An Economic General Equilibrium Model for Evaluation of Production Support Policies in Developing Countries

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An Economic General Equilibrium Model for Evaluation of Production Support Policies in Developing Countries

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Abstract

This paper introduces a Computable General Equilibrium (CGE) model for the evaluation of production support policies in developing countries. It is a multi-sector, multi-market, multi-household model appropriate for what-if policy analysis. We describe the main aspects of the model. The model assumes small open economy, imperfect capital mobility, imperfect substitution between imported and domestic commodity, nested CES structure in production, nested CES structure in consumption, and heterogeneity of domestic products in one category. We consider transport margin, wholesale margin, import tariffs, import subsidy, production tax, value added tax, goods and services tax, and other transfer payments. We calibrate the model based on the 2001 Micro Consistent Matrix of Iran. The initial validation tests approve the validity of the model.

Keywords

Computable General Equilibrium, tax policy, industrial policy, production support, Iran

JEL

C68, H22, D58, L52

1 Introduction

Computable General Equilibrium or CGE models are widely used in policy impact measurement and what-if analysis. A CGE is typically a multi-sector, multi-commodity, multi-factor, and multi-household economic model based on General Equilibrium approach. The sectoral framework helps considering sectoral changes and re-allocation of production factors among different production sectors (activities). The multi-household framework is appropriate for finding losers and winners of a shock or policy. Therefore, it is a good tool for distributional and welfare analysis. A CGE is sometimes a multi-region model which is able to capture the impacts of trade or the impacts on trade.

This paper introduces the technical structure of a computable General Equilibrium model for for the evaluation of production support policies in developing countries. We show the application of this framework in industrial and mineral policy analysis in Iran. However, it can be applied to other countries in the world. Although many CGE models are made for developing countries, we put one step forward to extend the model dimensions and to improve the assumptions leading to the high accuracy of the analysis. Database flexibility makes this model a powerful tool in economic decision making. The model for Iran includes 147 commodity and 99 production activities. We have a 147x99 dimension for supply matrix, use matrix, wholesale margin matrix, and transport margin matrix.

2 Database

The data used in general equilibrium models must have an appropriate structure. Otherwise, calibration and policy analysis is not possible. In other words, the particular balanced structure of the data is required. Several suitable structures have been introduced and applied in empirical works. In this report, we will briefly introduce four main data structures which are National Accounts (NA), Input-Output (IO) tables, Social Accounting Matrix (SAM), and finally Micro Consistent Matrix (MCM).

2.1 Typical Databases for CGE models

Some aggregated CGE models are calibrated based on Aggregated National Accounts. National accounts are a systematic and quantitative picture of economic activities in a given period (quarterly or annually). This information is established in a set of interconnected and integrated macroeconomic accounts that are based on concepts, definitions, classifications, and rules of international recommendations of SNA. In the System of National Accounts, all the transactions in the economy are considered It -includes manufacturing, distribution, and consumption of goods and services, capital formation, imports, exports, and etc.-. The Information about these transactions is presented in a comprehensive framework and in the form of numerical tables so that it is standard for decision-making purposes, policy recommendation, and economic analysis. In national accounts, the accounts are divided into three groups: current accounts, accumulation accounts, and balance sheets. Current accounts include generation, distribution, and consumption of income accounts. Accumulation accounts include capital account, financial, other changes in the value of assets and revaluation. Despite the useful information available in national accounts, sometimes the more detailed and sectoral database is required.

Although general equilibrium theory had been considered by economists since the late nineteenth century, computation of a sectoral model was not possible. Because general equilibrium models typically include a lot of variables with complex mathematical equations that may not be solved without computers. Leontief was one of the first economists who published his work to fill the gap between experience and the theory. He presented a general equilibrium model in a simple framework of the input-output table that made the policy analysis possible. Input-output tables explain the sectoral components of an economic system and describe all transactions between different economic activities. They are usually used in analyzing the detailed structure of the economy and also in economic planning. In Input-output table, it is easily possible to extract basic balances of the economy at the national level and sectoral level (production of various goods and services). In these tables, the degree of interdependence of different sectors to each other and the degree of reliance in final demand are shown with numbers. Abstract image of the input-output table is as follows.

Table 1: General framework of input-output tables

	Commodities/activities	Final demand	total
Commodities/activities	*Intermediate demand account*	*Final demand account*	Total supply/demand
Production factors	*Value Added account*		
Total	Total supply/demand		

Most of CGE models are calibrated based on SAM (Social Accounting Matrix). Social Accounting Matrix is a combination of social data with macroeconomic and sectoral data. This table is designed based on microeconomic and macroeconomic relations in an algebraic matrix. Social accounting, both statistically and functionally, is broader than the macro national accounting system. The main task of macro accounting is regulating macroeconomic statistics, such as aggregate consumption, total investment, total savings, total exports, and total imports. While the main task of social accounting is arranging economic data of different economic sectors. Table 2 shows the typical structure of a social accounting matrix.

Table 2: The general structure of the social accounting matrix

		1	2	3	4	5	
		Production account	Factors of production account	Institutional account	Capital formation account	ROW account	Sum
1	Production account	Intermediate input matrix (1,1)		Final consumption of goods and services by institutions (1,3)	Capital formation (1,4)	Export of goods and services (1,5)	Sum of producers income
2	Factors of production account	VA matrix (2,1)				factors earnings from abroad (2,5)	Sum of factors income
3	Institutional account		Allocation of factors income to institutions (3,2)	Current and capital transfers between institutions(3,3)		institutions earning from abroad (3,5)	Sum of institutions income
4	Capital formation account			Domestic savings of institutions (4,3)		Net loan from abroad (4,5)	Sum of saving
5	ROW account	Import of goods and services from abroad (5,1)	Payment of factors of production to abroad (5,2)	Payment of institutions to abroad (5,3)	Trade balance (5,4)		Sum of ROW income
	Sum	Total value of supply	Total payments of factors	Total payments of institutions	Total cost of investment	Total payment of ROW	

Social accounting matrix can be expressed in a different way. This matrix is consistent with micro data that is called MCM or "Micro Consistent data Matrix. In general, this matrix is very similar to social accounting matrix with minor differences. MCM is taken from Rutherford (1995) general equilibrium modeling studies. MCM is a modified form of social accounting matrix that is appropriate for CGE modeling which is based on Mixed Complementarity Problem or MCP. This matrix, unlike the social accounting matrix, is not symmetric. This matrix expresses the interactions of economic agents in the form of positive and negative figures. There are also conceptual differences. Concepts of supply and demand for markets, plus revenue and cost for agents are used in MCM instead of using input and output for each account (as it is common in SAM).

In a typical CGE model, three blocks of equations are considered. These are (1) zero-profit condition for economic activities, (2) income balance condition for households, governments, institutions and abroad, and (3) equality of supply and demand or market clearance condition for commodities, production factors, and foreign currency. Keeping these conditions in mind, we can explain rows and columns of MCM matrix. Columns show zero profit or income balance condition, while rows show market equilibrium. MCM columns specify agents (producers, consumers, institutions, and government) and rows specify markets or transfer payments in the economy. For our general equilibrium modeling, it is necessary to provide economic data in the form of MCM matrix like the following table.

Table 3: MCM table structure and its components

		1	2	3	4	5
		producers	institutions	government	exports	imports
1	commodity markets	Supply and demand matrix	Final demand matrix	Public cost matrix	Exports matrix	Imports matrix
2	Factors of production markets	Creating domestic income matrix	private income allocation matrix	Government income allocation matrix	Creating foreign income matrix	foreign income allocation matrix
3	Taxes and subsidies	Taxes on production matrix	Taxes to institutions matrix	Public income matrix		Imports tariffs matrix
4	Exchange market				Supply of foreign exchange matrix	demand for foreign exchange matrix

As you see, the structure is very similar to social accounting matrix. But this matrix is a rectangular matrix. Rows show markets and taxes and subsidies. In MCM, revenues are entered in positive figures and costs are entered with negative signs. If a consumer has an endowment of a good to supply it, then the number is positive in the table. Or if a producer produces more than one product, the numbers are positive. The figures in this table show the value. Positive numbers in rows show the "value of" supply and negative numbers show the "value of" demand. If the equilibrium state of the economy has been achieved, total supply equals total demand and the sum of the row would be zero in the table (Shahmoradi et al., 2009).

2.2 Micro Consistent Matrix of IRIGE

Designing a general equilibrium model requires sectoral information in a consistent framework. An MCM is designed for our model. In our MCM, all economic activities are classified into 99 economic activities. Classification of economic activities in this matrix focuses on industries and mining subsectors. Furthermore, all goods and services are classified into 147 categories, with a special focus on industrial and mineral products. In this matrix, some economic activities supply more than one product. Finally, the factors of production include labor, operating surplus, and mixed income.

2.2.1 Domestic production matrix

Domestic production block is part of the supply (make) table in national accounts. This block provides information about goods and services that are produced in the country. In this block, the products are displayed in rows and activities in columns. Domestic production block in MCM shows the monetary value of commodities that activities have supplied. Since the block is a rectangular matrix, an activity can produce several types of goods and services. Also, a product category may be produced by several production activities.

2.2.2 Imports matrix

Imports block is also a part of the supply table in national accounts. This block includes imports of goods, imports of services, tariffs on imports, and subsidy on imports. In other words, this table shows the imported value of goods and services of each product category.

2.2.3 Intermediate input matrix

The intermediate input block is a part of the use table in national accounts. This block shows the value of intermediate input that each activity has used. Its size in terms of a number of activities and products is the same as domestic production block. In fact, the cost of each activity can be seen in the columns of the use table. In the system of national accounts, intermediate input is the value of goods and services used as input in the production process. Intermediate inputs do not include consumption of fixed capital.

2.2.4 Institutions matrix

Institutions consumption table is a part of the use table in the national accounts. In this section, consumption of each institution is shown in the form of final expenses of government and final expenses of households. However, each of these consumer groups can be classified into subgroups, but in MCM it is expressed in the form of an aggregated matrix.

2.2.5 Exports matrix

The exports block is also a part of the use table in the national accounts. In this block, the exports value of each classification of goods and services is expressed.

2.2.6 Capital formation matrix

Gross fixed capital formation, changes in inventories, and net acquisition of precious assets are shown in capital formation matrix. Gross fixed capital formation includes a net acquisition of tangible and intangible fixed assets like machinery, equipment, and buildings. Inventory changes include changes in materials and consumption goods, manufactured goods, existing product for resale and semi-manufactured goods. Net acquisition of precious objects is the last component of gross capital formation. Precious objects include objects that made of stones and precious metals, and they work as a store of value like art, jewelry, etc.

2.2.7 Value added matrix

The main components of value added are compensation of employees, net taxes on production and imports, consumption of fixed capital, net operating surplus, and mixed income. Employee compensation includes wages and salaries and employer contributions to social security. Taxes and subsidies are divided into taxes on VA, taxes, tariffs, and subsidies on imports, taxes, and subsidies on export, and other taxes and subsidies on production.

2.2.8 Transportation margin matrix

Domestic product matrix shows the value of goods at producer price. Because transportation margin is an important element between producer and consumer prices, the transportation margin block is considered separately. This block shows the cost that is paid for the transportation of intermediate input. This block includes transportation costs for goods and activities separately. The transportation cost for final consumption is also expressed.

2.2.9 Wholesale margin matrix

Wholesale and retail margin (trade margin), is one of the most important elements between producer and consumer prices. This matrix shows each paid for wholesale and retail services for buying intermediate input. This block includes trade margin costs for goods and activities separately. The wholesale and retail cost for final consumption is also expressed.

2.2.10 Institutions income matrix

Institutions income block shows the amount of resources income in the economy that is allocated to institutions. In other words, this block shows the institutional allocation of labor income, tax income, operating surplus income and mixed income.

3 The technical structure of the model

In this section, we introduce variables and parameters used in the model in mathematical form. The core part of the model is developed in a team of economists and is well-documented and well-known. This framework is applied in the assessment of the following policies: Cash Subsidy Transfer (Shahmoradi et al., 2011; Manzoor & Haqiqi, 2013); Access to Public Services (Mortazavi et al., 2013; Haqiqi & Mortazavi, 2012); Resources Boom (Manzoor et al. 2012a; Haqiqi & Bahador, 2015; Haqiqi & Bahalou, 2013); Generational Justice (Haqiqi, 2012; Haqiqi et al, 2013); Trade Barriers (Haqiqi & Bahalou, 2013) ; Labor Market Policies (Haqiqi & Bahalou, 2015; Manzoor and Bahaloo, 2015); Environmental Emissions (Manzoor and Haqiqi, 2012a); Energy Price Reform (Manzoor et al. 2010; Manzoor et al. 2012b; Manzoor & Haqiqi, 2012b; Sharifi et al., 2014) ; Energy Efficiency (Manzoor et al., 2011; Haqiqi et al., 2013) ; Energy Demand (Manzoor et al., 2012c; Manzoor & Haqiqi, 2013); Direct Investment (Manzoor et al. 2013). In this version, we focus on the production support and trade policies.

Here, calibration and validation methods will be briefly discussed. Almost all computable general equilibrium models have basic assumption of (1) market clearance of all goods and services, (2) market clearance of factors of production, (3) zero profits in all production activities, and (4) Income balances for economic institutions.

3.1 Price relations and total supply

Total supply in the economy consists of domestic production, imports, supply from inventory. The inventory itself may be imported or domestically produced. We assume imports and domestic production are imperfect substitutes (Armington, 1969). Therefore, total supply function must be in a form that shows this substitution. The figure below shows the nested structure of total supply in the economy.

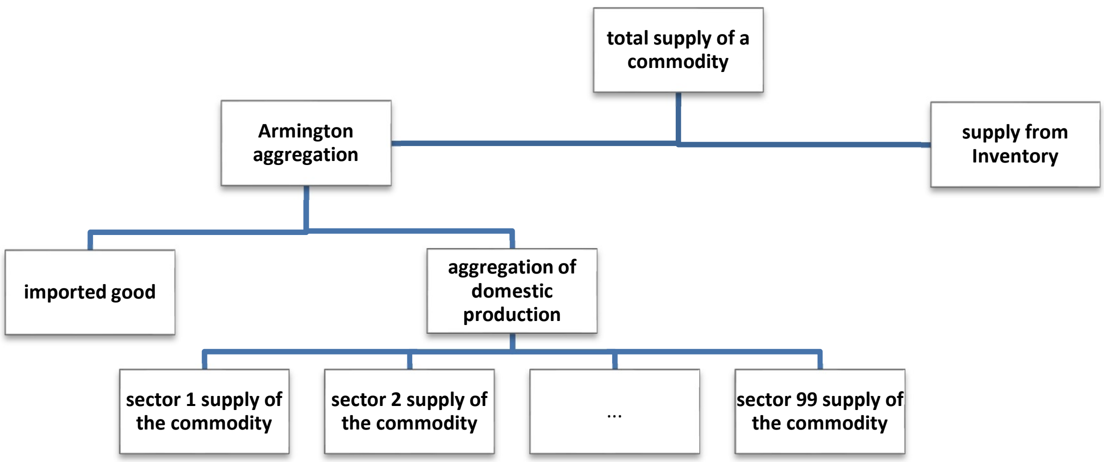

Figure 1: Nested structure of total supply

Thus the aggregate supply function of the economy can be displayed in price form as:

$$\pi_{as,g} = PAS_g - \left[\alpha_{as,g,ar} PAR_g^{1-\beta_{as,g}} + \alpha_{as,g,n} PN_g^{1-\beta_{as,g}}\right]^{\frac{1}{1-\beta_{as,g}}} \leq 0$$

where PN is inventory supply price index, PAR is Armington price index, and PAS is total supply price index of a specific commodity. In this equation, α is the share parameter, and β is substitution elasticity in the corresponding layer. Finally, n is inventory index, ar is Armington index, and as is total supply index. Suppose g is the set of commodities in the model and belongs to $\{g_1, g_2, \ldots, g_{147}\}$.

Armington aggregator function shows the substitution of imports and domestic production. The price form of this function is:

$$\pi_{ar,g} = PAR_g - \left[\alpha_{ar,g,m} PM_g^{1-\beta_{ar,g}} + \alpha_{ar,g,dp} PDP_g^{1-\beta_{ar,g}}\right]^{\frac{1}{1-\beta_{ar,g}}} \leq 0$$

where, PDP is a domestic commodity price index, and PM is imported goods price index. Moreover, m is an index of imports and dp is an index of domestic production. In this equation, α is the share parameter, and β is substitution elasticity between domestic and imported commodities.

Because a commodity may be supplied by several different activities, the different price index for goods in each sector is assumed. This assumption implies the heterogeneous nature of these commodities. Thus, a domestic product supply function is defined. The price form of this function is as follows:

$$\pi_{ds,g} = PDP_g - \left[\sum_s \alpha_{ds,g,s} PP_{g,s}^{1-\beta_{ds,g}} \right]^{\frac{1}{1-\beta_{ds,g}}} \leq 0$$

where, $PP_{g,s}$ is producer price index of specific commodity g in a sector s, α is share parameter, and β shows the degree of heterogeneity between domestic commodities.

Import price is defined as a function of the foreign exchange rate, foreign price, and import tariff or subsidy. So, the import price index function has been defined as follows:

$$\pi_{im,g} = PFX\,.PMF_g\,.(1 - msr_g) - PM_g\,.(1 + mtr_g) \leq 0$$

where PMF is imported good price index, PFX is exchange rate, msr is the import subsidies rate, and mtr is the import tariff rates.

3.2 Domestic production

Activities produce their products using intermediate commodities and factors of production. A special nested structure for domestic production is assumed. The production costs can be divided into energy and non-energy costs. The next figure shows the detailed structure of production in each sector.

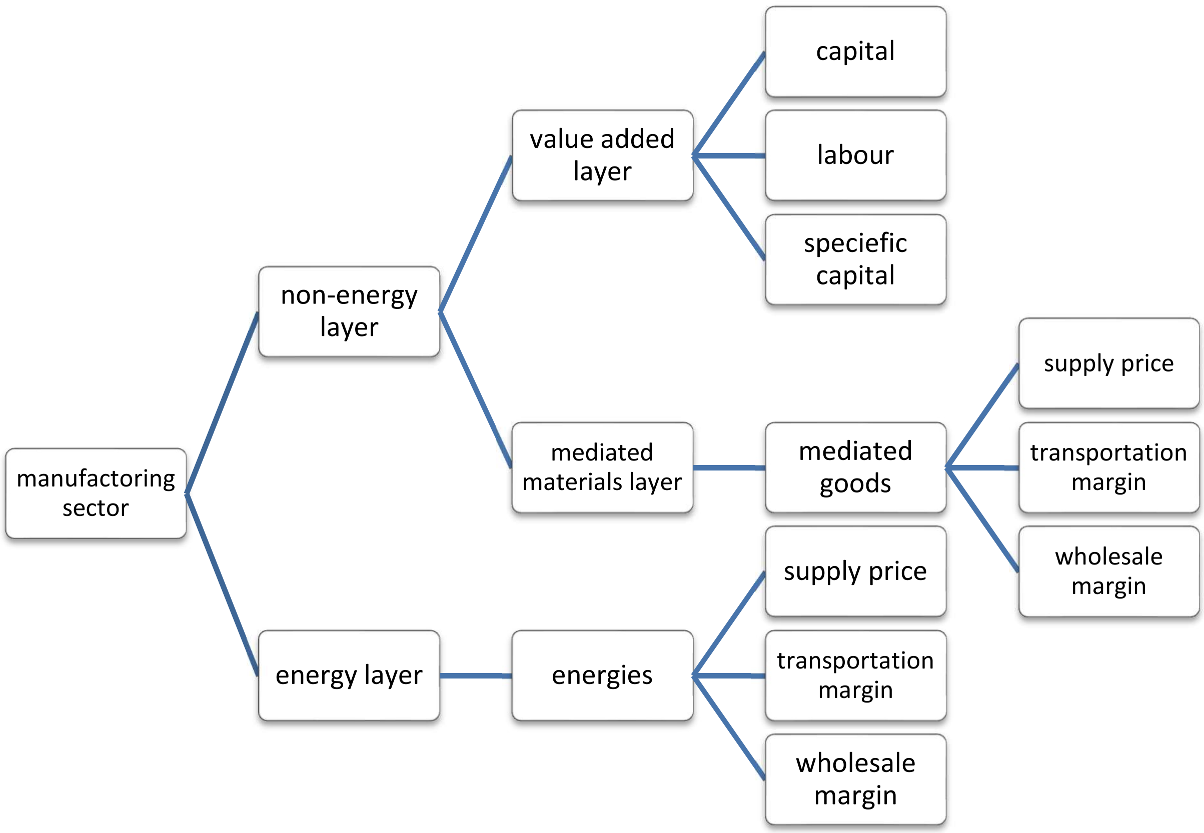

Figure 2: production structure

The upper nest shows domestic production as a function of energy composite and non-energy composite. The mathematical formula is as follows:

$$\pi_{o,s} = \left[\sum_{s} \delta_{o,s,g} \left[(1+str_{g,s}) PP_{g,s} \right]^{1-\theta_{o,s}} \right]^{\frac{1}{1-\theta_{o,s}}} - \left[\alpha_{o,s,en} PEN_{s}^{1-\beta_{o,s}} + \alpha_{o,s,ne} PNE_{s}^{1-\beta_{o,s}} \right]^{\frac{1}{1-\beta_{o,s}}} \leq 0$$

where PNE is non-energy prices, PEN is energy prices and PP is prices of products. In this structure, θ is elasticity of transformation, δ is the share of each product in the total income, and str is the tax rate on the product. In this equation, s is the set of production factors belongs to $\{s_1, s_2, \ldots, s_{99}\}$, o denotes output nest, en stands for energy composit, and ne is used for non-energy composite.

Energy composite cost depends on energy prices, transportation cost, and wholesale margin costs. We assume a substitution between various energy commodities. Therefore, the energy layer function in production is as follows:

$$\pi_{en,s} = PEN_{s} - \left[\sum_{en} \left[\alpha_{s,en,tp} PTP_{en} + \alpha_{s,en,wh} PWH_{en} + \alpha_{s,en,en} PIN_{en,s} \right]^{1-\beta_{en,s}} \right]^{\frac{1}{1-\beta_{en,s}}} \leq 0$$

where PIN is energy input price, PWH is wholesale cost index and PTP is transportation cost index, α is share parameter, and β shows the substitution elasticity between energy commodities.

Non-energy composite is divided into intermediate composite and value added composite. Therefore, the functional form of the non-energy layer in production is as follows:

$$\pi_{ne,s} = PNE_s - \left[\alpha_{ne,s,va} PVA_s^{1-\beta_{ne,s}} + \alpha_{ne,s,ma} PMA_s^{1-\beta_{ne,s}} \right]^{\frac{1}{1-\beta_{ne,s}}} \leq 0$$

where PMA is an intermediate composite price index and PVA is value added price index per unit of production. The intermediate composite includes inputs costs, transportation costs, and wholesale margins. Therefore, the intermediate composite layer can be expressed mathematically like this:

$$\pi_{ma,s} = PMA_s - \left[\sum_{ne} \left[\alpha_{s,ne,tp} PTP_{ne} + \alpha_{s,ne,wh} PWH_{ne} + \alpha_{s,ne,ma} PIN_{ne,s} \right]^{1-\beta_{ma,s}} \right]^{\frac{1}{1-\beta_{ma,s}}} \leq 0$$

In the value-added layer labor and capital are combined with a substitution elasticity. The functional form of value added layer can be presented like this.

$$\pi_{va,s} = PVA_s - \left[\sum_{f} \alpha_{va,s,f} PF_{f,s}^{1-\beta_{va,s}} \right]^{\frac{1}{1-\beta_{va,s}}} \leq 0$$

where PF is a particular price for any factor of production.

Note that intermediate input prices are determined considering taxes and total supply prices. If Ntr shows the tax rate, and PC depicts the commodity price the input price is determined by

$$PIN_{g,s} = PC_g (1 + ntr_g)$$

For transportation and wholesale margins, we define the following functional forms:

$$\pi_{tp,g} = PTP_g - PAS_{gg} \leq 0, \quad (gg = transportation\_services)$$

$$\pi_{wh,g} = PWH_g - PAS_{gg} \leq 0, \quad (gg = wholesale\_services)$$

One of the significant assumptions of this study is the absence of "full mobility" of capital and labor among different sectors. In other words, capital and labor are defined as imperfectly mobile between sectors. We assume a degree of mobility between sectors. Therefore, the wage of factors of production must be defined separately for each sector. If W is a wage of a factor of production we have:

$$\pi_{fs,f} = \left[\sum_{s} \delta_{fs,f,s} PF_{f,s}^{1-\theta_{fs,f}} \right]^{\frac{1}{1-\theta_{fs,f}}} - W_f \leq 0$$

where PF is sectoral wage, δ is sectoral share, θ is the degree of mobility, and fs denotes factor supply function.

3.3 Export-Domestic supply

A commodity is either supplied domestically or abroad. Domestically supplied products are either consumed as inputs of production or reached by households for final consumption. However, transportation and wholesale margins also affect the commodity price.

The price function showing export allocation and domestic supply are as follows:

$$\pi_{xd,g} = \left[\delta_{xd,g,x} PX_g^{1-\theta_{xd,g}} + \delta_{xd,g,d} PC_g^{1-\theta_{xd,g}}\right]^{\frac{1}{1-\theta_{xd,g}}} -$$

$$\left[\sum_g \left[\alpha_{xd,g,tp} PTP_g + \alpha_{xd,g,wh} PWH_g + \alpha_{xd,g,g} PAS_g\right]^{1-\beta_{xd,g}}\right]^{\frac{1}{1-\beta_{xd,g}}} \leq 0$$

PC is commodity price and PX is export price. As the export of commodities is along with the supply of foreign currency, so we have:

$$\pi_{ex,g} = PFX.PEF_g - PX_g \leq 0$$

where PEF is commodity price in the export markets.

3.4 Household's expenditure

Household's expenses are divided into energy composite and non-energy composite. The nested structure of the household's expenses is presented as:

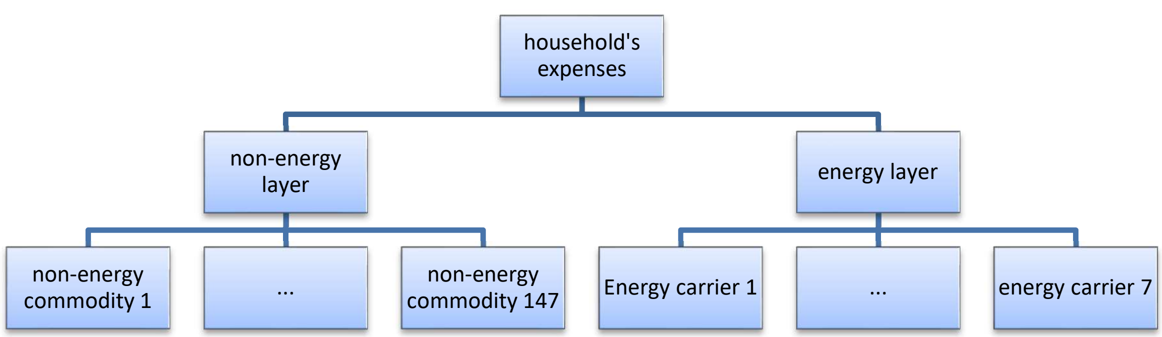

Figure 3: Household's expenses structure

So, the price form of household's expenses function is:

$$\pi_{wlf,h} = CPI_h - \left[\alpha_{wlf,h,en} PEN_h^{1-\beta_{wlf,h}} + \alpha_{wlf,h,ne} PNE_h^{1-\beta_{wlf,h}}\right]^{\frac{1}{1-\beta_{wlf,h}}} \leq 0$$

where CPI shows the consumer price index, PEN is energy composite price index, PNE is non-energy composite price index. We assume a substitution among energy carriers. Therefore, the energy layer in households' expenses is defined as:

$$\pi_{en,h} = PEN_h - \left[\sum_{en} \left[\alpha_{en,h,en} PC_{en} \right]^{1-\beta_{en,h}} \right]^{\frac{1}{1-\beta_{en,h}}} \leq 0$$

Similarly, the non-energy layer is defined as:

$$\pi_{ne,h} = PNE_h - \left[\sum_{ne} \left[\alpha_{ne,h,ne} PC_{ne} \right]^{1-\beta_{ne,h}} \right]^{\frac{1}{1-\beta_{ne,h}}} \leq 0$$

On the other hand, households are owners of production factor. Supply of production factors generates their income. They may spend it on saving, tax, consumption, and purchase of foreign currency. So, the income balance condition for households is:

$$\sum_f FE_h.W_f - NETTAX_h - CON_h.CPI_h - PS.SAV_h - FXD_h.PFX = 0$$

where FE is the initial stock of household's capital and labor, Con shows the consumption level, SAV is the level of saving, PS depicts saving price index. Also, FXD is the purchase of foreign currency and NETTAX is net payment of tax.

3.5 Market clearance conditions

Each particular market includes supply and demand. We assume market clearance for all commodities and production factors which implies that the value of supply is equal to the value of demand. However, our model considers the supply and demand behavior in separate blocks. Next table shows the abstract version of MCM used in the model. Reading through rows of the table, positive signs show supply and negative signs show demand. Each price index represents a particular market. Finally, columns display different blocks.

Market clearance conditions for this model are obtained based on Shephard's Lemma. They are obtained through differentiating from zero profit conditions with respect to the corresponding price variables. Thus, knowing zero profit conditions is enough to have all market clearance conditions. Therefore, in this paper, we do not mention market clearance conditions. Those who are interested can find the details of demand and supply functions in Rutherford (1998; 1999), Shahmoradi et al (2010), Manzoor et al. (2012), and Haqiqi (2014).

Table 4: an abstract version of MCM used in the model

	AS	AR	DS	IM	O	EN_S	NE_S	MA	VA	IN	IP	WH	FS	XD	EX	WLF	EN_H	NE_H	H
PAS	+									-	-	-		-					
PAR	-	+																	
PM		-		+															
PDP		-	+																
PP			-		+														
PFX				-											+				-
PEN					-	+													
PNE					-		+												
PTP						-		-			+			-					
PWH						-		-				+		-					
PIN						-		-		+									
PVA							-		+										
PMA							-	+											
PF									-				+						
W													-						+
PX														+	-				
PC														+			-	-	
CPI																+			-
PEN_H																-	+		
PNE_H																-		+	

4 GAMS code and calibration

After the mathematical formulation of general equilibrium, it is necessary to write the codes in the appropriate software. GAMS software is used in this research. Next figure shows the first screen of code. To learn the more, coding framework of the model is described in the next section.

GAMS code starts by introducing SETS. Set of goods, production activities, households, and factors of production have been introduced into the program.

```
SETS
         S SECTORS /S1*S99/
         G GOODS AND SERVICES /G1*G147/
         H HOUSEHOLDS /URBAN, RURAL, NPI, GOVT /
         F FACTORS /LAB, MX, SRPLS/
```

For 28x34 version of the model SET definition is like this:

```
SETS
         S SECTORS /S1 , S9, S10, S11, S12, S13, S14, S15, S18, S21, S24, S25, S26,
         S27, S28, S29, S30, S31, S32, S42, S46, S47, S48, S49, S51, S55, S66, S99/

         G GOODS AND SERVICES /G1, G13, G14, G15, G16, G17, G18, G19, G20, G21,
         G22, G23, G37, G43, G45, G46, G47, G48, G49, G50, G60, G61, G62, G68,
         G71, G73, G74, G75, G88, G92, G94, G95, G97, G109/
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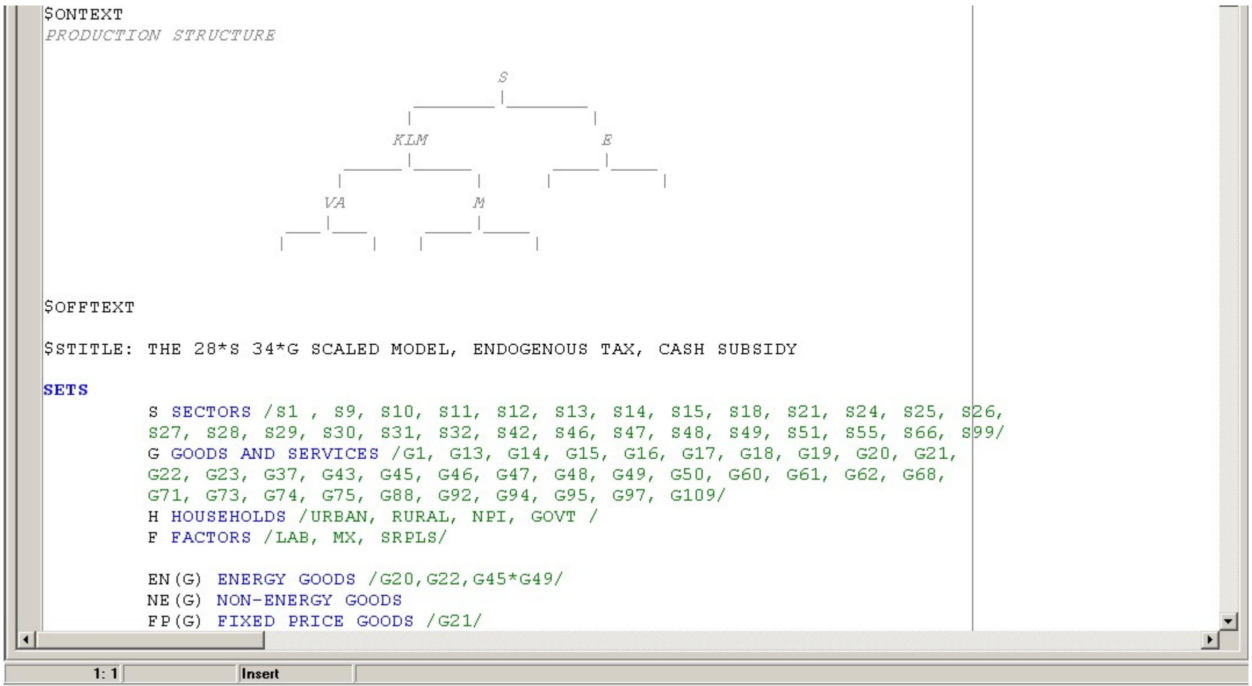

```
$ONTEXT
PRODUCTION STRUCTURE

                                   S
                         _________|_________
                        |                   |
                       KLM                  E
                   ______|______       _____|_____
                  |             |     |           |
                 VA             M
              ____|____     _____|_____
             |         |   |           |

$OFFTEXT

$STITLE: THE 28*S 34*G SCALED MODEL, ENDOGENOUS TAX, CASH SUBSIDY

SETS
         S SECTORS /S1 , S9, S10, S11, S12, S13, S14, S15, S18, S21, S24, S25, S26,
         S27, S28, S29, S30, S31, S32, S42, S46, S47, S48, S49, S51, S55, S66, S99/
         G GOODS AND SERVICES /G1, G13, G14, G15, G16, G17, G18, G19, G20, G21,
         G22, G23, G37, G43, G45, G46, G47, G48, G49, G50, G60, G61, G62, G68,
         G71, G73, G74, G75, G88, G92, G94, G95, G97, G109/
         H HOUSEHOLDS /URBAN, RURAL, NPI, GOVT /
         F FACTORS /LAB, MX, SRPLS/

         EN(G) ENERGY GOODS /G20,G22,G45*G49/
         NE(G) NON-ENERGY GOODS
         FP(G) FIXED PRICE GOODS /G21/
```

1: 1 Insert

Figure 4: A view of the code (28x34 version)

Then the data are transferred from MCM. MCM blocks are defined separately. We employ Xlimport syntax to import data from excel file. This syntax is easy to use and straightforward method of importing data into GAMS.

```
PARAMETER USE(*,*)   USE (CONSUMPTION) MATRIX;
$libinclude xlimport USE IRIGE_MCM.xls USE!A1:AO43
DISPLAY USE;

PARAMETER SUP(*,*)   MAKE (SUPPLY) MATRIX;
$libinclude xlimport SUP IRIGE _MCM.xls SUP!A1:AO43
DISPLAY SUP;

PARAMETER IMP(*,*)   IMPORT MATRIX;
$libinclude xlimport IMP IRIGE _MCM.xls IMP!A1:AO43
DISPLAY IMP;

PARAMETER TRN(*,*)   TRANSPORTATION COST (MARGIN) MATRIX;
$libinclude xlimport TRN IRIGE _MCM.xls TRN!A1:AO43
DISPLAY TRN;

PARAMETER TRD(*,*)   TRADE COST (MARGIN) MATRIX;
$libinclude xlimport TRD IRIGE _MCM.xls TRD!A1:AO43
DISPLAY TRD;
```

Then other parameters are defined and their values are assigned. These parameters include tax rate, subsidies rate, tariff rate, substitution elasticity parameters, and etc.

```
PARAMETERS
         PMF             IMPORT PRICE INDEX
         PEF             EXPORT PRICE INDEX
         MTR(G)          IMPORT TARIFF RATE
         MSR(G)          IMPORT SUBSIDY RATE
         STR(S)          SECTOR TAX RATE
         ITR(H)          INCOME TAX RATE
         itr0(h)         BENCHMARK INCOME TAX RATE
         msr0(g)         BENCHMARK IMPORT SUBSIDY RATE
         mtr0(g)         BENCHMARK IMPORT TARIFF RATE
         str0(s)         BENCHMARK SECTOR TAX RATE
         NITR(G,S)       ENDOGENOUS INPUT TAX RATE
         NCTR(G)         ENDOGENOUS COMMODITY TAX RATE
...
```

In the next stage, endogenous variables and equations are introduced. In MCP each variable is the complement of an equation or inequality. Some of the variables are displayed below.

```
         AL(S)                          !ACTIVITY LEVEL OF SECTOR S
         IMPORT(G)$SUP(G,"IMP")         !IMPORT LEVEL OF GOOD G
         EXPORT(G)$USE(G,"EXP")         !EXPORT LEVEL OF GOOD G
         G_SUPPLY(G)                    !SUPPLY DISAGGREGATOR FUNCTION
         TRNSPRT                        !TRANSPORT COST FUNCTION, OF GOOD G TO SECTOR S
         TRADE                          !WHOLESALE COST FUNCTION, OF GOOD G TO SECTOR S

         PSS(G,s)$sup(g,s)               !SUPPLY PRICE OF GOOD G IN SECTOR S
         PI(G,S)$USE(G,S)                !INPUT PRICE FOR EACH SECTOR
         PF(F,S)$USE(F,S)                !FACTOR PRICE IN SECTOR S
         PM(G)$SUP(G,"IMP")              !IMPORT PRICE OF GOOD G
         PX(G)$USE(G,"EXP")              !EXPORT PRICE OF GOOD G
         PT(G)$SUP(G,"TRN")              !TRANSPORT COST OF GOOD G TO SECTOR S
         PW(G)$SUP(G,"TRD")              !WHOLESALE COST OF GOOD G TO SECTOR S
         PN(G)$SUP(G,"NVNT")             !INVENTORY PRICE INDEX
         CPI(H)                          !CONSUMER PRICE INDEX (REAL & RELATIVE PRICES)
         PFX                             !EXCHANGE RATE INDEX
         W(F)                            !FACTOR PRICE INDEX
...
```

Note that after introducing the model, for initial validation, we set the iteration limit to zero. Then we remove this limitation for further counterfactual policy analysis.

4.1 Calibration

We can confirm the validity of the general equilibrium model through benchmark calibration. Without any shock or policy, the level of unknown variables (prices, levels of activity, wages, income levels, etc) must be equal to initial values in the model. In other words, if the model can replicate the benchmark in the absence of any new policy, the validity of the model is confirmed and it is ready for further analysis. Each policy or shock brings the economy out of its initial position and reaches a new equilibrium. So, any policy analysis is possible by a comparison of the initial and secondary states.

A process in which the independent variables achieve conformity between the observed and simulated values is known as calibration. For calibration of prices and quantities in the model, Harberger method is used. Harberger (1969) method expresses that since the prices and aggregated quantities of goods in general equilibrium models are not visible, it is better to use a price index and a quantity index. For simplicity of calculation, it has been suggested that we assume one of the indexes to be one. Thus at the benchmark, it is assumed that the value of the transaction is equal to quantities and then prices index will be one. If the model fails to calibrate the initial data, the structure of the model must be revised.

4.2 Initial validation stages

Model validation has different stages. The first phase is shown in the next figure. The first stage after defining the model is solving the model with zero iteration and replication of the benchmark data. At this stage, the error is calculated. Running and solving the model, the validation is confirmed in several ways. If the residual value is large, it can be concluded that the model is not well defined. It is necessary to identify the variable that causes large residuals and then correct it. If the model does not replicate initial values, we can conclude that markets are not cleared or zero profit conditions are not defined properly. In this case, the causes of demand and supply surplus must be recognized. Also, the causes of positive or negative profit must be identified.

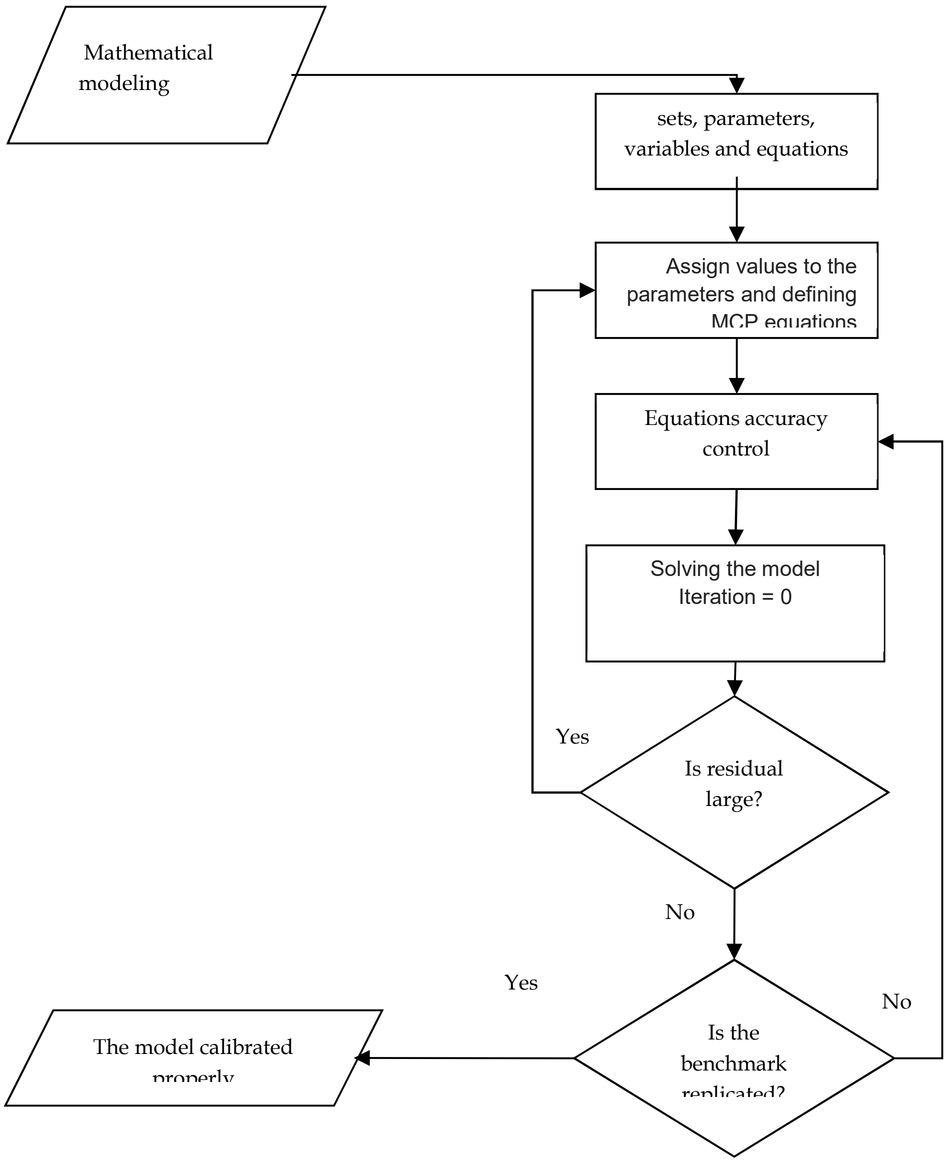

Figure 5: Initial validation stages

4.2.1 The size of the residual in the first stage

Running the final model, we find that our model is valid. The residual value is about 0.0006. Because the data is used on the scale of millions, the number of residual shows the accuracy of the defined model. The solution report of the model is shown below. The first row shows the solver. The second row shows the numbers of unknown variables in the model are 2569 and the numbers of nonzero parameters in the calculation have been 15296. The initial and final state of the data shows that the equations are well-defined. Finally, the last line shows the amount of residual.

```
PATH            May 24, 2010 23.4.3 WIN 17710.17719 VS8 x86/MS Windows
2569 row/cols, 15296 non-zeros, 0.23% dense.
Path 4.7.02 (Fri May 21 13:29:44 2010)
Written by Todd Munson, Steven Dirkse, and Michael Ferris

INITIAL POINT STATISTICS
Zero row of order . . . . . . .  0.0000e+000 eqn: (TAX)
Total zero rows . . . . . . . .  1
Maximum of X. . . . . . . . . .  1.9919e+004 var: (KFRM)
Maximum of F. . . . . . . . . .  1.0000e+000 eqn: (FCPP.'G20')
Maximum of Grad F . . . . . . .  3.8114e+004 eqn: (CPI.'URBAN')
                                             var:  (WELFARE.'URBAN')
INITIAL JACOBIAN NORM STATISTICS
Maximum Row Norm. . . . . . . .  7.6227e+004 eqn: (WELFARE.'URBAN')
Minimum Row Norm. . . . . . . .  1.8438e-005 eqn: (INPUT.'G19'.'S30')
Maximum Column Norm . . . . . .  7.6227e+004 var: (WELFARE.'URBAN')
Minimum Column Norm . . . . . .  1.8438e-005 var: (INPUT.'G19'.'S30')

Major Iteration Log
major minor  func  grad  residual    step  type prox    inorm  (label)
    0     0     1     1 6.4622e-004           I 0.0e+000 3.5e-004 (SAV)

FINAL STATISTICS
Inf-Norm of Complementarity . .  3.5023e-004 eqn: (SAV)
Inf-Norm of Normal Map. . . . .  3.5023e-004 eqn: (SAV)
Inf-Norm of Minimum Map . . . .  3.5023e-004 eqn: (SAV)
Inf-Norm of Fischer Function. .  3.5017e-004 eqn: (SAV)
Inf-Norm of Grad Fischer Fcn. .  6.0819e+000 eqn: (PS.'G95')
Two-Norm of Grad Fischer Fcn. .  1.0553e+001

FINAL POINT STATISTICS
Zero row of order . . . . . . .  0.0000e+000 eqn: (TAX)
Total zero rows . . . . . . . .  1
Maximum of X. . . . . . . . . .  1.9919e+004 var: (KFRM)
Maximum of F. . . . . . . . . .  1.0000e+000 eqn: (FCPP.'G20')
Maximum of Grad F . . . . . . .  3.8114e+004 eqn: (CPI.'URBAN')
                                             var:  (WELFARE.'URBAN')

 ** EXIT - iteration limit.

Major Iterations. . . . 0
Minor Iterations. . . . 0
Restarts. . . . . . . . 0
Crash Iterations. . . . 0
Gradient Steps. . . . . 0
Function Evaluations. . 1
Gradient Evaluations. . 1
Total Time. . . . . . . 0.156000
Residual. . . . . . . . 6.462212e-004
```

4.2.2 Benchmark replication

Solving the model, we find that the initial values of all variables are correctly calculated. In other words, all the variables are properly replicated. Because the Harberger method is used, the initial values of price and activity level variables are all equal to one. As an example, the calculated values of the activity level variable are presented below. Note that each endogenous variable has four assigned value: LOWER, LEVEL, UPPER, MARGINAL. In the solution report, "Level" column shows the value of variables, while "lower" column shows the minimum, "upper" column shows maximum, and marginal column shows -1 x net profit of each activity.

```
---- VAR AL  ACTIVITY LEVEL OF SECTOR S
       LOWER     LEVEL     UPPER    MARGINAL

S1       .        1.000     +INF  -4.958E-5
S9       .        1.000     +INF  -4.121E-5
S10      .        1.000     +INF  7.1088E-6
S11      .        1.000     +INF  -3.487E-5
S12      .        1.000     +INF  -4.583E-7
S13      .        1.000     +INF  -4.320E-5
S14      .        1.000     +INF  -6.443E-6
S15      .        1.000     +INF  9.6708E-5
S18      .        1.000     +INF  3.5387E-6
S21      .        1.000     +INF  4.2100E-5
S24      .        1.000     +INF  -2.566E-5
S25      .        1.000     +INF  -9.625E-6
S26      .        1.000     +INF  -5.695E-5
S27      .        1.000     +INF  -4.130E-5
S28      .        1.000     +INF  3.3661E-6
S29      .        1.000     +INF  -3.526E-6
S30      .        1.000     +INF       .
S31      .        1.000     +INF  -4.517E-5
S32      .        1.000     +INF  2.0350E-4
S42      .        1.000     +INF  -4.118E-5
S46      .        1.000     +INF  -9.573E-6
S47      .        1.000     +INF  6.8344E-6
S48      .        1.000     +INF  -3.061E-5
S49      .        1.000     +INF  6.2442E-5
S51      .        1.000     +INF  -8.432E-6
S55      .        1.000     +INF  -4.542E-5
S66      .        1.000     +INF  -2.470E-6
S99      .        1.000     +INF  1.4892E-4
```

One important variable in our model is the level of welfare. We assume a Hicksian welfare index for urban and rural households as well as non-profit institutions and government. Benchmark replication results for these variables is represented here:

```
         LOWER     LEVEL     UPPER    MARGINAL

URBAN      .        1.000     +INF  2.6837E-6
RURAL      .        1.000     +INF  -1.455E-5
NPI        .        1.000     +INF       .
GOVT       .        1.000     +INF  -9.200E-6
```

5 Subsidy Policy Analysis

To see the performance of the model, we simulate some counterfactual subsidy policy scenarios here. Iran started its Economic Reform Plan in early 2011. The first stage of the reform includes a huge rise in fuel prices, removing bread subsidy, cutting milk subsidy, and paying cash subsidy to all urban and rural households.

It seems that the government is going to pay sectoral subsidy in the next stages of the reform after 2014. Policy makers are interested in measuring the impacts of those sectoral subsidies. We assume 3 scenarios of subsidy payment to different activities. Each scenario differs in sectoral share from the subsidy. Sectoral share form subsidy is determined according to (1) weight in consumption bundle, (2) weight in labor employment, and (3) weight in industrial import. The shares are considered according to the following table. We assume that this subsidy is paid out of Economic Reform Plan revenues; therefore no more tax is required to finance the policy. The subsidy is about 7 billions of US dollars per year (50% of the first stage expected revenue).

Table 5: Three scenarios of sectoral share in industrial subsidy payment

	Share in industrial subsidy according to consumption share	Share in industrial subsidy according to employment share	Share in industrial subsidy according to import share
Coal and Lignite	0.00%	1.00%	0.10%
Iron ores	0.00%	0.30%	0.50%
Stone, sand, clay	0.01%	1.60%	0.06%
Other mining	0.01%	0.60%	0.40%
Food products, tobacco, and beverage	49.80%	17.60%	8.30%
Textiles, leather, wearing apparel	17.30%	14.30%	9.90%
Wood and paper products	1.50%	4.40%	3.00%
Refinery and chemical products	6.10%	0.00%	12.70%
Plastic and rubber products	0.80%	3.60%	1.80%
Glass and glass products	0.80%	1.10%	0.50%
Non-metallic mineral products	0.80%	11.90%	0.70%
Machinery and equipments	10.40%	24.60%	45.80%
Iron and steel	0.00%	6.90%	6.30%
Copper products	0.00%	0.80%	0.05%
Aluminum	0.00%	1.40%	0.20%
Other basic metals	0.00%	0.00%	1.10%
Motor vehicles, trailers, and semi-trailers	12.40%	9.50%	8.50%

We find that this policy leads to net welfare gain for households. The results are reported in table 6. As this table depicts, rural households are better off by 3.05%, while urban households gain 2.87 more welfare in scenario (1). The pattern is almost the same in other scenarios. The welfare gain is mainly due to a rise in employment and a fall in consumer prices. As table 6 demonstrates, manufacturing employment increases by 3.06, 5.66, 5.65 percent in scenario (1), (2), and (3) respectively. Furthermore, table 6 shows that manufacturing export also increases by 14.20, 13.27, and 13.99 percent in scenario (1), (2), and (3) respectively. In contrast, manufacturing imports decreases by 5.10, 5.02, 6.38 percent in scenario (1), (2), and (3) respectively.

Table 6: the impact of subsidy payment on welfare, activity level, employment (% change)

	subsidy payment according to consumption share (1)	Subsidy payment according to employment share (2)	subsidy payment according to import share (3)
Welfare			
urban households	2.87	2.57	2.43
rural households	3.05	2.69	2.42
Employment			
Total employment	-0.44	0.36	0.79
Manufacturing employment	3.06	5.66	5.65
Import			
Total import	0.71	0.24	-0.90
Manufacturing import	-5.10	-5.02	-6.38
Export			
Total export	2.55	2.70	2.95
Manufacturing export	14.20	13.27	13.99
Activity level			
Agriculture	1.29	-0.30	-0.65
Extraction of coal and lignite	-2.83	18.61	3.13
Extraction of oil and gas	-0.06	-0.04	-0.03
Extraction of iron ore	-0.67	6.46	11.44
Extraction of copper ore	0.42	9.28	2.60
Quarrying of stone, sand, and clay	-3.14	2.88	0.36
Other mining	-0.95	21.45	16.56
Manufacture of food and beverage products	4.76	1.30	0.17
Manufacture of textiles	17.62	13.09	10.69
Manufacture of wood and paper products	1.42	12.25	10.19
Manufacture of coke and refined petroleum products	20.47	19.44	22.22
Manufacture of chemicals and chemical products	-2.87	-7.43	2.95
Manufacture of rubber and plastics products	-1.42	6.28	3.62
Manufacture of glass and glass products	2.45	6.42	-1.26
Manufacture of other mineral products	-7.82	-1.92	-7.23
Manufacture of basic iron and steel	-9.42	-0.40	-1.95
Manufacture of basic copper	-3.40	-0.96	2.24
Manufacture of basic aluminum	-4.48	2.75	-7.20
Manufacture of other basic metals	0.68	6.11	13.20
Manufacture of motor vehicles, trailers, and semi-trailers	4.08	2.19	2.39
Electric power generation, transmission, and distribution	1.05	2.45	2.03
Manufacture of gas; distribution of gaseous fuels	15.35	16.64	16.82
Water collection, treatment, and supply	2.67	2.23	2.18
Construction of buildings	-7.41	-6.29	-7.55
Wholesale and retail trade	-1.72	-0.99	-0.62
Transportation and storage	-4.01	-2.46	-1.76
Real estate activities	-0.80	-0.95	-1.07
Other services	-1.62	-1.39	-0.79

Source: research findings

6 Conclusion

IRIGE is a computable General Equilibrium model for industrial and mineral policy analysis in Iran. Describing the model, this paper tries to introduce the main aspects of the model. Zero profit conditions are discussed. In addition, the method of finding market clearance conditions is explained. We assume imperfect capital mobility, imperfect substitution between imported and domestic commodity, nested CES structure in production, nested CES structure in consumption, and heterogeneity of domestic products in one category. We consider transport margin, wholesale margin, import tariffs, import subsidy, production tax, value added tax, goods and services tax, and other transfer payments.

According to available criterion, we confirm the validity of the model in this study. On one hand, the amount of residual in "zero-iteration" is negligible. On the other hand, the benchmark values of the unknown variables are properly calibrated (benchmark replication). The model is now ready for policy analysis.

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