

MuDan: A Model for
MULTisectoral Development ANalysis
of China. Version 2.0
A Report by Clopper Almon, 1993 July 2

MuDan is an interindustry model intended to trace the industrial development of China over several decades. It works at the level of 33 sectors and produces final demand, output, prices, value added, and employment for these sectors.

MuDan version 2 represents a significant advance over Mudan 1.2 completed in December of 1992. New data on exports and imports made possible a study of input-output coefficient change which has added greatly to the realism of the results. Most of the behavioral functions remain exceedingly primitive. Labor productivity, for example, has not been linked in any way with investment. Export and import functions have no price sensitivity. Any serious use of the model will require improvements in at least these areas.

In order to make a self-contained document, this report on version 2.0 will borrow material from the report on version 1.2. It will describe the contents of MuDan, what variables are in it and how they are derived. The second section deals the new Across-the-Row coefficient changes. The third section discusses the questions of real and nominal anchors -- what determines the overall price level and the total employment generated in the model. Since the Chinese economy is quite different in many respects from those for which other models of this sort have been built, it is necessary to be somewhat inventive in this area. The fourth section is a walk through one iteration of the model to show the logical sequence of calculations. The fifth section is a guide to setting up the model and running it on a computer. Some very preliminary but encouraging results are presented in the sixth section, and the last section is devoted to suggestions about directions for further development of the model.

MuDan was prepared for the Development Research Center (DRC) of the State Council of China. Version 2 is the work of Pan Shengchu of the Beijing Institute of Finance and Statistics and of Wang Yinchu of the Economic Information Agency of Jiangsu province in Nanjing, and Clopper Almon of the University of Maryland. Pan and his students prepared the data, and Pan participated actively in the formulation of the model. The programming of the model the estimation of equations was done by Wang. The software used was the Interdyme system, developed by the Inforum group at the University of Maryland. The work was supported by a United Nations grant to the DRC. All the model builders wish to thank Li Shantong of the DRC for her interest and support.

1. Contents of MuDan

MuDan works in the framework of the 33-sector version of the 1987 input output table. The names of the sectors are shown in Table 1. At this level of detail the model shows: output, prices, final demand, and value added. Total final demand is divided into Rural consumption, Urban consumption, Public (or social) consumption, Capital investment (by product bought), Inventory investment, Exports, Imports, and Other. The "Other" seems to be a sort of statistical discrepancy. Public consumption represents both government purchases and purchases by firms of housing and other goods and services for their employees. Five components of value added are shown: Wages, Taxes and benefits, Welfare contributions, Depreciation, and Other. This "Other", however, is often a large portion of total value added, sometimes several times larger than Wages. It represents the financing for the firms' share of Public consumption. It will play a key role in the logic of MuDan. Labor productivity and Employment are also shown at the 33-sector level.

Table 1: Sectors of the 1987 Input-Output Table

1 Agriculture	18 General machinery
2 Coal	19 Transportation equipment
3 Crude oil and natural gas	20 Electrical machinery
4 Metallic minerals	21 Electronic equipment
5 Non-metallic minerals	22 Instruments
6 Food processing	23 Equipment repairing
7 Textiles	24 Other industry
8 Clothing and leather	25 Construction
9 Timber and furniture	26 Freight Transportation
10 Paper and printing	27 Commerce
11 Electricity and steam	28 Catering
12 Petroleum refining	29 Passenger Transportation
13 Coke and gas supply	30 Public Services
14 Chemicals	31 Education and Health
15 Building Materials	32 Banking and Insurance
16 Primary metals	33 Public Administration
17 Fabricated metal products	

MuDan shows consumption of rural households in eleven categories and consumption of urban households in nineteen categories, as shown in Table 2. Its consumption functions work in these categories; the results are then sent through a "bridge matrix" to convert them into demands on the thirty-three sectors. The consumption functions make per capita consumption

Table 2: Consumption Categories

Rural Households

- 1 Grains and products
- 2 Meat and vegetables
- 3 Prepared foods
- 4 Clothing
- 5 Fuel
- 6 Daily goods
- 7 TV,Hifi,Video,paper,pen,etc.
- 8 Books, newspapers, magazines
- 9 Medicine and health care
- 10 Other goods
- 11 Services

Urban Households

- 01 Grains and products
- 02 Meat and vegetables
- 03 Cigarettes, wine, tea
- 04 Prepared foods
- 05 Clothing
- 06 Daily goods
- 07 TV,Hifi,Video,paper,pen,etc.
- 08 Books, newspaper, magazines
- 09 Medicine and health care
- 10 Fuel
- 11 Other goods
- 12 Rent for housing
- 13 Water and electricity
- 14 Education
- 15 Child care
- 16 Transportation
- 17 Post & communications
- 18 Entertainment
- 19 Other service

of each category depend on per capita income and relative prices. Rural income is determined by a regression on wage income in agriculture and on total wage income in all other sectors. A similar regression was used for urban income. Interestingly, the coefficients on non-agricultural wages wanted to add to less than 1.0. Even when they were forced to add up to 1.0, the coefficients on agricultural income added up to 1.38. The difference probably represents in-kind payments in agriculture which appear in income but not in wages. It needs to be clarified.

Investment for 34 divisions of state industry is currently exogenous. There are simple regression functions for 5 divisions of cooperative industry. These functions, however, use mainly investment by state industry as an explanatory variable, so cooperative investment is also largely essentially exogenous. Exports are estimated as time trends. Imports are estimated as linear functions of domestic demand.

Value added, as mentioned above, is composed of five components: Wages, Taxes and benefits, Welfare contributions, Depreciation, and Other. "Welfare contributions" refers to something like "contributions for social insurance." The treatment of these items anchors the real

and nominal aspects of the model. It is important to understand the need for these anchors and how they work.

2. Across-the-row Coefficient Changes

With data on outputs, exports, and imports it is possible to compare domestic use (domuse) of each product,

$$\text{domuse} = \text{output} + \text{imports} - \text{imports},$$

with the constant-coefficient use, u , calculated by the equation

$$u = A*\text{out} + \text{Mcr}*\text{hcr}*\text{rpop} + \text{Mcu}*\text{hcu}*\text{upop} + B*\text{capital} + \text{pub} + \text{othdm}$$

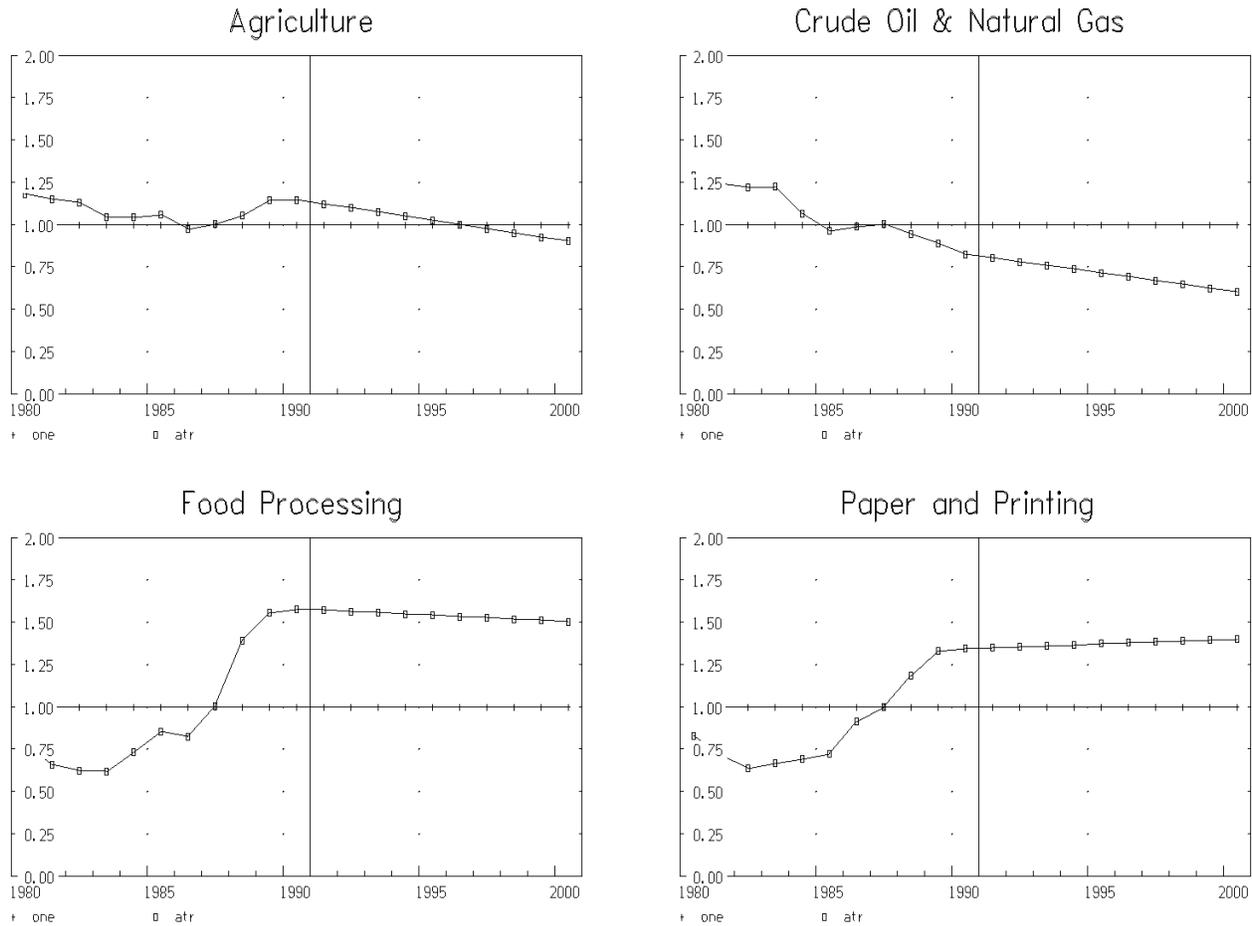
where

A	is the matrix of input-output coefficients
out	is the vector of output
hcr	is household consumption per capita in rural areas in 11 categories
rpop	is rural population
Mcr	is a bridge matrix between the 11 categories of rural consumption (columns) and input-output sectors, rows.
hcu	is household consumption per capital in urban areas
upop	is urban population
Mcu	is a bridge matrix between 19 urban household consumption categories and i-o sectors.
capital	is investment by 40 purchasers of capital goods
B	is a distribution matrix for capital investment (columns match capital; rows, i-o sectors.)
pub	is public consumption
othdm	other demand is basically a residual error column in the i-o table.

The two vectors, domuse and u , were calculated for each year from 1980 to 2000. The time series of ratios of the elements of domuse to u indicate whether use of a product has been growing faster or slower than it would have done had all the elements of the matrices remained constant. We refer to these ratios as "across-the-row scaling factors." If we multiplied each row of the A, Mcr, Mcu, and B matrices and the pub and othdm vectors by the corresponding across-the-row scaling factor and used the modified matrices in the equation for u , then u would be equal to domuse. Unfortunately, the columns of Mcr, Mcu, and B would no longer sum to 1, as is required for these distribution matrices. These columns were then renormalized to sum to 1, and the across-the-row scaling factors recomputed. This process was repeated ten times; further repetition produced no change in the across-the-row scaling factors.

For the forecast, the across-the-row scaling factors were judgmentally extrapolated. Graphs below show the historically calculated values followed by the extrapolation used in the

forecast shown below for four sectors. A full set of graphs can easily be viewed.



The rapid growth in Food Processing is noteworthy. Its role is to increase the elements of the consumption distribution matrices, M_{cr} and M_{cu} . Since the columns of this matrix have to sum to one, the effect is to reduce the share going to Agriculture. The rising factor for Paper reflects increased consciousness of packaging in Chinese industry.

3. Real and Nominal Anchors

In models of the USA economy, the essential real anchor is the labor force, and the nominal anchor is the money supply. In a boom, employment increases towards the relatively fixed labor force; unemployment decreases; wages and profits are pushed up; prices rise; and, with a given quantity of money, money becomes tight and chokes off the expansion. In a recession, the opposite happens to moderate the fall.

It is not immediately clear what corresponds to this process in China. China has no statistics on unemployment and labor force. Unemployment is zero by definition. It is similarly unclear exactly what corresponds to money supply. Perhaps bank loans could play the role. For

the moment, however, MuDan has a simpler mechanism. The nominal anchor is provided by making the nominal wage rate in each industry exogenous. In the base run, all nominal wage rates follow the same index. Each, however, can be given its own course. To get a real anchor, a "labor force" variable was created. In the past, it is defined as total employment. For the future, it is projected by a time trend.

But what happens in the model to make generated employment match the projected labor force? Here we had to improvise a bit of theory. If too much employment was being generated, something would have to be done to reduce real income. Either nominal wages had to be cut or prices had to increase. Since nominal wages were exogenous, that option was out. Something would have to be done to raise prices. But prices are determined from the equation

$$p = pA + v$$

where p is the row vector of prices, v is the row vector of value added per unit of output, and A is the input-output matrix. Thus, to change prices, we have to change some other element of value added. Wages are out. That leaves Taxes and benefits, Welfare contributions, Depreciation, and Other. Depreciation is determined by past investment and can hardly be affected by current business conditions. Tax rates have changed radically over the last ten years, but can hardly be modified automatically in the business cycle. Similarly welfare contribution rates seem unlikely candidates to adjust over the course of the cycle. Only OVA, "Other value added" is left. Since it includes the profits of enterprises, it seemed the logical candidate to be adjusted to get employment to match the labor force. Consequently, if employment exceeds labor force -- meaning a boom -- OVA is scaled up -- meaning high profits -- and vice versa. The scaling is uniform over all sectors. In practice, the scaling factor varied from about .5 to about 2.0. Nonetheless, the resulting series on OVA appears rather smooth. The projected labor force was matched exactly.

The functions for OVA (before scaling) make OVA per unit of output in prices of the *previous* year functions of time. A similar approach is used for Taxes per unit of output.

Some of the productivity growth equations show growth rates that are hardly likely to be continued in the future. In any sector with a productivity growth in excess of 5 percent per year, the excess over 5 was arbitrarily reduced by ten percent per year.

4. The Cycle of Computations

We are now in a position to describe the cycle of computations of MuDan in a year. The first step is to multiply each row of the A , Mcr , Mcu , and B matrices by the corresponding element of the across-the-row scaling factor vector, ami , for the year in question. The columns of Mcr , Mcu , and B are then renormalized to sum to 1.

The calculations then begin with assumed values of rural household income and of urban household income and of prices paid by these households. From this information, the consumption functions calculate consumption in the categories shown in Table 2. These functions make consumption per capita of each item (in constant prices) a function of real per capita

income and the relative price of that item. Savings rates are specified exogenously for rural and urban households. (In the base run, rural households were assumed to save ten percent of their income, while urban households saved five percent.) Total expenditures are then scaled to equal income less saving. These demands are then converted to the input-output sectors. The exogenous investment (by investing sector) is also converted to the supplying input-output sectors. Then household consumption, investment, exports, and public consumption are added together to give a final demand from which imports have not been subtracted. This final demand is then used in a Seidel iterative solution of the input-output equations in which imports and outputs are simultaneously calculated. (The imports depend on the total demand for the product, which is known at each step in the Seidel process.) The imports thus calculated are then subtracted from the final demand.

Labor productivity in each sector is then calculated as a function of time and the rate of change of output. Some manufacturing sectors had rates of productivity increase between ten and twenty percent per year in the period from 1984 - 1990. Such growth can clearly not be maintained. In the forecast, rates of growth of over five percent per year were gradually reduced towards five percent. Once labor productivity is ready, employment is computed simply by dividing output by productivity.

Total wages are then computed by multiplying employment by the exogenous nominal wage rate in each sector and summing over sectors.

Taxes, Welfare contributions, and Depreciation are next calculated. The ratio of taxes deflated by the previous year's price index to output in constant prices is taken as an exogenous, policy variable. Welfare contributions in each industry are a function of wages in that industry. The initial OVA estimate is made like that of taxes: the ratio of OVA deflated by prices of the previous year to constant dollar output is an exogenous policy variable. Then in each iteration after the first two, the OVA scalar is adjusted according to the ratio of employment to labor force. These components are then added to wages to obtain a value added vector. It is then divided by output in constant prices to get "unit value added", that is, value added in current prices per unit of output in constant prices. Prices are then calculated as described above. By using the same matrices employed above to distribute rural household consumption to input-output sectors, price indexes for the various rural consumer categories are calculated. Similarly, price indexes for each of the urban consumer categories and for the investment categories are calculated. The vector of rural consumption in constant prices is then evaluated in current prices. The ratio of the sum of this current-price vector to the sum of the constant-price vector gives an overall index of the prices paid by rural consumers. Similarly, the overall index of urban consumers is calculated.

The final step in the calculations is to distribute wages by industry to rural and urban households. Total wages were divided between Agricultural wages (Ag) and Non-agricultural wages (Nag). The equations are:

$$\text{rural income} = 17 + .15*\text{Nag} + 1.25*\text{Ag}$$

$$\text{urban income} = -95 + .85 * \text{Nag} + .13 * \text{Ag}$$

The constant terms are inconsequential. Note that while exactly 100 percent of non-agricultural wages is allocated to one or the other income, some 138 percent of agricultural wages are allocated. Income thus exceeds wages. The statistical reasons for this disparity should be investigated.

The incomes in these two equations are nominal. Each is divided by the corresponding overall price index to yield the implied real income for rural and urban households. These incomes were assumed at the beginning of the cycle of calculations. If the implied values are sufficiently close to the assumed values, we are ready to go on to the next year; if not, we repeat the cycle starting with the implied values just calculated as the assumed values.

5. Operation of MuDan

Since MuDan is built with the Interdyme software, the general Interdyme manual is the operating manual of MuDan. We give here only the briefest guide to what is particular to MuDan.

First, install the Interdyme software. Create a directory by the name of Dyme and copy into it the file exe.zip from Disk 1, Programs. Unzip this file with pkunzip. Put this Dyme directory on your system's path. Pdg 5.22 or above should also be installed and on the path.

Next, install MuDan. Make a Mudan directory and from Disk 2 copy mudan.zip and across.zip into it and unzip. To build and run the model it is sufficient to give the command:

```
all
```

Study of the all.bat file shows the necessary steps. In the initial program you will be asked to help with the ras balancing procedure. Thereafter, you will get several initial blue screens. Simply tap Escape to accept the initial values and continue.

This procedure will produce the equation files with their estimated values of rho for the rho adjustment. In the equation files in the mudan.zip file, these rho values have been set to 1. To use the files, just do

```
pkunzip mudan *.eqn  
dyme
```

To look at the results of your run graphically, give the command

```
vam -vDyme -iAll.shw
```

To produce a file suitable for printing of the growth rates of various vectors, do

compare <comp.inp

6. Preliminary Results

The projections which are emerging from the model show very strong growth continuing over the rest of this decade, such as shown in Table 3.

Table 3. Growth Rates of Output

	1987	1990	1991	1992	1993	1995	2000
Agriculture etc.	5.8	7.6	7.0	6.9	6.2	5.8	5.2
Coal	8.6	2.3	8.0	5.8	5.5	5.1	4.7
Crude Oil & Natural Gas	14.5	3.1	2.4	2.0	2.0	1.7	1.0
Metal Ores	20.0	7.2	9.8	7.0	7.6	7.2	6.8
Non-Metallic Minerals	14.3	1.7	6.5	4.2	4.8	4.3	3.4
Food Processing	18.4	9.4	6.2	8.9	7.8	7.4	7.3
Textiles	13.3	5.8	5.9	6.8	6.0	5.4	4.7
Clothing and Leather	20.4	16.9	6.0	7.8	6.8	6.2	5.5
Timber and Furniture	22.5	6.0	7.0	5.6	6.9	6.6	5.9
Paper and Printing	20.6	12.3	6.8	6.8	7.1	6.9	6.8
Electricity etc.	9.2	6.1	7.1	5.3	4.8	4.4	4.0
Petroleum Refining	14.3	3.8	4.3	4.1	4.1	3.9	3.6
Coke and Gas Supply	13.5	10.2	11.1	7.7	8.3	8.1	7.9
Chemicals	18.5	13.1	9.1	7.7	8.4	8.0	7.6
Building Materials	18.6	5.4	9.7	7.1	7.5	7.1	6.3
Metallurgy	12.3	4.8	8.3	4.6	5.3	5.0	4.8
Metal Products	23.5	8.5	8.9	7.0	7.9	7.5	7.5
Machinery Building	21.2	1.2	8.8	6.8	7.4	7.1	6.8
Transportation Equipment	19.9	4.2	7.3	5.0	5.3	5.1	7.6
Electrical Equipment	16.7	4.5	8.9	6.1	8.5	8.2	8.7
Electronic and Communication Eq	44.8	13.5	8.7	8.4	10.3	9.6	9.2
Instruments	15.5	2.9	8.7	5.7	6.4	6.4	6.6
Equipment Repairing	19.1	2.5	10.0	6.7	7.1	6.8	6.6
Other Industry	-13.0	11.2	5.6	6.1	6.1	5.7	5.1
Construction	10.0	-0.3	9.5	5.4	5.8	5.4	4.2
Freight Transportation	10.3	2.4	5.6	6.6	6.3	6.2	6.1
Commerce	8.9	-7.4	6.5	5.5	5.7	5.3	4.9
Catering	11.5	-1.9	8.1	11.1	11.5	10.7	9.9
Passenger Transportation	10.5	-7.3	3.7	11.7	7.7	8.2	10.4
Public Services	9.4	-6.3	-15.3	8.7	6.4	6.8	7.3
Education, Health and Science	12.2	17.1	7.2	6.9	8.3	8.7	9.2
Banking and Insurance	14.1	18.2	8.9	8.2	8.4	8.0	7.7
Public Administration	13.9	11.6	5.1	5.1	5.1	5.1	5.1

While the rates of growth diminish somewhat from that of 1987, they continue quite high. At the moment, there is talk of financial restraint to slow down the economy. Any financial restraint, however, should reckon with the possibility of continued rapid growth shown by these forecasts.

7. Suggestions for Further Work

A much clearer idea is needed of the working of financial factors in the Chinese economy. What determines the availability of credit? What measures can be used for this availability? A financial side needs to be developed and incorporated into the model.

Some relation needs to be developed between investment and labor productivity or capacity expansion. In the present version, there is no reason to invest. Investment just eats up resources and gives nothing in return. Obviously that is quite unrealistic. Likewise, there is no connection between Public or social final demand and the number of employees in non-agricultural industry. This is again unrealistic. Nor is there any connection between the Other Value Added which finances some of this social demand and the level of that demand.

The input-output table distinguished between Welfare contributions, Taxes, and OVA in the value added rows, but there is no corresponding subdivision of the Public, social consumption final demand vector. Division of this final demand at least between state expenditures and expenditures by firms should be given a high priority. Otherwise, the model cannot look at budget balances of the state and of firms.

When there is serious export and import data, the exports need to be connected to demands from other countries, and their exports to China need to be related to the demands generated by MuDan. In other words, MuDan needs to be integrated into the Inforum international system.

While thirty-three sectors were quite enough for a pilot-plant model, they will prove quite inadequate for in-depth analysis of industrial development. In the USA, the minimum size that we find useful is about eighty sectors, while most industrial users need the detail offered by a 300 or 400 sector model. Thus, plans should begin for expansion of MuDan at least up to the level of the 100-odd sectors available from the 1987 input-output table.

It is the writer's opinion that this model can now be developed rapidly in China by the staff that is already working on it. It remains useful, however, to continue an exchange and discussion on the economic aspects of the model as it grows and develops. The Inforum group at the University of Maryland is happy to receive one or two researchers connected with the model for a period of one to two months each year. Also about once every other year an Inforum staff member could visit China to exchange ideas on the development of and application of the model.