THE SYSTEM DYNAMICS ANALYSIS OF THE NATIONAL FINANCIAL AND MONETARY SYSTEM OF CHINA

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ABSTRACT

Based on the system dynamics approach, this paper tries to examine the structural causes of the long term performance of the economy after the reform, make the comparative researches on the financial and monetary system between before and after the reform, and evaluate whether the system dynamics approach is a powerful tool to analyze the economy in a developing country such as China. After the description of the structure of the national financial and monetary model of China, the modeling approach is summarized in the paper. The formulation of the principal subsystems and the interactions among them are briefly introduced. The behavior of the model, and the four economic leverages -- price, tax rate, interest rate, and loan leverage, are mainly concerned and discussed. The policies designed for economic reform are examined with the DYNAMO simulation, the different results related to the different policies are compared. At last the programs and the possible futures related to them for the economic reform are given in suggestion.

I. INTRODUCTION

China has been on the economic reform for years. From the traditional central planning economy, the economy of China has been changing into the combination of both central planning and free market economy. As the economic reform progress is just like an experiment progress, many problems we encounter in the progress should be analyzed and solved. A critical problem among them is how to reform the national financial and monetary system, since the financial and monetary system is the key part of an economy.

I.1 The problem encountered in the paper

By financial and monetary system, we mean that two main parts are included: financial part and monetary part. For financial part, we refer to the national price subsystem, the goverment budget and tax subsystem, wage subsystem, and the relationship between

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investment and accumulation. For monetary part, we refer to the national bank subsystem, credit subsystem and the money issue subsystem. As a whole, the financial and monetary system is the interaction of all the subsystems described above.

The reforming progross in the national financial and monetary system is also like an experiment progress. And there are also many problems we should analyze and try to solve them. For example, what is the appropriate relationship between investment and accumutation? how to reform the price subsystem? how to balance the inflation and the growth rate of wage? how to make out the national budget after the reform? how to adjust the tax and the interest rate? what is the suitable policy to issue the long, middle and short term loan? and so on. Researches on the financial and monetary field will be helpful for the economic reform in China and will provide some guidances in making the long term economic reform strategy.

I.2 The purpose of the research

The following results are expected to be achieved by the research.

1. The comprehensive study on the national financial and monetary system may be the first try in China. Since such a problem is used to being studied sperately in China before.

2. The quantitative results of the research on the national financial and monetary system in China are not common, even currently.

3. Certain financial and monetary policies can be tested and evaluated by the research, and some new policies are expected to be designed.

4. The methodology of system dynamics approach applied to analyze the national financial and monetary system of China is tested. System dynamics has been widely applied in many fields, but relatively speaking the applications are hardly applied in the financial and monetary field and even not in China.

I.3 The assumptions in the paper

At the beginning of the research, some assumptions are made which determine the scope of the model in some stages. The assumptions include:

1. The potential production in industry is only determined by two factors -- capital and labor. The labor factor is measured by two sub-factor -- the number of labors and the educational effect on labor. All these two factors are integrated by Cobb-Douglas production function. The national potential productive capacity in China is mainly determined by the potential production capacity in industry, and it is the main constraints of supply.

2. The four price indexes or the price index of industrial, agricultural, business product, and the consumption, are the main signals reflecting the change of price.

3. There are four economic leverages in the financial and monetary system of China. They are the price leverage, wage leverage, interest rate leverage, and the tax rate leverage. The economic leverages are the most effective tools to adjust , control and affect the behavior of the financial and monetary system when they cooperate with each other.

I.4 The modeling approach selected

The national financial and monetary system, as we described above, consists of some subsystems. The scale of the system is very large, since many problems and variables are involved in the system. Among all of them in the system, there are many nonlinear input - output relationships such as the relationship between tax rate and wage growth rate, the increasing price rate of consumption and the growth rate of wage, and so on. It can be seen that the national financial and monetary system is a typical large scale, nonlinear, and high order system.

As mentioned above the research is expected to show the long term system behavior after the reform, test some policies and try to design some new policies, and study the system quantitatively. But all these expectations are not easily to be realized for such a large scale, nonlinear, and high order system, if the research methodology is only borrowed from the traditional financial and monetary theory and economic theory. There are two aspects here, first of all, the traditional financial and monetary theory and economic theory describe the static equalibrium states or an adjustment to a new equlibrium state, rather than the dynamic process. But the long term system behavior after reform is just a dynamic process and there is nearly no static states in the process of adjustment; second, financial and monetary theory is not easy to be applied in policy test and design. Some economic theory like econometrics can be applied to test policies, but the long process can not be effectively discovered and behavior equations of econometric models describle the states resulting from the decisions of participants from the system, without necessarily elucidating the decision making process itself.

System dynamics may be the only one method which can make the expectations be realized. Because first, dealing with the large scale, nonlinear, and high order system is the special characteristics of system dynamics; second, the long term behavior of the financial and monetary system after reform can be studied effectively; third, the dynamics process is the basic feature of system dynamics; fourth, the policy laboratory as it is usually called is another basic feature of system dynamics; and the last, a more direct behavior approach by formulating the goals and objectives of the participants is usually taken by

system dynamics models. Therefore system dynamics approach is suitable to model and analyze the national financial and monetary system of China and may realize all the expectations.

II. MODEL DESCRIPTION

II.1 The general structure of model

The whole national financial and monetary system of China has four subsystems. They are the investment, the bank, the wage and the price subsystem.

The relationship of these four subsystems is shown in figure 1.

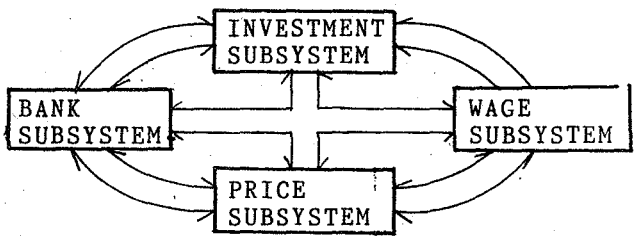


Figure 1. The general structure of the model

II.2 The detailed description of the individual subsystem

1. Investment subsystem

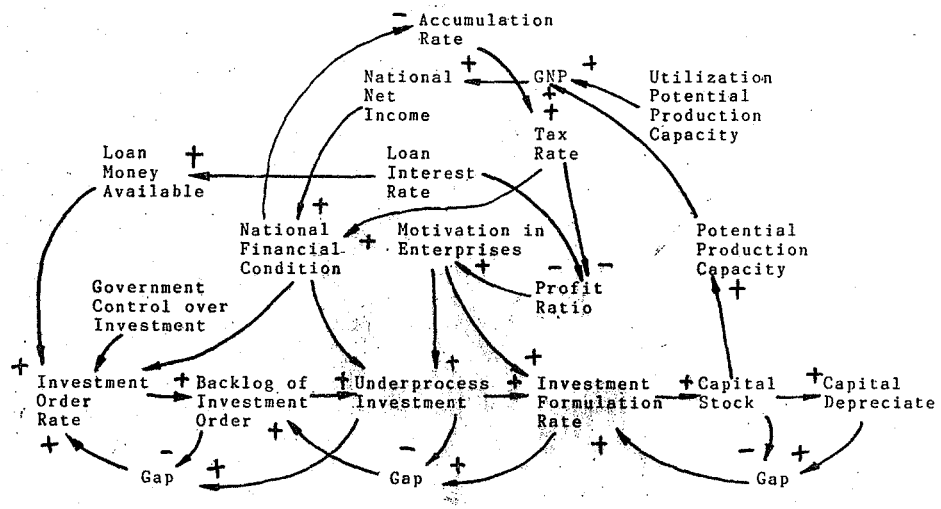


Figure 2. The simplified causal loops of the investment subsystem

The investment subsystem, shown in figure 2 in a simplified causal loop version, determines the investment rate and accumulation rate decisions.

In this subsystem, the goal of the investment order rate is based on the demand for investment and current national economic condition (mainly depending on the increase rate of production and the increase rate of the national income). The investment foumulation rate is based on the current capital depreciation rate (described above), national financial condition (mainly depending on the national income rate, loan availability, interest rate and tax rate), and the motivation from the enterprises (which is mainly determined by the microeconomic efficiency). The short term fluctuations in the desired investment formulation and planned investment formulation caused by the change in demand and national economic condition are, however, tempered by the futher goals towards investment smoothing and the desire to utilise the available national capacity to investment as fully as possible. Similar to the mechanism and the adjustment process of the investment order rate, the short term fluctuations caused by the change in financial condition or/and motivation in enterprises are also tempered by future goal towards investment smoothing and the desire to utilise available capacity in investment formulation as fully as possible.

The current capital stock is a factor of production which determines the potential production capacity with another factor of production (labor and educational effectivenes, as assumed above) together. The potential production capacity is calculated by a Cobb-Douglas production function which developed by professor Qifan Wang and his colleagues in the system dynamics national model of China (SDNMC) in 1984.

The actual production rate is determined by the potential production capacity and the production condition which is mainly based on the productive raw meterial availability and the economic condition described above. The actual production rate is a very powerful factor which mainly determines the national financial income working together with the accumulation rate, determines the consumption goods production capacity which determines the consumption level further, and determines the capital product production capacity which then determines the production raw material availability and capital product availability.

The accumulation rate in the subsystem, working together with the actual production rate, determines the accumulation which determines the financial condition further. The accumulation rate is one factor which affects the staff wage and the demand for consumption goods.

2. Bank subsystem

What we interested in this subsystem is not the balance or the calculation of credit and debt of the national bank system, but the interest rate, loan interest rate, and their effects on the tax rate and further on the whole national financial and economic condition.

As shown in figure 3, the simplified causal loop version of the bank subsystem determines the decisions of the interest rate, loan rate, demand for money in circulation, and the tax rate.

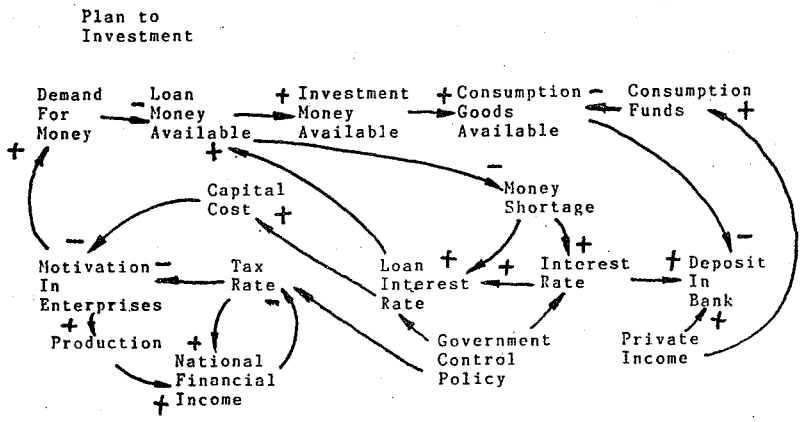


Figure 3. The simplified causal loops of the bank subsystem

In this subsystem, the interest rate, tax rate, loan interest rate, and the demand for money interact on each other. The goal of interest is determined by the investment subsystem. And the long term objectives for the decision maker in this subsystem are assumed to increase the long term output of the economy. All adjustments of interest rate, loan interest rate, and tax rate are based on such an assumption.

There are some dominant loops in the subsystem which mainly determine the adjustment mechanism of the interest rate, loan interest rate, and tax rate.

The first one among them is shown in figure 4.

The structure shown in the figure as following consists of two loops, one is positive feedback, another is negative. For a developing country like China the shortage of investment money is an outstanding phenomenon. In a long period during the process of developing the phenomenon will not change. This means that the function of the negative feedback is strong than the positive feedback in a long period, but the tendency will be improved

gradually.

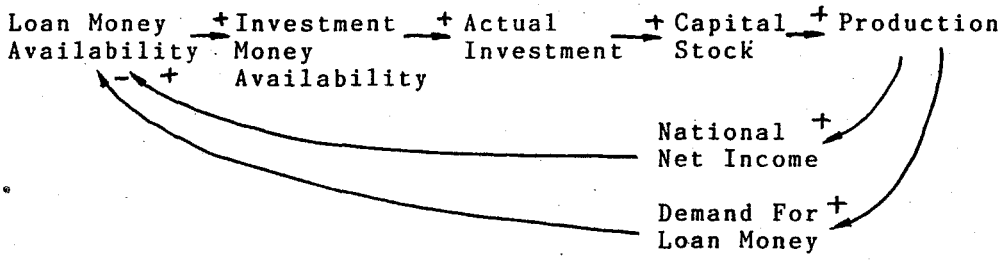


Figure 4. The dominant loop of loan money shortage

The second dominant loop is shown in figure 5.

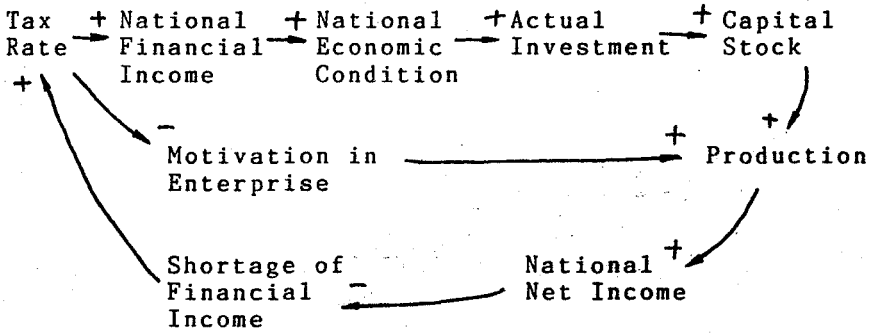


Figure 5. The dominant loop of financial income shortage

There are also two feedback loops in the structure shown in the figure above, one positive, another negative. The positive feedback loop means that the increase in the tax rate will cause further increase in the shortage of the national income, and the shortage of the national income will cause the further increase in the tax rate. This is caused by the decrease of the motivation in enterprises. The negative feedback means that the increase of the tax rate will cause the decrease of the shortage of the financial income and the tendency to increase tax will decline. Because the increase of the tax rate causes the increase in the total national financial income. The interaction of these two loops determines the behavior of tax rate change. As a developing country, Chinese goverment should improve the tendency of increase the tax rate at a suitable range.

The third dominant loop is shown in figure 6.

This microstructure consists of four negative feedbackloops. That means the interest rate, and even the loan interest rate are impossible to be pushed at a very high level. This microstructure is a stable structure.

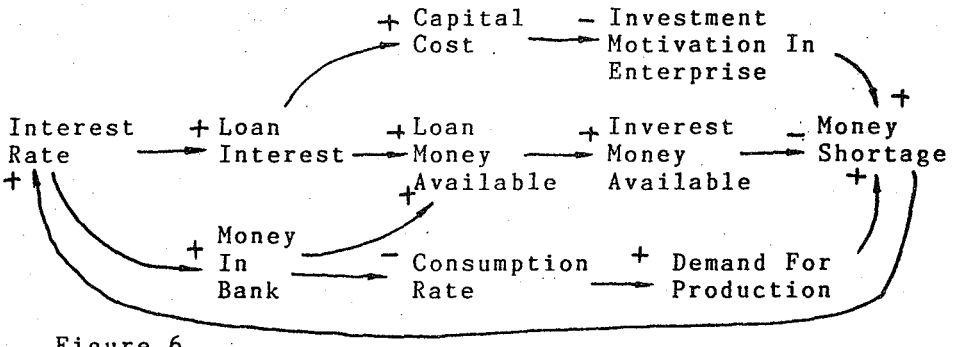


Figure 6.

3. Wage subsystem

The average level of wage is mainly determined by the GNP (Gross National Products), the consumption price level and the its tendency to increase. The simplified causal loop version of the wage subsystem is shown in figure 7.

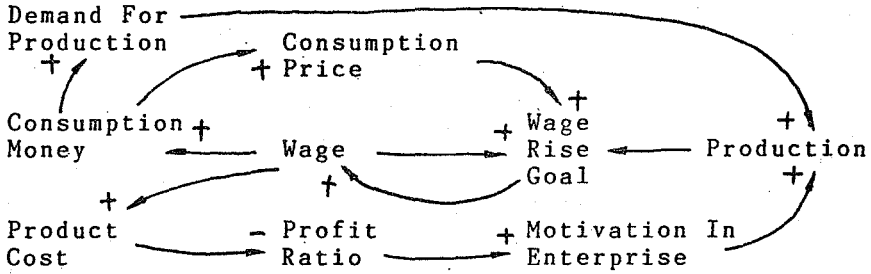
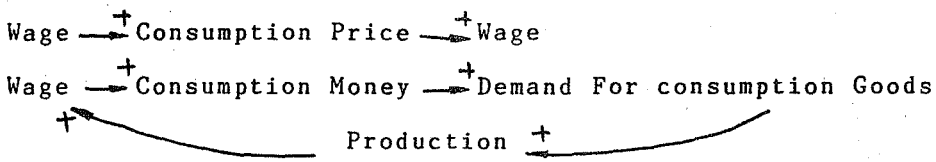


Figure 7. The simplified causal loop of wage subsystem

The mechanism of wage change is based on the three positive feedback loops and one negative feedback loop. The limit of production is the main constraint to the increase of wage level. The positive feedback loops as following are the most important stimulation to the increase of wage.



The adjustment of the long term objectives of the average wage level also serves the long term objectives of the output as assumed above.

4. Price subsystem

There are many kinds of product prices. The behavior modes and

the mechanism of all these product prices are very complex. And it seems nearly impossible to research and make clear the behavior modes and the mechanism of all. Here only four kinds of prices are chosen to study the general behavior modes and the mechanism of price. They are the industrial, agricultural, business product, and consumption price.

The simlified causal loops of the price subsystem are shown in figure 8.

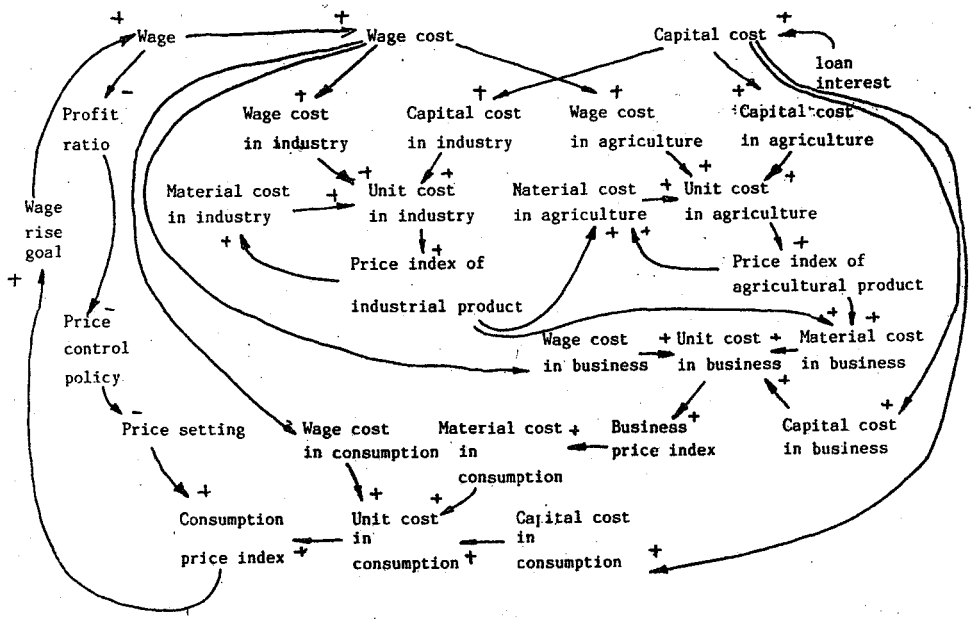


Figure 8. The simplified causal loops of the price subsystem

From the simplified causal loops of the price subsystem above, it is obviously found that there is a strong motivation to push the price either to increase or decrease quickly. Because there are some strong positive feedback loops in the subsystem, which interact in its subsystem and also with other subsystems to produce the mechanism of tending to accelerate or decelerate the price change. The only obstructions of the change of price are the price control and adjustment policies from the goverment. The price control and adjustment policies are based on the necessity of the long term objective -- to increase the national production output and improve the efficiency of the microeconomy.

II.3 The brief description of the interaction among subsystems

All subsystems described above certainly interact with each other. Figure 9 as following only shows the most important interactions resulting from the net effect of many feedback loops

among all interactions.

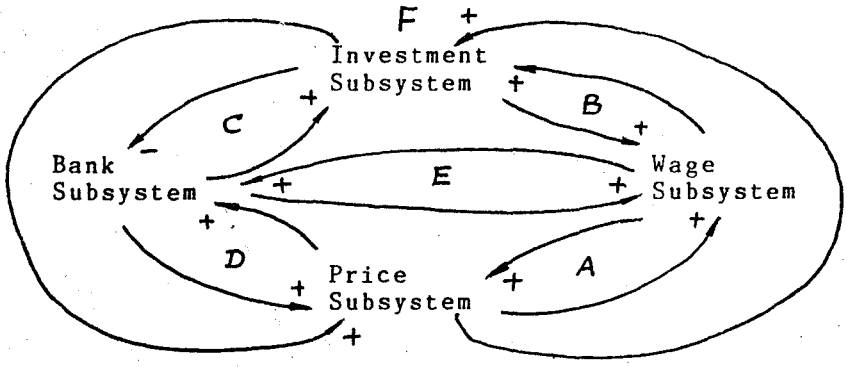


Figure 9. The important interactions among all subsystems

There are 6 feedback loops in the figure above. All of them is the dominant relationship which is not only emerged in the process of simulation but also exists in the real national financial and monetary system of China. The actions of these 6 feedback loops representing the real national financial and monetary system of China are briefly described as following.

Loop A represents the wage -- price sprial.

Loop B represents the multiplier -- accelerator interaction between the investment and the wage increase.

Loop C is the self worsening interaction between the investment and the loan money availability.

Loop D is the self reinforcing interaction between the interest rate and the consumption price.

Loop E represents the self improving interaction between the total money in bank and the private wealth.

Loop F represents the interaction between the change of price and the change of the national economic condition. This is also a multiplier -- accelerator interaction, but it seems a little bit weak compared with all the five loops above.

III. BASE RUN ANALYSIS

III.1 The background of the base run

Based on the structure of the model described above, the current version of the system dynamics national financial and monetary model of China (NFMMC) consists of some 380 equations.

As the NFMMC gets supports from another model -- the national model of China (NMC), which was developed by professor Qifan

Wang and his collegues in 1984, some variables like the labor variable can be described as exogenous variables in the NFMMC model by geting the values and the behaviors of the variables from the NMC model and this nearly change the function of the NFMMC model. Therefore, although the equation number in the NFMMC model is not so large compared with other big models, the fundamental functional and behavioral characteristics of the national financial and monetary system of China, we believe, have almost been descovered.

Many outputs and the variables in the NFMMC model can conveniently communicate with, connect to, and be used by the NMC model. So the NFMMC model can be served as a member of the model group in which the system dynamics is introduced to model the national economy of Chian.

The simulation period lasts over 50 years since 1965.

III.2 The base run analysis

The results of the base run are shown in figure 10, 11, 12, and 13.

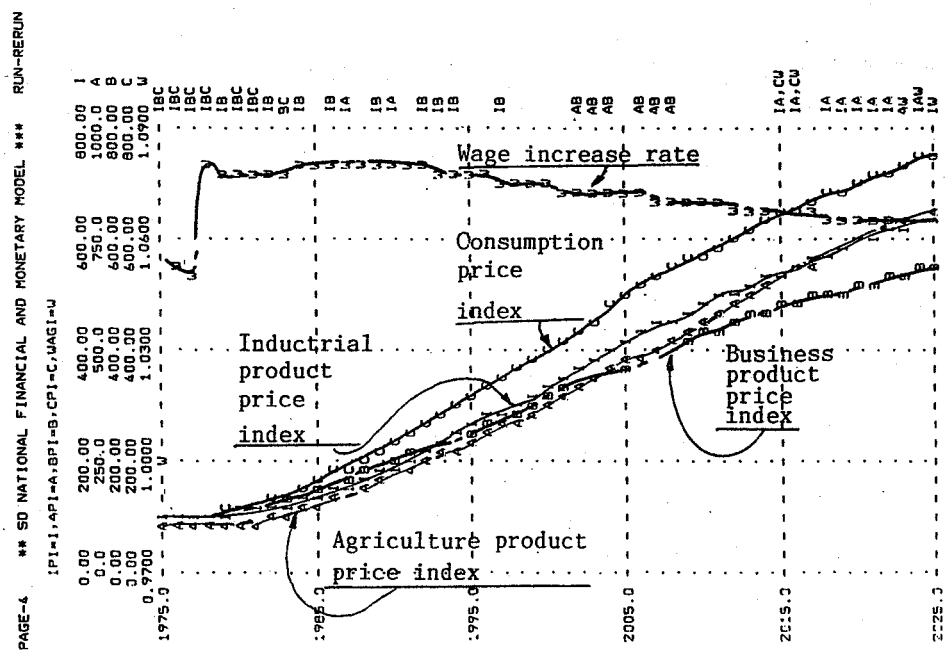


Figure 10. The base result of wage and price

Figure 10 is the simulation result of wage and price. The Chinese economy was the central planning economy before 1979. As 1975 was

selected as the base year in the simulation, the all price indexes in 1975 should be set 100, of course. It can be seen from the simulation that the agricultural product price has the greastest growth, the second is the consumption price, the third is the business product price, and the industrial product price has the smallest growth. The growth tendency of all price indexes should have been improved after 2015. The wage growth rate reaches its peak during the period betwee 1983 to 1993, then it will decrease gradually. As the growth rate of wage can be more easily enlarged when the base of wage is smaller than it can been done when the base of wage is larger. The average growth rate is about 6% per year in the base run.

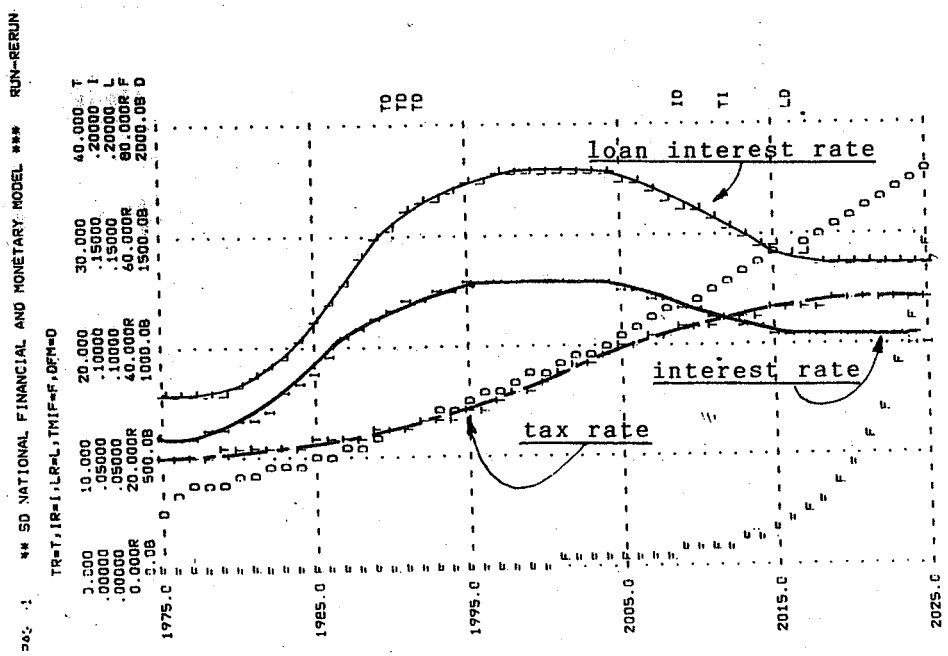


Figure 11. The base run result of interest, loan interest and tax rate

Figure 11 shows the behavior of the interest rate, loan interest, and the change of the tax rate. The tax rate behavior is a typical S - shape growth. Both the interest rate and the loan interest rate begin to increase in 1980. After about 18-year adjustment, the interest and the loan interest rate reach their highest values, then they stand in the stages for about 10 years, and then they decrease. From 2015, the interest rate and the loan interest rate will be at their stable stages. It can been seen from such a figure that both the interest and the loan intreest rate show an overshoot behavior. The reason is that the investment money is seriously short because of the investment booming from 1985 to 2015.

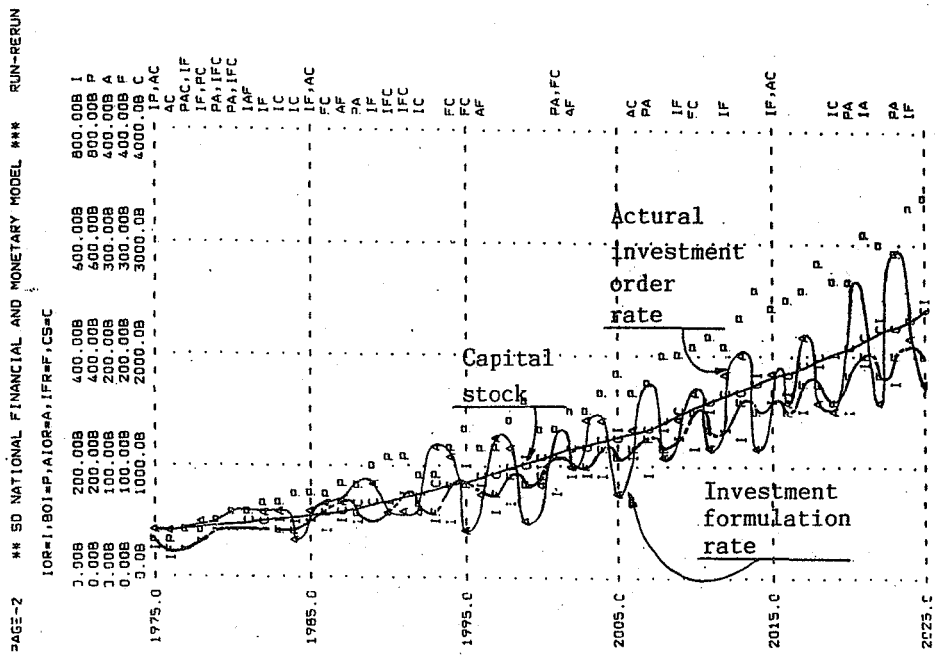


Figure 12. The base run result of investment production and national income

Figure 12 shows the base run simulation results of the investment, production and the national income change. The underprocess investment shows the behavior like the exponential growth. The fluctuation superposed on the exponential growth is not so strong and the period of the fluctuation is about 4 - 5 years. This fluctuation is caused by the 5 year development plan of China. As a developing country, although the investment money is seriously short, the investment always becomes booming if the goverment loosens its control over the scale of the inverstment. At the begining of a 5 year development plan the investment becomes to increase but it is under the control of the government, there is no booming. Then the investment becomes booming by the loosening control. The investment gets its greatest booming in the middle of the plan. Then the booming tendency becomes weak by the strengthened control from the government. By the end of the plan, the investment falls to the lowest value and then returns to the ordinary value of the plan.

The behavior of the backlog of the investment order is similar to the underprocess investment and caused by the change of the underproces investment.

The capital stock and the production (which is shown in figure

13) all show an exponential growth, superposed with a weak fluctuation. The period of the fluctuation is almost equal to that of the underprocess investment and the cause is just the same.

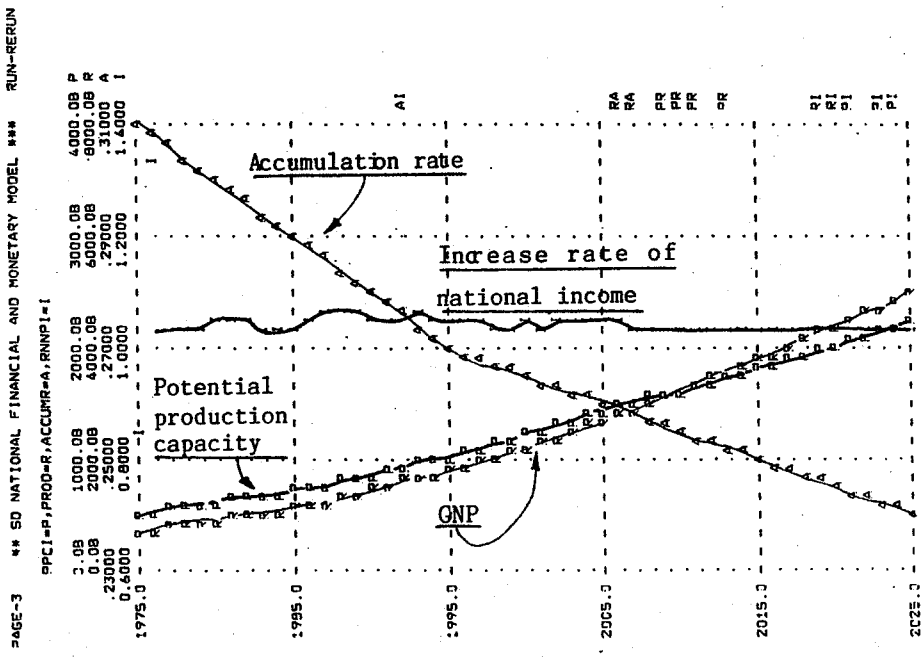


Figure 13. The base run result of national income and accumulation rate

The national income increase rate and the accumulation rate are also shown in figure 13. The increase rate of the national income is almost stable except the small fluctuations in some years. The accumulation rate is shown as an exponential decrease from 31% in 1975 to about 24% in 2025.

IV. POLICY TEST

IV.1 The multi-objectives of the policies

There should be some objectives for policy, otherwise the policy need not be designed and used to interfere and control the economy. But the long term objectives of the policies can not be single one, since any economies can not be measured by only one parameter or one objective.

The ordinary objectives applied to measure the condition, state, and the development of a economy are the development speed, the economic efficiency, the living standard of people, the potential

capacity of development, the inflation rate, the unemployment rate, and so on. According to the real economic situation in China, three main objectives may be selected to measure the state of the economy which can reflect the main situation of the economy. They are: 1. the economic efficiency measured by the profit - capital ratio; 2. the development speed measured by the increase rate of production; and 3. the condition built for the further development measured by the accumulation and the investment money availability. The weight for the different objectives should be certainly different. Here 0.4, 0.35, and 0.25 are chosen for the three different objectives correspondingly.

IV.2 Feasible policies governing the national economy of China.

As a developing country, " shortage " is the foundmental feature in economy. The demand can not be satisfied by the supply available. Based on such a feature, some economic policies applied in dvelopied countries are not suitable to be applied in China.

The Chinese economy is a vast scale system. There is no any inputs (or the feasible policies) which can push the economy to reach the same level in developed countries in a short period like 50 years. The economic development is a gradual process, we can not expect to find a feasible policy to realize the infeasible goals. Therefore the feasible policies can be considered as the economic policies which is suitable to the actual economic condition in China and can push the economy development effectively.

Such economic policies are not seperated, they should be formed a policy system. As the key part of the national economy, the national financial and monetary system should play the key role in the economy, to control the development speed of the economy, to build the good condition for the further development of the economy, and also to give the fine background for the further economic reform.

IV.3 The example of the feasible economic policy analysis -- the economic leverage analysis

Certainly there are many different policies which satisfy the condition of the feasible economic policy as we described above. The four economic leverages -- the price, interest, tax, and loan leverage, are the main policies among the all feasible economic policies suitable to China. In this paper, the four economic leverages are studied as the example of the policy analysis.

The four different economic leverages have the different functions, of course. These different functions are studied based on the NFMMC model.

1. The wage leverage

Wage is the main sources of the consumption money or the consumption demand. From figure 3 it is certain that the growth of wage will cause the increaes of consumption price index if the consumpltion money is bigger than the productive capacity of consumption product. For example, if the average increase growth rate of wage is about 8% per year, it can be found by simulation that the consumption price index will reach 1000 in 2025. But if the average growth rate of wage is about 4% per year, then the consumption price index will only be about 650 in 2025.

The growth rate of wage is also related to the motivation in enterprises, this is also an important factor for the development of the economy. But if the growth rate of wage is larger than the increase rate of consumption goods available, then the high inflation will become the hard obstruction for the economy. And as the increase of cost caused by the increase of wage is also an obstruction for enterprises. From the simulation, it is obvious that if the growth rate of the wage is higher than 6% per year, the motivation for enteprises and the development of the national economy will all be obstructed badly.

From the analysis above, it is found that the growth rate of wage effectively controls the inflation, to affect the motivation in enterprises and the development of the economy. After simulation and calculation of the multi objectives it is clear that the growth rate of wage should be controlled in the range of from 4% to 7% per year.

2. Price leverage

The price leverage is a way the government applies to control the genaral inflation rate, or to adjust the price relationship among the whole price system.

As the price increase is a natural phenomenon in economy, the attempt to restrain the inflation should not be too strong, otherwise it is also an obstruction to the development of the economy. After the reform the most prices should be mainly adjusted by the free market itself. From the simulation, it has been found that if the increase rate of the industrial product price index is less than 3.5% or higher than 10% per year, the development of the economy will be badly obstructed.

The adjustment of the price relationship among all the different product prices is a very complex process, since there are thousands and thousands of prices in the economy. This is mainly a problem of micro economics. What we interested in is mainly the aggregative or the macro behavior mode of price, so only four kinds of prices are selected to be studied in the paper. They are the industrial, agricultural, business product, and the consumption prices index. The sequence of the increase rate of them is discovered by the comparative study. It is:

the price increase rate of agricultural product >

the increase rate of consumption price >
the increase rate of industrial product price >
the increase rate of busine product price

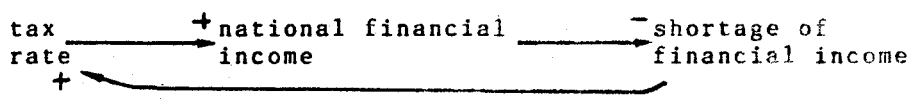
Because first, the agriculther products are the higher labor tension, and the productivity in agriculture could not be raised quickly compared with the other industries, but the living standard of perasents can not be very low, therefore the labor cost in the agriculture become higher and higher, so does the price index of the agriculture; second, whatever happenes in any product price all effects the consumption price; third, the increase of the industrial product price is mainly caused by the internal structure of the industry; and last, the business product price increase is mainly caused by the increase in the industrial product, but some of the increase from the outside have been weakened by the structure mechanism of business.

The price adjustment among all the different prices are also related to the industrial adjustment.

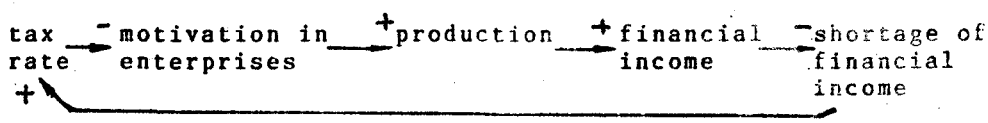
Through simulation and calculation of the multi objectives of the economy it is suggested that the the price leverage should be mainly applied to control the growth rate of the consumption funds and to adjust the industrial structure. Controling the growth rate of wage is an effective way to realize the growth rate of the consumption funds. The increase rate of the consumption price index should be countrolled within about 4% per year.

3. Tax leverage

As described above, there are two main feedback loops related to the change of the tax rate. The first one is:



The second one is:



The first is the positive feedback and the second is negtive. By the model simulation we found that if the tax rate is less than 20% or higher than 35% in 2010, the national financial income will all decrease quickly. The suitable range for the tax rate change in 2010 perhaps is within 20% to 35% by the comparative calculation of the multi-objectives of the different policies based on the simulation.

4. Interest and loan interest rate leverage

The interest rate mainly determines the depositable money in

bank. The increse of the interest rate will make the deposit in bank also increase, and this will lighten the pressure of the money shortage and the consumption goods availability. But it will also lead to the increase of the capital cost and then the prices.

The loan interest is mainly determined by the interest rate, the higher the interest rate, the higher the loan interest rate; on the other hand, the more the money available to investment, the less demand for loan (as the cost of the capital increases too).

In the comparative study by simulation and calculation of the multi-objectives target we found that the range for the changes of the interest rate and the loan interest rate are from 6% to 14% and 8% to 18% respectively.

Apart from the four economic leverages above, the relationship between the accumulation and the consumption is also an importan factor which can not be neglected in the policy analysis, although it may not be regarded as a economic leverage. From simulations we are sure that if the accumulation rate is adjuste from 31% in 1975 to 25% in 2025, the economic condition will be improved a lot.

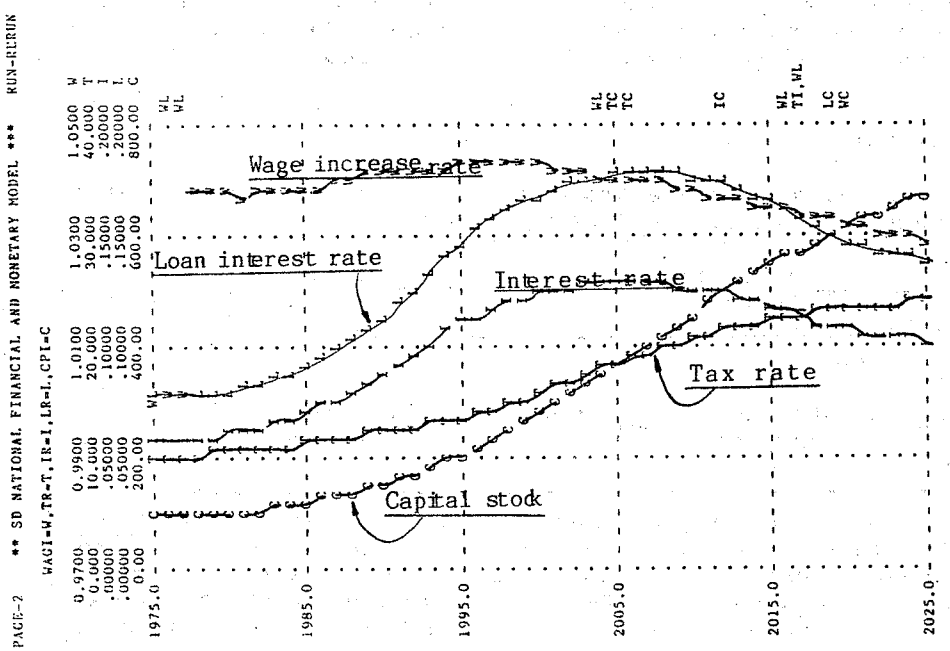


Figure 14 (a). The simulation result of the interaction of economic leverages

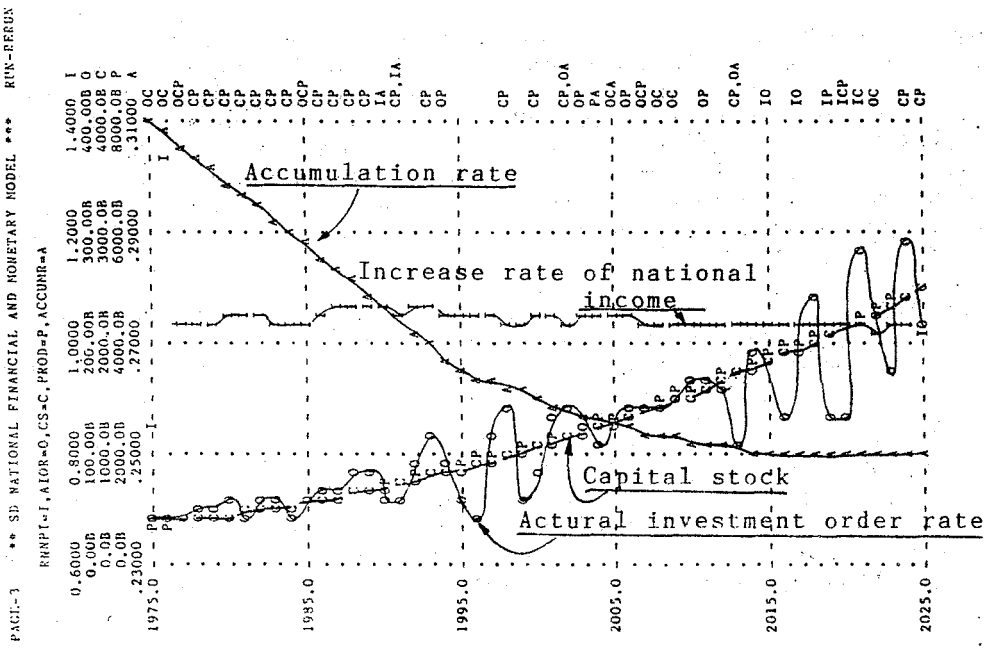


Figure 14 (b). The simulation result of the interaction of economic leverages

The economic policies have been analyzed individually above. But this is not enough, since there are many causal and feedback relationships in the real economic system and in the NFMMC model, which make the behavior of the whole system be not equal to the simple sum of the behavior of every single part. Therefore all economic leverages and the important relationship should be interacted to form a much better function and behavior. We have made the interaction of all economic leverages with some important relationship together. Figure 14 is the simulation result of the interaction

From the figure above, we suggest the government adjust the national economy in such a way: the tax rate should be adjusted from 10% in 1975 to 24% in 2025 and the process should be the S - shape; the interest rate and loan interest rate should be adjusted from 6% and 8% in 1975 to 11% and 14% in 2025 correspondingly, and the processes are like the overshoot (but the peak of the ovrshout has to be limited); the average growth rate of wage should be within abou 4 - 5% per year; the accumulation rate should decrease to 24% in 2025 from 31% in 1975.

V. CONCLUSIONS

In this paper we present our fresh research and points of view about the reform of the national financial and monetary system of China. It is the first try to apply the system dynamics to model and analyze the national financial and monetary system of China. The research is still on progress, and much effort is still devoted to refine the model and improve the research. But by our experience we believe that the system dynamics is a powerful tool for us to be apply in China to deal with the national financial and monetary problem.

The NFMMC model deals with a large scale, nonlinear, and high order system. According to our analysis above, all economic leverages should be used carefully and comprehensively. If the increase rate of the consumption price index and the growth rate of wage are all controlled at 4% per year, the average accumulation rate is adjusted to 27% by 2000 and from 31% in 1975 gradually decreases to 25% in 2025, the interest rate and the loan interest rate are processed from 6% and 8% in 1975 to 11% and 14% in 2025 correspondingly, the peak of the overshoot is limited bellow 15% and 18%, then the economy of China can be led to a healthy and constant development with considerable good economic state.

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