Utilizing System Dynamics Models in Analyzing Macroeconomic Variables of Yemen

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1. Abstract

The purpose of the System Dynamics method is to study the relationship between structure and behavior in non-linear, dynamic systems. In such systems, the significance of various structural components to the behavior pattern exhibited, changes as the behavior unfolds. Changes in structural significance modify that behavior pattern which, in turn, feeds back to change the relative significance of structural components. We develop a macroeconomic model through which we can study the characteristics of the feedback between structure and behavior. This model is based on multiplier-accelerator model, and inventory – adjustment model. This work is an extension of the work by Nathan Forrester on the use of basic macroeconomic theory to stabilize policy analysis. The design of a System Dynamics model begins with a problem and a time frame that contribute to the problem. They are listed and their structural relationships sketched the factors with particular attention to characterizing them as levels (or stocks) and rates (or flows) that feed or drain them. Levels and rates must alternate in the model; no level can control another without an intervening rate or any rate influence another without an intervening level.

2. Dynamic Hypotheses

The main assumption in the model is that exponential growth of oil production, GDP and other variables in the real life cannot continue forever. Exponential growth implies a constant doubling time. In all real systems, there will be limits, and when a system state approaches its limit, stress takes place in the system.

3. The Model

INITIAL TIME = 1990
FINAL TIME = 2020 , TIME STEP = 1 YEAR

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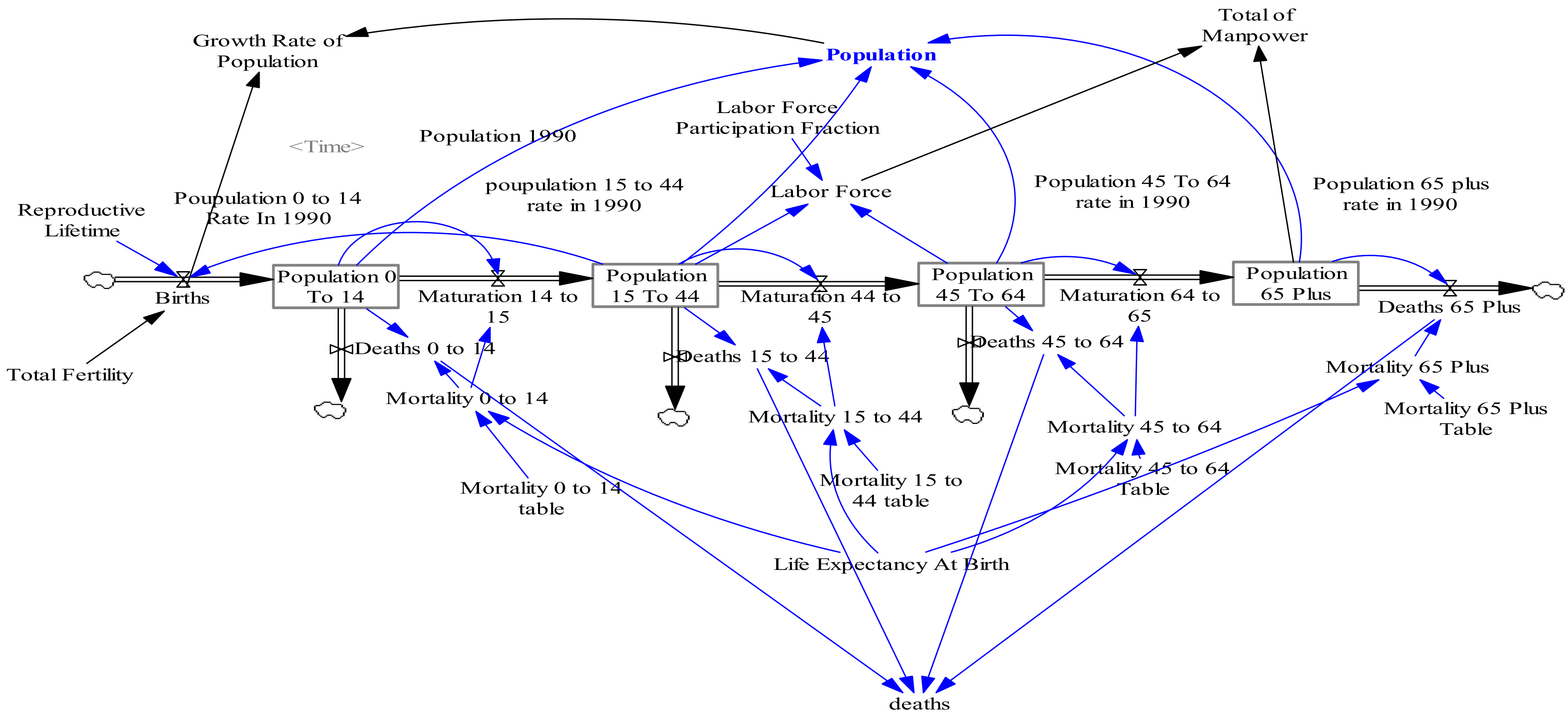
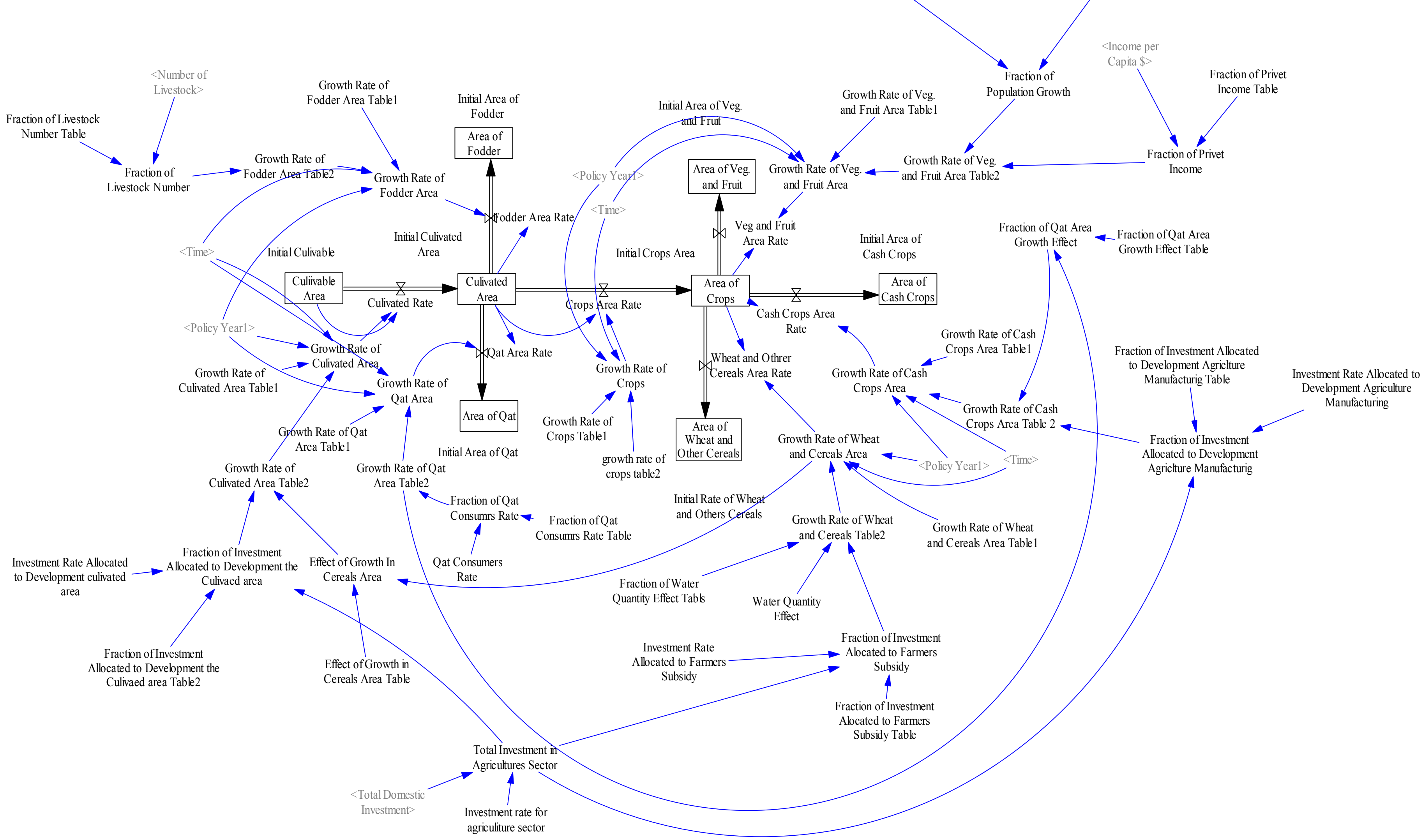
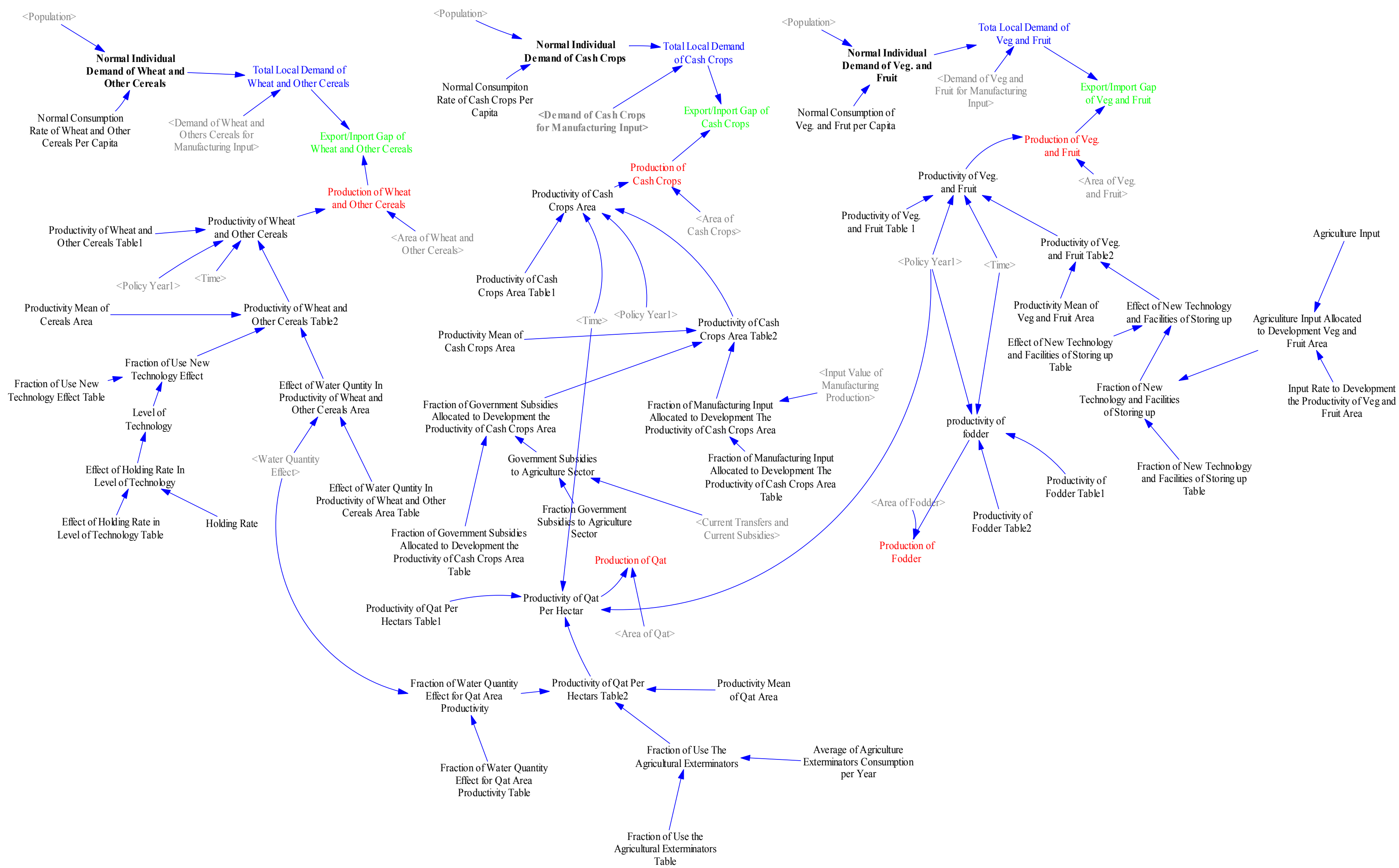
1- POPULATION VIEW



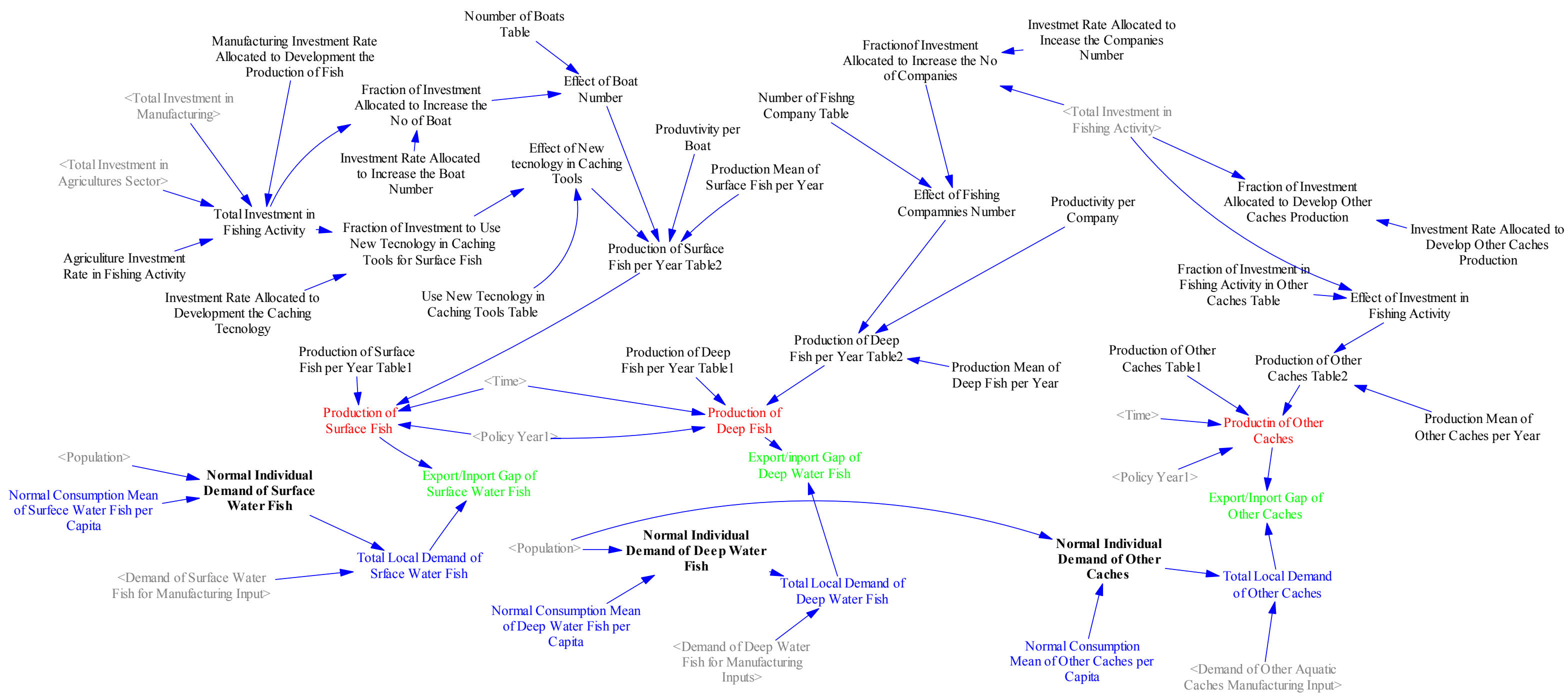
2- AREA OF AGRICULTURE VIEW

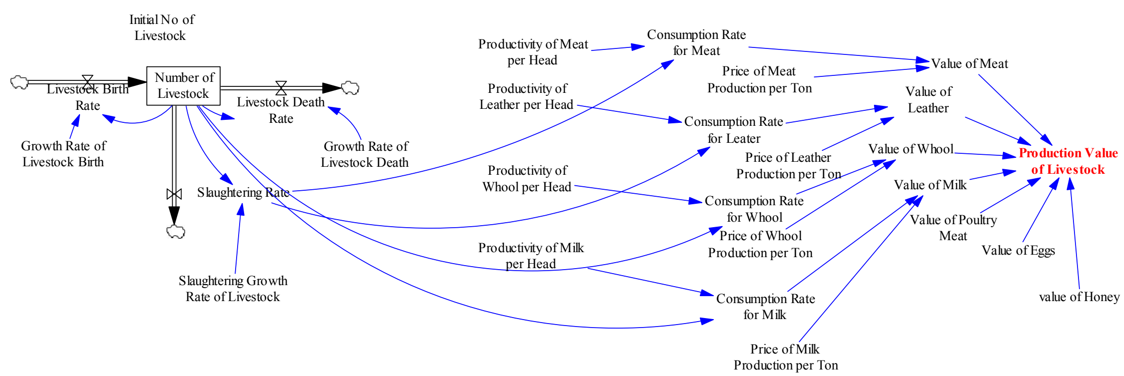


3- CROPS PRODUCTION VIEW

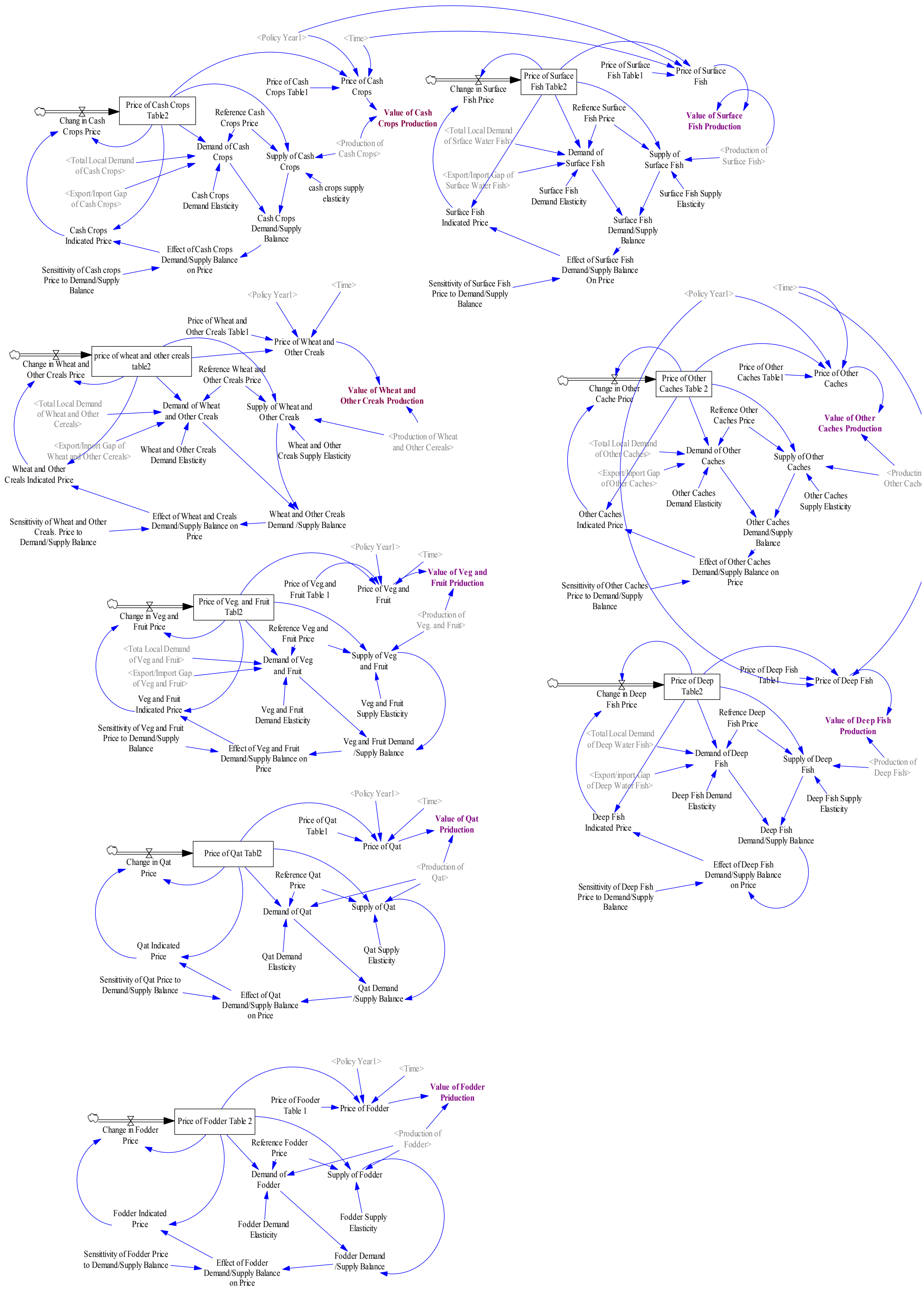


4- FISHING PRODUCTION VIEW

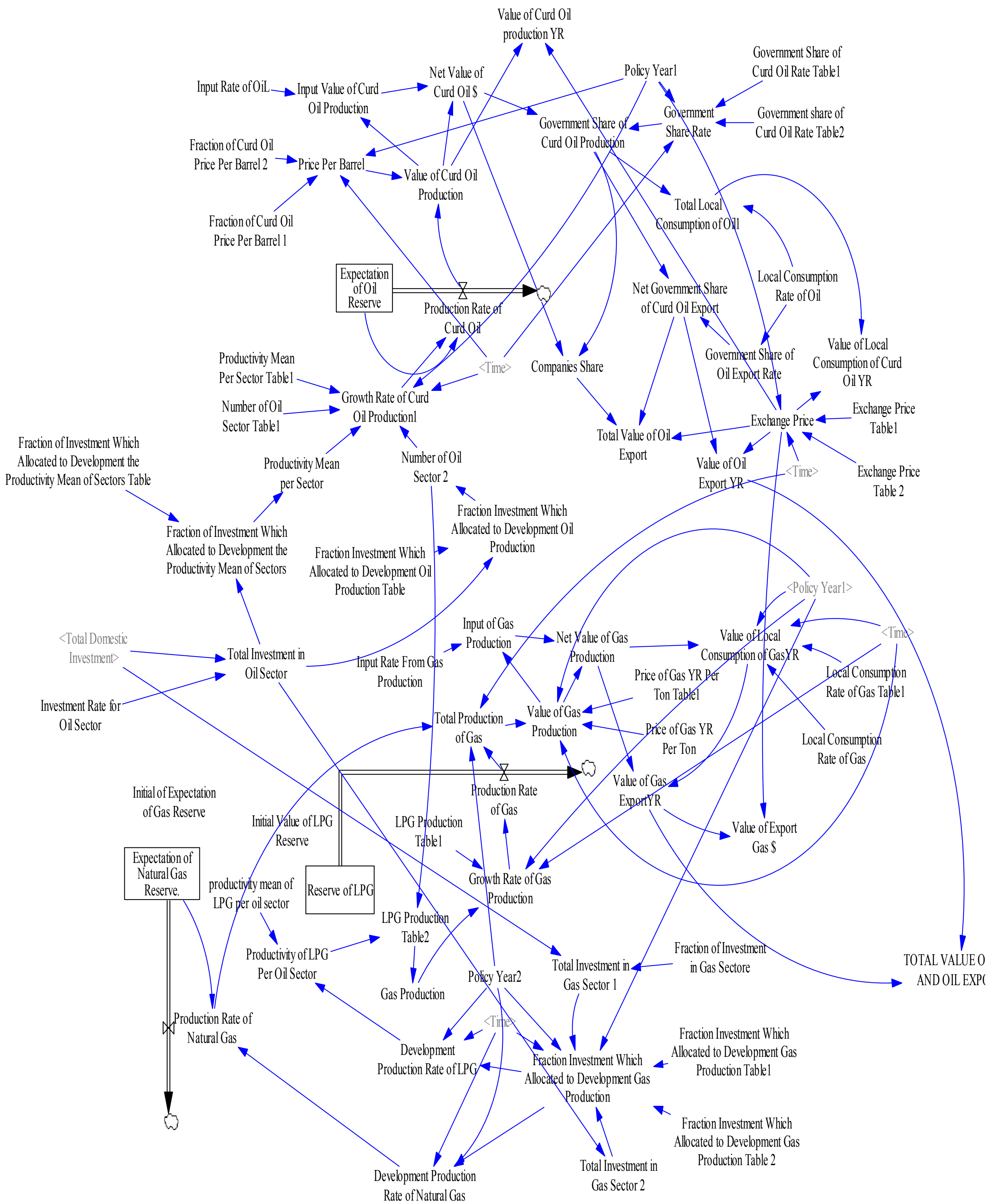




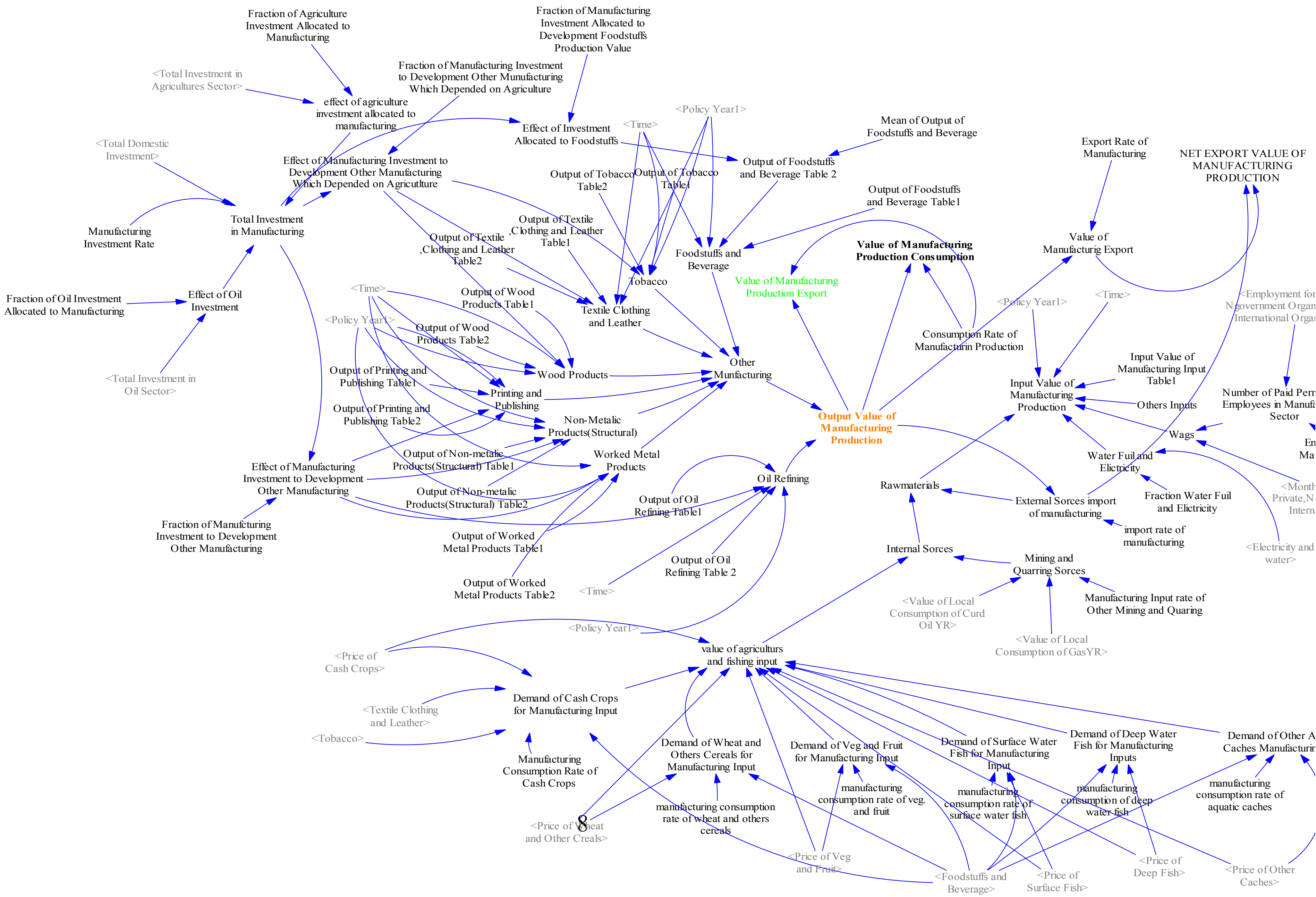
5- Equilibruim Price and Value of Crops View



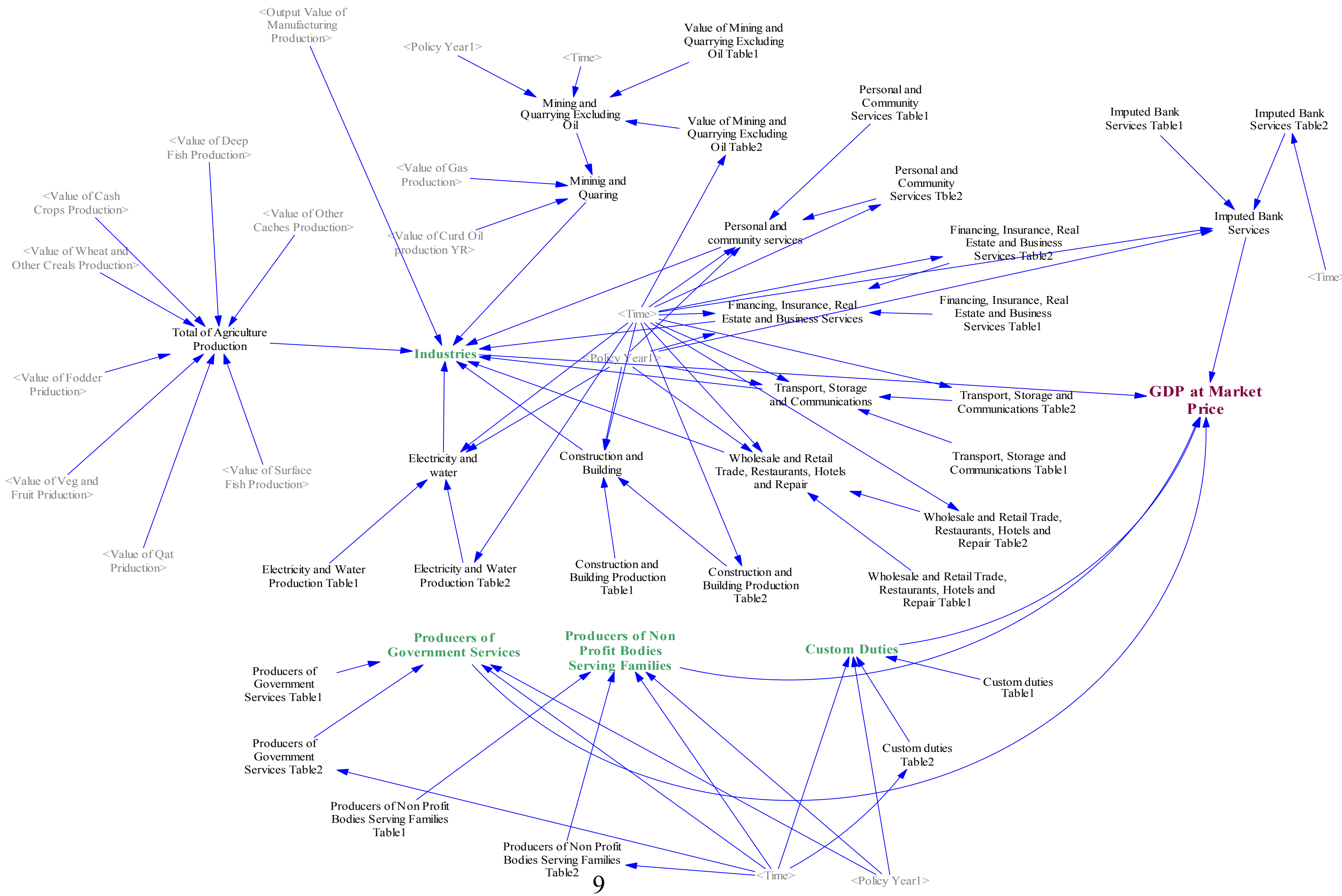
6- Oil and Gas Production View



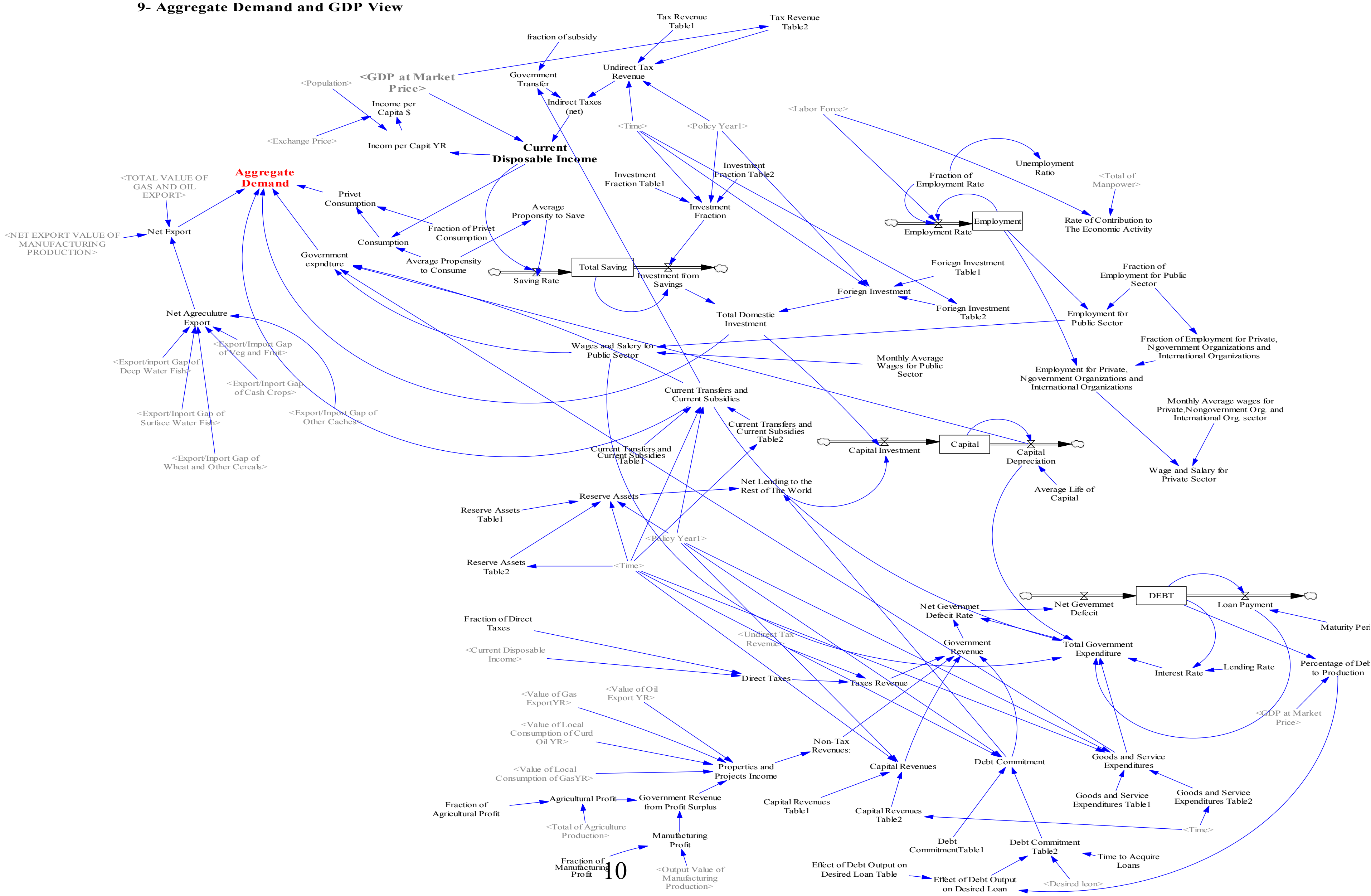
7- Manufacturing Production View



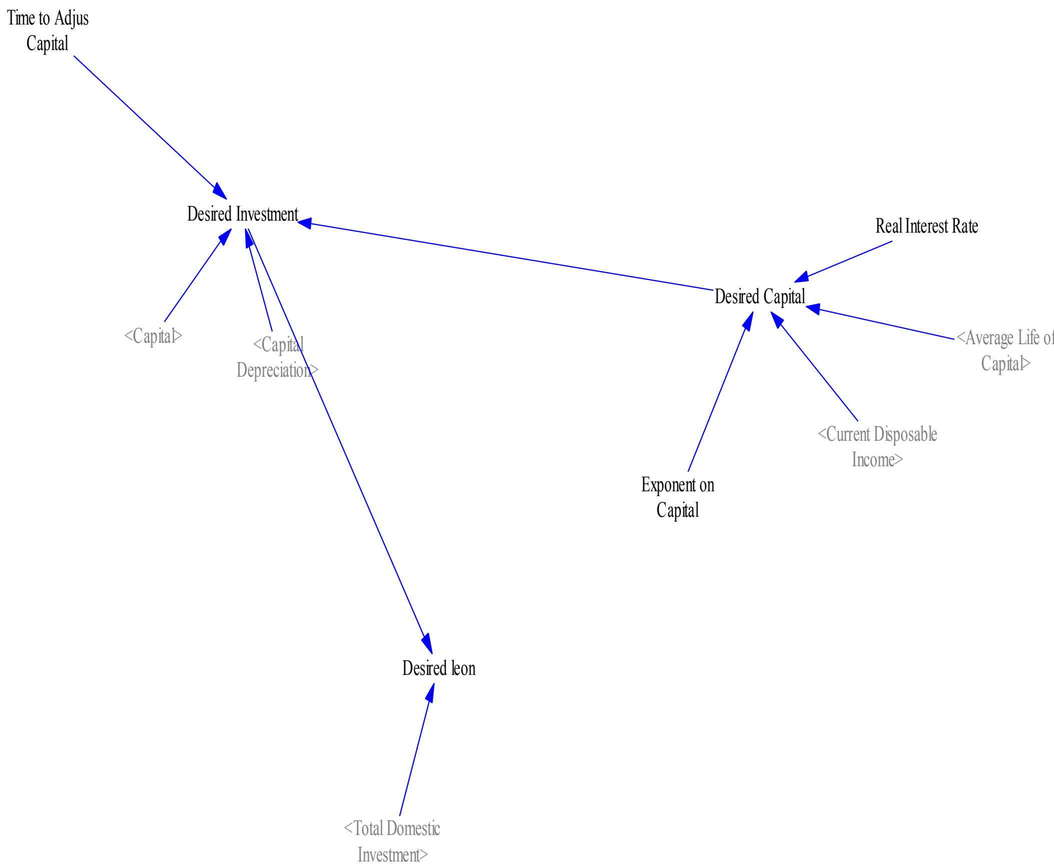
8- Total Production View



9- Aggregate Demand and GDP View



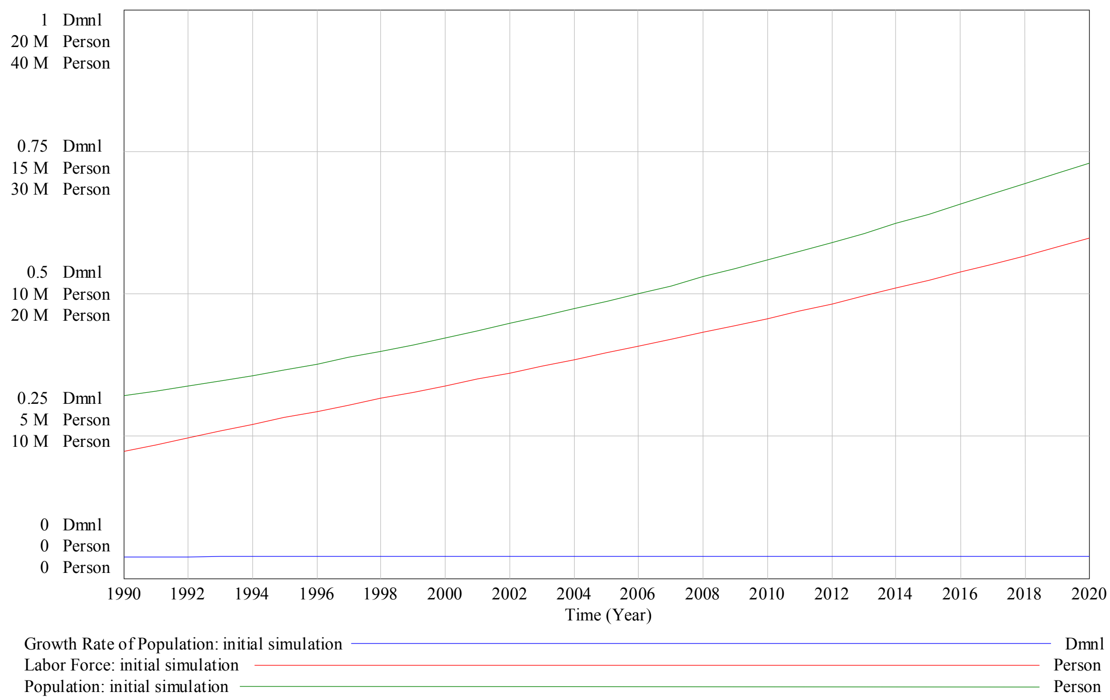
10- Desired View



4. Initial Simulation

It is a state of the system before our policies through 1990-2020

Figure (6-1) Population, Labor Force and Growth Rate of Population



The figure shows growth of population, Labor Force and Growth Rate of Population through 1990-2020 in initial state of the system.

$$\xi_t = \sum_{1}^{n} \xi_{nt} \quad , n=1,2..,4$$ **see appendix(1)**

$$\xi_{1t} = \int_{t_0}^{t} (b - d - m_{1t})dt + i_1$$

$$\xi_{2t} = \int_{t_0}^{t} (m_{1t} - d_{2t} - m_{2t})dt + i_2$$

$$\xi_{3t} = \int_{t_0}^{t} (m_{2t} - d_{3t} - m_{3t})dt + i_3$$

$$\xi_{4t} = \int_{t_0}^{t} (m_{3t} - d_{4t})dt + i_4$$

$$\frac{\partial \xi_{1t}}{\partial t} = b - (d_{1t} + m_{1t}) = [F * \xi_{2t} * 0.5 / RL] - [(\xi_{1t} * mo_{1t}) + (\xi_{1t} * \frac{(1 - mo_{1t})}{15})]$$

$$\frac{\partial \xi_{2t}}{\partial t} = m_{1t} - (d_{2t} + m_{2t}) = \frac{\xi_{1t} * (1 - mo_{1t})}{15} - \left[(\xi_{2t} * mo_{2t}) + \frac{\xi_{2t} * (1 - mo_{2t})}{30} \right]$$

$$\frac{\partial \xi_{3t}}{\partial t} = m_{2t} - (d_{3t} + m_{3t}) = \frac{\xi_{3t} (1 - mo_{2t})}{30} - \left[(\xi_{3t} * mo_{3t}) + \frac{\xi_{3t} * (1 - mo_{3t})}{20} \right]$$

$$\frac{\partial \xi_{4t}}{\partial t} = m_{3t} - d_{4t} = \frac{\xi_{3t} * (1 - mo_{3t})}{20} - (\xi_{4t} * mo_{4t})$$

$$b = F * \xi_{2t} * 0.5 / rl$$

Where

ζ_{nt}= population number
F=Total fertility=5.8 child/wn
i_n=Initial value of population ,n=1,2..,4
m_{nt}= Maturation rate ,n=1,2..,4 ,t=1,2,3 ....,30
mo_{nt}= Mortality fraction
n=Age group
t=Time,(1990-2020)
d= death rate
b=birth rate
RL=Reproductive Lifetime=30 years

Table (1) Result of Initial Simulation of Population View

Time (Year)	Growth Rate of Population (person)	Labor Force (person)	Population
1990	0.0362015	4.44635e+006	1.28086e+007
1991	0.0370693	4.69488e+006	1.31423e+007
1992	0.037761	4.93718e+006	1.34957e+007
1993	0.0383056	5.1744e+006	1.38674e+007
1994	0.0387281	5.40761e+006	1.42561e+007
1995	0.0390499	5.63772e+006	1.46609e+007
1996	0.0392891	5.86559e+006	1.50809e+007
1997	0.0394609	6.09195e+006	1.55153e+007
1998	0.039578	6.31748e+006	1.59637e+007

1999	0.039651	6.54279e+006	1.64255e+007
2000	0.0396888	6.76845e+006	1.69006e+007
2001	0.0396987	6.99496e+006	1.73886e+007
2002	0.0396867	7.22279e+006	1.78893e+007
2003	0.0396578	7.45236e+006	1.84027e+007
2004	0.039616	7.68409e+006	1.89288e+007
2005	0.0395646	7.91833e+006	1.94675e+007
2006	0.0395064	8.15545e+006	2.0019e+007
2007	0.0394434	8.39577e+006	2.05833e+007
2008	0.0393775	8.6396e+006	2.11607e+007
2009	0.03931	8.88725e+006	2.17513e+007
2010	0.0392421	9.13898e+006	2.23554e+007
2011	0.0391745	9.39509e+006	2.29731e+007
2012	0.039108	9.65584e+006	2.36049e+007
2013	0.0390431	9.92148e+006	2.4251e+007
2014	0.0389802	1.01923e+007	2.49118e+007
2015	0.0389195	1.04684e+007	2.55875e+007
2016	0.0388613	1.07503e+007	2.62787e+007
2017	0.0388056	1.10379e+007	2.69856e+007
2018	0.0387525	1.13317e+007	2.77086e+007
2019	0.0387021	1.16319e+007	2.84483e+007
2020	0.0386543	1.19386e+007	2.9205e+007

Figure (2-5) Cultivable Area, Cultivated Area and Cultivated Rate

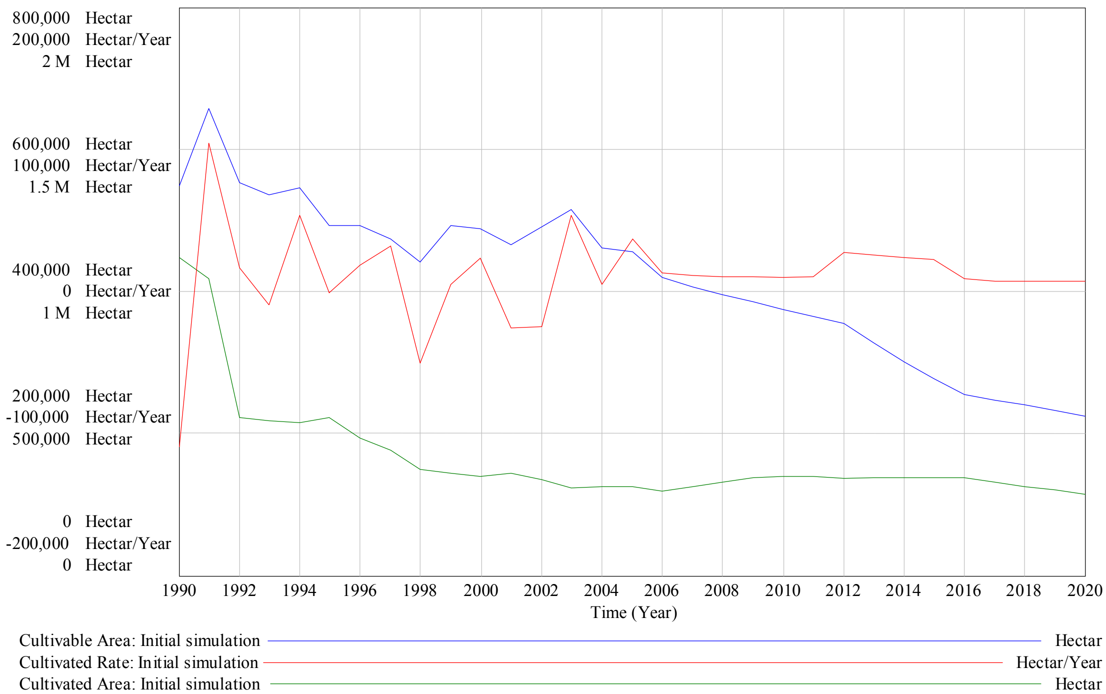


Figure (2-5) Cultivated Area, Crops, Qat, Fodder Area

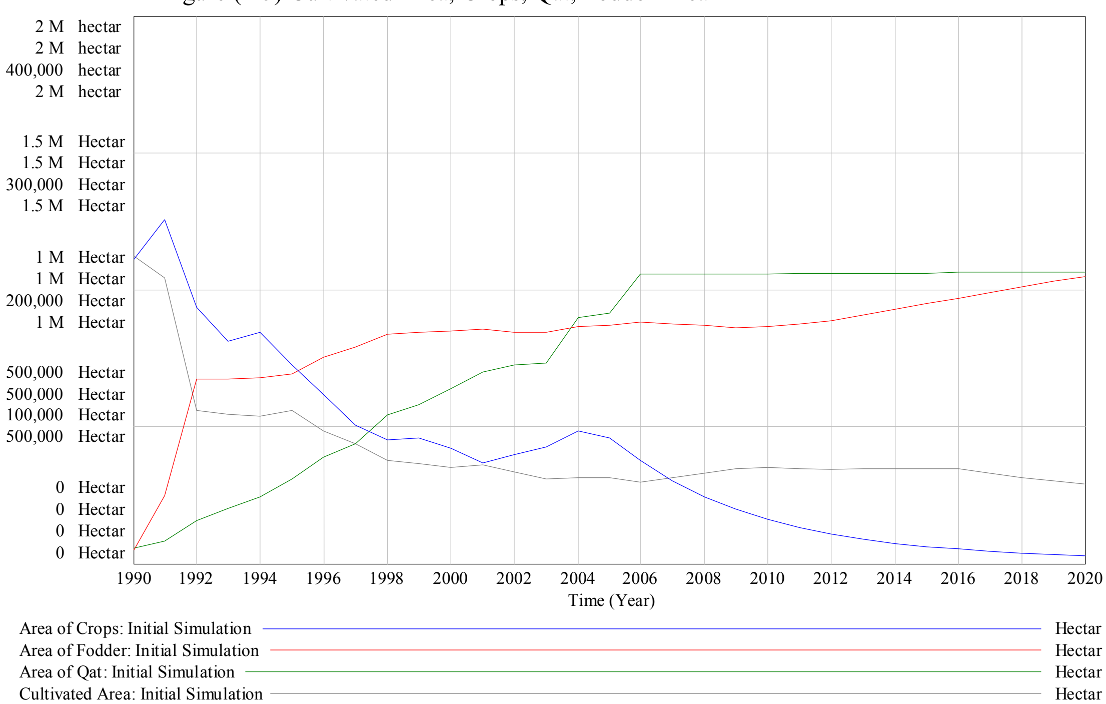
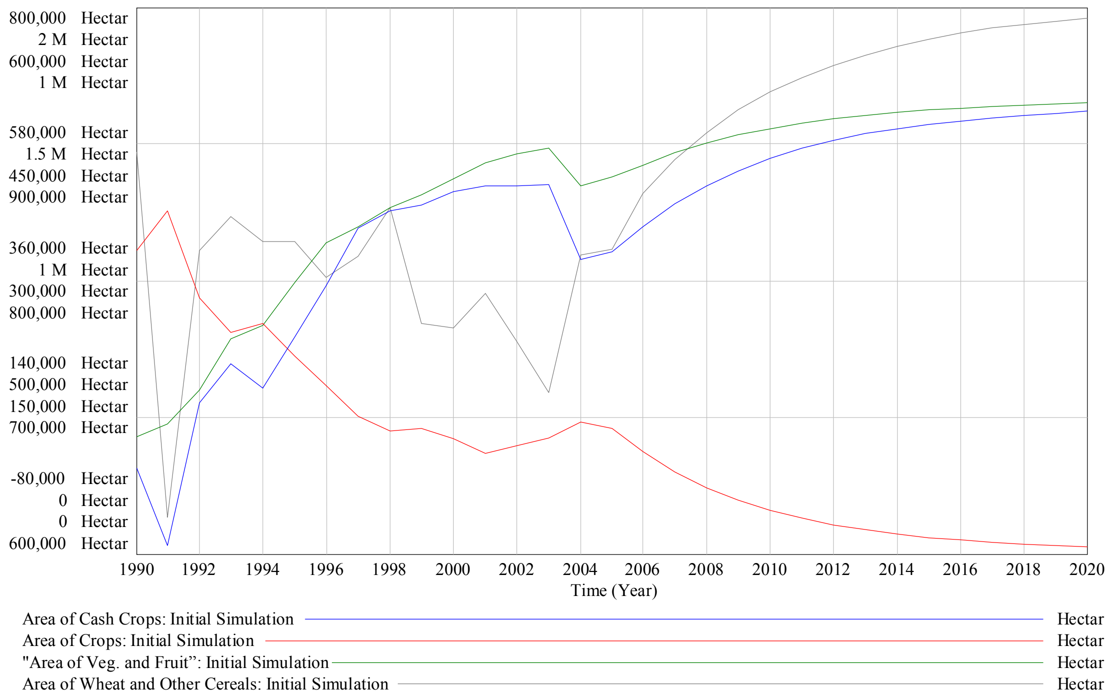


Figure (4-5) Area of Crops, Cash Crops, Wheat and other Cereals, Veg. and Fuit Area



$$cbl_t = -\int [cdr_t + ica]\, dt$$ **See appendix (2)**

$$\frac{\partial cbl}{\partial t} = -\psi_{cbl}(cbl_t)$$

$$cd_t = \int_{t_0}^{t} [cdr_t - (car_t + qar_t + far_t)]dt + icda$$

$$\frac{\partial cd}{\partial t} = (\psi_{cbl}(cbl_t) - ((\psi_{crops}(cd_t) + \psi_{fodder}(cd_t) + \psi_{qat}(cd_t))$$

$$ca_t = \int_{t_0}^{t} [car_t - ((ccar_t + vfar_t + wcar_t)]dt + ica)$$

$$\frac{\partial ca}{\partial t} = (\psi_{crops}(cd_t) - (\psi_{cashcrops}(ca_t) + \psi_{\text{Veg. and Fruit}}(ca_t) + \psi_{\text{Wheat and Cereals}}(ca_t)))$$

$$cca_t = \int_{t_0}^{t} ccar_t dt + icca$$

$$\frac{\partial cca}{\partial t} = \psi_{cashcrops}(ca_t)$$

$$vfa_t = \int_{t_0}^{t} vfar_t dt + ivfa$$

$$\frac{\partial vfa}{\partial t} = \psi_{veg.andfruit}(ca_t)$$

$$wca_t = \int_{t_0}^{t} wcar_t dt + iwca$$

$$\frac{\partial wca}{\partial t} = \psi_{wheaq\tan dcereals}(ca_t)$$

$$foda_t = \int_{t_0}^{t} fodar_t dt + ifoda$$

$$\frac{\partial foda}{\partial t} = \psi_{fodder}(cd_t)$$

$$qata_t = \int_{t_0}^{t} qatar_t dt + iaqta$$

$$\frac{\partial qata}{\partial t} = \psi_{qat}(cd_t)$$

$$\psi_{cbl} = \psi_t(t) \forall t \in T1,\ fid\ [\psi_{wheat,creals}(\kappa)] \forall t \in T2]$$

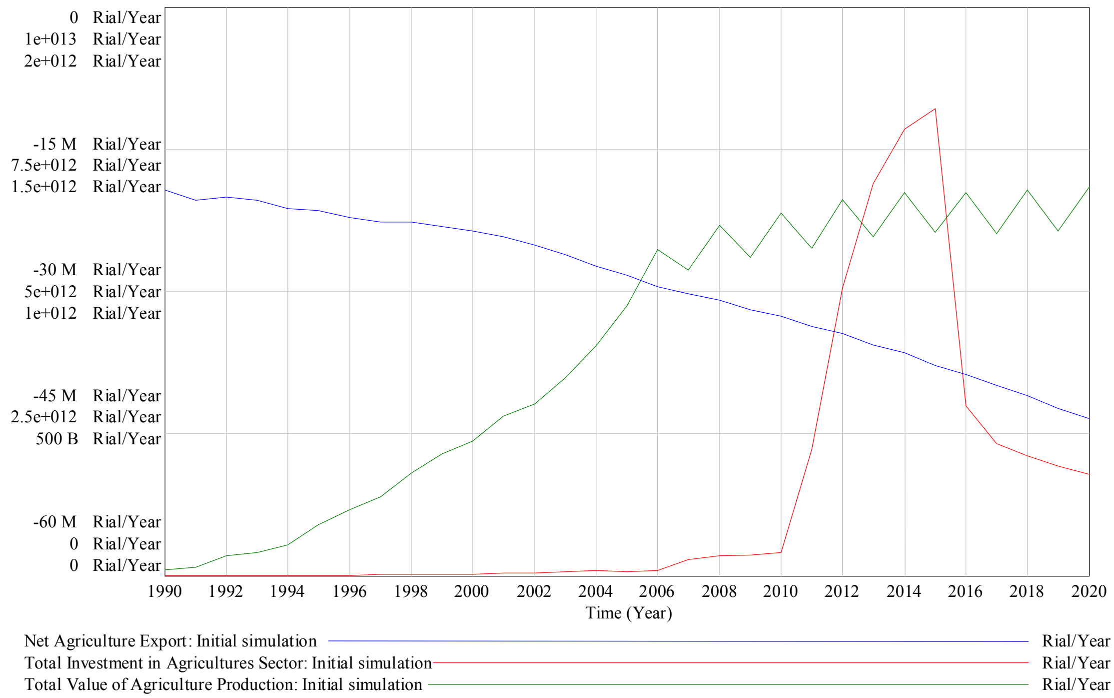
$$fid = fid_{table}[\rho_{dcbla}(AGINV)]$$

$$AGINV = \rho_{AGINV}(TINV)$$

Where
cbl=Cultivable Area
cd=Cultivated Area
ca=Area of Crops
cca=Area of Cash Crops
vfa="Area of Veg. and Fruit"
wca=Area of Wheat and Other Cereals
foda=Fodder Area
qata=Qat Area
Ψ_{group}=*Growth Rate of Area*
i_{group}=*Initial value of Area*
T1= Time period before policy year (1990-2005)

T2= Time period after policy year (2006-2020)
fid= Fraction of Investment Allocated to Development the Cultivated area
k= Effect of Growth in Cereals Area
ρ_{dcble}*=Coefficient of Development cultivated area*
AGINV= Total Investment in Agricultures Sector
ρ_{AGINV}*= Coefficient of Investment in Agricultures Sector*
TINV= Total Domestic Investment

Figure (5-5) Net agriculture Export, Agriculture Investment and Net Export



Total Values of Agriculture Production = Value of Cash Crops Production + Value of Deep Fish Production + Value of Fodder Production +Value of Other Caches Production + Value of Qat Production +Value of Surface Fish Production + Value of Veg and Fruit Production + Value

$$TVAP_t = \left[\sum_i^h VCP_i + \sum_i^j VFP_i\right]_t + PVQ_t + PVF_t$$

Where
$TVAP_t$= Total Values of Agriculture Production
VCP=Value of Crops Production
VFP=Value of Fishing Production
PVQ_t=Production Value of Qat
PVF_t=Production Value of Fodder
h=Number of agriculture Crops
j=Number of fishing kinds
And
VCPi= $ccprov_t$ +$wcprov_t$+$vfprov_t$

$Ccprov_t = P_t^{cashcrops} * ccpro_t$

$ccpro_t = cca_t * ccproy_t$

$$ccproy_t = ccproy_t(t)\forall t \epsilon T1, [\mu_{ccproy} + (\lambda_1 ctcs) + (\lambda_2 IVMP)]_t \forall t \in T2$$

$$ctcs_t = ctcs(t)\forall t \in T1, \{-3.82565e13 + [1.91976e010(t)]\}\forall t \in T2$$

$$IVMP_t = IVMP_t(t)\forall t \in T1, \sum_i^d MI_i, \forall t \in T2$$

Where

ccprov=C ash Crops Productive Value

wcprov=Wheat and Careals Productive Value

μ=Productivity Mean of Cash Crops Area

λ_1= coefficient of Current Transfers and Current Subsidies

λ_2=Coefficient of Input Value of Manufacturing Production

$$\mathrm{P}_t^{cashcrops} = \mathrm{P}_t^{cashcrops}(t)\forall t \in T1, \int_{t_0}^{t} (xccp)dt + iP^{cashcrops} \quad \forall t \in T2$$

$$\frac{\partial ccp}{\partial t} = ccip_t - \left(\int_{t_0}^{t} (xccp_t)dt + iP^{cashcrops} \right)$$

$$ccip_t = \left(\int_{t_0}^{t} (xccp_t)dt + iP^{cashcrops} \right) * eccdsb_t$$

$$eccdsb_t = (ccdsb_t)^{sccp}$$

$$ccdsb_t = ccd_t / ccs_t$$

$$ccd_t = (cctld_t + ccxig_t) * e^{ccde * \ln[\frac{\int_{t_0}^{t} (xccp_t)dt + iP^{cashcrops}}{ccrP}]}$$

$$ccs_t = (ccpro_t) * e^{ccse * \ln[\frac{\int_{t_0}^{t} (xccp_t)dt + iP^{cashcrops}}{ccrP}]}$$

where

$P_t^{cashcrops}$ = *Equilibrium Price of Cash Crops*

$xccp_t$= *Change in Cash Crops Price*

$iP^{cashcrops}$=*Initial Value of Cash Crops*

$ccip_t$= *Cash Crops Indicated Price*

$eccdsb_t$= *Effect of Cash Crops Demand/Supply Balance on Price*

sccp= Sensitivity of Cash crops Price to Demand/Supply Balance=1

$ccdsb_t$= *Cash Crops Demand/Supply Balance*

ccd_t= *Demand of Cash Crops*

ccs_t= *Supply of Cash Crops*

ccrP= Reference Cash Crops Price= 306507(Rial)

ccde= Cash Crops Demand Elasticity= -1

ccse= Cash Crops Supply Elasticity= 1

$cctld_t$= *Total Local Demand of Cash Crops*

$ccxig_t$= *Export/Import Gap of Cash Crops*

$ccpro_t$= *Production of Cash Crops*

$ccprov_t$= *Value of Cash Crops Production*

$ccproy_t$= *Productivity of Cash Crops Area*

$$NAE_t = \lfloor \sum_i^h EIGC_i + \sum_i^j EIGF_i \rfloor_t$$

$$\sum EIGC = EIGCC + EIGWC + EIGVF$$

$$EIGCC_t = ccpro_t - tldcc_t$$

$$tldcc_t = ccdmi_t + ccnid_t$$

$$ccnid_t = \delta(\xi_t)$$

Where

NAE=Net of Agriculture Export

EIGC=Export/Import Gap of Crops

EIGCC=Export/Import Gap of Cash Crops

tldcc=Total Local Demand of Cash Crops

ccdmi= Demand of Cash Crops for Manufacturing Input

ccnid= Normal Individual Demand of Cash Crops

δ= Normal Consumpiton Rate of Cash Crops Per Capita

Table (2-5) Result of Initial Simulation of Agriculture View

Time (Year)	**Net Agriculture Export** *(RIAL)* **Net Export** *RIAL*	**Total Value of Agriculture Production** *RIAL*
1990	-1.94018e+007	2.16339e+010
	2.2379e+009	2.91099e+010
1991	-2.04054e+007	7.03195e+010
	4.14423e+009	8.31123e+010
1992	-2.01108e+007	1.08991e+011
	5.14581e+009	1.77486e+011
1993	-2.04203e+007	2.34333e+011
	1.00906e+010	2.77576e+011
1994	-2.12863e+007	3.60331e+011
	2.16939e+010	4.28393e+011

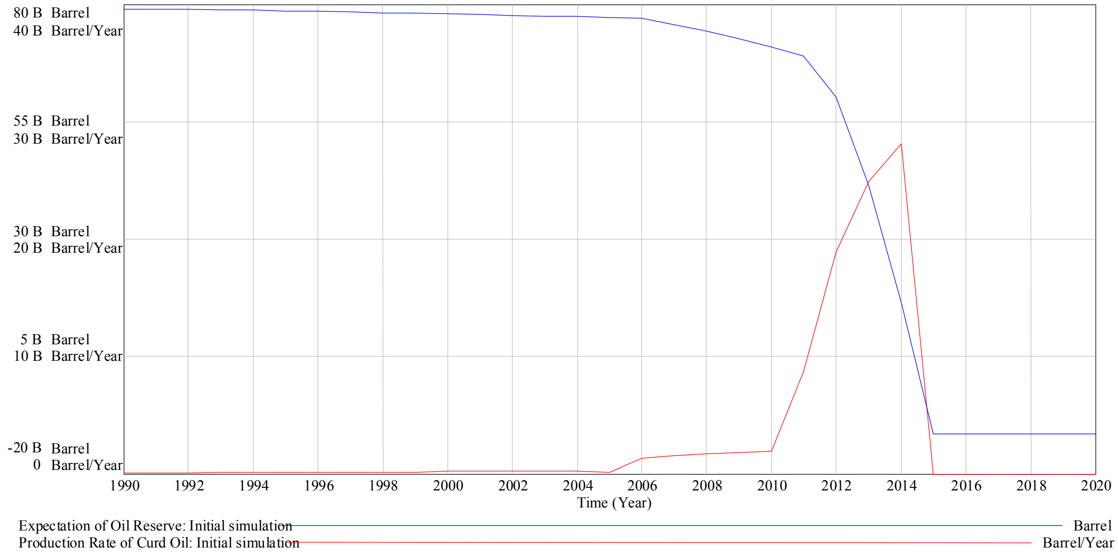
1995 -2.14961e+007
4.52395e+010
1996 -2.21679e+007
7.39684e+010
1997 -2.26645e+007
7.30805e+010
1998 -2.26415e+007
5.40093e+010
1999 -2.31264e+007
9.076e+010
2000 -2.37045e+007
1.7315e+011
2001 -2.42576e+007
1.43496e+011
2002 -2.51117e+007
1.47531e+011
2003 -2.61757e+007
1.7487e+011
2004 -2.73935e+007
2.20713e+011
2005 -2.83187e+007
3.24606e+011
2006 -2.94818e+007
2.96436e+012
2007 -3.02914e+007
3.4914e+012
2008 -3.09195e+007
3.88253e+012
2009 -3.18942e+007
4.18743e+012
2010 -3.26233e+007
3.99843e+013
2011 -3.37325e+007
8.70036e+013
2012 -3.44854e+007
1.0944e+014
2013 -3.56428e+007
1.20278e+014
2014 -3.65247e+007
1.23263e+014
2015 -3.7741e+007 5.19911e+013

2016 -3.87025e+007
4.23378e+013
2017 -3.99895e+007
3.82528e+013
2018 -4.09928e+007
3.49218e+013
2019 -4.23264e+007
3.19342e+013

4.7331e+011
5.59893e+011
6.0323e+011
6.94967e+011
8.09341e+011
9.48176e+011
1.14606e+012
1.07753e+012
1.23264e+012
1.12117e+012
1.27549e+012
1.15159e+012
1.32298e+012
1.19112e+012
1.34664e+012
1.20784e+012
1.34811e+012
1.20163e+012
1.35617e+012
1.21087e+012
1.36556e+012

2020 -4.33915e+007
2.92206e+013

Figure (6-5) Expectation Oil Reserve and Production Rate of Curd Oil (1990-2020)



Figure(7-5) Total Investment in Oil Sector and Total Value of Oil Export

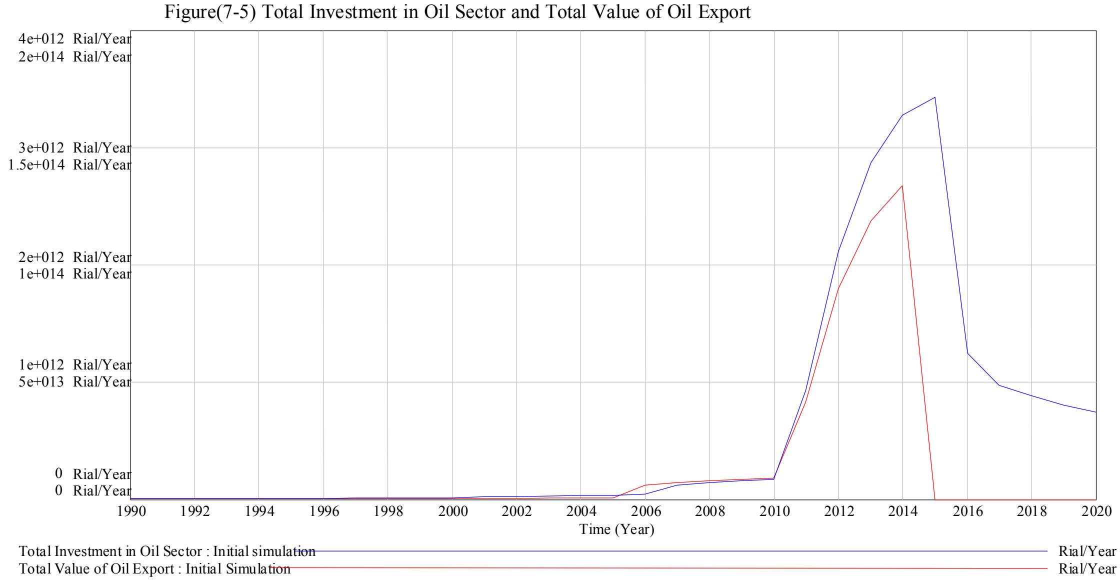
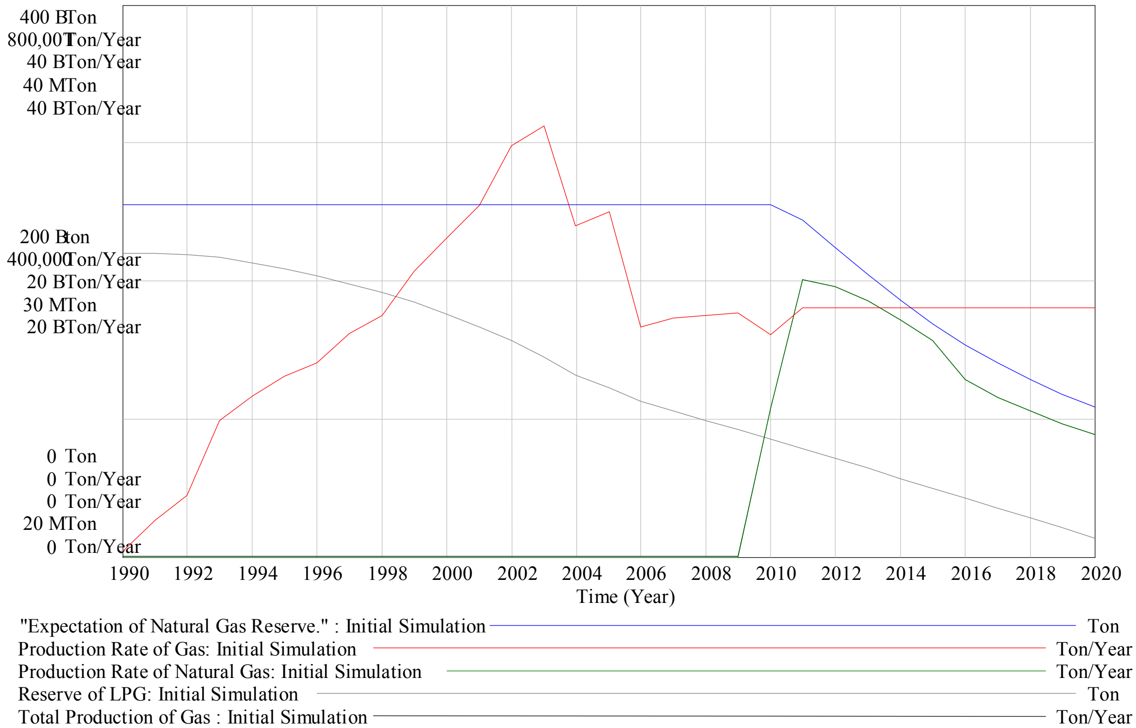


Figure (8-5) Selected Variables



$$EOR_t = -\int_{t_0}^{t} (prco_t)dt + iEOR \quad , EOR>=0$$

$$\frac{\partial EOR}{\partial t} = prco_t : EOR > 0, 0 : EOR \leq 0$$

$$prco_t = \Phi_1(t) * \mathrm{N}_1(t) : t \in T1, \Phi_2 * \mathrm{N}_2 : t \in T2$$

$$\Phi_2 = \Gamma(TIOS_t)$$

$$\mathrm{N}_2 = \Omega(TIOS_t)$$

$$TIOS = \beta_1 * (TINV_t)$$

$$copv_t = prco_t * P_{\$/barrel}$$

$$P_{\$/barrel} = P_{\$/barrel}(t) \forall t \in T1, P^*_{\$/barrel} \forall t \in T2$$

$$invop_t = \beta_2 * (copv_t)$$

$$ncopv_t = copv_t - invop_t$$

$$gscop_t = \beta_3 * (ncopv_t)$$

$$csop_t = (1-\beta_3) * ncopv_t$$

$$tlcco_t = \beta_4 * (gscop_t)$$
$$xco_t = \left([(1-\beta_4) * tlcco_t] + csop_t\right) * xP_{YRI\$}$$
$$tlcco_t^* = tlcco_t * xP_{YRI\$}$$
$$xP_{YRI\$} = xP_{YRI\$}(t)\forall t \in T1, xP_{YRI\$}^*\forall t \in T2$$

Gas Production

$$RLPG_t = -\int_{t_0}^{t}(gpr_t)dt + iRLPG$$
$$\frac{\partial RLPG}{\partial t} = gpr_t : RLPG > 0{,}0 : RLPG \le 0$$
$$gpr_t = gpr_t(t)\forall t \in T1, gpr_t^*\forall t \in T2$$
$$gpr_t^* = \mathrm{N}_2 * \theta$$
$$\theta = (\theta^* * dprg_t) + dprg_t$$
$$dprg_t = 0\forall t \in T3, fidgp_t\forall t \notin T3$$
$$fidgp_t = \mathrm{A}_2(TIGS2)\forall t \in T3, \mathrm{A}_1(TIGS1)\forall t \in T2{,}0\forall t \notin T3 or T2$$
$$TIGS2_t = TIOS_t$$
$$TIGS1_t = \beta_5 * (TINV_t)$$
$$ENGR_t = -\int_{t_0}^{t}(ngpr_t)dt + iENGP$$
$$\frac{\partial ENGR}{\partial t} = dprng_t * ENGR_t$$
$$dprng_t = fidgp_t\forall t \in T3{,}0\forall t \notin T3$$
$$TPG_t = (dprg_t + dprng_t)\forall t \in T3, (dprg_t)\forall t \notin T3$$
$$TPGV_t = TPG_t * gP_t$$
$$gP_t = gP_T(t)\forall t \in T1, gP_t^*\forall t \in T2$$
$$NTPGV_t = TPGV_t - (\beta_6 * TPGV_t)$$
$$lcgp_t = lcgp_t(t)\forall t \in T1, (\beta_7 * NTPGV_t)\forall t \in T2$$
$$xgp_t = NTPGV_t - lcgp_t$$

Where
EOR_t= Expectation of Oil Reserve
$prco_t$= Production Rate of Curd Oil
Φ= Productivity Mean Per Sector
N= Number of Oil Sector
TIOS= Total Investment in Oil Sector
TINV= Total Domestic Investment
cpov= Value of Curd Oil Production
$P_{\$lbarrel}$= Price Per Barrel
Inovp= Input Value of Curd Oil Production
gscop= Government Share of Curd Oil Production
ncopv= Net Value of Curd Oil $
csop= Companies Share
tlcco= Total Local Consumption of Oil
xco= Value of Oil Export YR
$xP_{YR/\$}$= Exchange Price
β_1= Investment Rate for Oil Sector
β_2= Input Rate of OiL
β_3= Government Share Rate
β_4= Local Consumption Rate of Oil
RLPG= Reserve of LPG
Gpr= Production Rate of Gas
θ= Productivity of LPG Per Oil Sector
dprg= Development Production Rate of LPG
fidgp= Fraction Investment Which Allocated to Development Gas Production
TIGS= Total Investment in Gas Sector
ENGR= Expectation of Natural Gas Reserve
ngpr= Production Rate of Natural Gas
dprng= Development Production Rate of Natural Gas
TPG= Total Production of Gas
TPGV= Value of Gas Production
gP_t= Price of Gas YR Per Ton
NTPGV= Net Value of Gas Production
lcpg= Value of Local Consumption of GasYR
xgP= Value of Gas Export YR
β_5= Total Investment in Gas Sector
β_6= Input Rate From Gas Production
β_7= Local Consumption Rate of Gas

Table (3-5) Result of Initial Simulation of Oil View

Time (Year)	*Prco`(Barrel/*	*$P_{\$lbar}$*	*$xP_{YR/\$}$*	*Xco(Rial/Y*	*TIOS(Rial/Y*
EOR(Barrel)	*Year)*	*rel*	13.92	*rar)*	*ear)*
1990 7.9e+010	6.81044e+007	12	22.12	5.53803e+	2.60546e+0
1991 7.89319e+010	7.45916e+007	12.5	28.5	009	08
1992 7.88573e+010	6.42028e+007	14	39.54	1.00403e+	1.98629e+0
1993 7.87931e+010	7.78794e+007	15.8	55.24	010	09
1994 7.87152e+010	1.21451e+008	15.2	100	1.24706e+	2.54047e+0
1995 7.85938e+010	1.23724e+008	16.9	129.2	010	09
1996 7.847e+010	1.24505e+008	4	8	2.36279e+	3.82768e+0

1997	7.83455e+010	1.30495e+008	20.3	135.8	010	09
1998	7.8215e+010	1.32919e+008	8	8	4.95075e+	2.55817e+0
1999	7.80821e+010	1.41274e+008	18.4	55.75	010	09
2000	7.79409e+010	1.5722e+008	4	161.7	1.01574e+	4.52344e+0
2001	7.77836e+010	1.5786e+008	14.9	3	011	09
2002	7.76258e+010	1.57738e+008	4	168.6	1.55079e+	6.05391e+0
2003	7.7468e+010	1.55114e+008	18.6	3	011	09
2004	7.73129e+010	1.52532e+008	7	176	1.46954e+	9.30471e+0
2005	7.71604e+010	1.49996e+008	27.3	183	011	09
2006	7.70104e+010	1.25658e+009	9	184	1.32229e+	1.44657e+0
2007	7.57538e+010	1.47951e+009	24.5	191.4	011	10
2008	7.42743e+010	1.64495e+009	8	2	1.97159e+	1.43759e+0
2009	7.26294e+010	1.77391e+009	27.9	196	011	10
2010	7.08554e+010	1.86244e+009	5	196	3.25523e+	1.36501e+0
2011	6.8993e+010	8.68719e+009	36.6	196	011	10
2012	6.03058e+010	1.88781e+010	51.5	196	2.89751e+	1.91628e+0
2013	4.14277e+010	2.49123e+010	19	196	011	10
2014	1.65154e+010	2.80795e+010	51	196	3.29272e+	2.14978e+0
2015	-1.1564e+010	0	51	196	011	10
2016	- 1.1564e+010	0	51	196	3.80204e+	2.62739e+0
2017	-1.1564e+010	0	51	196	011	10
2018	- 1.1564e+010	0	51	196	4.98408e+	3.34398e+0
2019	- 1.1564e+010	0	51	196	011	10
2020	- 1.1564e+010	0	51	196	7.14196e+	3.28783e+0
			51	196	011	10
			51	196	5.98548e+	3.97449e+0
			51	196	012	10
			51	196	7.04735e+	1.22027e+0
			51		012	11
			51		7.83538e+	1.41639e+0
			51		012	11
			51		8.44966e+	1.56685e+0
					012	11
					8.87135e+	1.66897e+0
					012	11
					4.13796e+	9.27616e+0
					013	11
					8.9922e+0	2.11075e+0
					13	12
					1.18664e+	2.87182e+0
					014	12
					1.33751e+	3.27128e+0
					014	12
					0	3.42601e+0
					0	12
					0	1.24067e+0
					0	12
					0	9.71542e+0
					0	11
						8.76873e+0

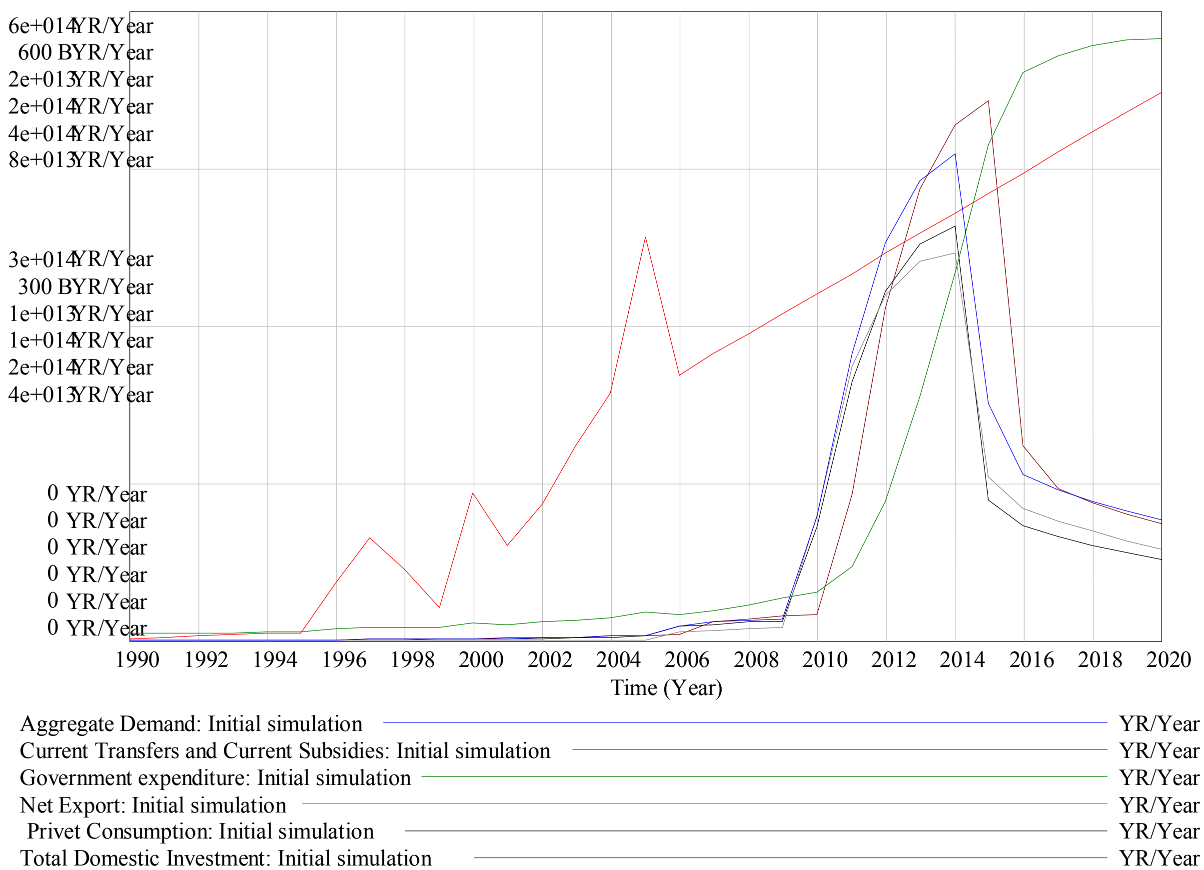
11
8.05739e+0
11
7.40354e+0
11

Table (4-5) Result of Initial Simulation of Gas View

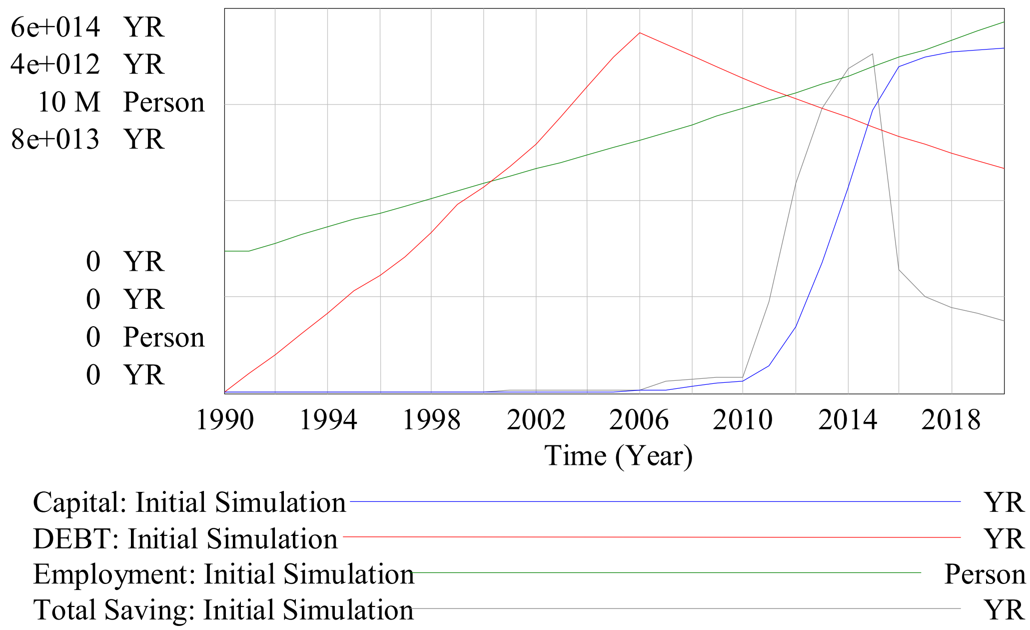
Time (Year)	Gpr(Ton/Y	ENGR(Ton	Ngpr(Ton/Y	xgP(YR/Ye	TVGOE(YR/Ye
RLPG(Ton)	ear)	)	ear)	ar)	ar)
1990 3.1e+007	7433	2.54873e+	0	0	2.46647e+009
1991 3.09926e+007	51771	011	0	0	4.47161e+009
1992 3.09408e+007	89200	2.54873e+	0	0	5.554e+009
1993 3.08516e+007	197069	011	0	0	1.06582e+010
1994 3.06545e+007	232815	2.54873e+	0	0	2.23687e+010
1995 3.04217e+007	261178	011	0	190848	4.63149e+010
1996 3.01605e+007	280080	2.54873e+	0	2.27738e+	7.67816e+010
1997 2.98805e+007	324270	011	0	006	7.60459e+010
1998 2.95562e+007	349383	2.54873e+	0	1.94048e+	5.68364e+010
1999 2.92068e+007	413220	011	0	006	9.44774e+010
2000 2.87936e+007	462783	2.54873e+	0	4.15683e+	1.76925e+011
2001 2.83308e+007	508109	011	0	006	1.4928e+011
2002 2.78227e+007	595025	2.54873e+	0	2.53082e+	1.53601e+011
2003 2.72277e+007	624813	011	0	006	1.83555e+011
2004 2.66029e+007	480000	2.54873e+	0	3.83465e+	2.26461e+011
2005 2.61229e+007	500000	011	0	007	3.32642e+011
2006 2.56229e+007	331738	2.54873e+	0	1.81089e+	2.97198e+012
2007 2.52911e+007	346416	011	0	007	3.49909e+012
2008 2.49447e+007	349914	2.54873e+	0	5.73261e+	3.89024e+012
2009 2.45948e+007	352598	011	0	007	4.19514e+012
2010 2.42422e+007	322199	2.54873e+	1.07555e+0	0	3.99921e+013
2011 2.392e+007	360000	011	10	5.92416e+	8.70116e+013
2012 2.356e+007	360000	2.54873e+	2.00894e+0	008	1.09448e+014
2013 2.32e+007	360000	011	10	6.1908e+0	1.20286e+014
2014 2.284e+007	360000	2.54873e+	1.95885e+0	08	1.23272e+014
2015 2.248e+007	360000	011	10	1.09766e+	5.19993e+013
2016 2.212e+007	360000	2.54873e+	1.85522e+0	009	4.23458e+013
2017 2.176e+007	360000	011	10	1.14622e+	3.82607e+013
2018 2.14e+007	360000	2.54873e+	1.71915e+0	009	3.49297e+013
2019 2.104e+007	360000	011	10	1.1578e+0	3.19422e+013
2020 2.068e+007	360000	2.54873e+	1.57151e+0	09	2.92286e+013
		011	10	1.16668e+	
		2.54873e+	1.27976e+0	009	
		011	10	3.55888e+	
		2.54873e+	1.1563e+01	013	
		011	0	6.64729e+	
		2.54873e+	1.05563e+0	013	
		011	10	6.48158e+	
		2.54873e+	9.65335e+0	013	
		011	09	6.13869e+	
		2.54873e+	8.83324e+0	013	

011	09	5.68845e+
2.44117e+		013
011		5.19993e+
2.24028e+		013
011		4.23458e+
2.04439e+		013
011		3.82607e+
1.85887e+		013
011		3.49297e+
1.68695e+		013
011		3.19422e+
1.5298e+0		013
11		2.92286e+
1.40183e+		013
011		
1.2862e+0		
11		
1.18064e+		
011		
1.0841e+0		
11		

Figure (9-5) Mine Result of Initial simulation of GDP View



Figure(10-5) Main Results for Initial Simulation of GDP View



$$Y_t = PC_t + GE_t + TINV_t + NE_t$$

$$PC_t = \alpha_{PC} * C_t$$

$$C_t = \alpha_c * CDI_t$$

$$CDI_t = GDP_t - NIT_t$$

$$GDP_t = IND_t + PGS_t + PNPSF_t + CDU_t - IBS_t$$

$$NIT_t = ITR_t - gt_t$$

$$ITR_t = ITR_t(t) \forall t \in T1, f(GDP_t) \forall t \in T2$$

$$gt_t = \alpha_{subsidy} * CGTS_t$$

$$GE_t = PWS_t + CGTS_t + CAD_t + GOSE_t$$

$$PWS_t = \mu_{PS} * PEM_t * 12$$

$$CGTS_t = CGTS_t(t) \forall t \in T1, (\alpha_{CGTS} + \beta_{CGTS}(t) \forall t \in T2$$

$$CAD_t = {CA_t}/{\mu_{ALC}}$$

$$CA_t = \int_{t_0}^{t} (CAI_t - CAD) dt_t + iCA$$

$$\frac{\partial CA_t}{\partial t} = CAI_t - CAD_t$$

$$CAI_t = \max(0, TINV_t + NLRW_t)$$

$$NLRW_t = RA_t + DC_t$$

$$RA_t = RA_t(t) \forall t \in T1, [\alpha_{RA} + \beta_{RA}(t)] \forall t \in T2$$

$$DC_t = DC_t(t) \forall t \in T1, [\max(0, (\frac{DL_t}{tal}) * edodl)] \forall t \in T2$$

$$TINV_t = INFS_t + FINV_t$$

$$INFS_t = \alpha_{INV} * TS_t$$

$$TS_t = \int_{t_0}^{t} (SR_t - INFS_t) dt + iTS$$

$$\frac{\partial TS_t}{\partial t} = SR_t - INFS_t$$

$$SR_t = (1 - \alpha_C) * CDI_t$$

$$NE_t = NAE_t + NOGE_t + NMPE_t$$

$$DEBT_t = \int_{t_0}^{t} (NGD_t - LP_t) dt + iDEBT$$

$$\frac{\partial DEBT_t}{\partial t} = NGD_t - LP_t$$

$$NGD_t = (-NGDR_t) \forall NGDR \leq 0, 0 \forall NGDR > 0$$

$$NGDR_t = GR_t - GE_t$$

$$LP_t = {DEBT_t}/{mp}$$

$$EMP_t = \int_{t_0}^{t} EMPR_t dt + iEMP$$

$$\frac{\partial EMP}{\partial t} = EMPR_t$$

$$EMPR_t = (\alpha_{EMP} * LF_t) - EMP_t$$

$$LF_t = (\xi_{2t} + \xi_{3t}) * \alpha_{LF}$$

$$INC_t / capita = \frac{CDI_t}{\xi_t}$$

Where

Y_t= Aggregate Demand

PC_t=Privet Consumption

GE_t=Government expenditure

NE_t=Net Export

C_t=Consumption

CDI_t=Current Disposable Income

GDP_t=GDP at Market Price

NIT_t="Indirect Taxes (net)"

IND_t=Industries

PGS_t=Producers of Government Services

$PNPSF_t$=Producers of Non Profit Bodies Serving Families

CDU_t=Custom Duties

IBS_t=Imputed Bank Services

ITR_t=Indirect Tax Revenue

gt_t=Government Transfer

$CGTS_t$=Current Transfers and Current Subsidies

PWS_t=Wages and Salary for Public Sector

CAD_t=Capital Depreciation

$GOSE_t$=Goods and Service Expenditures

PEM_t=Employment for Public Sector

μ_{PS}=Monthly Average Wages for Public Sector

CA_t=Capital

μ_{ALC}= Average Life of Capital

CAI_t= Capital Investment

$NLRW_t$= Net Lending to the Rest of The World

RA_t= Reserve Assets

DC_t= Debt Commitment

$INFS_t$= Investment from Savings

$FINV_t$= Foreign Investment

TS_t= Total Saving

SR_t= Saving Rate

NAE_t= Net Agriculture Export

$NOGE_t$= TOTAL VALUE OF GAS AND OIL EXPORT

$NMPE_t$= NET EXPORT VALUE OF MANUFACTURING PRODUCTION

NGD_t= Net Government Deficit

LP_t= Loan Payment

$NGDR_t$= Net Government Deficit Rate

GR_t= Government Revenue

mp= Maturity Period

EMP_t= Employment

$EMPR_t$= Employment Rate

LF_t= Labor Force

INC/capita= Income per Capita YR

Table (5-5) Result of Initial Simulation of GDP View

Time	Aggregate Demand	Privet Consumption	Government expndture	Total Domestic Investment	Current Transfers and Current Subsidies	Net Export
1990	3.0009e+011	6.31772e+010	2.27189e+011	5.21092e+009	2.27447e+009	2.2379e+009
1991	3.6756e+011	9.13468e+010	2.29232e+011	3.97258e+010	3.11144e+009	4.14423e+009
1992	4.45684e+011	1.40541e+011	2.45032e+011	5.08094e+010	4.15672e+009	5.14581e+009
1993	5.43537e+011	1.91286e+011	2.60201e+011	7.65536e+010	5.40557e+009	1.00906e+010
1994	6.27211e+011	2.66944e+011	2.80429e+011	5.11634e+010	6.98038e+009	2.16939e+010
1995	8.78244e+011	4.42896e+011	2.92828e+011	9.04688e+010	6.8107e+009	4.52395e+010
1996	1.30038e+012	6.77097e+011	3.72805e+011	1.21078e+011	5.5432e+010	7.39684e+010
1997	1.55029e+012	7.54505e+011	4.38132e+011	1.86094e+011	9.8475e+010	7.30805e+010
1998	1.63388e+012	7.96232e+011	4.25714e+011	2.89313e+011	6.8609e+010	5.40093e+010
1999	1.81191e+012	9.91471e+011	4.10632e+011	2.87519e+011	3.1527e+010	9.076e+010
2000	2.41194e+012	1.27701e+012	5.47194e+011	2.73002e+011	1.41579e+011	1.7315e+011
2001	2.60801e+012	1.47037e+012	5.20295e+011	3.83256e+011	9.0597e+010	1.43496e+011
2002	2.9382e+012	1.6446e+012	5.85073e+011	4.29956e+011	1.3104e+011	1.47531e+011
2003	3.53611e+012	1.97873e+012	6.71092e+011	5.25478e+011	1.8594e+011	1.7487e+011
2004	4.06942e+012	2.18949e+012	7.54496e+011	6.68795e+011	2.3592e+011	2.20713e+011
2005	5.13349e+012	2.82304e+012	9.43311e+011	6.57565e+011	3.84967e+011	3.24606e+011
2006	1.40932e+013	9.24321e+012	8.36819e+011	7.94899e+011	2.53885e+011	2.96436e+012
2007	1.77445e+013	1.05776e+013	9.61952e+011	2.44053e+012	2.73083e+011	3.4914e+012
2008	1.98585e+013	1.17025e+013	1.14844e+012	2.83278e+012	2.9228e+011	3.88253e+012
2009	2.14376e+013	1.2455e+013	1.35005e+012	3.1337e+012	3.11477e+011	4.18743e+012
2010	1.17981e+014	7.2769e+013	1.55944e+012	3.33793e+012	3.30679e+011	3.99843e+013
2011	2.73017e+014	1.64769e+014	2.34246e+012	1.85523e+013	3.49876e+011	8.70036e+013
2012	3.78731e+014	2.22249e+	4.45797e+	4.22151e+	3.69074e+011	1.0944e+014
2013	4.37945e+014				3.88271e+011	1.20278e+014
2014	4.64133e+014				4.07468e+011	1.23263e+014
2015	2.26239e+014				4.26666e+011	5.19911e+013
2016	1.59128e+014				4.45863e+011	4.23378e+013
2017	1.43375e+014				4.6506e+011	3.82528e+013
2018	1.33037e+014				4.84258e+011	3.49218e+013
2019	1.23783e+014				5.03455e+011	3.19342e+013
2020	1.15453e+014				5.22652e+011	2.92206e+013

014	012	013
2.52067e+	7.7755e+0	5.74364e+
014	12	013
2.63348e+	1.1688e+0	6.54257e+
014	13	013
8.95515e+	1.57494e+	6.85202e+
013	013	013
7.35082e+	1.80227e+	2.48134e+
013	013	013
6.66321e+	1.85945e+	1.94308e+
013	013	013
6.11979e+	1.88955e+	1.75375e+
013	013	013
5.61623e+	1.90684e+	1.61148e+
013	013	013
5.17627e+	1.91395e+	1.48071e+
013	013	013

Table (6-5)Result of Initial Simulation of GDP View

Time(Year)	Total Saving(YR)	Employment(Person)	Capit(YR)	DEBT(YR)
			1.5074e+010	5e+007
1990	1.0136e+010	3.69047e+006	1.82613e+010	2.02294e+011
1991	1.80008e+010	3.69047e+006	5.4199e+010	3.97682e+011
1992	2.37554e+010	3.89675e+006	1.09031e+011	6.10961e+011
1993	3.65486e+010	4.09786e+006	1.85436e+011	8.30743e+011
1994	4.97454e+010	4.29476e+006	2.28669e+011	1.05744e+012
1995	6.94208e+010	4.48832e+006	2.86642e+011	1.22907e+012
1996	1.15178e+011	4.67931e+006	3.23128e+011	1.41747e+012
1997	1.85874e+011	4.86844e+006	4.53282e+011	1.67709e+012
1998	1.97515e+011	5.05631e+006	7.83599e+011	1.95331e+012
1999	2.07066e+011	5.24351e+006	9.94153e+011	2.13841e+012
2000	2.57839e+011	5.43052e+006	9.89424e+011	2.35892e+012
2001	3.84954e+011	5.61782e+006	1.21999e+012	2.585e+012
2002	3.97777e+011	5.80582e+006	1.52153e+012	2.86763e+012
2003	4.2769e+011	5.99491e+006	1.95223e+012	3.17151e+012
2004	5.14584e+011	6.18546e+006	2.47372e+012	3.47837e+012
2005	5.69393e+011	6.37779e+006	2.9438e+012	3.74277e+012
2006	7.34151e+011	6.57222e+006	5.58025e+012	3.61801e+012
2007	2.42634e+012	6.76902e+006	1.00525e+013	3.49741e+012
2008	2.82538e+012	6.96849e+006	1.49734e+013	3.38083e+012
2009	3.1302e+012	7.17087e+006	2.01216e+013	3.26813e+012
2010	3.33526e+012	7.37641e+006	4.24728e+013	3.1592e+012
2011	1.90267e+013	7.58536e+006	1.04792e+014	3.05389e+012
2012	4.34345e+013	7.79793e+006	2.03165e+014	2.95209e+012
2013	5.9133e+013	8.01435e+006	3.19381e+014	2.85369e+012
2014	6.73701e+013	8.23483e+006	4.40055e+014	2.75857e+012
2015	7.05572e+013	8.45958e+006	5.07078e+014	2.66661e+012
2016	2.54581e+013	8.68881e+006	5.23048e+014	2.57773e+012
2017	1.98992e+013	8.92271e+006	5.30885e+014	2.4918e+012
2018	1.79401e+013	9.16149e+006	5.34869e+014	2.40874e+012
2019	1.64666e+013	9.40535e+006	5.35791e+014	2.32845e+012
2020	1.51118e+013	9.65447e+006		

5. Discussion

In a complex system we cannot compute every effect and behavior of variables on model. The mathematical approaches to the study of dynamical systems are existed since the days of Newton and Leibniz (Peter Turchin,2005). The most common and incredibly fruitful mathematical tool is the differential equation, which looks like this:

$$X' = f(X)$$

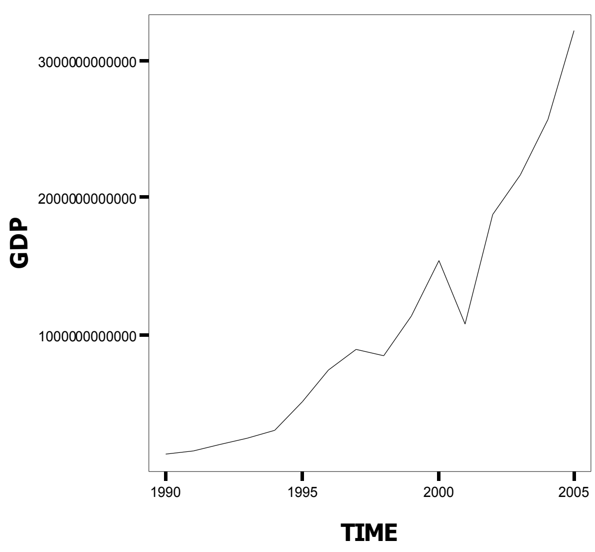
where X is a variable describing some aspect of the system. On the left hand side we see X with a dot on top, which denotes the derivative, or rate of change of X. To the right of the equals sign, $f(X)$ means some function of X. For example, if $f(X)=rX$, then we have an exponential model: $X'=rX$, which assumes that the rate of change of the variable X is directly proportional to the value of the variable X. Even a third order, linear differential equation is unsolvable by inspection. Important situations in management, economics, medicine, and social behavior usually lose reality if simplified to less than fifth-order nonlinear dynamic systems. Often the model representation must be twentieth order or higher.

The previous model represents the actual system behavior as it is observed in real life. It should be decrease the random error because we can put every variables which we think in the model and we can test every change in it. Values and Parameter values are drawn from all available sources, not merely from statistical analysis of time series. Regression modeling is usually a cross-sectional view of the relationship among variables at a single point in time. The numbers of cases included in a sample provide the variation to construct the parameter estimates. In contrast, simulation modeling (System Dynamics model) is a longitudinal analysis of the variables and their relationship over time. Thus, time is a primary variable as is the effect that variables have on each other. The difference is largely between a cross-sectional and a longitudinal analysis. The methods overlap when time is used as a variable in the regression equation that leads to time-series analysis. The purpose of the two methods is still different, however. The emphasis in regression analysis (linear or non-linear) is to estimate the regression coefficients as indicators of the structure of a system; the emphasis in simulation analysis (System Dynamics) is to use those coefficients in extrapolating the value of variables over time.

Let's take GDP value to comparing between System Dynamics model and linear regression model.

Table (6-1) GDP (Million Rial) at 1990-2005(CSO,2005)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
126489	150986	192047	238332	306404	511058	736385	888808	849321	1132619	1538636	1076049	1878007	2160608	2563490	3208501



The above graph shows real historical data of GDP.

We can estimate the parameters from linear function as follow:

$Y = \alpha + \beta X$

Where α and β are constant. The kind of relationship between independent and dependent variables is taken from economic theory. The simple regression model in which time is independent variable and GDP is dependent variable, the estimated value of parameters is *α = -368083522.87 β = 184821.46*

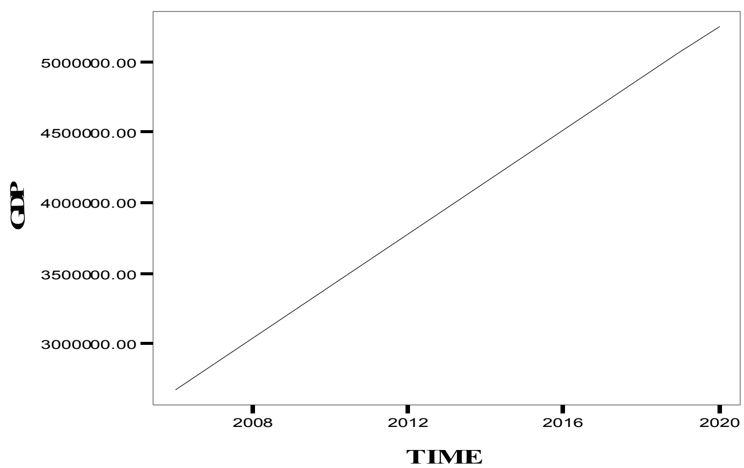
GDP_T =-368083522.87 + 184821.46 (Time) + ε

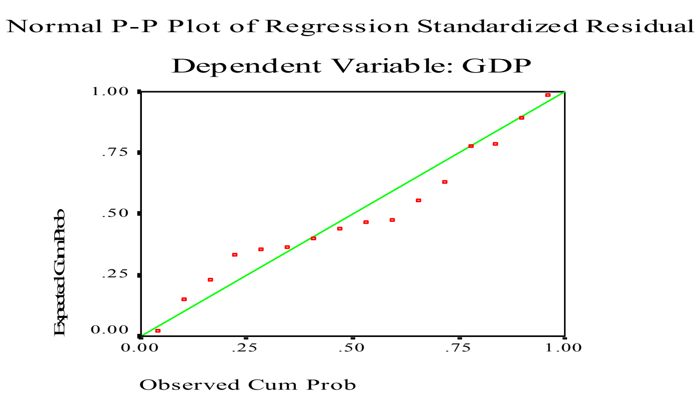
(-10.28) (10.31)

Where ε is error term

R= 0.94 DW= 0.82

That is meaning the time variable determining 94% for the change average of GDP.
It underestimate the true variance.
the t values look too good
will reject H_0 when it is true
So estimates will be unbiased but inefficient (not least variance).
Statistically this model have autocorrelation problem. Time is often a parameter of the equation because we hope to use the model to forecast a value for a certain time period, but time cannot stand alone as the economic independent variable.
The below graph show the prediction value for GDP through 2005-2020 period





Economic theory was telling us about GDP function as follow:
GDP = Consumption + Government expenditure + Investment + Net export

Table (6-2) GDP Component through 1990-2005

Year	GDP	CONS	INVES	GEXP	NEXP
1990	**126489**	**93298**	**18046**	**22115**	**-7330**
1991	**150986**	**130802**	**24334**	**28800**	**-32950**

1992	**192047**	**154274**	**43026**	**37187**	**-42440**
1993	**238332**	**212810**	**48249**	**45483**	**-68210**
1994	**306404**	**243543**	**64390**	**57585**	**-59114**
1995	**511058**	**428428**	**112713**	**74017**	**-104100**
1996	**736385**	**483433**	**170879**	**97458**	**-15385**
1997	**888808**	**571757**	**221215**	**116832**	**-20996**
1998	**849321**	**576227**	**276465**	**124473**	**-127844**
1999	**1132619**	**770168**	**278493**	**156273**	**-72315**
2000	**1538636**	**797196**	**264274**	**194133**	**124209**
2001	**1076049**	**1086959**	**325114**	**236313**	**13715**
2002	**1878007**	**1265702**	**347128**	**279088**	**-13911**
2003	**2160608**	**1448769**	**447822**	**1448769**	**-32545**
2004	**2563490**	**1698053**	**519868**	**1698053**	**23672**
2005	**3208501**	**2058537**	**594523**	**2058537**	**162500**

The above table shows real historical data of GDP and macroeconomic variables.
We can use multi regression analysis to estimate statistical parameter by using SPSS program:

$\alpha = 81460.89$ $\beta_1 = 0.67$ $\beta_2 = 1.99$ $\beta_3 = 0.16$ $\beta_4 = 1.48$

$R = 0.98$ $DW = 3.09$

$$GDP = 81460.89 + \underset{(0.88)}{0.67}\,(\mathbf{CONS}) + \underset{(1.50)}{1.99}\,(\mathbf{INVES}) + \underset{(1.53)}{0.16}(\mathbf{GEXP}) + \underset{(1.15)}{}\ \underset{(2.00)}{1.48}\,(\mathbf{NEXP}) + \varepsilon$$

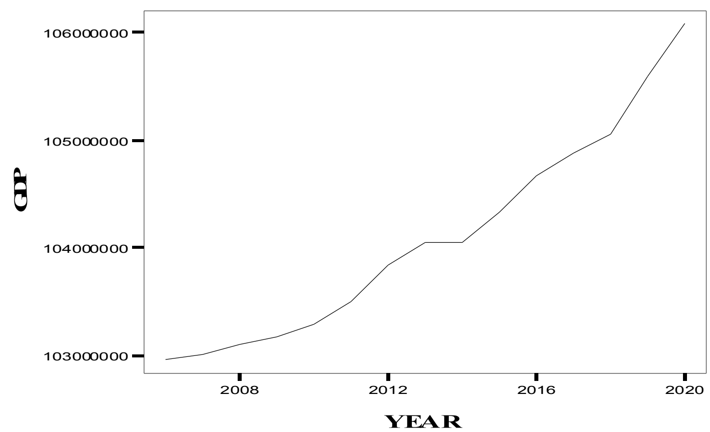
In this model we can't predict through time but we can do if we know any values of independent variables. It is inflexible to change parameters estimator values; we have insignificant estimators for all parameters. If we enter the time into the model we have the follow equation:

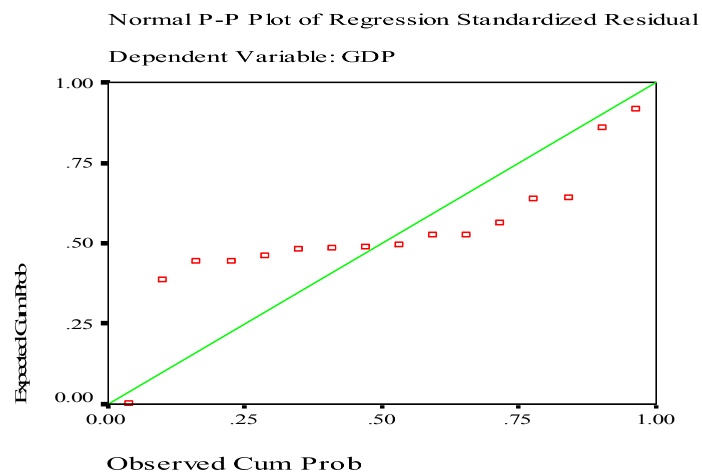
$\alpha = -101923864.74$ $\beta_1 = 0.45$ $\beta_2 = 0.95$ $\beta_3 = 0.29$ $\beta_4 = 1.55$ $\beta_5 = 51243.78$

$R = 0.99$ $DW = 3.10$

$$GDP = \underset{(-0.85)}{-101923864.74} + \underset{(0.85)}{0.45}(\mathbf{CONS}) + \underset{(0.53)}{0.95}(\mathbf{INVES}) + \underset{(1.38)}{0.29}(\mathbf{GEXP}) + \underset{(2.06)}{1.55}(\mathbf{NEXP}) + \underset{(0.85)}{51243.78}\,(\mathbf{YEAR}) + \varepsilon$$

Where ε is error term



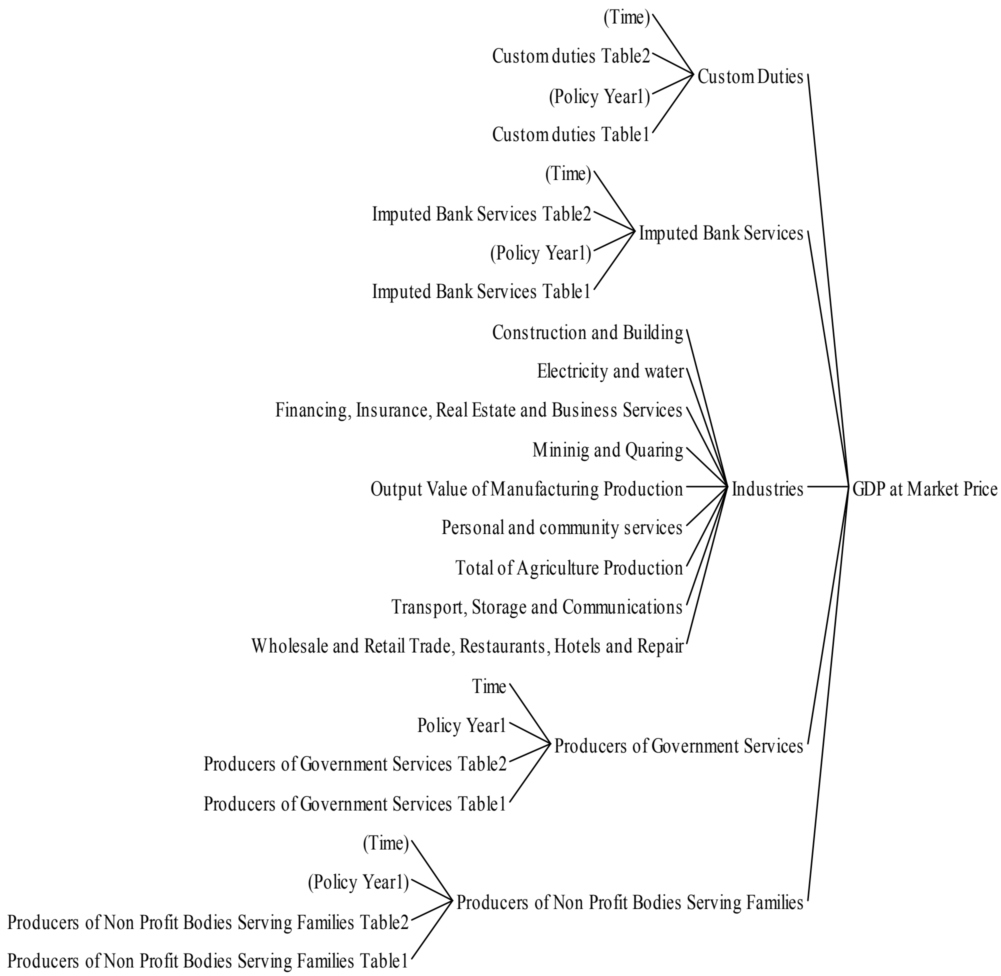


The above graphs show the predicted value of GDP and residuals through 2006-2020 periods. This model tells us about GDP increase forever and 99% of change in GDP value depend only on five variables as function shows, but if we are in need to understand and determine the behavior of the variables and their interactive effect, we must make more analysis and more function with more variables.

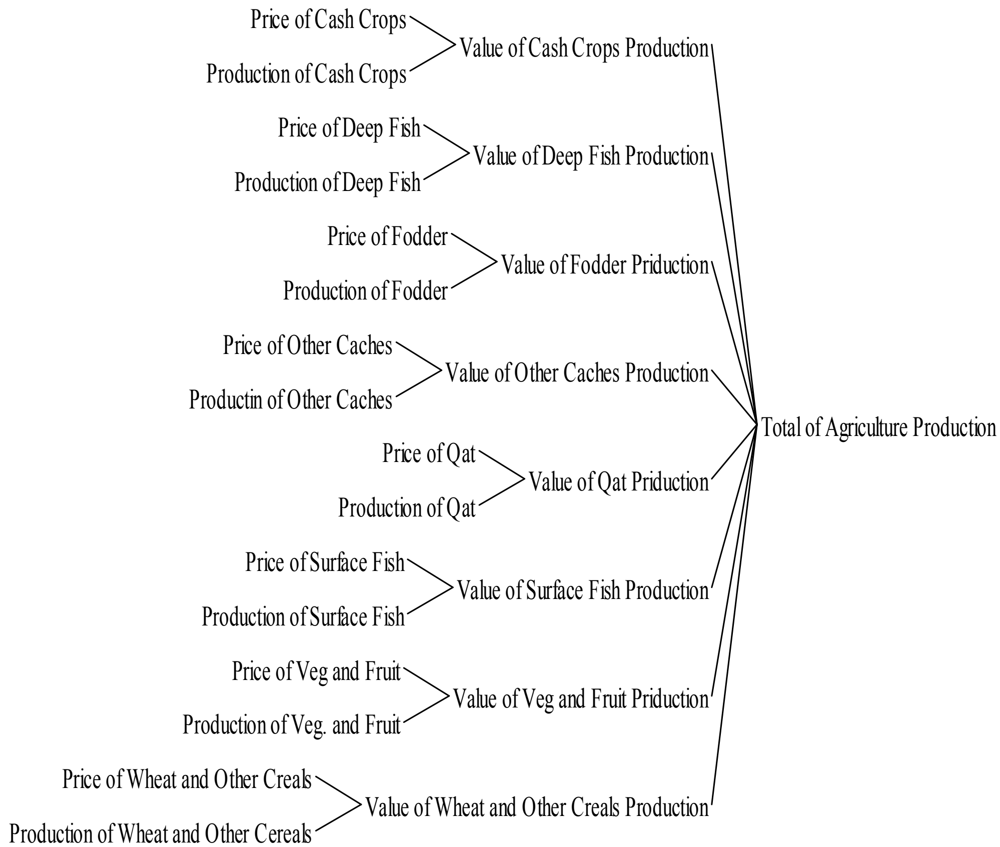
6. System Dynamics Model Analysis

From macroeconomic system dynamic model of Yemen we can see the main difference between System Dynamics model and other linear or non-linear models which we can use in statistical analysis. We have more than 600 variables in our models. The model consists of 4 kinds of variables, Level, rate, lookup and constant. These variables relate to each other by 500 linear and non-linear equations with statistical parameters estimator. All stock equations are integral which depend on accumulation and all flows equation are differential. However, in this study we are not focus on mathematical solutions but we show the theoretical properties for System Dynamic and the main difference than regression analysis .

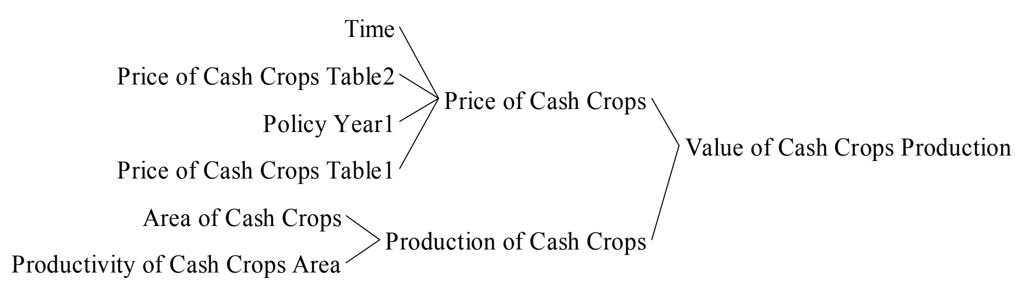
If we choose one of main variables, for example GDP. The relationship between variables which affect GDP was get from model diagram that shows causal loop. We can add any variables which we think and we can make all possible causal loop. The below diagram show all real components of productive sector and the historical data of GDP in the model.



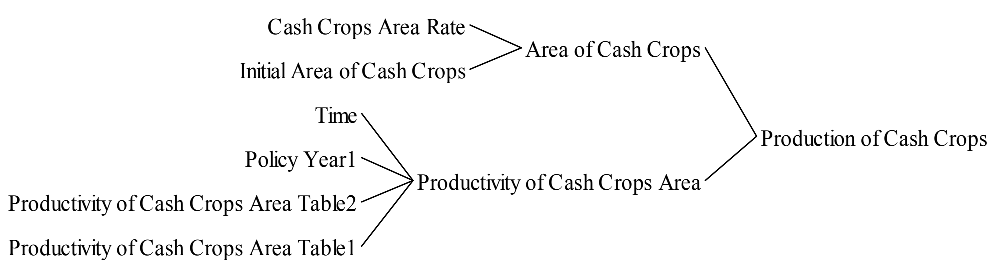
Also we can take one of these components to know its components for example agriculture sector.



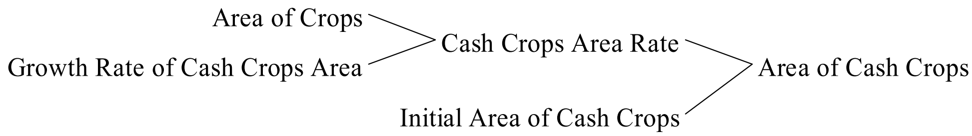
we take one of crops and we see variables and parameters which make effect, for example: Cash Crops.



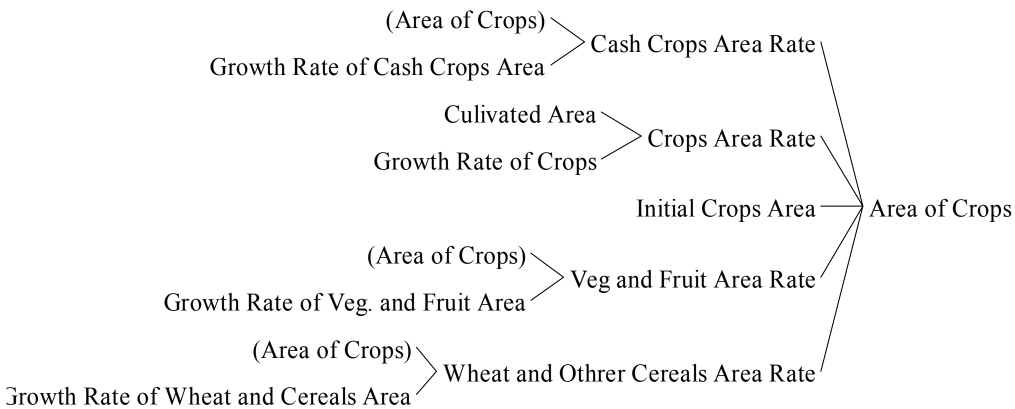
and we take one of these variables and show all possible formula which relating to parameters.
For example: Production of Cash Crops



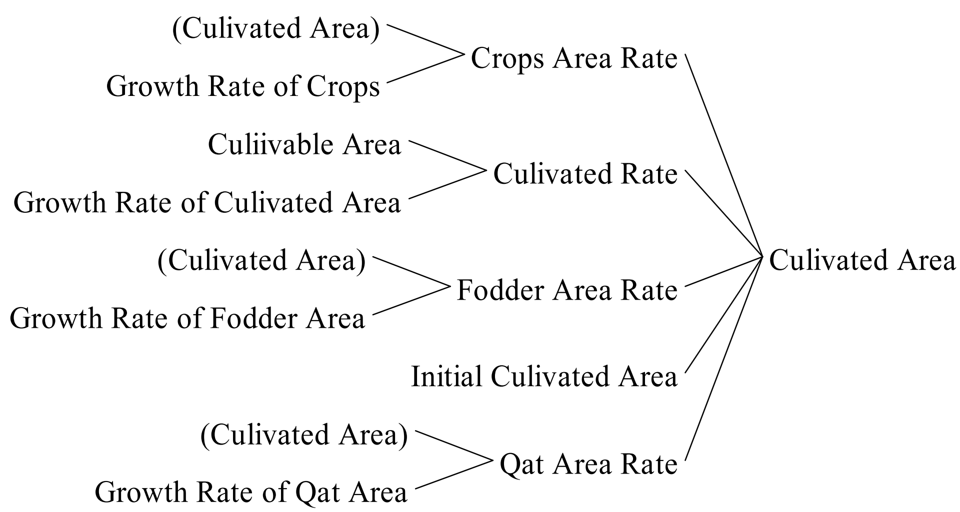
From production of Cash Crops diagram we take Area of Cash Crops variable.



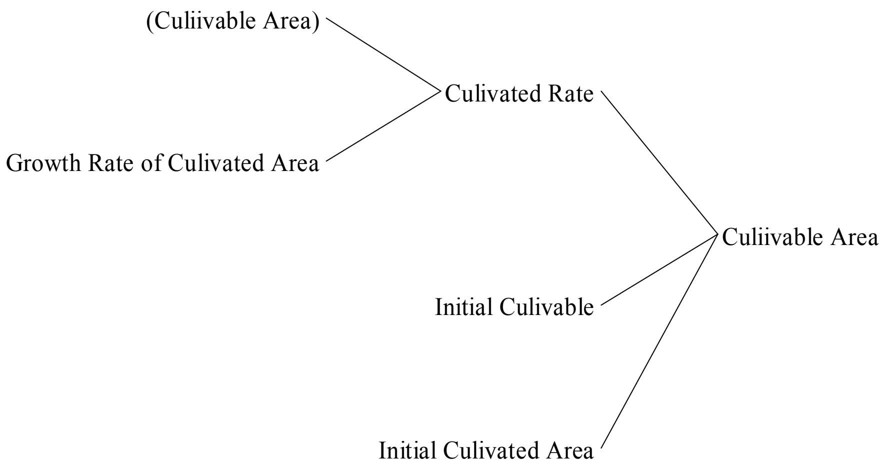
Area of Crops



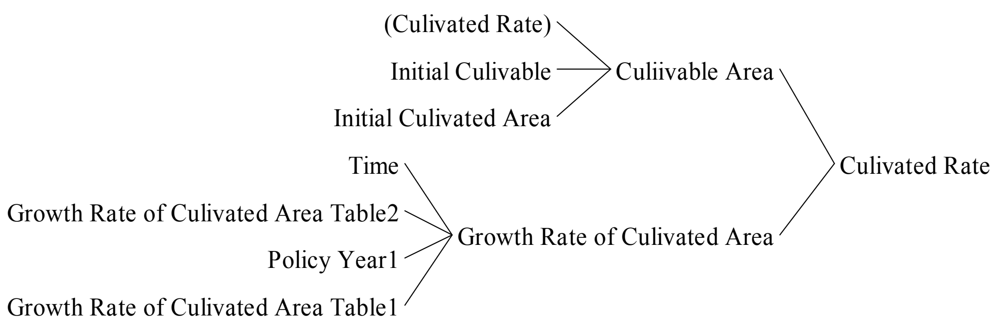
Cultivated Area



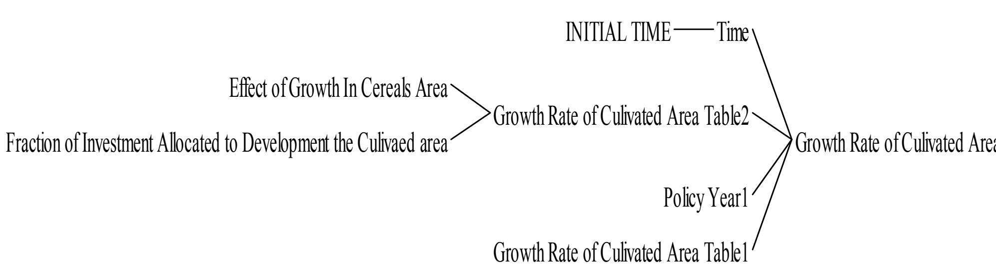
Cultivable Area



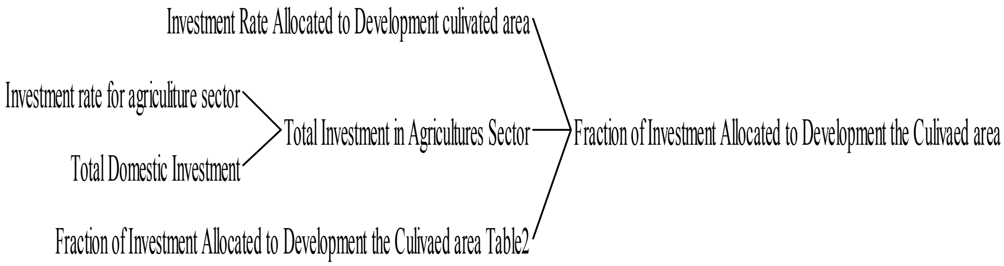
Cultivated Rate



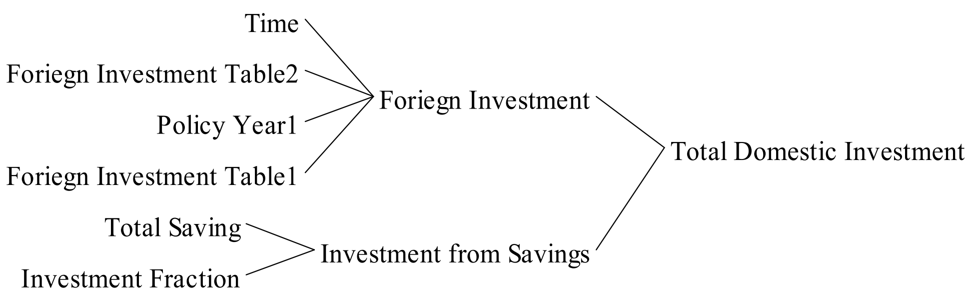
Growth Rate of Cultivated Area



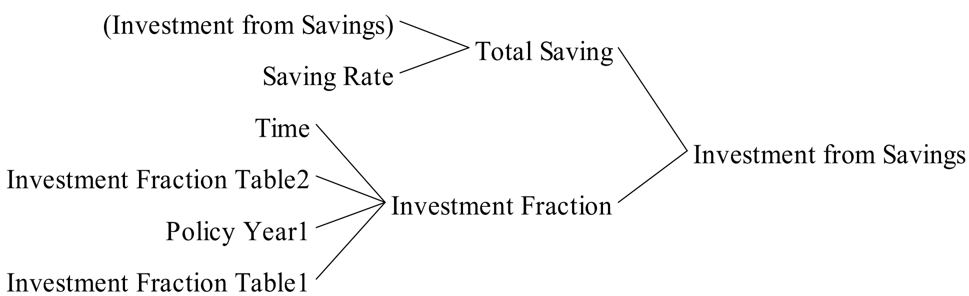
Fraction Investment Allocated to Development the Cultivated Area



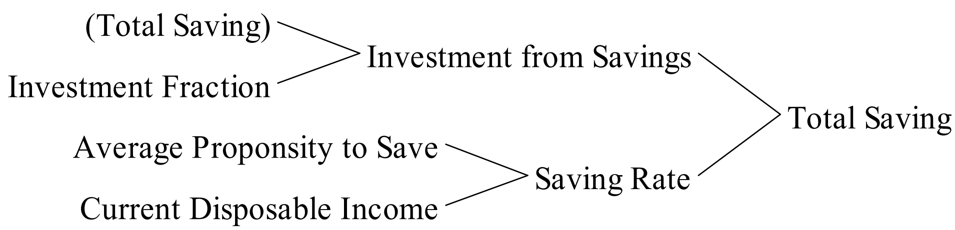
Total Domestic Investment



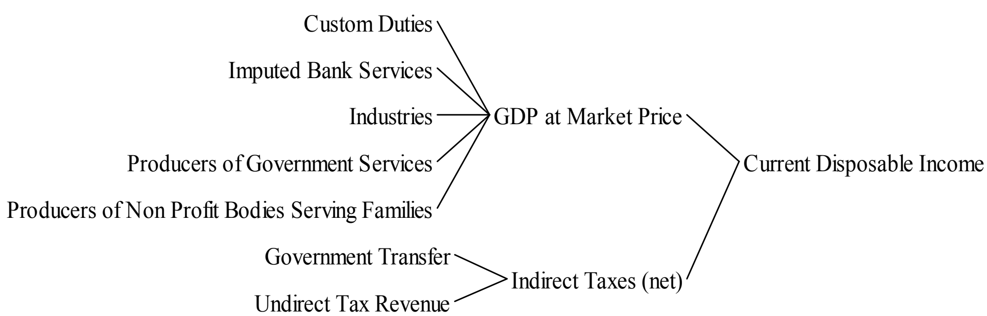
Investment From Saving



Total Saving



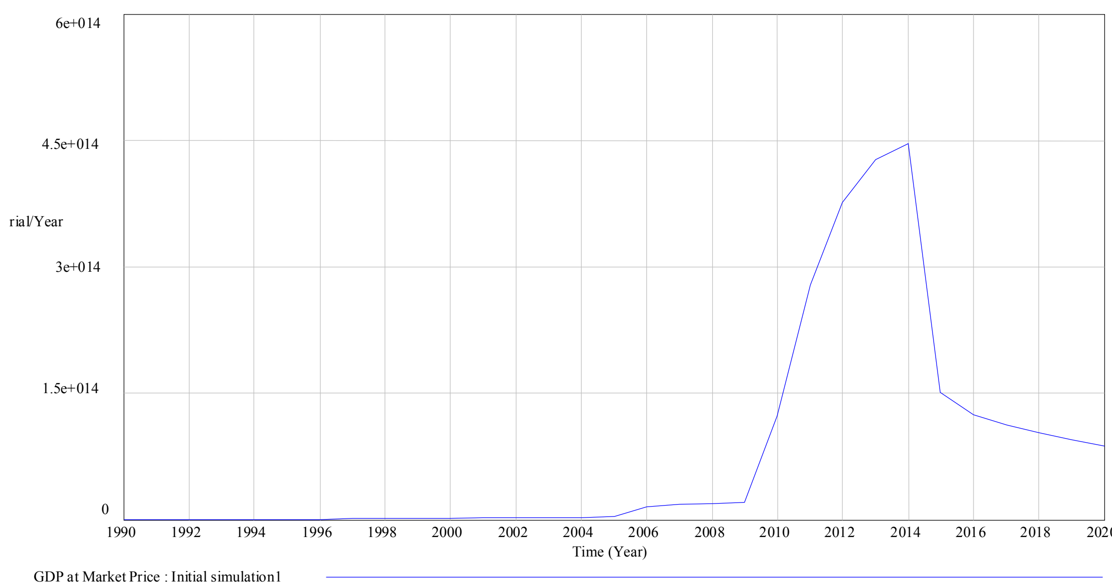
Current Disposable Income



All of previous diagram lead us to beginning step, so more loops we can follow in same way.

In our model the GDP chart presents the historical data and prediction value through 1990-2020 periods.

Figure (6- 1)GDP at Market Price , historical and predicted value (1990-2020)



in above chart we note increase in GDP value until 2014 then beginning to decrease because production value in Yemen depends on oil production and oil production depends on Production Rate of Cured Oil that depends on Expectation of Oil Reserve, this causality relationship is not exist in regression analysis as we see in the three regression models. So system dynamic is more realistic than regression model and holistic.

7. Sensitivity Analysis

Sensitivity analysis is used to determine how “sensitive” a model is changed according to the change of the parameters value within the model and the changes in the structure of the model. Sensitivity tests help us to understand dynamics of a system. Experimenting with a wide range of values can offer insights into behavior of a system in extreme situations. Discovering that the system behavior greatly changes for a change in a parameter value can identify a leverage point in the model, a parameter whose specific value can significantly influence the behavior mode of the system. in this analysis we focus on parameter sensitivity. we depend on historical data which compute from statistical books. We try to determine economics variables and behavior of the production sector in the future under follows realties

1- our model is open model, we can add many of variables.

2- we assume the data is true.

3- we focus on main productive sectors only as agriculture and oil sector.

4- we use OLS method to estimate unknown parameters in all subsystem in the model.

5- we use computer program simulation (VENSIM PLE) which used monte-carlo simulation method.

The model is described macroeconomic of Yemen as we thought. In initial state of the model we can see the growth in agriculture sector is limited because the cultivable Area will be decreased and also oil sector,which all production value depend on it, will decrease. It will be ended after many years. So we are in need to discover other sources or develop the source which existent. System Dynamic provide many Scenarios to solve problem and give us many choices to make decision.

In our model, we can see

1- Total Fertility is very high

2- Cultivable Area is limited

3- Consumption of agriculture production is very high

4- Growth in fishing sector is very low

5- Trading balance is negative

6- Most income is oil production income

7- Oil production per year is decrease and Expectation of Oil Reserve is limited

8- Government expenditure is very high

9- DEBT is very high

10- Domestic investment is very low

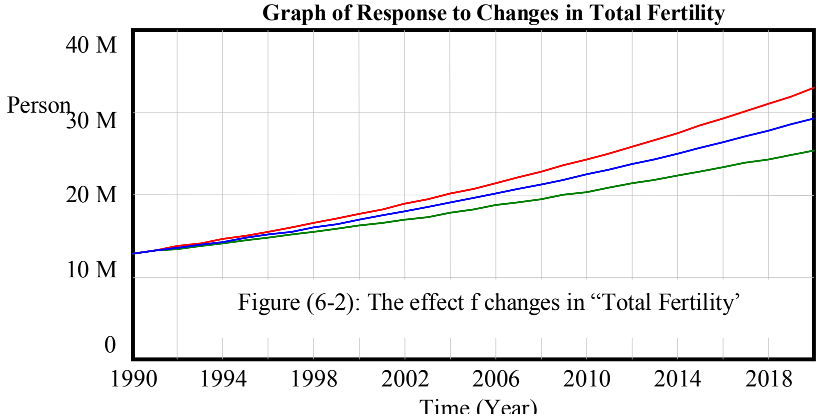
In this section we look at model and explore how sensitive it is to changes in parameters and initial values of stocks.

Let's now look at the behavior of the system when started in equilibrium. We can't choose all variables in the model because they are many, but we focus on main variables to explain behavior of the system.

First Scenario

Let's assume that the Total Fertility change to 5 child/wn and 6.5 child/wn another way at time 1 year. Below Figures show the resulting behavior of the variables which affect parameters.

Graph of Response to Changes in Total Fertility

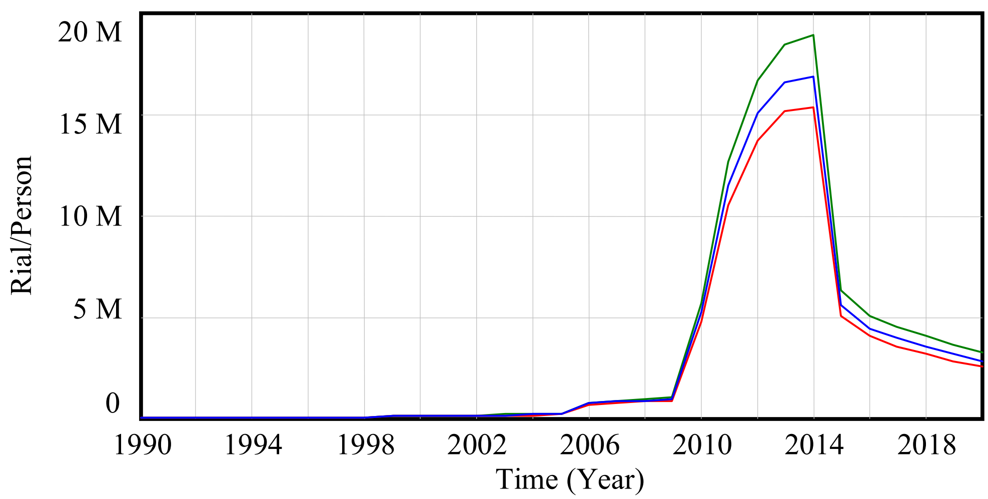


Population : Total Fertility 5.8 (child/wn) person
Population : Total Fertility 6.5 (child/wn) person
Population : Total Fertility 5 (child/wn) person

Figure (6-2): The effect f changes in “Total Fertility’

A change in "Total Fertility" creates a simultaneous change in the initial number of population, where "Total Fertility" is low, births rate is low. The result is a number of population in curve 3 growth lower than a number of population in curve 2 and 1.

Graph of Response to Changes in Total Fertility



Income per Capita YR :Total Fertility 5.8 (child/wn) Rial/person
Income per Capita YR : Total Fertility 6.5 (child/wn) Rial/person
Income per Capita YR : Total Fertility 5 child/wn) Rial/person

Figure (6-3): The effect of changes in “Total Fertility’

When we divide income to population, income per capita is increase.

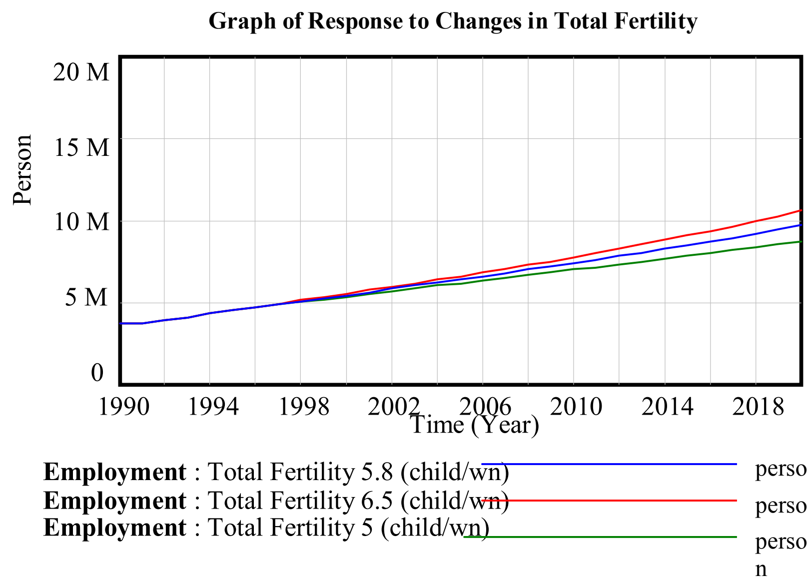


Figure (6-4): The effect of changes in "Total Fertility'

low number of population, a result is low number of employment.

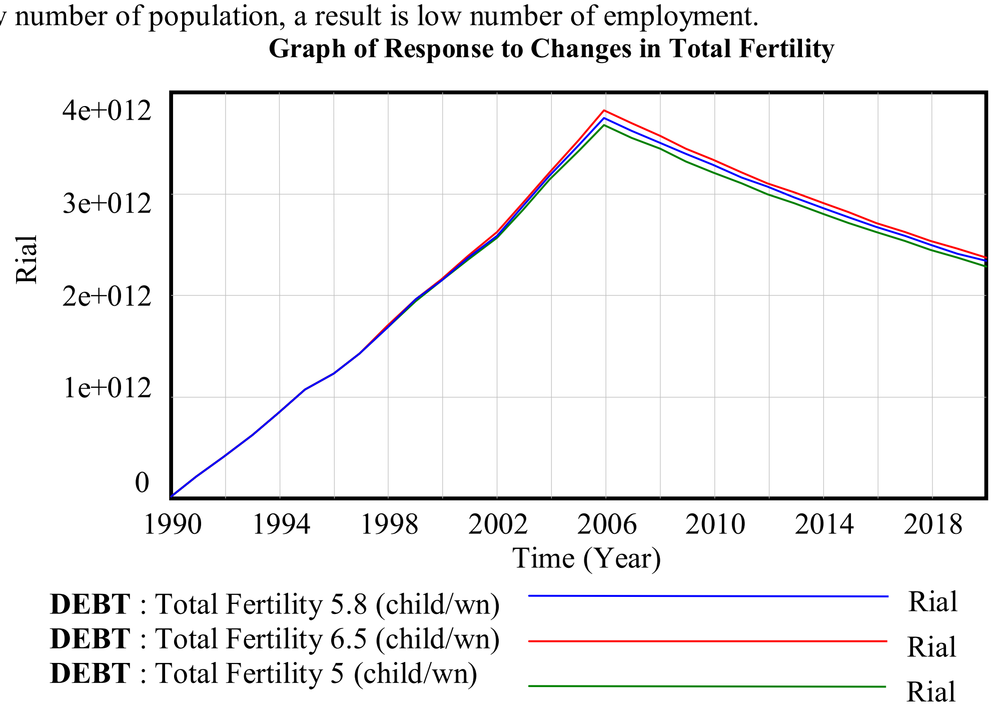


Figure (6-5): The effect of changes in "Total Fertility'

low number in employment, cause low number employment in public sector so low value of government expenditure lead to low debt.

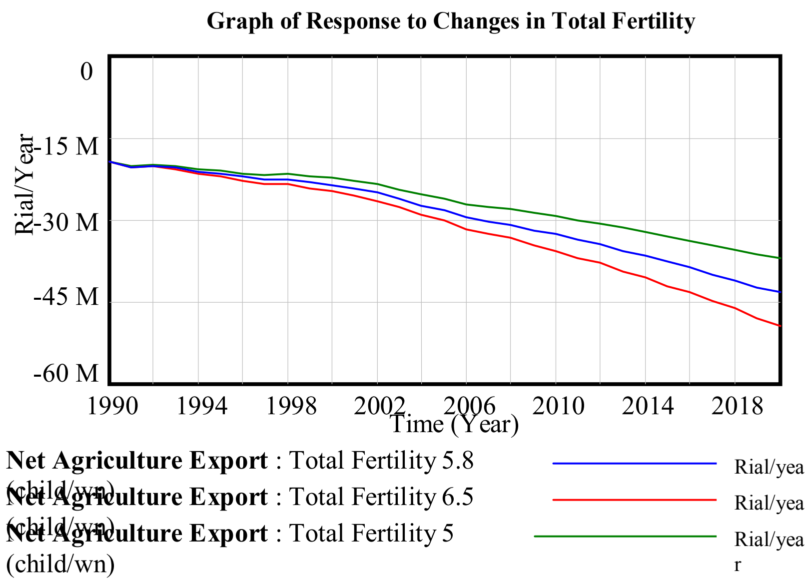


Figure (6-6): The effect of changes in "Total Fertility'

low population, result low local consumption of agriculture production so export value of agriculture production will be increased during the time. Although the three curves do not look exactly the same, these parameter changes do not affect the general mode of behavior of the system. All three curves show a small decrease and increase in the variables right after the step increase or decrease.

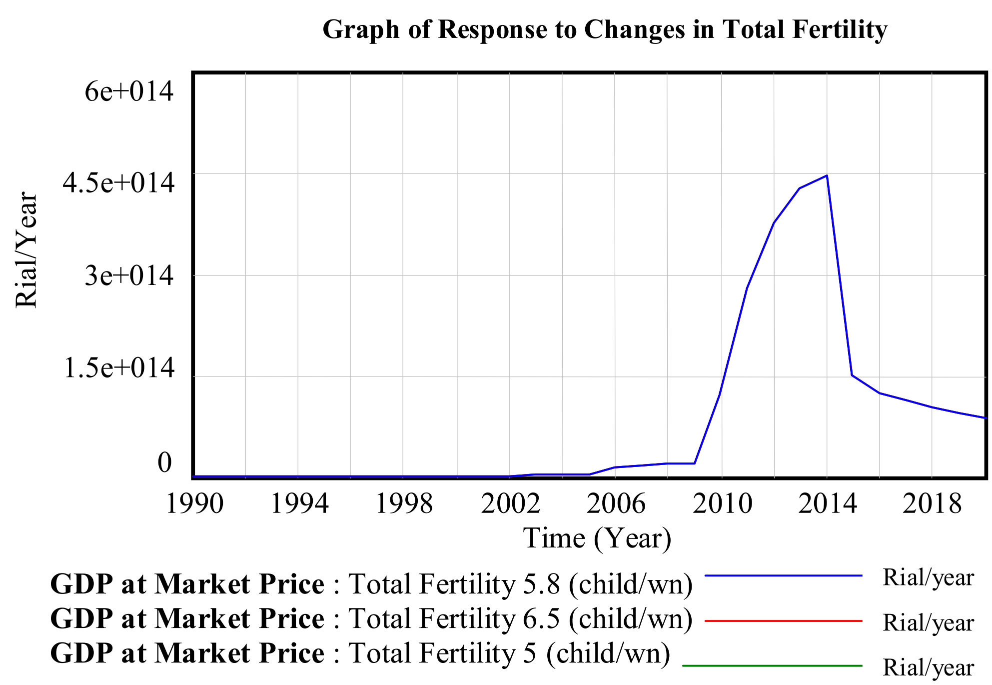


Figure (6-7): The effect of changes in "Total Fertility'

The GDP variable does not respond for change in Total Fertility. we are interested in the behavior of "Aggregate Demand ." and "GDP" What parameters and initial values should be used in a sensitivity analysis of the Yemen macroeconomic model?
We assume that Investment Fraction, Total Fertility, Fraction of private Consumption, Average Propensity to Consume, Investment Rate for Oil Sector and Investment Rate for agriculture Sector are the parameters which we use in sensitivity analysis of our model.

Second Scenario

We change value of parameter during the time as follow:

1- Increase of the Investment Fraction to one unit
2- Decrease of the Total Fertility to three *child/wn*
3- Decrease of the Fraction of Private Consumption to *0.5625*
4- Decrease of Average Propensity to Consume to *0.6625*
5- Increase of Investment Rate for agriculture Sector to *0.55*
6- Decrease of Investment Rate for Oil Sector to *0.025*

below graphs show response of the model to change in parameters which we selected in Second Scenario.

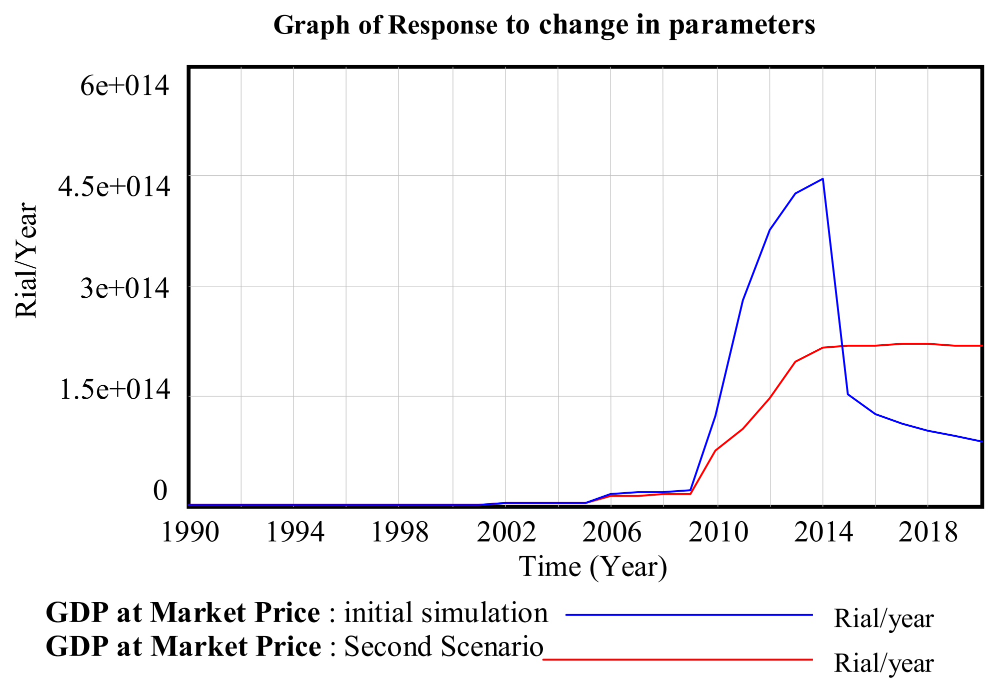


Figure 6-8: The effect of changes in parameters of Second Scenario

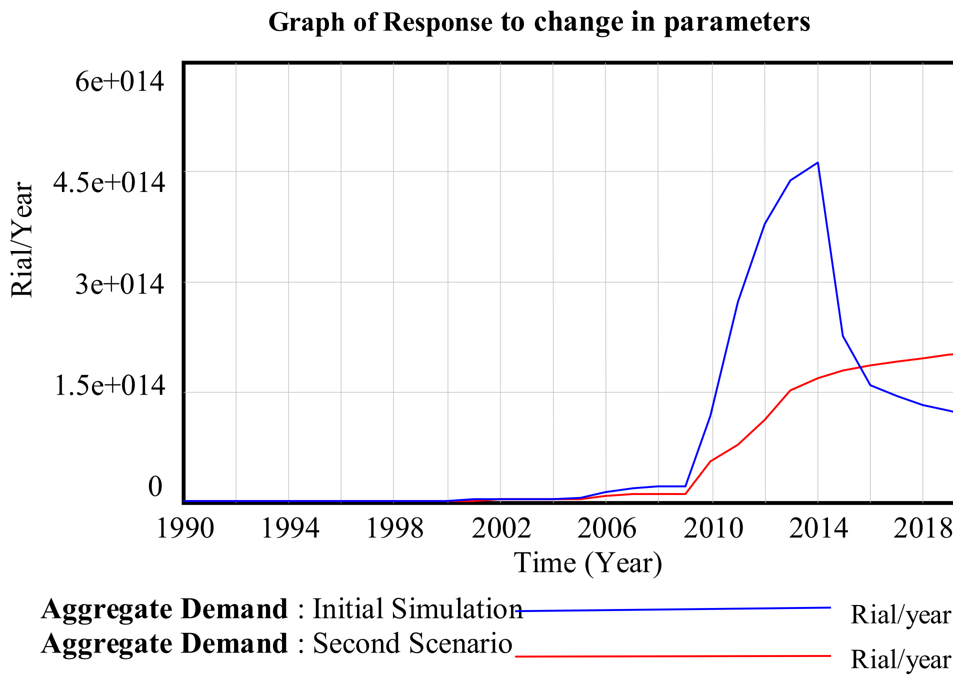


Figure 6-9: The effect of changes in parameters of Second Scenario

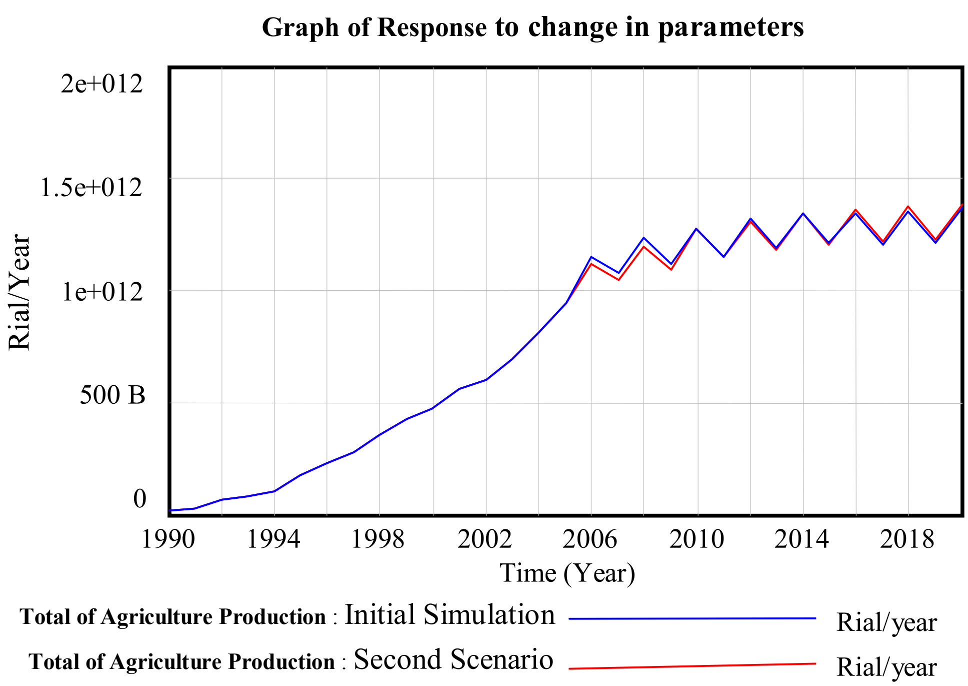


Figure 6-10: The effect of changes in parameters of Second Scenario

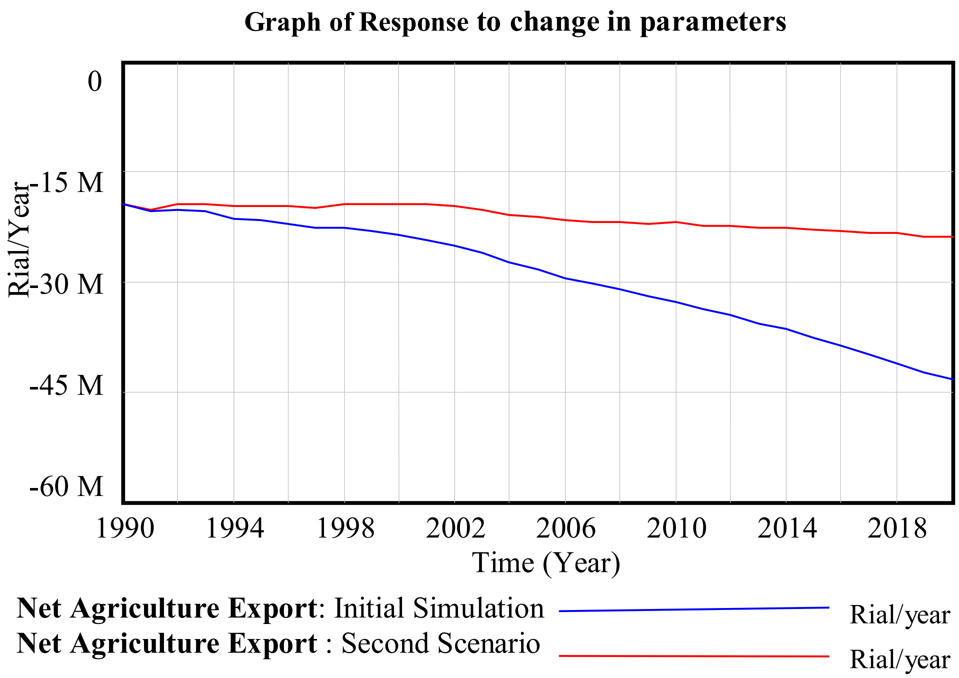


Figure 6-11 : The effect of changes in parameters of Second Scenario

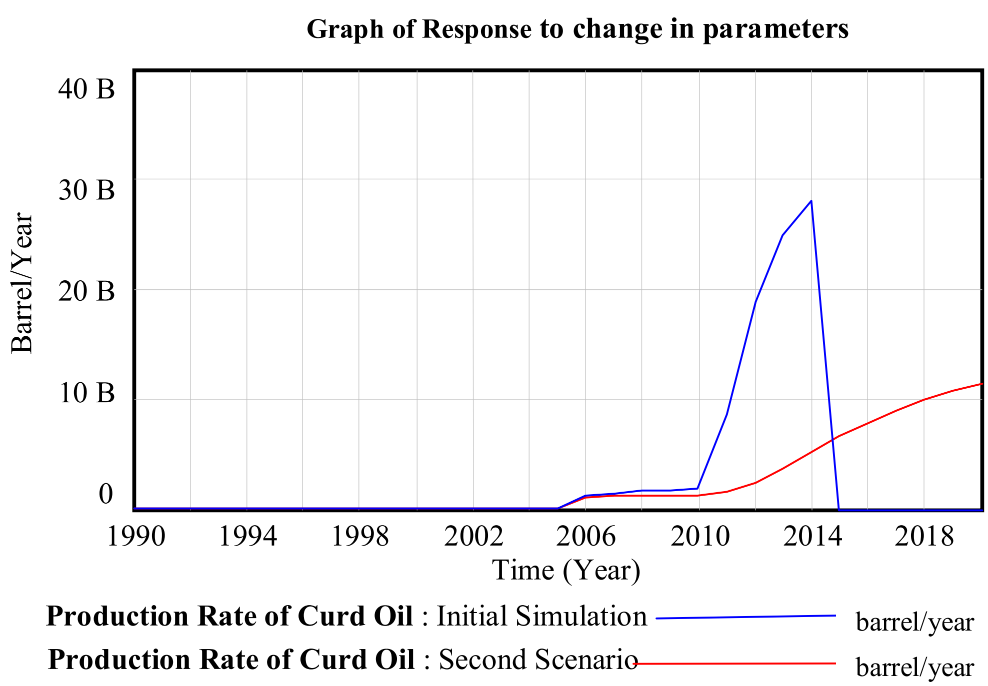


Figure 6-12 : The effect of changes in parameters of Second Scenario

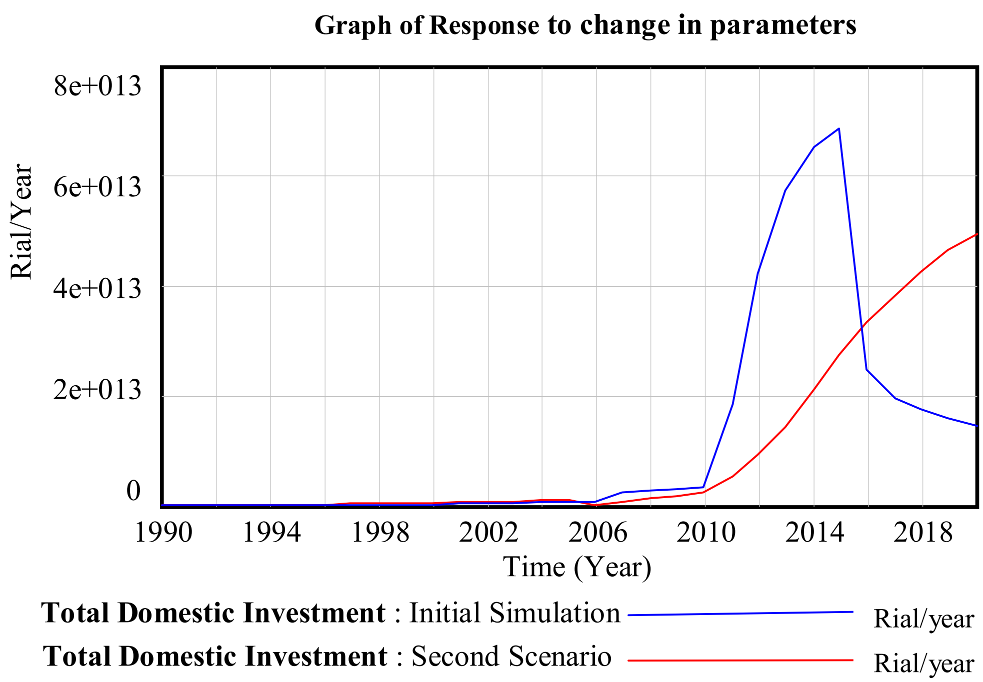


Figure 6-13: The effect of changes in parameters of Second Scenario

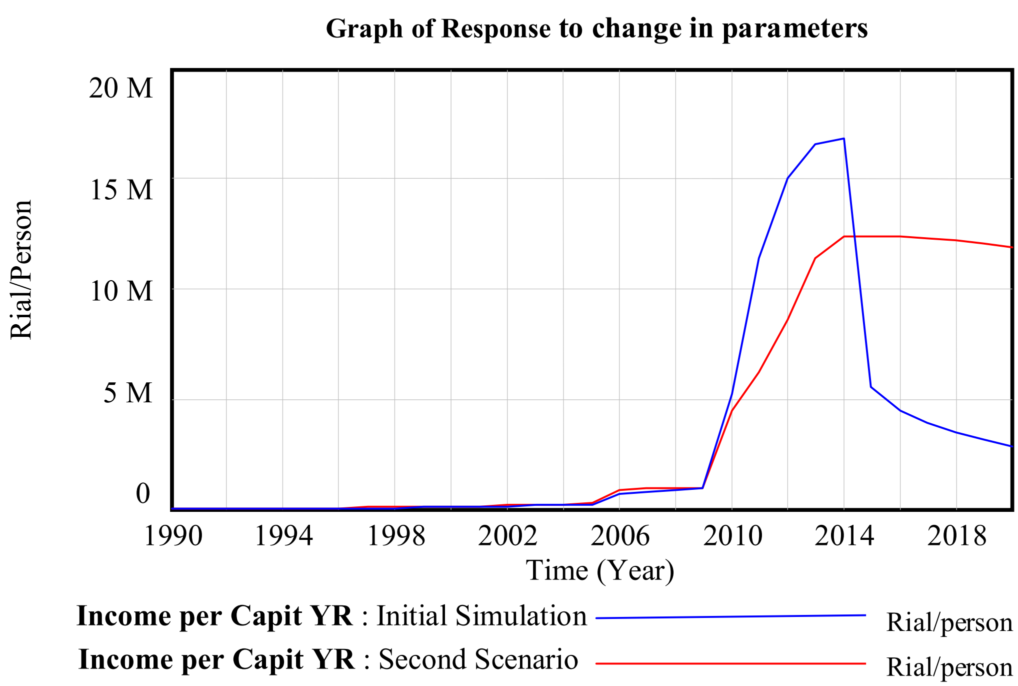
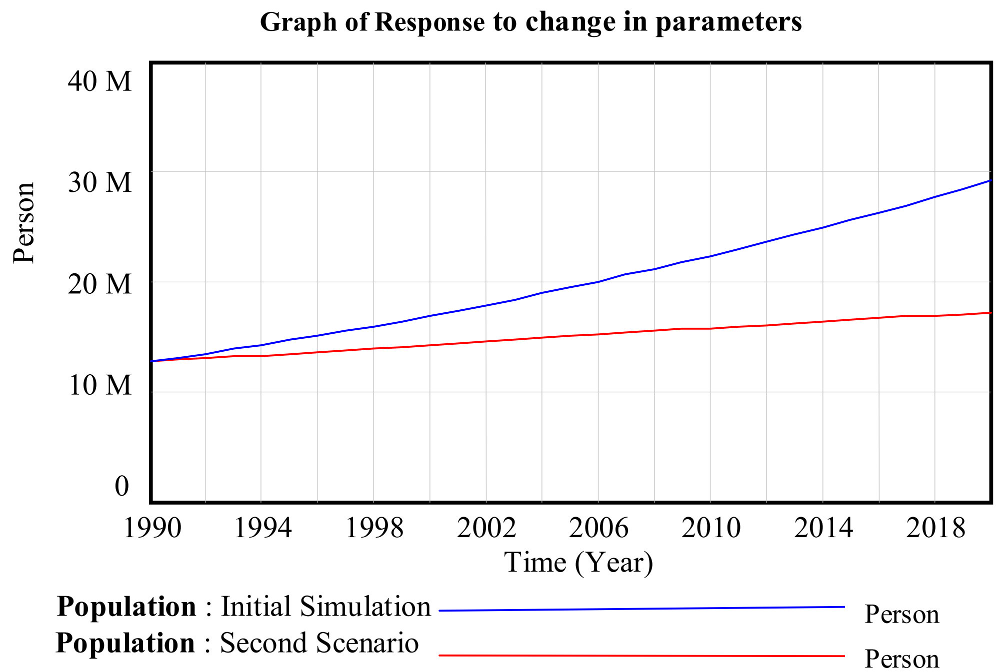


Figure 6-14: The effect of changes in parameters of Second Scenario



Figure(6-15) : The effect of changes in parameters of Second Scenario

Sensitivity analysis again showed that changing the value of parameters makes some difference in the behavior of the model, while the general behavior mode is relatively insensitive to parameter changes. Some parameter changes affect the behavior to a larger extent than others. Changes in some parameters affect the equilibrium values. We can make a thousand of scenarios and notes for all change in variables or model behavior easily.

8. Conclusions

We studied System Dynamics models and its implementation on macroeconomics analysis to know the real behavior of complex system and solved the problem which emerge when we can't have more of data and we compared it with another models (regression). It is distinguished from others because it provides wide look for the problems and means of detecting changes in system which we study. Although the system contains more than 600 variables and their major interrelated relations, it is easily to be understood and competence of the controlling the change tools which give us distance of forecasting to a long term and ability to strategically planning.

System Dynamics models can provide better forecasts than traditional approaches. In and of itself, this should allow decision maker to make better decisions. But in addition, the use of System Dynamics models for forecasting allows decision makers to: (1) get an early warning of sectors structural changes, (2) identify key sensitivities and scenarios, and(3) determine appropriate buffers and contingencies for forecast inaccuracies. These benefits can further enhance business performance. Therefore we can define the System Dynamics as a modern type of statistical analysis depends on feedback data and concerns with making nonlinear and two-way relationships between variables interacting with each others to estimate parameters having more specificity and reality.

9. Recommendation

The importance of any statistical models establish from their ability to relating all variables which we think make effect on phenomena that we study, and our ability to change the structure of this model when we need that. also we can evaluate a quality of the statistical model and its ability to prediction for variables behavior when we use efficient estimate method for parameters to get much reality and less standard error with high statistical significance for expected values in the model. System Dynamics model provides us all above mentioned things. Therefore we recommend to use this model in studying all economical phenomenon and build real structure of all subsystem in our model and revise all of macroeconomic policies in Yemen. We need to make strategically planning for a long time for the wealth sources in our country because the result of the initial simulation in our model is very dread as long as we depend on oil production only to provide the economic activity. we must think about next generations and should make good plans by choosing perfect and scientific method to evaluate and analyze the present time to build the wide base for future. System Dynamic model leads us to know the behavior of system components now and in the future, also it enables us to change the economic, social, political, financial and educational policies and know the effects of change in our life.

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