Diagrammatic Back of the Envelope (BOTE) Model for One Country Two Factors and Four Commodities (124) with Illustrations from full Ethiopia CGE model and Showing HOS Origin and 123 Alternative

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List of Acronyms

BOTE	Back Of The Envelope
CARIS	Centre for the Analysis of Regional Integration at Sussex
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CFA	Comprehensive Framework of Action
CGE	Computable General Equilibrium
CPI	Consumer Price Index
DfID	Department for International Development
EDRI	Ethiopian Development Research Institute
ERCA	Ethiopian Revenues and Customs Authority
ESF	Exogenous Shocks Facility
FAO	Food and Agriculture Organisation
FSAV	Foreign Savings
GDP	Gross Domestic Product
HOS	Heckscher-Ohlin-Samuelson
IDS	Institute of Development Studies
IFPRI	International Food Policy Research Institute
IFS	International Financial Statistics
IMF	International Monetary Fund
LIC	Low Income Country
LTO	Large Tax Payers Office
MPS	Marginal Propensity to Save
PRGF	Poverty Reduction and Growth Facility
PRS	Poverty Reduction Strategy
PRSP	Poverty Reduction Strategy Papers
SAM	Social Accounting Matrix
TofT	Terms of Trade
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
WEO	World Economic Outlook
WFP	World Food Program

1. Introduction

1.1 Overview

Typically, a single country Computable General Equilibrium (CGE) model has a large number of sectors, factors and households. Many country CGE modellers use the well-known PRSP123 model (Devarajan and Go, 2003) miniature model with one country, two factors and three goods to explain the analytical structure of the larger country CGE model. Unfortunately, the PRSP123 model does not reflect the empirical realities of most single countries being modelled because it excludes non-tradable goods. The large SAM-based CGE model of Ethiopia reported in section 3 has over 30% of output that is non-tradable measured by all of the definitions of non-tradable tested (see Ahmad et al 2010).

The central sections of this paper sketch the maths and the diagrams of a Back of the Envelope (BOTE) 124 model with one country, two factors and four goods. Many of the diagrams are three-dimensional which are less familiar to some readers. However, the key diagrams can be reduced to a more familiar 2-dimensionals. In addition, the standard Heckscher-Ohlin-Samuelson (HOS) model can be illustrated as a 2-dimensional version of the BOTE 124 model, which is where CGE modellers began in the early 1970s when faced with the drive towards complete specialisation in standard trade models. See Evans (1972) on Ricardian models and Dixon et al (1977, 1982) who was the first CGE modeller to use Armington functions in a standard HOS model.

There is much more to building the BOTE 124 model than comparing it to models long consigned to the history of economic thought. A clear and accurate miniature BOTE 124 model provides the missing link to insights into the role of non-tradable goods in single country CGE models. Think of the new mineral finds in Africa or the dramatic expansion of shale oil production in the US and the consequent Dutch Disease effects that follow. The analytical strength of the BOTE 124 model means that it really can be used to help understand how the bigger main single country CGE models work. Finally, the analytical insights gained with the help of the BOTE 124 model help elaborate the analytical foundations of results decomposition exercises based on the main model.

The paper is organised as follows. Section 2 presents the BOTE 124 model, its relationship with the precursor HOS and PRSP123 models, and the impact results for changes in foreign savings, FSAV and the terms of trade, TofT. The large CGE model for Ethiopia is briefly summarised in section 3 with the macro and decomposition results and discussed for two scenarios closely related to the BOTE 124 results for FSAV and the TofT discussed in section 2. From the point of view of the modeler who is trying to explain policy results from a large and complex CGE model, having the BOTE 124 miniature model and decomposition of results are obviously an advantage. It is also important that the miniature BOTE 124 model accurately reflects what is standard formulation in large single country CGE models.

1.2 Summary of the Key Results

Typically, a single country CGE country model has a large number of sectors, factors and households. Making sense of the key strategic results as well as the detailed results is difficult and often speculative. The miniature 124 model in diagrams presented here is designed to assist in the understanding of key strategic results of a larger single country CGE model. The key results so far are:

Increased Foreign Savings

In summary, the effects of an increase in foreign savings will:

- increase economic welfare , not including any welfare costs of repayment of foreign savings,

- lead to an appreciation of the real exchange rate,
- increase the output of the non-tradable good,
- increase imports and the share of imports in tradable goods final tradable good consumption,
- sharply decrease exports

By extension, the above results hold for a radical increase in foreign savings as a result e.g. of a Gleneagles Aid agreement; note the potential development implications, in particular the increase in profitability and production of non-tradable goods, increased reliance on imports, a fall in exports and an appreciation of the real exchange rate. A good deal of attention as been given to the adverse developmental implications of firms and the better off in low income countries using tax havens to escape from domestic taxation; insofar as these effects lead to a capital outflow and negative foreign savings, the effects are the reverse of the above: a fall in economic welfare, a depreciation of the real exchange rate, a decrease in the output of non-tradable goods, a decrease in imports, an increase in exports and potentially adverse developmental effects.

Favourable Terms of Trade Effects

In many respects, the effects of improved terms of trade are similar to the increase in foreign savings summarised above. The key differences lie in the impact on exports, imports and the production of the domestic tradable good:

- the increase in imports and the share of imports in tradable goods and the increase in final tradable good consumption is not as strong when the increased income is generated by an improvement in the terms of trade rather than a capital inflow
- exports decrease as additional income from a terms of trade improvement is spent on non-tradable goods but this effect is not as strong as when the additional income is generated by increased foreign savings
- an increase in the availability of foreign exchange by a terms of trade improvement rather than by additional foreign savings is potentially better in developmental terms, but the appreciation of the real exchange can have adverse effects on those sectors that do not experience the improved terms of trade, sometimes called the Dutch Disease.
- Understanding the decomposition results is enhanced by the increased clarity of the underlying analytical results from the BOTE 124 model.

The 124 Back of the Envelope or BOTE 124 model is set out with CES functions as used in most large CGE models. For example, the sector production functions in the domestic tradable sector and in the non-tradable sector are CES functions. The producer choice in the allocation of the domestic tradable sector output between domestic tradable goods and export goods is through a CES CET function. Similarly, consumers' choice reflecting the imperfect substitution between the imported good versus the domestically produced tradable good is modelled by a CES Armington function. The welfare function combines the composite import and tradable domestic good and the non-tradable good to yield social welfare.

Evans and Ghelani (2012) present results of the disaggregated Ethiopia CGE model with a decomposition of the poverty results by source of shocks. These earlier results are combined with the key strategic results of the BOTE 124 model, adding to the transparency of the results obtained from the main model experiments and the poverty decomposition of those results. Our preliminary finding suggests that looking at the results from three complementary perspectives is useful both to the researcher and to the policy versions of the models.)

1.3 Nature of BOTE 124 Model and Typical Results

The BOTE 124 model is perfectly competitive and all factors are fully mobile. It is in short a comparative static neo-classical model. The behavior of the BOTE 124 model is illustrated with four sets of policy experiments:

(i) FSAV or changes in foreign exchange flows, either aid or private capital flows
(ii) TofT or terms of trade changes
(iii) Changes in income distribution
(iv) Changes in unemployment or changes in technical change

These policy experiments are illustrated in section 2.4 below but in this draft only the changes for FSAV and TofT are included.

Some common criticisms of CGE models may also be applied to the BOTE 124 model. For example, should the results obtained be dismissed as neoliberal? Or should they be criticized for leaving out heterodox alternatives to the neoliberal policy agenda? The answer to both questions is "No".

Broadly speaking, the neoliberal agenda emphasizes freer trade and open markets, privatization, deregulation, and increasing the role of the private sector in modern society. Of these policies, trade policy liberalization is most easily modelled in the typical large CGE model. Other components of the neoliberal agenda can be superimposed exogenously on an open economy CGE model. Thus, to brand a CGE model as neoliberal is to miss the point about using such a model to test alternative neoliberal policy experiments using exogenously estimated shocks without judging the model itself as being neoliberal. Similarly, a set of heterodox policy alternatives, often taken to mean a set of macro-economic policies that focus on growth rather than short-run financial stability, and micro-economic policies that attempt to capture skill and employment generation, improved gender balance and other inequalities in the economy. Such heterodox policy experiments can be modeled in the larger CGE model. Thus, the best place to develop either neoliberal or heterodox policy alternatives is in the main CGE model. The proposed BOTE 124 model below compliments the main CGE model but does not mean that all of the policy experiments are covered in the BOTE 124 model.

2. Detailed Exposition of the Structural Characteristics of the BOTE 124 Model

2.1 The BOTE 124 Model Compared with the HOS and PRSP123 Models

The BOTE 124 model reduces a large open single country CGE model to a series of 3 and 2-dimensional diagrams which have a strong affinity with the typical HOS trade theory diagrams, whilst Dixon and Rimmer (1999) reduce the results of indirect tax changes obtained from a large dynamic recursive CGE model to BOTE supply and demand diagrams. The Dixon and Rimmer calculations derive their usefulness from the fact that their BOTE results closely approximate the empirical results of their larger model which can be readily understood by policy makers. The usefulness of the diagrammatic form of the BOTE 124 model arises from its capacity to explain the strategic results of a large single country CGE model analytically. At some later date it should be possible to construct an empirical version of the BOTE 124 model to use in conjunction with a larger single country CGE model. Moreover, the key 3-dimensional diagrams of the BOTE 124 model can be reduced to more familiar 2-dimensions. In addition, HOS model can be illustrated as a 2-dimensional reduction of the BOTE 124 model, which is where CGE modellers began in the early 1970s when faced with the drive towards complete specialisation in standard trade models. See Evans (1972) on Ricardian models and Dixon et al (1977, 1982) who was the first CGE

modeller to use Armington functions in a standard HOS model. Similarly, the PRSP 123 model can be shown as a 2-dimensional reduction of the BOTE 124 model.
Diagram 1 below shows the production tree of the BOTE 124 model. First, the lowest level, capital and labour are used in the domestic tradable sector and the non-tradable sector to produce the domestic tradable composite good and the non-tradable good using CES production functions. The RHS of the bottom level shows the supply and demand conditions for labour and capital. The next tier shows, on the LHS shows the disaggregation of the composite domestic tradable output into exports, Q_e and the domestic tradable good, Q_{dt} via the CET function. The penultimate tier shows the aggregation of the domestic tradable good and imports, Q_{dt} and Q_m, into the Armington composite, Q_{dtm}. The balance of payments is shown on the RHS of the export and import entries. At the final level of the production tree, the Armington composite good and the non-tradable good combine to produce country welfare. The upper RHS entry shows the real exchange rate as used in the theory of international trade where there are non-tradable goods as- the price of non-tradable goods relative to the price of tradable goods.

Diagram 1: Production Tree for the BOTE 124 Model

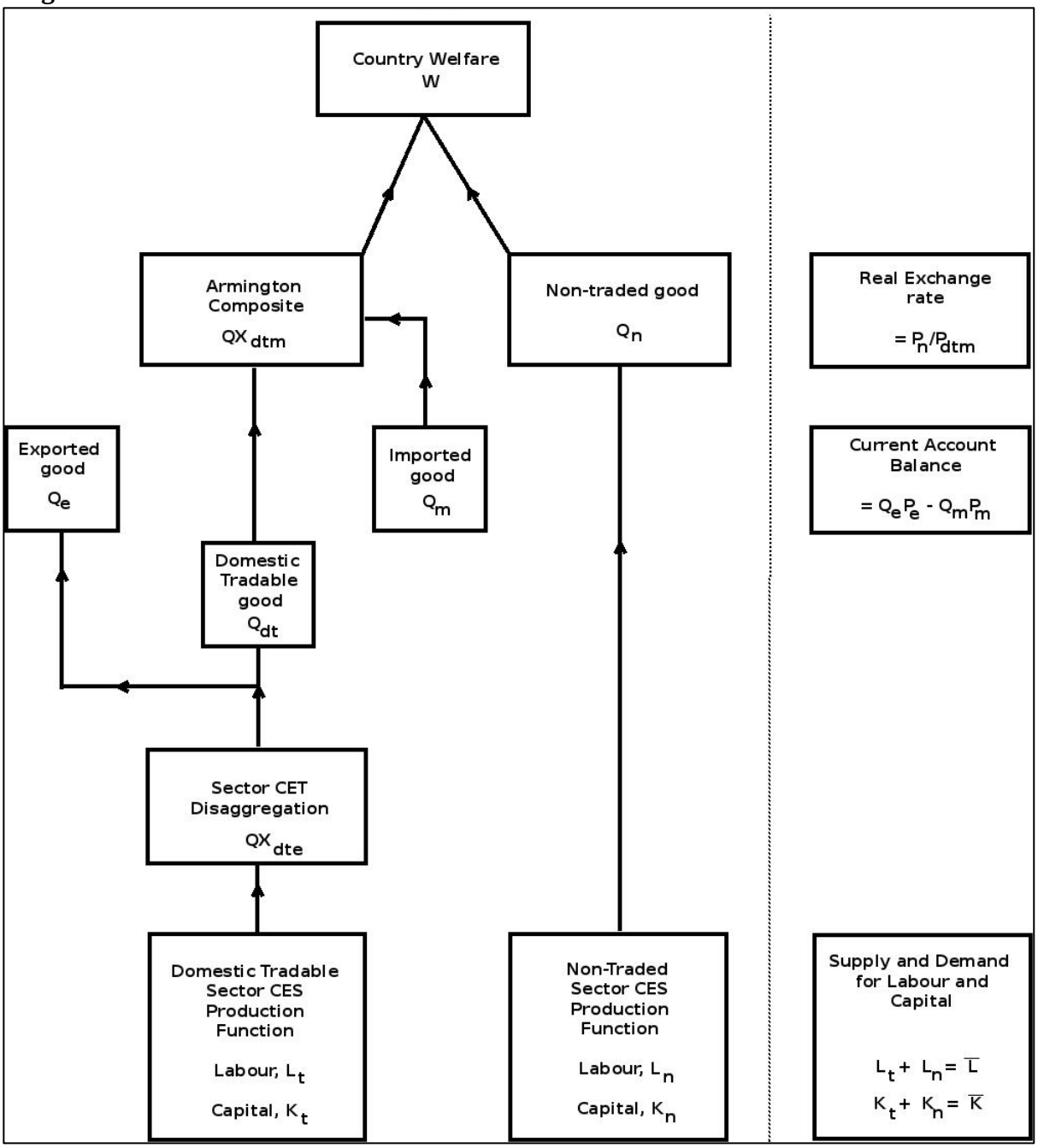


Diagram 2 shows the standard HOS model with two tradable and non-tradable goods and two factors of production. When both tradable goods are produced, a small change in equilibrium output will not change the real exchange rate. However, when complete specialisation in one or the other of the tradable goods takes place, the real exchange rate varies as the resources shift between the tradable and non-tradable goods (see Evans, 1989, Fig 4.5, p103) as is frequently noted in the trade theory literature. With many more tradable goods than factors, a high degree of specialisation is likely in the multidimensional HOS model.
In the form of the production tree, the BOTE 124 and the HOS models look very similar. However, the difference arises from the CET and Armington functions. In the BOTE 124 model, the domestic tradable good and the export good are important substitutes in the production function. Similarly, the domestic tradable good and the imported good are important substitutes in consumption i.e., in the Armington function. Thus, the CET and the

Armington functions allow the BOTE 124 model to include 4 goods including 1 non-tradable good, and 2 factors, ruling out specialisation, whereas the HOS model with 3 goods including 1 non-tradable good has a tendency towards complete specialisation.

Diagram 2: Production Tree for The H-O-S Model

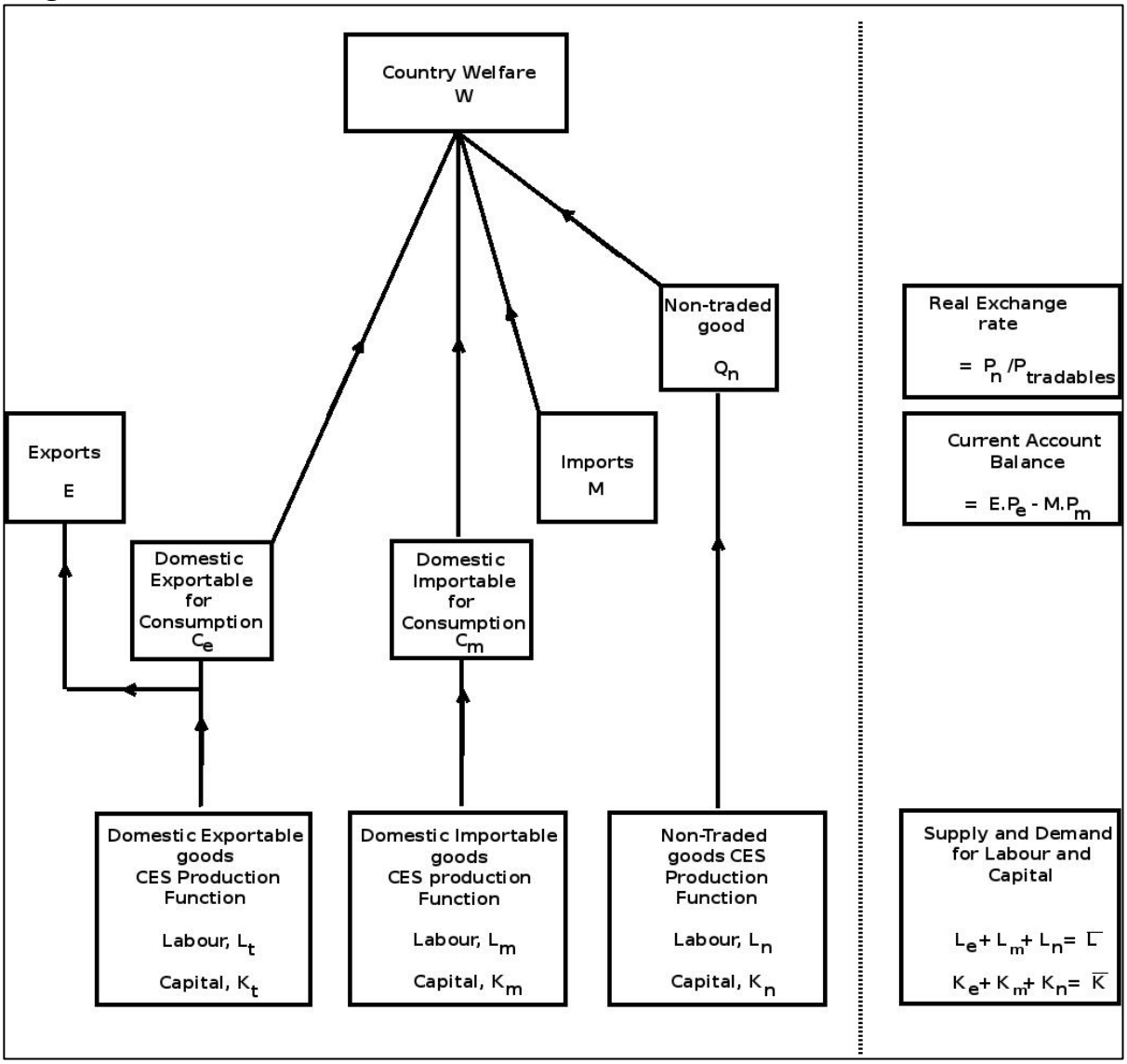
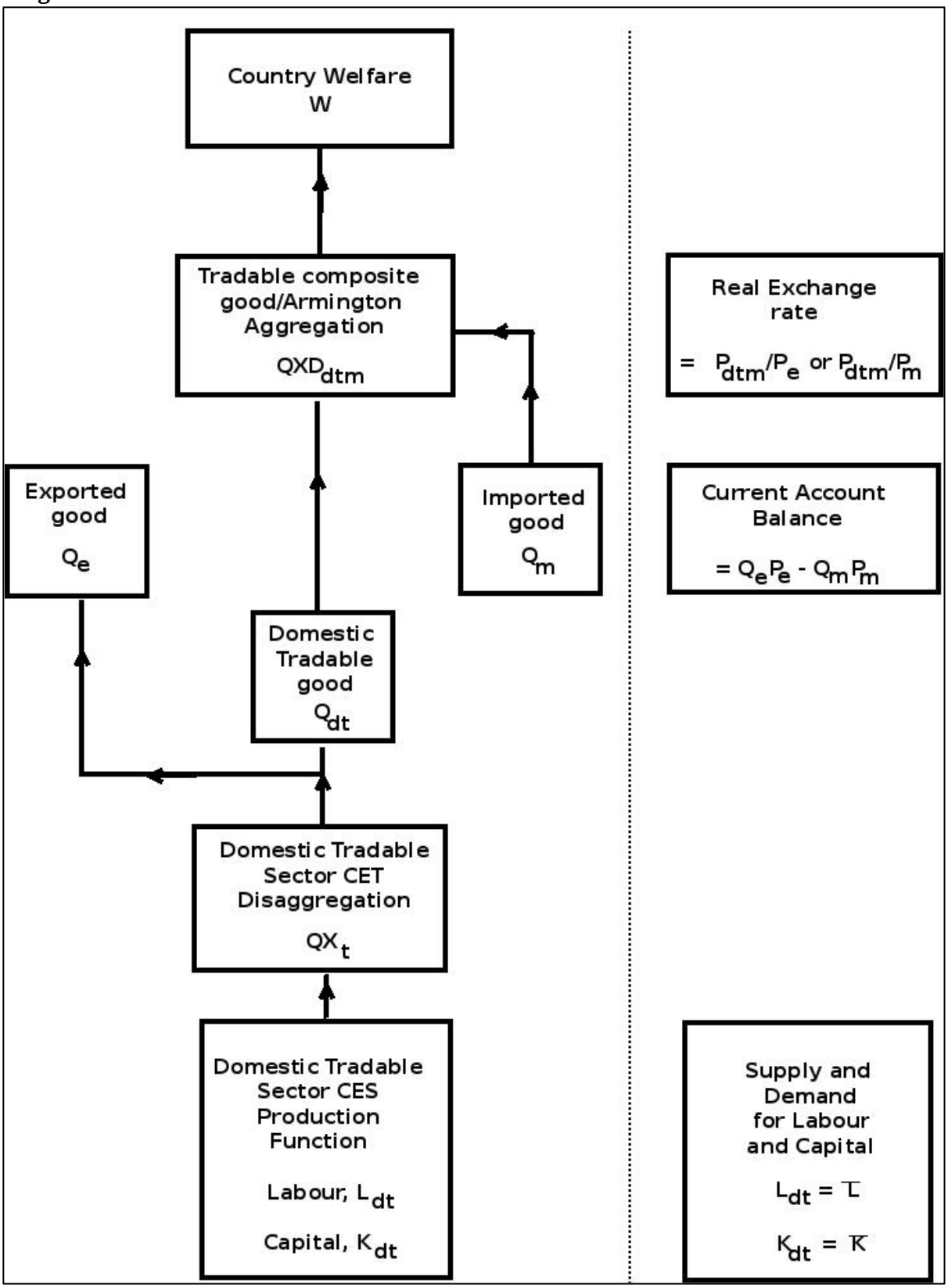


Diagram 3: Production Tree for the PRSP123 Model



It is clear from the comparison of the tree diagram for the 124 model shown in Diagram 1 and for the 123 model as shown in Diagram 3, that the absence of a non-tradable sector in the 123 model means that it cannot reflect what is actually done in the large single country CGE models and it does not capture the real exchange rate because there is no non-tradable sector.

2.2 The Structure of the BOTE 124 Model

2.2.1 Production Side

In developing a diagrammatic exposition of the BOTE 124 model, the key equations and the profit maximizing conditions are based on CES functions as used in the larger CGE model for Ethiopia are shown below. However, the diagrams themselves are drawn using computer aided drawings rather than exact numerical examples of the functions shown in the text below.

In the BOTE 124 model, there are four goods produced by two sectors, an exported and domestically tradable good produced by the domestic tradable sector, and a non-tradable good produced by the non-tradable sector. The output of the domestic tradable sector is a composite good made up of the imperfectly substitutable export and domestically tradable goods Q_e and Q_{dt}. The presence of a composite good is indicated by X so that the output of the domestic tradable sector is QX_{dte} given by a Constant Elasticity of Substitution (CES) or Constant Elasticity of Transformation (CET) aggregation of Q_e and Q_{dt}. Equations (1) – (4) below define the important relationships involved in the CET specification and Table 1 defines the relevant variables and parameters:

$$QX_{dte} = \alpha_{dte}[\delta_{dte}Q_e^{\rho_{dte}} + (1-\delta_{dte})Q_{dt}^{\rho_{dte}}]^{1/\rho_{dte}} \quad (1)$$

The cost minimizing condition applied to (1) yields the relationship between the quantity of exports and the domestic tradable good and relative prices (2):

$$(Q_e/Q_{dt}) = [(P_e/P_{dt}).((1-\delta_{dte})/\delta_{dte})]^{[1/(\rho_{dte}-1)]} \quad (2)$$

The price of the composite domestic tradable and exported goods is given by:

$$PX_{dte} = (Q_e/QX_{dte})P_e + (Q_{dt}/QX_{dte})P_{dt} \quad (3)$$

Table 1: CET Variables and Parameters:

$\boldsymbol{QX_{dte}}$	is the quantity of the domestic tradable composite made up of the domestic tradable good and the export good
$\boldsymbol{Q_e}$	is the quantity of the export good
$\boldsymbol{Q_{dt}}$	is the quantity of the domestic tradable good
$\boldsymbol{1/(\rho_{dte}-1)}$	is the elasticity of transformation between exports and domestic tradable good
$\boldsymbol{P_e}$	is the price of the export good
$\boldsymbol{P_{dt}}$	is the price of domestic tradable good
$\boldsymbol{PX_{dte}}$	is the price of the composite domestic tradable good and export good

In each sector there is a constant returns to scale, CES production function requiring mobile capital and labour to produce sector outputs as shown in equations (4) – (7). The supply and demand balance for each factor is shown in equations (6) and (7) below:

$$QX_{dte} = \alpha_{dte}[\delta_{dte}K_{dte}^{-\rho_{dte}} + (1-\delta_{dte})L_{dte}^{-\rho_{dte}}]^{(-1/\rho_{dte})} \quad (4)$$

$$Q_n = \alpha_n[\delta_n K_n^{-\rho_n} + (1-\delta_n)L_n^{-\rho_n}]^{(-1/\rho_n)} \quad (5)$$

$$K_{dte} + K_n = \overline{K} \quad (6)$$

$$L_{dte} + L_n = \bar{L} \quad (7)$$

Solving the profit maximising conditions in production yields equations (8) and (9) below:

$$(K_{dte}/L_{dte}) = [(w/r).\{(\delta_{dte}/(1-\delta_{dte})\}]^{[1/(1+\rho_{dte})]} \quad (8)$$

$$(K_n/L_n) = [(w/r).\{(\delta_n/(1-\delta_n)\}]^{[1/(1+\rho_n)]} \quad (9)$$

Table 2: Production Function Variables and Parameters:

$\boldsymbol{QX_{dte}}$	is the composite output of the domestic tradable good and the export good
$\boldsymbol{Q_n}$	is the total output of the non-tradable good and sector
$\boldsymbol{K_{dte}}$	is the amount of capital used in the production of the composite domestic tradable and the export good
$\boldsymbol{K_n}$	is the amount of capital used in the production of the non-tradable sector
$\boldsymbol{L_{dte}}$	is the amount of labour used in the production of the domestic tradable and export good
$\boldsymbol{L_n}$	is the amount of labour used in the production of the non-tradable sector
$\boldsymbol{\bar{K}, \bar{L}}$	are the stocks of capital and labour
r, w	is the rate of profit and the wage rate
$\boldsymbol{\alpha_t}$, $\boldsymbol{\alpha_n}$, $\boldsymbol{\delta_t}$, $\boldsymbol{\delta_n}$, $\boldsymbol{\rho_t}$, $\boldsymbol{\rho_n}$	are parameters
$\frac{\mathbf{1}}{(\mathbf{1}+\boldsymbol{\rho_t})}$ and $\frac{\mathbf{1}}{(\mathbf{1}+\boldsymbol{\rho_n})}$	are the elasticities of substitution between labour and capital.

From equations (5) – (8), given stocks of $\bar{K}$ and $\bar{L}$, the Production Possibility Frontier PPF can be derived. The profit maximising conditions applied to (4) – (7) give the relationship between factor use and factor prices shown in (8) and (9).

2.2.2 Demand Side

There are two components to domestic demand, a composite good made up of the imperfectly substitutable imported and domestic tradable goods, Q_m and Q_{dt}, the non-tradable good Q_n. The composite good is a CES or Armington aggregation of the imported good and the domestic tradable good, QX_{dtm}, as shown in equation (11) below:

$$QX_{dtm} = \alpha_{dtm}[\delta_{dtm}Q_m^{-\rho_{dtm}} + (1-\delta_{dtm})Q_{dt}^{-\rho_{dtm}}]^{(-1/\rho_{dtm})} \quad (10)$$

Solving the cost minimization condition yields (12):

$$(Q_m/Q_{dt}) = [(P_{dt}/P_m).\{(\delta_{dtm}/(1-\delta_{dtm})\}]^{[1/(1+\rho_{dtm})]} \quad (11)$$

The price of the composite domestic tradable and imported goods is given by:

$$PX_{dtm} = (Q_m/QX_{dtm})P_m + (Q_{dt}/QX_{dtm})P_{dt} \quad (12)$$

Table 3: Armington Variables and Parameters:

$\boldsymbol{QX_{dtm}}$	is the quantity of the Armington composite good
$\boldsymbol{Q_m}$	Is the quantity of the imported good

$\frac{\mathbf{1}}{(\mathbf{1}+\boldsymbol{\rho_{dtm}})}$	is the elasticity of substitution between the imported good and domestic tradable good
$\boldsymbol{P_{dt}}$	is the price of domestically produced tradable good $\boldsymbol{Q_{dt}}$
$\boldsymbol{P_m}$	is the domestic price of imported good $\boldsymbol{Q_m}$
$\boldsymbol{PX_{dtm}}$	is the price of the Armington composite good $\boldsymbol{QX_{dtm}}$

The welfare function is defined by the quantities consumed of the Armington composite good QX_{dtm} and the non-tradable good Q_n, as shown in equation (13) below:

$$W = f(QX_{dtm}, Q_n) \tag{13}$$

The balance of payment condition is shown in equation (14) for the case when there is no capital flow. Capital inflows or foreign savings, defined by FSAV, can be included in equation (16) on the LHS, as is shown in section 6.1 below.

$$P_e Q_e = P_m Q_m \tag{14}$$

2.3 The Initial Equilibrium of the BOTE 124 Model

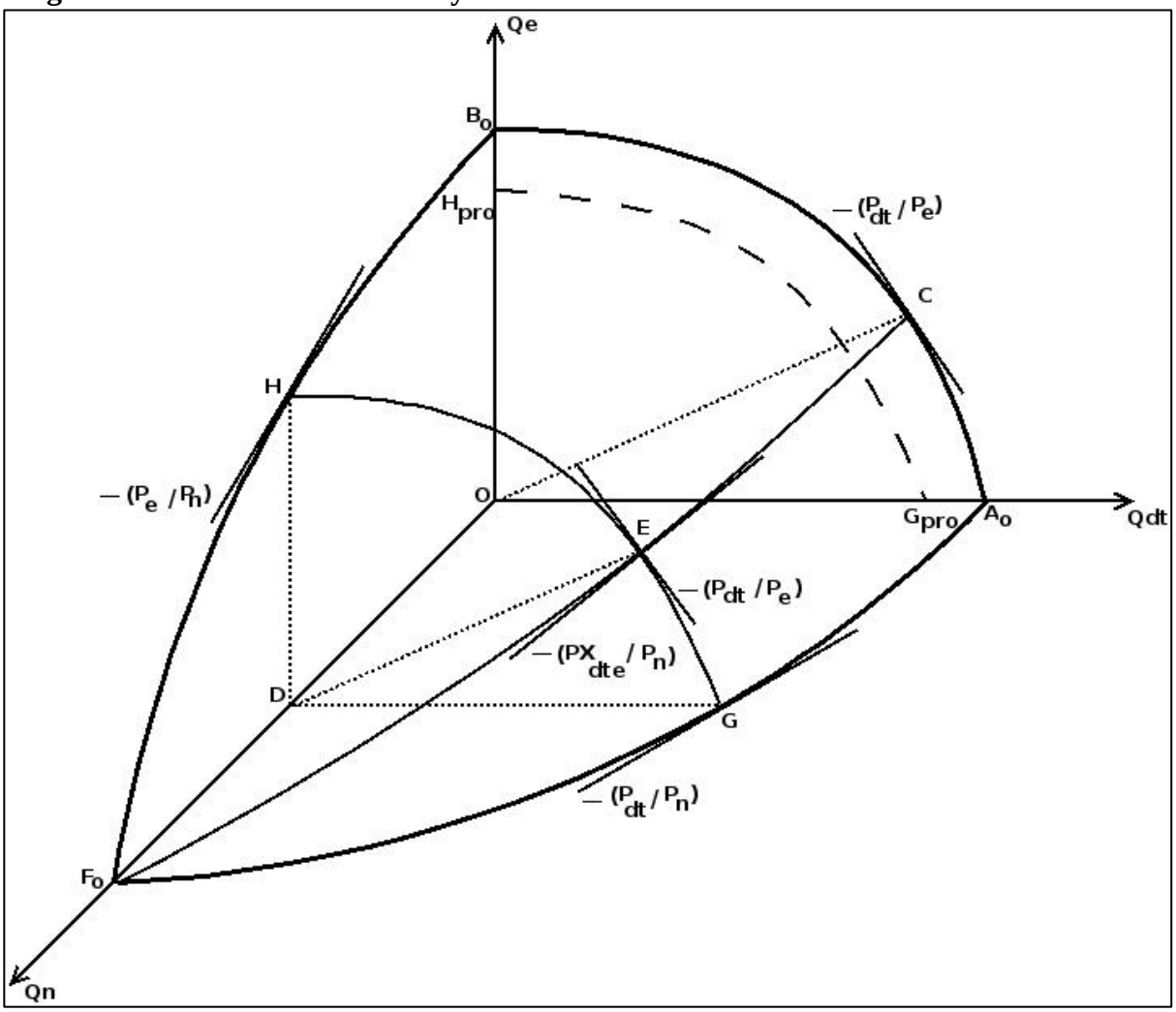
When constructing the production possibilities frontier, PPFs and consumption possibilities frontiers, CPFs, it was assumed that the domestic tradable sector was labour intensive. It was also assumed that all the CES functions were constant returns to scale. The combined effect of the latter assumption allowed for useful simplification of the diagrammatic argument. It was also assumed that the welfare function was homothetic.

The PPF shown in Diagram 4a below is defined for three goods, Q_e , Q_{dt} and Q_n . As set out in equation (1), the domestic tradable composite goods QX_{dte} or CET composite is made up from the domestic tradable good, Q_{dt} and the export good, Q_e . In Diagram 4a, the locus of extreme points (A_0, C, $B_{0)}$ are defined by the CET function in equation (1) when non-tradable goods production is zero or Q_n = 0 for a given amount of the CET composite good QX_{dte} . The cost minimisation of the CET function equation (1) yields (2), the relationship between relative prices and the proportions of the domestic tradable and export good. Thus, when $Q_n = 0$ and for a given amount of the composite good QX_{dte} , the ratio of the quantities of the exported good and the domestic tradable good (Q_e/Q_{dt}) will be a function of the relative prices of the export good and the domestic tradable good (P_e/P_{dt}), drawn as an inverse relationship with a negate sign in the north-east quadrant of Diagram 4a. When the set of relative prices -(P_{dt}/P_e) is given, the final equilibrium for Q_n = 0 will be at C.

The final step in building the production possibilities frontier is to add in the production of the non-tradable good Q_n . Consider the case when production is at Q_n with Q_n and $Q_e = 0$. Keeping Q_e = 0, production of Q_n will take place as capital and labour shift from Q_{dt} production to Q_n production; the frontier A_0F_0 is the normal production possibilities frontier defined by the equations (4) to (7) above. Note that it is the composite CET good QX_{dte} that enters into the production function (4) and a normal production function for the non-tradable good Q_n shown in equation (5). By assumption, the model economy is labour abundant relative to capital and the domestic tradable goods sector is capital intensive relative to non-tradable goods production. In this case, as Q_n expands relative to QX_{dte} , wages will rise relative to the returns on capital. By similar argument, at B_0, the output of the non-tradable and domestic tradable goods Q_n and Q_{dt} will be zero. As the production point shifts around the locus B_0F_0, the production possibilities frontier is mapped out in (Q_e, Q_n) space and for a

given set of relative prices -(P_e / P_n) is given, the final equilibrium for Q_{dt} = 0 will be at H. When the export good and the domestic tradable good are both non-zero and given by the proportions, (Q_e /Q_{dt}) corresponding to the rays OC and DE, the production possibilities frontier will be on the locus CEF_o and relative prices -(P_{dt} / P_e). The final production possibilities frontier will be the three-dimensional surface ($A_0B_0F_0$) in (Q_{dt} , Q_e , Q_n) space as shown in Diagram 4a below.

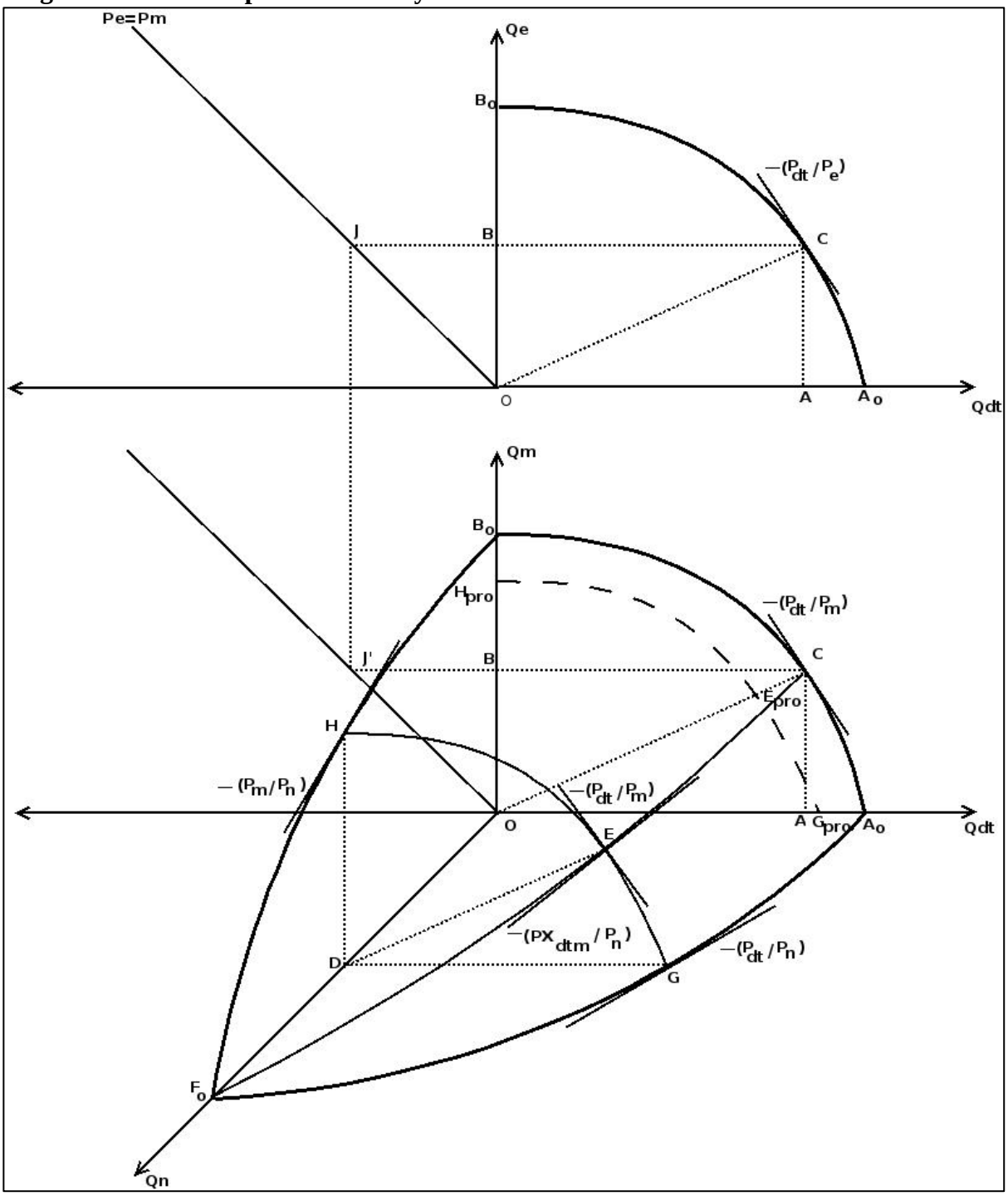
Diagram 4a: Production Possibility Frontier in 3 Dimensions



There are a number of properties of the PPF shown in Diagram 4a that can be developed. The optimal proportions of (Q_e/Q_{dt}) given by the ray OC in (Q_{dt}, Q_e) space can apply for any feasible value of the non-tradable good such as $Q_n = OD$ shown in Diagram 4a. The transformation curve GEH shows the trade-off between the domestic tradable good Q_{dt} and the export good Q_e. The point E was chosen such that $-(P_{dt}/P_t)$ is the same as at C and the optimal proportions of (Q_e/Q_{dt}) are the same at E as at C. Holding $-(P_{dt}/P_e)$ constant the locus of points on the PPF surface can be traced out as on CEF_0, and the optimal proportions (Q_e/Q_{dt}) will be constant for every point on the locus CEF_0. Moreover, the transformation curve GEH for $Q_n = OD$ can be projected onto the (Q_{dt}, Q_e) space, given by $G_{pro}H_{pro}$ as shown by the dashed lines in Diagram 4a. When all the functions used in constructing the PPF are constant returns to scale, the frontiers A_0B_0, GEH and $G_{pro}H_{pro}$ $G_{pro}H_{pro}$ have

exactly the same shape, a property which is exploited below when reducing the results in 3-dimensions to 2-dimensions in Diagram 4d.
The key difference between the PPF and the CPF is that imports, not exports enter into consumption. Thus, the welfare part of Diagram 4b below shows the division of production of the domestic tradable sector into domestic tradable and imported goods, Q_{dt} and Q_m. Once optimal levels of Q_{dt} and Q_m are determined for given relative prices $-(P_{dt}/P_e)$ at C, exports are transformed into imports at given world prices (P_e/P_m) in the upper left hand quadrant and imports transferred by the 45-degree line in the left-hand quadrant of the lower part of Diagram 4b to the lower vertical axis. The exports Q_e are used to purchase imports Q_m, which enter final consumption when combined with the domestic tradable good Q_{dt} in the Armington composite QX_{dtm}.
In the exposition which follows, the special case when $Q_n = 0$ and no non-tradable goods will be used for simplification as the argument develops. Also, projections of the surface from the PPF from 3-dimensional to 2-dimensional space will be used. Thus for a given $\overline{Q_n} = OD$, the PPF is sliced by the cone DGH which when HG is projected on to the (Q_{dt}, Q_e) space, given by $G_{pro}H_{pro}$, as shown by the dashed lines in Diagram 4a. When all the functions used in constructing the PPF are constant returns to scale, the relative price of the export and domestic tradable good on A_0B_0, HG and $G_{pro}H_{pro}$ for a given ratio of export to domestic tradable goods will be the same.
The Consumption Possibilities Frontier, CPF is shown in Diagram 4b below. The upper part shows the division of the domestic tradable sector production into the exported good, Q_e and the domestic tradable good, Q_{dt} when all capital and labour is allocated to domestic tradable sector production. The upper left-hand quadrant shows, for given world prices, the transformation of the exported good Q_e into imports Q_m through the price line $P_e = P_m$ and the 45 degree line in the upper left hand quadrant of the lower diagram, and finally to the vertical axis in the lower part of the diagram.

Diagram 4b: Consumption Possibility Frontier in 3 Dimensions



Some important characteristics of the CPF are as follows:

1. For $Q_n = 0$, the frontier A_0B_0 gives the possible combinations of imports and the domestically produced good in the (Armington) composite. When $P_e = P_m$, foreign savings, FSAV= 0, and when the parameters of the CET and Armington functions are the same, then $(P_{dt}/P_e) = (P_{dt}/P_m)$ and $(Q_{dt}/Q_e) = (Q_{dt}/Q_m)$ and the point C on the CET locus in the upper part of Diagram 4b corresponds to the point C in the lower part of the Diagram 4b. Because, the Armington function works on the demand side, the C in the lower part of Diagram 4b is determined by equation (12). Through the

balance of payments condition, equation (16) and the CET equation (2), the point C in the upper part of Diagram 4b is determined.

2. For a given production and consumption of the non-tradable good $Q_n = OD$, the curved line HG on the CPF surface gives the possible equilibrium combinations of Q_n and Q_{dt}. A possible final equilibrium is at point E.
3. As with the PPF, the CPF combines two frontiers A_0F_0 and B_0F_0 where increased Q_n is obtained with lowered supply of Q_{dt} and Q_e. For a given production and consumption of the non-tradable good $Q_n = OD$, the curved line HEG on the CPF surface gives the possible equilibrium combinations of Q_m and Q_{dt} . A possible final equilibrium is at point E.
   When the Armington, CET, production and welfare functions are all constant returns to scale, E can be chosen such that the slope of HG at E is given by the initial prices $(P_{dt}/P_m)_0$ which are the same as at C on A_0B_0 and as at E_{pro} on $G_{pro}H_{pro}$, the projection of HEG onto the (Q_m, Q_{dt}) plane.
4. Similarly, the proportions of Q_m and Q_{dt} are also the same at C, E and E_{pro}, given by the rays OC and DE.
5. The properties of the CPF can be developed further as shown by construction, the locus of points CEF_0 on the CPF surface in Diagram 4b have the same relative price ratio for the domestic tradable good and the imported good, $-(PX_{dt}/P_m)$. Given that the Armington, CET and production functions are constant returns to scale, it follows that the length of the rays OC and OE gives the amount of the Armington composite good QX_{dtm}. This property will be exploited in the 2-dimensional simplifications as shown in Diagrams 4c and 4d below.

Diagram 4c: Consumption Possibility Frontier in 3 Dimensions

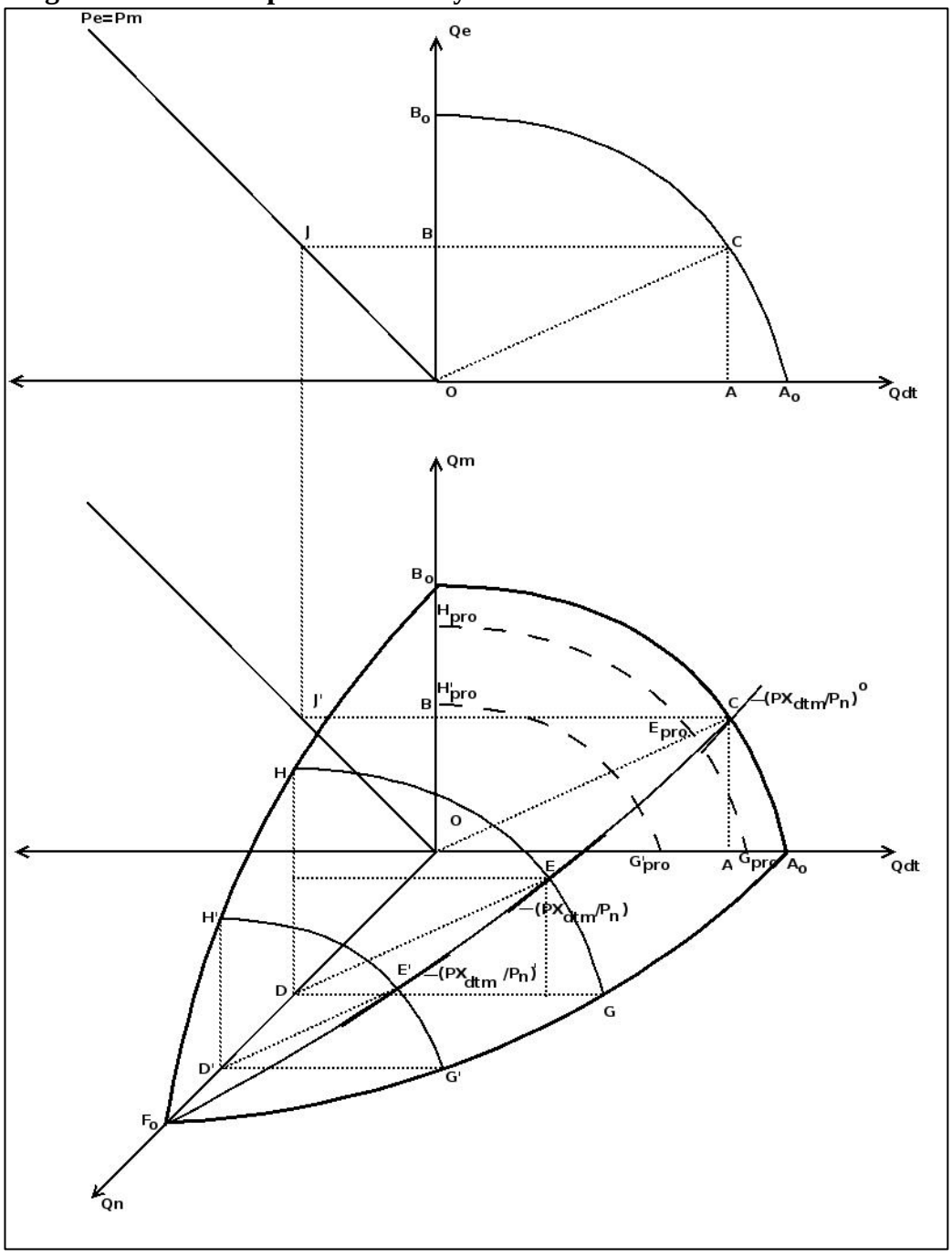


Diagram 4c is identical to Diagram 4b in all respects except an additional cone is D'G'H' added with the output of the non-tradable good Q_n equal to $OD' > OD_0$. As in Diagram 4b, the relative price $-(P_{dt}/P_m)$is constant on the locus CEE' but the relative price $-(PX_{dtm}/P_n)$ is falling and the real exchange rate, the relative price of non-tradable to tradable goods is increasing. The amount of the domestic tradable composite good QX_{dtm} falls as Q_n rises but the proportion of the export good and the domestic tradable good, (Q_e/Q_{dt}) is constant as indicated by the rays OD, DE and D'E'. The fall in QX_{dtm} is also tracked by the projections $G_{pro}H_{pro}$and $G'_{pro}H'_{pro}$.

As can be seen from equation (15), the welfare function is in two dimensions and is difficult to plot this in 3-dimensional space in Diagram 4c. However, given the assumptions of constant returns to scale CES functions, Diagram 4c can be reduced to 2-dimensions and the final

equilibrium illustrated in Diagram 4d below.

Diagram 4d: Consumption Possibility Frontier in 2 Dimensions

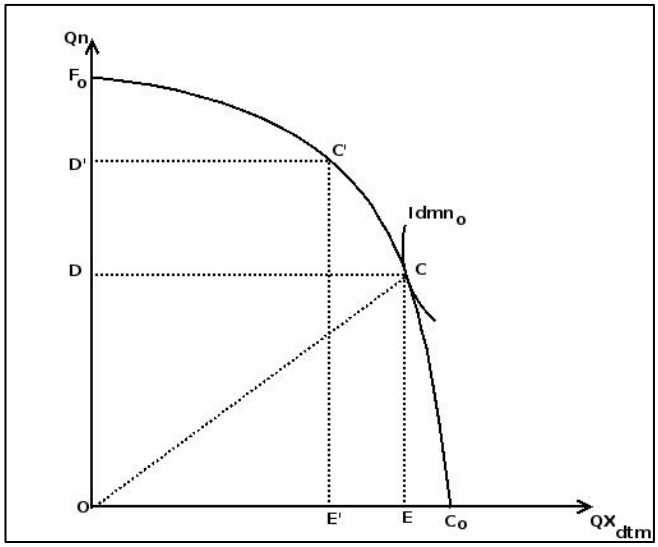


Diagram 4d is constructed from Diagram 4c and from the welfare function as given by equation (15) above. For example, at given initial relative prices $-(PX_{dtm}/P_m)_0$ and $Q_n = 0$, the length of the ray OC in Diagram 4c gives an extreme point C_0 in Diagram 4d for the production of QX_{dtm}, the quantity of the Armington composite good. As C on the ray OC moves along the locus CEE'F_0, the amount of the Armington composite QX_{dtm} falls until it reaches O as Q_n increases until it reaches a maximum at F_0 in Diagram 4d. The locus of possible equilibrium points CEE'F_0 in Diagram 4c corresponds to the frontier C_0CC'F_0 in Diagram 4d above. The final equilibrium at C in Diagram 4d is where the welfare function in the initial position $Idmn_0$ is tangent to C_0CC'F_0 at C. The point C in Diagram 4d corresponds to E in Diagram 4c where DE gives the amount of QX_{dtm} in Diagram 4c and OE in Diagram 4d above. A shift in the welfare function at constant initial prices of the domestic tradable and imported goods $-(P_{dt}/P_m)_1$ could shift the final equilibrium point from C to C' in Diagram 4d, increasing the output of the non-tradable good from OD to OD' in Diagram 4d, and from OD to OD' in Diagram 4c. Thus a shift in the welfare function towards more non-tradable goods will decrease the relative price of the Armington composite relative to non-tradable goods, $-(PX_{dtm}/P_n)_0$ or an increase the price of non-tradable relative to tradable goods, an appreciation to the real exchange rate.

2.4 Using the BOTE 124 Model to Illustrate Impact of Experiments

2.4.1 Effects of Increasing FSAV

The aim of section 2.4.1 is to show how an initial equilibrium such as the one shown in Diagram 4b changes when FSAV increases. In section 2.3, different equilibrium positions are shown for varying levels of FSAV. This section shows how the initial equilibrium changes when FSAV is changed from the initial value of zero, first in 3-dimensions and then in 2-dimensions. Diagram 5a shows how the CPF changes when FSAV increases when the non-tradable good production is zero, $Q_n = 0$. In Diagrams 5b-5d, non-tradable goods production is non-zero or $Q_n > 0$ in the initial equilibrium before FSAV increases and the initial equilibrium shifts.

In Diagram 5a below, exports are generated in the upper part of the diagram and transformed into imports for consumption in the lower part of the diagram. The initial CPF is shown by the frontier $A_0B_0F_0$ and the initial equilibrium is at C_0 with $Q_n = 0$, for the initial prices,

$-(P_{dt}/P_m)_0$. The ray OC_0 gives the proportions of Q_m and Q_{dt} in the Armington composite, QX_{dtm}. Since $P_e = P_m$, the CET proportions at C_0 in the upper part of Diagram 5a and at C_0 in the lower part of the diagram are the same. The introduction of $FSAV_1$ shifts the world price line $P_e = P_m$ to the left by the amount $FSAV_1$. With an increase in foreign savings to $FSAV_1$, the original frontier $A_0B_0F_0$ has a linear shift upwards by $FSAV_1$ and the new frontier is $A_0S_1B_1F_1F_0$. The new CPF is made up of the original surface $A_0B_0F_0$ and a new vertical component $A_0S_1F_1F_0$.

When $Q_n = 0$, as relative prices adjust to $FSAV_1$, the new equilibrium is at C_1 in the lower part of Diagram 5a with relative prices equal to $-(P_{dt}/P_m)_1$. The share of Q_m and Q_{dt} in the Armington composite shifts from the ray OC_0 to OC_1; as the price P_m falls relative to P_{dt}, the share of imports rises when $FSAV_1$ is introduced. Imports Q_m increase to OB_1 and the production of Q_{dt} increases to OA_1. From the upper part of Diagram 5a it can be seen that the increased production of Q_{dt} is also equal to OA_1 but there is a fall in exports $Q_e$to OB_1 as the relative price of exports fall. Because $P_e = P_m$, the relative prices at C_0 and C_1, respectively, in the upper and lower parts of the Diagram 5a are the same. That is, $-(P_{dt}/P_m)_0 = -(P_{dt}/P_e)_0$ and $-(P_{dt}/P_m)_1 = -(P_{dt}/P_e)_1$. The breakdown of the price changes can also be seen from the lower part of Diagram 5a. At the initial output of the domestic tradable good Q_{dt} at A'_0 increased foreign savings $FSAV_1$ increases imports by C_0C_1 at the initial relative price $-(P_{dt}/P_m)'_0 = -(P_{dt}/P_e)_0$ at the consumption point C'_0. The final adjustment takes place when consumption shifts to C_1 and the final relative prices fall to $-(P_{dt}/P_m)_1$. Finally, the breakdown of imports with $FSAV_1$ can be seen from the upper left hand quadrant in Diagram 5a. Total imports with are given by B_1J_I, with the export component equal to $B_1J'_0$, and the foreign savings component $FSAV_1$ by J'_0J_1.

Diagram 5a: CPF with FSAV and no Non-Tradable Goods

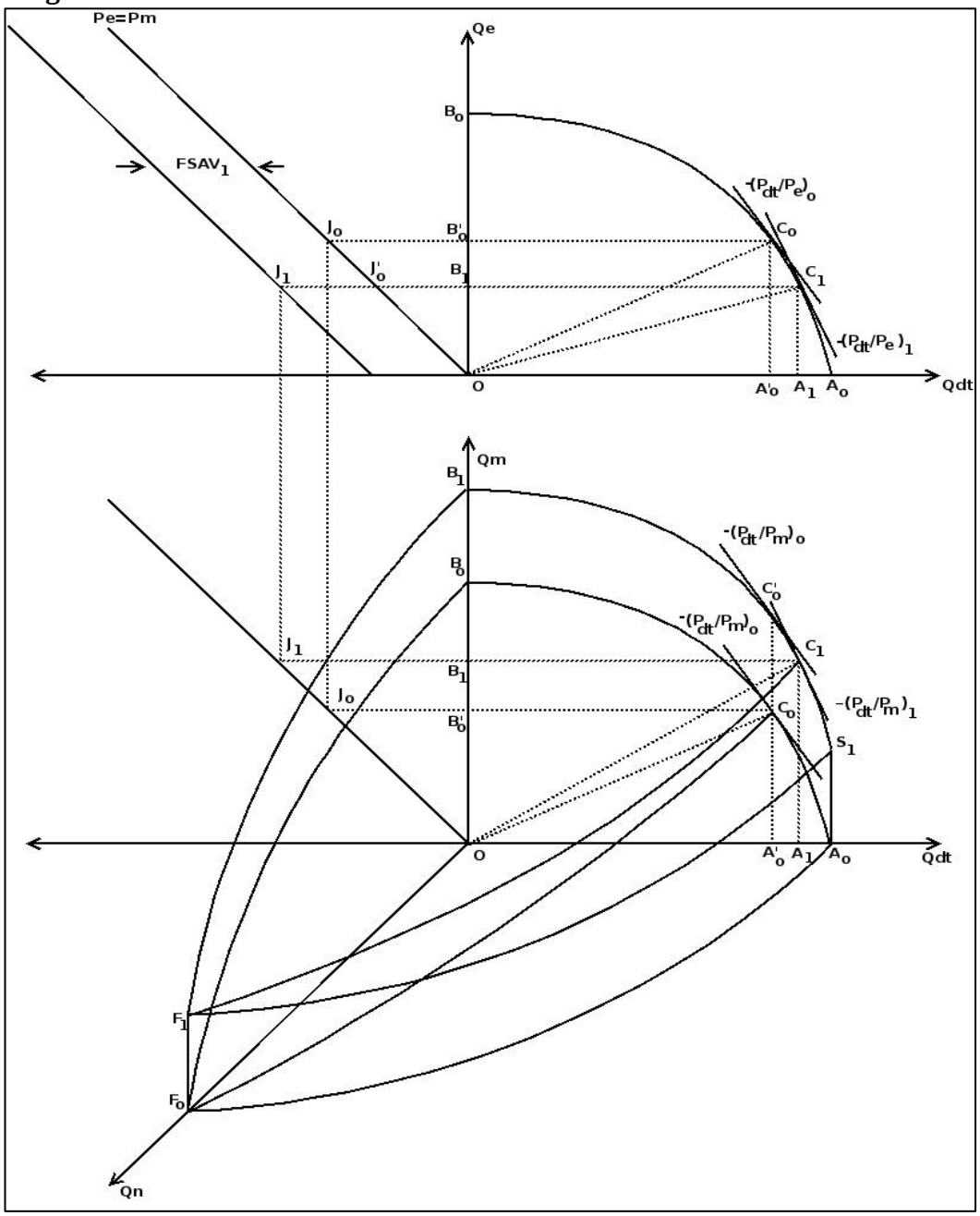
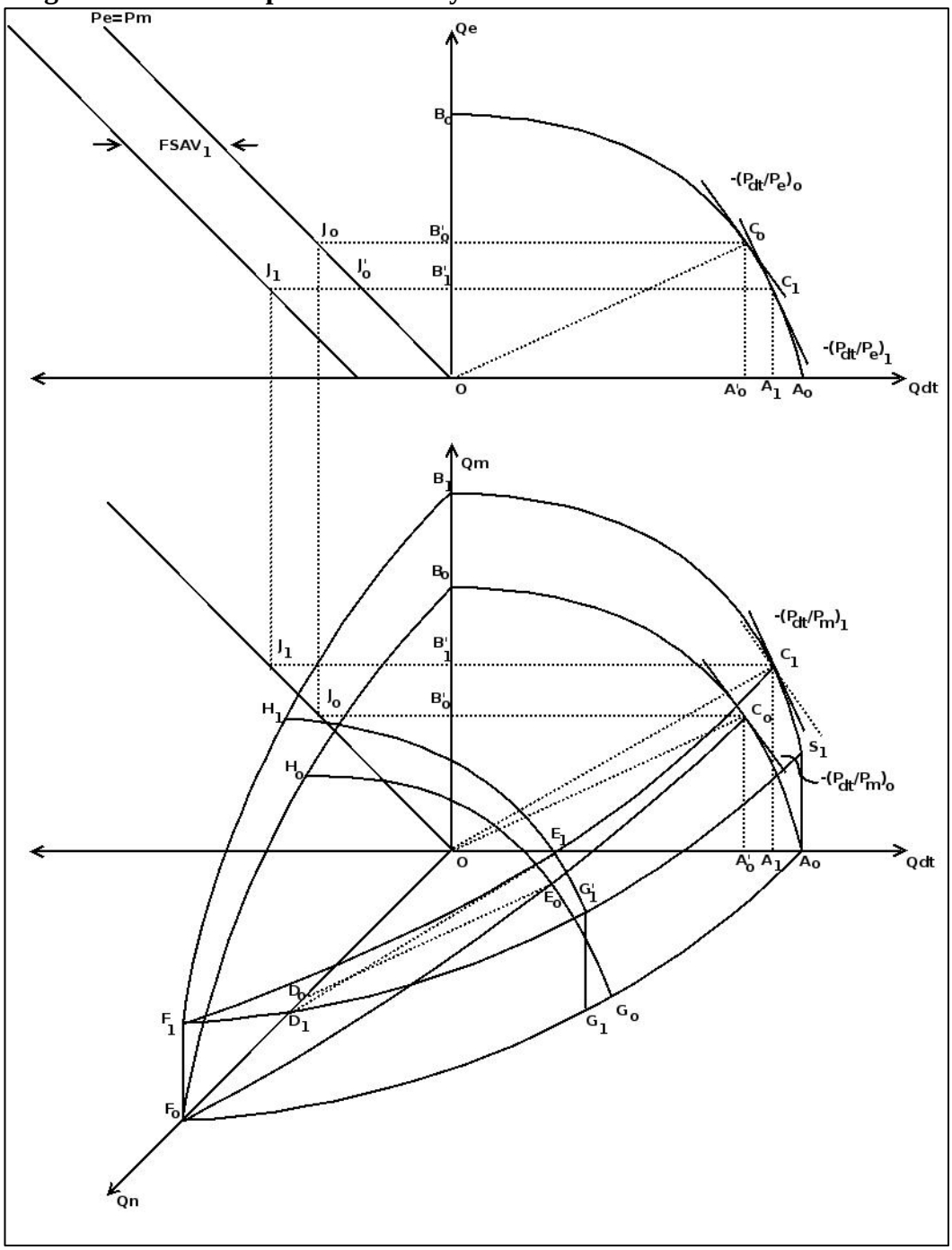


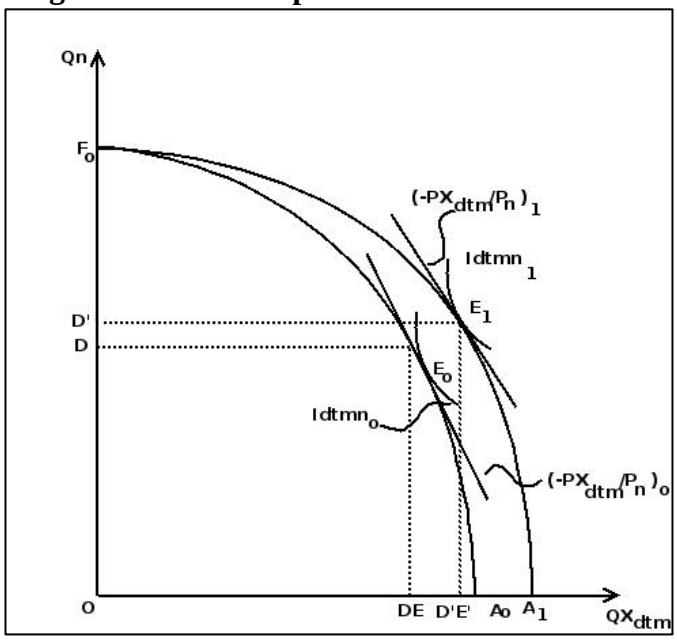
Diagram 5b below shows what happens when $FSAV_1$ is introduced and when non-tradable goods, Q_n, are produced. Diagram 5b is the same as 5a except for the initial and new equilibrium points added for non-tradable goods Q_n being produced. For $Q_n = OD$ a possible initial equilibrium point E_0 on the interior frontier H_0G_0 is shown, where E_0 is on the locus C_0F_0 at constant initial prices $-(P_{dt}/P_m)_0$. By construction, the proportions of $Q_m$and Q_{dt} in the Armington composite at C_0 and E_0 are the same since the rays OC_0 and DE_0 are parallel. With $FSAV_1$ and for $Q_n = OD_1$ a possible equilibrium point is E_1 on the interior frontier $H_1G'_1G_1$ is shown, where E_1 is on the locus C_1F_1 at constant final prices $-(P_{dt}/P_m)_1$. By construction, the proportions of Q_m and Q_{dt} in the Armington composite at C_1 and E_1 are the same since the rays OC_1 and DE_1 are parallel.

Diagram 5b: Consumption Possibility Frontier with FSAV and Non-Tradable Goods



The catch with Diagram 5b is that it is difficult to locate the new equilibrium point diagrammatically because it is in 3-dimensions. The 2-dimensional Diagram 5c shows how this can be done. The final equilibrium point, which is derived from Diagram 5b, is illustrated in Diagram 5c below:

Diagram 5c: Consumption Possibilities Frontier in 2 Dimensions with FSAV



In Diagram 5b at the initial prices – $(P_{dt}/P_m)_0$ the amount of the Armington composite QX_{dtm}, is given by the length of the ray OC_0 for. As Q_n increases and QX_{dtm} falls, the trade-off between the Armington composite and the non-tradable good at the initial relative prices $-(P_{dt}/P_m)_0$ can be derived from Diagram 5b by plotting the changes in the amount of Q_n and QX_{dtm}as the point C_0 moves to the left on C_0F_0. As Q_n increases the locus of possible equilibrium points is mapped out. A possible equilibrium point is given by E_0 when $Q_n = OD_0$. In 2-dimensions, this trade-off is shown in Diagram 5c as A_0F_0. Given the welfare function $Idtmn_0$, and the initial equilibrium is given by E_0. When $Q_n = 0$, the maximum amount of the Armington composite is given by OA_0 in Diagram 5b and OC_0 in Diagram 5c. The final equilibrium for the Armington composite and the non-tradable good with an increase in welfare at E_1 compared with the initial equilibrium, E_0 and a new level of welfare $Idtmn_1$. The real exchange rate at E_1 appreciates compared with E_0 in Diagram 5c as the relative price of the non-tradable good appreciates, or $-(PX_{dtm}/P_n)_1 < -(PX_{dtm}/P_n)_0$.

The final equilibrium composition of Q_{dt} and Q_m in the composite good QX_{dtm} is shown in Diagram 5d below:

Diagram 5d: Equilibrium for Imports and Domestically Tradable Goods with FSAV

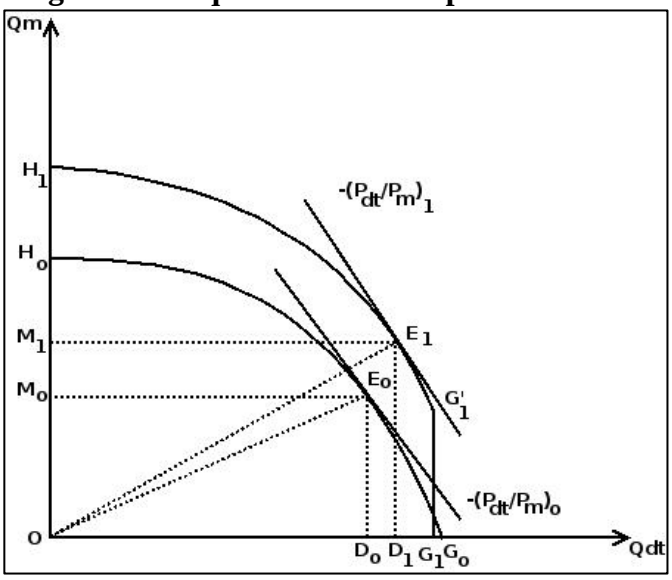


Diagram 5d can be derived from Diagram 5b by noting that Diagram 5d is the projection of G_0H_0 and G_1H_1 into (Q_{dt}, Q_m) space in Diagram 5b, to yield G_0H_0, and G_1H_1 in Diagram 5d. The final equilibrium points E_0 and E_1, respectively, are also from Diagram 5b, as are the rays OE_0 and OE_1, respectively, which give the proportions of Q_{dt} and Q_m of in the composite good QX_{dtm}.

In summary, the effects of an increase in foreign savings $FSAV_1$ will:

- increase economic welfare , as shown in Diagram 5c
- lead to an appreciation of the real exchange rate, as shown in Diagram 5c
- increase the output of the non-tradable good, as shown in Diagram 5c
- increase imports and the share of imports in tradable goods final consumption shown in Diagram 5d
- decrease in exports, which can be shown from Diagram 5d, where H_0H_1 is equal to $FSAV_1$ and M_0M_1 is the increase in imports; by inspection, the increase in imports is less than the foreign savings, so exports must have decreased.

2.4.2 Effects of Terms of Trade (TofT) Improvement

The analysis of terms of trade effects runs along similar lines to the analysis of FSAV changes. The impact of terms of trade changes with $Q_n = 0$ is shown in 3-dimensions in Diagram 6a below and for $Q_n > 0$ in Diagrams 6c and 6d. The key difference between a foreign capital inflow and a terms of trade improvement is that the terms of trade improvement has a multiplicative effect on foreign exchange receipts, whereas increased foreign savings has a linear effect on foreign exchange receipts. Thus, the consumption possibilities frontier with increased foreign savings rises by a constant amount equal to the increased foreign savings, whereas in Diagram 6b, the consumption possibilities rises by a proportion equal to the terms of trade improvement, this difference can be seen by comparing Diagrams 5d and 6d. In Diagram 5d, the increased foreign savings substantially increases both Q_m and Q_{dt} as additional imports financed by increased foreign savings combine with the domestic tradable good in the composite good QX_{dtm}, whilst it can be seen from Diagram 5b that exports also fall sharply. In contrast, from the upper part of Diagram 6b for $Q_n = 0$, it

can be seen that the increase in Q_{dt} from the terms of trade improvement is relatively smaller compared with the foreign savings case shown in the upper part of Diagram 5b, and the impact of improved terms of trade on exports is relatively less. By exclusion, the same argument holds for the case when $Q_n > 0$. In summary, increased foreign savings divert tradable goods production away from exports compared with improved terms of trade.

Diagram 6a: Consumption Possibility Frontier with TofT Change and no Non-tradable Goods

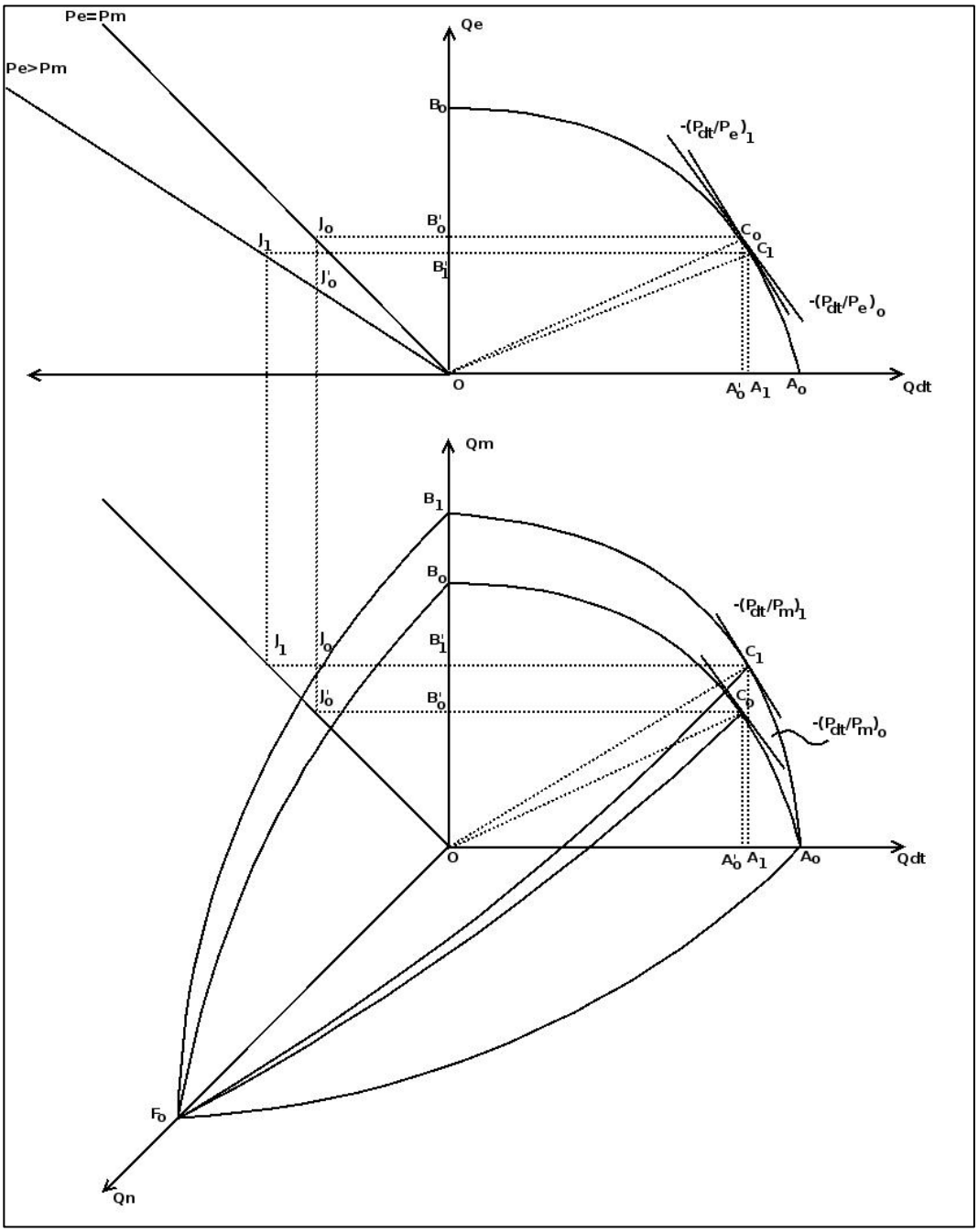


Diagram 6b: Consumption Possibility Frontier with Tof T Change and Non-tradable Goods

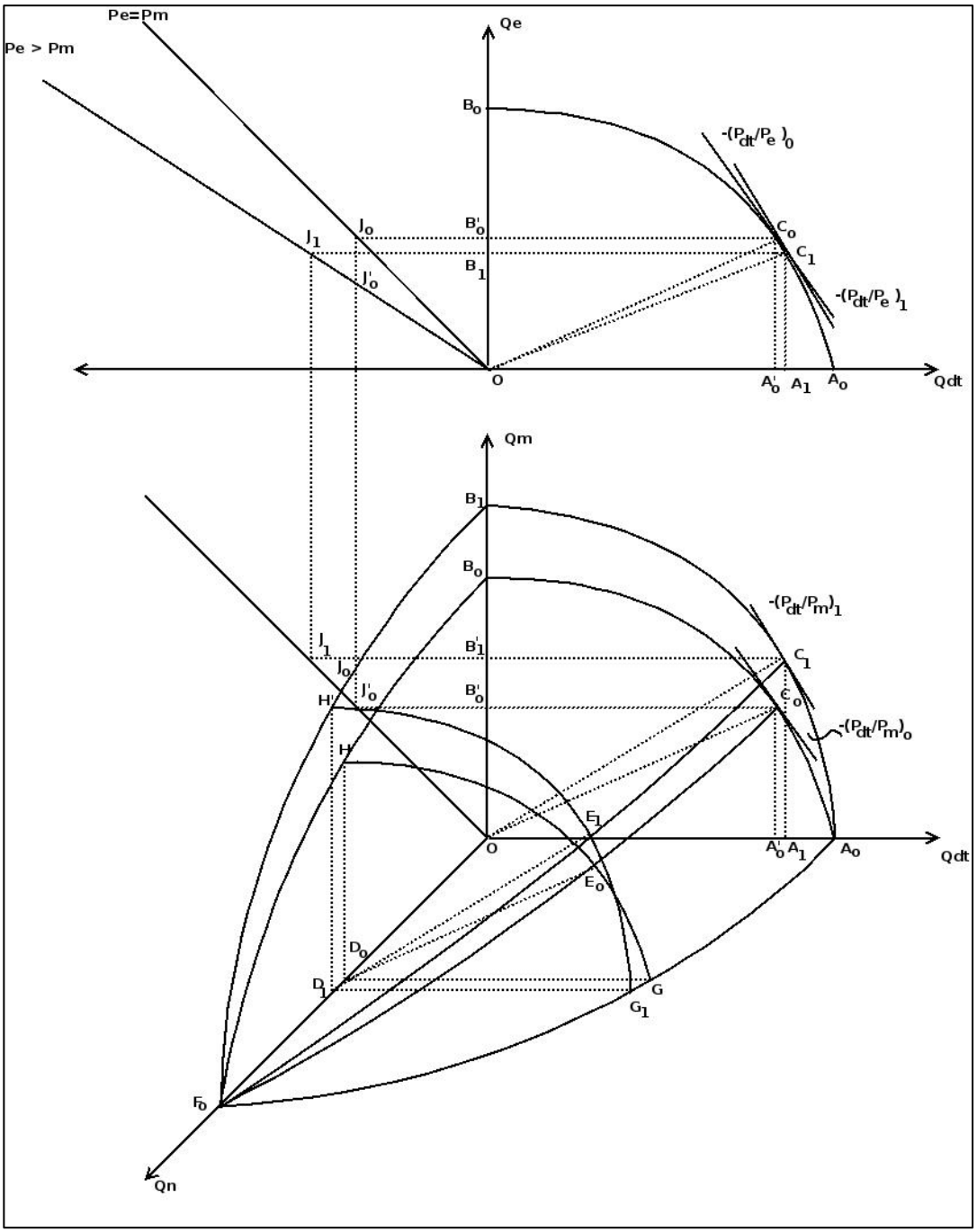


Diagram 6c: Consumption Possibilities Frontier in 2 Dimensions with TofT Improvement

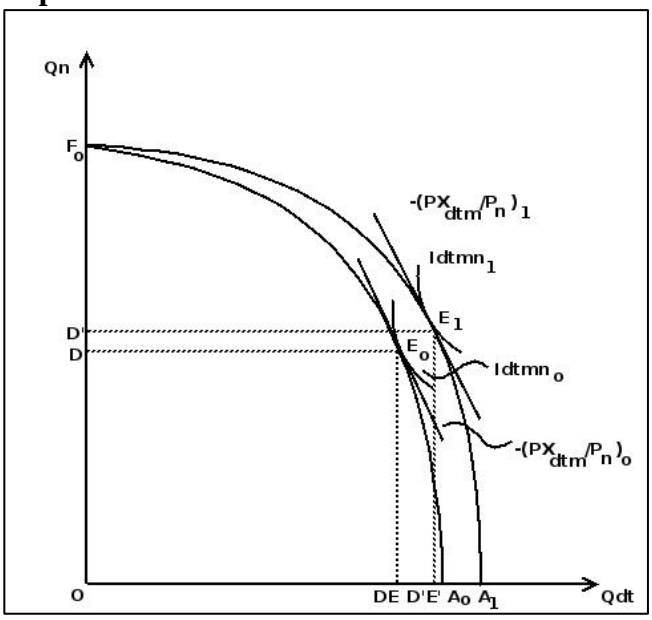
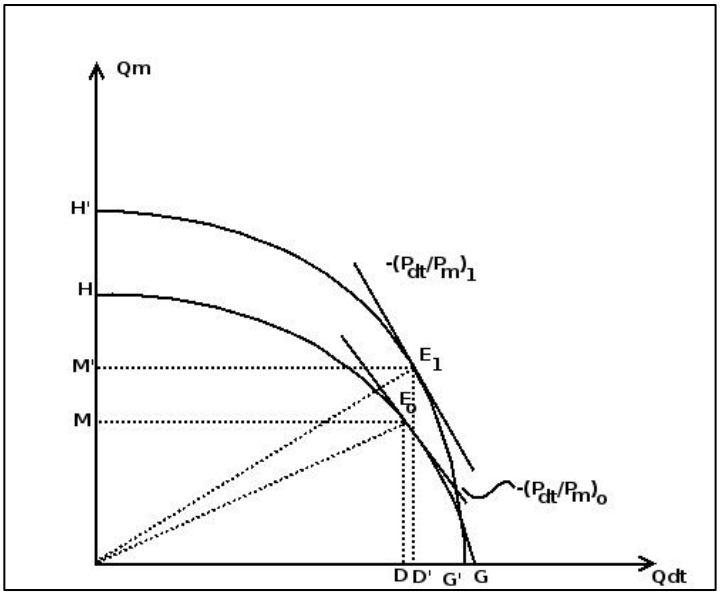


Diagram 6d: Equilibrium for Imports and Domestically Tradable Goods with ToT Change



2.4.2 FSAV and TofT Effects on Income Distribution

The impact of FSAV and TofT effects in wages and profits follow from the impact of changes on Q_n output relative to the output of the domestic tradable sector, QX_t. When there is a capital inflow FSAV or a terms of trade improvement TofT, the output of the capital intensive domestic tradable sector decreases relative to the output of the labour intensive non-tradable sector and wages increase relative to profits.

2.4.2 Unemployment and Technical Change Effects

The impact of changes in unemployment and technical change follow from the effect of these changes on the A_0F_0 frontier in the 3-dimensional CPF Diagrams 5a and 6a above. When unemployment decreases, or when factor productivity increases in both sectors, the A_0F_0 frontier shifts outwards in both cases. This shifts the A_1F_0 frontier outwards in Diagram 5c leading to an increase in economic welfare from the fall in unemployment or increase in productivity.

3. BOTE 124 and the Results of the Ethiopia Main CGE Model

3.1 The Ethiopia Distribution and Poverty Model

Comparative static and recursive dynamic CGE distribution and poverty models are now widely available for the analysis of income distribution and poverty issues in lower income countries (see for example Bourguignon et al, 2008). These are usually based on Social Accounting Matrices (SAMs) and have considerable sector, factor and household disaggregation.

The distribution and poverty CGE model for Ethiopia used in this research is comparative static. The key modelling assumptions are:

1. The distribution and poverty CGE model is calibrated to the 2005/06 Ethiopia SAM (Ahmed et al, 2010) and updated to 2007/08. The SAM accounts do not exactly match the national accounts used. For present purposes it is assumed that the two sets of accounts are at least in similar proportions for the main national accounts categories in the respective base periods.
2. Value added is modelled using constant CES production functions for factor inputs (land, livestock, capital, various types of labour and non-agricultural capital for five regions).
3. Intermediate inputs into production are determined by Leontief fixed proportions.
4. Payments from each factor of production are allocated to households and other institutions using fixed shares derived from the base SAM.
5. Household consumption is modelled using a LES specification. Imported goods are assumed to be imperfect substitutes for domestically produced goods (Armington assumption). In experiment with the model reported below (clos2) the marginal propensity to save (MPS) is a fixed behavioural parameter.
6. Exported goods are imperfect substitutes for domestically produced and consumed goods. (The Constant Elasticity of Substitution or CET assumption) as shown in the 124 model in section 2.

Imports are imperfect substitutes for domestically produced goods. The Armington assumption as shown in the 124 model is section 2.

7. The domestic price of each commodity adjusts so that domestic supply equals domestic demand.
8. Capital stock is fixed in each sector for all regions. Livestock is specified by region and is allocated so that the marginal return to livestock is equalised for each crop in a given region. Land is specified by region and is allocated so that the marginal return to land is equalised for each crop in a given region. Labour is specified for each sector for all regions so that the marginal return to labour is equalised for each crop and industry.
9. Labour markets have the total supply of labour fixed for each skill type. Real wages adjust so that demand for labour is equal to supply unless the real wage for any particular type of labour is fixed in which case there will be unemployment (e.g. unskilled labour).
10. External accounts have variable foreign savings (foreign capital inflows) and an endogenous real exchange rate.
11. The numeraire (i.e. reference price) is the Consumer Price Index (CPI).
12. The full set of equations for the distribution and poverty model are set out in Robinson et al (2010).

The Closures adopted for clos2 are summarised in Table 4 in section 3.1.2.

3.1.1 Methodology

Our work to date focuses on income distribution, poverty and development impacts of macroeconomic policies and projections in Ethiopia. The methodology is based on the macroeconomic policies and projections in IMF Article IV reports, linked to the SAM based comparative static distribution and poverty CGE model for Ethiopia.

The decomposition of the poverty results in the main model was achieved by running the model for each component of each scenario to obtain the decomposed poverty impact. The model was also run re-combining the elements of each scenario, and for all scenarios together. We then compared a linear combination of each component of the scenario results with the direct calculation of the of the scenario results. We found that almost without exception the linear combination of the component results accurately predicted the scenario results estimated directly by the CGE model. This check of the decomposed results by linear re-aggregation increased our confidence in decomposition method. The final step in the analysis was then to draw on the main model, the BOTE 124 model, and the decomposed poverty impact results, to flesh out the poverty impact of each scenario and the key drivers of the results for shocks to government expenditure and terms of trade.

A key methodological issue is the choice between partial and general equilibrium approaches, where partial equilibrium includes the case where scenarios are simulated using consistency methods such as the Financial Programming approach (see for example McCulloch, Cirera and Winters (2001), World Bank (2003a, 2003b). This choice affects how the macroeconomic and the income distribution and poverty components are built, and how the two components are linked. For example, the Poverty Reduction Strategy Papers (PRSPs) use a partial equilibrium approach throughout, whilst Devarajan and Go (2003) link a partial equilibrium macroeconomic analysis to a small CGE model of income distribution and poverty. As a consequence of the partial equilibrium approach, the PRSP approach has no linkages between the Article IV macroeconomic scenarios and the income distribution

and poverty impact analysis. That is, there is no analytical framework that allows for the analysis of income distribution and poverty impacts of macroeconomic shocks and policy responses that can be obtained with a comparative static or a recursive dynamic CGE model of income distribution and poverty.
A more intellectually satisfying approach by Agénor (2007) integrates the macroeconomic and the income distribution and poverty sides of the analysis into a general equilibrium model, but his main focus is on middle-income countries. Bourguignon et al (2008) present a number of highly disaggregated income distribution and poverty CGE models, which provide useful insights into the key macroeconomic and economy wide determinants of income distribution and poverty impacts. However, the macroeconomic components of the Agénor and Bourguignon models are not linked to immediate IMF policy and country concerns in Africa as the Article IV projections are.

3.1.2 Distribution and Poverty Model Closure

The macro closure assumptions made in the distribution and poverty model are crucial for the linking of the IMF Article IV projections for Ethiopia to the income distribution and poverty model. The choices of exogenous and endogenous variables for the chosen closure are summarised in Table 4 below:

Table 4 Alternative Macro and Factor Market Closures

Closure 2

Closures	Key Exogenous	Key Endogenous
FOREIGN EXCHANGE MARKET		
		Foreign Savings (Current a/c deficit)
		Exchange Rate (Birr/$)
	World Prices	
INVESTMENT-SAVINGS		
	Total Investment	
	Household MPS	
	Government expenditure	Government Savings
FACTOR MARKETS	Unskilled Agricuiltural wage	Other wage rates
	Semi-skilled manufacturing wage	Other factor prices
	All factor supplies	
NUMERAIRE	Consumer price index (2005/6 base)	

3.1.3 Measuring the Real Exchange Rate

In the BOTE 124 model discussed in section 2, there are two ways in which the real exchange rate can be measured, from the export side as shown in the production possibility Diagram 4a, or from the import side as shown in Diagram 4b. When the current account is in balance, differences between the export price and import price composites should have little economic significance. However, when there is a large structural current account deficit, it makes more sense to use the import side, i.e. $-(PX_{dtm}/P_n)$ as measured in the BOTE 124 model. We call this the trade theory measure of the real exchange rate or just "trade". This measure of the real exchange rate is probably used less frequently than a macro measure of the real exchange rate, which adjusts changes in domestic prices by the money exchange rate. The idea is to obtain a measure of changes in competitiveness. These ideas can be set out in a mini version of the equations of the main CGE model by combining the model notation and the BOTE 124 notations in an obvious way. Thus, in equations (15)-(19) below, all

variables are in capitals and are in percentage change and all parameters are in lower case.

$$P_{dtm} = ER + P_m \quad (15)$$

$$P = s_{dtm}.P_{dtm} + s_n.P_n \quad (16)$$

Hence,

$$P_n = (P - s_{dtm}.P_{dtm})/s_n \quad (17)$$

This leads to –

$$(P_n - P_{dtm}) = ([P - P_m] - ER)/s_n \quad (18)$$

Here,
ER is the exchange rate
s_{dtm}, s_n are the shares of composite Armington and non-tradable goods entering into final demand price of dtm and n entering final demand (Absorption).

3.2 Scenarios

Based on our earlier work, we have developed the following main scenarios for the analysis of the poverty, income distribution and development impacts in the medium run, briefly summarized below:

1. **Global financial crisis**: Income and terms of trade shocks affecting export shocks, food and energy prices, and macroeconomic shocks.
2. The second set of scenarios explores the impact on growth strategies of **alternative sources of savings,** particularly private capital flows in the context of direct and indirect tax reform as a part of a wider search for new development strategies for LICs beyond ODA that has already begun in the development community.

3.3 Data Sources and Structure of the Ethiopia SAM

Data sources include: World Economic Outlook for the most recent terms of trade data, updated IMF Article IV macroeconomic projections and available technical change estimates. Estimates of the initial rates of direct and indirect taxes and their reform start from the Ethiopia SAM 2005/06 (Ahmed et al, 2010).
The SAM is highly disaggregated allowing for a large model with 46 activities, 22 commodities, 15 factors and 14 households types. Households are classified by urban and rural, poor and non-poor and according to their income size. It also includes 5 agricultural zones that capture some of the basic elements of differentiation between favourable and less favourable agricultural landscapes.
Agricultural activities are divided into the 5 regions, as are two of the factors used in agricultural activities, land and livestock. The two types of agricultural labour are mobile across activities and regions. There are two types of labour and one type of capital, which are mobile across the industrial and service activities. Regions of origin and destination divide foreign trade. In this application, there is no regional disaggregation of trade.
The large degree of sector and regional disaggregation in the SAM is likely to ensure that the poverty and distribution impact results for macroeconomic scenarios are as large as possible.

All results are based on the most recent data sources possible. In all scenarios, the highly disaggregated household and labour in the Ethiopia SAM have been exploited in the impact results on distribution, poverty, inequality and development.

3.4 Preliminary Results to Date

There are two main components to our work on income distribution and poverty impacts of each scenario:

-Terms of trade effects

- Foreign savings effects

First results for these two scenarios have been obtained for the medium run. Presentation of the results through the lens of the highly detailed main model, the strategic 124 model, and the decomposition of the poverty results by source of shocks, greatly adds to the transparency and usefulness of the results obtained. This is useful both to the researcher and to policy versions of the models.

3.4.1 Summary of Results and Decomposition

The modified Reform Scenario based on IMF Article IV macroeconomic projections published in 2010 were successfully linked to a SAM based comparative static CGE model. At this stage, impact effects on household consumption were estimated without a fuller development of the welfare function (changes in stocks and distribution weights were not included) and consumption impact effects of macroeconomic shocks and policy responses on Urban and Rural, Poor and Non-Poor were obtained. Strong illustrative results for terms of trade shocks and government expenditure were estimated for the medium run (the MR result is roughly for 3 years from 2007/08 to 2010/11). The link from the modified Reform Scenario in IMF(2010) to the SAM based comparative static CGE model combined the projected changes in Article IV macroeconomic policies and other policies or shocks which were directly modelled in the distribution and poverty model. Thus the summary and decomposition results provides an essential first step in the development of a methodology to analyse distribution and poverty Impacts of macroeconomic shocks and policy responses.

To follow the results in a little more detail, the symbols terms used in the reporting tables are defined in Table 5 below:

Table 5: Reporting Symbols and Description

GAMS Name	Description
sim	The full set of sims defined
stQABSORP	Absorption
stQCDTOT	Private Ponsumption
stQEDTOT	Enterprise Consumption
stQGDTOT	Government Consumption
stQINVTOT	Investment Consumption
stIMPORT	Import Demand
stEXPORT	Export Supply
REXR	Exchange Rate
TofT	Terms of Trade
Agri Unskilled	Agricultural Labour
Industrial Unskilled	unskilled workers in industrial sector
TOTSAV	Total Savings
HHTOT	Household Total Savings
GSAV	Government Savings
FSAV	Foreign Savings
POTH	Other Agriculture
RGEXP	Government Expenditure

The first column in tables 6 and 7 show the base period value for each of the variables reported and the subsequent entries across the rows show the percentage change in the variable under the simulation shown in the column headings. The base values are for 2005/06, the year of the SAM used in the calculation. However, for the purposes of the simulations the base year is 2007/08. In effect, the structure of the SAM for 2005/06 is assumed to be the same in 2007/08 and all quantities are measured in terms of 2005/06 prices. Since the results are all reported as a percentage change on the base, they are independent of the prices in which the quantities are measured. That the model results are influenced by changes in economic structure over time is a potential source of error which model builders and users must always be aware of and take into account when interpreting results.

Economic welfare in this model is measured in two ways. The first is for household consumption, and primary stress is given to this welfare measure in the full decomposition analysis. The household welfare function used given the same weights to all households, an assumption that could be dropped in favour of a welfare function with differential weights for poor and non-poor households. One of the important advantages of moving to a recursive dynamic CGE model is that welfare measures can take into account consumption over time. The second welfare measure is for economy-wide changes in absorption or the sum of household, government and investment expenditure on domestic goods and imports measured at a point in time. Both measures are affected by expenditure out of current economic flows, but also by changes in economic stocks that are not captured in a comparative static model. The most important example is the change in the demand for foreign saving or capital and aid inflows FSAV. An increase (decrease) in foreign saving now will increase (decrease) current and future consumption and absorption but, to the extent that future payment obligations are incurred by the present increase (decrease) in FSAV, repayments will have to be made as a charge (credit) against future consumption or

absorption. The model correctly captures the impact effects of any increase in foreign savings, for example on trade or the real exchange rate. In so far as the increased (repatriated) foreign savings are managed efficiently, welfare will also increase (decrease) when both current flows and future repayments are fully taken into account. Thus when interpreting the economy-wide results for changes in absorption (QABSORP), especially for large changes in FSAV, the results must be interpreted as impacts on current flows only and care needs to be taken to for look for signs that the current benefits are invested (repatriated) efficiently. The same general caveat holds for household consumption, but with an important qualification. An economy wide increase (decrease) in FSAV may not affect poor rural and poor urban households. The same exclusion may hold for non-poor rural households. The caveat does hold for changes in foreign investment associated with an economy wide increase in FSAV by non-poor urban households, which must be repaid at a later date. Thus, for the core of the decomposition results discussed below, the changes in current consumption in poor rural and urban households and rural non-poor households may not be much affected by the investment implications of changes in the economy-wide foreign savings FSAV. In short, it is only for economy-wide changes in QABSORP and for non-poor urban consumption that the caveat mainly holds.

In the summary table 6, the real exchange rate measures the relative price of domestic goods compared to foreign goods, or the relative price of non-tradables to tradables. This measure of the real exchange rate corresponds to that used in international economics. It is different from the widely used real effective exchange rate, which is the trade-weighted measure of the domestic country exchange rate compared to that of her trading partners. The terms of trade index TOFT is a trade-weighted index based on the world price changes. The percentage change in employment is for unskilled labour, which is employed at a fixed wage for agricultural labour, which is treated as unskilled, and for unskilled industrial labour.

Finally, in the discussion of the results for the medium run, the primary focus is on the summary macroeconomic table 6 and on the decomposition table 7.

The summary results for Clos2 MR are shown in Table 6 below. Broadly speaking, the MR terms of trade effects on absorption are strong and positive, as are the effects of increased government spending. The increase in government expenditure is financed by drawing rapidly from government savings. There is a fall in exports and an increase in imports. Little difference is observed between changes in the two measures of the real exchange rate (trade and macro). The powerful terms of trade effect affects the real exchange rate, which in turn drives up agriculture unskilled unemployment. Again, the overall welfare effects cannot be assessed because the negative changes in absorption are accompanied by an even larger fall in the demand for foreign exchange.

Table 6. Clos 2 Medium Summary Macroeconomic Results and Decomposition Run (Percentage change on base)

	Base	RGEXP_MR	POTH_MR
stQABSORP	1588.420	0.858	2.221
stQCDTOT	1147.546	0.389	3.074
stQGDTOT	159.098	5.759	0.000
stQINVTOT	281.776	0.000	0.000
stEXPORT	167.738	-2.640	7.230
stIMPORT	582.669	1.558	3.341
$REXR_{trade}$	1.000	-0.042	1.341
$REXR_{macro}$	1.000	-0.011	0.343
Percentage change in employment on base			
agri unskilled	442.243	-0.022	6.461
industrial unskilled	20.581	0.362	0.237
Percentage change in savings on base			
HHTOT	155.585	0.349	3.545
GSAV	32.609	-37.448	-0.327
foreign savings $	130.743	9.250	-4.911
MPS	0.118	0.000	0.000

The consumption impact effects of the policy experiments in the MR under Clos2 are shown in Table 7.

Table 7: Decomposition of Impact on Household Consumption in Medium-run

resHEXP	Rural Poor	Rural Non-poor	Urban Poor	Urban Non-poor	All Households
Baseline	197.750	672.354	43.029	234.413	1147.546
Percentage change on baseline					
RGEXP_MR	0.174	0.322	0.712	0.703	0.389
POTH_MR	5.307	3.874	-0.527	-0.431	3.077

The decomposition table 6 aggregates households from changes by household region (Economic Zones EZ1-EZ5), poor and non-poor (P and NP) and household size (small and big), to rural poor, rural non-poor, urban poor, urban non-poor. See Ahmad et al (2010) for a discussion of the household categories.
We can observe from Table 7 that the positive terms of trade impact effects on consumption are stronger for Rural Households whereas, the Government transfers to the Urban Households is much greater than the transfers to the Rural ones. The key driver of the decomposition results are the real exchange rate effects and the increase in the foreign savings combined with falling government savings. The major beneficiaries of the foreign exchange controls are the Rural Poor, the Rural Non-Poor and the Urban Poor. Urban Non-Poor households experience a large fall in household consumption and all other households gain.

4. Conclusion

From the point of view of the modeler who is trying to explain policy results from a large and complex CGE model, having the BOTE 124 miniature model and decomposition of results are obviously an advantage. It is also important that the miniature BOTE 124 model accurately reflects what is standard formulation in large single country CGE models. It emerges that the role of non-tradable goods in model

formulation and in empirical practice, and the policy importance of Dutch Disease effects, warrants further research.

It was found that building the BOTE 124 model was much more than an exercise in the history of economic thought. It actually reflects the way in which the main CGE is built. By focussing on key policy concerns (Dutch Disease, terms of trade), it provides insights into policy options that can easily be lost in the detail of the main CGE model. For example, from our large Ethiopia CGE model, we found that the focus of the BOTE 124 model on the impact of real exchange rate arising from a terms of trade shock and using EXPRtrade sharpened the interpretation of the decomposition results. The EXPRmacro measure of the real exchange rate was of little help in this case. In the case of government expenditure shocks, the 124 model was only partly useful because the additional detail in the main model (Government savings as well as FSAV) turned out to be empirically important. The focus of the BOTE 124 model on $REXR_{trade}$ as the microeconomic incentive governing resource allocation appeared to be more reliable.

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