Economic Policy Research Center

CGE ANALYSIS OF REGIONAL TRADE FOR GEORGIA

Principal interest of the study is to investigate effects of free trade policies on Georgian economy. We estimate fundamental gains from open trade policies in terms of gains from better resource allocation due to liberalized trade and gains from improved external market access. Also, we evaluate industry level impacts of trade policy scenarios as well as decompose total gains from improved trade position of Georgia among partner countries. In the study we assume fiscally neutral behavior of government and in all scenarios we experiment with replacement instruments for lost tariff revenues. For proposed analysis we build CGE model of Georgian economy. This is because we are interested in impacts of trade and tax policies on the entire economy, rather than on a single industry.

Three main trade partners of Georgia include Russia, Turkey and Azerbaijan and geographically Georgia is located at the heart of this triangle, giving good climate to country for benefiting from trade flows among its neighbors. Georgia already can be characterized as rather open economy with trade volume representing high percentage of GDP and in spite of domestic lobbying government consistently has expressed its determination to further integrate economy in external world. We model impacts of trade liberalization on a Georgian economy. We do it with a particular focus to explore country's geopolitical advantages in respect of being a neighbor of two larger economies, which are Russia and Turkey. Abolishment of trade barriers will open the economy, give positive stimulus to macroeconomic health and will lead to increased trade flows, that will alter the structure of economy. Specifically, we hypothesize that such policy will increase portion of trade flows between Russia and Turkey that go through Georgia, and on a sectoral level this will expand transportation services in particular. We hypothesize that freer access to Georgian markets will increase imports in Energy and Gas sector, which constitute high proportion of domestic consumption, as well as in agriculture and several other highly protected sectors. We'll give model estimates by how much domestic production changes.

Our model is suitable tool to assess efficiency gains that are brought by abolishment of relative protection and therefore by improved resource allocation. We'll decompose total welfare gains from our experiment into gains from better economy structure and gains from improved external access [1; 3]. This is done to test which fundamental gain from trade liberalization offers more substantive improvement for Georgia. We will also examine sources of these gains that accumulate due to tariff abolishment.

Tariff reduction will cut revenues for government, which is constrained not to expand its fiscal deficit that could deteriorate macroeconomic situation. We calculated our model estimates of which revenue source may be the best policy for rising lost tariff revenues. In terms of marginal excess burden, which describes efficiency losses from marginal increases in government revenues [9], the value added tax seems to be the reasonable option. Our model estimates of MEB of vat is around 9%, which is lower compared to that of other tax sources (for instance, MEB of labor tax is appr. 15%). We shall conduct our policy scenarios simultaneously experimenting with various replacement mechanisms for lost tariff revenues.

Literature Survey

Starting point for our study in CGE literature is given in Rutherford and Paltsev [9]. Authors elaborate on the efficiency of indirect tax instruments in Russia in terms of their marginal excess burden. The work mainly serves pedagogic purposes and it gives basics of model construction in CGE, use of functional forms, computational syntax, construction of SAM and sensitivity analysis. Because of pedagogic nature of the work, authors do not concentrate on tax policy scenarios, but only analyze relative efficiency of government revenue sources and the distortions they cause.

Harrison, Rutherford and Tarr [1] give a model of free trade agreement between Turkey and EU in non-agricultural sectors. Same time, common external tariffs of EU are incorporated on Turkey's imports against EU most favored nations. The study gives decomposition of total welfare gains into gains that accrue from market access to EU and third countries. It is shown that Turkey gains most from improved market access to third countries. Estimates come from static model, but in line with what is asserted in literature, the authors show in later papers that gains from dynamic steady state analysis are several times larger than static gains calculated with the model.

In recent years there have been several studies that analyze CIS economies in general equilibrium setting. In most cases studies concentrate on Russian economy. Alekseev [4] and Alekseev, Tourdyeva, Yudaeva [6] study effects that EU enlargement due to accession of Central and Eastern European countries will have on Russian production sectors and foreign trade. Abolishment of trade barriers between the EU and the candidate countries will promote the trade creation between the EU and the CEEC's and with respect to Russia it may cause a trade diversion. In this light of trade creation and trade diversion the authors address the question of Russian production diversification and foreign trade position with standard GTAP multiregional model. The point, on which the study does not elaborate, however, is that non tariff barriers, which are yet notable source of Russian foreign trade distortions are not addressed. Alekseev and other authors too, Vincent Aussilloux and Michael Pajot [7] who concentrate not only on Russia, but on former Soviet Union region as a whole, argue that EU enlargement will lead to more efficient production within the Union and, therefore improved competition on export markets allow candidate countries to capture market shares in industries such as energy and metallurgy, which suffer most for CIS as a result of EU enlargement.

Some authors Sulamaa, Widgren [8] estimate impacts of possible EU-CIS Free Trade Agreement. Although at this stage full membership is not an option for CIS countries, it seems that open attitude in foreign policy towards CIS and therefore, FTA agreement is evident future solution that EU could take to avoid marginalization of non EU member eastern states. Authors estimate three basic scenarios, which are: simple FTA between EU and CIS, decreased market segmentation between imported and domestic products and improved productivity in CIS states. Study concludes that although beneficial for the CIS countries, EU-CIS FTA does not seem to be beneficial neither for the EU nor for the rest of the world. Same time, gains for CIS states mainly stem not from FTA itself, but from increased substitution effect and especially from improved productivity.

There are works that model Russia's accession to WTO. Two papers, on which we rely methodologically are the papers by Jensen, Rutherford and Tarr [3] and by Alekseev, Tourdyeva, Yudaeva [6]. In Jensen, Rutherford and Tarr it is shown that in comparative static model with CRS, Russia gains more from tariff reduction, rather than from improved market access, the fact that is generally argued in trade literature. The study is innovative in the sense that technology impact on productivity growth in services sector are modeled with increasing returns to scale and it is shown that 70% of total gains from Russia's accession comes from liberalization of barriers

to FDI in services. When comparative steady state is considered, it is shown that Russia gains one forth of its GDP due to capital accumulation.
Combined tax and trade liberalization policy analysis with CGE is given in Konan and Maskus [10]. Authors give effects of single policy option, a well as of combined policy packets, on Egyptian economy. The main portion of the work is decomposition of joint policy effects into individual and interaction terms.

MODEL: Our model is a small open economy model with perfectly functioning markets which includes fourteen sectors of Georgian economy (list of industries is given below) and it differentiates external sector among four regions. The choice of the model is determined by the objectives of the study. That is, we are interested in trade and tax policy effects on the entire economy, rather than on a single industry, and computable general equilibrium is the most appropriate choice to simultaneously analyze country's trade position, welfare, macroeconomic changes, production in different industries and country's overall economic stance that is due to policy option which we simulate. We employ comparative static model, where time is allowed for the economy to adjust for a new equilibrium, but as opposed to comparative steady state, capital is fixed and this equilibrium does not represent long-run. So, there is significant simplification in the model, which underestimates gains from policies. Nevertheless, the comparative static is appropriate tool to estimate (i) reduction in relative protection, which implies more efficient resource allocation in sense of what is valued at external markets and (ii) improved external market access.
Our CGE model builds on the standard structure of Arrow-Debreu equilibrium. There is representative household, who owns primary factors and determines demand of final commodities to maximize welfare. Producers maximize profits constrained with production technology. Condition that demand is equated with supply determines prices in markets. Production is differentiated among regions and also between domestic good and what is produced abroad using Armington's assumption. Government collects taxes and tariffs and demands vector of goods and services. Finally, every market clears to arrive at a general equilibrium of economy. Model is calibrated in base-run equilibrium and counterfactual policy scenarios are analyzed based on calibrated parameters.
We use following formulation and the functional forms:
Production: Production is described with production function combining intermediate inputs X_{ij} and value-added Y_i. Given the prices of factor and intermediate inputs, producers operate to minimize costs subject to constraint: $Z_j = \min\{\frac{X_{ij}}{ax_{ij}}, \frac{Y_j(L_j, K_j)}{ay_j}\}$

Domestic output is produced for sales at domestic and external markets. Constant Elasticity of Transformation (CET) function describes transformation possibilities. Firms determine share of domestic goods and exports, given the prices, to maximize their profits subject to the constraint: $Z_j = \theta_j(\sum_r \xi e_{ir} E_{ir}^{\frac{1+\eta}{\eta}} + \xi d_i D_i^{\frac{1+\eta}{\eta}})^{\frac{\eta}{1+\eta}}, \quad r \in \{regions\}$ and η is elasticity of transformation. In the same manner, given the import and domestic prices, firms determine share of imports and domestic output in composite product. Substitution possibilities are represented with Constant Elasticity of Substitution (CES) functions $Q_j = \gamma_j(\sum_r \delta m_{ir} M_{ir}^{\frac{\sigma-1}{\sigma}} + \delta d_i D_i^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}$.

- **Consumption:** Consumption is described with household utility maximization, which is subject to constraint on income, which households receive from factor endowments. Utility is represented with Cobb-Douglas function $\sum_i \alpha_i \log X_i$, $\alpha_i \geq 0, \sum_i \alpha_i = 1$ and household preferences, prices and net income determine private demand functions.

- **Government:** Government collects variety of taxes on production, including value added tax, taxes on primary factor uses, excise taxes and import tariffs as well as direct taxes on households. Revenues are spent on goods and services purchases, which are determined according to product prices $X_i^g = \frac{\mu_i}{p_i}(T^d + \sum_j T_j + \sum_{jF} T_j^F + \sum_j T_j^m - S^g)$

The model is calibrated on a base-run equilibrium and syntax is written in GAMS to calculate policy simulated equilibriums of economy.

Detailed equations of CGE model are as follow:

Following sectors of Georgian economy are included in the model:

AGRICULTURE AND FORESTRY	TRANSPORTATION
MINING	COMMUNICATIONS
ENERGY AND GAS	FINANCIAL SERVICES
OTHER MANUFACTURING	REAL ESTATE SERVICES
CONSTRUCTION	EDUCATION
TRADE SERVICES	HEALTHCARE
HOTEL AND HOSPITALITY SERVICES	OTHER SERVICES

Behavior of agents is derived with Lagrangians according to respective optimization problems. The system includes following blocks: domestic production, domestic output transformation into domestic good and exports, Armington aggregation of domestic good and imports into composite good, government behavior, household behavior, BoP conditions and market clearing conditions. Export and import prices and capital flows are exogenously fixed in static small economy model and exchange rate adjusts to ensure that balance of payment condition is fulfilled.

The nested equations for production block are as follow: We use Cobb-Douglas function for composite factor formation and Leontief function for gross output formation combining value added and intermediate inputs. The simultaneous equations describing domestic production are derived from profit maximizing behavior of each production level agent and zero profit conditions.

$$Y_j = b_j \prod_h F_{hj}^{\beta_{hj}}, \quad \forall j$$

$$F_{hj} = \frac{\beta_{hj} p_j^y}{(1+\tau_{hj}) r_h} Y_j, \quad \forall h, j$$

$$X_{ij} = ax_{ij} Z_j, \quad \forall i, j$$

$$Y_j = ay_j Z_j, \quad \forall j$$

$$p_j^s = ay_j p_j^y + \sum_i ax_{ij} p_j^q \quad \forall j$$

The notations are as follow:

Y_j *Value added produced by j – th sector*

F_{hj} *Input of the h – th factor by j – th sector*

p_j^y *Price of the value added of the j – th sector*

r_h *Factor price*

π_j Profit of $j-th$ sector at the top stage production
Z_j Gross output of $j-th$ sector
X_{ij} Intermediate input of the $i-th$ sector demanded by $j-th$ sector
ax_{ij}, ay_j Coefficients of minimum requirement for unit of gross output
p_j^s Supply price of the $j-th$ sector
p_i^q Price of $i-th$ intermediate good

Armington assumption is used for treatment of domestic goods and exports. CET function gives decomposition of domestic output.

$$Z_i = \theta_i(\xi e_i E_i^{\phi_i} + \xi d_i D_i^{\phi_i})^{\frac{1}{\phi_i}}, \quad \forall i$$

Demand functions are:

$$E_i = \{\frac{p_i^s \xi e_i \theta_i^{\phi_i}}{p_i^e}\}^{1/1-\phi_i} Z_i$$

$$D_i = \{\frac{(1+\tau_i) p_i^s \xi d_i \theta_i^{\phi_i}}{p_i^d}\}^{1/1-\phi_i} Z_i, \ \forall i$$

Notations :
θ Productivity parameter of transformation function
$\xi e, \xi d$ Share parameters of transformation function, $\xi e + \xi d = 1, \quad \xi e, \xi d \geq 0$
ϕ Parameter related to elasticity of transformation, $\phi \geq 1$
D_i $I-th$ domestic good
p_i^d Price of $i-th$ domestic good

Similarly

$$Q_i = \gamma_i(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i})^{\frac{1}{\eta_i}}, \quad \forall i$$

$$M_i = \{\frac{p_i^q \delta m_i \gamma_i^{\eta_i}}{(1+\tau m_i) p_i^m}\}^{1/1-\eta_i} Q_i, \forall i$$

$$D_i = \{\frac{p_i^q \delta d_i \gamma_i^{\eta_i}}{p_i^d}\}^{1/1-\eta_i} Q_i, \quad \forall i$$

Notations :
Q_i Output of $i-th$ composite good
p_i^q Price of $i-th$ composite good
$\gamma, \delta m, \delta d$ Productivity and share parameters of CES function
η Parameter related to elasticity of substitution

Household demand function for each commodity is:

$$X_i^p = \frac{\alpha_i}{p_i^q}(\sum_h r_h FF_h - S - T^d) \quad \forall i,$$

X_i^p Household consumption of $i-th$ commodity
α Share parameters in household utility function, $(0 \leq \alpha_i \leq 1, \sum_i \alpha_i = 1)$

S Household saving

Balance of payment condition follows:

$$p_i^e = \varepsilon p_i^{We}, \quad \forall i$$

$$p_i^m = \varepsilon p_i^{Wm}, \quad \forall i$$

$$\sum_i p_i^{We} E_i + S^f = \sum_i p_i^{Wm} M_i$$

$Notations:$

p_i^m, p_i^e Import and export prices in local currency

p_i^{We}, p_i^{Wm} World prices in foreign currency terms (exogenous)

ε Exchange rate

S^f Current account deficit in foreign cuirrency

E_i Export volume of $i-th$ commodity

Government revenues and spending:

$$T_j = \tau_j p_j^s Z_j, \quad \forall j$$

$$T^d = \tau d \sum_h r_h FF_h,$$

$$T_i^m = \tau m_i p_i^m M_i, \quad \forall i$$

$$T_{hj}^f = \tau_{hj} r_h F_{hj}$$

$$X_i^g = \frac{\mu_i}{p_i^q}(T^d + \sum_j T_j + \sum_{hj} T_{hj}^f + \sum_j T_j^m - S^g), \quad \forall i$$

T_j $j-th$ commodity production tax revenue

τ_j Production tax rate

T^d Taxes on household

τd Direcxt tax rate

FF_h $h-th$ factor endowment

T_i^m Import tariff revenue from importing $i-th$ commodity

τm_i Import tax rate

M_i Import of $i-th$ commodity

X_i^g Public consumption of $j-th$ commodity

μ_i Share for consuming $j-th$ commodity, $(0 \le \mu_i \le 1, \sum_i \mu_i = 1)$

Finally, we conclude the model with market clearing conditions for commodity and factor markets and arrive at a general equilibrium of economy.

$$Q_i = \sum_j X_{ij} + X_i^p + X_i^g + X_i^v, \quad \forall i$$

$$\sum_j F_{hj} = FF_{h,} \quad \forall h$$

DATA: Core Input-Output model is constructed based on the Supply/Use data provided by the Department of Statistics of Georgia in SUT for the year 2001. The table includes information on fourteen sectors of Georgian economy.

Database COMEXT was used for obtaining data on Georgian trade with EU and Russian customs statistics data for Georgian trade with Russia. Data is then aggregated into the model sectors. Detailed data on trade flows between Georgia and Turkey and Georgia and other CIS countries come from Department of statistics of Georgia.

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Appendix: CGE Syntax In GAMS:

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*--------------------------------------------------
* GAMS program for CGE model of Georgian economy
*----------------------------------------------
option limcol=0, limrow=0;
$offsymxref offsymlist

* definition of sets for suffix-------------------------------
set u   SAM entry    /AGR, MAN, HPR, CTR, TRD, HTL, TRN, CMN, FNC, RST, PA, EDU,
HLT, COM, LAB, CAP, HOH, GOV, INV, IDT, TRF, SBS, EXT/
   i(u) sectors    /AGR, MAN, HPR, CTR, TRD, HTL, TRN, CMN, FNC, RST, PA, EDU, HLT,
COM/
   h(u) factors    /LAB, CAP/
   n(i) goods excluding Trade and Public Administration for determining utility /AGR, MAN,
HPR, CTR, HTL, TRN, CMN, FNC, RST, EDU, HLT, COM/;

alias (u,v), (i,j), (h,k);
*------------------------------------



* loading data------------------------------------
Table     SAM(u,v)           social accounting matrix
        AGR    MAN    HPR    CTR    TRD    HTL    TRN    CMN    FNC    RST    PA    EDU
AGR       187.8  327.6  482.7        4.3    13.7   0.6                      7      1
MAN       455.7  445.9  53.5   179.6  51.1   16     134    22.8   9.9    20.1   55.5   17.5
HPR
CTR      4.9    12.1         6.6    4.4    2.8    2.8    3.4         13.5         0.8
TRD      118.3  669    82.7
HTL      0.1    4           0.3    1.9    0.2    1.6    0.3    2.1    1.9    2.1    0.6
TRN      4      25.2         6.4    110.2  2.6    18.3   3.4    1.3    2.8    3      1.3
CMN      1      12.3         0.6    7      1.9    23     4.4    7.2    1.8    8.9    1.1
FNC      0.1    7.9          1.3    11.2   8      1.9    0.4    2.9    0.1    2.1    0.1
RST      7.3    18.2         2.1    18.8   5.8    21.8   4.2    2.8    3      6      10
PA            3.8         0.1    4.4    1.6    2      0.4    9      19.9         0.7
EDU                              0.1                                     0.2
HLT      0.6    0.2                 0.1    0.1    0.2                     3.6
COM      4.6    3            0.4    2.5    2.2    1.7    0.3    4.1    3.3    4.1    1.2
LAB      931    245    84     62     218    46     173    46     61     137    175    139
CAP      465.3  490    168    124    436    90.6   346.7  93.4   30.1   272.4  87.9   68.6
HOH
GOV
INV
IDT      7.7    321.7        20.5         4.7    18.3   7.8    4.8    8.9
TRF
SBS           -70
EXT      95.6   1815.9 0     0      0      0      0      0      0      0      0      0

+        HLT    COM    LAB    CAP    HOH    GOV    INV    IDT    TRF    SBS    EXT
AGR       2.5                        961.5       197.6                   97.7
MAN       104.4  45.6                 1668.1       494.3                   557.8
```

```
HPR                                 870.9                               0
CTR       1      0.4                  84.3         266.9                     0
TRD                                                                      0
HTL       0.5    1.4                  179.2                                 0
TRN       1.2    5.2                  379.4                                 181.6
CMN        2.7    13.9                  97.9                                 3.1
FNC       0.6    0.6                  63.2   34.8                            0
RST       1.8    6.3                  358.7  17.9                            0
PA       0.2    70.4                        242.7                         0
EDU                                  124.9  116.9                         0
HLT       1      0.2                  327.5  32.2                            0
COM       9.1    7.2                  217.9  25                               0
LAB       161    91
CAP       79.5   42
HOH                     2569    2794.5
GOV                                  265.7              397          -70
INV                                 -235.7 123.2                          1071.3
IDT      0.2    2.4
TRF
SBS
EXT       0      0
;
*------------------------------------------------

*loading initial values--------------------
Parameter     Xp0(i)  household consumption of i-th good
            F0(h,j) h-th factor input by j-th firm
            Y0(j) value added
            X0(i,j) intermediate input
            Z0(j) output of j-th good
            FF(k) k-th factor endowment by household

            Xg0(i) gov consumption
            Xv0(i) investment demand
            E0(i) exports
            M0(i) imports
            D0(i) domestic good
            Td0 direct tax by household
            Q0(i) armington's composite good
            S0 private saving by household
            Sg0 government saving
            Sf foreign saving in US dollars

            G0(i)   government subsidies

            pWe(i) export price in US dollars
            pWm(i) importprice in US dollars
            T0(j) indirect tax
            Tm0(j) import tariff

            tau(i) indirect tax rate
```

```
        taum(i) import tariff rate

;
T0(j)=SAM("IDT",j);
Tm0(j)=SAM("TRF",j);
Xp0(i)=SAM(i,"HOH");
F0(h,j)=SAM(h,j);
Y0(j)=sum(h,F0(h,j));
X0(i,j)=SAM(i,j);
G0(i)=SAM("SBS",i);
Z0(j)=Y0(j)+sum(i,X0(i,j))+G0(j);
FF(k)=SAM("HOH",k);
M0(i)=SAM("EXT",i);
tau(j)=T0(j)/Z0(j);
taum(j)=(Tm0(j)/M0(j))$(M0(j) ne 0);

Xg0(i)=SAM(i,"GOV");
Xv0(i)=SAM(i,"INV");
E0(i)=SAM(i,"EXT");

D0(i)=(1+tau(i))*Z0(i)-E0(i);
Td0=SAM("GOV","HOH");
Q0(i)=Xp0(i)+Xg0(i)+Xv0(i)+sum(j,X0(i,j));
S0=SAM("INV","HOH");
Sg0=SAM("INV","GOV");
Sf=SAM("INV","EXT");

pWe(i)=1;
pWm(i)=1;
  display Xp0, F0, Y0, Z0, X0, FF, Xg0, Xv0, E0, M0, D0, Td0, Q0, S0, Sg0, Sf, T0, Tm0,
tau,taum,G0;


*calibration------------------
Parameter
     eta(i)   substitution elasticity parameter
     phi(i)   transformaton elasticity parameter;
* CET and CES elasticies from GTAP database.

eta("AGR")=(2.2-1)/2.2;
eta("MAN")=(2.2-1)/2.2;
eta("HPR")=(2.2-1)/2.2;
eta("CTR")=(1.9-1)/1.9;
eta("TRD")=(1.9-1)/1.9;
eta("HTL")=(1.9-1)/1.9;
eta("TRN")=(1.9-1)/1.9;
eta("CMN")=(1.9-1)/1.9;
eta("FNC")=(1.9-1)/1.9;
eta("RST")=(1.9-1)/1.9;
eta("PA")=(1.9-1)/1.9;
eta("EDU")=(1.9-1)/1.9;
```

```
eta("HLT")=(1.9-1)/1.9;
eta("COM")=(1.9-1)/1.9;

phi("AGR")=(2.2+1)/2.2;
phi("MAN")=(2.2+1)/2.2;
phi("HPR")=(2.2+1)/2.2;
phi("CTR")=(1.9+1)/1.9;
phi("TRD")=(1.9+1)/1.9;
phi("HTL")=(1.9+1)/1.9;
phi("TRN")=(1.9+1)/1.9;
phi("CMN")=(1.9+1)/1.9;
phi("FNC")=(1.9+1)/1.9;
phi("RST")=(1.9+1)/1.9;
phi("PA")=(1.9+1)/1.9;
phi("EDU")=(1.9+1)/1.9;
phi("HLT")=(1.9+1)/1.9;
phi("COM")=(1.9+1)/1.9;

Parameter
        alpha(i) share parameter in utility function of household
        beta(h,j) share parameter in production function
        b(j) scale parameter in production function
        ax(i,j) intermediate input requirement coefficient
        ay(j) value added input requiement coefficient
        mu(i) gov consumption share
        lambda(i) investment demand share
        deltam(i) share parameter in armington function
        deltad(i) share parameter in armington function
        gamma(i) scale parameter in armington function
        xid(i)  share parameter in transformatin function
        xie(i) share parameter in transformation function
        theta(i) scale parameter in transformation function
        ss average propensity to save for household
        ssg average propensity for gov saving
        taud direct tax rate on household
        omega(i)   average propensity for gov subsidies

;
alpha(i)=Xp0(i)/sum(j,Xp0(j));
beta(h,j)=F0(h,j)/sum(k,F0(k,j));
b(j)=Y0(j)/prod(h,F0(h,j)**beta(h,j));

ax(i,j)=X0(i,j)/Z0(j);
ay(j)=Y0(j)/Z0(j);
mu(i)=Xg0(i)/sum(j,Xg0(j));
lambda(i)=Xv0(i)/sum(j,Xv0(j));
deltam(i)=(1+taum(i))*M0(i)**(1-eta(i))/((1+taum(i))*M0(i)**(1-eta(i))+D0(i)**(1-eta(i)));
deltad(i)=D0(i)**(1-eta(i))/((1+taum(i))*M0(i)**(1-eta(i))+D0(i)**(1-eta(i)));
gamma(i)=Q0(i)/(deltam(i)*M0(i)**eta(i)+deltad(i)*D0(i)**eta(i))**(1/eta(i));
xie(i)=(E0(i)**(1-phi(i)))$(E0(i) ne 0)/((E0(i)**(1-phi(i)))$(E0(i) ne 0)+D0(i)**(1-phi(i)));
xid(i)=D0(i)**(1-phi(i))/((E0(i)**(1-phi(i)))$(E0(i) ne 0)+D0(i)**(1-phi(i)));
```

```
theta(i)=Z0(i)/(xie(i)*E0(i)**phi(i)+xid(i)*D0(i)**phi(i))**(1/phi(i));

ss=S0/sum(h,FF(h));
ssg=Sg0/(Td0+sum(i,Tm0(i))+sum(j,T0(j)));
taud=Td0/sum(h,FF(h));
omega(i)=G0(i)/(Td0+sum(j,Tm0(j))+sum(j,T0(j)));

        display                     alpha,beta,b,                     ax,ay,mu,
lambda,deltam,deltad,gamma,xie,xid,theta,ss,ssg,taud,omega;
*----------------------------------

*defining model system-------------
Variable      Xp(i) household consumption of i-th good
          F(h,j) h-th factor input by j-th firm
          X(i,j) intermediate input
          Y(j) value added
          Z(j) output of j-th good

          Xg(i) gov consumption
          Xv(i) investment demand
          E(i) exports
          M(i) imports
          Q(i) armington's composite good
          D(i) domestic good

          pd(i) i-th domestic good price
          ps(i) supply price of i-th good
          pq(i) armington's composite good price

          py(i) value added price
          pm(i) import price in local currency
          pe(i) export price in local curency

          r(h) h-th factor price
          epsilon exchange rate

          Td   direct tax by household
          S   household saving
          Sg  government saving

          T(i) indirect tax
          Tm(i) import tariff
          G(i) government subsidies

          UU utility
;

Equation      eqXp(i) household demand function
          eqpy(j) value added aggregation function
          eqX(i,j) intermediate demand function
          eqY(j) value added demand function
```

```
        eqF(h,j) factor demand function
        eqps(j) unit cost function
        eqTd    direct tax revenue function
        eqXg(i) gov demand function
        eqXv(i) investment demand function
        eqpe(i) world exprot price equation
        eqpm(i) world import price equation
        eqepsilon balance of payments
        eqpqs(i) armington function
        eqM(i) import demand function
        eqD(i) domestic good demand function
        eqpqd(i) market clearing condition of composite good
        eqpz(i) transformation function
        eqr(h) factor market clearing
        eqDs(i) domestic good supply function
        eqE(i) export supply function
        eqS    private saving function
        eqSg  gov saving function
        eqT(j) indirect tax revenue function
        eqTm(i) import tariff revenue function
        eqG(i) government subsidy supply


        obj utility function
;

*[household consumption]--
eqXp(i)..    Xp(i) =e= alpha(i)*(sum(h,r(h)*FF(h))-S-Td)/pq(i);

*[domestic production]---
eqpy(j)..   Y(j) =e= b(j)*prod(h,F(h,j)**beta(h,j));
eqX(i,j)..   X(i,j) =e= ax(i,j)*Z(j);
eqY(j)..     Y(j) =e= ay(j)*Z(j);
eqF(h,j)..   F(h,j) =e= beta(h,j)*py(j)*Y(j)/r(h);
eqps(j)..    ps(j) =e= ay(j)*py(j)+sum(i,ax(i,j)*pq(i))+G(j)/Z(j);

*[government behavior]--
eqTd.. Td =e= taud*sum(h,r(h)*FF(h));
eqXg(i)..  Xg(i) =e= mu(i)*(Td+sum(j,T(j))+sum(j,Tm(J))-Sg+sum(j,G(j)))/pq(i);

eqG(i)..   G(i)=e=omega(i)*(Td+sum(j,T(j))+sum(j,Tm(j)));

eqT(i)..   T(i) =e= tau(i)*ps(i)*Z(i);
eqTm(i)..   Tm(i) =e= taum(i)*pm(i)*M(i);


*[investment behavior]---
eqXv(i)..   Xv(i) =e= lambda(i)*(S+Sg+epsilon*Sf)/pq(i);

*[international trade]---
eqpe(i)..         pe(i) =e= epsilon*pWe(i);
```

```
eqpm(i)..        pm(i) =e= epsilon*pWm(i);
eqepsilon..        sum(i,pWe(i)*E(i))+Sf =e= sum(i,pWm(i)*M(i));

*[armington function]---
eqpqs(i)..     Q(i) =e= gamma(i)*(deltam(i)*M(i)**eta(i)+deltad(i)*D(i)**eta(i))**(1/eta(i));
eqM(i)..                  M(i)   =e=   (gamma(i)**eta(i)*deltam(i)*pq(i)/((1+taum(i))*pm(i)))**(1/(1-
eta(i)))*Q(i);
eqD(i)..        D(i) =e= (gamma(i)**eta(i)*deltad(i)*pq(i)/pd(i))**(1/(1-eta(i)))*Q(i);

*[transformation function]
eqpz(i)..   Z(i) =e= theta(i)*(xie(i)*E(i)**phi(i)+xid(i)*D(i)**phi(i))**(1/phi(i));
eqE(i)..        E(i)  =e=  ((theta(i)**phi(i)*xie(i)*(1+tau(i))*ps(i)/pe(i))**(1/(1-phi(i)))*Z(i))$(xie(i)
ne 0);
eqDs(i)..     D(i) =e= (theta(i)**phi(i)*xid(i)*(1+tau(i))*ps(i)/pd(i))**(1/(1-phi(i)))*Z(i);

*[market clearing]
eqpqd(i)..   Q(i) =e=Xp(i)+Xg(i)+Xv(i)+sum(j,X(i,j));
eqr(h)..     FF(h) =e= sum(j,F(h,j));

*[savings]--
eqS..    S =e= ss*sum(h,r(h)*FF(h));
eqSg..       Sg =e= ssg*(Td+sum(j,T(j))+sum(i,Tm(i)));

*[fictitous objective function]
obj..   UU =e= prod(n,Xp(n)**alpha(n));

*---------------

*initializing variables--------------
Xp.l(i)=Xp0(i);
F.l(h,j)=F0(h,j);
X.l(i,j)=X0(i,j);
Y.l(j)=Y0(j);
Z.l(j)=Z0(j);
Xg.l(i)=Xg0(i);
Xv.l(i)=Xv0(i);
E.l(i)=E0(i);
M.l(i)=M0(i);
Q.l(i)=Q0(i);
D.l(i)=D0(i);
pd.l(i)=1;
ps.l(i)=1;
pq.l(i)=1;

py.l(j)=1;
pm.l(i)=1;
pe.l(i)=1;
r.l(h)=1;
epsilon.l=1;
Td.l=Td0;
T.l(i)=T0(i);
```

```
Tm.l(i)=Tm0(i);
S.l=S0;
Sg.l=Sg0;
G.l(i)=G0(i);
*--------------------

*setting lower bounds to avoid division by zero------

*-------------------
*numeraire-----
r.fx("LAB")=1;
*--------------
*defining and solving model-----------------
model JORDAN  /all/;

solve JORDAN  maximizing UU using nlp;



tau("AGR")=tau("AGR")*0.8;

solve Jordan maximizing UU using nlp;

*Display of Changes-----------------------
Parameter
dXp(i), dF(h,j), dX(i,j), dY(j), dZ(j), dXg(i), dXv(i),
dE(i), dM(i), dQ(i), dD(i), dpd(i), dps(i), dpq(i), dpy(j),
dpm(i), dpe(i), dr(h), depsilon, dTd, dT(i), dTm(i), dS, dSg, dG(i);

dXp(i)=(Xp.l(i)/Xp0(i)-1)*100$(Xp0(i) ne 0);
dF(h,j)=(F.l(h,j)/F0(h,j)-1)*100;
dX(i,j)=(X.l(i,j)/X0(i,j)-1)*100$(X0(i,j) ne 0);
dY(j)=(Y.l(j)/Y0(j)-1)*100;
dZ(j)=(Z.l(j)/Z0(j)-1)*100;
dXg(i)=(Xg.l(i)/Xg0(i)-1)*100$(Xg0(i) ne 0);
DXv(i)=(Xv.l(i)/Xv0(i)-1)*100$(Xv0(i) ne 0);
dE(i)=(E.l(i)/E0(i)-1)*100$(E0(i) ne 0);
dM(i)=(M.l(i)/M0(i)-1)*100$(M0(i) ne 0);
dQ(i)=(Q.l(i)/Q0(i)-1)*100;
dD(i)=(D.l(i)/D0(i)-1)*100$(D0(i) ne 0);
dpd(i)=(pd.l(i)/1-1)*100;
dps(i)=(ps.l(i)/1-1)*100;
dpq(i)=(pq.l(i)/1-1)*100;
dpy(i)=(py.l(i)/1-1)*100;
dpm(i)=(pm.l(i)/1-1)*100;
dpe(i)=(pe.l(i)/1-1)*100;
dr(h)=(r.l(h)/1-1)*100;
depsilon=(epsilon.l/1-1)*100;
dTd=(Td.l/Td0-1)*100;
dT(i)=(T.l(i)/T0(i)-1)*100;
dTm(i)=(Tm.l(i)/Tm0(i)-1)*100$(Tm0(i) ne 0);
```

```
dS=(S.l/S0-1)*100;
dSg=(Sg.l/Sg0-1)*100;
dG(i)=(G.l(i)/G0(i)-1)*100$(G0(i) ne 0);


display
dXp, dF, dX, dY, dZ, dXg, dXv,
dE, dM, dQ, dD, dpd, dps, dpq, dpy,
dpm, dpe, dr, depsilon, dTd, dT, dTm, dS, dSg, dG;

*Welfare measure: Hicksian equivalent variations------------
Parameter    UU0   utility level for base run
             WW  total welfare change
             ep0   expenditure function for the base run
             ep    expenditure function for the simulation run
             EV    Hicksian equivalent variations;

UU0 = prod(n,Xp0(n)**alpha(n));
WW=UU.l-UU0;

ep0=UU0/prod(n,(alpha(n)/1)**alpha(n));
ep=UU.l/prod(n,(alpha(n)/1)**alpha(n));
EV=ep-ep0;

display EV,WW, UU.l;




*-----------------
*end of model-------------------
*------------------------------------------
```