An Introduction to Mudan Model(CUFE Version)

by

Pan Shengchu Yuan Songqi

The Central University of Finance and Economics, Beijing, China

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Mudan is a Multisectoral dynamic model of Chinese economy, which was developed under the guidance of Prof. Almon at the beginning of 1990s.

The initial model was a 33 sector model based on China 1987 I-O table. It was changed to 63 sector model when we learned that at most 63 sectors time series data could be acquired. New Industrial Classification of National Economy was published at the end of 1994. It resulted in a lot of changes in statistic data and had huge influence on our model. To adapt this change, we modified Mudan to 59 sector model based on China 1992 I-O table.

Researchers of this stage (1992-1995) were from Development Research Center of State Council, Information center of Jiangsu Province and Central University of Finance and Economics.

The research team of Central University of Finance and Economics (CUFE) continued to improve Mudan model on the basis of the 59 sector model since 1995. The main improvements are:

- Rebuilding 59 sector databank of china economy based on new Industrial Classification of National Economy(national standard 94), and extending the range of time series to year 2000 (1985-2000).
- Estimating sectorial behavior equations of wages, depreciation, profit, tax, investment, imports and exports, making these variables become endogenous.

In this paper, we will give a brief introduction on the structure, main equations and iteration process of Mudan model (CUFE version).

I. I-O Framework of Mudan

Mudan is based on a 59-sector I-O table, whose structure is described in table I. At the top-left of the table is a matrix named A，which is a 59X59 matrix of intermediate products. The rows represent the intermediate input, while the columns intermediate uses. Figures in each cell has double meaning: horizontally it represents the volume of goods or services that the sector consumes in the production process, and vertically it represents the amount of products or services that the output sector produces for each input sector as intermediate use.

Right to A matrix is various components (fdi) of final use such as rural residential consumption, urban residential consumption, social consumption, fixed capital investment, change in inventories, imports, exports and other final demand. Sum of each row of the table represents total demand of each sector.

Beneath A matrix is items of value added（initial input），including wages, depression, taxes and profits. Sum of each sector’s intermediate input and value added gets the sector’s total input, which is equal to the total demand of each sector.

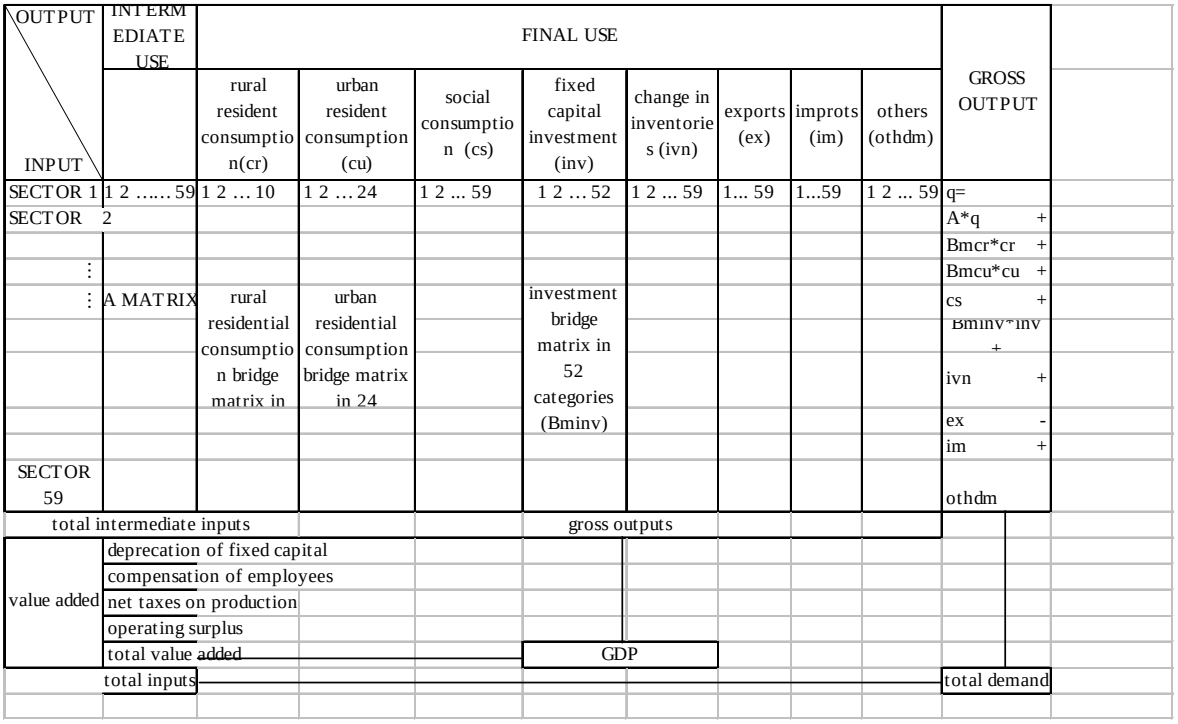

Fig. 1 I-O framework of mudan model

The corresponding production side I-O Equation is (1) below.

II. Modules and main equations

There are three modules in Mudan, the production module, the price-income module and the accounting module.

A. Production Module

In this module，each sector's final demand data in constant price are calculated，including residential consumption, social consumption, fixed assets investment, storage, imports, exports and other final demand. Then, the I-O equation compute the total output of each sector. Finally, we get productivities and employment.

1. I-O equations

$$A\times q + Bmcr\times hcrT + Bmcu\times hcuT + Bminv\times inv + cs + ivn + ex - im + othdm = q \quad (1)$$

Where:

A = I-O input coefficient matrix, 59×59

q = gross output, 59×1

Bmcr = bridge matrix for rural household consumption, 59×10

hcrT = rural household consumption by 10 categories, 10×1

Bmcu = bridge matrix for urban household consumption, 59×24

hcuT = urban household consumption by 24 categories, 24×1

Bminv = bridge matrix for investment in fixed-assets, 59×52

inv = investment in fixes-assets, 52×1

cs = government expenditure, 59×1

ivn = inventory changes, 59×1

ex = exports, 59×1

im = imports, 59×1

othdm = other final demand, for statistical error adjustment purpose, 59×1

All of above components are in constant prices. Consumption, investment, exports and imports are calculated separately based on behavior equations, and then a *seidel* procedure is employed to compute gross output.

2. Consumption equations

There are three kinds of consumption in Mudan, social consumption, rural residential consumption and urban residential consumption. Social consumption is yield by government and organization，and is exogenous. The rural consumption data are divided into 10 categories and the urban consumption data are divided into 24 categories. The classifications can be found in appendix II and appendix III.

For rural resident,

$$hcr_{it} = a_0 + a_1 \times incr_t + a_2 \times relp_{it} + a_3 \times hcr_{it-1} \qquad (2)$$
$$i = 1,2,...,10 \quad t = 1985,...2000$$

where: hcr_{it} = rural resident's consumption per capita for category i at time t

$incr_{it}$ = rural resident's income per capita at time t

$relp_{it}$ = price index for category i relative to overall price index for rural household consumption, 1992=100

hcr_{it-1}=lag value of $hcr_{it.}$

For urban resident,

$$hcu_{it} = a_0 + a_1 \times incu_t + a_2 \times dincu_t + a_3 \times relp_{it} \qquad (3)$$
$$i = 1,2,...,24 \quad t = 1985,...2000$$

where, hcu_{it} = urban resident's consumption per capita for category *i* at time *t*

$incu_t$ = urban resident's income per capita at time *t*

$dincu_t$ = the first difference of $incu_t$

$relp_{it}$ = price index for category *i* relative to overall price index for urban household consumption, 1992=100

3. Fixed investment equations

There are 52 sectors of investment in Mudan. We adopt an accelerator model, which displays good fitness for Chinese economic reality.

General equation takes following form:

$$inv_{it} = a_0 + a_1 \times dq_{it} + a_2 \times dq_{it-1} + a_3 \times dq_{it-2} + a_4 \times wear_{it-1} + a_5 \times invp_{it} \qquad (4)$$

where: inv_{it} = investment of the sector *i* at time *t*

dq_{it} = the first difference of the output of the sector *i* at time *t*

$wear_{it}$ = depreciation of the sector *i* at time *t*, adjusted by "unit bucket"

$invp_{it}$ = investment price index of sector *i* at time *t,1992=100*

4. Imports and exports equations

Mudan uses Logistic Curve function in Imports and exports equations.

import：

$$\frac{im_{it}}{ddm_{it}} = \frac{a_0 * \exp(a_1 * price_{it} / fpi_{it})}{1 + a_3 * \exp(a_2 * t80)} \quad (5)$$

where, im_{it} = import for sector *i* in time *t*（in ten billion RMB，nominal ）

ddm_{it} = domestic demands index for sector I in time t ，1987=100

$price_{it}$= domestic price index for sector I in time t

fpi_{it} =import price index for sector I in time t

t80= a simple time trend，1980 = 1

export：

$$\frac{ex_{it}}{fdm_{it}} = \frac{a_0 * \exp(a_1 * fpe_{it} / price_{it})}{1 + a_3 * \exp(a_2 * t80)} \quad (6)$$

where, ex_{it}= import for sector *i* in time *t*（in ten billion RMB，nominal ）

fdm_{it}= foreign demand index for sector *i* in time *t*, 1987=100

fpe_{it}= the ratio of domestic price to foreign price of sector *i* in time *t*

$price_{it}$= domestic price index for sector I in time t

t80= a simple time trend，1980 = 1

5. Productivity and employment

$$prt_{it} = a_0 + a_1 \times dq_{it} + a_2 \times kl_{it-1} + a_3 \times time_t \quad (7)$$

where，prt_{it}=productivity of sector i

dq_{it}=$output_t$ - $output_{t-1}$ of sector i

kl_{it-1}=fixed assets investment/employment of sector I (lag value)

$$emp_{it} \equiv q_{it} / prt_{it} \quad (8)$$

where，emp_{it}=employment of sector i

q_{it}=total output of sector i

prt_{it} =productivity of sector i

It must be pointed out that imports and outputs should be computed synchronously. The reason is imports depend on outputs. So, a Seidel was used in the production module to solve the problem. Another aggregated data, GNP in constant price and total employment population are computed in this module.

B. Price-income module

Each sector's value added contains four components: wage, depreciation, profits and taxes. All data in price-income module are nominal. Price indexes are computed in this module too.

1. Wages equations

For agriculture sectors,

$$\ln wpcag_t = a_0 + a_1 \times \ln prtagN_t + a_2 \times \ln time \quad (9)$$

where，$wpcag_t$= average wage rate of agriculture sector, defined as total wages divide

employ population

$prtagN_t$ =nominal productivity for agriculture

time= the simple time trend

For non-agriculture sectors,

$$\ln wpcnoag_t = a_0 + a_1 \times \ln prtnoagN_t + a_2 \times \ln time \quad (10)$$

where，$wpcnoag_t$= average wage rate of non-agriculture sectors

$prtnoagN_t$= nominal productivity for non-agriculture sectors

time= the simple time trend

$$\ln wpc_{it} = a_0 + a_1 \times \ln wpcnoag_t + a_2 \times \ln prt_{it} \quad (11)$$

where，wpc_{it}= wage rate of sector i

$wpcnoag_t$= average wage rate of non-agriculture sectors

prt_{it}= productivity of sector i.

Wage rates multiplying employee gives wages of each sector.

2．Depreciations of fixed assets equations

$$dep_{it} = a_0 + a_1 \times CapstkN_{it} + a_2 \times time_t \quad (12)$$

where，dep_{it}= depreciations of fixed assets of sector i

$CapstkN_{it}$= the stock of fixed assets investment of sector i

3．Profits equations

$$prf_{it} = a_0 + a_1 \times dqN_{it} + a_2 \times prices_{it-1} \quad (13)$$

where，prf_{it}= profit of sector i

dqN_{it}= $output_t$ - $output_{t-1}$ of sector i

$prices_{it-1}$=price index of sector i, lag value,1992=100

4．Taxes equations

$$tax_{it} = a_0 + a_1 \times va_{it} + a_2 \times time_t \quad (14)$$

where，tax_{it}= tax of sector i；va_{it}= nominal value added of sector I

5．Value added equations

value added：

$$va_{it} \equiv wage_{it} + dep_{it} + prf_{it} + tax_{it} \quad (15)$$

where，va_{it}= nominal value added of sector i

$wage_{it}$= wage of sector i

dep_{it}= depreciation of fixed assets of sector i

prf_{it}= profit of sector i

tax_{it}= tax of sector i

value added Per unit output in constant price is defined as:

$$unitva_{it} \equiv va_{it} / out_{it} \quad (16)$$

where，$unitva_{it}$= value added per unit output in constant price of sector i;

va_{it}= nominal value added of sector i

out_{it}= total output of sector i in constant price

6．Price eqations

$p \times A + unitva = p$ （17）

where，p= price vector（1×59）

A= input coefficient matrix（59×59）

Unitva= unit value added vector（1×59）

7. Income equations

rural resident:

$$\ln incrNT_t = a_0 + a_1 \times \ln agoutN_t + a_2 \times \ln time \quad （18）$$

where，$incrNT_t$= total nominal income of rural resident；

$agoutN_t$= nominal total output of agriculture sectors

Urban resident：

$$\ln incuNT_t = a_0 + a_1 \times \ln noagoutN_t + a_2 \times \ln time \quad （19）$$

where，$incuNT_t$=total nominal income of urban resident；

$noagoutN_t$= nominal total output of non-agriculture sectors

rural and urban total nominal income divided by rural and urban population respectively are resident income per capita。

In some sectors, we use log form of the equations in order to get a fitter regression result.

In price income module，price is computed though a PSeidel iterative like we treat output, through consumption bridge matrix and investment bridge matrix，price indexes in categories are calculated further.

C. Accounting module

This module plays a role as national economy accountant. It generates price indexes for aggregated data through weighted average, computes rural and urban residential income, nominal GDP and GDP in current price. For the time being，some of the functions are still in progress, what has been done are as follows:

1. Calculating each price index, including GDP inflator, rural residential consumption price index, urban residential consumption price index, social consumption price index, fixed assets investment price index and etc.

2. Summing each sector's data to get macro economy aggregated ones, including GDP、residential consumption、residential saving、social consumption、investments、imports、exports、wages、profits、employment and etc.

III. Computing process

The computing process of Mudan is shown in Figure 2.

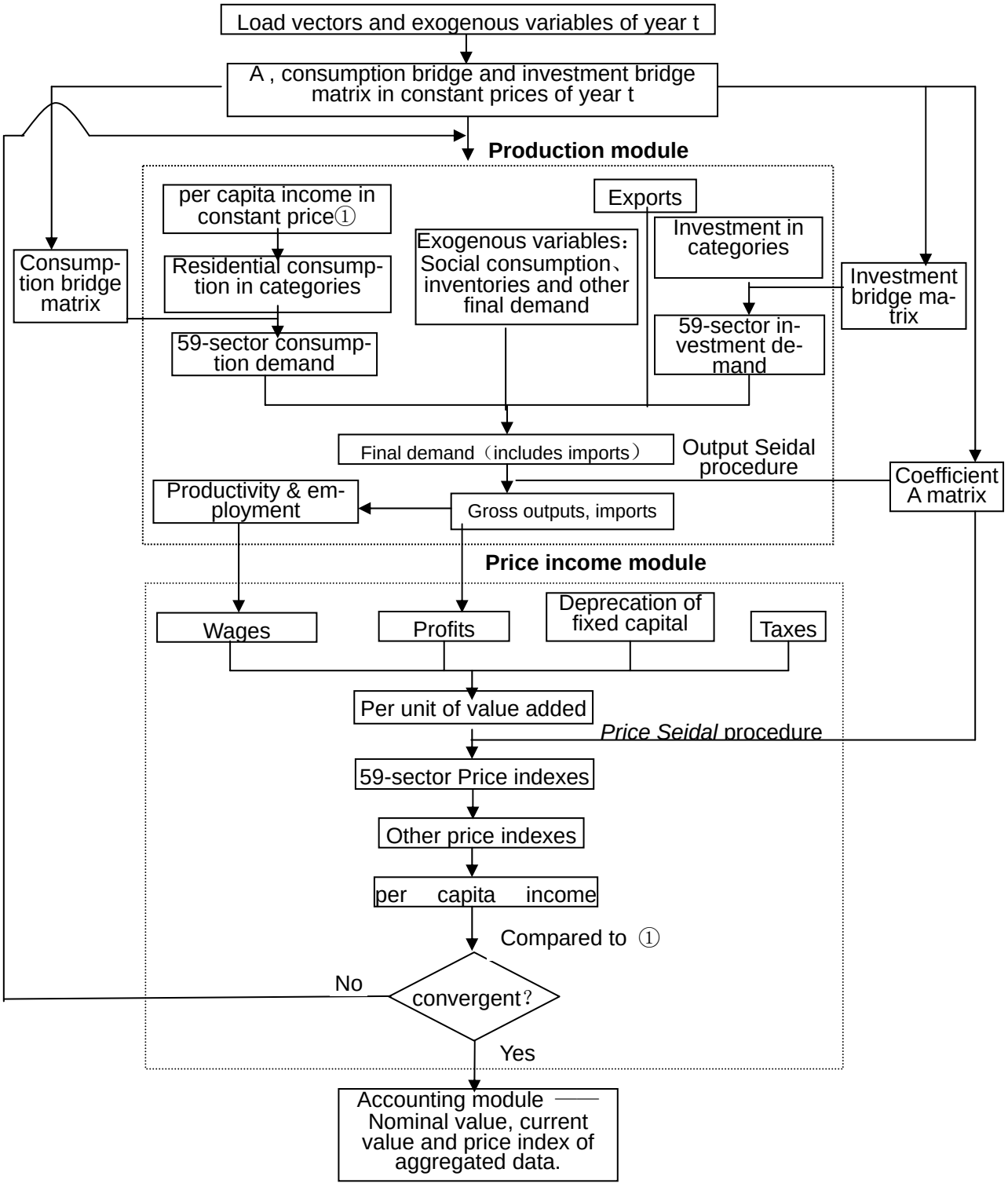

Fig. 2　Iteration process of Mudan

Appendix I. The classification for Mudan sectors

Sec#	Sector Name	Sec#	Sector Name
1	Farming	31	Metal products
2	Forestry	32	Machinery
3	Livestock	33	Railway Equipment
4	Fishing	34	Motor vehicles
5	Coal mining	35	Ships, boats
6	Crude petroleum and natural gas	36	Aircrafts
7	Ferrous ore mining	37	Other transportation equipment
8	Non-ferrous ore mining	38	Electric machinery and equipment
9	Non-metal minerals mining and other mining	39	Electronic and communication equipment
10	Logging and transportation of timber and bamboo	40	Instrument, meters and office machinery
11	Food processing and manufacturing	41	Other manufacturing
12	Beverages	42	Electricity, steam and hot water production and supply
13	Tobacco manufacturing	43	Gas utility
14	Textiles	44	Water production and supply
15	Wearing apparel	45	Construction
16	Leather, fur and their products	46	Railway transportation
17	Sawmills and bamboo etc. products	47	Highway transportation
18	Furniture	48	Water transportation
19	Paper and paper products	49	Air transportation
20	Printing industries	50	Pipeline transportation
21	Culture, education, and sports articles	51	Post and communications
22	Petroleum refineries and coking products	52	Commerce
		53	Restaurants
23	Chemical industries	54	Finance and insurance
24	Medicines	55	Real estate, and social services
25	Chemical fibers	56	Health care, sports and social welfare
26	Rubber products	57	Education, culture, arts, movie and amusement
27	Plastic products		
28	Building materials and non-metallic mineral products	58	Scientific research and polytechnic services
29	Primary iron and steel manufacturing	59	Public administration and others
30	Primary non-ferrous metals manufacturing		

Appendix II Rural Household Consumption Categories

No.	Category
1	Staple food
2	Non-staple food
3	Other food
4	Clothing
5	Residence
6	Household facilities, articles, and services
7	Medicines and medical services
8	Transportation and communication
9	Cultural, educational and recreational commodities and services
10	Other commodities and services

Appendix III Urban Household Consumption Categories

No.	Category	No.	Category
1	Grain	13	Shoes, hats and socks
2	Meat, poultry, and fats	14	Appliances and furniture
3	Fish and aquatic products	15	Other household articles
4	Vegetables	16	Medicine and medical equipments
5	Flavorings and sugar	17	Transportation
6	Tobacco	18	Post and telecommunication
7	Liquor and beverages	19	Articles for culture and entertainment
8	Fresh and dried fruits	20	Education and children care
9	Cake and dairy products	21	Sports and entertainment
10	Dining out	22	Housing
11	Garments	23	Utilities
12	Cloths and tailoring	24	Jewelry, make-up and others

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