Ensuring food security is not only the responsibility of the national government but the right of the common people of the nation. In order to keep track of the issue, the Indian government has decided to undertake bulk procurement of basic food crops like paddy, wheat and coarse serial; and distribute them to the downtrodden people at a very nominal price. In this paper, we have applied Computable General Equilibrium (CGE) modelling based on India’s Social Accounting Matrix (SAM) to study the impacts of trade liberalisation and food subsidy policies on the macroeconomic variables. We find that, subsidy policy in basic food crops like, paddy, wheat and coarse cereals along with some reallocation of budgetary expenditures in other developmental activities will certainly reduce food insecurity, destitution and hunger among the targeted population. This will increase overall social welfare as in the whole process of food transfer mechanism, the upper tier of the urban and rural population will have to sacrifice less than the welfare gain enjoyed by the targeted rural and urban population.

**Keywords:** Food Security, Social Accounting Matrix, CGE.

### 1.0 Introduction

National level committee to address the issue of food security has been set up to examine the provisions and opportunity of government’s planning and policy in providing food security as the part of constitutional obligation and to fulfil international conventions. To ensure food security at the household level, government is implementing targeted public distribution system (TPDS) under which subsidised food grains are provided to people below the poverty line (BPL) and above poverty line (APL).
The government of India has proposed a new legislation namely “National Food Security Bill 2011” that aims at providing food and nutritional security to all the citizen of our nation by ensuring the access to adequate quantity of food at affordable prices and to live a life with dignity. This turns out to be a shift from welfare based approach to right based approach. About two thirds of the population will be entitled to receive subsidised food grains under TPDS after implementation of the Bill. It will also confer legal rights on women and children and other special groups such as destitute, homeless, disaster and emergency affected persons and persons living in starvation, to receive meal free of charge or at affordable price.

The Committee points out that under the existing TPDS, allocation of food grains are being made by the Central government to states/UTs based on the accepted number of 6.52 crore BPL households (including 2.43 crore Antodaya Anna Yojana {AAY} households) and 11.5 crore APL households. The allocations are based on the population estimates for the year 2000 of the Registrar General of India, using 1993-94 poverty estimates of the Planning Commission. Accordingly, the quantum of food subsidy for the year 2010-11 was Rs.65,045 crore which is likely to increase to Rs.88,977 crore during the year 2012-13. Further, the department has informed that using the population figures of 2011 Census and poverty estimates of 1993-94 and taking household size as 5.3 as per census 2001, the quantum of subsidy for 2011-12 works out to Rs.95,787 crore which is likely to increase to Rs.1,09,796 crore for the year 2012-13. As per provisions of the National Food Security Bill, 2011, the food subsidy for 2012-13 shall be Rs.1,12,205 crore. There will thus be marginal increase in the food subsidy during 2012-13 from Rs.1,09,796 crore to Rs.1,12,205 crore which work out to Rs.2409 crore.

While noting that the proposed National Food Security Bill, 2011 is going to be an important step towards the elimination of hunger and under nutrition in India, the committee feel that it is of utmost importance that the Bill remains a simple yet effective framework of the public distribution system ensuring food security to the people of India. The committee are also conscious of the large amount of subsidy involved in the implementation of the Bill and are aware that it is likely to increase substantially in the coming years.

The purpose of this paper is to model food security in an applied general equilibrium framework, commonly known as CGE (Computable General Equilibrium) framework in order to analyse different policy options for the government to finance the subsidy required for ensuring food security in India. In our CGE model based of Social Accounting Matrix (SAM) we would have segregated three prominent food sectors, i.e., (1) Rice, (2) Wheat, and (3) Coarse serial, for which food subsidies will be provided. We
classify the households into two rural and two urban type households in accordance with the provision of food subsidies made for the households.

2.0 Survey of Literature

Indian economy embraced new phase of economic development with reforms undertaken since 1991. The chief purpose was to becoming globally competitive through greater openness of trade, foreign capital and technology inflows while private sector was expected to play greater role reducing public sector activities. In several noteworthy works CGE modelling approach based on SAM has been applied with the aim of analysing the comparative static effects of selected post-1991 trade and domestic policy reforms on trade, domestic factor income and consumption, economic welfare and intersects oral allocation of resources. CGE models are essential based on SAM. There is a rich tradition of constructing SAM for India which extends India’s input/output table and provide consistent database for simulation based policy analysis. Several CGE models have been developed for India in recent years. We may classify the models into two groups: structuralist and neoclassical. Taylor (1983), de Janvry and Subbarao (1986), Panda and Sarkar (1990), Storm (1993) and Naastepad (1998) are some of the models for India in the structuralist tradition. Contrary to this, Narayana et al. (1991), Subramanian (1993) and Parikh et al. (1997) belong to the neoclassical tradition. The structuralist models emphasised on short run macroeconomic issues such as inflation, wage indexation and demand management. On the other hand, the neoclassical models focus on long run issues like relative prices and resource allocation mechanisms. Since the main logic for trade liberalisation is to enhance efficiency through inter-sectoral resource reallocation, most of the trade focused CGE models developed for the analysis of liberalized international trade, belongs to the neoclassical tradition and focus on medium run issues like, agricultural trade liberalisation, foreign capital inflow, technological up-gradation et cetera. Parikh et al. (1997) examined the impacts of trade liberalisation in an applied general equilibrium model with nine agricultural sectors, one non-tradable non-agricultural sector and one tradable non-agricultural sector and five rural and five urban expenditure classes. Policy alternatives are accessed based on equivalent incomes of expenditure classes. Their simulation study demonstrates that relevance of accounting for large country effects in rice trade. They also estimate optimal tariff/quota for rice exports of India. Panda and Sarkar (1990) studied the appropriate framework for analyzing various implications of change in administered prices in a general equilibrium model in which output, price, income and expenditure are determined simultaneously. Few notable works like Panda and Quizon (2001), and Panda and Ganesh-Kumar (2008)
attempted to analyze sectoral resource allocation and output effects of trade liberalisation in India. Panda and Quizon (1999) studied the impacts of agricultural and other sectoral trade liberalisation through the reduction of import duty in a CGE framework and their simulation results show that trade liberalisation in agriculture and non-agriculture taken together help to increase GDP growth and real income for all classes of population in rural and urban India. Moreover, only manufacturing liberalisation in their study benefited all the rural and urban household classes. Panda and Ganesh-Kumar (2009) attempted to assess the impact of trade liberalisation on growth, poverty and food security in India. They used a national level CGE model following Dervis, De Melo and Robinson (1982) tradition, to show that GDP growth and reduction of poverty, that usually takes place owing to trade liberalisation, may not necessarily improve food security and nutritional status of the poor. CGE based study by Sinha et al. (2003) examined the impact of socially relevant policy changes on the welfare of the women in India. Macroeconomic analysis is conducted by considering various economic agents of the economy having gender distinction within a SAM. National bio-diesel policy in CGE framework is studied by Guntilake et al. (2011). They examined economy-wide impacts of the expansion of bio-diesel production using CGE model. Increased public expenditure in different social sectors, like in higher education is studied in CGE framework by Ojha and Pradhan (2009). They applied CGE modelling in accessing macroeconomic and sectoral impacts of HIV and AIDS in India. Considering a five sector CGE model their study concludes that the increase in health expenditure of the households and the government causes a reduction of domestic savings which crowds out private investment.

We find that no serious attempt has been made to model India’s food security issue and its alternative financing opportunities. In this connection, this paper attempts to find out the cost and benefits of the alternative financing opportunities so far as India’s food security has been concerned.

3.0 Social Accounting Matrix (SAM)

CGE models are traditionally based on SAM which is matrix representation of all transactions and transfers that takes place between different production activities, various factors of production and different institutions like households, corporate and government within the country and with respect to rest of the world in a particular financial year. SAM therefore defines a comprehensive framework that can depict full circular flow of income from production activities to factor service providers like households. Each row of a SAM represents total receipts of any account and column
represents expenditure of that account. Therefore row total is supposed to be equal with corresponding column total. An entry in the \( i \)th row and \( j \)th column represents receipts of \( i \)th account from the \( j \)th account.

A SAM is a database and extension over input/output matrix (I/O). Use of I/O matrix is widely accepted with the pioneering work of Wassily Leontief. I/O matrix however, does not represent interrelationship between factor value added and agent’s final expenditure. Extension of an I/O table with the introduction agent’s behavior and institutional characteristics one can get essential features of a SAM. This can depict entire circular flow of income much more effectively. Our CGE model is based on schematic structure of SAM (Table 1) and for calibration of the model we constructed Food SAM for India for the year 2003-04 following Saluja and Yadav (2006).  

4.0 Structure of the CGE

**Sectors and agents:** Following SAM of India for the year 2004 produced by Saluja and Yadav (2006), Ojha and Pradhan (2009), and Ojha et al. (2009); we grouped all sectors of the economy into seven aggregated sectors, i.e., (1) Primary sector consists of all agricultural products excepts food items, minerals, primary products such as iron ores, crude petroleum and agro process activities; (2) Secondary sector is comprised mainly of all manufacturing activities like cotton and textile, plastic, rubber and lather products, cement, different chemical products et cetera; (3) Infrastructural sector consists infrastructural services; (4) Other service sectors like education, healthcare, public administration, bank and insurance, postal services et cetera; and three separate food sectors (5) Paddy; (6) Wheat; and (7) Coarse serial. We considered four types of agents in the economy, i.e., (a) household; (b) firm; (c) government; and (d) rest of the world (ROW). There are four types of households, i.e., (i) RHH 1 (Rural agricultural and other labourers); (ii) RHH 2 (Agricultural self employed and other households); (iii) UHH 1 (Urban salaried class); and (iv) UHH 2 (Urban casual labour and others). All other countries and regions are clubbed together into ROW. Among them RHH 2 and UHH 2 household classes are entitled to receive food subsidy from the government.

**Production and Factor inputs:** We have considered two basic factors of production, i.e., labour and capital that take part in the production process within which substitution is possible through Cobb-Douglas production technology. Each production unit requires intermediate inputs following fixed coefficient type Leontief technology.
Table 1: Schematic Structure of Social Accounting Matrix

<table>
<thead>
<tr>
<th>Activity</th>
<th>Com Factors</th>
<th>HH</th>
<th>PC</th>
<th>PE</th>
<th>Govt.</th>
<th>IT</th>
<th>CA</th>
<th>Row</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase of raw material</td>
<td></td>
<td>HH consumption</td>
<td></td>
<td></td>
<td>Govt. Consumption</td>
<td>Gross Fixed Capital Formation</td>
<td>Exports</td>
<td>Aggregate Demand</td>
<td></td>
</tr>
<tr>
<td>Value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Net factor income</td>
<td>Factor Income</td>
</tr>
<tr>
<td>Endowment of HH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Govt. transfer</td>
<td></td>
<td>Net current transfer</td>
<td>Total Household Income</td>
<td></td>
</tr>
<tr>
<td>Operating Profits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Interest on debt</td>
<td></td>
<td></td>
<td>Income of Private Corporate</td>
<td></td>
</tr>
<tr>
<td>Operating Surplus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Income of Public Department</td>
<td></td>
</tr>
<tr>
<td>Income from entrepreneur</td>
<td>Income tax by household</td>
<td>Corp. taxes</td>
<td></td>
<td></td>
<td>Total indirect taxes</td>
<td>Net capital transfer</td>
<td>Total govt. Earnings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes on Intermediate</td>
<td>Taxes on Purchases</td>
<td>Taxes on Purchases</td>
<td>Taxes on investment</td>
<td>Tax on exports</td>
<td>Total Indirect Taxes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td>Household savings</td>
<td>Corp. savings</td>
<td>Public sector savings</td>
<td>Govt. savings</td>
<td>Foreign savings</td>
<td>Gross savings of Economy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Foreign exchange</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Com – commodities; HH – households; PC – Private corporation; PE – Public enterprises; IT – Individual taxes; CA – Capital account; Row – rest of the world*
Prices: Product prices are determined from the equality of price and average cost. Average cost is comprised of basic factor cost, cost of intermediate inputs that includes cost of energy inputs. Increasing returns to scale is assumed through the presence of fixed cost in the production units.

Household income and expenditure: Households are rendering factor services in terms of labour and capital while in return they are receiving factor payments in the form of wages and rentals respectively. We have considered four types of household, two of them are rural type and other two are urban type. Household spends his income for consumption purposes. We have assumed linear expenditure system type demand function for household. RHH 2 and UHH 2 household classes are receiving procured food, i.e., (a) Rice, (b) Wheat, and c) Coarse serial in almost negligible price.

Government income and expenditure: The sources of income of the government are (a) direct, indirect and corporate taxes, (b) import tariff\(^2\), and (c) income from entrepreneurial activity. In the expenditure front, we assumed government’s expenditure in any sector is exogenously determined, i.e., determined in the government’s budget and adjusted to benchmark SAM. Difference between government’s income and expenditure is government’s savings\(^3\). Government is purchasing food crops from the market at the market price and distributing those food crops among the rural and urban households.

Specific GAMS (Generalized Algebraic Modeling System) code for food transfer to different household

\[
X_{p1}(fd,SHH) = \alpha_1(fd,SHH) * (HI(SHH) - Sp1(SHH) - Tdr(SHH)) / pq(fd) + gt1(SHH) * Xg(fd);
\]

\[
X_{p1}(fd,NSHH) = \alpha_1(fd,NSHH) * (HI(NSHH) - Sp1(NSHH) - Tdr(NSHH)) / pq(fd);
\]

\[
X_{p1}(nfd,HH) = \alpha_1(nfd,HH) * (HI(HH) - Sp1(HH) - Tdr(HH)) / pq(nfd);
\]

Investment and Savings: We considered neo-classical type closure rule where investment is guided by saving. Total saving is comprised of (i) household saving, (ii) government saving, (iii) corporate saving, and (iv) foreign savings. Total saving is converted to total investment.

Armington function and trade: International trade in our model is guided by Armington function\(^4\) (Armington, 1969). Total availability of composite commodity in the domestic economy is composed of domestically produced variety of the good demanded by the domestic people and foreign variety of the same good. Both types of variety are combined together following a constant elasticity of substitution (CES) type preference function.
Production of output and transformation: Total supply of each domestic good produced using labour, capital and intermediate input is used up by export of that good and to meet up domestic demand of domestic variety. Both export and domestic demand of the produced good are combined together following CES type transformation function.

Factor prices and equilibrium: We consider two basic factors of production i.e. labour and capital. Total supply of basic factor is fixed in value terms and factor prices are flexible. Physical quantity of labour or capital may change in different simulation experiments following demand and supply equilibrium mechanism in the factor market. Demand for factor is originated from the production of goods and services.

Equilibrium in commodity market: In the commodity market total supply of the composite commodity is constituted by domestic variety as well as imported foreign variety corresponds to each good. Demand for the composite commodity is generated from household consumption, government consumption expenditure, total investment demand and demand for intermediate input. Composite commodity price is determined from the demand and supply of composite commodity.

GDP and Welfare: Under perfect competition GDP has been computed adding all sectoral outputs. Social welfare has been of Cobb-Douglas type and depends on private household consumption.

5.0 Food SAM (FSAM) and Calibration of the Model

The parameters of the constructed model are estimated in conjunction with the benchmark dataset. In few instances, econometric estimates obtained from other studies have been applied for the purpose of parameter estimation. For example, parameter values of armington function. Remaining parameters are chosen, such that, they are consistent with the benchmark data. Here, we have manipulated the equations of the model, so that parameters can be represented as the function of the data and solved the equations to obtain parameter values. This process is known as calibration, a deterministic procedure, in which we get point estimates of the parameters without having any standard errors (Figure 1). Calibrated CGE model will be solved to check whether it can reproduce a replica of the benchmark data. If benchmark SAM is not regenerated during solve of the model, we have to re-specify our model and re-estimate the parameters until the model generates a replica of the benchmark SAM.

We have used constructed by segregating separate food sectors. In our FSAM we have total seven sectors. Four of them are conventional production sectors excepting
food sectors namely (1) Primary sector (Other than food), (2) Secondary manufacturing sector, (3) Infrastructural services, and (4) Other service sectors and three of them are food sectors, namely (5) Rice, (6) Wheat, and (7) Coarse serial.

**Figure-1:** Flow chart of Calibration process

- **BASIC DATA**
  - Input/Output table, National Income Accounts.

- **MODEL STRUCTURE**
  - Sectors, Factors, Agents, Circular Income flows.

- **BENCHMARK DATA**
  - Social Accounting Matrix.

- **SPECIFICATION OF FUNCTIONAL FORMS**
  - Cobb-Douglas, CES, Leontief, LES.

- **CALIBRATION OF MODEL**
  - Deterministic estimation of model parameters.

- **REPLICATION OF BENCHMARK DATA**

- **CHECK MODEL**
  - Check model with economic theory.

- **SIMULATION OF POLICY CHANGE**

- **POLICY APPRAISAL**
  - Compare counterfactual solution with benchmark data.
Our constructed SAM is for the year 2003-04 (Table 2 and 3) and we aggregated the SAM produced by Saluja and Yadav (2006) for the same year according to our requirement.

**Table 2: Food SAM of India -2003-04**

(Rs. in Lakhs)

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Paddy</th>
<th>Wheat</th>
<th>Coarse Serial</th>
<th>Primary sector</th>
<th>Secondary sector</th>
<th>Infrastructure</th>
<th>Other service</th>
<th>Labour</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>394849</td>
<td>46428</td>
<td>242314</td>
<td>124705</td>
<td>1247075</td>
<td>214577</td>
<td>0</td>
<td>3033</td>
<td>47538</td>
</tr>
<tr>
<td></td>
<td>2682315</td>
<td>385428</td>
<td>3320466</td>
<td>3320466</td>
<td>3320466</td>
<td>3320466</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>933804</td>
<td>57808</td>
<td>779244</td>
<td>779244</td>
<td>779244</td>
<td>779244</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1590796</td>
<td>192714</td>
<td>199323</td>
<td>199323</td>
<td>199323</td>
<td>199323</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>34303121</td>
<td>33210796</td>
<td>33210796</td>
<td>33210796</td>
<td>33210796</td>
<td>33210796</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>775827</td>
<td>5798</td>
<td>779244</td>
<td>779244</td>
<td>779244</td>
<td>779244</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3320466</td>
<td>1903344</td>
<td>3320466</td>
<td>3320466</td>
<td>3320466</td>
<td>3320466</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2456189</td>
<td>8107588</td>
<td>6659444</td>
<td>6659444</td>
<td>6659444</td>
<td>6659444</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2456189</td>
<td>8107588</td>
<td>6659444</td>
<td>6659444</td>
<td>6659444</td>
<td>6659444</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 3: Food SAM of India 2003-04 (continued)

<table>
<thead>
<tr>
<th>Capital</th>
<th>Labour</th>
<th>Other service</th>
<th>Infrastructure</th>
<th>Secondary Sector</th>
<th>Primary sector</th>
<th>Coarse Serial</th>
<th>Wheat</th>
<th>Paddy</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>11734098</td>
<td>5644772</td>
<td>13296472</td>
<td>9738070</td>
<td>390861</td>
<td>595959</td>
<td>1125841</td>
<td>RHH1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>18534595</td>
<td>5679316</td>
<td>15681302</td>
<td>14496584</td>
<td>1054145</td>
<td>2140500</td>
<td>3055968</td>
<td>RHH2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>25392996</td>
<td>6855314</td>
<td>14754899</td>
<td>10020308</td>
<td>64696</td>
<td>291839</td>
<td>326698</td>
<td>UHH1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>5250963</td>
<td>1209437</td>
<td>818775</td>
<td>260612</td>
<td>103682</td>
<td>878272</td>
<td>969227</td>
<td>UHH2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Pvt. Corps</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Pub. Enterprises</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>24837174</td>
<td>1871435</td>
<td>5157523</td>
<td>241670</td>
<td>52</td>
<td>28584</td>
<td>25749</td>
<td>Govt.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Ind. Taxes</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>693607</td>
<td>3260561</td>
<td>55622644</td>
<td>1803896</td>
<td>-2694</td>
<td>-96064</td>
<td>921324</td>
<td>Capital a/c</td>
</tr>
<tr>
<td>-1095200</td>
<td>-312600</td>
<td>4824222</td>
<td>10605075</td>
<td>25376947</td>
<td>2978019</td>
<td>31824</td>
<td>262897</td>
<td>404391</td>
<td>Rest of the world</td>
</tr>
<tr>
<td>120352089</td>
<td>130721521</td>
<td>106094471</td>
<td>100069843</td>
<td>231376699</td>
<td>93480335</td>
<td>1825080</td>
<td>5853378</td>
<td>8860050</td>
<td>Total</td>
</tr>
<tr>
<td>Total</td>
<td>Rest of the World</td>
<td>Capital a/c</td>
<td>Indirect taxes</td>
<td>Government</td>
<td>Enterprises</td>
<td>Private Corporations</td>
<td>UHH2</td>
<td>UHH1</td>
<td>RHH2</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------</td>
<td>-------------</td>
<td>----------------</td>
<td>------------</td>
<td>-------------</td>
<td>----------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>53666294</td>
<td>0</td>
<td>10308227</td>
<td>1517569</td>
<td>224068</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>80904465</td>
<td>0</td>
<td>20323643</td>
<td>2035126</td>
<td>3506373</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>93533470</td>
<td>0</td>
<td>21205637</td>
<td>13333662</td>
<td>1500237</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17821354</td>
<td>0</td>
<td>2945766</td>
<td>440247</td>
<td>2906519</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10774100</td>
<td>4674700</td>
<td>6099400</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4626200</td>
<td>4626200</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40437165</td>
<td>-16661127</td>
<td>685000</td>
<td></td>
<td></td>
<td>1190924</td>
<td>9113270</td>
<td>9824402</td>
<td>52075667</td>
<td></td>
</tr>
<tr>
<td>24616465</td>
<td>24616465</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>67692335</td>
<td>5094808</td>
<td>1216819</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>49026796</td>
<td>-3426241</td>
<td>-157127</td>
<td>-248200</td>
<td></td>
<td>2562618</td>
<td>6175802</td>
<td>2157927</td>
<td>993035</td>
<td></td>
</tr>
<tr>
<td>49026796</td>
<td>67692335</td>
<td>24616465</td>
<td>40437165</td>
<td>4626200</td>
<td>10774100</td>
<td>17821354</td>
<td>93533470</td>
<td>80904465</td>
<td>53666294</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Paddy</td>
<td>Wheat</td>
<td>Coarse Cereals</td>
<td>Primary</td>
<td>Secondary</td>
<td>Infra.</td>
<td>Service</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
<td>----------------</td>
<td>---------</td>
<td>-----------</td>
<td>--------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>$\beta_{i}$ (Labour)</td>
<td>Share parameter in production function</td>
<td>0.583</td>
<td>0.583</td>
<td>0.583</td>
<td>0.561</td>
<td>0.577</td>
<td>0.449</td>
<td>0.582</td>
<td></td>
</tr>
<tr>
<td>$\beta_{i}$ (Capital)</td>
<td>Share parameter in production function</td>
<td>0.417</td>
<td>0.417</td>
<td>0.417</td>
<td>0.439</td>
<td>0.423</td>
<td>0.551</td>
<td>0.418</td>
<td></td>
</tr>
<tr>
<td>$b_{j}$</td>
<td>Production function shift parameter</td>
<td>1.972</td>
<td>1.972</td>
<td>1.972</td>
<td>1.98</td>
<td>1.97</td>
<td>1.98</td>
<td>1.97</td>
<td></td>
</tr>
<tr>
<td>$ay_{i}$</td>
<td>Composite factor requirement</td>
<td>0.412</td>
<td>0.393</td>
<td>0.421</td>
<td>0.766</td>
<td>0.283</td>
<td>0.621</td>
<td>0.786</td>
<td></td>
</tr>
<tr>
<td>$mu_{i}$</td>
<td>Government consumption share</td>
<td>0.0005</td>
<td>0.00005</td>
<td>0.00001</td>
<td>0.01</td>
<td>0.075</td>
<td>0.010</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>$taum_{i}$</td>
<td>Import tariff rate</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>3</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>$tind_{i}$</td>
<td>Indirect tax rate</td>
<td>-0.003</td>
<td>-0.005</td>
<td>-0.003</td>
<td>-0.004</td>
<td>0.012</td>
<td>0.010</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>$\phi_i$</td>
<td>$\delta m_i$</td>
<td>$\delta d_i$</td>
<td>$\eta_i$</td>
<td>$\theta_i$</td>
<td>$\gamma$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------</td>
<td>-----------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Share param. Of domestic good(Trans)</td>
<td>Share parameter of export.</td>
<td>Scale parameter in transfomation func.</td>
<td>Elasticity of substitution in Armington.</td>
<td>Share parameter of domestic good.</td>
<td>Share parameter of imported good.</td>
<td>Scale parameter in Armington function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>2.5987E-5</td>
<td>2.5987E-5</td>
<td>8454.853</td>
<td>0.5</td>
<td>0.999</td>
<td>0.001</td>
<td>0.512</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>4.3811E-6</td>
<td>4.381E-6</td>
<td>13249.413</td>
<td>0.5</td>
<td>0.999</td>
<td>0.001</td>
<td>0.496</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>3.4238E-5</td>
<td>3.4268E-5</td>
<td>4751.280</td>
<td>0.5</td>
<td>0.994</td>
<td>0.006</td>
<td>0.435</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>7.9559E-8</td>
<td>4.020E-7</td>
<td>54980</td>
<td>0.5</td>
<td>0.710</td>
<td>0.29</td>
<td>1.624</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>2.034E-8</td>
<td>5.41E-8</td>
<td>138610</td>
<td>0.5</td>
<td>0.715</td>
<td>0.285</td>
<td>1.655</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>4.77E-8</td>
<td>1.29E-7</td>
<td>78534</td>
<td>0.5</td>
<td>0.829</td>
<td>0.171</td>
<td>1.077</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>6.33E-8</td>
<td>2.5E-7</td>
<td>63972</td>
<td>0.5</td>
<td>0.814</td>
<td>0.186</td>
<td>1.98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Parameter | Description | RHH1 | RHH2 | UHH1 | UHH2
--- | --- | --- | --- | --- | ---
\\(\text{taud}_b\) | Direct tax rate. | 0.018 | 0.41 | 0.017 | 0.190
\\(\text{gt}_b\) | Parameter for govt. transfer. | 0.413 | 0.189 | 0.365 | 0.048
\\(\text{ssp}_b\) | Propensity to save for households. | 0.344 | 0.14 | 0.243 | 0.029
\\(\text{r}_b\) (Labour) | Labour income share for households. | 0.233 | 0.246 | 0.128 | 0.041
\\(\text{r}_b\) (Capital) | Capital income share for households. | 0.268 | 0.117 | 0.563 | 0.078

### 6.0 Policy Simulation Experiments

After estimating the model parameters through benchmark equilibrium, we performed simulation experiments to obtain the impacts of policy change (Table 5). We have changed the policy parameters appropriately and solved the model once again to obtain counterfactual equilibrium data values. We made three simulation experiments related to trade liberalisation a) 50% reduction of import tariff b) Technological upgradation and c) Greater foreign capital inflow. In order to obtain the impacts of policy changes, counterfactual equilibrium values are compared with benchmark equilibrium values of the macroeconomic variables.
Experiment 1: Trade liberalisation in Food crop sector

We reduced import tariff and subsidy by 100% respectively in food sectors, i.e., (a) Paddy, (b) Wheat, and (c) Coarse serial. As a result, share of import in total domestic consumption increases in food sectors along with the increase in export. However there is depreciation of real exchange rate by 3.314 per cent owing to greater demand of foreign exchange to pay the import. This makes export profitable and we find export increases almost every sector. Change in export and import affects domestic production pattern. Sectoral domestic production rises in manufacturing industries and Infrastructural service sectors, sectoral output however falls in agricultural sector and very little percentage in other service activities due to shift of labour and capital towards industrial sectors. Greater supply of composite commodity due to higher import leads to fall of composite commodity prices in almost every sector (Figure 2).

According to our assumption wage rate is acting as the numerare and total basic factors payments are fixed exogenously i.e. adjusted to benchmark SAM value. Sectoral change in demand and supply of physical volume of labour and capital along with substitution possibilities leads to rise of rental rate approximately by 0.2%. Although this may lead to an increase of household income, we get reduction of household income for all types of household due to sharp decrease of government transfer owing to fall of government income from lower tariff revenue earning. This leads to fall of household consumption among rural self employed and urban salaried class. Composition of product variety within household consumption however shifts from domestic to foreign variety. Social welfare rises by very little percentage owing to increased private consumption among rural labour class and urban non-salaried casual working class whose income has not reduced owing to lesser government transfer.

Experiment 2: Higher government procurement of food crops and distribution of the same to the rural and urban households

According to our model assumption government can procure food crops from the market at market price. This procured amount is distributed among the urban casual worker class and informal worker class i.e. among UHH-2 and rural agricultural and non agricultural labour class i.e. among RHH-2, in subsidised price which is very low as compared to the procurement price. We assumed zero prices for the distributed amount.

The immediate impact is the increase in food consumption of the RHH-2 and UHH-2 type of households. But this entails reduction of consumption of non-food items by all types of households. Since government is spending much without having increased its income, its budgetary deficit increases. Thus social welfare increases due to the
escalation of food consumption, but at the same time there is increased deficit for the government⁵.

Figure 2: Major Interactions due to import liberalisation

Import Liberalisation

- Reduction in Import Price Relative to Domestic Price
- Rise in Share of Imports in Total Domestic Demand
- Change in Domestic Production Pattern
- Change in Labour demand across sectors
- Wage Rate

Change in Real Exchange rate

Change in Share of Exports in Total domestic Production

Change in Domestic Relative Prices

Change in Demand for Composite Good

Change in Level and Distribution of Income
Experiment 3: Higher government procurement and distribution of food crops along with lower government expenditure in non-food sectors.

We have experimented the scenario where government is procuring food grains from the market at market price and distributing the same to the rural and urban households (RHH-2 and UHH-2) at a very negligible price. Since in our previous experiment, the economy ends up with high fiscal deficit, in this section we experimented higher government procurement of food crops along with budgetary expenditure reduction on non-food items.

We find that food crop consumption has been increased in food sectors for RHH-2 and UHH-2 whereas there has been a reduction of consumption in non-food items. Government’s budgetary deficit reduces because of this policy changes.

Table 5: Simulation Experiment Results

<table>
<thead>
<tr>
<th>ECCONOMIC VARIABLES</th>
<th>BASE RUN VALUE</th>
<th>EXP.-1</th>
<th>EXP-2</th>
<th>EXP.-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro Indicators</td>
<td>Rs. In lakhs</td>
<td>% change</td>
<td>% change</td>
<td>% change</td>
</tr>
<tr>
<td>GDP</td>
<td>4.75E+08</td>
<td>0.238</td>
<td>-0.004</td>
<td>0.043</td>
</tr>
<tr>
<td>Gross investment</td>
<td>67692335</td>
<td>0.577</td>
<td>-0.143</td>
<td>0.417</td>
</tr>
<tr>
<td>Gross consumption</td>
<td>462304387</td>
<td>0.78</td>
<td>0.055</td>
<td>0.04</td>
</tr>
<tr>
<td>Welfare</td>
<td>5.10E+07</td>
<td>0.234</td>
<td>0.15</td>
<td>0.2</td>
</tr>
<tr>
<td>External Account</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Import</td>
<td>4.97E+07</td>
<td>9.38</td>
<td>-0.30</td>
<td>0.065</td>
</tr>
<tr>
<td>Export</td>
<td>45206080</td>
<td>8.6</td>
<td>-0.027</td>
<td>0.057</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>1</td>
<td>3.314</td>
<td>-0.027</td>
<td>0.057</td>
</tr>
<tr>
<td>Government Account</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Govt. Income</td>
<td>40437165</td>
<td>-23.24</td>
<td>-0.013</td>
<td>0.024</td>
</tr>
<tr>
<td>Govt. Expenditure</td>
<td>23776038</td>
<td>5.83</td>
<td>0.945</td>
<td>-2.75</td>
</tr>
<tr>
<td>Govt. Savings</td>
<td>-16661127</td>
<td>-2.92</td>
<td>-0.230</td>
<td>-2.49</td>
</tr>
<tr>
<td>HH Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RHH1</td>
<td>40413419</td>
<td>0.751</td>
<td>-0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>RHH2</td>
<td>5.44E+07</td>
<td>1.23</td>
<td>0.358</td>
<td>0.003</td>
</tr>
<tr>
<td>UHH1</td>
<td>3.58E+08</td>
<td>0.85</td>
<td>-0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>UHH2</td>
<td>9490968</td>
<td>-0.345</td>
<td>0.123</td>
<td>0.102</td>
</tr>
</tbody>
</table>

(All values are results for the year 2023.)
### Sectoral output

<table>
<thead>
<tr>
<th>Sector</th>
<th>Output</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>1.648860E+7</td>
<td>0.678</td>
<td>0.441</td>
<td>0.53</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.171261 E+7</td>
<td>-0.178</td>
<td>0.567</td>
<td>0.63</td>
</tr>
<tr>
<td>Coarse Cereal</td>
<td>4006486.9</td>
<td>-0.98</td>
<td>0.002</td>
<td>0.018</td>
</tr>
<tr>
<td>Primary sector</td>
<td>7.85E+07</td>
<td>-1.2</td>
<td>-0.025</td>
<td>0.066</td>
</tr>
<tr>
<td>Secondary sector</td>
<td>1.91E+08</td>
<td>.84</td>
<td>-0.049</td>
<td>0.121</td>
</tr>
<tr>
<td>Infrastructural services</td>
<td>9.86E+07</td>
<td>1.11</td>
<td>-0.005</td>
<td>0.062</td>
</tr>
<tr>
<td>Other Services</td>
<td>8.47E+07</td>
<td>.284</td>
<td>0.009</td>
<td>-0.188</td>
</tr>
</tbody>
</table>

### Composite prices

<table>
<thead>
<tr>
<th>Sector</th>
<th>Prices</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>1.00E+00</td>
<td>-0.71</td>
<td>-4.95392E-4</td>
<td>0.004</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.00E+00</td>
<td>-0.912</td>
<td>-4.48116E-4</td>
<td>0.003</td>
</tr>
<tr>
<td>Coarse Cereal</td>
<td>1.00E+00</td>
<td>-0.783</td>
<td>-4.94652E-4</td>
<td>0.004</td>
</tr>
<tr>
<td>Primary sector</td>
<td>1.00E+00</td>
<td>-1.3</td>
<td>-7.02052E-4</td>
<td>0.004</td>
</tr>
<tr>
<td>Secondary sector</td>
<td>1.00E+00</td>
<td>-2.52</td>
<td>-5.75726E-4</td>
<td>0.004</td>
</tr>
<tr>
<td>Infrastructural services</td>
<td>1.00E+00</td>
<td>-1.45</td>
<td>-4.52854E-4</td>
<td>0.004</td>
</tr>
<tr>
<td>Other Services</td>
<td>1.00E+00</td>
<td>-0.80</td>
<td>-4.71941E-4</td>
<td>0.003</td>
</tr>
</tbody>
</table>

### Sectoral Import

<table>
<thead>
<tr>
<th>Sector</th>
<th>Import</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>26.00</td>
<td>54.9</td>
<td>0.444</td>
<td>0.532</td>
</tr>
<tr>
<td>Wheat</td>
<td>25.00</td>
<td>54.78</td>
<td>0.571</td>
<td>0.629</td>
</tr>
<tr>
<td>Coarse Cereal</td>
<td>148.00</td>
<td>54.21</td>
<td>0.006</td>
<td>0.013</td>
</tr>
<tr>
<td>Primary sector</td>
<td>1.28E+07</td>
<td>10.45</td>
<td>-0.021</td>
<td>0.062</td>
</tr>
<tr>
<td>Secondary sector</td>
<td>2.87E+07</td>
<td>8.48</td>
<td>-0.045</td>
<td>0.115</td>
</tr>
<tr>
<td>Infrastructural services</td>
<td>3.33E+06</td>
<td>10.37</td>
<td>-8.73945E-4</td>
<td>0.058</td>
</tr>
<tr>
<td>Other Services</td>
<td>4.21E+06</td>
<td>11.24</td>
<td>0.013</td>
<td>-0.193</td>
</tr>
</tbody>
</table>

### Sectoral Export

<table>
<thead>
<tr>
<th>Sector</th>
<th>Export</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>40391</td>
<td>6.76</td>
<td>0.437</td>
<td>0.541</td>
</tr>
<tr>
<td>Wheat</td>
<td>262897</td>
<td>7.47</td>
<td>0.564</td>
<td>0.638</td>
</tr>
<tr>
<td>Coarse Cereal</td>
<td>31824</td>
<td>6.51</td>
<td>-8.88786E-4</td>
<td>0.022</td>
</tr>
<tr>
<td>Primary sector</td>
<td>2978019</td>
<td>5.57</td>
<td>-0.028</td>
<td>0.070</td>
</tr>
<tr>
<td>Secondary sector</td>
<td>25376947</td>
<td>9.87</td>
<td>-0.052</td>
<td>0.125</td>
</tr>
<tr>
<td>Infrastructural services</td>
<td>10605075</td>
<td>8.62</td>
<td>-0.008</td>
<td>0.065</td>
</tr>
<tr>
<td>Other Services</td>
<td>4824222</td>
<td>6.33</td>
<td>0.006</td>
<td>-0.183</td>
</tr>
</tbody>
</table>
7.0 Concluding remarks

Ensuring food security is not only the responsibility of the national government but the right of the common people of the nation. In order to keep track the issue Indian government has decided bulk procurement of basic food crops like paddy, wheat and coarse serial; and distribute them to the downtrodden people at a very nominal price. This policy has been proved to be very promising to reduce food insecurity and hunger and to bring a large section of the population in an honoured livelihood, so far as poverty, hunger and destitution are concerned. But at the same time government must ensure adequate fund for providing huge subsidy required for the food sector. Government may create budgetary provision by slightly reducing allocation of funds in other developmental activities.

Endnotes

2. Net indirect tax mentioned in the SAM has been classified into domestic indirect tax and import tariff.
3. In the Indian context government savings in most of the cases is negative that constitute large part of country’s fiscal deficit. Expenditure of the government is usually determined in annual budget.
4. Armington function is a special type of function that aggregates domestic variety and foreign variety to give rise to the demand for composite commodity.
5. If government finances deficit by the borrowing from central bank and creating more money, this will end up with inflationary pressure which will ultimately reduce purchasing power of the households

References


**APPENDICES**

**APPENDIX-1: Mathematical Structure of the CGE Model**

Production Block:

\[
Y_j = b_j \left[ \prod_h F_{h,j}^{\beta_{j,i}} \right] 
\]

(1)

\[
X_{i,j} = ax_{i,j} \cdot Z_j
\]

(2)

\[
Y_j = ay_j \cdot Z_j
\]

(3)

\[
F_{h,j} = \beta_{h,j} \cdot py_j \cdot Y_j / pf_h
\]

(4)

\[
pz_j = ay_j \cdot py_j + \sum_i ax_{i,j} \cdot pq_i + \frac{FC_j}{Z_j}
\]

(5)

Government behavior:

\[
GINC = Td + Tdc + TInd + NCAT + ENT + TARR - Ts
\]

(6)

\[
Td = \sum_b tau_{b} \cdot \left[ \sum_h pf_h \cdot FF_h \cdot r_{h,b} + GT_b + NCUT_b \right]
\]

(7)

\[
Tdc = tcorp \cdot (OPR + IND)
\]

(8)
\[ OPR = sop \cdot \left[ \sum_h pf_h \cdot FF_h + NF_1 + NF_2 \right] \] (9)

\[ TInd = \sum_b \tau u z_j \cdot p z_j \cdot Z_j \] (10)

\[ TARR = \sum_i \tau u m_i \cdot p m_i \cdot M_i \] (11)

\[ Ts = taus \cdot \sum_i pe_i \cdot E_i \] (12)

\[ X g_i = mu \times GDP/ pq_i \] (13)

\[ GT_b = gt_b \cdot GINC \] (14)

\[ GEXP = \sum_i X g_i + \sum_b GT_b + Ts \] (15)

\[ S_G = GINC - GEXP \] (16)

Investment behaviors:

\[ X v_i = \lambda m d_i \cdot \left[ Dep + \sum_b Sp_b + Sg + Sc + Sf \cdot \epsilon s \right] \bigg/ pq_i \] (17)

Savings:

\[ HHIN_b = \sum_h \left[ \sum_h FF_h \cdot pf_h + NF_1 + NF_2 \right] \cdot r_{h,b} + NCUT_b + GT_b \] (18)

\[ HHIN_b = \left[ \sum_h FF_h \cdot pf_h + NF_1 + NF_2 \right] \cdot r_b + NCUT_b + GT_b \] (18.a)

Where \( r_b = \sum_h r_{h,b} \)

\[ Sp_b = ssp_b \cdot HHIN_b \] (19)

\[ Sc = ssc \cdot (OPR + IND) \] (20)

Household consumption:

\[ Xp_{i,b} = \alpha m b_{i,b} \cdot \left[ HHIN_b - Td_b - Sp_b \right] \bigg/ pq_i \] (21)

International trade:

\[ pm_i = \epsilon s \cdot p Wm_i \cdot (1 + \tau m_i) \] (22)

\[ pe_i = \epsilon s \cdot p We_i \cdot (1 +\tau s) \] (23)
\[
\sum_i pW_iE_i + Sf + \sum_b NCUT_b + NF_1 + NF_2 + NCAT + Ts = \sum_i pWm_iM_i
\]  

(24)

Armington function:

\[
Q_i = \text{gamma}_i\left[\text{deltam}_i \cdot M_i^{\text{eta}_i} + \text{deltad}_i \cdot D_i^{\text{eta}_i}\right]^{\frac{1}{\text{eta}_i}}
\]  

(25)

\[
M_i = \left[\text{gamma}_i^{\text{eta}_i} \cdot \text{deltam}_i \cdot \frac{pq_i}{pm_i}\right]^{\frac{1}{1-\text{eta}_i}}
\]  

(26)

\[
D_i = \left[\text{gamma}_i^{\text{eta}_i} \cdot \text{deltad}_i \cdot \frac{pq_i}{pd_i}\right]^{\frac{1}{1-\text{eta}_i}}
\]  

(27)

Transformation function:

\[
Z_i = \text{theta}_i \cdot \left[\text{xie}_i \cdot E_i^{\text{phi}_i} + \text{xid}_i \cdot D_i^{\text{phi}_i}\right]^{\frac{1}{\text{phi}_i}}
\]  

(28)

\[
E_i = \left[\text{theta}_i^{\text{phi}_i} \cdot \text{xie}_i \cdot (1 + \text{tind}) \cdot \frac{p_{zi}}{pe_i}\right]^{\frac{1}{1-\text{phi}_i}}
\]  

(29)

\[
D_i = \left[\text{theta}_i^{\text{phi}_i} \cdot \text{xid}_i \cdot (1 + \text{tind}) \cdot \frac{p_{zi}}{pd_i}\right]^{\frac{1}{1-\text{phi}_i}}
\]  

(30)

Market clearing condition:

\[
Q_i = \sum_b X_p_{i,b} + X_g_i + X_v_i + \sum_j X_{i,j}
\]  

(31)

\[
\text{FF}_{h,i} = \sum_j F_{h,j}
\]  

(32)

Fictitious Objective function:

\[
\text{UU} = \sum_b \prod_i X_p_{i,b}^\alpha
\]  

(33)

**APPENDIX-1A: List of Endogenous Variables**

- \(Y_j\) = Combined input used in \(j^{th}\) activity.
- \(F_{h,j}\) = Demand for basic input \(h\) in \(j^{th}\) activity.
- \(Z_j\) = Output of \(j^{th}\) activity.
- \(py_j\) = Price of combined input in \(j^{th}\) activity.
\( pf_h = \) Price of basic input \( h \).
\( pq_i = \) Price of the \( i^{th} \) commodity.
\( GINC = \) Total Government income.
\( Td = \) Household income tax.
\( Tdc = \) Corporate tax.
\( TInd = \) Indirect tax
\( FF_h = \) Factor price of the \( h^{th} \) factor.
\( GT_b = \) Government transfer to the \( b^{th} \) household.
\( gt_b = \) Government income share transferred to \( b^{th} \) household.
\( Xp_{i,b} = \) \( b^{th} \) household consumption of the \( i^{th} \) good.
\( Xg_i = \) Government consumption of the \( i^{th} \) good.
\( X_{i,j} = \) \( i^{th} \) sector’s output goes to \( j^{th} \) sector as intermediate input.
\( Xv_i = \) \( i^{th} \) commodity used as investment good.
\( pq_i = \) Price of the \( i^{th} \) commodity.
\( pe_i = \) Price of export.
\( Sg = \) Government savings.
\( Sp_b = \) Private savings of the \( b^{th} \) household.
\( Sc = \) Corporate savings.
\( \epsilon = \) Exchange rate.
\( HHIN_b = \) Income of the \( b^{th} \) household.
\( pe_i = \) Export price of good \( i \) in domestic currency.
\( pm_i = \) Imports price of good \( i \) in domestic currency.
\( pd_i = \) Price of domestic good.
\( pz_i = \) Supply price of the \( i^{th} \) good.
\( pWe_i = \) World export price.
\( pWm_i = \) World import price.
\( E_i \) = Export of good i.
\( M_i \) = Import of good i.
\( \epsilon \) = Exchange rate.
\( Q \) = Output composite good.
\( D_i \) = Output domestic good.
\( UU \) = Social welfare function.

**APPENDIX-1B: List of Exogenous Variables**

\( b_j \) = Production function shift parameter.

\( \beta_{i,h} \) = Share of \( h \)th input within combined input in \( j \)th activity.

\( ax_{i,j} \) = Per unit requirement of \( i \)th commodity in \( j \)th activity as intermediate input.

\( ay_j \) = Per unit requirement of combined input in \( j \)th activity.

\( r_{h,b} \) = \( h \)th factor income share of \( b \)th household.

\( ENT \) = Income of the government from entrepreneurial activity.

\( tau_{b} \) = Share of total household income paid as income tax by \( b \)th household.

\( mu_i \) = Share of government expenditure on \( i \)th commodity.

\( NCAT \) = Net transfer to government.

\( SF \) = Foreign savings at world prices.

\( lambda \) = Proportion of savings converted into investment.

\( Dep \) = Depreciation of capital.

\( FF_h \) = Total factor demand of the \( h \)th factor.

\( gamma \) = Scale parameter in Armington function.

\( delta_{i} \) = Share coefficient of domestic good in Armington function.

\( deltam \) = Share coefficient of import good in Armington function.

\( eta_i \) = Constant determining elasticity of substitution in Armington function.

\( theta_i \) = Scale parameter transformation function.

\( xie_i \) = Share parameter of export in Transformation function.

\( xid_i \) = Share parameter of domestic good in transformation function.
\( \phi_i \) = Constant determining elasticity of substitution in Transformation function.

\( tind \) = Indirect tax rate.

\( taum_i \) = Import tariff rate.

\( taus \) = Export subsidy rate.

\( NCUT_b \) = Net current transfer to \( b^{th} \) household.

\( tcorp \) = Share of corporate income to tax.

\( OPR \) = Operating profit.

\( IND \) = Interest on debt.

\( sop \) = Share of operating profit to total factor income.

\( NF_1 \) = Net labor income earned abroad.

\( NF_2 \) = Net capital income earned abroad.

\( Tpurhh \) = \( b^{th} \) household purchase tax.

\( Tpurg \) = Government purchase tax.

\( Ting \) = Taxes on intermediate.

\( Tinv \) = Taxes on investment good.

\( Ts \) = Taxes on export.

\( tpurhh_b \) = Share of household purchase paid as purchase tax by \( b^{th} \) household.

\( tpurg \) = Share of government purchase paid as purchase tax.

\( ting \) = Share of intermediate good purchase to tax.

\( tinv \) = Share of investment to tax.

\( taus \) = Share of export paid as tax.

\( FC_j \) = Fixed cost in the jth sector.