INFORMATION FOR POLICY MAKING: NUMERICAL EXAMPLES OF POVERTY IMPACT OF TERMS OF TRADE SHOCKS IN ETHIOPIA USING A MINIATURE 124 MODEL AND BACK-OF-THE-ENVELOPE CALCULATIONS

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New Draft

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1.Introduction

This paper examines the poverty impacts of global macroeconomic shocks as estimated from international sources such as the World Economic Indicators and domestic macroeconomic policy shocks as estimated primarily from Article IV reports faced by a typical low income country. Our country example is Ethiopia.

Every era has favoured ways of generating and explaining economic policy results. In the 1960's for the typical OECD country, trade policy reform was high on the agenda and the standard two country two factor two commodity Heckscher-Ohlin trade model and diagram figured prominently in trade policy analysis, and the single country partial equilibrium diagram dominated quantitative trade policy analysis. For developing countries, a new breed of single country linear programming models of the allocation of savings/investment, and foreign exchange in planner's prices, often with a large number of sectors, replaced input/output models. One trade policy application of this class of models proved influential amongst trade policy analysts and amongst trade policy makers in Australia, simulating market prices rather than planner's prices, was Evans (1972).

The 1970's brought a new class of economic policy models, namely Computable General Equilibrium models or CGE models, led by Dixon et al (1982) amongst others, using continuous rather than discontinuous functions. The new CGE models quickly superseded the 2x2x2 Heckscher-Ohlin or H-O-S model because in a many commodity and many factor world with continuous functions, the number of commodities is well in excess of the number of factors and the model tends to have an unrealistically high degree of specialisation in trade. In contrast, the new CGE models embodied a specification of imports and exports that eliminated the tendency towards complete specialisation in the H-O-S model.

Typically, CGE models are large and complex, so that presentation of the essential results for policy makers is challenging both for modellers and for policy makers. The standard single country CGE models such as used by modellers such as Peter Dixon and Maureen Rimmer at the Centre of Policy Studies at Victoria University in Melbourne are around 100 sectors, ranging up to 500 sectors for more detailed analysis as in their US CGE or USAGE (Applied General Equilibrium) model, see (Dixon and Rimmer (2002)). Dixon and Rimmer overcome the model size difficulties for presentation by constructing a series of ad-hoc Back of the Envelope or BOTE tables and diagrams to help make key policy results accessible for policy makers.

Another approach to making CGE models accessible to policy makers is the World Bank 123 model, one country, two factors and three commodities (see Devarajan and Go (2003)). However, this well-known miniature CGE model was rejected in our work on Ethiopia because it does not have a non-traded good, an unfortunate omission since our work on Ethiopia suggests that about 1/3 of GDP is in non-traded goods. Thus, our development of a 124 miniature CGE model (one country, two factors, four commodities) can be seen as an essential complement to the presentation approach of Dixon and Rimmer using ad hoc BOTE tables and diagrams. A diagrammatic and mathematical exposition of the 124 model can be found in Evans and Ghelani (2013, 2014).

In this paper, we have combined our diagrammatic work on the 124 model with an aggregation of the results of our historical 22-commodity comparative static CGE model of Ethiopia in the search for an accessible analytical approach to summarising key model results for the policy maker. We combine the new results from the 124 model diagrams with our previous work on the decomposition of the poverty experiments to provide the policy maker with a set of BOTE results for the presentation of poverty impact results using a large historical terms of trade shock.

2. Methodology

The first part of the paper sketches out a diagrammatic exposition of the 124 model. The basic components of the 124 model are:

1. A two factor two commodity production possibilities frontier.
2. An Armington function that transforms imports into domestic good where the imported goods are imperfect substitutes with the domestic good.
3. A Constant Elasticity of Transformation or CET function that transforms domestic goods into exports where the domestic goods are imperfect substitutes with exports.
4. A social welfare function based on non-traded goods and a combined import and domestic import-competing good or the Armington composite good.
5. An analytical structure that generates competitive product and factor prices.
6. A large number of additional components can be added, for example an employment function, an expectations function, an investment function – the list in CGE applied policy analysis is very long indeed.

The diagrammatic version of the 124 model (Back of the Envelope or BOTE diagrams) shows the characteristics of an equilibrium position. This allows us to show the level of exports, share of imports in the Armington composite good, the level of the domestic traded and the non-traded goods, the relative price of imports and the domestic traded good, the level of the money exchange rate that governs balance of payments equilibrium, and the relative price of the Armington composite and non-traded goods or the real exchange rate.

The 124 model equilibrium is then shocked with an improvement in the price of exports or the terms of trade (TofT). This allows us to follow the causal links between the terms of trade improvement, the change in exports and imports, and the change in economic welfare.

We then aggregate the results of a historical terms of trade shock for Ethiopia from our 22-sector CGE model into traded and non-traded goods, netting out intermediate goods and apply them to the 124 model described above by aggregating. We show the shift in the equilibrium from the terms of trade shock using two 2-dimensional diagrams to present some of the results important for policy making decisions concerning structural change and the impact of the large terms of trade improvement on the flow of savings. Our 2-dimensional diagrams are complemented for poverty impacts using our earlier poverty decomposition analysis. In combination, with the model results, our accessible Back of the Envelope or BOTE diagrams could usefully feed into the policy making process for assessing the impact of pro-poor policies in the context of economic growth and development in Ethiopia.

3. A Sketch of the 124 Model in Diagrams

Starting with these ideas and adding building blocks as the narrative develops, a sketch of the 124 model can be built up. A more detailed description can be found in the Appendix. The sketch of the 124 model in Diagram 1 looks more complicated than it is. First, in the SE quadrant is the production possibilities frontier, a basic building block in all economic models, showing the trade-off between the non-traded and the domestic traded goods production, Qn and Qdt. An increase in the relative price of the non-traded good increases the production of Qn relative to Qdt and the trade-off between Qdt and Qn is shown by the locus AoGFo. The slope of this locus will be given by minus the ratio of the domestic prices -(Pdt/Pn).

The CET function and exports are shown in the NE quadrant of the upper diagram. Suppose that there is no production of the non-traded good Qn. Thus, the production of the domestic traded good Qdt will be

at Ao in the upper NE part of Diagram 1 and the degree of substitutability of the domestic traded good Qdt and exports Qe is shown by the function AoCBo with a slope in domestic prices of –(Pdt/Pe.ER) where ER is the money exchange rate which brings export prices in $ to domestic prices. The locus AoCBo is drawn such that at the point A, 0A is the amount of Qdt sold domestically and AAo is transformed into exports AC. A combination of domestic sales and exports given by the point C with a price ratio of –(Pdt/Pe.ER); Qe is an imperfect substitute for the domestic tradable good Qdt. The idea behind the CET function can be illustrated with respect to corn. African corn is usually inferior to internationally traded European or American corn so that in a notional African equilibrium, the low quality African is sold domestically and the higher quality European or American corn is exported.

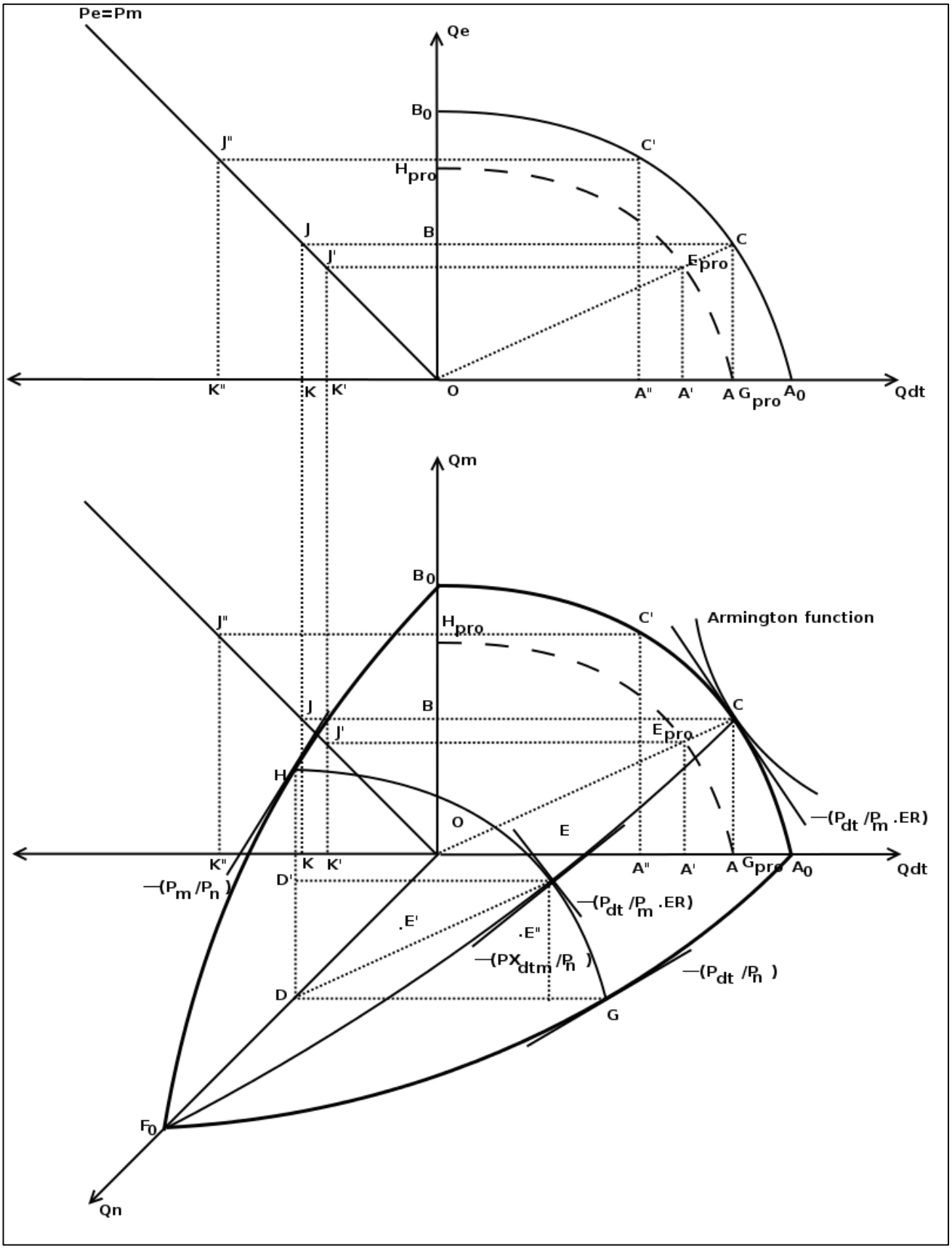
The CET function in the upper NE part of Diagram 1 with a trade-off between Qdt and Qe, can be re-drawn in terms of the domestic traded good Qdt and imports Qm, reflecting the fact that imports are simply exports transformed into imports through foreign trade. Thus, when the terms of trade TofT are given and Pe=Pm as shown by the diagonal in the upper NW quadrant of the Diagram 1, the amount of exports Qe associated with the point C and equal to AC (=0B) can be transformed into the equivalent amount of imports Qm equal to 0J. Using the diagonal in the upper NW quadrant, the amount of imports 0J in the upper part of the diagram can be transformed using the 45 degree line into imports Qm equal to 0B in the lower diagram. Thus the locus AoCBo which is concave to the origin and labelled “CET from import side” showns the locus of possible points on the consumption possibilities frontier in (Qdt, Qm) space.

Finally, the locus BoHFo shows the extreme points of the consumption possibilities frontier in (Qm,Qn) space. When all of the domestic traded good is used to produce exports which are then imported , the point Bo on the consumption possibilities frontier is determined. As imports are lowered, labour and capital are released from Qdt production via exports and imports until only the non-traded good Qn is produced at Fo.

The 124 model is completed by two sets of demand-side behavioural relationships. The consumption shares of imports and the domestic traded good is determined by what is known as the Armington function, the inverse of the CET function. Imports are treated as an imperfect substitute for the domestic tradable good, shown by the function that is convex to the origin in the lower NE quadrant and tangent to the convex function AoCBo, labelled “Armington function”, at C. Think of a difference in the quality of imports and domestic production, say cars. If imported cars are of higher quality, then for given relative prices –(Pdt/Pm.ER), an equilibrium combination of Qm and Qdt could be at C.

The final equilibrium is determined by the social welfare function, the Armington composite good made up of imports and the domestic traded good, Qm and Qdt, and the non-traded good, Qn. Thus, for a given relative price of imports and the domestic traded good Qdt, the locus of possible final equilibrium points will be CEFo as shown in the lower part of Diagram 1 in the SE quadrant with a possible final equilibrium point at E. As check of the way in which CET and Armington functions work, consider a shift in the Armington function to the left in the lower NE diagram. Thus, if the initial equilibrium is at C in the lower NE quadrant, the shift in the Armington function results in a devaluation of the money exchange rate ER, increasing the domestic price of imports relative to the domestic traded good -(Pdt/Pm.ER). The devaluation in the money increases the domestic price of exports, thus increasing export sales Qe and lowering the share of output of the domestic traded good available for domestic sales as the equilibrium point C in the upper NE part of the diagram shifts upwards and to the left., as shown in Diagram 1 over.

Diagram 1: Real Exchange Rate REXR, Money Exchange Rate ER in the 124 model and the Consumption Possibilities Frontier CPF



A two dimensional version of the consumption possibilities frontier is shown in Diagram 2 below, where the locus CEFo from Diagram 1 is plotted in 2-dimensional space for a given relative price of the Armington composite good and the non traded good, -(PXdtm/Pn)o. The resultant locus CoCC'Fo in Diagram 2 has an initial equilibrium point at C for the social welfare function Idmn0. A shift of the social welfare function to Idmn1 to the left of Idmn0 will lead to a new equilibrium point such as C' and an appreciation of the real exchange rate REXR, an increase in the relative price of the non-traded good relative to the price of the Armington composite good.

Diagram 2: Consumption Possibility Frontier in 2 Dimensions

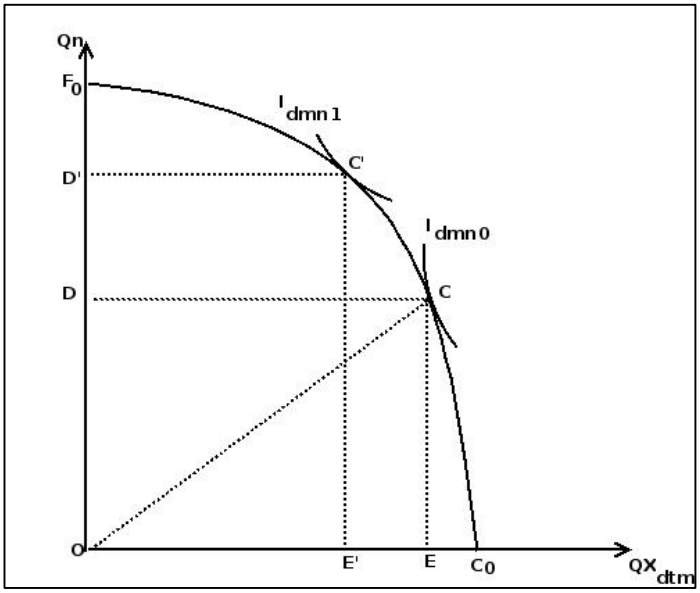
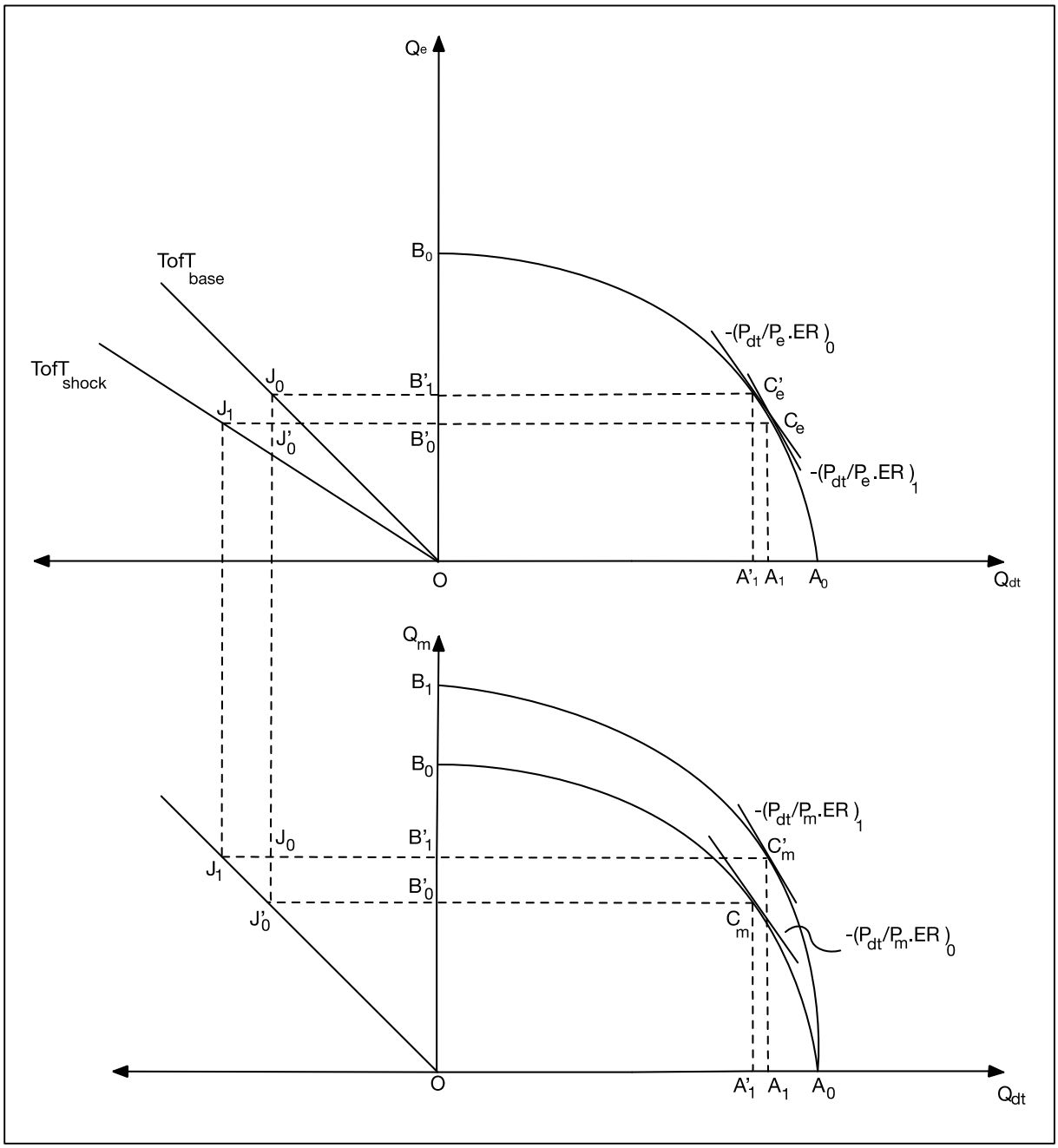


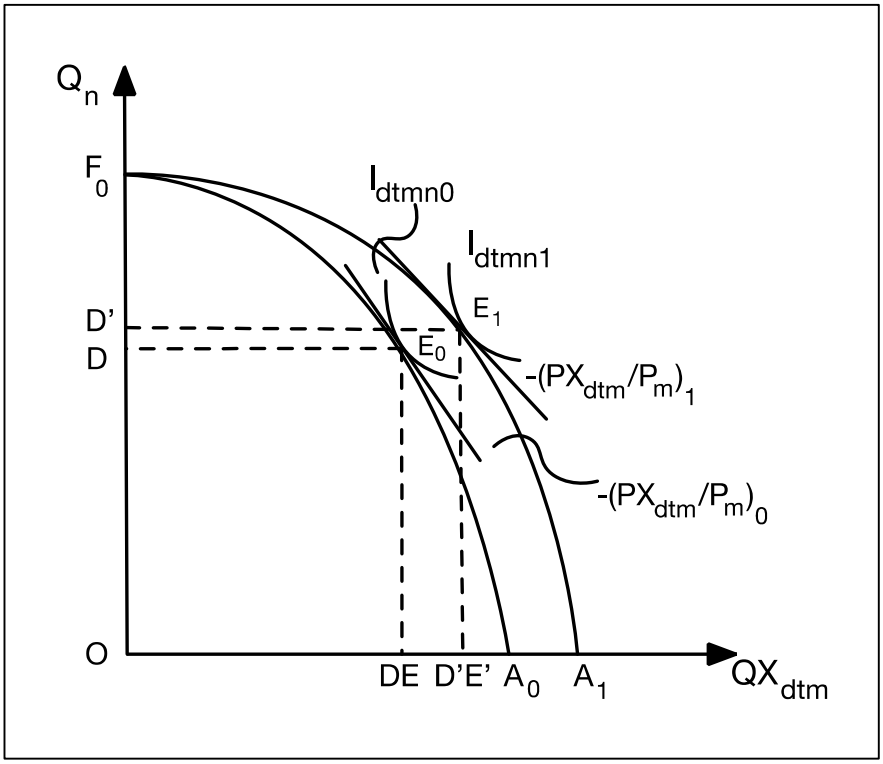
Diagram 3 below shows the impact of a terms of trade improvement when the output of the non-traded good is held constant. Thus, when Qn is held constant, the effect is the same in Diagram 1 as setting Qn = 0 and removing the Qn axis as shown in Diagram 3 below. The resultant initial consumption possibilities frontier is AoCmBo. The impact of a TofT shock and the impact on exports can be seen from the upper diagram. As the price of exports increases, the export equilibrium will shift from Ce to C'e, increasing imports from OB'0 to 0B1.

Diagram 3: Consumption Possibilities Frontier with TofT shock and no Non-Tradable Goods



It can readily seen from Diagram 3 that the TofT shock pivots the consumption possibilities frontier on the extreme point A0, the maximum possible production of the domestic tradable good when Qn=0. Diagram 4 is similar to Diagram 2 except the social welfare function remains unchanged but there is a terms of trade shock TofT that increases the supply of the Armington composite good. The consumption possibilities frontier now pivots on the extreme point Fo for the production of the non-traded good (See Diagram 4 below). The new consumption possibilities frontier A1E1F0 has equilibrium at E1 and an appreciation of the real exchange rate.

Diagram 4: Consumption Possibilities Frontier in 2 Dimensions with TofT shock



We have explored further some of the properties of the 124 model in Evans and Ghelani (2013), some of which are discussed in the Appendix. For present purposes, we describe a 2-dimensinal consumption possibilities frontier, and what happens in the 2-dimensional diagrams when the model is shocked by a terms of trade improvement.

The next step is to use actual model results from a historical example from Ethiopia in the two dimensional diagrams developed above to elucidate key results. At this stage, it was not possible to use the three dimensional diagram – the graphics for levels were too difficult.

4. Short Run Historical Results

Between 2005/6 and 2007/8, there was a large favourable terms of trade shock affecting the Ethiopian economy. Our modelling of this and other shocks are described in Evans and Ghelani (2014). Briefly, our CGE model was based on the Ethiopian 2005/6 SAM, and in addition to the within-period shocks that were modelled, we also made a set of comparative static approximation shocks in the Short Run (SR), Medium Run (MR) and Long Run (LR) covering the years 2007/8, 2008/9, 2010/11. For present purposes, we have only used the SR result for a large favourable terms of trade shock affecting agricultural exports, referred to as POTH_SR in the model notation.

The CGE model is quite straightforward. It has 22 commodities, 5 types of labour, sector specific capital, land and livestock in agriculture. The industrial sectors, there is mobile labour and capital. There are 14 types of households. The exogenous data for the terms of trade shock came from the IMF WEO. Key exogenous variables included government expenditure,

investment. The trade balance was assumed to be covered in part by exogenous development assistance flows and in part by mobile private capital flows. The aggregate welfare function was absorption made up of C+I+G+M. For disaggregated poverty estimates, we aggregated households into urban and rural, poor and non-poor, and used household consumption as the disaggregated welfare indicator.

The SR summary results for POTH_SR for the short run favourable terms of trade shock affecting agricultural exports are shown in Table 1 below. The decomposition of household income is shown in Table 2.

Table 1: Summary Macroeconomic Results

SR Clos2 (% change on base)	Base	POTH_SR	POTH_SR
rperSMACRO SR	Level	Level	%
absorption	1624.77	1700.49	4.66
private consumption	1147.55	1223.26	6.60
government consumption	158.29	158.29	0.00
investment consumption	318.94	318.94	0.00
export supply	167.74	197.95	18.01
import demand	298.48	313.39	5.00
Money Exchange Rate ER	100.00	94.34	-5.66
Real exchange rate REXR	100.00	98.43	-1.57
Terms of trade	100.00	110.52	10.52
Percentage change in employment on base			
Agric unskilled labour employment	442.24	501.24	13.34
Ind unskilled labour employment	20.58	20.71	0.63
Skilled labour employment	141.27	141.27	0.00
Total labour employment	604.10	663.22	9.79
Percentage change in savings on base			
total savings	318.94	317.50	-0.45
household savings	155.58	172.20	10.68
government savings	32.61	33.24	1.93
foreign savings in birr	130.74	112.06	-14.29
foreign savings in $	130.74	115.45	-11.70

Table 2: Decomposition of Household Consumption Expenditure:

Clos2 Short Run

	Baseline 2005/6	Wheat SR	Petrol SR	Oth Ag SR	PMS SR	All_TofT_SR	Sum Sims SR
Household rural poor	210.65	-0.96	-0.37	9.10	-3.99	2.32	3.78
Household rural non-poor	659.46	-0.77	-0.37	8.34	-3.95	1.83	3.24
Household urban poor	43.03	-1.39	-0.26	-0.74	-0.39	-2.95	-2.78
Household urban non-poor	234.41	-0.71	-0.31	0.79	-2.20	-2.72	-2.42
Total	1147.55	-0.82	-0.35	6.60	-3.47	0.81	1.96

At a glance, the summary macroeconomic results as shown in Tables 1 and 2 indicate:

- A strong over-all welfare benefit from the terms of trade change
- A strong appreciation of the money exchange rate ER
- A modest appreciation of the real exchange rate REXR
- A strong employment effect on unskilled labour
- A strong positive effect on household savings
- A modest increase in government savings
- A strong outflow of private savings
- Both poor and non-poor rural households have strong gains in consumption
- Non-poor urban households have a very small gain, and poor urban households practically show a small loss in consumption.

In addition, the decomposition results in Table 2 show the terms of trade impact on household consumption in rural poor and non-poor, urban poor and non-poor households for all of the terms of trade results experiments conducted. Table 2 shows the vertical and horizontal decomposition results. Taking first the vertical decomposition results, the strong benefits of the TofT shock for Other Agriculture (Oth Ag) for Rural households are in contrast to the weak or negative effects on Urban households. With regard to horizontal decomposition, the total of all the terms of trade experiments leave Rural households with much weaker consumption benefits and moderately strong negative consumption effects for Urban households. Compared with the experiment in which all TofT effects were run together, the sum of the consumption impact of each of the TofT experiments run individually give very similar results – the results for All TofT sims vs the Sum of All sims are very similar. This horizontal decomposition allows a direct comparison of the strength of the consumption impact effects between different experiments.

The next step is to translate some of these results into the back of the envelope and diagrammatic framework suggested above by the 124 model.

5. Short Run Historical Results in BOTE and Diagramatic Mode

5.1 Back of the Envelope (BOTE) Equations

The results data in Table 3 below is used in the quantification of the model equations (1)-(5-) below as appropriate. The data is roughly in model in notation from source Table 1 above. The definitions should be obvious. The main change in Table 3 below is the * notation used to indicate net output ie output net of input flows.

Table 3: Data Used in Model Notation for BOTE Equations

definition	variables	base	POTH_SR	ange on B
		level	level	%
Quantity of net domestic tradable good	Qdt*	834.77	882.33	5.70
Quantity of net non-tradable good	Qn*	266.93	277.11	3.81
Quantity net goods	Qdtn*	1101.70	1159.43	5.24
Quantity of exports	Qe	167.90	198.14	18.01
Quantity of imports	Qm	298.48	313.40	5.00
Terms of trade	TofT	100.00	110.52	10.52
Money exchage rate	ER	100.00	94.34	-5.66
Real exchange rate	REXR	100.00	98.43	-1.57
Agric unskilled labour employment	Ag Unskld	442.24	501.24	13.34
Ind unskilled labour employment	Ind Unskld	20.58	20.71	0.63
Skilled labour employment	Skld	141.27	141.27	0.00
Total labour employment	Total	604.10	663.22	9.79
Foreign savings	FSAV in $	130.74	115.44	-11.70
Domestic price of exports	Pi_e	1.00	1.04	4.26
Domestic price of imports	Pi_m	1.00	0.94	-5.66
Price of non-traded good post Toft shock	Pn* shock	1.00	1.02	1.79
Price of domestic traded good post TofT	Pdt* shock	1.00	0.99	-0.57

The standard representation of a 2-commodity and two-factor economy is shown in equations (1)-(5).

$$Yinc = A * F(R, L) \quad (1)$$

$$Yexp = C + I + G + (X - M) \quad (2)$$

$$W/P = A * F_l(R/L) \quad (3)$$

$$Q/P = A * F_k(R/L) \quad (4)$$

$$or, Q/P = g(A, W/P) \quad (5)$$

where,

Yinc = GDP from the income side

Yexp = GDP from the expenditure side

C = Consumption

I = Investment

G = Government Expenditure

X = Exports

M = Imports

W/P = Real Wages measured in terms of the price of GDP

and W/Pcpi is the real wage measured in terms of consumer prices

A = Technology

R = Resource, a composite factor consisting of mainly land and a small amount of capital

L = Labour

Given the strong employment effect of the terms of trade shock of over 10%, the valuation of the RHS of equation (3) will be less than 1. Noting that in the model, the real wage of unskilled labour is fixed in terms of the price of consumer goods and using the data shown in Table 3, the LHS of (3) is:

$$(W/Pcpi)*(Pcpi)/P = 0.98 \qquad (3a)$$

Thus, for (R/L) to increase as is noted in Table 3, the LHS of equation (3a) has to be less than one, as is the case above. Further fine tuning to valuate the of equation (3a) could be done to improve the empirical estimates of the LHS of equation (3), and by using a Cobb-Douglas production function for the valuation of the RHS of equation (3).

5.2 Back of the Envelope (BOTE) Diagrams

As with the BOTE equations, the key steps required to translate model results into a format that fits the diagrammatic story is to divide sectoral outputs into the domestic traded good, and the non-traded good, and to net out intermediate inputs so that net output is shown in the diagrams, not gross output including intermediate inputs. Already, each sector is divided for the model into traded and non-traded good for model inputs, but not for model outputs. However, it was a straightforward exercise to divide sector outputs into traded and non-traded goods, and to estimate from the SAM the share of intermediate inputs in production for each sector. Somewhat to our surprise, the share of intermediate inputs in the non-traded sectors was well over 50%, a finding that will require checking as we proceed to update and extend our results in a dynamic model of Ethiopia.

The model notation used in Table 1 was adjusted in an obvious way so that the model results shown ***Model Units NG ** in Table 4 could be used to draw to scale Diagram 3, the 2-dimensional diagram for the trade-off between the output of the domestic tradable output Qdt and exports Qe, and the trade-off between domestic tradable good output and imports, shown in Diagram 5 below. The notation is used to indicate that output quantities are now net of input/output flows. The culmination of the

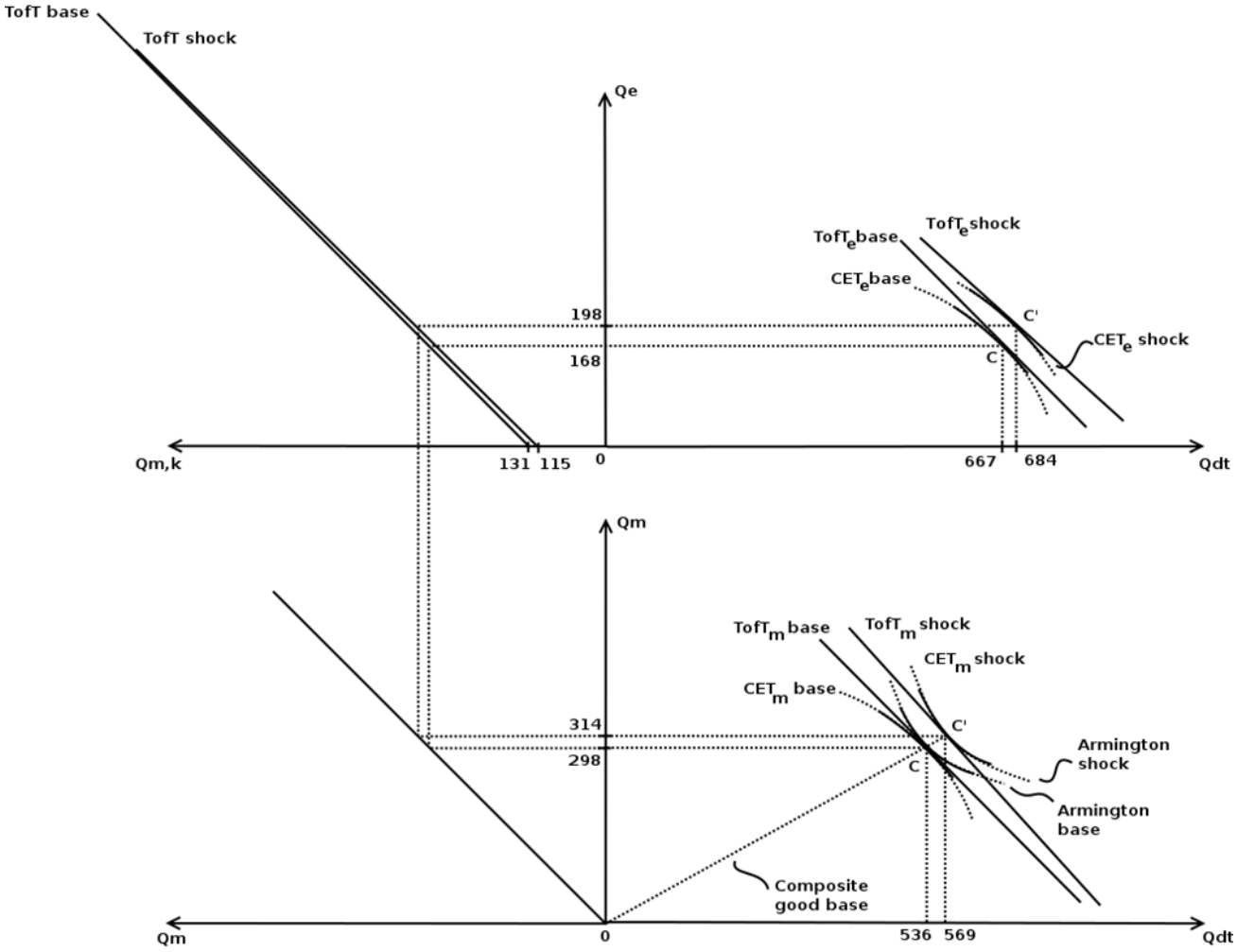
diagrammatic presentation is in Diagram 6, which shows the consumption possibilities frontier in two dimensions and the social welfare function.

Table 4: Data Used in Diagrams 5 and 6 in Diagrams Notation

	base		shock	%	difference
Qdt*base	835	Qdt*shock	882	6	48
Qn*base	267	Qn*shock	277	4	10
Q*base	1102	Q*shock	1159		58
Qebase	168	Qeshock	198	18	30
Qmbase	298	Qmshock	314	5	15
Qedtbase	667	Qedtshock	684	3	17
Qmdtbase	536	Qmdtshock	569	6	32
QXdtmbase	835	QXdtmshock	882	6	48
TofTwbase	100	TofTwshock	111	11	11
TofTebase	100	TofTeshock	105	5	5
TofTmbase	100	TofTmshock	94	-6	-6
TofTqxbase	100	TofTqxshock	98	-2	-2
Employmenybase	604	EmploymenyShock	663	10	59
FSAV$base	131	FSAV$shock	115	-12	-15
Qe+FSAV$base	299	Qe+FSAV$shock	314	5	15

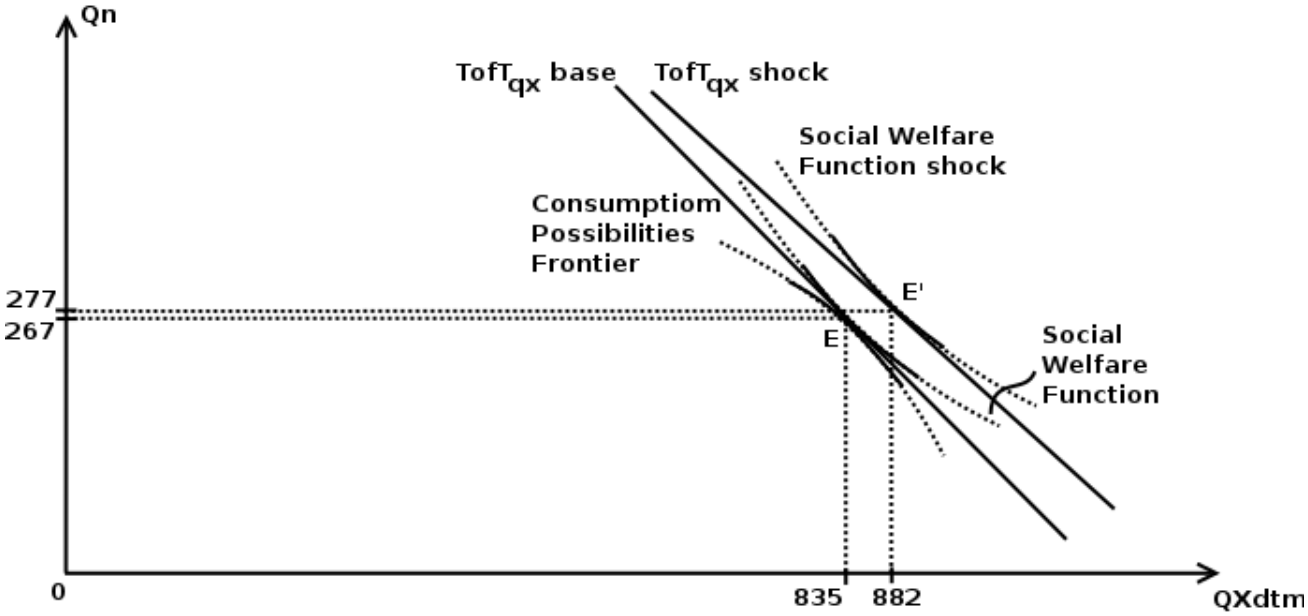
In Diagram 5, as the increased price of exports improve the domestic price of exports net of the money exchange rate appreciation, relative to the domestic traded good and shifting exports and the domestic tradable good from C to C' in the upper NE. This increases unskilled agricultural labour income earned by rural households which in turn is large enough to lower foreign savings, as seen in the upper NW quadrant as a shift in the terms of trade line towards the origin, thus lowering import capacity after the shock. Never-the-less, base (shock) of imports of 298 (314) units is covered by 168(198) units of exports and 131(315) of foreign saving in the base(shock) period (allowing for rounding errors). The new equilibrium between imports and domestic tradable output is shown by the shift from C to C' in the lower NE diagram.

Diagram 5.Impact of Terms of Trade Shock on Exports and Imports



In Diagram 6 below, the initial and final points of consumption are shown at E and E', reflecting a welfare improvement from the terms of trade shock of roughly 5%, in line with the model results shown in Table 1. Both the points E and E' reflect the combinations of Qn and QXdtm obtained from model sectoral outputs shown in Table 1 above. In particular, the change in slope of the price lines TofTqx through Eo and E1 tangent to the social welfare function and the consumption possibilities frontier reflect the appreciation of the real exchange rate REXR in Table 1 of about -1.5%.

Diagram 6: Consumption Possibility Frontier in 2 Dimensions



6. Summary and Conclusions

The results presented in Diagrams 5 and 6 show the causal links from the terms of trade shock to the final welfare response. First, the terms of trade shock rotates the terms of trade line in the upper NW quadrant to the left and the money exchange rate appreciates so that only some of the terms of trade shock is translated into a domestic export price rise relative to the price of the domestic traded good, shown by the shift of the export and domestic traded goods equilibrium from C to C' and a rotation of the TofTe price line to the left. The fact that C' is to the NE of C indicates a strong outward shift in the CETeshock function as export expansion increases the employment of unskilled agricultural labour. The final equilibrium is shown in Diagram 6, where the terms of trade improvement increases social welfare by roughly 5.0%. Also, Diagram 6 illustrates the appreciation of the real exchange rate as the TofTqx line rotates to the left. As noted in the Appendix, the money and real exchange rates do not necessarily move in the same direction.

The obvious question is, do the diagrams help policy makers better understand the model results? The BOTE equations and diagrams do make the causal lines from the initial terms of trade shock starkly clear. Testing policy makers is obviously a next step, especially the "presentability" of Diagram 1 and the contrast between money and the real exchange rate. The poverty indicators as shown in Table 2 will, for now, have to be used with the BOTE diagrams for a discussion of disaggregated poverty impacts.

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Appendix: The money and real exchange rates a small CGE model

This appendix sets out the relationship between the money and real exchange rates, ER and REXR, in a small CGE model for one country, two factors and four commodities, or a back-of-the-envelope BOTE 124 model. Diagram 1 sets out the model equilibrium and describes the equilibrium adjustment process in a 3-dimensional diagram for two factors say, capital and labour) and four commodities (exports, Qe, imports, Qm, domestic tradable goods, Qdt, and non-traded goods,Qn). This model differs from the well-known 123 miniature CGE model for one country, two factors (capital and labour) and three commodities(Qm, Qe and Qdt), see Evans and Ghelani(2013) for a full exposition of the 124 BOTE model in comparison with the 123 model. In the 124 BOTE model, adjustment to external or policy shocks is facilitated by the money exchange rate, ER which adjusts to maintain the balance of payments equilibrium, and the real exchange rate REXR equal to the ratio of the price of theArmington composite good and the price of the non-traded good, which adjusts so that the structural balance is maintained between tradable and non-traded goods.

Definitions: all variables are in levels and are uppercase. All parameters are lower case.

P_m is the world price of imports.

P_e is the world price of exports.

P_{dt} is the price of the domestic tradable good

Psh_m is the cost share of the imports

Psh_{dt} is the cost share of the domestic tradable good

P_n is the producer price of non-traded goods.

PX_{dtm} is the price of the composite good on the import side

Q_m is the quantity of imports

Q_{dt} is the quantity of the domestic tradable good

Q_n is the quantity of the non-traded good

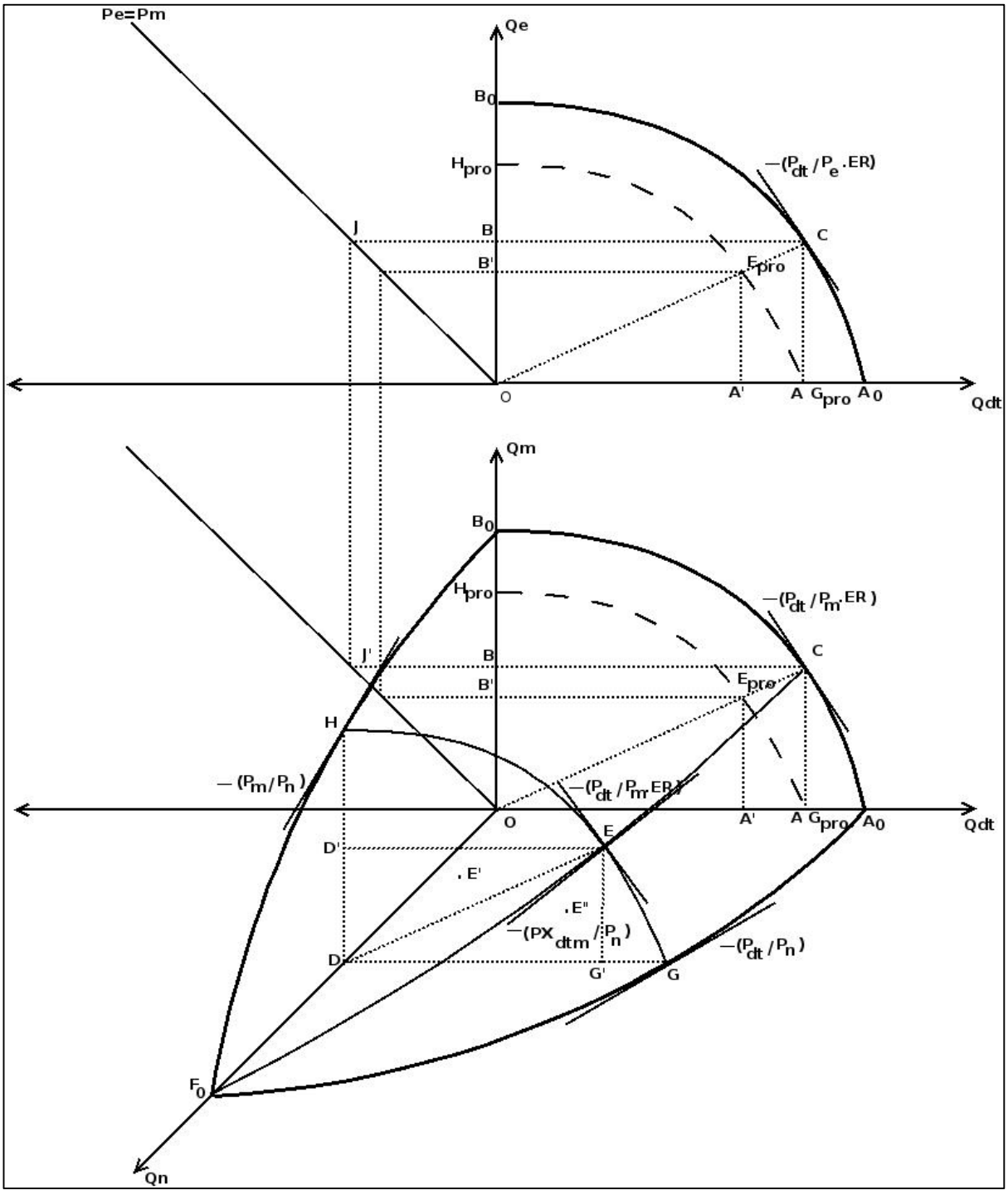
QX_{dtm} is the quantity of the composite good on the import side

Qsh_{dt} is the quantity share of the domestic tradable good

ER is the exchange rate in current prices, the ratio of the price of the domestic goods to foreign goods.

REXR is the real exchange rate. It is the ratio of traded to non-traded goods in purchaser prices.

Diagram A1: Real Exchange Rate REXR, Money Exchange Rate ER in the 124 model and the Consumption Possibilities Frontier CPF



The lower part of the Diagram 1A below is in three dimensions, imports, Q_m, the domestic tradable good, Q_{dt}, and the non-traded good, Q_n. Imports are obtained through exports on to the world market, shown in the upper quadrant of the diagram. The domestic tradable good is transformed into exports according to a CET or constant elasticity of transformation function, shown by A_0CB_0, where OA_0 is the maximum amount of the domestic tradable good that can be produced. Imports are obtained from exports at an assumed given set of world prices$P_e = P_m$. Thus, OA amount of Q_{dt} transforms into OB amount of exports and into OB amount of imports at the world price ratio P_m/P_e and the domestic price

ratio– $(P_{dt}/P_e.ER)$for exports and – $(P_{dt}/P_m.ER)$for imports. Given $P_e = P_m$, the CET frontier A_0CB_0 in the upper quadrant translates into A_0CB_0 in the northeast quadrant of the lower part of the diagram. In the south-east quadrant of the lower part of the diagram when exports and therefore imports are zero, the consumption possibilities frontier A_0GF_0 follows from the underlying production functions and factor supplies. The consumption possibilities frontier in the north-west quadrant of the lower part of Diagram A1, B_0HF_0, follows when consumption of $Q_{dt} = 0$and all resources are used either to produce the domestic tradable good Q_{dt}which is transformed into imports Q_m through trade, and the non-traded good Q_n. The 123 model follows in diagram 1A when the non-traded good$Q_n = 0$, depicted by the locus CEF_0. There is no adjustment of the money exchange rate required when moving on the locus CEF_0. However, adjustment of the price of the Armington composite PX_{dtm} relative to the price of the non-traded good will be required and $REXR = -PX_{dtm}/P_n$ will fall in order to restore equilibrium when point E shifts towards F_0 on the CEF_0 locus.

Now consider an equilibrium point such as C in the northeast quadrant of the lower part of the diagram. At point C, the consumption of $Q_n = 0$ and the equilibrium price ratio equals– $(P_{dt}/P_e.ER)$satisfying the Armington function that determines equilibrium proportions of Q_m andQ_{dt}. The equilibrium price ratio for the exports is given by– $(P_{dt}/P_e.ER)$. Now suppose that the domestic traded good is the numeraire good and that there is a shift in tastes such that the new equilibrium point is to the left of C in the north-east quadrant in the lower part of the diagram. Since the world price of the domestic tradable good P_{dt} is fixed, the domestic price of imports $P_m.ER$will have to increase relative to the domestic price of the domestic tradable good, $P_{dt}$for a new equilibrium price ratio to be established. Similarly, from the upper part of diagram 1A, the domestic price of exports $P_m.ER$ will rise. The new money exchange rate, exports will increase to pay for the shift in tastes towards the imported good.

Consider a new initial equilibrium point at E, where some of the non-traded good $Q_n$is produced. When the production functions, the CET function and the Armington functions are all homothetic, a locus such as CEF_0 on the CPF can be drawn whereby the tangent at C and E will have identical ratios of the domestic price of imports – $(P_{dt}/P_m.ER)$ will be the same. For all points on the locus A_0GF_0, a locus similar to CEF_0 can be drawn with a constant – $(P_{dt}/P_m.ER)$shifting around the frontier to F_0 and a falling – $(P_{dt}/P_m.ER)$as C shifts towards B_0.

Consider now the equilibrium point E. The locus HEG is for points on the consumption possibilities frontier for which the production of the non-traded good is held constant at OD. The locus HEG can be projected into the Q_mQ_{dt}plane.

Some characteristics of Diagram 1A can be described. The rectangle DD'EG' in the southeast quadrant of the lower part of the diagram shows the equilibrium quantities of imports $Q_m$and the domestic tradable good that will be associated with the non-traded good $Q_n$equal to OD. Consider first a displacement of the equilibrium at E to the left on the locus of GEH, say by a change in preferences towards the traded good, Q_m. In this case, an increase in the money exchange rate, ER will decrease the relative domestic price ratio – $(P_{dt}/P_m.ER)$or an increase in the relative domestic price of the imported good and restore the balance of payments to equilibrium. From the upper part of Diagram 1A, the depreciation of ER will induce an expansion of exports Q_e, a part of the adjustment process on the export side.

Finally, a shift in the final equilibrium point from E to a point to the right of E on the locus HEG, say from a shift in final preferences towards the domestic tradable goodQ_{dt}, will require an appreciation of the money exchange rate ER to restore balance of payment equilibrium. Note that in both cases when the equilibrium shifts from E to the left or to the right on the locus HEG, the money exchange

rate depreciates (increases) or appreciates (decreases) without changing the real exchange rate $REXR = -PX_{dtm}/P_n$.

Now consider a displacement of equilibrium at E to a point E' to the southwest of E, or to a point E" to the southeast of E. In the case of a shift in the equilibrium from E to E', the money exchange rate ER will depreciate as before, but the real exchange rate REXR will appreciate as $-PX_{dtm}/P_n$ falls.

Similarly, a shift in the equilibrium E to E" will entail an appreciation of the money exchange rate as ER falls, as well as an appreciation of the real exchange rate REXR equal to $-PX_{dtm}/P_n$. In summary, in response to a shock that shifts the equilibrium, the money exchange rate ER adjusts to restore balance of payments, and the real exchange rate, REXR adjusts to restore the structural balance between tradables and non-tradables. Furthermore, the sign of the adjustment of ER and REXR can move in opposite directions.

(Mathematical exposition to follow diagrammatic exposition concerning the relationship between ER and REXR).