STIMULATIONS AND OBSTRUCTIONS TO THE ECONOMIC GROWTH OF CHINA

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ABSTRACT

This paper tries first to put some key factors together in an integrated system (The System Dynamics Socio-Economic Model of China), and then reveals the dynamics of stimulations and obstructions. The stimulation results of the model show that the stimulation function of different factor changes with time, and at different times, different stimuli will be the leading factors. Overpopulation, shortage in energy supply, transportation backlog, and severe pollution are all serious problems troubling China currently and in the future. The paper also studies some possible ways to remove those barriers.

I. INTRODUCTION

This paper is essentially based on the research work of "The System Dynamics Socio-Economic Model of China". At this time, the work is still in the progress.

China is now about to take off in the economic development. It is very important to understand what makes the economy grow and what obstructs its growth, both at present and in the future.

Though no one knows for sure what will really happen in the future, we can simulate the behaviors of some economic factors under certain assumptions or policies. In this way it can be possible to make efforts in good directions and take actions to release the potential barriers, ensuring an enduring bright future.

In accordance with this hope, this paper tries to reveal the dynamics of stimulations and obstructions to China's economic growth.

Agriculture sector is not involved in this paper.

II. THE PRODUCTION FUNCTION

In our research, we apply the Cobb-Douglass production function to calculate the potential production capacity. The reason we call it "potential" is that our Cobb-Douglass production function does not take energy, transportation, and pollution factors into accounts. The result derived directly from the Cobb-Douglass function shoud be modified by the multipliers of these factors in order to get the "actual" production capacity.

Four factors are considered in the Cobb-Douglass production function: labor force, capital stock, education level and technology level. Each is defined respectively as follows:

- Labor force

Main labor force includes males from 22 to 60 years of age, and females from 22 to 55.

- Capital Stock

Capital stock includes all those fixed capital in all economic sectors except service sector.

- Education Level

Education level represents the amount of schooling embodied in people and measured in people-years of schooling.

- Technology Level

Technology level is defined as the "pure" technology, i.e., the capital is separated from technology. So technology level is treated as a direct multiplier in the Cobb-Douglass function.

The Cobb-Douglass production function can be expressed in the following form:

$$\begin{matrix}\text{POTENTIAL}\\\text{PRODUCTION}\\\text{CAPACITY}\end{matrix} = \text{CONST} \times \left(\begin{matrix}\text{LABOR}\\\text{FORCE}\end{matrix}\right)^{EL} \times \left(\begin{matrix}\text{CAPITAL}\\\text{STOCK}\end{matrix}\right)^{EC} \times \left(\begin{matrix}\text{EDUCATION}\\\text{LEVEL}\end{matrix}\right)^{ED} \times \left(\begin{matrix}\text{TECHNOLOGY}\\\text{LEVEL}\end{matrix}\right)$$

UNIT: (yuan/year)
CONST = 470
EL = 0.5 (Exponent of Labor)
EC = 0.4 (Exponent of Capital)
ED = 0.1 (Exponent of Education)

$$\begin{matrix}\text{ACTUAL PRODUCTION}\\\text{CAPACITY}\end{matrix} = \left(\begin{matrix}\text{POTENTIAL PRODUCTION}\\\text{CAPACITY}\end{matrix}\right) \times EM \times TM \times PM$$

EM : Energy Multiplier
TM : Transportation Multiplier
PM : Pollution Multiplier

III. STIMULATIONS TO THE ECONOMIC GROWTH

What are the factors which stimulate the economy to grow? How do they stimulate? What are the effects of the different stimuli? In what way does China's economy develop? These are the issues that we will raise and discuss in this paragraph.

1. The Stimuli

Based on the factors we considered in the Cobb-Douglass production function, we think the following four variables are the most important stimuli the economic growth of China:

- Labor Force
- Capital Stock
- Technology Level
- Education Level

The quantitative stimulation functions of labor, capital, education and technology are calculated by the following formulas:

$$\text{Labor Function} = \frac{\text{Labor Force Growth Rate}}{\text{Production Capacity Increase Rate}}$$

$$\text{Capital Function} = \frac{\text{Capital Increase Rate}}{\text{Production Capacity Increase Rate}}$$

$$\text{Education Function} = \frac{\text{Education Level Increase Rate}}{\text{Production Capacity Increase Rate}}$$

$$\text{Technology Function} = \frac{\text{Technology Level Growth Rate}}{\text{Production Capacity Increase Rate}}$$

Production Capacity Increase Rate is calculated by the following formula:

$$\text{Production Capacity Increase Rate} = \frac{(\text{Pro. Cap.})_n - (\text{Pro. Cap.})_{n-1}}{(\text{Pro. Cap.})_{n-1}}$$

n: number of years

A similar calculation is used to calculate the labor force increase rate, the capital stock increase rate, the education level growth rate, and the technology level growth rate.

2. Dynamics of Stimulations

The simulation results show clearly the evolution of the stimulation functions of the four stimuli to the economic growth from year 1965 to year 2065, as Figure 3-1:

In the figure, we can define four periods, representing four different structures of stimulations.

a. Period 1: 1965-1980

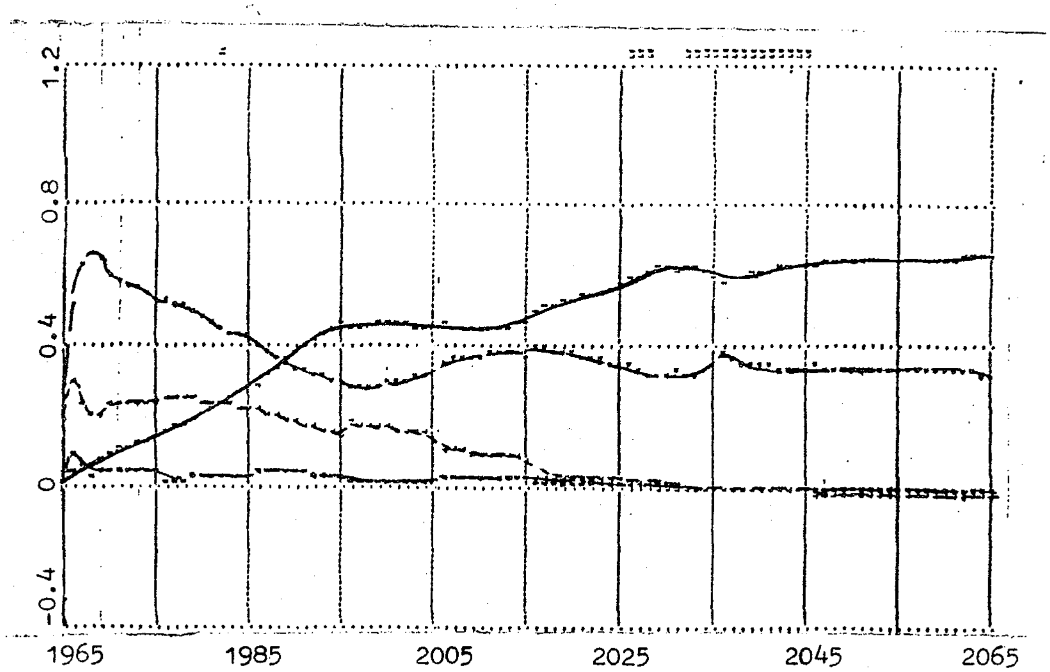
In this period, capital was the dominant stimulus. We can summarize four conditions characterizing this period:

1). A decline in capital function
2). A little increase in labor function
3). A significant increase in technology function
4). No significant increase in education function

The four stimuli's functions are distributed as:

- capital function (0.67 - 0.46)
- labor function (0.2 - 0.26)
- technology function (0.03 - 0.24)
- education function (0.054 - 0.036)

This mode conforms to the following facts:



———— : TECHNOLOGY FUNCTION
—— —— : CAPITAL FUNCTION
------ : LABOR FUNCTION
——·—— : EDUCATION FUNCTION

Figure 3-1. Evolution of Stimulation Functions

1. Before 1980, the economic growth of China was mainly caused by capital investment and labor force increase. It implies that capital intensive and labor intensive production departments were the two most important parts of China's production structure.

2. With a certain base of capital and labor in the economy, the function of technology progress to the economic growth rises quickly. From Figure 3-2, we can see that in about 1980, the technology function caught up the labor function.

b. Period 2 (1980 - 1990)
During this period, China is undergoing dramatic changes in the economic structure. First, China is reforming its economic system from a closed to an open system. Meanwhile, a large amount of technology transfer is being made from western advanced countries. Second, China has become very much aware of the importance of the efficiency of production activities.

There are two ways to improve the production efficiency. One is by better management, which is not discussed in this paper. The other is to through the technological progress.

The mode of the stimulation functions proves the above changes. The degrees of the four stimuli's functions are distributed as:
- capital function (0.44 - 0.35)
- technology function (0.26 - 0.39)

- labor function (0.25 - 0.2)
- education function (0.05 - 0.06)

In this period, the technology function has risen quickly because of the large amount of the technology transfer, and the capital function continues to decline.

We should notice that in this period the labor function has begun to go down and the education function has increased by a small amount.

The significant growth of China's population creates great pressures on material supply, housing and transportation, etc.. On the other hand, it also provides a plentiful labor source which has plaved an important role in China's economic growth. However, now the labor function to the economic growth begins to decline. It implies the coming of a new stage in China's economic development in which capital and technology are critical.

c. Period 3 (1990 -2065)
In this period, technology becomes the leading factor to the economic progress. In the following section we discuss the behaviors of the capital function and the technology function.

1. Capital function
From 1990 - 1995, capital function continues to decline. After 1995 and until 2015, capital function has a 20 years rising period. This shows that after some years of technology transfer, a new capital investment oriented period is necessary in order to ensure long term growth.

2. Technology function
In the period from 1995 to 2015, the technology function maintains a roughly stable trend. After year 2015, with the base of a large amount of capital investment in the previous 20 years, the technology function rises again until year 2030, and then levels off.

3. Labor function
The labor function continues to decline. There are no sudden changes expected for the future.

The significance of the agove stimulation function trends lies in the fact that it tells us the future economic growth of China will be mainly depended on technological progress and capital investment, and that technological progress is in a sense the most important stimulus. Though currently capital may be still an effective stimulus, in the long run, the stagnation of our technology level would have dire effects on China's economic development.

IV. OBSTRUCTIONS TO THE ECONOMIC GROWTH

The barriers which might obstruct the economic growth of China are distributed along the way to the future. Some are clear, some are not: some are near, and some are far. Since in China people are very much concerned about the obstructions in near future, we will discuss these barriers according to two periods. The first period is from now to the year 2000 which is thought of as "current". The second period is after the year 2000 which is considered to be "future".

1. Current barriers

Some of the most important problems which are currently troubling China"s economy are:

a. Excessive population, which puts great pressures on food and material supply.
b. Shortage of energy supply.
c. Overload on transportation capacity.
d. Severe pollution.

Food and material supply are not discussed in this paper. Here we are mainly concerned with the other factors.

The following three variables are defined as the indicators of these three factors respectively:

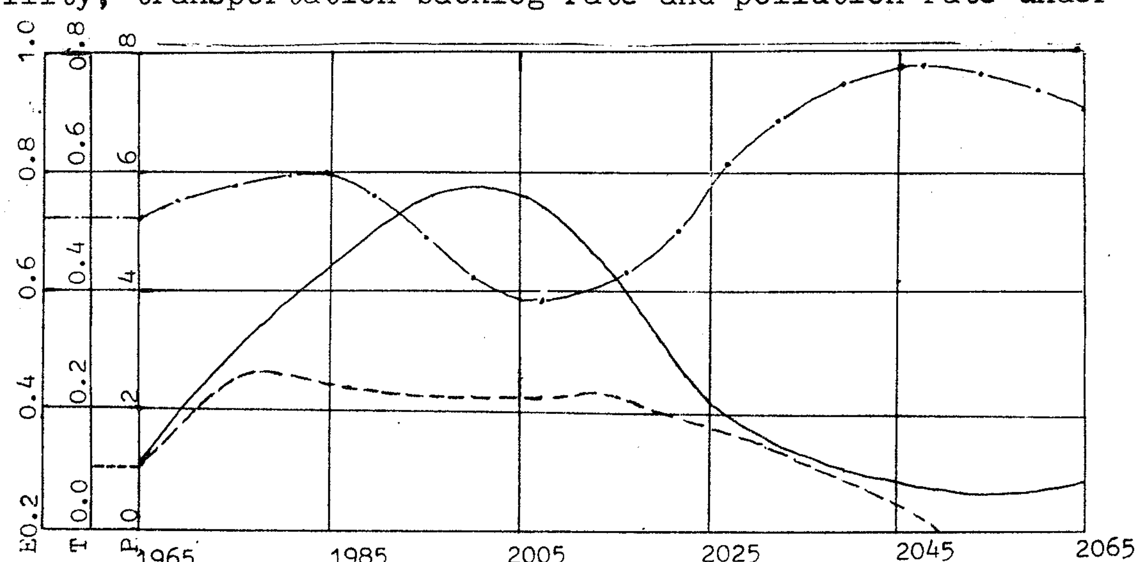
$$\text{Energy Availability} = \frac{\text{Energy Demand}}{\text{Total Energy Output}}$$

$$\text{Transportation Backlog Rate} = \frac{(\text{Trans. Demand}) - (\text{Trans. Capacity})}{\text{Trans. Capacity}}$$

$$\text{Pollution Rate} = \frac{\text{Pollution}}{\text{Pollution Normal}}$$

Figure 4-1 shows the evolution of the values of these three indicators from 1965 to 2065.

This figure reveals the development trends of energy availability, transportation backlog rate and pollution rate under



P : Pollution Rate (———)
E : Energy Availability (—.—.—)
T : Transportation Backlog Rate (------)

Figure 4-1. Evolution of Energy Availability, Transportation Backlog Rate and Pollution Rate the current policies on energy production investment, transportation capacity investment and pollution control investment.

These policies can be summarized as:
a. 15% of annual total capital investment for energy production.
b. 20% of annual total capital investment for transportation capacity.
c. 1%of annual national income for pollution control.

We can see in this figure that we have no reason to be overly happy. Energy availability, transportation backlog rate, and pollution rate are all in serious conditions from 1980 to 2000. Energy availability goes down by 26%, pollution rate goes up by 55%, and transportation backlog rate declines by only 11%.

Because of the big investment, actual total production capacity increased by 316% from 1980 to 2000. However, within this period the production loss due to energy shortage, transportation backlog and pollution amounts to 25%, as Figure 4-2.

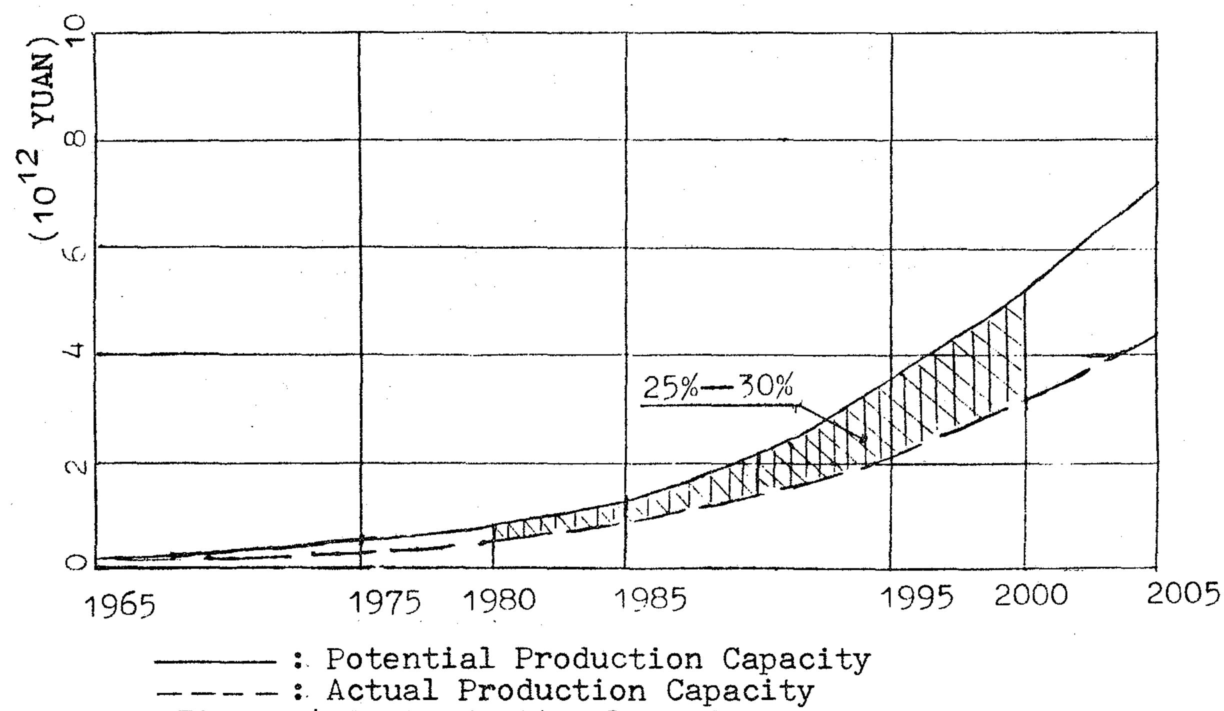
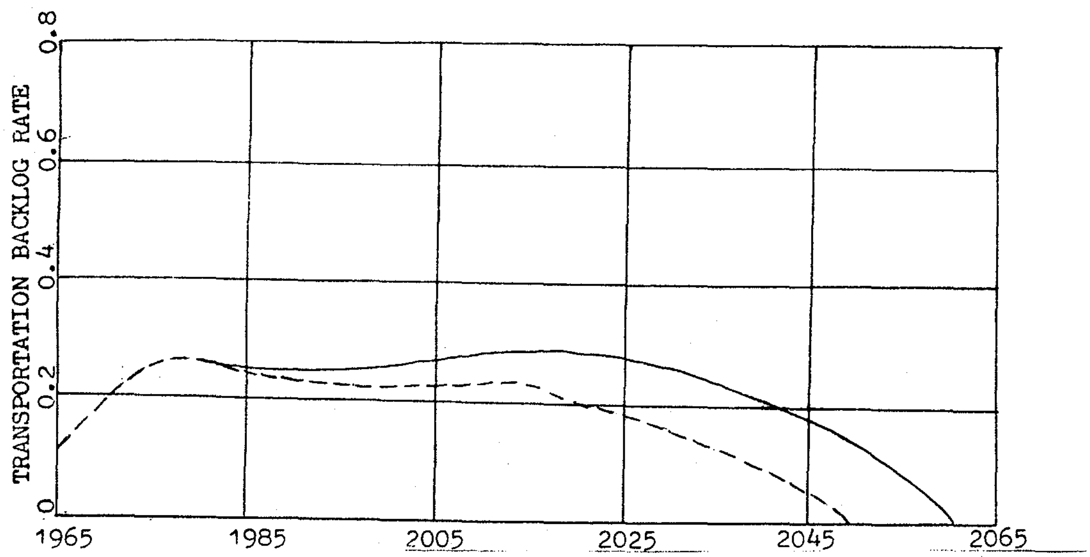


Figure 4-2. Production Loss due to Barriers

Energy availability in the year 2000 is about 0.6. In this case the production capacity idle rate is about 8% (this figure can be calculated using the energy-production multiplier). In other words, 8% of production capacity is left idle because of the insufficiency in energy supply.

In fact, the most troublesome problem currently bothering us. is the overloading of transportation capacity. If China continues its historical policy (transportation investment rate is about 10% of the annual total capital investment), the tranportation backlog rate would go up much higher than shown in Figure 4-1, see Figure 4-3.



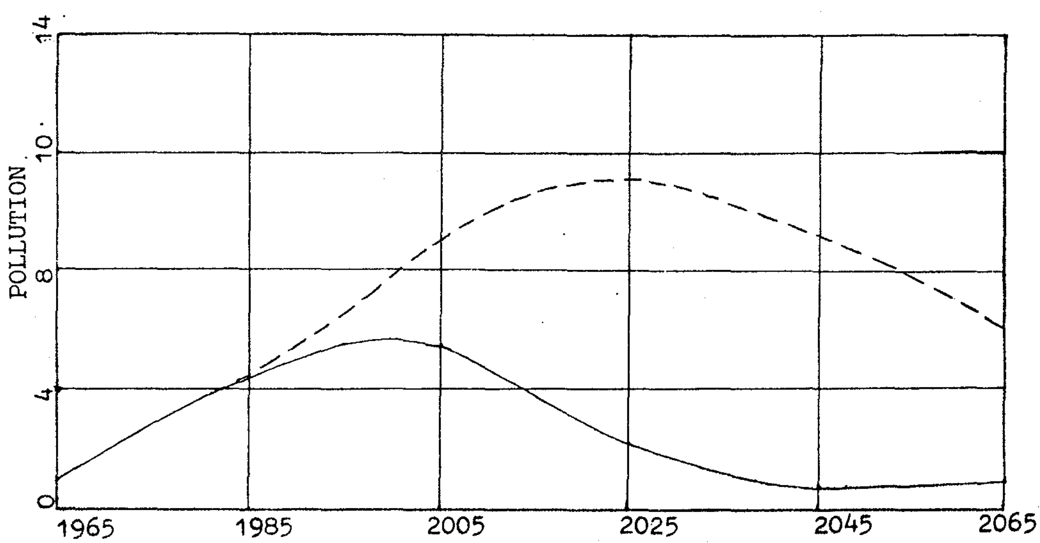
----: Transportation backlog rate under current policy
———: Transportation backlog rate under historical policy

Figure 4-3. Transportation Backlog Rate under Historical Invesment Policy

Pollution is also potential enemy to the economic growth. If we invest nothing in pollution control, environmental conditions will get to be much worse. Figure 4-4 shows two curves of pollution rate evolution. One indicates the case under current pollution control policy and the other indicates the case without pollution control investment, as we described previously.

2. Future barriers

Looking into the future of China, three factors seem likely to become barriers if no appropriate actions are taken to prevent them.



------ : POLLUTION RATE WITH NO POLLUTION CONTROL
——— : POLLUTION RATE WITH POLLUTION CONTROL

Figure 4-4. Pollution Rate Curves

First, population will remain at a high level (over 1.2E9) for 100 years in the future.

In Figure 4-5, curve(a) represents the situation if the policy of 1 child per family is strictly followed into the future (actual fertility is 1.3). It shows that by the year 2065, China's population will decline to 0.97E9. This would be the best possible case theoretically. The problem is that an unbalanced age distribution would develop. The percentage of elderly people in the population would rise rapidly as a result of reduced birthrate. Hence our conclusion is that the situation represented by curve (a) may represent a mere dream.

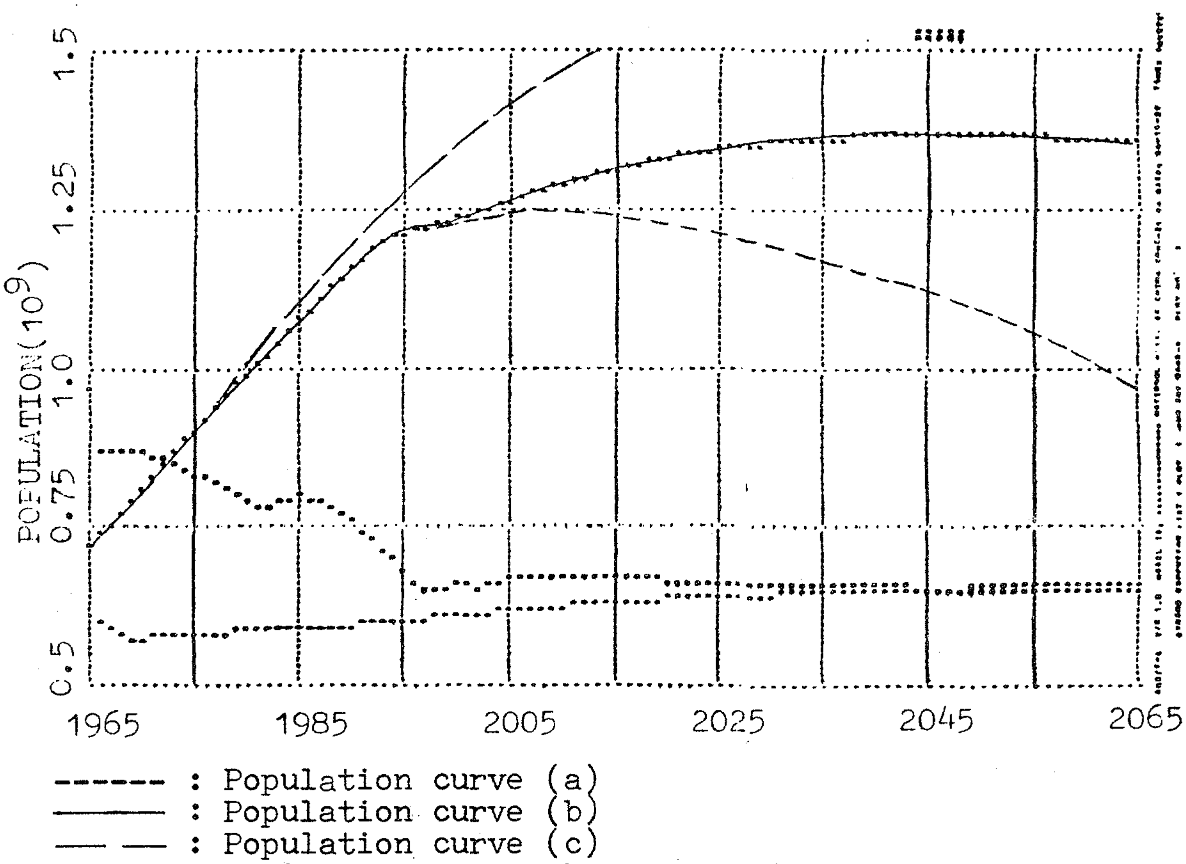


Figure 4-5. Population Development Trend in China

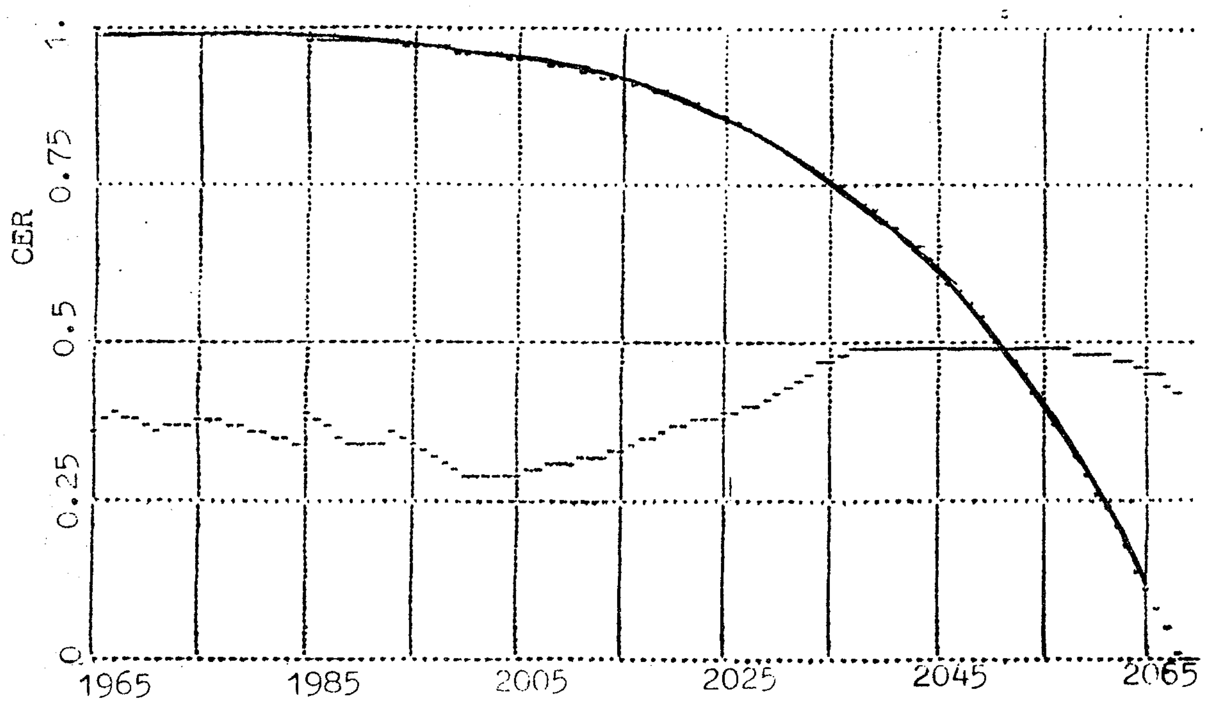
Curve (c) represents the case without population control policy of any kind. This is also an extreme situation that we would strobgly prefer not to have, and in fact it has a relatively low possibility of occurrence.

Curve (b) represents the case that we think most probable to happen. The expected family fertility (number of children per family) is assumed to be 1 (actual fertility is 1.3) before the year 2000 and 1.6 (actual fertility is 1.87) after the year 2000. This curve shows that for more than 80 years, the population of China will remain at a high level of 1.2E9, and that only after the year 2055 will population begin to decline at a very low rate.

Hence China will have to endure great pressures from the excessive population during the next 50-100 years.

Second, if no effort is made on pollution control, China's environmental conditions will worsen because of the rapid growth in pollution rate along with the industrialization, as Figure 4-4.

The third potential obstruction comes from the energy barrier. The depletion oc conventional energy is the essential source of this barrie. Figure 4-6 is the conventional energy depletion curve.

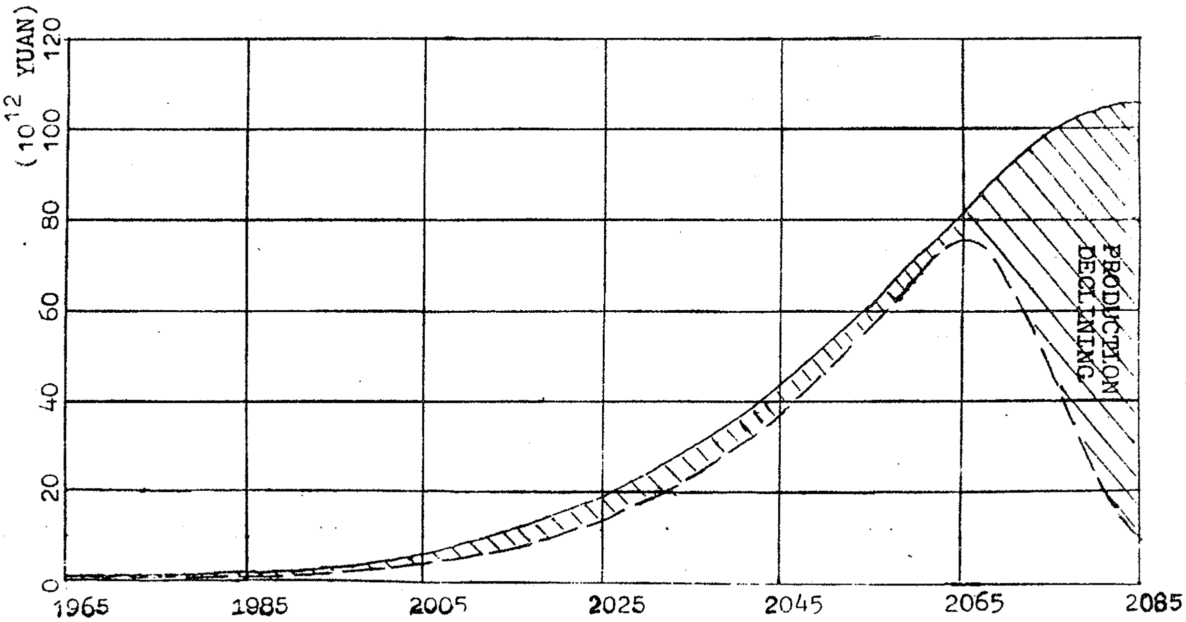


CER : Conventional Energy-reserve Remaining-rate
Figure 4-6. Conventional Energy Depletion Curve

It shows us that assuming there is no increase in the initial conventional energy reserve (in our research the initial time is the year 1965), the conventional energy reserve will be depleted graduallym with the threat of conventional energy exhaustion in about 2065, leading to the decline of economic production, as in Figure 4-7.

IV. POLICIES TOWARD THE REMOVAL OF THE BARRIERS

Certainly those barriers lying ahead of us are unwanted. Accordingly, what sort of efforts should be made by us effectively to remove those barriers so as to achieve the persistent economic growth? This is the key issue that we are going to discuss in this paragraph.



——— : Potential production capacity

– – – – : Actual production capacity

Figure 4-7. Production Decline due to Conventional Energy Depletion

1. Efforts to Remove Current Barriers

Population control is the fundamental policy that we should carry out without hesitation. Even with an expected fertility of 1, the population of China will still reach over 1.2E9 in the year 2000. If the fertility is 2, the population will climb up to 1.35E9. In the latter case, the national income per capita would be 8% less than in the former case in the year 2000.

The only way to remove the barriers of transportation and pollution is to invest money on them (if we don't consider the option of non-growth).

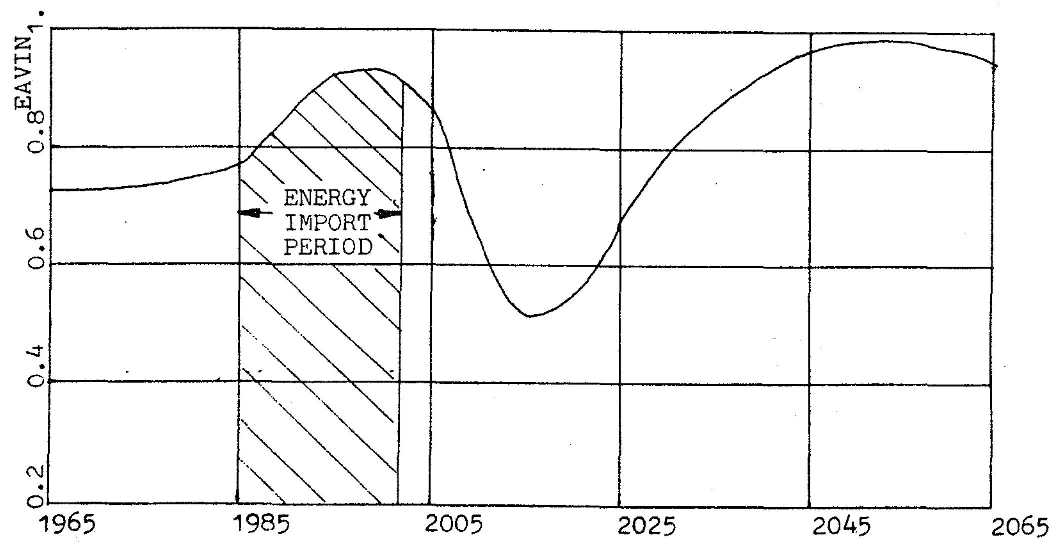
With respect to energy, what we seek is to increase the availability of energy supply. One of the ways is of couse to increase investment in energy production. The table below indicates the energy availability in 1995 and 2000 resulting from different investment rates (annual energy investment/annual capital investment).

INVESTMENT RATE 1990-2000	ENERGY AVAILABILITY 1995	2000
15%	0.68	0.59
16%	0.69	0.6
17%	0.7	0.63
18%	0.71	0.64

Table 4-1. Investment Rate and Energy Availability

The table shows that when we increase the energy investment rate by 3% from 1990 to 2000, energy availability in the year 2000 rises by only 0.05. The delay function in energy investment and production restrains the growth.

A quick way to increase energy availability is to take the policy of energy importation. However, the side effects of energy importation would be serious, if the money which was initially for domestic energy production was diverted for energy importation. (See Figure 5-1)

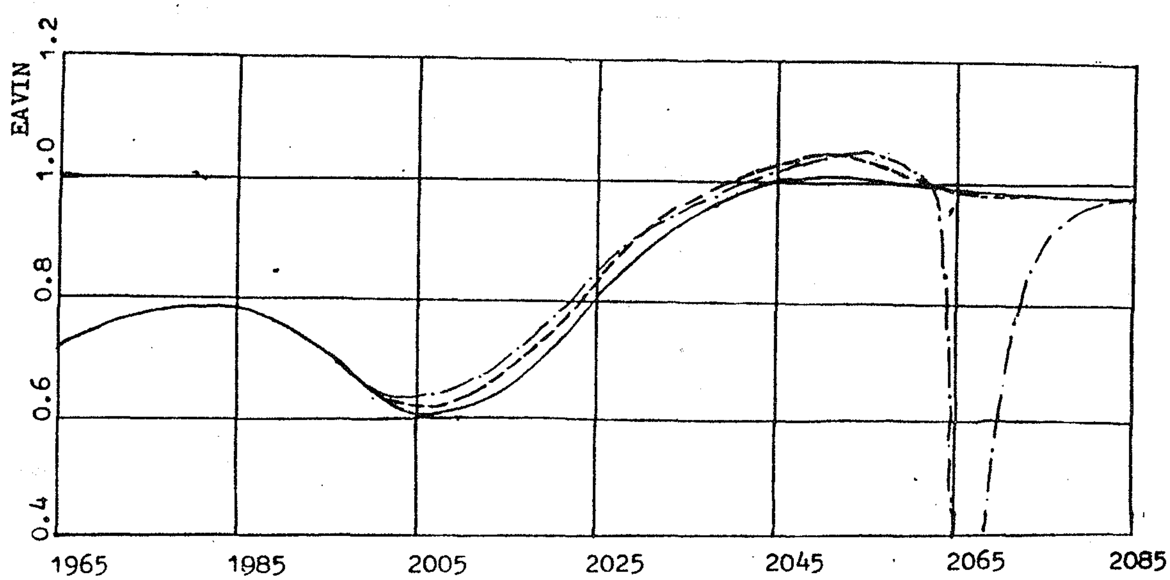


EAVIN : Energy AVailability INdicator
Figure 5-1. Effect of Energy Importation to Energy Availability

In the situation indicated in Figure 5-1, the energy import policy is applied from 1990 to 2000 to compensate 95% of the energy shortage and it is stopped after 2000. By using this policy, we can have a really high energy availability before the year 2000. However, things would be much worse after the year 2000 than in the case without energy importation. So we conclude that energy importation might not be a good approach to remove the current energy barrier, unless the energy importation will not affect the domestic energy production (from the aspect of investment), or unless China is going to meet its energy demand by energy importation forever.

2. Efforts to Remove Future Barriers

In the following section we focus our discussions on future energy barrier. Because of the finite conventional energy conventional energy reserve, it is certaib that there will come a day of energy exhaustion. The only way to remove the future energy barrier is to develop and apply new energy sources. We can understand that capital and time are two essential requirements for new energy development. Assuming the new energy development time (from preliminary research to application) is at least 50 years, Figure 5-2 shows three different possibilities for energy transition with different starting times.



———: Energy transition starting time 2000
– – – –: Energy transition starting time 2010
— —: Energy transition starting time 2030

Figure 5-2. Three Cases of Energy Transition

Curves (a), (b), and (c) indicates three transitions with starting times of 2000, 2010, and 2030 respectively. Figure 5-2 shows:

a. Energy development starting time should not be later than the year 2000. If the starting time is the year 2030, energy availability and hence industrial production, will begin to decline about in 2070. In fact, we should start our work in new energy development and application at the beginning of the 21st century.

A smooth energy transition is very important for the steady economic growth. There is no doubt that a disconnection in conventional energy supply and new energy supply will cause serious bad effects in China's economy and society.

b. There is a trade-off between future smooth energy transition and current high energy availability. Figure 5-2 shows, earlier new energy development starting time gives us a smoother energy transition process, but makes current energy availability lower. We can make our choice of the starting time according to the money and energy availability states.

VI. SUMMARY

We presented in this paper the preliminary results and points of our research in the stimulations and obstructions of China's economic growth, currently and in the future. The stimulation functions of labor, capital, technology and education change with time. Within different time periods, different stimuli are the dominant or the most effective. In less than 20 years from now, technological progress will be the key stimulus to the economic growth.

Looking forward to the future, we should keep ourself clear-headed. Obstinate population growth, conventional energy depletion and long existing pollution set many obstacles on the road of China. Any careless decisions and policies might cause the economy to stop growing and even to decline.

As we have said previously, what we have done is only the preliminary work. It is the first time that we have applied System Dynamics to analyze China's domestic socio-economic problems. Much effort is still being devoted to revising and improving the work. We believe that htere are many similar aspects in essence in economic systems of different countries. System Dynamics can be a powerful tool for us to apply in China.

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