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Full Length Research Paper

Effect of agricultural efficiency improvement on Sudan economy

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This study attempts to assess the impact of improving agricultural efficiency on Sudan economy. It focuses on the effect of improving the efficiency of sesame, sorghum, cotton, wheat; due to their economic important in Sudan economy; on macroeconomic and sectoral variables. It uses the International Food Policy Research Institute (IFPRI) standard Computable General Equilibrium (CGE) model to achieve its objectives. Sudan Social Accounting Matrix (SAM) for year 2004 constitutes the core database for the CGE model. The model results reveal that improving the efficiency of each agricultural commodity would increase its own output and exports, and reduce exports of the other commodities. However, the expected increases in output would generate different mixed changes on the other crops. It also indicates that improving wheat production efficiency would result in reducing its import, while improving the efficiency of the aggregate agricultural sector would increase wheat imports. The overall effect of improved efficiency of each commodity would improve the GDP due to improvement in private consumption and investment regardless of balance of trade deterioration. The study recommends an integrated agricultural efficiency improvement to achieve sound economic performance. It also encourages the innovation of fast food from local commodities to improve the balance of payment.

Key words: Sudan, agricultural efficiency, CGE, GDP.

INTRODUCTION

The interest of national and international organizations by the use of agricultural technology in the production of agricultural good has grown as a result of the world trade liberalization, coupled with concerns over food security, high rates of population growth, the volatility of prices in global markets, and the use of limited and frequently degraded natural resources. The assessment of agriculture can provide insights about how efficiently the agricultural sector is using its endowments.

The 2003 Maputo Declaration directed African Union member countries to increase agricultural investments to at least 10% of their national budgets. To measure progress toward this target, the Comprehensive Africa Agriculture Development Programme (CAADP), under the AU's New Partnership for Africa's Development (NEPAD), agreed to monitor agricultural expenditures, setting a 6% yearly target for growth in agricultural Gross Domestic Product (GDP) in countries where agriculture plays a dominant economic role. One of CAADP's four foundational pillars focuses on increasing investments in agricultural research, extension, education, and training as a means of promoting growth in agricultural productivity (NEPAD, 2006).

Total population of Sudan was 40 millions in 2008. About 62% are working in agriculture, whereas about 65% reside in rural areas. Unemployment rate is high and it is much higher in urban than in rural areas. This is due mainly to the mass rural-urban migration in recent years.

The agriculture sector plays an important role in the Sudan's growth, industrialization, exports and environment. It contributes more than 39% to GDP and it is the main source of livelihood. Approximately one-third

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of the total area of the Sudan is suitable for agriculture, yet only about 21% of arable land is cultivated. Despite its predominant position in the overall economy of the Sudan, agricultural productivity is variable and output remains far below potential performance (FAO, 2010).
Sorghum, millet and wheat are the major staple foods produced and are primarily consumed domestically. Crop cultivation is divided between a modern, market-oriented sector comprising mechanized, large-scale irrigated and rain-fed farming (mainly in central Sudan), and small-scale farming following traditional practices, which is carried out in parts of the country where rainfall or other water sources allow for cultivation.

The main constraints facing the agriculture sector are: weakness or lack of infrastructure, heavy dependence on rain, Low productivity, poor services available in input and output markets, drought, desertification and environmental degradation, external debt, which drains the country's resources, and social and political instability (Elsheikh, 2001; Ministry of Finance and National Economy, 2009).

The unfavorable climatic conditions, and associated challenges for crop and livestock production, worsen food insecurity in most states, stretching the limits of communities' coping mechanisms. The current low levels of production are further worsening the food security status of affected communities in North Sudan (FAO, 2010).

In order to reverse the decline and improve the country's economic situation, the government of Sudan launched an economic recovery programme in the mid-eighties with a view to ensuring sustained growth by moderating monetary expansion. The international donor community was approached for assistance in preventing a further decline of agriculture and in reviving the productive capacity of the sector through a series of rehabilitation measures targeting the irrigated sub-sector.

These loans were used primarily for importing crop inputs, spares and replacement machinery and also included measures aimed at facilitating policy and institutional reforms. Although the initial two Agricultural Rehabilitation Programmes had been reasonably successful, the country still suffered from macro-economic difficulties since reforms implemented had yet to be fully felt throughout the agricultural sector. The government of Sudan therefore requested the donor community to continue funding the program. These efforts were intended to create a framework which is conducive to greater efficiency and long-term growth through introduction of more realistic producer prices, reduction of state intervention in production and marketing, and rationalization of resource allocation (African Development Bank, 1996).

Historically, the year 1990 distinguishes two periods with respect to economic policies. Intensive government intervention in the production and marketing processes was dominant before that date, with few structural adjustment policies that were enacted as a result of the Structural Adjustment Programs of the IMF (Arab Organization for Agricultural Development, 1994). In 1992 the government has declared a major policy shift towards market-oriented economy and intensive liberalization of the economy from governmental intervention.

Recently, the Sudan has taken a new and strategic direction to support agriculture. This new direction is manifest in the five years Revival Agricultural Program (ARP) launched in 2008. The main focus of the program is to increase the efficiency of agricultural sector through invited private sector involvement and improving technology development and transfer among the farmers.

The agricultural sector in the Sudan is characterized by low productivity; (as proved by many studies below); in spite of availability of virgin natural resources, mainly fertile land and water. This is due, mainly, to the limited technology development and transfer, as well as the poor management of resources. Thus, improving agricultural efficiency is vital in Sudan if its rapidly increasing population is to be provided with adequate food, employment, and a better standard of living. Moreover there have been many changes in reducing trade barriers to conform to the requirements of the World Trade Organization (WTO) conditions since the application of Sudan to access the organization in late 1990s. The WTO concessions to the LDCs (green box) would lead to better research and technology transfer resulting in improving efficiency of crop production in Sudan. This will allow country to produce more food at lower cost, improve nutrition and welfare, and release resources to other sectors.

Therefore this study attempts to assess the impact of improving agricultural efficiency on Sudan economy. It focuses on the effect of improving the efficiency of Sesame, Sorghum, Cotton, Wheat and other agricultural commodities[1] on macroeconomic (GDP, balance of trade, private consumption and investment) and sectoral variables (import, export and output).

LITERATURE REVIEW

Thurlow and Seventer (2002) used the International Food Policy Research Institute (IFPRI) Computable General Equilibrium (CGE) model to simulate the economy wide impact of improvement in total factor productivity by 1% in South Africa agricultural sector. The model has been based on 1998 Social Accounting Matrix (SAM) for South Africa and the results indicate that an increase in total factor productivity has been growth enhancing.

Many studies evaluated the sectoral agricultural efficiency in Sudan. Elbushra (2007) used the IFPRI CGE model based on Sudan SAM for year 2000 to assess the

[1] It includes all agricultural activities other than sesame, sorghum, cotton and wheat

impact of improving agriculture productivity on Sudan economy. The study revealed that the industrial sector had played a key role in determining total domestic output level. At the same time, the model results indicated that agricultural sector was still the determining sector if its efficiency was improved. Moreover the results indicated that improving agricultural efficiency would lead to further positive effect of macroeconomic policies (tariff and taxies and exchange rate policies) and it offsets the negative effect of international price increase.

Siddig (2009) applied IFPRI CGE and Global Trade Analysis Project (GTAP) CGE model for Sudan economy. The study revealed that improving agriculture sector efficiency would improve GDP, private income and consumption, government income, foreign trade, and the trade balance. Moreover, improved agricultural efficiency means that economy's ability to bear external shocks will improve.

El Agab (2008), FadAllah (2010) and Albashir (2010) used stochastic frontier econometric models to estimate the technical efficiency of producing wheat in Gezira scheme and to determine the main factors behind the inefficiency. Their results revealed that the mean technical efficiency of wheat production had been ranging between 63 and 73%. This is in line to the global study of Trueblood and Coggins (2001) findings that estimated agricultural technical efficiency of Sudan to be about 67%. This implies that farmers can increase their output through better management of available scarce resources. The results also show that gender, marital status, education level and land tenure are significant factors in explaining the technical inefficiency in agriculture in Sudan.

Literature shows that agricultural efficiency in Sudan is low, for example Telleri and Hassan (2011) studied the diverse performances of the agricultural sectors of the 12 countries using the Malmquist Index. They revealed that the most agricultural productive countries were Turkey, Algeria, Tunisia and Jordan, followed by Morocco, Egypt, Syria and Pakistan. Finally, the agricultural sectors of Iran, Sudan, Yemen and Ethiopia were, in comparison, the least productive ones. The implication of this study is that national and international organizations need to increase their efforts to improve the performance of the agricultural sector in the least productive countries. This requires increased investment in agricultural research, improved infrastructure and supporting policies. Without such action, the livelihoods of the rural people and competitiveness of their agricultural sectors will remain marginal.

RESEARCH METHODOLOGY

One of the main tools of tracing the anticipated policy impacts is the use of econometric modelling. The study uses the standard CGE model developed by IFPRI to achieve its objectives. It is structured on the tradition of trade-focused CGE models of developing countries described in Dervis de Melo, and Robinson (1982). This model has been applied to a large number of countries, including Tanzania, Uganda, Zambia, Zimbabwe, Brazil, Chile, Egypt, Malawi, Mexico, Mozambique, South Africa, and Swaziland (Löfgren et al., 2002).

CGE model is an economy-wide model that solves general equilibrium markets simultaneously. They are applied to policy analysis linking different producing sectors and micro and macro levels together. The model is a set of simultaneous nonlinear equations defining the behaviour of different actors (Appendix 1). Production is carried out by activities that assumed to maximize profits subject to their technology. Recently the constant elasticity of substitution (CES) production functions are more used in applied CGE model than Cobb-Douglas(C-D), as it does not impose any prior restriction on the value of elasticity of substitution (σ) between factors where the C-D imposed a unitary σ. So the activity level is a CES function of value added and aggregate intermediate input use. The value added function is also a CES function of disaggregated factor quantities. Activities demand factors at the point where the marginal cost of each factor is equal to the marginal revenue product.

The model includes a set of constraints. These constraints cover markets (for factors and commodities), balances for saving-investment, government, and the rest of the world accounts. The macro constraints (model closures) are specified as follows: in the factor market balance, all demand variables are flexible while the supply variables are fixed, whereas the factor wage is the equilibrating variable. In the government balance, the government savings is flexible while all tax rates are fixed. Regarding the current account balance, foreign savings is fixed and the real exchange rate is the equilibrating variable. For the saving- investment balance, investment is fixed while saving is a flexible variable (investment-driven model).

Social Accounting Matrix (SAM) serves as database for general equilibrium modelling**.** In the SAM, rows represent receipts, while columns represent expenditures. Hence, the sum of a row and that of a column provides the total receipts and the total payments by a given account, respectively. In the tradition of double entry accounting, the sum of each row must equal the sum of its corresponding column (Siddiqi and Salem, 2006). In this study Sudan SAM for year 2004 developed by Elshiekh et al. (2011) is used as the core database for the CGE model (Table 1). Year 2004 was chosen as a base year due to availability of data required in disaggregated form to serve the objectives of the research.

The activity and commodity accounts are disaggregated into agriculture, industry and service accounts. The agriculture account is further

Table 1. Sudan social accounting matrix for year 2004 (SDG million).

Expenses	Receipts	Prod. Factor		Current acc		Capital acc		Agric activity					Indust. Act.	Service act.
		lab	Cap	hh	gov	S-I	Dstk	Asesa	asorg	acott	awhea	aother		
Prod. factor	Lab							88.9	140.2	23.7	20.2	3168.3	1656.4	12683.9
	Cap							503.6	794.7	134.1	114.7	17957.8	8466.9	19502.4
current acc.	Hh	17780.5	41392.4		2669.7									
	Gov		6081.8											
capital acc.	S-I			9737.0	1222.3									
	Dstk					1845.0								
Agric. act.	Asesa													
	Asorg													
	Acott													
	Awhea													
	Aother													
	Aind													
	Aser													
Agric. comm	Csesa			175.7	0.6		3.5	95.4	4.6				108.4	114.0
	Csorg			471.1	1.6		9.3		135.3			25.9	21.7	681.6
	Ccott			14.4	0.0		0.3		0.1	0.3	0.0		4.3	21.7
	Cwhea			322.1	1.1	0.0	6.4		2.7		22.7		158.0	403.2
	Cother			11064.7	697.9	105.5	1676.5					1839.0	3924.2	6099.2
Industry com				4450.5	119.5	3635.9	68.3	6.4	1.4	1.4	2.7	259.4	2138.9	3383.8
Service comm.				35554.1	4916.2	7483.2	80.8	183.9	195.0	78.4	43.0	2246.2	4059.0	7444.1
Taxes and tariff	Ytax			760.7										
	Atax							42.0	44.6	30.6	15.0	12.8	990.1	414.7
	Tar													
	Vtax							34.0	34.0	9.8	8.3	192.1	159.9	289.6
Rest of the world acc		1.1			679.3									
Total		17781.5	47474.2	62550.3	10308.2	13069.6	1845.0	954.2	1352.5	278.2	226.7	25701.5	21687.9	51038.3

Table 1. continued.

Expenses	Receipts	agic commodity					Industry Comm.	Service	Taxes and tariffs				Rest of world	Total
		csesa	csorg	ccott	cwhea	cother			ytax	atax	tar	vtax		
Prod. factor	lab													17781.5
	cap													47474.2

Table 1. continued.

current acc.	hh												707.8	62550.3
	gov								760.7	1549.8	1188.0	727.8		10308.2
capital ac.	S-I												2110.4	13069.6
	DSTK													1845.0
Agic. act.	asesa	954.2												954.2
	asorg		1352.5											1352.5
	acott			278.2										278.2
	awhea				226.7									226.7
	aother					25701.5								25701.5
Industry act.							21687.9							21687.9
Sevice act.								51038.3						51038.3
Agic. comm	csesa												451.9	954.2
	csorg												6.0	1352.5
	ccott												237.2	278.2
	cwhea													916.2
	cother												814.9	26221.8
Industry comm.													8250.4	22318.5
Sevice comm.													108.6	62392.6
Taxes and tariff	ytax													760.7
	atax													1549.8
	tar				19.9	11.2	66.9	1090.0						1188.0
	vtax													727.8
Rest of world acc.					669.7	509.1	563.6	10264.3						12687.1
Total		954.2	1352.5	278.2	916.2	26221.8	22318.5	62392.6	760.7	1549.8	1188.0	727.8	12687.1	

Source: Authors calculation.

disaggregated into Sesame, Sorghum, Cotton, Wheat and other agriculture accounts. This disaggregation is based on the relative importance of these commodities to the Sudanese economy (export, imports and food security issues).

The factor of production account is disaggregated into labour and capital accounts. The saving- investment account is disaggregated into fixed capital formation and change in stocks accounts. Lastly, taxes and tariffs are disaggregating into income tax, activity tax, import tariff, and value added tax accounts. Thus, the model provides detailed description of the Sudanese economy, with special emphasis on agricultural sector. The data sources are Central Bureau of Statistic, Central Bank of Sudan, Sudan Customs Authority, Ministry of Agriculture and Forestry, and Ministry of Finance and National Economy.

Most of the model's parameters are set endogenously in a manner that assures the base solution would exactly reproduce the values of SAM (calibration process). Elasticities are set exogenously for the remaining parameters. The CGE model is implemented using GAMS software that computes both equilibrium prices and quantities.

Different simulations have been based on the ARP focused objectives to determine the percentage change of the values of the endogenous variables, compared to those of the base-year. These simulations (Table 2) are done by increasing the efficiency parameter for both labour and capital of the value added function of the disaggregated agricultural sector by 5%.

Table 2. Scenario Codes.

Scenario codes	Scenarios
Eff- ses	5% increase in the production efficiency parameter of sesame
Eff-sor	5% increase in the production efficiency parameter of sorghum
Eff-cot	5% increase in the production efficiency parameter of cotton
Eff-whe	5% increase in the production efficiency parameter of wheat
Eff-oth	5% increase in the production efficiency parameter of other agricultural commodities
Eff-agg	5% increase in the production efficiency parameter of the aggregate agricultural sector

Source: Authors' Design.

Table 3. Impact of Improving Agricultural Efficiency on the Level of Sectoral Domestic Output.

Variables	Base value (10 Billion SD)	Percentage change from the base					
		Eff-ses	Eff-sor	Eff-cot	Eff-whe	Eff-oth	Eff-agg
Sesame	9.54	5.524	-0.001	-0.020	-0.008	-0.307	5.158
Sorghum	13.53	0.011	2.762	0.003	0.003	0.384	3.159
Cotton	2.78	-0.070	-0.003	5.926	-0.010	-0.417	5.393
Wheat	2.27	-0.029	0.008	-0.011	4.116	-0.015	4.074
Other agric	257.01	-0.006	0.005	-0.002	0.000	3.718	3.712
Industry	216.88	-0.061	0.001	-0.024	-0.005	0.302	0.217
Service	510.38	0.014	0.055	0.005	0.005	0.677	0.757
Total	1012.39	0.044	0.066	0.013	0.011	1.351	1.486

Source: Model results.

It worth mentioning that improving agricultural efficiency in Sudan by large margin is difficult to attain in the short run and hence the 5% was assumed and chosen.

RESULTS AND DISCUSSION

The model results (Table 3) reveals that improving the efficiency of each agricultural commodity alone would increase its own output reflecting in increasing the total output. However, the expected increases in output would generate different mixed changes on the other commodities. For example the expected increase in output of sesame was associated with an increase in sorghum and other agriculture outputs, while that of cotton was associated with an increase in sorghum output only. Similarly, the expected increase in other agriculture would be accompanied by an increase in sorghum output only. The effect of the expected increase in sorghum output was associated with an increased output of wheat and other agriculture, while the effect of increase in wheat would result in an increase in quantity of sorghum only. From these results it could be concluded that improving the efficiency of a commodity would increase its own output and that of its competitive ones as more resources will be released from efficiency aspect.

Improving the aggregate efficiency of all crops together (Eff-agg) would increase the output level of each one resulting in increasing the aggregate output level (by 1.48%). For example sesame harvest being a delicate process with high losses would generate extra output compared to other crops if its efficiency is improved.

The model results show that improving crop efficiency would result in reducing its import due to increase in its output level. This is true for both wheat and other agricultural crop as shown in Table (4). On the other hand the effect of improved efficiency of each agricultural commodity (Eff-ses, Eff-sor, Eff-cot) would increase imports of wheat and other agriculture. It worth mentioning that only increasing efficiency of wheat or sorghum, would lead to decrease in total imports. This is expected as wheat is the major import agricultural commodity and sorghum is its main substitute crop in Sudan.

In case of wheat, the effect of improving the efficiency of the aggregate agricultural sector (Eff-agg) would reduce its output and increase its imports. This would supplement domestic wheat production and sorghum consumption deficit due to its increased exports (Table 5).

The model results indicates that improving the efficiency of any agricultural commodity would increase its respective export and reduce exports of the other commodities as shown in Table 5. The respective increase in export is due to increase in its domestic output level (Table 3). It is clear that improvement of the aggregate efficiency of agricultural sector ((Eff-agg),

Table 4. Impact of improving agricultural efficiency on the level of sectoral imports.

Variables	Base value (10 Billion SD)	Percentage change from the base					
		Eff-ses	Eff-sor	Eff-cot	Eff-whe	Eff-oth	Eff-agg
Sesame	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sorghum	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cotton	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wheat	6.895	0.069	0.044	0.024	-0.817	1.062	0.374
Other agric	5.203	0.192	0.047	0.067	0.030	-3.428	-3.113
Industry	6.306	0.115	0.029	0.041	0.017	1.007	1.207
Service	113.543	0.200	-0.012	0.073	0.026	1.458	1.743
Total	131.947	0.189	-0.005	0.069	-0.018	1.223	1.454

Source: Model results.

Table 5. Impact of improving agricultural efficiency on the level of sectoral exports.

Variables	Base value (10 Billion SD)	Percentage change from the base					
		Eff-ses	Eff-sor	Eff-cot	Eff-whe	Eff-oth	Eff-agg
Sesame	4.519	9.631	-0.042	-0.049	-0.021	-1.218	8.256
Sorghum	0.060	-0.530	31.56	-0.195	-0.081	-5.619	23.38
Cotton	2.372	-0.089	-0.009	6.835	-0.013	-0.621	6.066
Wheat	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other agric	8.149	-0.448	-0.088	-0.158	-0.068	21.46	20.58
Industry	82.504	-0.200	-0.022	-0.076	-0.022	-0.257	-0.566
Service	1.086	-0.448	0.223	-0.164	-0.045	-1.238	-1.647
Total	98.690	0.230	-0.006	0.084	-0.026	1.469	1.746

Source: Model results.

Table 6. Impact of improving agricultural efficiency on macroeconomic variables.

Variables	Base value (10 Billion SD)	Percentage change from the base					
		Eff-ses	Eff-sor	Eff-cot	Eff-whe	Eff-oth	Eff-agg
Private consumption	520.530	0.067	0.084	0.021	0.014	1.967	2.162
Investment	130.700	0.011	0.112	0.000	0.010	-2.164	-2.035
GDP	687.210	0.056	0.086	0.017	0.013	1.630	1.810
Balance of Trade	-33.258	0.069	-0.003	0.025	0.004	0.493	0.587

Source: Model results.

would increase their output level reflecting in increasing their export and total export, with notable increase in sorghum export as it starts from a small base value.

The model results (Table 6) reveals that improvement of agricultural efficiency of each commodity would improve the GDP, private consumption and investment and it deteriorates the balance of trade deterioration (except in sorghum case). The deterioration in the balance of trade is achieved as the increase in total export is not enough to cover the increasing imports (Tables 4 and 5).

The overall effect of aggregate efficiency improvement of agricultural sector (Eff-agg) would improve private consumption and would decline the investment and balance of trade, with a net result of GDP improvement.

RECOMMENDATIONS

Crop productivity in Sudan is proved to be low and declining due to poor technology development and transfer, poor management of agricultural services and resources. The model simulations results depict considerable increases in agricultural output with subsequent improvement on the macroeconomic indicators due to 5% in agricultural efficiency. Therefore it is recommended to improve the efficiency of crop production in Sudan in an integrated manner.

Sudan import of wheat is growing steadily, despite the exerted effort of the government to expand wheat production in the country. The model findings show that improving the efficiency of wheat production will reduce its imports by 0.817%, with negative implication on export on the rest agricultural commodities. Therefore it is recommended to reduce the extra investment on wheat production.

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APPENDIX 1: Mathematical model statement

The model equations are classified into four blocks: prices, production and trade block, institutions block and system constraint block.

Prices block

$$PM_c = pwm_c * (1 + tm_c) * EXR$$

$$PE_c = pwm_c * (1 - te_c) * EXR$$

$$PX_c = (PDS_c * QD_c + PE_c * QE_c) / QX_c$$

$$PINTA_a = \sum PQ_c * ica_{c\,a}$$

$$CPI = \sum PQ_c * cwts_c$$

Production and trade block

$$QA_a = \alpha_a^a * (\delta_a^a * QVA_a^{-\rho_a^a} + (1 - \delta_a^a) * QINTA_a^{-\rho_a^a})^{-1/\rho_a^a}$$

For the CES function

$$\sigma = 1/1 + \rho$$

$$WF_F * WFDIST_{f\,a} = PVA_a (1 - tva_a) * QVA_a * \sum_{f \in F} \delta_{f\,a}^{va} * QF_{fa}^{-\rho_a^{va}})^{-1} * \delta_{fa}^{va} * QF_{f\,a}^{-p_a^{va} - 1}$$

$$QQ_c = \alpha_c^q * (\delta_c^q * QM_c^{-p_c^q} + (1 - \delta_c^q) * QD_C^{-\rho_c^q})^{-1/\rho_c^q}$$

$$QM_c \div QD_c = \left(PDD_c / PM_c * (\delta_c^q / 1 - \delta_c^q)\right)^{1/1 + p_c^q}$$

$$QX_c = \alpha_c^t * (\delta_c^t * QE_c^{p_c^T} + (1 - \delta_c^t) * QD_C^{-\rho_c^t})^{1/\rho_c^t}$$

$$QE_c \div QD_c = \left(PE_c / PDS_c * (1 - \delta_c^t / \delta_c^t)\right)^{1/p_c^t - 1}$$

For CET function

$$\Omega = 1/(1 + \rho)$$

Institutional block

$$YF_f = \sum WF_f * WFDIST_{f\,a} * QF_{f\,a}$$

$$YIF_{i\,f} = shif_{i\,f} * ((1 - tf_f) * YF_f - trnsfr_{row\,f} * EXR)$$

$$YI_h = \sum YIF_{h\,\mathrm{f}} + trnsf_{h\,\mathrm{gov}} + trnsfr_{h\,\mathrm{row}} * EXR$$

$$EH_h = (1 - \sum shii_{ih}) * (1 - MPS_i) * (1 - TINS_h) * YI_h$$

$$YG = \sum TINS_i * YI_i + \sum tf_f * YF_f + \sum tva_a * PVA_a * QVA_a + \sum ta_a * PA_a * QA_a +$$
$$\sum tm_c * pwm_c * QM_c * EXR + \sum tq_a * PQ_a * QQ_a + \sum YIF_{gov\mathrm{f}} + transf_{gov\mathrm{row}} * EXR$$

$$EG = \sum PQ_c * QG_c + \sum trnsfr_{i\,\mathrm{gov}} + GSAV$$

System constraint block (Model closures)

$$\sum QF_{f\,\mathrm{a}} = QFS_f$$

$$\sum pwm_c * QM_c + \sum trnsfr_{row\mathrm{f}} = pwe_c * QE_c + \sum trnsfr_{i\,\mathrm{row}} + FSAV$$

$$S = I$$

$$S = \sum S_i + S_g + S_f * EXR$$

Thus

$$\sum MPS_i * (1 - TINS_i) * YI_i + GSAV + EXR * FSAV = \sum PQ_c * QINV_c + \sum PQ_c * qdst_c$$

Where:

ITEM	Name of the item
ta(A)	rate of tax on producer gross output value
te(C)	rate of tax on exports
tf(F)	rate of direct tax on factors
tm(C)	rate of import tariff
tq(C)	rate of sales tax
tva(A)	rate of value-added tax
EG	government expenditures
QQ_c	Quantity of exports
EH_h	consumption spending for household
$QF_{f\,\mathrm{a}}$	Quantity demanded of factor f from activity a
EXR	exchange rate (LCU per unit of FCU)
QG	government consumption demand for commodity
QH_{ch}	Quantity consumed of commodity c by household h
GSAV	government savings
$QINT_{ac}$	Quantity of commodity c as intermediate input to activity a
$QINV_c$	Quantity of investment demand for commodity
MPS_i	marginal propensity to save for household
QM_c	Quantity of imports of commodity
PA_a	Activity price (unit gross revenue)

QQ_c	Quantity of goods supplied to domestic market (composite supply)
PDD_c	Demand price for commodity produced and sold domestically
PDS_c	supply price for commodity produced and sold domestically
QX_c	aggregated quantity of domestic output of commodity
PE_c	export world price (domestic currency)
$QXAC_{ac}$	Quantity of output of commodity c from activity a
PM_c	import world price (domestic currency)
TABS	total nominal absorption
PQ_c	composite commodity price
$trnsf_{h\,\mathrm{gov}}$	transfers from domestic government institution to household institution
$trnsf_{h\,\mathrm{rov}}$	transfers from domestic rest of the world to household institution
PVA_a	Value-added price
WF_F	economy-wide factor wage
PX_c	aggregate producer price for commodity
YIF_{if}	Transfer of income to domestic institution I from factor f
$PXAC_{ac}$	producer price of commodity c for activity a
YG	government revenue
QA_a	Quantity (level) of activity *a*
YI	Income of domestic non-government institution
QD_c	Quantity sold domestically of domestic output
FSAV	foreign savings (FCU)
$TINS_h$	direct tax rate for domestic institution i or factor f
$WFDIST_{fa}$	wage distortion factor for factor f in activity a
IADJ	investment adjustment factor
pwm_c	World price of import (in hard currency)
pwe_c	World price of export (in hard currency)