the proceeds to the household account as gross domestic income. The household spends its income on final consumption, taxes and savings. The government budget surplus measures public savings and whereas the balance of trade measures, foreign savings.

Mathematical Structure

As we all know, a data set does not "speak for itself". There is a need to consider explicitly the mathematical structure embodied in it and which is thought to have generated the observations. The data contained in a SAM is considered an outcome of individual agents' behavior and interaction, subject to relevant socioeconomic constraints. To be sure the core model or its extensions (and even the SAM) reveal to a certain extent the underlying view of the world that should guide the analysis of the issues involved. However, that extent is not sufficent for a thorough empirical investigation This is due to the fact that the general functional forms used do not show explicitly how the included variables are related. For a SAM-based analysis, we need to specify equations describing the behavior of the agents, the constraints they face and the equilibrium condition in various markets. The result is a computable general equilibrium model (CGE).

The model is specified in four basic blocks: the price block essentially describes the structure of incentives facing the private sector. The government uses a combination of trade and domestic taxes along with an exchange rate regime to drive a wedge between domestic and world prices for the tradeables and between the producer and consumer prices for the non-tradeables.

The supply block shows that sectoral production plans are guided by profit maximization. Sectoral production functions have a nested structure. Output is a linear function of value added and intermediate consumption. Value added is a constant elasticity of substitution (CES) function of labor and capital. If one is not particularly interested in explicit factor allocations, then production functions may be replaced by a transformation function between domestic and export supply.

The demand block distinguishes intermediate demand from final demand. The former is linked linearly to the production activities. Final demand is composed of private, government and investment consumption. Private consumption is defined residually as private total income minus private savings. Note the implicit assumption that government spending is distributionally neutral. This assumption is translated by the inclusion of government spending in private income. This is as if all net tax revenues were returned to the consumer in a lump-sum fashion. Thus the model can only be used to analyze efficiency issues.

The last block represents various equilibrium conditions and constraints. Full employment is assumed in all factor markets. Supply must equal demand for the domestic good, the composite good (both for final and intermediate use). There may be a balance of trade deficit or surplus. The exchange rate is assumed fixed and the government must balance its budget. The aggregate level of investment is determined by aggregate savings. The system is therefore closed[4].

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[4] **For an example of a one sector model see de Melo and Robinson (1989) p. 52**

Model Calibration

Although, the above mathematical structure is thought to have generated the data contained in the associated SAM, the structure still hinges on a few unspecified shift, share and elasticity parameters which characterize a typical behavioral equation. Therefore, in other to ensure that the model is consistent with base year data, a base run is conducted. That is values of characteristic parameters are found such that if only the base year data is used as input data, the same data is reproduced as the solution of the model. The process is known as model calibration.

To illustrate what is involved, consider the supply-demand block of the one-sector small country model discussed under imperfect substitution in section 3.

In that specification, the shift and share parameters are (A,B) and (α,β) respectively. Suppose that any variable with a zero subscript represents a data point from the base year e.g. E_o would be the base year level of exports. Calibration could proceed as follows.

Let σ *and* Ω stand for our best guess about the elasticities of substitution and transformation. Then, by definition:

$$\varrho = 1-(\frac{1}{\sigma})$$

$$h = 1+(\frac{1}{\Omega})$$

From equation 3.2, we have:

$$\left[\frac{E_o}{D_o}\right]^{\frac{1}{\Omega}} \cdot \frac{q_o}{P_o^*} = \frac{1-\alpha}{\alpha} \tag{5.1}$$

Where $p' = p_1$
Call the whole *rhs*, E_o^*. Hence,

$$\alpha = \frac{1}{E_o^*+1} \tag{5.2}$$

Similarly

$$\beta = \frac{1}{M_o^*+1} \tag{5.3}$$

Where

$$M_o^* = \left[\frac{P_o^m}{q_o}\right]\left[\frac{M_o}{D_o}\right]^{\frac{1}{\sigma}} \tag{5.4}$$

With $p^m = p_2$
A and B are determined respectively from equations 3.1 and 3.3. Thus

$$A = \bar{X}_d\left[\alpha E_o^h + (1-\alpha)D_o^h\right]^{-\frac{1}{h}} \tag{5.5}$$

$$B = Z_o\left[\beta M_o^{-q} + (1-\beta)D^{-q}\right]^{\frac{1}{q}} \tag{5.6}$$

When used in a base run along with appropriate equilibrium conditions the above parameter estimates should lead the model to reproduce the initial conditions (i.e. input data).

Simulation and Optimization

Once a model has been calibrated, it is ready to be used for impact analysis. This involves changing the value of one or more exogenous variable from its base level, in accordance with the issue at hand. Then the model thus is driven to a new solution. The resulting values of the endogenous variables reflects the impact of the exogenous change or shock. This may be a change in the external trade environment (capital flows, world prices) or in a policy instrument (tariff or domestic taxes).

In terms of numerical analysis, the model could be implemented on an ordinary simulation system or using an optimization algorithm. In the latter case, an objective function must be specified along with the other equations of the model. However, care should be taken so that the objective function used does not conflict with the rest of the model. For instance, if the objective function is a consumer welfare index or utility function then, its structure imposes restrictions on the specification of the demand system. A Cobb-Douglas utility function leads to a linear expenditure system for the consumer. Furthermore, the choice of an objective function determines the economic interpretation of the shadow prices associated with various constraints. By definition, shadow prices are given in units of the objective function.

A model is termed square when the number of endogenous variables is equal to the number of independent equations. Such a model would yield a unique solution that coincides with the optimal solution. The only advantage for solving such a model with an optimization algorithm seems to lie in the associated shadow prices. However, an optimization package such as the General Algebraic Modeling System (GAMS) becomes extremely handy in the context of optimal policy formulation. Choice is introduced in the model by making relevant policy instruments endogenous rather than exogenous variables.

Note that both simulation and optimization results hinge on the assumed structure of the economy. The robustness of these results is determined through sensitivity analysis. The same experiments are conducted under

different structural characteristics as measured by various shift and share parameters and elasticities and any change is noted. This implies that the model is recalibrated each time. Such a procedure should delineate the range of validity of the results and hence of their policy implications. To illustrate, we fit a one sector CGE to the data contained in table.

6. CONCLUSION

For most developing countries, the 1980s have beenare the decade of structural adjustment. These countries are essentially primary commodity exporters with small domestic markets and subject to frequent and severe terms of trade or capital flow shocks. To better understand the destabilizing effect of these shocks and the impact of various policy responses, general equilibrium analysis presents the most appropriate framework. Model specification within that context obeys the two fundamental principles of economics: optimization and equilibrium. The optimization principle imposes restrictions on agents' behavior and equilibrium imposes an overall material balance on the entire system.

The Salter-Swan model of a dependent economy is the kernel around which most models of the impact of macroeconomic imbalances and adjustment policies are built. It is a single-country as opposed to a multi-country trade model. Policy implications stemming from this model have limited application within the context of developing countries. Certain fundamental assumptions such as the fixity of the terms of trade or the perfect substitution between home and imported goods are deemed too restrictive. This provides guidance on how to extend the model to accommodate various issues of interest while reflecting the structural characteristics of the country under consideration. In fact, the impact of various shocks upon the economy and the effectiveness of various policy packages hinge crucially on structural parameters such as income and substitution elasticities. These measures reveal the relative ease with which agents do respond to incentives by deploying resources accordingly. This responsiveness itself depends ultimately upon the socioeconomic structure of the country as revealed by the configuration and the functioning of the institutional network. For the purpose of empirical analysis, it is important that these institutional aspects be correctly factored in the model. Then the policy implications of the model become relevant.

APPENDIX 1

Some properties of the revenue and cost functions.

1. Definitions

Let p and x stand for vectors of output prices and quantities respectively. denote by w, v the vectors of primary input prices and quantities respectively. assume that technology is convex in the sense that the set of feasible production plan (x, v) in convex. This assumption effectively rules out increasing returns to scale and increasing marginal rate of substitution and transformation.

If production decisions are guided by profit maximization then the best production plan will maximize the value of output subject to the given supplies of primary factors. Alternatively the optimal decision minimizes the cost of production for a given level of output. This optimal behavior may be described either by the revenue or the cost functions as follows:

(1) $r(p,v) = \max [p.x \textit{ such that } (x,v) \textit{ feasible}]$

(2) $c(w,x) = \min [w.v \textit{ such that } (x,v) \textit{ feasible}]$

2. Convexity

The revenue function is convex in p. To see this let x_o be the optimal level of output when prices are p_o. For any other price vector p, x_o is still feasible but not necessarily optimal. Hence,

(3) $r(p,v) \geq p.x_o$

Subtract:

$r(p_o,v) = p_o.x_o$

from (3) to get:

(4) $r(p,v) - r(p_o,v) \geq (p-p_o).x_o$

This inequality shows that as a function of output prices, the revenue function increases faster than linearly *i.e.* it is convex in p.

The derivative property, also known as the Hotelling's lemma follows from the above convexity result. Consider a change in the ith price only. Then (4) implies that:

(5) $r(p,v) - r(p_o,v) \geq (p_i-p_{io})x_{io} = hx_{io}$

Where $h = p_i-p_{io}$

and h not equal to zero.

Divide both sides by h and take limits as h tends to zero to get:

$$\lim_{h \to 0} [r(p,v) - r(p_o,v)] / h \begin{cases} \geq x_{io} \text{ if } h>0 \\ \leq x_{io} \text{ if } h<0 \end{cases}$$

Let $D^+_i\, r(p_o, v)$ be the limit of the left hand ratio as h goes to zero through positive values and $D^-_i\, r(p_o, v)$ the limit as h goes to zero through negative values. If these limits exist, then:

(6) $D_i^- r(p_o,v) \leq x_{io} \leq D_i^+ r(p_o,v)$

This generalizes to:

(7) $D_p^- r(p_o,v) \leq x_o \leq D^+ r(p_o,v)$

If the two limits are different, then $r(p, v)$ has a kink at x_o, and x_o is not unique. Otherwise

(8) $x_o = D_p r(p_o,v)$

The convexity of the revenue function also implies that price changes are non-negatively correlated with the resulting changes in output supplies. this result follows directly from inequality 4 which implies that:

(9) $r(p_o,v) - r(p,v) \geq (p_o - p).x$

Adding (4) and (9), we get:

(10) $(p_o - p).x + (p - p_o).x_o \leq 0$

Multiplying through by -1 we get:

(11) $(p - p_o).(x - x_o) \geq 0$

3. Concavity

Under the assumption of convex technology, the revenue function is concave in factor supplies v.

Let (x_o, v_o) and (x, v) be two optimal production plans. Define

(12) $\bar{x} = \theta x_o + (1-\theta)x$

(13) $\bar{v} = \theta v_o + (1-\theta)v$

for all $\theta \in [0, 1]$. The production plan (x, v) is feasible because the set of feasible production plans is convex by hypothesis. Therefore:

(14) $\bar{r}(p,v_o,v) = \theta r(p,v_o) + (1-\theta) r(p,v)$

is an attainable level of revenue. But $r(p, v)$ can be no less. Hence,

(15) $r(p,\bar{v}) \geq \theta r(p,v_o) + (1-\theta)\, r(p,v)$

i.e. the revenue function is concave in v. The implied derivative property is:

(16) $D_v^+ r(p,v_o) \leq w_o \leq D_v^- r(p,v_o)$

or

(17) $w_o = D_v r(p,v_o)$

when the left and right derivatives coincide. Thus w_o measures the effect on the optimal revenue level of having additional units of primary factors and arranging production optimally. This is the vector of shadow prices of factors of production.

Also by concavity of $r\,(p,\, v)$ in v, we know that the revenue function increases slower than linearly in v, *i.e.*

(18) $r(p,v) - r(p,v_o) \leq (v-v_o).w_o$

This implies that demand prices of factors (or shadow prices) are non positively correlated with their quantities. In other terms

(19) $(w-w_o).(v-v_o) \leq 0$

With respect to the cost function, it can also be shown that, this function is concave in factor prices w. The implied derivative property is:

(20) $D_w^+ c(w_o,y) \leq v_o \leq D_w^- c(w_o,y)$

or

(21) $v_o = D_w c(w_o,y)$

4. Homogeneity

Both the revenue and cost functions are linearly homogeneous (*i.e.* of degree one) in output and factor prices respectively. Under constant returns to scale the revenue function is also homogeneous of degree one in v.

For the revenue function, the first result is equivalent to stating that an equiproportinate change in all output prices does not alter the optimum output mix, but only changes its value. To see this, let x maximize revenue at p. Suppose that there is a different vector of outputs x^* that maximizes revenue when prices are $p^* = \theta p$, $\theta > o$. Then
Dividing both sides by θ we get:
This contradiction prouves the proposition.

(22) $p^{*}x^{*} > p^{*}x$

(23) $px^{*} > px$

The homogeneity of the cost function with respect to factor prices is similarly established.

Under constant returns to scale, if (x, v) is feasible so is $(\theta x, \theta v)$, $\theta > 0$. By definition,

(24) $r(p,v) = px$

Multiplying both sides by θ we get:

(25) $\theta r(p,v) = p.(\theta x)$

But it takes $(\theta.v)$ to produce $(\theta.x)$, hence:

(26) $r(p,\theta v) = \theta r(p,v)$

This shows that the revenue function is homogenous of degree one in v under constant returns to scale. By Euler's Theorem

(27) $r(p,v) = v.D_v r(p,v) = w.v$

This result points out the duality between the revenue and the cost function.

5. Duality

The maximum revenue associated with a production plan is equivalent to the minimum value of factor endowments subject to the constraint that unit cost be at least as great as the price of any good. Formally stated, this gives:

(28) $r(p,v) = \min \{w.v; c_j(w) \geq p_j \text{ for all } j\}$

The programming problem defined in (1) may be specified as:

(29) $r(p,v) = \max \{p.x \; ; \; \sum_j a_{ij} x_j \leq v_i \; , \; x_j \geq 0\}$

Where a_{ij} is the amount of input i required per unit of output j. The associated Lagrangean is:

(30) $L(x,w) = \sum_j p_j x_j + \sum_i w_i (v_i - \sum_j a_{ij} x_j)$

Since both the objective function and the feasible set are convex. The Kuhn-Tucker conditions are both necessary and sufficient. The quasi-saddle point (x^{*}, w^{*}) is found by solving simultaneously (31) - (34).

(31) $\frac{\partial L}{\partial x_j} = P_o - \sum_i w_i a_{ij} \leq 0 \; , x_j \geq 0$

(32) $x_j (p_j \sum_i w_i a_{ij}) = 0$

(33) $\frac{\partial L}{\partial w_i} = v_i - \sum_j a_{ij} x_j \geq 0, \quad w_i \geq 0$

(34) $w_i (v_i - \sum_j a_{ij} x_j) = 0$

The dual to the above problem is given by

(35) $\min \{ \sum_i w_i v_i ; c_j (w) \geq p_j , w_i \geq 0 \}$

The Lagrangean is:

(36) $\mathcal{L}(w,x) = \sum_i w_i v_i + \sum_j x_j (p_j - c_j (w))$

Again, the Kuh-Tucker conditions are necessary and sufficient for optimality. This is so because $w.v$ is a convex function of w given v, and the $c_j(w)$ are concave, thus their upper contour sets are convex. The feasible set is therefore convex because it is an intersection of convex sets. The Kuhn-Tucker condition are:

(37) $\frac{\partial \mathcal{L}}{\partial w_i} = v_i - \sum_j D_i c_j (w) x_j \geq 0, \; w_i \geq 0$

(38) $w_i (v_i - \sum_j D_i c_j (w) x_j) = 0$

(39) $\frac{\partial \mathcal{L}}{\partial x_j} = p_j - c_j(w) \leq 0, \; x_j \geq 0$

(40) $x_j (p_j - c_j(w)) = 0$

Condition 31 along with the associated complementary slackness equation 33 may be interpreted as a rule for competitive pricing. If $x_j^* > 0$, then:

(41) $p_j = \sum_i w_i^* a_{ij}(w^*)$

Where the right hand side of (41) equals the unit or marginal cost of producing output j. It is also equal to $c_j (w^*)$. Furthermore $x_j^* = 0$ implies that,

(42) $p_j \leq C_j(w^*)$

In other terms, any good produced has unit (marginal) cost equal price. Thus any good not produced must have its unit cost above price. Equation 32 therefore implies that:

(41) $p_j = \sum_i w_i^* (w^*)$

Similarly, conditions 33 and 34 state that any factor fully employed has a positive shadow price otherwise it is a free good. Hence:
Therefore:

$$(44)\ \sum w_i^* v_i = \sum_i w_i^* \sum_j a_{ij}(w^*) x_j^*$$

$$= \sum_i \sum_j w_i^* a_{ij}(w^*) x_j^*$$

$$= \sum_j x_j^* \sum_i w_i^* a_{ij}(w^*)$$

$$= \sum_j x_j^* c_j(w^*)$$

$$(45)\ r(p,v) = p.x^* = w^*.v$$

Equation 45 states that the shadow value of factor endowment is equal to the maximum attainable revenue from selling outputs at prevailing prices p.

Similarly equations 38 and 40 associated with the dual problem along with the homogeneity of unit cost function imply that the minimum value of factor endowment is equal to the revenue function, thus establishing proposition 28.

APPENDIX 2

The Stolper-Samuelson Theorem

This concerns the effect on w of a small change in p. Consider the case of two goods produced with two factors of production. Assume that good 1 is intensive in the use of factor 1 and that production is further characterized by constant returns to scale and no joint products. The following two conditions will hold if both goods are produced

(1) $c_1(w_1,w_2) = p_1$

(2) $c_2(w_1,w_2) = p_2$

Where $c_j(w)$ is the unit cost function in industry j. Invoking Euler's Theorem on the grounds that unit costs are homogeneous of degree one in w, we have:

(3) $a_{11}w_1 + a_{12}w_2 = p_1$

(4) $a_{21}w_1 + a_{22}w_2 = p_2$

Assuming that only p_i changes, ceteris paribus, then we have to solve the following system in changes in factor prices:

(5) $a_{11}\frac{\partial w_1}{\partial p_1} + a_{12}\frac{\partial w_2}{\partial p_1} = 1$

(6) $a_{21}\frac{\partial w_1}{\partial p_1} + a_{22}\frac{\partial w_2}{\partial p_1} = 0$

Hence,

(7) $\frac{\partial w_1}{\partial p_1} = \frac{1}{a_{11} - a_{12}(\frac{a_{21}}{a_{22}})}$

and

(8) $\frac{\partial w_1}{\partial p_1} = -\frac{a_{21}}{a_{22}}\frac{\partial w_1}{\partial p_1}$

Given our assumption about factor intensity we have:

(9) $\frac{a_{11}}{a_{12}} > \frac{a_{21}}{a_{22}}$

This implies that:

$$\frac{\partial w_1}{\partial p_1} > 0$$

$$\frac{\partial w_2}{\partial p_1} < 0$$

Furthermore equation 3 implies that:

$$(10)\ p_1 > a_{11} w_1$$

or

$$(11)\ \frac{p_1}{w_1} > a_{11}$$

Multiplying the *lhs* of (7) by p_1/w_1 and the *rhs* by a_{11} we conclude that:

$$(12)\ \frac{p_1}{w_1}\ \frac{\partial w_1}{\partial p_1} > \frac{a_{11}}{a_{11} - a_{12}(\frac{a_{21}}{a_{22}})} > 1$$

Hence, an increase in p_1 raises the price of factor 1 (in which good 1 is relatively more intensive) by a greater proportion, and lowers the price of factor 2. Note that the magnification effect observed here is due to the implicit assumption of factor mobility. The increase in p_1 causes some reallocation of factor 2 to sector 1, there by raising further the marginal product of factor 1 in that sector.

APPENDIX 3

Revenue and expenditure under constant elasticity of export transformation and import aggregation

The specification of a Computable General Equilibrium model is based on the two fundamental principles of economics: optimization and equilibrium. In the context of a simple case of a small open economy with one representative consumer the allocation of resources consistent with the two principles is such that the consumer's utility is maximized subject to production and balance of trade constraints. In section 3 of the text, we have seen that when the assumption of perfect substitution between home and foreign goods is dropped, one common alternative is to assumed constant elasticity of export transformation and import substitution. This assumption poses some restrictions on the functional forms of export supplies and import demands as shown by equation 3.2 and 3.4 of section 3. Given that we have modeled production and consumption decisions using revenue and expenditure functions it becomes interesting to investigate the structure of these functions implied by the assumption of constant elasticity.

We begin with the revenue function. The optimal value of GDP in the context of one sector model is given by:

$$(1)\quad r(p_1,q,\bar{x}) = \max \{ p_1E+qD \ s.t. \ \bar{x} = A(\alpha E^h+(1-\alpha)D^h)^{\frac{1}{h}} \}$$

The associated Lagrangean is:

$$(2)\quad L(E,D,\lambda) = p_1E+qD+\lambda(\bar{x}^h-A^h(\alpha E^h+(1-\alpha)D^h)$$

The first order conditions are:

$$(3)\quad \frac{\partial L}{\partial E} = p_1-\lambda hA^h\alpha E^{h-1} = 0$$

$$(4)\quad \frac{\partial L}{\partial D} = q - \lambda hA^h(1-\alpha)D^{h-1} = 0$$

$$(5)\quad \frac{\partial L}{\partial \lambda} = \bar{x}^h - A^h(\alpha E^h+(1-\alpha)D^h) = 0$$

Multiplying (3) and (4) by E and D respectively and taking the ratio, we get:

$$(6)\quad \frac{p_1E}{qD} = \frac{\alpha E^h}{(1-\alpha)D^h}$$

Adding one to both sides:

$$(7)\quad \frac{p_1E+qD}{qD} = \frac{\alpha E^h+(1-\alpha)D^h}{(1-\alpha)D^h}$$

This is equivalent to:

$$(8)\quad \frac{r(p_1,q,\bar{x})}{qD} = \frac{\bar{x}^*}{(1-\alpha)D^h}$$

Where $\bar{x}^* = (\bar{x}/A)^h$

Equation 8 implies:

$$(9)\quad r(p_1,q,\bar{x})(1-\alpha)D^h = qD\bar{x}^*$$

Dividing both sides by D, we get:

$$(10)\quad D^{h-1} = \frac{q\bar{x}^*}{(1-\alpha)r(p_1,q,\bar{x})}$$

So

$$(11)\quad D = \frac{(q\bar{x}^*)^{\frac{1}{h-1}}}{\left[(1-\alpha)r(p_1,q,\bar{x})\right]^{\frac{1}{h-1}}}$$

$$= r(p_1,q,\bar{x})^{\frac{1}{1-h}}(1-\alpha)^{\frac{1}{1-h}}\bar{x}^{*\frac{1}{1-h}}q^{\frac{1}{1-h}}$$

Thus

$$(12)\quad qD = r(p_1,q,\bar{x})^{-\Omega}(1-\alpha)^{-\Omega}\bar{x}^{*\Omega}q^{\Omega h}$$

Where $\Omega = \dfrac{1}{h-1}$

Similarly

$$(13)\quad p_1E = r(p_1,q,\bar{x})^{-\Omega}.\alpha^{-\Omega}\bar{x}^{*\Omega}p_1^{\Omega h}$$

Using the definition of $r(p_1, q, x)$ we have:

$$(14)\quad r(p_1,q,\bar{x}) = p_1E+qD$$

and

$$(15)\quad r(p_1,q,\bar{x}) = r(p_1,q,\bar{x})^{-\Omega}\ \bar{x}^{*\Omega}\left[\alpha^{-\Omega}\ p_1^{\Omega h} + (1-\alpha)^{-\Omega}\ q^{\Omega h}\right]$$

Multiplying both sides by $r\ (p_1, q, x)^{\Omega}$ and solving we get:
From the following relation

(16) $r(p_1,q,\bar{x}) = A^{-1}\left[\alpha^{-\Omega}\, p_1^{(\Omega+1)} + (1-\alpha)^{-\Omega}\, q^{(\Omega+1)}\right]^{\frac{1}{\Omega+1}} \bar{x}$

(17) $r(p_1,q,\bar{x}) = P_x\, \bar{x}$

We conclude that the producer price index is given by:

(18) $P_x = A^{-1}\left[\alpha^{-\Omega}\, p_1^{(\Omega+1)} + (1-\alpha)^{-\Omega}\, q^{(\Omega+1)}\right]^{\frac{1}{\Omega+1}}$

Also note that by the envelope theorem

(19) $\dfrac{\partial r}{\partial p_1} = E$

$$= \frac{1}{\Omega+1} A^{-1}\left[\alpha^{-\Omega}\, p_1^{(\Omega+1)} + (1-\alpha)\, q^{(\Omega+1)}\right]^{-\frac{\Omega}{\Omega+1}} \alpha^{-\Omega}\, p_1^{\Omega}\, \bar{x}(\Omega+1)$$

(20) $E = A^{-1}\left[\alpha^{-\Omega}\, p_1^{(\Omega+1)} + (1-\alpha)\, q^{(\Omega+1)}\right]^{-\frac{\Omega}{\Omega+1}} \alpha^{-\Omega}\, p_1^{\Omega}\, \bar{x}$

Similarly

(21) $\dfrac{\partial r}{\partial q} = D$

$$= A^{-1}\left[\alpha^{-\Omega}\, p_1^{(\Omega+1)} + (1-\alpha) q^{(\Omega+1)}\right]^{-\frac{\Omega}{\Omega+1}} (1-\alpha)^{-\Omega}\, q^{\Omega}\, \bar{x}$$

Thus

(22) $\dfrac{E}{D} = \dfrac{\alpha^{-\Omega} p_1^{\Omega}}{(1-\alpha)^{-\Omega} q^{\Omega}}$

$$= \left[\frac{(1-\alpha)p_1}{\alpha q}\right]^{\Omega}$$

as stated in the text.

With respect to the consumer good, the minimum cost of acquire the composite good is given by the expenditure function.

(23) $e(p_2,q,u) = \min\{\, p_2 M + qD \text{ s.t. } u = B(\beta M^{-\varrho} + (1-\beta)D^{-\varrho})^{\frac{-1}{\varrho}}\}$

Setting $r = -\varrho$ and defining $\sigma = 1 / 1 + \varrho$ as the elasticity of substitution, then by analogy to the case of the revenue function we have:

$$(24)\quad e(p_2,q,u) = B^{-1}\left[\beta^{\sigma}\, p_2^{(1-\sigma)} + (1-\beta)^{\sigma}\, q^{(1-\sigma)}\right]^{\frac{1}{1-\sigma}} u$$

Furthermore

$$(25)\quad \frac{\partial e}{\partial p_2} = M$$

and

$$\frac{\partial e}{\partial q} = D$$

Hence

$$(26)\quad \frac{M}{D} = \left[\frac{\beta q}{(1-\beta)p_2}\right]^{\sigma}$$

Note that when $\varrho = 0$ the CES utility reduces to a Cobo Douglas function and $\sigma = 1$.

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