

A SYSTEM DYNAMIC MODEL AND POLICY ANALYSIS FOR
NATIONAL EDUCATION AND ECONOMY DEVELOPMENT

Xu Qingrui , Zhu Keqin , Li Junji
Department of Industrial Engineering & Management
Zhejiang University , Hangzhou , China

Abstract. Most of the developing countries are faced the problem how to allocate limited resource to education to promote economy growth. In this paper, the System Dynamics methodology is employed to solve the problem. The interactions between education, economy and Science-Technology (S&T), and the inherent mechanism of education and economy are studied. Based on these studies, a system dynamics model for national education and economy development is established. According to the actual social-economic situation of China, several different resource allocation policies for education are tested on the model. Finally, some useful policy suggestions about resource allocation for education are given, such as the proper ratio of education expenditure to national income and the proper ratios of resources allocated to different levels of education.

INTRODUCION

For developing country, one of the most difficult problems in the development of economy is how to allocate its limited resource properly to make its economy grows continuously. It has been confirmed that education made great contribution to the growth of economy by the experience of the developed countries. So, education can be seen as a type of investment to the growth of economy. Further, the experience of the developed countries also shows that the contributions to the growth of economy in the different levels of education are different. Therefore, the interrelation and mechanism between education and economy, and the proper scale and structure of education based on the demand of economy in different development stage of economy should be studied. Then the proper resource allocation policies in education can be determined, which will be advantageous to the long-term goals of national economy development under the limitation of the national finance.

A System Dynamics model is established for solving the problems of the coordinate development between education and economy in China. Different from other research work, the main point of this research is that Science & Technology (S&T) has strong influence on the change of industrial structure and the change of industrial structure reflects the fundamental development of economy. Such change produces the demand for labors and professionals. Therefore, the change of educational scale and structure should meet the demand from the development of economy and S&T. Meantime, the development of education can not go beyond the limitation of resource in certain stage of development. Based on this main point, the model is developed into five sectors which are education, R&D, industry, finance and population. In China, the problem of the coordinate development between education and economy is a hot topic of research. Although a lot of studies have been done, most of them are based on the

qualitative analysis or the simple statistical methods. Few studies have been done from the point that the inherent feature of the coordinate development between education and economy is the coordination between the structure of education and industries in the different development stage of economy.

In this paper, the relationship between the structure of education and industry, and the mechanism and relationship between levels of education are studied in depth. Meantime, the relationship between education and S&T, and the relationship between industry and S&T are also discussed. By the simulation based on the model, some new results are obtained. First, the proper ratio which education investment holds in the national income during the different phase of economy development is obtained. Second, the proper ratio of resource allocation among the different educational levels during the development of economy and the change of industrial structure is also obtained.

ANALYSIS OF THE SYSTEM MECHANISM AND THE MODEL STRUCTURE

The interrelations between five sectors are shown clearly in figure 1. For example, education sector supplies the educated labors and

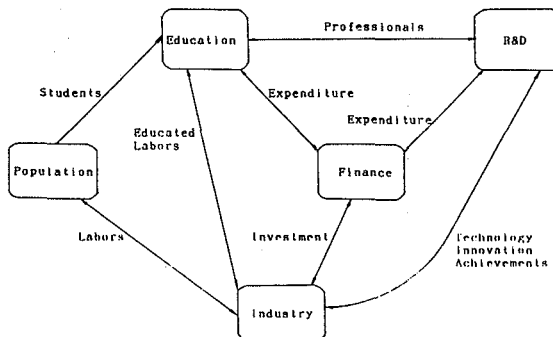


Figure 1. The general structure of the model

professionals for industry and R&D sector considering the demand from industry and R&D sector respectively. Meantime, education sector get the budget from finance sector and distributes new demands to finance sector based on the needs of coordinate development between education, economy and S&T. In the following, the three main sectors which are education, R&D and industry will be discussed in detail.

Education Sector

For the purpose of this research, education sector is divided into three parts, which are elementary education, secondary education and high education. The causal loop diagram of education sector is shown in figure 2. Here, some rational assumptions are made: first, the fixed assets investment for education is ignored, because it holds a little proportion in total resource allocated to education. Second, the students in higher level of education directly come from the graduated students in lower level of education, ignoring the little proportion of students who come from labors.

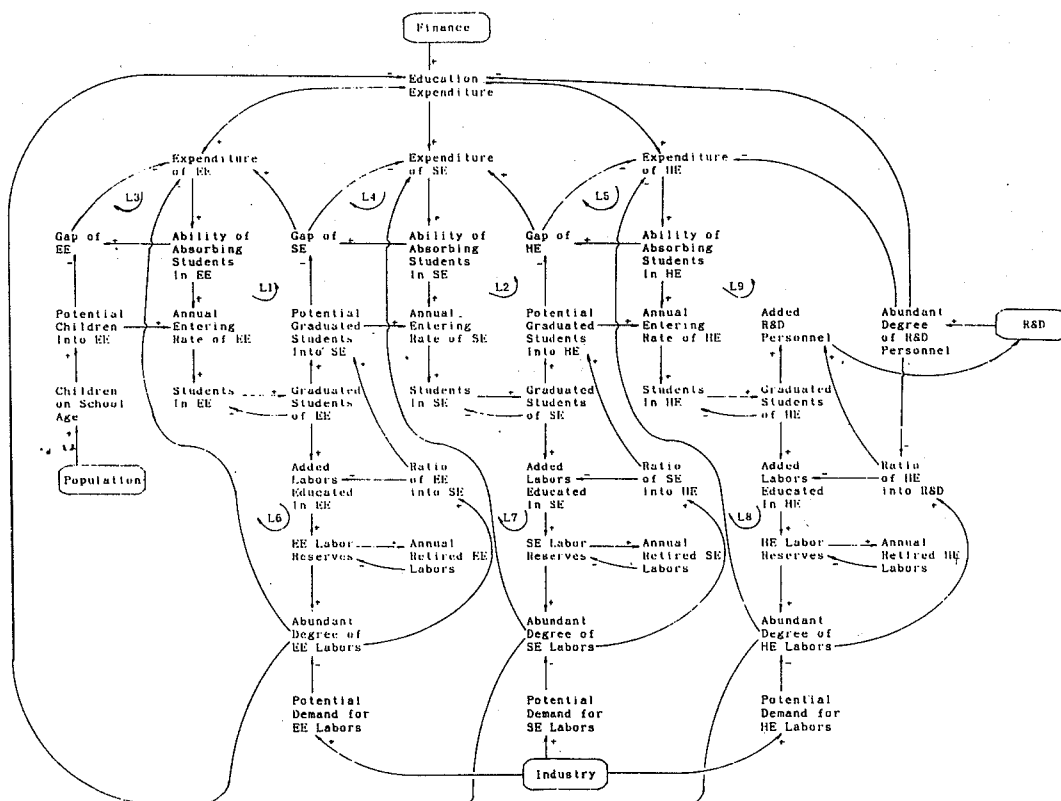


Figure 2. The causal loop diagram of education sector

Based on these assumptions and the inherent mechanism of education procedure, the negative feedback loops L1-L5 are established, which control the output of education in every level and the allocation of resource between three levels. Considering the interrelations between education, R&D and industry, the feedback loops L6-L9 are constructed. L9 reflects the coordinate development between R&D and education. In general, as the development of R&D, the demand for R&D professionals is changing, consequently the education sector tries to meet the new demand. As the same principle, the feedback loops L6-L8 represent the coordination between the development of education and industries. With the development of economy and the change of industrial structure, the demand for educated labors is also changed and the gap of educated labors will be overcome by the supply of education.

R&D Sector

In this model, the activity of S&T is represented by R&D, which is the core of S&T. For focusing on the main problem to be solved, the inherent structure of R&D is ignored. This assumption is reasonable because the main contribution of R&D achievements to economy comes from the results of technology innovation.

When the input of R&D is certain, the output of R&D is determined by the inherent mechanism of R&D procedure. As shown in figure 3, the output of R&D is represented by R&D achievement reserves which is

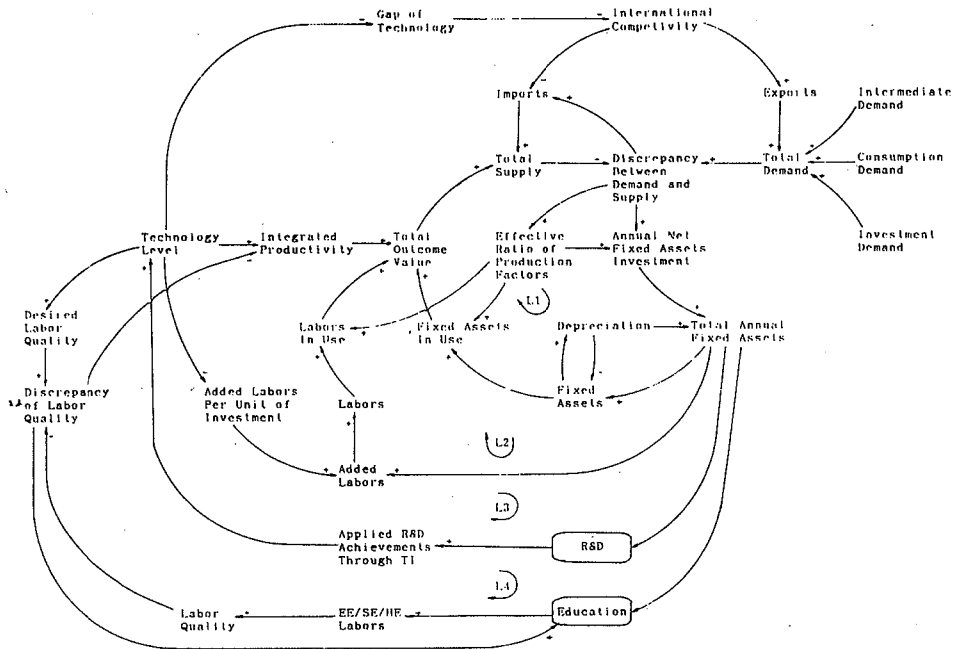


Figure 4. The causal loop diagram of industry sector (part)

disadvantageous effect to productivity resulting from the discrepancy of labor quality.

POLICY ANALYSIS

As discussed above, the scale of education expenditure and the ratios of resource allocated between three levels are mainly decided by the social-economic situation at that time. Through model simulation, a tendency of the ratio of education expenditure to national income and the ratio of education expenditure of each level to total education expenditure is obtained. The ratio of education expenditure to national income changes as S-shaped, while the ratio of elementary education expenditure to total education expenditure decreases from the first position to second position and the ratio of secondary education expenditure to total education expenditure grows into the main parts of total education expenditure. Compared with the actual behaviors shown by the statistics of most developed countries, the behaviors of the model are similar. Thus the model can be used to test real world policies based on the viewpoint of system dynamics that system's structure decides system's behavior.

Using this model to analysis the development of education and economy in China under the basic policy during the period from 1985 to 2035, the following results are given:

. The ratio of education expenditure to national income grows rapidly during the first twenty years, then slows down, and finally tend to a certain value. Because resource allocated to

education in basic policy based on the demand for education from economy and S&T, and the limitation of national finance, so the rapid growth of the ratio means that the growth rate of resources allocated to education should be greater than the growth rate of national income. Meantime, the simulation result that the ratio grows rapidly at first is consistent with the current social-economic situation of China. In China, the economy can be identified as the primary industrialization, in which agriculture takes the great role in economy and industry develops rapidly. Through technology innovation, a great deal of new technology are applied in industries and the technology level of all industries is increased. So there is an increasing demand for educated labors, which is the main reason for the increasing of the ratio of education expenditure. Meantime, the development of S&T and the increasing demand for professionals are also responsible for the increasing of the ratio. During the last thirty years, the slowing growth rate of the ratio means that as the technology level of the nation arrives at a certain level, the demand for educated labors and professionals can be met by the coincident growth of education and economy. The simulation results also shows that agriculture takes the secondary role in national economy and industry becomes the main parts in national economy, which marks that the economy of China will enter into the industrialized stage. Unless there is a new technology revolution, the ratio of education expenditure will keep stable.

. The ratio of elementary education expenditure to total education and the ratio of secondary education expenditure are changing at the contrast direction and finally exchange their positions. During the first twenty years, the changing rates of the ratios of the secondary and elementary education expenditure are rapidly, and then the change rates of the two ratios are slowing down, finally they tend to certain values. This result shows that for being consistent with the increasing technology level, the quality of labors should be improved, which results in the need for raising the educational level of labors, especially the demand for labors educated in secondary education is enlarged. The result also conform to the behavior that the scale of the industries with higher technology level such as consumption goods industry is increased, which absorb more highly educated labors.

. The ratio of high education expenditure to total education expenditure is decreasing during the first twenty years, and then keeps in a certain level, finally it increases gradually. This simulation result is contrast to the general point of view which thinks that the ratio of high education will grow gradually as the development of economy. However, the result is consistent with the fact that the elementary and secondary education are faced with the serious shortage of expenditure in China, while the ratio of high education expenditure is comparatively too high compared with the similar stage of economy development in the developed countries. So the result means that under current social-economic situation in China, the ratio of high education expenditure should be compressed a little.

In a word, the ratio of education expenditure to national income and the ratios of resources allocated to three levels of education should be changed during the different development stage of economy. In general, the growth rate of education expenditure should be higher than the growth rate of national income, at least they are the same.

For comparison, the high education priority policy and the fixed ratio policy are tested based on the model. Some useful results are obtained as following:

. Under the high education priority policy, which means that the ratio of high education expenditure grows rapidly and arrives at the value that developed countries own, the growth rate of economy is slowed down compared with that under the basic policy. This is due to that the higher ratio of high education expenditure makes the elementary and secondary education expenditure become more shortage, which can not meet the growing demand for educated labors from the development of economy and the change of industrial structure. Finally, the productivity of some industries is decreased due to the unqualified labors. So, it is disadvantage to the development of economy if a developing country allocates too much resource to high education blindly compared with the current educational levels of developed countries, no regarding to its own social economic situation.

. Under the fixed ratio policy, which means that the ratio of education expenditure to national income and the ratios of resource allocated to three levels of education are unchanged no considering to the different development stage of economy, the behavior is worse than that under the high education priority policy. This is because both the educated labors and the professionals are becoming more and more shortage.

From the analysis above, following policy suggestions are available for government in policy making about the resource allocation in education:

. The growth rate of education expenditure should be greater than, at least the same as that of national income. However, based on the current situation in China, the growth rate of education expenditure should be greater than that of national income. From the simulation results, when the ratio of education budget rises to about 6.3%, the development of education and economy can be coincident.

. The ratio of high education expenditure should not be raised too fast in a developing country. Even in certain condition, the ratio of high education expenditure should be lowed to guarantee the coordinate development between the elementary/secondary education and the economy. From the simulation results, the government should drop down the ratio of high education expenditure from 20% to about 15%. However, this ratio can not be lowed further for the long-term development of economy.

CONCLUSION

From the discussion above, the problem about the resource allocation in education is solved successfully with the System Dynamics methodology. Especially, the study about the problem is based on the deep discussion of the interrelations between education and economy, and the inherent mechanism of education and economy. So, the obtained new conclusions are believable, such as the proper ratio of education expenditure to national income and the proper ratios of resource allocated to three levels of education in the different development stage of economy.

REFERENCE

- Forester, J.W., Industrial Dynamics, Cambridge, Mass:MIT press,1961
- Li Hanping, "The Mechanism and the SD Model of Technology Progress and the Change of Industrial Structure", Paper of MS Degree, Zhejiang University, 1988
- Li Yining, et al., Studies of the Economics of Education, People's Publishing Company of Shanghai, 1988
- Tomkins, R., "Structural Features of a System Dynamics Model of the UK Economy", in System Dynamics and Analysis of Change, B.E.Paulre(ed.), North-Holland Publishing Company, 1981
- Xu Qingrui, et al., "Science-Technology, Education and Economy System Dynamic Model", Proceedings of International Conference on System Science and Engineering (ICSSE' 88), 1988