

and output, which depends to a great extent on the level of production technology and the level of management.

In some sense, efficiency reflects statically the coordinated development of R&D and socio-economy which grows dynamically. Coordinated development means a long-term steady and equilibria growth of R&D and socio-economy.

therefore, in order that the R&D and socio-economy of a central city can develop coordinately, the following principles must be fulfilled,

a) Principles for function-coordination, or the rationality of the municipal functions, including the rationality of external functions and internal structure. As for the rationality of external functions, the important problem is how a central city finds a good balance among its functions of being a center of industry, a center of economy, a center of science and technology, a center of culture and a center of education etc., while for the rationality of industry composition, the balance of municipal infrastructure, ecological resources and economy structure.

b) Principle for spacial coordination, which concerns with the allocation of production forces and the distribution of product market between the system itself and its environment, or is finally ascribed to the relation between the interest of the local area and the interest of the whole. Therefore, coordination indicates not only in the sense of internal coordination but also the coordination among areas (we call them respectively internal coordination and external coordination).

c) Principle for temporal coordination. In order to assure a steady development, the big fluctuation should be avoided. Therefore the contradiction between long-term interest and short-term interest should be somehow compromised.

Based on our above understanding about the meaning of the coordinated development, we suggest the following main relation-variables be used to reflect the coordinated development of the R&D and socio-economy:

- * the proportion of GNP, capital stocks and employments respectively among the technology-intensive industry, capital-intensive industry and labor force-intensive industry.

- * the proportion of GNP, capital stocks and employments respectively among the primary industry, secondary industry and tertiary industry.

- * the indicator of macroscopic social economic efficiency, measured with the ratio of National Income or GNP over Total Social Product.

- * "degree of economics openness", measured with the ratios of the amount of total foreign trade over GNP and the ratios of the amount of technology transfer over GNP.

- * the elastic proportion of the improvement of average living standard(or consumption per capita) over the increase of GNP per capita(or national income per capita).

2. The coordinated development of R&D and socio-economy is obviously a multi-objective problem. Among the objectives are some internal objectives related with internal evaluation, or, in the other sense, some static objectives describing the state of system and some dynamic objectives portraying growth rate. Since there exists a hierarchical relation among various objectives, the objectives as a whole form an objective system(Table 1). The evaluation indicators reflecting the coordinated development appear also in the objective system as a part of the whole objectives.

For a multi-objective problem of a nonlinear system there exists no "optional" solution. The value of different social groups might influence tremendously the tradeoff among objective and there of the choice among strategies. Therefore the idea of employing comprehensive

indexes to transform a multi-level, multiobjective problem into a single objective problem might actually embed an unconscious assumption about the value choices of different social groups and will thus introduce unexpected bias to the solution of the problem.

Table 1: Objective system for the coordinated development of R&D and socio-economy.

| | | economy | society | technology |
|--------------|--------------------|---|--|---|
| first level | static objectives | GNP | Quality of life(OL) | technology level |
| | dynamic objectives | Growth rate of GNP | improvement of QL | technology progress rate |
| second level | static objectives | GNP of primary industry secondary industry tertiary industry technology-intensive industry Amount of foreign trade Amount of technology transfer | Consumption per capita Housing area per capita Municipal facilities per capita Pollution rate | the composition of latest research, applied research and development research |

Therefore, in our real study those objectives in the lower levels of the objective systems are actually replaced by responding constraints, with a preset satisfactory domains for each one and then we seek for the "optional" solution to the original problem simply based on those aggregate higher-level objectives.

II. Analysis on the Typical Problems Which Frustrate the Development of R&D and Socio-economy in an Average City in China and the Constraints Which Give Rise to These Problems:

The problems which perplex now the large cities in China stem both from the area of production forces and production relationship(or economic system). Here we only give a survey to the typical problems and constraints related with the demand and supply of production factors and the allocation of production forces.

1. The typical problems which frustrate the coordinated development of R&D and socio-economy in an average large city in China might include:

- * the imbalanced development of R&D and socio-economy. The ever putting undue emphasis on the rapid economic growth to the neglect of the improvement of municipal facilities(including transportation and telecommunication, municipal infrastructure, public welfare and ecological environment) has made the latter lag far behind the growth of economy and became a constraints to both the growth of economy and the improvement of residents living standard, while the ever pursuit of short-term economic interest to the neglect of the input to the technology sectors has made the progress of technology stagnant.

- * irrational industry composition. The over dependence on the

conventional industry has made the development of economy lopsided and the development of commercial industry, banking and insurance, transportation and telecommunication and other service industries shrink. Moreover, the internal composition within each of the three large industries is also irrational, which is well manifested in the fact that the output value of textile, chemistry metallurgy and heavy industries makes up near 80% of the whole output of the secondary industry while machinery, electronics and esp. new developing industries account for only a small proportion, and that know how industry, information processing and communication industry, banking and insurance, risk operation etc. make up also a small proportion in the tertiary industry.

2. As for the demand and supply of production factors and the rational allocation of production forces, the factors which block the coordinated development in an average large city in China include:

- *the insufficient supply of energy
- *the limited capacity of transportation and telecommunication
- *the shortage of raw material supply
- *the limited bearing capacity of ecological environment
- *the shortage of capital supply
- *the backwardness of technology
- *the coexistence of a great amount of underemployment and the labor force shortage
- *the current technological-socio-economic system and various external policies

III. The overall Thoughts and Framework of the Systems Dynamics Model for the Coordinated Development of R&D and Socio-economy in a Typical Large City of China

1. Figure 1 intends to illustrate schematically the main thoughts of the model. The main task of the model is to investigate the rational investment distribution among the three large subsystems--technology, economy and society, the rationalization of industry composition, and the socio-economic evaluation of technology progress. Thus, much attention is paid on these macro policy variables--the distribution policy of national income, the allocation of investment capital as well as labor forces, industry policy, R&D policy etc. A series of policy tests and policy analysis is conducted for these variables.

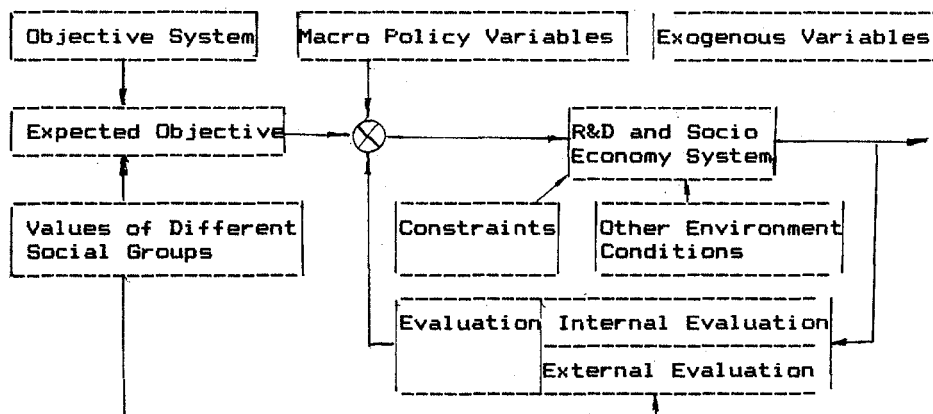


Figure 1: The overall thoughts and framework for the systems dynamics model for the coordinated development of R&D and socio-economy

2. The Systems Dynamics Model for the Coordinated Development of R&D and Socio-economy is a hierarchical and structural model. The first level of the model is composed of these subsystems-R&D, economy, society subsystem, coupled by the fourth subsystem of national income and its utilization. The second level of the model is the subdivision of the subsystems in the first level. For instance the economy subsystem is subdivided into the subsystems of conventional industry, new developing industry energy transportation, agriculture and tertiary industry etc. Similarly, the society subsystems is subdivided into the sub-systems of labor force, consumption, housing, municipal facilities, environment etc. .The whole model contains more than 500 DYNAMO equations.

3. The production and consumption of GNP center the whole model and the model focuses its attention mainly on the following variables : the distribution of national income, and the distribution of investment capital.

IV. Policy Tests and Policy Analysis

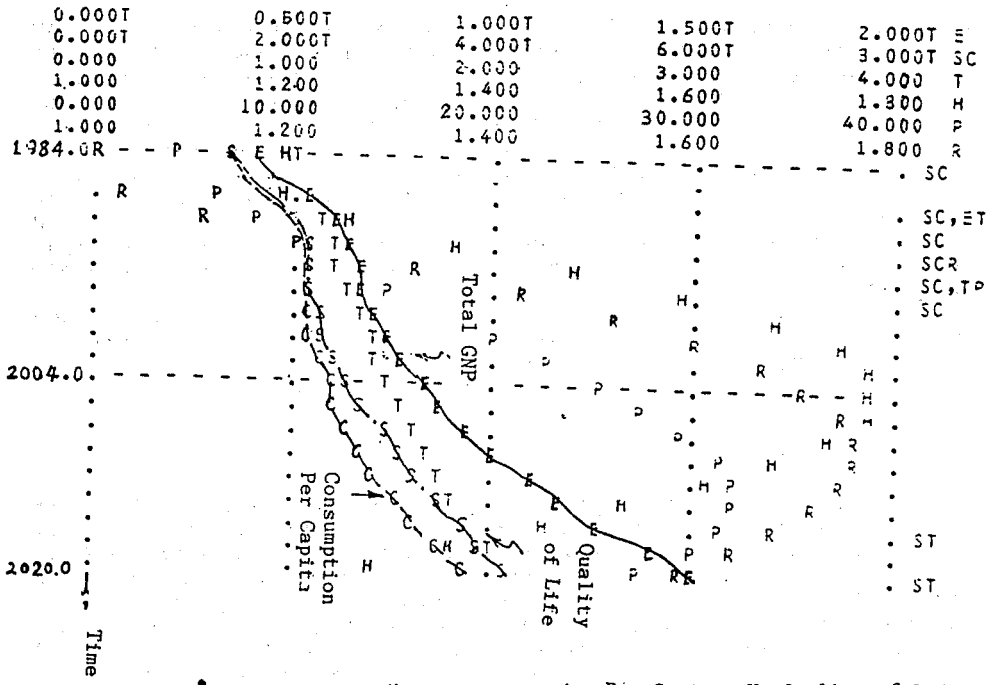
1. The strategy spectrum(possible development patterns) for the future development of R&D and socio-economy in Shanghai contains at least two optional extreme development patterns, and the combination of these two extreme patterns will generate several alternatives. In the first extreme pattern, the economic growth will be centered on the making of strategic planning, while in the second extreme pattern the adjustment of economic structure and the rationalization of municipal functions will be the most fundamental, and of greater priority, objective to be considered in the making of strategic planning,.Under the first strategic choice, the central and fundamental objective to be pursued is to maximize economic growth and spur Shanghai to be the economic center of China. To this end, the decision makers concerned might overuse the current economic facilities and be irresolute to the adjustment of economic structure. On the other hand, under the second strategic choice, the fundamental objective is not the maximal economic growth and to become the economic center of China instead, the rationalization of municipal functions by means of structure adjustment is the primary objective to be pursued. Shanghai should not only be the economic center of China, but also become the gate of China's connection to the world. Different strategic choices will actually correspond to different evaluation criteria. The evaluation criteria of the central government of China upon Shanghai should not simply base on the conventional economic indicators, instead, it should base on overall social and economic benefit of Shanghai to the whole China.

2. The base run of the model

The base run corresponds to the first strategic choice in the strategy spectrum i.e."economic growth prior to the adjustment of structure", the foundation of which is the various R&D and socio-economic system (structure and parameters) and policies in 1984. Figure 2. presents the main results of the base run simulation. It shows that GNP in 2000 will be only 1.87 times that in 1984 while quality of life will be improved by only 1.66 times, provided the investment mechanism and proportion in 1984 remain unchanged, and that GNP in 2020 2.05 times that in 2000 while quality of life by 1.81 times. Figure 2 illustrates the development trend of industry composition.

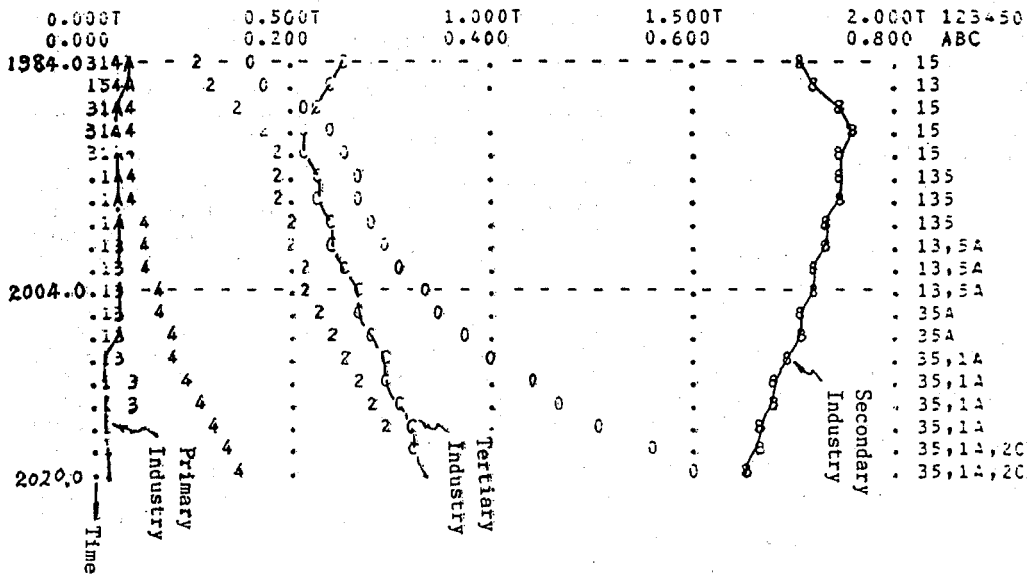
3. The Strategy of "Coordinated Development of R&D and Socio-economy"

After the base run, we try incessantly a series of other policy tests, and finally find a group of comprehensive policies which might bring about a scenario of what we mean by coordinated development. These comprehensive policies include:



E—Total GNP(10⁸RMB¥); SC—(RMB¥); T—Consumption Per Capita; H—Quality of Life

Figure 2 Main results of the base run simulation



ABC—GNP Ratio (dimensionless)

Figure 3 Development trend of industry composition

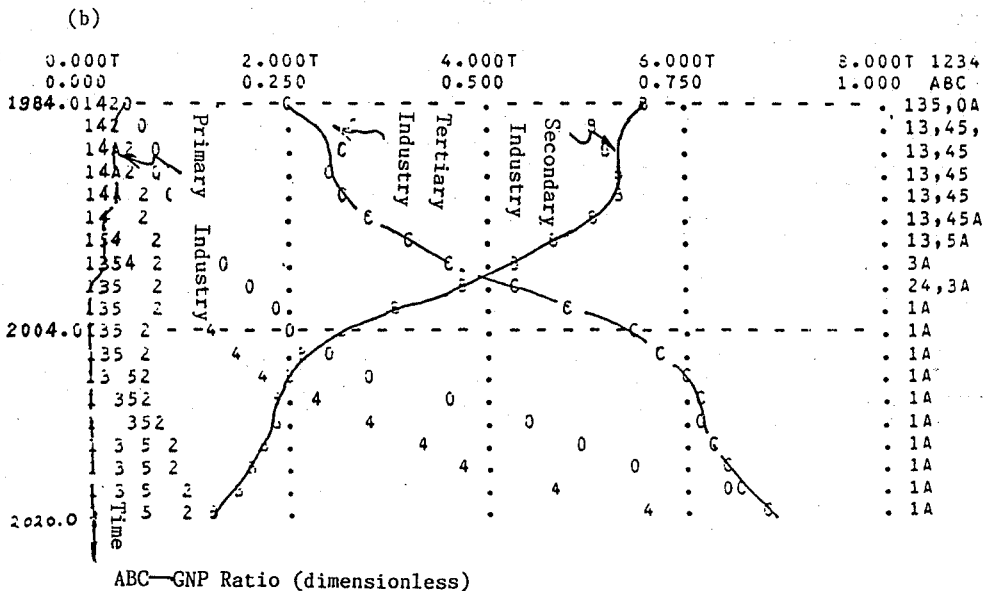
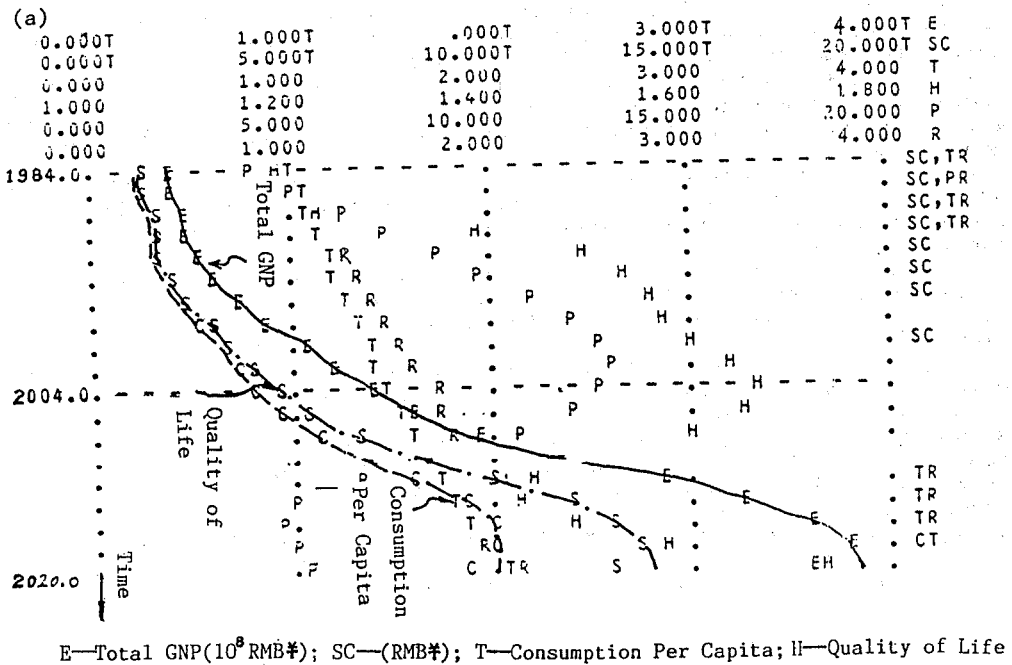


Figure 4 Simulation results of comprehensive policies

* increase nonproductive capital investment to the proportion of 45% of the total annual investment before the year 2000 and remain 50% during the period from the 2000 to the year 2020.

* adjust the distribution mechanism of the investment capital among industries from the old one which is fundamentally based on pursuing short-term economic interest to a new one of pursuing long-term social and economic benefit.

* adjust the price relations among industries, subsidize the development of new booming industries and meanwhile form a new price system which favor the development of both new booming industries and tertiary industries.

* increase gradually the capital input to R&D subsystem from about 1% of GNP in 1984 to 3.5% in 2000 and 4.5% in 2020, which are supposed to be the average proportion in the development countries at the same time.

* speed up the technology renewal of conventional industry and meanwhile increase the depreciation rate of capital assets. Figure 4 illustrates the simulation results of these comprehensive policies. It shows that under these policies the development of R&D and socio-economy will be switched gradually into an orbit of coordinated development in the 30 years to come (meeting the satisfactory domains preset for each objective of coordinated development) and will obtain a satisfactory economic growth (at an average of 6.26% annually) and social development.

The above policies are the main recommended one of our study.

V. Conclusions

This paper summarizes some of the authors tentative study on the issue of the coordinated development of R&D and socio economy for a typical city in China using Shanghai as a background of our study. The paper first discuss some theoretical problems on what we call coordinated development, then analyze the typical phenomena which characterize the unbalance of the development and the main reason (constraints) which give rise to these unbalance, and the outline the thoughts and framework of "the systems dynamics model for coordinated development of R&D and socio-economy" built by the authors using the approach of systems dynamics, and finally illustrate some main policy tests and policy analysis based on the above model and present some policy recommendation in view of the situation of Shanghai.

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