Developing a Recursive Dynamic CGE model of the Mongolian Economy: The ERI CGE model

Esmedekh Lkhanaajav
Munkh-Ireedui Bayarjargal
Vaanchig Ganshir

Economic Research Institute (ERI)

Abstract

The research aims to construct and test a dynamic CGE model for the Mongolian economy. The purpose of constructing the model is to assist in evaluating and analyzing the development of long-term sustainable policies.

Keywords:

CGE, Mongolian Economy, Economic Policy Analysis, GEMPACK

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Team Leader: **Esmedekh Lkhanaajav**
Team Members: **Munkh-Ireedui Bayarjargal**
Vaanchig Ganshir

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1. Introduction

1.1 Objective of the research project

Mongolia's geographical location, its economic structure and its mineral wealth give it unique characteristics. Tapping its natural resources in a way that equally benefits the social and economic well-being of Mongolians is the greatest challenge. The resources boom in recent years directly impacted remarkable economic growth, and affected Mongolia's economic structure, social welfare, institutional quality and environment.

According to Osborne et al. (2015) short-termism persists in Mongolia, from organizational planning through to high-level political decision making, and long-term visions and plans rarely exist. A long-term view and analysis are crucial for Mongolia's sustainable development. The creation of a long-term baseline for the Mongolian economy is vital for long-run policy evaluations and welfare analysis.

Analysis of a long-term view for the Mongolian economy requires economic modelling tools capable of investigating the underlying factors of the changes, evaluating policy alternatives to counteract negative effects and producing forecasts of the likely path that the Mongolian economy will take in the future.

Computable General Equilibrium (CGE) modelling is an extensively used and accepted tool for forecasting and policy analysis. CGE models belong to the economy-wide class of models, that is, those that provide industry disaggregation in a quantitative description of the whole economy (Dixon & Rimmer 2010a). CGE models are based on a comprehensive economy-wide database and can serve as a laboratory for policy analysis. The CGE framework helps capture interrelationships between economic sectors and accounts for the repercussion effects of policy (Dixon & Rimmer 2002). Even if only one sector is directly involved, there will be indirect effects on other sectors, so that economy-wide modelling is needed. For these reasons, CGE analysis has become a mainstream contributor to policy dialogues (Anderson, Martin & Van der Mensbrugghe 2012).

The main purpose of this research project is to construct and test a dynamic CGE model of the Mongolian economy. The model being developed will serve as a laboratory for economic analysis in order to develop informed views on policy in Mongolia.

1.2 CGE Modelling and Analysis

Interactions of agents and repercussions of episodes in an economy are capable of being captured in an economy-wide general equilibrium framework. The theory of general equilibrium analysis was pioneered by Walras (1877) and Edgeworth (1881). Leon Walras provided the first general equilibrium description of a complex economic system with the interactions of independent economic agents. Francis Edgeworth introduced the well-known tool of general equilibrium analysis of exchange that is named after him – the Edgeworth box. Major theoretical contributions related to the existence, uniqueness, stability and optimality of general equilibria were made also by Kenneth Arrow, Gerard Debreu, Hiroshi Atsumi, Hirofumi Uzawa and Michio Morishima from 1950 to the 1970s.

CGE modelling is an empirical approach of general equilibrium analysis. Since 1960, CGE modelling has gradually replaced other economy-wide approaches such as input-output modelling and economy-wide econometric modelling. It also became a dominant economy-wide framework for policy analysis in 1990s, with a vast amount of literature concerning various aspects and applications of CGE modelling (Dixon 2006). Dixon et al. (1992) described CGE modelling as an integration of a general equilibrium theoretical structure, data about the economy of interest, and solution methods to solve the models numerically. Dervis and Robinson (1982) identified CGE models as those that 'postulate neo-classical production functions and price-responsive demand functions, linked around an input-output matrix in a Walrasian general equilibrium model that endogenously determines quantities and prices'. Shoven and Whalley (1992) defined CGE modelling as a conversion of the Walrasian general equilibrium structure into realistic models of actual economies by specifying production and demand parameters, and incorporating data reflective of real economies. Dixon and Parmenter (1996) described the distinguishing characteristics of CGE models as follows:

(i) CGE models are general since they include explicit specifications of the behaviour of several economic agents/actors;

(ii) CGE models employ market equilibrium assumptions as they describe how demand and supply decisions made by different economic agents determine the prices of at least some commodities and factors that in turn ensure market equilibrium; and

(iii) CGE models are computable and produce numerical results.

CGE modelling can therefore be characterized by its applied nature and quantitative approach in general equilibrium analysis. Applied general equilibrium (AGE) modelling is an alternative term used to describe CGE modelling.

CGE models belong to the economy-wide class of models. Hence, they provide industry disaggregation and the behaviors of economic agents in a quantitative description of the whole economy.

2. ERI CGE Model of the Mongolian Economy

2.1 Introduction

ERI CGE is the single-country CoPS style recursive dynamic CGE model of the Mongolian economy. The overview about CoPS style CGE modelling can be found in Lkhanaajav (2016).

ERI CGE embodies characteristics of the Mongolian economy via calibrations to 2005 and 2012 Mongolian input-output data. It identifies 55 industries and 55 commodities in its 2005 database and 55 industries and 68 commodities in its 2012 database. Three primary factors are identified (labour, capital and land). The labour is further distinguished by 9 occupational types as in International Standard Classification of Occupations 2008 (ISCO-08), one digit major groups (ILO 2007). The model has a representative aggregate household.

Optimizing behavior governs decision-making by industries and households. Each industry minimizes its costs subject to given input prices and a constant-returns-to-scale (CRS) output function. Household demands are modelled via a representative utility-

maximizing household within a linear expenditure system (LES). Units of new industry-specific capital are cost minimizing combinations of Mongolian and imported commodities. Imperfect substitutability between imported and domestic varieties of each commodity is modelled using the Armington constant elasticity of substitution (CES) assumption.

The demand for any given Mongolian export commodity is inversely related to its foreign-currency price. The model recognizes consumption of commodities by government, and a variety of direct and indirect taxation instruments. It is assumed that all sectors are competitive and all markets clear. Purchasers' prices differ from producer prices by the unit value of indirect taxes and trade and transport margins. Further, ERI CGE has a top-down regional module which allows reporting the results of its applications both at the national level and at the provincial level.

Following Dixon *et al*. (1982), ERI CGE consists of a system of equations describing the behaviors of all economic agents in the economy. These agents are industries, investors, households, foreign sector and government. ERI CGE only describes the real economy; that is, only the markets for factors of production and goods and services are considered.

Demand and supply equations for private-sector agents are derived from the solutions to the optimization problems (i.e., cost minimization and utility maximization) which are assumed to constitute the behaviour of the agents in conventional neoclassical microeconomics. Producers operate in competitive markets which prevent the earning of pure profits. Economic agents base their decisions on changes in relative prices and income. The model calculates a number of macroeconomic indicators such as GDP, GNE, CPI and other variables in the System of National Accounts (SNA). The model is homogenous in all prices. One price, typically the consumer price index, nominal wage or nominal exchange rate, can be chosen as a *numeraire*.

2.2 Data requirement

Input-output tables are the main data input to CGE models. In the models, input-output tables provide an initial solution. A model's computations start from an initial solution defined by input-output tables of certain year and generate deviations away from that

solution due to the shocks under consideration. In addition, input-output tables provide the data for evaluation of numerous coefficients in the models (Dixon & Rimmer 2002). In addition to IOTs, a wide range of data from national accounts, government budgets, balance of payment, national surveys and censuses, and other statistical data are used. More data are often required for dynamic CGE models in their forecasting analysis and for micro-simulation CGE models in their distributional impact analysis. New generation financial CGE models require additional information about loanable fund markets and financial intermediaries. As computing power and software capability increase, CGE models contain greater details and thus require more and more information.

2.3 GEMPACK

GEMPACK (Harrison & Pearson 1996), developed in the Centre of Policy Studies (COPS) at Victoria University, Australia as an in-house software, is a suite of economic modelling software particularly designed for solving very large systems of non-linear equations and interrogating data and results in CGE models. GEMPACK automates the process of translating the model specification into a solution program (Horridge 2014). The implementation of CGE models can be written in levels and equations, percentage change equations or a mixture of them via algebra-like language used to describe and document the implementation. Then the GEMPACK program TABLO translates these texts into model-specific programs which solve the models. GEMPACK is equipped to handle a wide range of economic behavior and contains an advanced method solving inter-temporal models with adaptive and rational expectations. It is used in over 500 organizations in 100 countries, including Mongolia (Horridge et al. 2012).

2.4 Closures in ERI CGE

ERI CGE contain a large number of economic relationships linking observable features of the economy such as macroeconomic aggregates, commodity prices and outputs, household consumption composition and commodities with the structural features of the economy such as production technologies and household tastes.

With different closures ERI CGE is able to produce:

(a) Estimates of changes in technologies and consumer preferences using a historical closure;
(b) Explanations of historical episodes such as the recent mining boom in Mongolia employing a decomposition closure;
(c) Forecasts for industries, regions, occupations and households via a forecast closure; and
(d) Projections of the deviations from forecast paths that would be caused by the implementation of proposed policies and other shocks to the economic environment through a policy closure.

There are 4 types of closure used in CGE models, and these closures are more introduced below.

I. In the policy closure, naturally exogenous variables are exogenous and naturally endogenous variables are endogenous. In policy simulations, most of the exogenous variables adopt the values they have, either exogenously and endogenously, in the forecast simulations except the policy variables of focus. For example, if we are interested in the impact of a change in the value-added tax (VAT), the relevant tax variable is moved away from its baseline forecast path and then the effects of tax change on macro variables and other endogenous variables are calculated by comparing their paths in the policy simulation with their paths in the baseline forecast simulation.

II. In the forecast closure, we exogenise variables for which we have forecasts. These may include macro variables, industry or commodity level variables such as exports by commodity, and demographic variables. Naturally exogenous technology, preference and trade variables in forecast simulations are often exogenous and are given shocks that are informed by trends derived from historical simulations.

III. In the decomposition closure, those naturally exogenous variables are exogenous and shocked with the movements estimated by an historical simulation. Computations with decomposition closure enable us to identify the roles in the growth of industry outputs and other naturally endogenous variables of changes in technology, changes in preferences and most importantly in our case, changes in positions of export demand curves of minerals products as well as changes in other naturally exogenous variables.

IV. In the historical closure used to explain changes between two time periods, observations at a detailed commodity/industry level on movements in consumption, investment, government spending, exports, imports, employment, capital stocks and many other variables are exogenous and can be introduced to ERI CGE as shocks. Put simply, variables that are usually endogenous but observable are made exogenous and shocked by their changes between two points in time.

Computations with a historical closure are often used to generate up-to-date CGE database. In addition, they produce disaggregated estimates of movements in many naturally exogenous variables such as industry technologies, household preferences, required rates of return on capital and positions of export demand curves and import supply curves. Naturally exogenous variables are the variables that are not normally explained in CGE models whereas naturally endogenous variables are the variables that are normally explained.

3. Database for models and Validation tests

In building a CGE model the crucial step is to set up a database formulated in a given year. The theories of the model we have discussed in previous chapters are largely a set of equations which describe how the cells of the input-output database move through time and move in response to given shocks. Even though IO data provide the core data for CGE models, there are many other types of data and information concerning every aspect of the economy.

3.1 Core database

Figure 3.1 is a schematic representation of the core database for our models. It reveals the underlying structure of the ERI CGE model. From Figure 3.1, we can see that a core database consists of three parts: an absorption matrix, a joint production or MAKE matrix and a vector of import duties.

The column headings in the absorption matrix identify the following demanders:

(1) domestic producers divided into *i* industries;

(2) investors divided into *i* industries;

(3) a single representative household;

(4) an aggregate foreign purchaser of exports representing ROW;

(5) government demands; and

(6) changes in inventories.

Each cell in the illustrative absorption matrix in Figure 3.1 contains the name of the corresponding data matrix. For example, V2MAR is a 4-dimensional array showing the cost of *M* margins services on the flows of *C* commodities, both domestically produced and imported (*S*), to *I* investors.

Figure 3.1 The basic format of the ERI CGE model

	Absorption matrix		**Intermediate use**	**Final use**				**Future use**
			1	2	3	4	5	6
			Industries	Investors	Household	Export	Government	Inventories
		Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
1	Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
2	Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
3	Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
4	Labour	↑ OCC ↓	V1LAB					
5	Capital	↑ 1 ↓	V1CAP					
6	Land	↑ 1 ↓	V1LND					
7	Production Taxes	↑ 1 ↓	V1PTX					
8	Other Costs tickets	↑ 1 ↓	V1OCT					

C = Number of commodities (55 in 2005, 68 in 2012)
I = Number of industries (55)
S = Sources (domestic, imported) (Cockburn)
OCC = Number of occupation types (9)
M = Number of commodities used as margins (Cockburn)

	Joint production matrix
Size	← I →
↑ C ↓	MAKE

	Tariffs
Size	← 1 →
↑ C ↓	V0TAR

Source: Modified from Horridge (2014, p. 9)

Commodity flows are valued at basic prices; thus, they do not include any user-specific taxes or margins. The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output, minus any tax payable (i.e., VAT and excise duties), and plus any subsidy receivable, on that unit, as a consequence of its production or sale. The basic price of an imported good (s = 'imp') is the landed-duty-paid price, i.e., the price at the port of entry just after the commodity has cleared customs. In COPS-style CGE models like ERI CGE, basic prices are uniform across all users, including all industries, for the reasons described above.

The producer price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output, minus VAT, or similar deductible tax, invoiced to the producer, but it includes other taxes and subsidies. It excludes any transport charges invoiced separately by the producer (UN 2009).

The purchaser price is the amount paid by the producer, excluding any deductible VAT or similar deductible tax, in order to take delivery of a unit of good and service at the time and place required by the purchaser. The relationship between the prices is shown in Figure 3.2 below.

Figure 3.2 Prices relationship

	Output at basic prices
plus	taxes on products (excluding VAT)
less	subsidies on products
equals	**Output at producer prices**
plus	trade and transport margins
plus	non-deductible VAT
equals	**Output at purchaser prices/market prices**

Source: The research team's calculation

Let us have a look at the components of Figure 3.1, starting from row one. In the first row, the first matrix, V1BAS, can be interpreted as the direct flow of commodity *c*, from source *s*, used by industry *i* as an input into current production. V2BAS shows the direct flow of commodity *c*, from source *s*, used by industry *i* as an input to capital formation. V3BAS shows the flow of commodity *c* from source *s* that is consumed by a representative household. V4BAS is a column vector and shows the flow of commodity

c to exports. V5BAS and V6BAS show the flow of commodity *c* from source *s* to the government and change in inventories, respectively. Each of these matrices has *C*x*S* rows, one for each of *C* commodities from *S* sources. In standard applications, MONAGE recognizes one household, one foreign buyer, one category of public demand and one category of inventory demand. In the database, no imported commodity is directly exported or there are no re-exports. Hence, BAS4(c, s) is zero for s = 'imp'.

Costs separating producers or ports of entry from users appear in Figure 3.1 in the margins and sales tax matrices. The second row shows the values of margins services used to facilitate the flows of commodities identified in the BAS matrices in the first row. The commodities used as margins are domestically produced trade and transport services in our databases. Imports are not used as margin services. Each of the margin matrices has *C*x*S*x*M* dimension. This corresponds to the use of *M* margin commodities in facilitating flows of *C* commodities from *S* sources. Inventories (column 6) are assumed to comprise mainly unsold products, and therefore do not bear margins. As with the BAS matrices, all the flows in the MAR matrices are valued at basic prices. Consistent with the UN convention (UN 2009), we assume that there are no margins on services. In the case of margin flows, we assume that there is no cost separation between producers and users, i.e., there are no margins on margins. Hence, there is no distinction between prices received by the suppliers of margins (basic prices) and prices paid by users of margins (purchaser prices).

The third row shows commodity taxes on flows to different users. Unlike production taxes and import duties (both of which are included in the basic prices of commodities), these taxes can be levied at different rates on different users. In other words, commodity tax rates can differ between users and between sources. For example, the tax rate on a commodity used as an intermediate input to producers can be lower than that on household consumption of the same commodity. Some commodities such as tobacco products are subject to excise taxes. In the TAX matrices, negative entries indicate subsidies. For example, V1TAX('ElectWatHeat', 'dom') = -3,573.6 million MNT and V1TAX('ElectWatHeat', 'imp') = -146.6 million MNT, respectively, in the 2005 benchmark database.

Payments by industries for *O* occupational groups are recorded in Figure 3.1 in the matrix V1LAB. The vectors V1CAP and V1LND show payments by industries for use of fixed capital and land. In our databases, we require non-zero land rentals only for agricultural and mining industries. Other industries are treated as though they use no scarce land. The vector V1OCT records other costs incurred by industries, e.g., the costs of holding inventories.

Table 3.1 shows two types of data in ERI CGE along with corresponding sets and dimensions in the base years of 2005 and 2012. The coefficients of the core database are obtained from input-output accounts, while we impose or use from different sources or estimate various types of parameters and elasticities.

Table 3.1 ERI CGE database

Notation	Name	2005	2012
Sets			
COM	Commodities	55 Commodities	68 Commodities
IND	Industries	55 Industries	55 Industries
SRC	Sources	2 Sources	2 Sources
MAR	Margin commodities	2 Margin	2 Margin
OCC	Occupations	9 Occupations	9 Occupations
REG	Set REG regions	5 Regions	22 Regions
1. Coefficients in the core database			
V1BAS	Intermediate basic		COM*SRC*IND
V2BAS	Investment basic		COM*SRC*IND
V3BAS	Household basic		COM*SRC
V4BAS	Exports basic		COM
V5BAS	Government basic		COM*SRC
V6BAS	Inventories basic		COM*SRC
V1MAR	Intermediate margins		COM*SRC*IND*MAR
V2MAR	Investment margins		COM*SRC*IND*MAR
V3MAR	Household margins		COM*SRC*MAR
V4MAR	Export margins		COM*MAR
V5MAR	Government margins		COM*SRC*MAR
V1TAX	Intermediate tax		COM*SRC*IND
V2TAX	Investment tax		COM*SRC*IND
V3TAX	Household tax		COM*SRC
V4TAX	Export tax		COM
V5TAX	Government tax		COM*SRC
V1CAP	Capital Rentals		IND
V1LAB	Labour		IND*OCC
V1LND	Land Rentals		IND
V1PTX	Production tax		IND
V1OCT	Other costs		IND
MAKE	Multi-product matrix		COM*IND
V0TAR	Tariff revenue		COM
2. Parameters and elasticities			
SIGMA0	Elasticity of transformation		IND
SIGMA1	Armington elasticity – intermediate inputs		COM
SIGMA2	Armington elasticity – capital inputs		COM
SIGMA3	Armington elasticity – household consumption		COM

SIGMA1PRIM	Elasticity of substitution for Primary factors	IND
SIGMA1LAB	Elasticity of substitution between labour types	IND
FRISCH	Frisch parameter	1
DELTA	Household marginal budget share	COM
EXP_ELAST	Export elasticity	COM

Source: The research team's calculation

The CGE database is in values, but updating of the database occurs via changes in prices and quantities. The equations, derived from utility maximization and cost minimization problems, are satisfied with prices on one and the resulting quantities implied by the core data via calibration of the parameters or the introduction of shift variables. The equations in the models contain sufficient free parameters and shift variables so that they can be satisfied by the initial input-output data.

3.2 Construction of core database

3.2.1 Input-output Data

Mongolia compiled its first input output table in 1963 during the communist era. Subsequent communist era tables were produced in 1966, 1970, 1977, 1980 and 1983. These tables were produced in accordance with the Material Product System used in member countries of the former Council for Mutual Economic Assistance (COMEC).

After the collapse of communism, the Material Product System was replaced by the United Nations System of National Accounts (UNSNA) framework in 1991. Mongolia compiled experimental input output tables in 1997 and 2000 in order to implement the System of National Accounts (SNA). Subsequently, in 2008, Mongolia compiled official IOTs for 2005 in line with the standards of UNSNA 1993. The starting point for the ERI CGE database was the 2005 IOTs constructed by the National Statistical Office (NSO) of Mongolia in 2008. The 15 sector IOT is available in the public domain in the National Statistics Office Yearbook 2008. However, unpublished 55-industry-commodity IOTs and related data were used in the creation of the first Mongolian CGE database, which was developed by ERI in 2010. Fifty-five industries/commodities are listed in Appendix 1. In one of the first applications of CGE analysis involving the Mongolian economy, Fisher *et al*. (2011) used the same IOT data for assessing the macroeconomic consequences of the development of the OT copper mine by BAE's general equilibrium model of the world economy, MINCGEM. The country database for GTAP based on the same IOTs was

prepared by Begg *et al*. (2011) and was included in GTAP 8 Database (2012). Further, the NSO compiled Supply and Use Tables (SUTs) for the year 2008 in 2011. Subsequently, it produced 2010 IOTs in 2013 and 2011, 2012 IOTs in 2014, and 2013 IOTs in 2015. The 2012 ERI CGE database is based on unpublished 2012 IOTs with more disaggregated industries and commodities. The NSO's IOTs for 2005 and 2012 both contain information listed.

- An industry-by-commodity multi-production matrix (source-specific with domestic and imported subdivisions)
- A vector of the usage of labour (wages)
- A vector of net operating surplus (or net mixed income)
- A vector of indirect taxes on production
- A vector of taxes on products
- A vector of depreciation
- A vector of private consumption
- A vector of government consumption
- A vector of consumption by not-for-profit organizations and institutions
- A vector of gross fixed capital
- A vector of net change in valuables
- A vector of net change in stocks (working capital)
- A vector of exports on FOB

NSO generously provided all supplementary data used for compiling two types of IOTs (competitive and non-competitive) in each year. These are listed below (2005 SUTs at producer prices; 2012 SUTs at both basic and producer prices).

- Import matrices
- Transport margin matrix
- Trade margin matrices
- Taxes matrix
- Subsidies matrix
- Net taxes matrix
- Domestic VAT matrix
- Import VAT matrix
- VAT refund matrix
- Import duty matrix
- Export duty matrix
- Domestic Excise tax matrix
- Import Excise tax matrix

As mentioned above, IOT is based on SUTs, and is the core source of database, and contains extensive range of information about an economy.

3.2.2 Checks, adjustments and calculations

Due to the requirements shown, the following adjustments and checks were made in seven stages. Each of these stages, further, comprises steps associated with different checks and adjustments undertaken. Figure 3.3 illustrates the check and adjustment process. In each stage, we alter part of the database created in the previous stage. Due to the availability of data, relatively fewer adjustments were made compared to some other studies in which extensive data manipulations were needed.

Stage One. All necessary data were stored in input data file through the TABLO-generated program, which combines data into a single input file. We identified extra columns and rows in SUTs and IOTs. Extra row vectors of Supply Tables (STs) are the row vectors reflecting different types of producers (output for own final consumption, output of unincorporated market producers and output of other non-market producers), and the row vectors of CIF/FOB adjustments on exports and direct purchases abroad by residents. Extra columns in ST were vectors of Imports (CIF), Trade margins, and Net taxes, and were used to calculate Total supply at Purchasers' price. We also identified extra rows in Use Tables (UTs). These include:

- CIF/FOB adjustments on exports
- Direct purchases abroad by residents
- Direct purchases in domestic markets by non-residents
- Wages
- Other production taxes
- Production subsidy
- Depreciation
- Net/Mixed income

The 1993 SNA added another item in capital formation termed valuables, which are acquired and held as a store of value and not used primarily for production or consumption. In the 2005 IOT, there was a column vector for valuables. The range of products held as valuables is quite extensive and it is an area where existing goods may feature.

Stage Two. The TABLO-generated program undertakes preliminary consistency checks between various types of matrices through three steps. The program also checks flows in SUTs and IOTs for balance conditions and sign restrictions in the first step. The balance

conditions verify that total demand equals total supply and that total cost equals total output for each industry. IOTs and SUTs sometimes contain a few industries with negative gross operating surpluses. This is incompatible with the assumption of non-negative returns to fixed factors. Sign restriction checks verify these conditions. The following adjustments related to re-exports were undertaken in the second step. In this step, re-exported commodities were identified, because ORANIMON has no mechanism to accommodate re-exports, and, also, re-exports inflate export earnings and import expenditure.

Step three diagnoses if there is an excessive inventory accumulation of commodities. Even where available data are model-compatible, atypical features like an unusually large inventory need to be adjusted. Mongolian IO data typically display a large movement in the inventory of 'Livestock'. For instance, the 2012 benchmark IO data show an accumulation of inventories of 'Livestock' of MNT 480 billion, that is BAS6('Livestock', 'dom') = MNT 480,191 million.

The benchmark data in both 2005 and 2012 also show large inventories in 'Meat', which is a joint commodity produced by the 'Livestock' and 'Meat products' industries. In accordance with the NSA, there should be no margins for services and inventories.

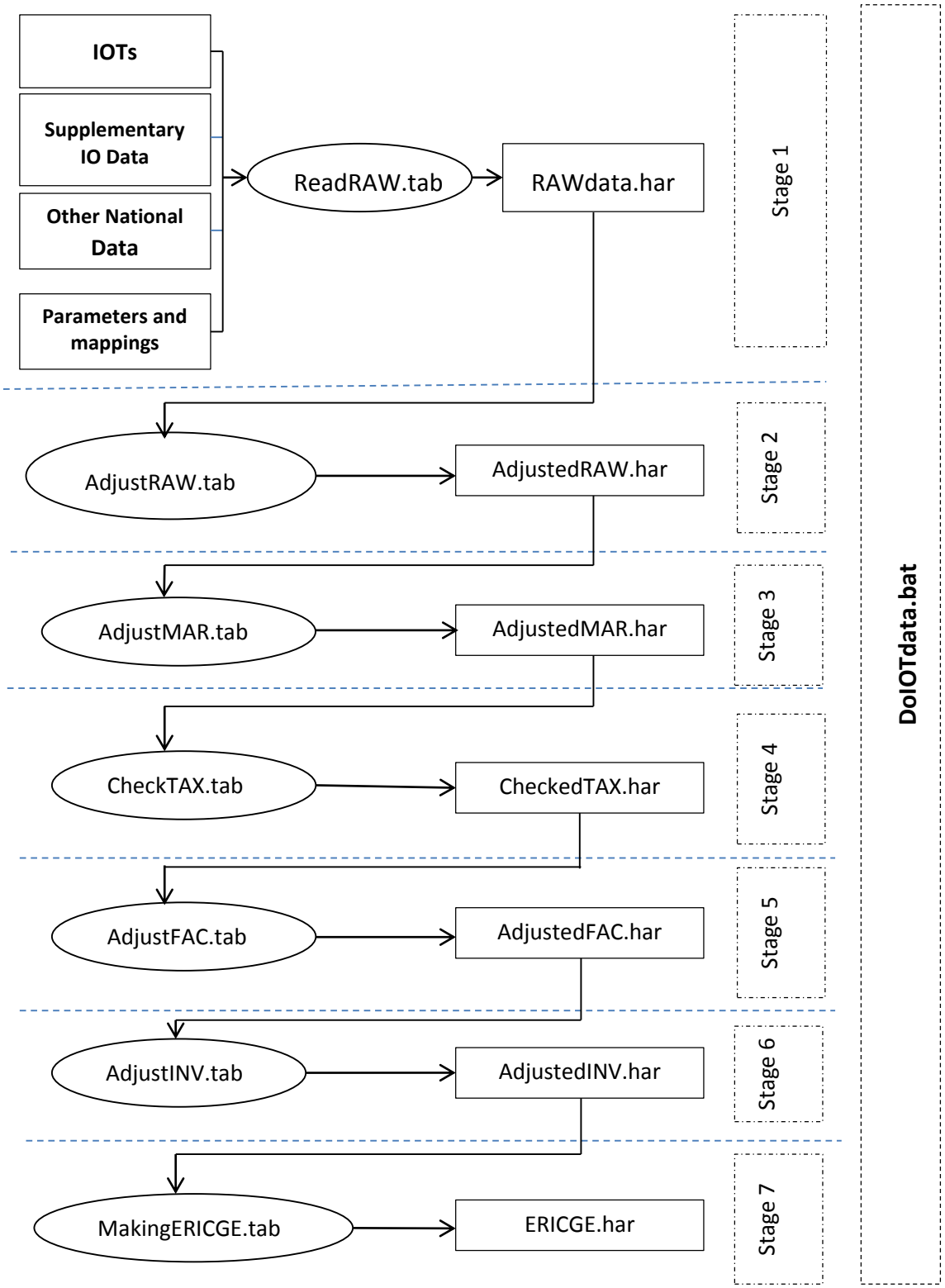
Stage Three. We disaggregate margins between those used to facilitate flows of domestic goods and those used to facilitate flows of imported goods. The disaggregation is performed as:

$$MAR(c,s,u,m) = MAR(c,u,m)\frac{BAS(c,s,u)}{\sum_s BAS(c,s,u) + TINY} \qquad \textbf{(3.1)}$$

where $MAR(c,u,m)$ is the margin service m used in facilitating the flow of commodity c to industry or final demander u; $BAS(c,s,u)$ is the basic-value flow of commodity c from source s (domestic or imported) to industry or final demander u; and $TINY$ is a very small number, 10^{-12}, to prevent divisions by zero.

Stage Four. Various checks for all types of taxes and subsidy matrices were completed. For instance, net taxes should equal taxes less subsidies, taxes should be the sum of all types of indirect taxes, and import duty matrix should be consistent with import matrixes, and so on.

Figure 3.3 Check and Adjustment process



Source: The research team's calculation

Stage Five. Necessary adjustments for primary factors were made through TABLO-generated programs AdjFAC.tab. IOTs often lack adequate detail on value added for CGE modelling. The value-added section of IOTs provides the main data for ERI GCE on resource constraints. The 2005 and 2012 IOTs divide value added for each industry in Mongolia into four categories:

- Compensation of employees;
- Other net taxes on production;
- Consumption of fixed capital; and
- Net operating surplus.

We require, however, the measures of labour input, capital input in each industry and land input for land-using industries.

To adjust to the required measures, each ERI CGE industry was carefully analysed. Furthermore, we split labour input into nine occupation-specific inputs, namely:

- Legislators, senior officials and managers
- Professionals
- Technicians and associate professionals
- Clerical workers
- Service workers and shop and market sales workers
- Skilled agricultural and fishery workers
- Craft and related trade workers
- Plant and machine operators and assemblers
- Elementary occupations

Stage Six. Adjustments for investments were completed through the TABLO-generated program in this stage. In ERI CGE there is an investor for each industry, as we have discussed in the theoretical section. The investors buy commodities to construct capital specific to their industries. However, the original IO data have only a single investor for the whole economy, represented in a single column showing the commodity composition of the investment. We needed to split the investment vector into a matrix (55 columns corresponding to 55 industries). We created an investment matrix in four steps. In the first step, we calculated the value of total investment at purchaser prices – $TOTINV$. This should be equal to the GDP estimate of economy-wide investment from the SNA and thus the related automated check was done. In the second step, we calculated the share for each industry of value added in the total value added (GDP) – $SHRVALADD(i)$ and the share of capital input in the aggregate capital

input $-SHRCAP(i)$. Then we defined the investment share of each industry – $SHRINV(i)$ as the average of two calculated shares – $(SHRVALADD(i) + SHRCAP(i))/2$. In the third step, we allocated the total amount of investment in the economy to each industry according to the shares found in previous step: $TARGINV(i) = SHRINV(i)TOTINV$. In the fourth step, we calculated the commodity-composition in the investment of each industry – $Invest(c,i)$ as:

$$Invest(c,i) = COMINV(c) * TARGINV(i)/TOTINV \quad \textbf{(3.2)}$$

Using the total investment by industries – $TOT(i)$ (column total), and by commodities – $TOT(c)$ (row total), we scaled rows and columns of the investment structure shares in (3.2).

Stage Seven. Through the TABLO-generated program, we created ERI CGE coefficients and parameters using the data constructed in previous stages and parameters from GTAP, as well as own estimations and calibrations. Let us take an example of investment again. In the previous stage, we estimated the investment structure shares. Since we have an imports table (a separate imports matrix as well as an imports part in the non-competitive IOT), we can determine a source-specific investment use of commodities at basic price – $INVBASIC(c,s)$. Thus, $V2BAS(c,s,i)$ can be found by:

$$V2BAS(c,s,i) = INVSHR(c,i) * INVBASIC(c,s) \quad \textbf{(3.3)}$$

Similarly $V2MAR(c,s,m,i)$ and $V2TAX(c,s,i)$ were determined in this stage.

All stages are automated via a DOS batch file doIOdata.bat, shown in Figure 3.3 on page 19, altogether or individually.

3.3 Validation tests and additional data

Validity is a key issue for stakeholders of a CGE modelling analysis. A CGE analysis can be considered valid when it: (a) is computationally sound, (b) uses accurate up-to-date data, (c) adequately captures behavioural and institutional characteristics of the relevant part of the economy, (d) is consistent with history, and (e) is based on a model that has forecasting credentials (Dixon & Rimmer 2013). This section is concerned with (a), for which test simulations are used exhaustively as a practical method.

3.3.1 Homogeneity tests

The first two tests that we carried out were nominal and real homogeneity tests. If ERI CGE is set up with no nominal rigidities, then a 10% shock to all of the exogenous nominal variables should increase all endogenous nominal variables by 10%, while leaving all real variables unchanged.

The next commonly used test is a real homogeneity test. If ERI CGE is set up with constant returns to scale in all production activities, then a 10% shock to all real exogenous variables should increase all real endogenous variables by 10%, while leaving all nominal variables unchanged. For a real homogeneity test, shocks should be applied to exogenous quantities of factor inputs and exogenously specified real demand.

The ERI CGE results for both 2005 and 2012 passed the tests.

3.3.2 Validation through the GDP Identity

Using the data input file ERICGE.har, the Tablo-generated program Formula.tab calculates aggregate variables in ERI CGE, including calculating GDP via both income and expenditure approaches. This check is powerful, because the two approaches involve distinct sets of variables that are linked through a large number of equations in the ERI CGE model.

These validation tests are conducted on core database based on IOTs, and after it, core database is augmented by additional information-elasticities, parameters, Government account, accounts with the rest of the world.

3.3.3 Elasticities and parameters

Behavioral elasticities and parameters for the model are presented below, along with their algebraic notations.

- Elasticity of substitution between primary factors-$\boldsymbol{\sigma 1 PRIM(i)}$
- Elasticity of substitution between labour occupations-$\boldsymbol{\sigma 1 LAB(o,i)}$
- Elasticity of transformation between industry outputs-$\boldsymbol{\sigma 1 OUT(i)}$
- Armington elasticity of substitution between domestic and imported intermediate inputs-$\boldsymbol{\sigma 1(c)}$
- Armington elasticity of substitution between domestic and imported inputs to capital formation-$\boldsymbol{\sigma 2(c)}$

- Armington elasticity of substitution between domestic and imported commodities – household consumption-$\boldsymbol{\sigma 3(c)}$
- Export demand elasticities, by commodity and by trading partners-$\boldsymbol{\gamma(c)}$
- Household expenditure elasticities-$\boldsymbol{\varepsilon(c)}$
- Frisch parameter-$\boldsymbol{FRISCH}$

The adopted and estimated for the period 2005 to 2012 values for each of them are shown in appendix 2 and 3.

3.3.4 Government account data

Government accounts are important because public policy discussion-budget income, deficit, debt, and so forth- is based on it. Hence, ERI CGE has detailed government accounts.

(a) Revenues:

1. Corporate income tax (CIT)
2. Personal income tax (PIT)
3. Value Added Tax (VAT)
4. Social security tax (SST)
5. Export duties (ExpDuties)
6. Import duties (Tariffs)
7. Excise taxes (ExciseTaxes)
8. Other taxes on commodities (OthComTax)
9. Business fees (FeesCharges)
10. Royalty/Land use tax (Royalty)
11. Transfers and Grants from foreigners (ForeignGrant)
12. Other government revenues (NonTaxRev)

(b) Operating Expenditure

1. Government consumption (V5TOT)
2. Interest payment on foreign debt (INTFD)
3. Interest payment on domestic debt (INTDD)
4. Benefits paid to households (BENEFITS)
5. Subsidies (Subsidies)
6. Other expenditure (OTHEXP)

(c) Government saving (=a-b)

(d) Government investment

(e) Overall balance (=c-d)

(f) Financing (=e)

1. Net foreign borrowing (FDEBIT)
2. Net domestic borrowing (DDEBIT)
3. Change in assets (GOVASSETSALE)

For example, public debt is influenced by budget deficits, and ERI CGE model offers budget neutrality or zero impact on the budget deficit. In other words, that increases in

any category of public expenditure and cuts in any types of tax must be offset by either decreases in other categories of public expenditure or increases in other types of taxes.

3.3.5 Accounts with the rest of the world

ERI CGE contains a quite detailed modelling of balance of payment account and changes in the international investment position. The data items required for these accounts include: trade balance account; investment income account; financial and capital accounts; stocks of foreign liabilities and foreign assets. We also need exchange rates in order to convert assets and liabilities from foreign currency to domestic currency, and the other way round when necessary.

The international accounts for Mongolia summarize the economic relationship between residents of Mongolia and non-residents. They provide an integrated framework for the analysis of an economy's international economic relationships, including its international economic performance, exchange rate policy, reserves management and external vulnerability. The international accounts in ERI CGE are divided into the aggregated balance of payments (BOP) and the aggregated international investment position (IIP).

3.3.5.1 The Balance of Payments (BOP)

The BOP in ERI CGE summarizes economic transactions between residents and non-residents during a specific time period – a year in our case. The different accounts within the BOP are distinguished according to the nature of the economic resources provided and received.

The BOP in ERI CGE consists of three accounts: the current account (CA), the capital account (KA) and the financial account (FA). The CA shows flows of goods, services, primary income, and secondary income between residents and non-residents. The CA balance (CAB) shows the difference between the sum of exports and income receivable and the sum of imports and income payable, where exports and imports refer to both goods and services, while income refers to both primary and secondary income. The value of CA balance equals the savings-investment gap for the economy. With inclusion

of the CA, ERI CGE is able to generate year-to-year results for the current account deficit, which has an important implication for national economy.

The KA shows credit and debit entries for non-produced nonfinancial assets and capital transfers between residents and non-residents, while the FA shows net acquisition and disposal of financial assets and liabilities.

Table 3.2 Aggregated Balance of payment, 2005 and 2012 (in millions USD)

Item	2005	2012
Current Account Balance (A+B+C)	**87.5**	**-3,362.3**
A. Goods and Services account	-85.9	-2,653.6
Exports	1,485.9	3,013.3
Imports	1,571.8	5,666.9
B. Income account	-51.7	-947.7
Net compensation of employees	2.8	-243.5
Net income from abroad	-54.5	-704.2
C. Current transfer	225.2	239.9
Transfers from foreigners to Mongolians		501.8
Transfer from Mongolians to foreigners		-262.4
Capital Account Balance (KAB)	0.0	120.4
Financial account balance balance (FAB)	**48.8**	**4,809.5**
New foreign equity held by Mongolians (DIA)	0.0	-43.2
New foreign equity in Mongolia (FDI)	185.3	4,451.8
New foreign debt, government		124.5
New foreign debt, private		276.4
Errors and omissions		-195.5
Balance of Payment	***134.5***	***1,371.7***
Changes in foreign reserves	-134.5	-1,371.7
Additional information		
GDP current (million USD)	2,523.6	12,292.6
Share of Current Account Balance in GDP	*3.30%*	*-32.70%*
Official exchange rate (USD 1.0)	*1205.2*	*1357.6*
Real interest rate	*8.72%*	*5.45%*

Source: The Central Bank of Mongolia

The sum of the balances on the current and capital accounts represents the net lending (surplus) or net borrowing (deficit) by the economy with the ROW. This is conceptually

equal to the net balance of the financial account. Hence, the financial account measures how net lending to or borrowing from non-residents is financed.

The financial account plus the other changes account explain the change in the IIP between beginning and end-periods.

3.3.5.2 International Investment Position (IIP)

The IIP measures the stock of Mongolia's foreign financial liabilities and foreign financial assets at a point in time. The difference between foreign financial liabilities and foreign financial assets is referred to as Mongolia's net international investment position or net foreign liability (NFL).

Table 3.3 International Investment Position, 2012 (in millions USD)

Item	2012
Assets	
DIA by Mongolians abroad	1,297.0
Foreign credit, total	5,183.0
Foreign credit, government	*4126.1*
Foreign credit, private	*956.9*
Total Foreign assets	**6,380.0**
Liabilities	
FDI stock in Mongolia	13,458.24
Foreign debt, total	4,451.90
Government debt	*2,184.10*
Private debt	*2,267.80*
Total Foreign liabilities	**20,599.50**
Net Foreign Liabilities	**14,219.40**
GDP in current USD	*12,292.6*
Net foreign liabilities as percent of GDP (%)	*115.7*
Foreign debt as percent of GDP (%)	*36.2*

Source: The Central Bank of Mongolia

The NFL represents either a net claim on or net liability to the ROW. Aggregated accumulation accounts, such as the KA, FA and other changes in financial assets and liabilities accounts (OCA), show the accumulation of assets and liabilities, their financing, and other changes that affect them. Accordingly, they explain changes between the opening and closing assets and liabilities in the IIP.

Whereas the CA is concerned with resource flows oriented to the current period, the accumulation accounts deal with the provision and financing of assets and liabilities, which are items that will affect future periods. That is, net liabilities imply that interest must be paid to foreigners.

The FA shows the net acquisition of financial assets and net incurrence of liabilities during the specified period. In contrast, the OCA shows flows that do not result from BOP transactions. The OCA covers changes in volume, other than BAP transactions, revaluation due to exchange rates, and other revaluation.

4. Historical simulation

4.1 Structural change

Structural change refers to changes in the overall size and structure or make-up of an economy in terms of the distribution of activity and resources among industries and regions. The make-up or structure of an economy is generally defined in terms of the distribution of output across industries or regions. Since production of goods and services require inputs, structural change also refers to the movement of primary inputs (land, labour and capital) and other production inputs between different industries or regions as a result of sustained or permanent changes in market conditions and/or of government policy (PC 2003b).

A variety of market-related influences (including technological changes and changes in consumer tastes and preferences) and government-related influences can create structural change.

According to Nobel laureate Prescott (2006), either one or more of the variables underlying an economic structure of an economy must be altered for structural change to take place. These fundamental structural variables are: (a) endowment; (b) technology; and (c) preferences.

The fourth variable which causes structural change is termed ‘institutions’. This refers to the set of laws, rules and regulations, and governance frameworks that influence the behaviors of producers and consumers (PC 2003b).

Over the past two decades, the structure of the Mongolian economy has changed, shifting away from agriculture and manufacturing towards services, but also with the mining industry growing in importance due to the mining boom. Economic activity has also shifted towards resource-rich areas. Changes in the structure of the economy have been driven by a range of factors. In recent years, the rate of structural change has increased, driven by the boom and bust in resource export prices and in mining investment.

4.2 Historical simulation

The COPS-style approach to fitting history is the technique of historical simulation. In general, there are three main purposes to doing historical simulations. The first is to update a CGE database to a recent year. The second is to estimate changes in structural variables. The third is to assess the plausibility of model estimations as a form of validation.

Observed data on output growth in a particular industry may be reconciled with observed industry inputs via an industry-specific technological change. The historical closure also enables us to estimate required rates of return on capital. So as to make observed data on changes in consumption of specific goods and services over time and observed changes in aggregate consumption consistent with the household demand theory of the model, we make taste changes for individual commodities endogenous.

Historical and forecasting simulations include imposing available information on the model and letting the model determine structural changes in the economy which are accountable for these known outcomes. Their key difference is that the historical simulation makes use of available historical data on economic variables, whereas the forecast simulation makes use of available forecasts from international and national organizations.

The role of the historical simulation is to ‘fill the gaps’ by inferring values for the unobservable variables that are consistent with what is already known about the Mongolian economy. Hence, the historical simulation involves forcing ERI CGE model to track economic history by exogenising and shocking observable variables, and allowing

the model to determine implied paths for naturally exogenous but unobservable variables, such as industry technologies, household preferences, required rates of return on capital, and positions of export-demand curves and import supply curves. The changes in these variables are, in fact, the sources of structural change in Mongolia.

We quantify several aspects of technical change in Mongolian industries for the period 2005 to 2012, including: intermediate-input-saving technical change; primary-factor-saving technical change; and import-domestic bias in technical change. It also quantifies the movement in export-demand curves and import supply curves. These quantifications are done in accordance with the economic theory underpinning the ERI CGE model.

The starting point of the historical simulation is an initial solution of 2005. This solution consists of the CGE database describing the links between all economic agents in 2005 and of a set of commodity and factor prices for that year. This detailed representation of the Mongolian economy can be regarded as a model solution in that it satisfies all the economic theory underpinning ERI CGE. From this initial solution, the economy undergoes changes over time to 2012.

4.3 Observed changes

The Mongolian economy had undergone a massive change for the period 2005 to 2012. The following table shows the changes in selected macro indicators that occurred between 2005 and 2012. These changes will be applied as shocks in different stages and the related explanations regarding the variable will be given in the following sections. The steps are designed carefully due to the sizes of the shocks, since most of the shocks are over 100% or very large, to avoid computational problems. The model variables are defined differently from the typical COPS-style model variables. For instance, the nominal exchange rate in our simulation is the MNT amount for buying one unit of USD. Instead of real depreciation, we use real appreciation in order to avoid negative percentage change over 100%. The shocks in steps are administered cumulatively. In other words, the shocks applied in previous stage or stages are included in next stages.

Table 4.1 Changes in selected macro indicators, between 2005 and 2012

Indicators	2005	2012	Change (%)
Population, end-year (millions)	2.551	2.868	12.4
Number of households (thousands)	611.03	768.26	25.7
Real GDP, at constant 2005 prices			
(in billions of MNT)	3,041.4	5,529.3	81.8
(in millions of USD and in constant exchange rates)	2,523.6	4,587.9	81.8
GDP, at current purchaser prices (in billions of MNT)	3,041.4	16,688.4	448.7
GNI, at constant 2005 prices (in billions of MNT)	2,979.1	4,992.7	67.6
Export value index (2005 = 100%)	100.0	406.8	306.8
Export volume index (2005 = 100%)	100.0	198.2	98.2
Import value index (2005 = 100%)	100.0	569.5	469.5
Import volume index (2005 = 100%)	100.0	372.4	272.4
Real investment, at constant 2005 prices (billions of MNT)	849.7	3,310.9	356.9
Real household consumption, at	1,678.1	3,953.83	135.6
Real public consumption, at constant 2005 prices (billions of MNT)	369.19	628.27	70.2
Employment of labour (thousands of persons)	1,009.9	1,103.6	9.3
CPI, end-year	100	223.2	123.2
GDP deflator	100	303.5	203.5
Exchange rate (MNT/USD period average)	1,205.2	1,359.2	12.8

Source: The Central Bank of Mongolia and NSO

The population increased by 12.43% with the annual average growth rate of 1.77% and the population under 18 grew by 15.5% for the period 2005 to 2012. The resources boom increased government revenues and encouraged political parties to create a large social welfare conditional cash transfer program known as the Child Money Programme (CMP), which began in 2005. CMP started as a targeted transfer in January 2005 and turned into a universal transfer in July 2006.

Inflation in Mongolia has been volatile and high, resembling a roller coaster ride with sharp rises and steep drops during the period. The consumer price increased by 123.2% from 2005 to 2012.

During the period, employment in terms of the number of persons increased by 9.3%. Mongolia has limited resources of labour and Mongolia's labour-force participation is low compared with that of other small transition countries (Batchuluun & Dalkhjav 2014).

According to the Organisation for Economic Cooperation and Development (2012), Mongolians work the longest in Asia and the Pacific region. Men and women work on average 581 minutes (almost 10 hours) and 637 minutes (almost 11 hours) per day, respectively.

The aggregate real public consumption grew by 70.2% over the period. Public consumption is the smallest expenditure component of GDP in Mongolia. The share of public consumption in GDP was 11.3% in 2005 and 13.3% in 2012.

Between 2005 and 2012, the aggregate real household consumption (*C*) grew by 135.6%. Private consumption is the largest expenditure component in Mongolia. The share of private consumption in GDP was 61.3% in 2005. The share, however, went down to 52.7% in 2012 by 8.5 percentage points due to a sharp increase in investment.

Out of the expenditure components of GDP, real investment grew largest, by around 289.6%, between 2005 and 2012. The contribution of investment to GDP, as a result, increased from around 30% in 2005 to around 45% in 2012, that is, by 15 percentage points.

There was a substantial increase in the export value index compared with that of the export volume index, showing a sharp growth in exports prices between 2005 and 2012. Minerals made up over 70% in 2005 and 89% in 2012 of Mongolia's total export earnings. Thus the economy had been highly reliant on world commodity prices during the period. A distant next major contributor to exports is the textiles and textile articles commodity, comprising 17.3% of total exports in 2005. The share of textiles and textile articles in exports, however, went down significantly to 5.3% in 2012. NSO publishes volume and price indexes for main export and import commodities. We have cross-checked the changes with GTAP 9, UNCTAD and trademap.org databases and have prepared yearly data on aggregated value-weighted changes in volumes of export and

import commodities in MONAGE. The nominal exchange rate depreciated by 12.8% for the period 2005 to 2012.

The agriculture sector employs the largest share of labour, accounting for 38% in 2005 and 30% in 2012, respectively, in total employment. The number of employees (hence, the number of hours worked) in the transportation and transportation support services sector rose most by 112.5% between 2005 and 2012, while the number of employees in agriculture fell by almost 16%.

There was a huge increase of 272.4% in the import volume from 2005 to 2012. The main import commodities were Machinery and Equipment and Fuels during the period. Fuels comprised around 20.5% in 2005 and around 19% in 2012 of the aggregate imports, as Mongolia is a net importer of refined petroleum. The share of Machinery and Equipment commodity was 14.5% in 2005 and increased to 29.5% in 2012, overtaking Fuels, and became the largest import commodity in 2012, due largely to investment growth. The import volumes of Fuels and Machinery and Equipment rose by 140% and 223%, respectively, during the period. The weighted average import tariff was 4.2% in 2005. The rate was raised to 4.94% in 2012, resulting in a 0.71% increase in the power of tariff.

Table 4.2 shows the changes in the outputs for the period 2005 to 2012. The most of the services sectors grew sharply during the period. The output of the mining sector, however, grew at relatively lower speed, indicating the investment phase of the major projects. In this stage, ERI CGE is set up to absorb data on movements in outputs of 38 ERI aggregate commodities.

Table 4.2 Sectoral outputs (millions MNT, in 2005 prices) and changes in real outputs (%)

Economic sectors	2005	2012	Growth	Annual growth
Agriculture	602,136.3	801,269.2	33.1	4.7
Mining	642,089.0	861,511.4	34.2	4.9
Manufacturing	175,155.9	295,225.0	68.5	9.8
Electricity and gas	75,928.2	111,667.2	47.1	6.7
Water supply, drainage	13,768.9	20,388.4	48.1	6.9
Construction	81,408.4	102,604.2	26.0	3.7
Trade	227,478.2	591,110.6	159.9	22.8
Transport, storage	256,726.4	605,013.9	135.7	19.4

Hotels & cafes	19,341.7	60,167.0	211.1	30.2
Communications	96,261.1	226,794.4	135.6	19.4
Financial intermediation & insurance	112,278.8	249,875.0	122.5	17.5
Real estate, renting & other business activities	160,522.7	217,574.6	35.5	5.1
Research & development	18,024.5	50,763.4	181.6	25.9
Other public supporting services	34,071.1	80,097.5	135.1	19.3
Public administration and defense	66,923.1	72,982.2	9.1	1.3
Education	86,528.6	102,230.4	18.1	2.6
Health and Social services	37,516.9	50,946.0	35.8	5.1
Cultural services	7,744.5	12,933.8	67.0	9.6
Other services	15,763.7	24,238.5	53.8	7.7

Source: The Central bank of Mongolia and NSO

Further, we introduced information on the export and import prices along with the USD value of exports and imports. The prices of Mongolian mineral commodities increased substantially during the period of 2005 and 2012. The mineral industries with relatively easier technology, such as the 'Coal' industry, responded relatively quickly to produce more. In 2012, Mongolia overtook Australia to become the largest coal exporter to China when the Australian coal industry was subdued by the flooding in Queensland (Batdelger 2014). From 2005 to 2012, the quantity of coal exports (solely to China) increased by 826.5%. In addition, we make a uniform adjustment to all foreign-currency export prices and import prices to ensure that the change in USD values of exports and imports implied by the ERI CGE historical simulation is consistent with the data.

Since the early years of the transition, Mongolia has relied on external concessional borrowing from the international organizations and donor countries. Concessional loans have low interest rates and very long maturities, implying low exposure to changes in interest rates and exchange rates. As the economy has progressed and moved to upper middle income status, the access to concessional loans has become limited. Mongolia started borrowing increasingly at market terms around 2012. The public sector's external borrowing rose 31% in 2012 after the government's USD 1.5 billion 'Chinggis' bond sales (named after Genghis Khan). Getting commercial type of debt increases Mongolia's risk level, especially when the government's repayment ability is affected by commodity price volatility.

Mongolia adopted a Value Added Tax (VAT) in 1998, effective from the 1 July of that year, on the recommendation of the WB and IMF. Mongolian VAT law was first developed on a New Zealand model with a registration threshold of MNT 15 million and rates of 0 and 10%. The VAT rate was raised to 13% in 1998 and to 15% in 2000. In the base year of 2005, the VAT rate was 15%, then reduced to 10% by the revised law of 29 June 2006. The VAT contributed around 21.6% and 26% of the budget revenues in 2005 and 2012, respectively.

4.4 Historical simulation results

The Mongolian economy underwent a massive change for the period 2005 to 2012. Through historical simulation, we estimated a number of structural variables, industry technologies, household preferences, required rates of return on capital, and positions of export-demand curves and import supply curves. The changes in these variables are, in fact, the sources of structural change in Mongolia. We estimated several aspects of technology change for industries. These include changes in sector-specific primary factor productivity, sector-specific input *c* saving technology in current production and capital formation, sector-specific all-input using technology and sector-specific labour-capital twist. The historical simulation was carried out in multi-steps, which were designed carefully due to the large sizes of the shocks so as to avoid computational problems.

In the historical simulation, we incorporated the observed changes in the Mongolian economy into the model from 2005 to 2012. The estimation results at macro level indicate:

- A large outward movement in the export demand;
- A significant change in the average propensity to consume;
- A massive change in the capital labour ratio;
- A small primary-factor saving technical change growth; and
- A slight overall technical change resulting in a small GDP contribution.

We tracked changes in multifactor productivity and changes in input-using technology affecting the use of each industry's commodities per unit of output across all industries. The simulation reveals that the economy needs efficiency and productivity improvement. In particular, the changes in sector-specific input *c* saving technology in

current production and capital formation, as well as sector-specific all-input using technology, were unfavourable. Agriculture, followed by the manufacturing sector, is the worst performer in terms of technical change, and this requires policy reform.

In addition, we estimated changes in capital/labour choices beyond those that can be explained by changes in relative factor prices. Due to the capital-intensive nature of mining industries and the development phase of major mining deposits such as the Oyu Tolgoi mine, we found a large shift towards capital. Mongolia is a net importer of machinery, vehicles and fuel. There was a massive increase in imports of those commodities due to rapid growth, the surge in investment and changes in consumer taste, leading to a huge shift towards imported commodities in the composition of overall and industry-level import and domestic mixes.

The changes in the average of technical change terms in current production for four aggregate sectors are shown in Table 4.3 below.

Table 4.3 Average of annual technical change (%), production (2005-2012)

	Average of technical change
Agriculture	1.94
Mining	-4.65
Manufacturing	0.54
Services	-0.18

Source: The research team's calculation and NSO

The worst performer in terms of technical change is the Agriculture sector. However, our finding may reflect more favourable weather in 2005 than in 2012, as Mongolia had one of the worst 'dzud' disasters in the 2009-2010 winter, losing approximately 20% of livestock or 8.5 million head. The livestock sector is in any case highly reliant on the pasture land, susceptible to weather shocks and lacks productivity improvement and technological change.

Over the period, household purchases of motor vehicles dramatically increased. Mongolia imported 5,280 cars in 2005. The number of cars imported increased to 46,409 in 2012. This increase (878.9%) is more than can be explained by changes in household income, the number of households and consumer prices. Mongolia does not produce

cars domestically. Hence, imports increase due to the preference shift to cars. For those 'net' import commodities, like cars and machineries, we cannot use the 'twist' idea so that we combine them into the preference change. There are strong consumer taste shifts to commodities such as 'Drinks' and 'Dairy Products' and services such as 'Services to Transportation'. Let us have a look at the sales composition of 'Drinks'.

Table 4.4 Sales decomposition of 'Drinks' in 2005 and 2012

Destination	Sales composition (%)	
	2005	2012
Intermediate	12.6	12.7
Investment	0	0
Household consumption	84.1	79.4
Exports	0.3	0.1
Government consumption	0	0
Stocks (future consumption)	3.1	7.8
Total	**100**	**100**

Source: The research team's calculation and NSO

From Table 4.4, it can be seen that there was little compositional change in domestically produced 'Drinks'. The sales value of the commodity increased by 16.5 fold as a result of substantial increase in its price and volume. One of items in 'Drinks', beer sales volume, for instance, grew by 714.4% for the period 2005 to 2012, showing the magnitude of the change.

The estimated twist changes were mostly in favour of imports. Mongolian producers and consumers became able to import a variety of intermediate, investment and final consumption commodities from many different countries. In particular, with the surge in investment and the demand pressures when the domestic economy is growing rapidly, there is a tendency for demand shift to occur towards import commodities. This occurred in Mongolia, bringing a huge change towards imported commodities in the composition of overall and industry-level import and domestic mixes.

There are some twist changes to domestically produced commodities. For instance, there was a favourable taste shift to domestically produced 'Leather Products', coupled with a strong import to domestic preference shift, helping the industry to survive.

Table 4.5 Sales decomposition of 'LeatherPrd'in 2005 and 2012

Destination	Sales composition (%)	
	2005	2012
Intermediate	2.1	28.5
Investment	0	0
Household consumption	0.8	40.4
Exports	95.4	25.2
Government consumption	0	0
Stocks (future consumption)	1.8	6
Total	**100**	**100**

Source: The research team's calculation and NSO

Table 4.6 shows the sales composition of 'LeatherPrd' commodity in 2005 and 2012. The commodity was mainly exported in 2005. Due to the structural changes, there was a substantial increase in domestic use; a massive share increase of 39.6 percentage points in household consumption and 26.4 percentage points in intermediate consumption.

Table 4.6 Domestic and imported sales composition of 'LeatherPrd'

Sales		Intermediate	Household
2005	Domestic	50	5.7
	Imported	50	94.3
2012	Domestic	88.1	55.6
	Imported	11.9	44.4

Source: The research team's calculation and NSO

The main reason for 'LeatherPrd' industry to become the biggest loser was its trade exposure. Table 4.6 provides the domestic and imported shares of 'LeatherPrd' commodity for intermediate use and household consumption. It can be seen that there was a substantial shift toward the domestically produced 'LeatherPrd' in both intermediate and household uses. Underlying reason is the positive change in consumer taste and twist to domestically produced 'LeatherPrd', perhaps due to a quality improvement and a variety increase.

Table 4.7 Main items in 'LeatherPrd'

Main items in 'LeatherPrd'	2005	2012	Change (%)
Leather footwear (thousand pairs)	3.00	18.30	510.0
Leather coat (thousand pieces)	3.60	13.90	286.1

Leather jacket, shirt (thousand pieces)	4.20	8.30	97.6

Source: The research team's calculation and NSO

Table 4.7 shows the changes in sales volumes of main items in 'LeatherPrd'. There was not major technological improvement in the industry, yet the outputs of main items in 'LeatherPrd' composite commodity increased. It is one of the down-stream industries related to Mongolian livestock sector, in which there is a comparative advantage. Thus, there is a room for the industry to grow sustainably if the policy measures to improve productivity and technology are implemented.

For the mining and services sectors, the investment and capital ratio are substantially higher in 2012 than in 2005, resulting in a very strong positive change in the real investment. The average propensity to consume in 2012 was also much higher than in 2005, leading to a large increase in private consumption.

The details of the simulation are included in the handbook of ERI CGE model along with the instructions to replicate the simulation.

4.5 Concluding remarks for the historical simulation

The Mongolian economy underwent a massive change for the period 2005 to 2012. The historical simulation provides an explanation of some of the main macro developments in the Mongolian economy during the period. Through historical simulation, we estimated a number of structural variables, industry technologies, household preferences, required rates of return on capital, and positions of export-demand curves and import supply curves. The changes in these variables are, in fact, the sources of structural change in Mongolia. We estimated several aspects of technology change for industries. These include changes in sector-specific primary factor productivity, sector-specific input *c* saving technology in current production and capital formation, sector-specific all-input using technology and sector-specific labour-capital twist.

We tracked changes in multifactor productivity and changes in input-using technology affecting the use of each industry's commodities per unit of output across all industries. The simulation reveals that the economy needs *efficiency and productivity improvement*. In particular, the changes in sector-specific input saving technology in

current production and capital formation, as well as sector-specific all-input using technology, were unfavourable. Agriculture, followed by the manufacturing sector, is the worst performer in terms of technical change, and this requires policy reform.

In addition, we estimated changes in capital/labour choices beyond those that can be explained by changes in relative factor prices. Due to the capital-intensive nature of mining industries and the development phase of major mining deposits such as the Ouy Tolgoi mine, we found a large shift towards capital. Mongolia is a net importer of machinery, vehicles and fuel. There was a massive increase in imports of those commodities due to rapid growth, the surge in investment and changes in consumer taste, leading to a huge shift towards imported commodities in the composition of overall and industry-level import and domestic mixes.

Mongolia's endowment in natural resources has given it a comparative advantage in the production and export of mineral products. Mongolia's terms of trade increased greatly over the past decade, reaching a peak in 2011. This unprecedented improvement in the terms of trade, coupled with the large inflow of FDI, had been driven by the industrialisation and urbanisation of Mongolia's neighbour and main trading partner, China.

Externally generated growth is, however, a double-edged sword. The Mongolian economy had undergone a massive change between 2005 and 2012. Thus, the boom brought with it economic fragility, notably vulnerability to commodity price slumps and an adverse shock to FDI.

Productivity is often viewed as a key to raising living standard in the long run. Australian governments undertook a series of economic reforms through the 1980s that delivered exceptional growth in national income and helped mitigate Dutch disease effects. In particular, the microeconomic reforms that aimed to increase technical, allocative and dynamic efficiencies have helped the Australian economy to increase its flexibility and have sustained long-run economic growth for a quarter of a century. The EERI CGE historical simulation results confirm that this type of reform is necessary for the Mongolian economy. The historical simulation results show that the economy lacks

technical efficiency improvements. Especially when confronted by ‘dog days’, productivity improvement through microeconomic reforms, coupled with enhancement in institutional quality, may help Mongolia to avoid getting stuck in the ‘resources trap’.

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6. Appendix

Appendix 1.1. Industries and Commodities in ERI CGE

	Industries/Commodities	ERI CGE name
01	Crops	Crops
02	Animal husbandry and other agriculture	Livestock
03	Forestry and logging	ForestryLogs
04	Fishery	Fishery
05	Coal	Coal
06	Oil (petroleum) and natural gas	OilNatGas
07	Iron and copper ore: Metal ore	MetalOres
08	Other mining	OtherMining
09	Meat, meat products, fruit, vegetables, oils and fats	MeatFrVgOilF
10	Dairy products	DairyPrd
11	Flour mill products and cereal foods	FlourCereals
12	Other food products	OtherFoodPrd
13	Soft drinks, cordials and syrups	Drinks
14	Tobacco products	TobaccoPrd
15	Knitting mill products	KnittingMill
16	Clothing and fur, fur products	ClothingFurs
17	Leather and leather products	LeatherPrd
18	Wooden products (excluding wooden furniture)	WoodenPrd
19	Pulp, paper and paperboard	PulpPaper
20	Printing and services to printing, Publishing, recorded media, etc	PrintingMdia
21	Coke, liquid and nuclear fuel	FuelPrd
22	Chemical products	ChemicalPrd
23	Rubber and ceramic products	RubberPlasti
24	Non-metal mineral products	NMetalMinPrd
25	Iron and steel	IronAndSteel
26	Metal products excluding machinery and equipment	MetalPrd
27	Machinery and equipment	MachineryEqp
28	Document processing and calculation equipment	Computers
29	Electrical equipment	ElectEquip
30	Radio, TV and communication equipment	RadioTVEqp
31	Medical equipment	MedicalEqp
32	Transport equipment	TransportEqp
33	Furniture	Furniture
34	Secondary raw material processing	SecRawMatPrc
35	Electricity, water and heating supply	ElecWatrHeat

36	Water supply, sewerage and drainage services	WaterDrains
37	Construction	Construction
38	Trade: wholesale and retail trade	Trade
39	Accommodation, cafes and restaurants	HotelCafes
40	Land transport: road and rail	LandTransprt
41	Air transport	AirTransport
42	Services to transport, storage, water transport	SvcToTrnsprt
43	Communication services	CommunicSvc
44	Insurance	Insurance
45	Other financial services excluding compulsory social security	OthFinancSvc
46	Services to finance, investment and insurance	SvcToFinance
47	Real estate services	RealEstate
48	Vehicle, equipment and household appliance rental	EquipRental
49	Technical and computer services	TechnicalSvc
50	Scientific research	ScienceResch
51	Other business activities	OthBusActvts
52	Government administration and defence	GovAdminDfnc
53	Education	Education
54	Health and social services	HealthSocSvc
55	Other community, social and personal service activities	OtherSvc

Source: The research team creation

Appendix 1.2. Industries in ERI CGE (2012)

ISIC	**2012**	№	**54**	**ERI HF**	**44**
011-013, 016	Crop production, related service activities	1	Crops	Crops	1
014, 017	Animal production, hunting	2	Livestock	Livestock	2
02	Forestry and logging	3	Forestry	ForestFish	3
03	Fishing and aquaculture	4	Fishery		
05	Mining of coal and lignite	5	Coal	Coal	4
06	Extraction of crude petroleum and natural gas	6	CrudeOil	OilNatGas	5
07	Mining of metal ores	7	MetalOres	MetalOres	6
08	Other mining and quarrying	8	OtherMining	OthMinServ	7
09	Mining support service activities	9	MiningServ		
10	Manufacture of food products	10	FoodProd	FoodProd	8
11	Manufacture of beverages	11	Drinks	Drinks	9
12	Manufacture of tobacco products	12	TobaccoProd	TobaccoProd	10
13	Manufacture of textiles	13	Textiles	Textiles	11
14	Manufacture of wearing apparel	14	WearApparel	WearApparel	12
15	Manufacture of leather and related products	15	LeatherProd	LeatherProd	13
16	Manufacture of wood and of products of wood and cork, except furniture manufacture of articles of straw and plaiting materials	16	WoodenProd	WoodenProd	14
17	Manufacture of paper and paper products	17	PulpPaper	PulpPaper	15
18	Printing and reproduction of recorded media	18	PrintingMed	PrintingMdia	16
19	Manufacture of coke and refined petroleum products	19	CokeRefinOil	CokeFuelPrd	17
20	Manufacture of chemicals and chemical products	20	ChemicalProd	ChemPhar	18
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	21	PharmaProd		
22	Manufacture of rubber and plastics products	22	RubberPlast	RubberPlast	19
23	Manufacture of other non-metallic mineral products	23	OthNMetProd	OthNMetProd	20
24	Manufacture of basic metals	24	BasMetalPrd	BasMetalPrd	21
25	Manufacture of fabricated metal products, except machinery and equipment	25	FabricMet	FabricMet	22
26	Manufacture of computer, electronic and optical products	26	CompElectOpt	CompElectOpt	23

27	Manufacture of machinery and equipment	27	MachineryEqp	MachTransEqp	24
28-30	Manufacture of motor vehicles, trailers and semi-trailers; other machinery and	28	MotorVecEqp		
31	Manufacture of furniture	29	Furniture	Furniture	25
32	Other manufacturing	30	OtherManuf	ManufNec	26
325	Manufacture of medical and dental instruments and supplies	31	MedicalEqp		
33	Repair and installation of machinery and equipment	32	RepairInst		
35	Electricity, gas, steam and air conditioning supply	33	ElecGasHeat	ElecGasHeat	27
36-37	Water supply; sewerage management	34	WaterDrains	WaterSeWaste	28
38-39	Waste management and remediation activities	35	WasteRemed		
41-43	Construction	36	Construction	Construction	29
45-47	Wholesale and retail trade; repair of motor vehicles and motorcycles	37	Trade	Trade	30
49-50	Land and water transport	38	Transport	Transport	31
51	Air transport	39			
52	Warehousing and support activities for transportation	40	Warehousing	SvcTransNec	32
53	Postal and courier activities	41	PostalCour	CommunicSv	34
55-56	Accommodation and food service activities	42	HotelCafes	HotelCafes	33
58-63	Information and communication	43	InfCommunic	CommunicSvc	34
64	Financial service activities, except insurance and pension funding	44	FinanSvc	FinSvc	35
65	Insurance, reinsurance and pension funding, except compulsory social security	45	InsurancePen	InsuranceSup	36
66	Activities auxiliary to financial service and insurance activities	46	OthFinanSvc	FinSvcNec	37
68	Real estate activities	47	RealEstate	RealEstOth	38
69-75	Professional, scientific and technical activities	48	ProfTechSvc	ProTecAdmSvc	39
77-82	Administrative and support service activities	49	AdminSupSvc		
84	Public administration and defence; compulsory social security	50	GovAdminDfnc	GovAdminDfnc	40
85	Education	51	Education	Education	41
86-88	Human health and social work activities	52	HealthSocSvc	HealthSocSvc	42
90-93	Arts, entertainment and recreation	53	ArtEntRecSvc	OtherSvcAct	43
94-96	Other service activities	54	OtherSvc		
97-99	Other activities	55	OtherAct	OthActvts	44

Source: The research team creation

Appendix 1.4 ERI CGE and GTAP map

	COM	Gtap 57 Commodities	2012 CC 67	GTAP map
1	PDR	Paddy rice	1 Crops	wht
2	WHT	Wheat	2 Livestock	ctl
3	GRO	Cereal grains nec	3 Forestry	frs
4	V_F	Vegetables, fruit, nuts	4 Fishery	fsh
5	OSD	Oil seeds	5 Coal	coa
6	C_B	Sugar cane, sugar beet	6 CrudeOil	oil
7	PFB	Plant-based fibers	7 MetalOres	omn
8	OCR	Crops nec	8 StoneSandCla	omn
9	CTL	Cattle,sheep,goats,horses	9 OtherMine	omn
10	OAP	Animal products nec	10 ElecGasHeat	ely
11	RMK	Raw milk	11 NatWater	b_t
12	WOL	Wool, silk-worm cocoons	12 FoodProd	ofd
13	FRS	Forestry	13 DairyProd	mil
14	FSH	Fishing	14 MillProd	tex
15	COA	Coal	15 Beverages	b_t
16	OIL	Oil	16 TobaccoProd	b_t
17	GAS	Gas	17 YarnThread	tex
18	OMN	Minerals nec	18 Textiles	tex
19	CMT	Meat: cattle,sheep,goats,horse	19 WearApparel	wap
20	OMT	Meat products nec	20 LeatherProd	lea
21	VOL	Vegetable oils and fats	21 WoodenProd	lum
22	MIL	Dairy products	22 PulpPaper	ppp
23	PCR	Processed rice	23 CokeRefinOil	p_c
24	SGR	Sugar	24 BasChemiProd	crp
25	OFD	Food products nec	25 OthChemiProd	crp
26	B_T	Beverages and tobacco products	26 RubberPlast	ppp
27	TEX	Textiles	27 OthNMetGlPrd	nmm
28	WAP	Wearing apparel	28 Furniture	omf
29	LEA	Leather products	29 WasteScraps	omf
30	LUM	Wood products	30 BasMetalPrd	i_s
31	PPP	Paper products, publishing	31 FabricMet	fmp
32	P_C	Petroleum, coal products	32 GenMachine	ome
33	CRP	Chemical,rubber,plastic prods	33 SpecMachine	ome
34	NMM	Mineral products nec	34 OffComMachin	ome
35	I_S	Ferrous metals	35 ElectMachin	ele
36	NFM	Metals nec	36 RadioTVEqp	ele
37	FMP	Metal products	37 MedicalEqp	omf
38	MVH	Motor vehicles and parts	38 TransEquip	otn
39	OTN	Transport equipment nec	39 Construction	cns
40	ELE	Electronic equipment	40 Trade (61+62)	trd
41	OME	Machinery and equipment nec	41 AccoBeveServ	trd

42	OMF	Manufactures nec	42 PassenTrns	atp
43	ELY	Electricity	43 Transport	otp
44	GDT	Gas manufacture, distribution	44 RentTrns	ofi
45	WTR	Water	45 SuppTrnsServ	otp
46	CNS	Construction	46 PostalCour	otp
47	TRD	Trade	47 ElecWatDist	otp
48	OTP	Transport nec	48 FinanServ	ofi
49	WTP	Sea transport	49 RealEstate	dwe
50	ATP	Air transport	50 LeasRentServ	ofi
51	CMN	Communication	51 RandD	ros
52	OFI	Financial services nec	52 LegAccServ	obs
53	ISR	Insurance	53 OthProfTech	obs
54	OBS	Business services nec	54 TeleComm	cmn
55	ROS	Recreation and other services	55 SuppServ	obs
56	OSG	PubAdmin/Defence/Health/Educat	56 AgriSuppServ	obs
57	DWE	Dwellings	57 ReInSuppServ	obs
			58 ManuSuppServ	obs
			59 OthManuServ	obs
			60 GovAdminDfnc	osg
			61 Education	osg
			62 HealthSoServ	osg
			63 SewaWasServ	wtr
			64 MemOrgServ	ros
			65 CulSportServ	ros
			66 OtherServ	ros
			67 DomServ	ros

Source: The research team creation

Appendix 2. Elasticities of the substitutability between primary factors

Sectors		
01	Crops	0.239
02	Animal husbandry and other agriculture	0.239
03	Forestry and logging	0.2
04	Fishery	0.2
05	Coal	0.2
06	Oil (petroleum) and natural gas	0.2
07	Iron and copper ore: Metal ore	0.2
08	Other mining	0.2
09	Meat, meat products, fruit, vegetables, oils and fats	1.12
10	Dairy products	1.12
11	Flour mill products and cereal foods	1.12
12	Other food products	1.12
13	Soft drinks, cordials and syrups	1.12
14	Tobacco products	1.12
15	Knitting mill products	1.26
16	Clothing and fur, fur products	1.26
17	Leather and leather products	1.26
18	Wooden products (excluding wooden furniture)	1.26
19	Pulp, paper and paperboard	1.26
20	Printing and services to printing, Publishing, recorded media, etc	1.26
21	Coke, liquid and nuclear fuel	1.26
22	Chemical products	1.26
23	Rubber and ceramic products	1.26
24	Non-metal mineral products	1.26
25	Iron and steel	1.26
26	Metal products excluding machinery and equipment	1.26
27	Machinery and equipment	1.26
28	Document processing and calculation equipment	1.26
29	Electrical equipment	1.26
30	Radio, TV and communication equipment	1.26
31	Medical equipment	1.26
32	Transport equipment	1.26
33	Furniture	1.26
34	Secondary raw material processing	1.26
35	Electricity, water and heating supply	1.26
36	Water supply, sewerage and drainage services	1.26
37	Construction	1.4

38	Trade: wholesale and retail trade	1.68
39	Accommodation, cafes and restaurants	1.68
40	Land transport: road and rail	1.68
41	Air transport	1.68
42	Services to transport, storage, water transport	1.26
43	Communication services	1.26
44	Insurance	1.26
45	Other financial services excluding compulsory social security	1.26
46	Services to finance, investment and insurance	1.26
47	Real estate services	1.26
48	Vehicle, equipment and household appliance rental	1.26
49	Technical and computer services	1.26
50	Scientific research	1.26
51	Other business activities	1.26
52	Government administration and defence	1.26
53	Education	1.26
54	Health and social services	1.26
55	Other community, social and personal service activities	1.26

Source: The research team's calculation

Appendix 3. Armington, Household expenditure and Export elasticities

	Commodities	Armington Elasticities	Household expenditure elasticities	Export elasticities
01	Crops	4.45	0.47	8.9
02	Animal husbandry and other agriculture	2	1.04	4
03	Forestry and logging	2.5	1.27	5
04	Fishery	1.25	1.04	2.5
05	Coal	3.05	1.28	6.1
06	Oil (petroleum) and natural gas	5.2	1.08	10.4
07	Iron and copper ore: Metal ore	0.9	1.14	1.8
08	Other mining	0.9	1.14	1.8
09	Meat, meat products, fruit, vegetables, oils and fats	3.85	0.68	4
10	Dairy products	3.65	0.67	7.3
11	Flour, mill products and cereal foods	2.6	0.31	7.5
12	Other food products	2	0.52	4
13	Soft drinks, cordials and syrups	1.15	0.53	2.3
14	Tobacco products	1.15	0.53	2.3
15	Knitting mill products	3.75	0.87	7.5
16	Clothing and fur, fur products	3.7	0.69	7.4
17	Leather and leather products	4.05	0.72	8.1
18	Wooden products (excluding wooden furniture)	3.4	0.96	6.8
19	Pulp, paper and paperboard	2.95	0.78	5.9
20	Printing and services to printing, Publishing, recorded media, etc	2.95	0.78	5.9
21	Coke, liquid and nuclear fuel	2.1	0.95	4.2
22	Chemical products	3.3	0.86	6.6
23	Rubber and ceramic products	3.3	0.86	6.6
24	Non-metal mineral products	2.9	1.01	5.85
25	Iron and steel	2.95	1.08	5.9
26	Metal products excluding machinery and equipment	3.75	0.93	7.4
27	Machinery and equipment	4.05	0.88	8.1
28	Document processing and calculation equipment	4.4	0.71	8.1
29	Electrical equipment	4.4	0.71	8.8
30	Radio, TV and communication equipment	4.4	0.71	8.8
31	Medical equipment	3.75	0.82	7.4
32	Transport equipment	2.8	1.57	5.6
33	Furniture	3.75	0.82	7.4
34	Secondary raw material processing	3.75	0.82	7.4
35	Electricity, water and heating supply	2.8	1.12	5.6

36	Water supply, sewerage and drainage services	2.8	1.09	5.6
37	Construction	1.9	1.28	3.8
38	Trade: wholesale and retail trade	1.9	1.19	3.8
39	Accommodation, cafes and restaurants	1.9	1.19	3.8
40	Land transport: road and rail	1.9	0.92	3.8
41	Air transport	1.9	2.1	3.8
42	Services to transport, storage, water transport	1.9	1.63	3.8
43	Communication services	1.9	0.85	3.8
44	Insurance	1.9	1.04	3.8
45	Other financial services excluding compulsory social security	1.9	1.67	3.8
46	Services to finance, investment and insurance	1.9	1.67	3.8
47	Real estate services	1.9	1.49	3.8
48	Vehicle, equipment and household appliance rental	1.9	1.63	3.8
49	Technical and computer services	1.9	1.63	3.8
50	Scientific research	1.9	1.48	3.8
51	Other business activities	1.9	1.48	3.8
52	Government administration and defence	1.9	1.45	3.8
53	Education	1.9	1.45	3.8
54	Health and social services	1.9	1.45	3.8
55	Other community, social and personal service activities	1.9	1.48	3.8

Source: The research team's calculation