

A TENTATIVE SD MODEL APPLICABLE TO THE
STUDY OF LOCAL EDUCATION DEVELOPMENT
STRATEGY AND POLICY ANALYSIS IN THE
URBAN AREA OF SHANGHAI

Ching T. Yang

Shanghai Jiao Tong University

and

Xu Zi-yuan

Shanghai University of Engineering Science

This paper discusses the application of System Dynamics approach to the study of local education development planning which fosters a tentative SD model applicable to local education development strategy and policy analysis in the urban area of Shanghai. It can help decision making of the local government education authorities in this area. Based on education economic theory and the socio-economic development situation in Shanghai, this model, using DYNAMOIII language, contains four socio-economic sectors -- education, economic, social structure and social life, from which 730 variables were attained with 90 level equations 179 rate equations.

The present study shows that the simulation model is not only feasible and practical for the study

on local education system in Shanghai, but also applicable and useful to other urban areas as well.

1. INTRODUCTION

There is a big shortcoming in almost all previous education plannings. That is, when the plannings were worked out, economic growth was regarded as an unique goal of education development, or education was regarded as starting point and ending point. In fact, education is related with economic, social structure and social life, and influenced with them and acted with them. In this paper, we will, on the basis of the education economic theory and system theory, put local education, economic, population, manpower and social life together as a long-term social-economic dynamic system. The research, starting at February, 1985, was aided by Shanghai Institute of Interlligence Development and the Manpower Forecasting Office of Shanghai municipality.

The LEDSPA (Local Education Development Strategy and Policy Analysis) model proposed following is useful primarily as a quick turn-around strategy and policy analysis tool to be used by goverment education authorities and anyone who researchs in this field in the processes of working out education plan and in forcasting and comparing with different social-economic results of all kinds of plans.

2. BASIC MODEL STRUCTURE

The IEDSPA model contains four sectors -- education, economic, social structure and social life, which forms a special local social-economic system shown in Figure 1.

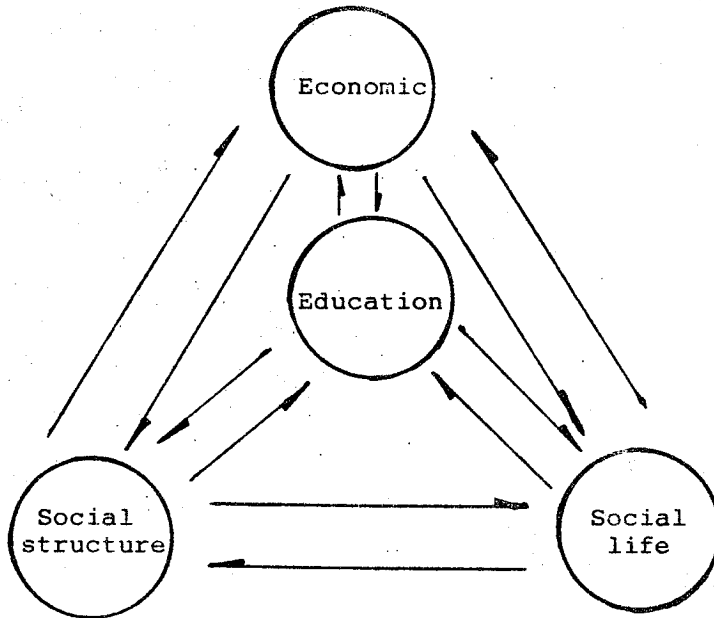


Figure 1. Sector organization of the LEDSPA model

Three types of flow indicates the relationship between these sectors and in a sector, they are money flow, people flow, and information flow. The money flow is used to describe reproduction and distribute processes of local national economy, which runs through economic sector and social life sector mainly. The people flow is used to describe the processes of local population activity, which runs through education sector and social structure sector mainly. Both money flow and people flow are the basic flow of the system,

but they don't control the system direct. The information flow, with the help of feedback structures, runs through all system and becomes a control network. On the basis of the changes of the basic flow, the flow decides the direction and rate of those basic flow. Owing to space limitations, the LEDSPA model will be described here only briefly (A more detailed review of the model can be found elsewhere.).

2. 1 Education Sector

In this sector, changing rules of students flowing in a school and between all types of schools and restricted factors, such as resources in student and teacher, are described mainly. According to the education development plan which comes from outside of the system, a set of behaviors inside education sector are produced, such as, the tendency of increase and decrease in student, teacher, school building and facilities, and running expenses. Here all kinds of schools are incorporated into six types. They are higher school, senior middle school, nine-year compulsory education, adult higher school, adult senior middle school and adult school under senior middle education.

Three kinds of indexes are considered in education efficiency. They are rate of student to teacher, running expenses per student and the quota of school building and facilities per student. The education investment includes both running expenses and capital expenditure in education.

Figure 2. shows the simple causal feedback loops contained in

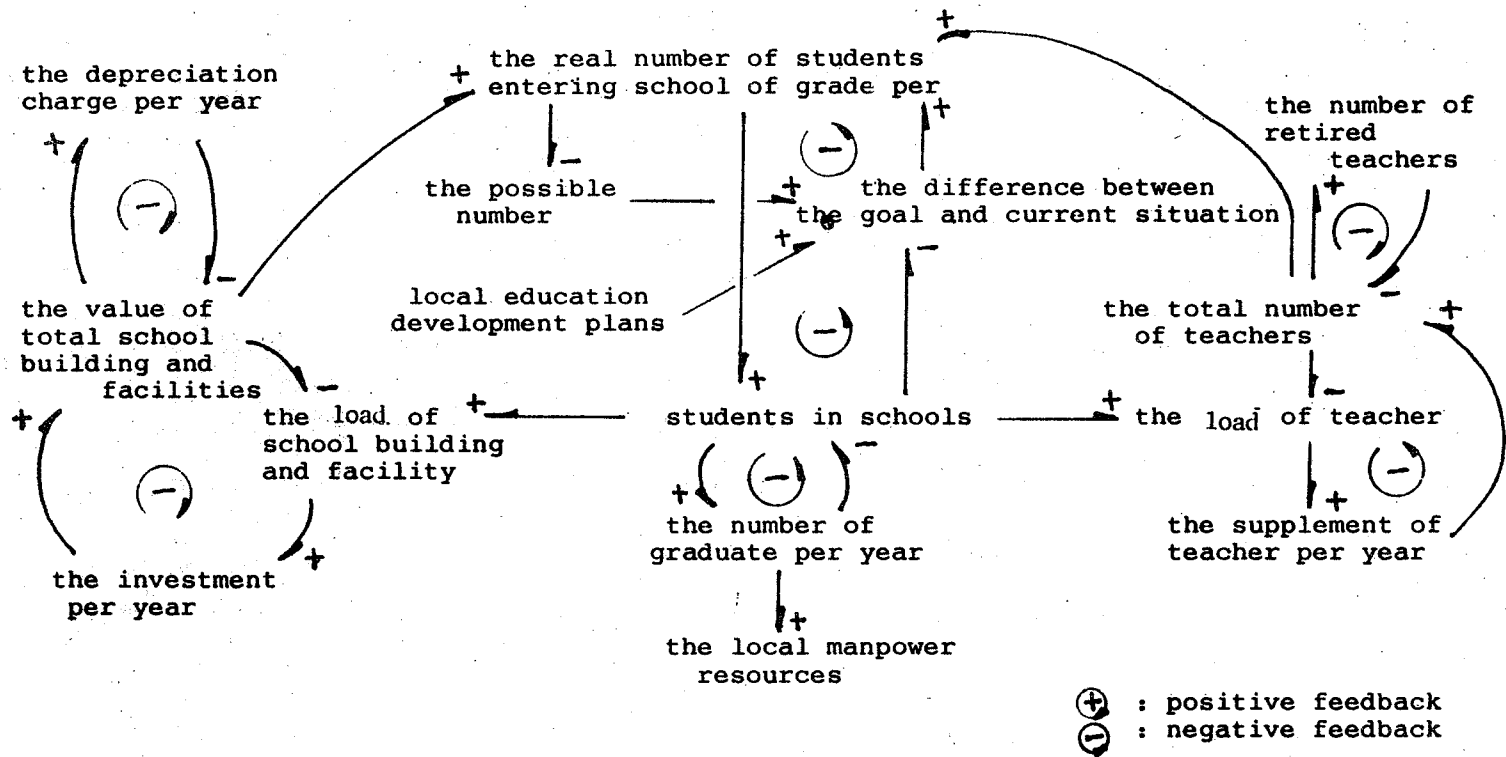


Figure 2. The causal feedback loops contained in education sector

the education sector.

2. 2 Social Structure Sector

Although many social-economic structure could be included in this sector, only population structure and labor force structure are discussed here, which is most closely related with education. Scientifically analysing population situation and its intelligence structure under a certain social development stage is very necessary for forecasting education development and social development in the future. Labor force structure is the junction of education structure and economic structure. In population part of this sector, the rules of the increase in population and the effects of population policy as well as local education development level are considered when modeling the part. The tendency of local population increase and population structure in the future are described mainly. The age structure year by year in population is used in order to accurately analyse the people flow in the system. Figure 3. shows the causal feedback loops contained in the population part.

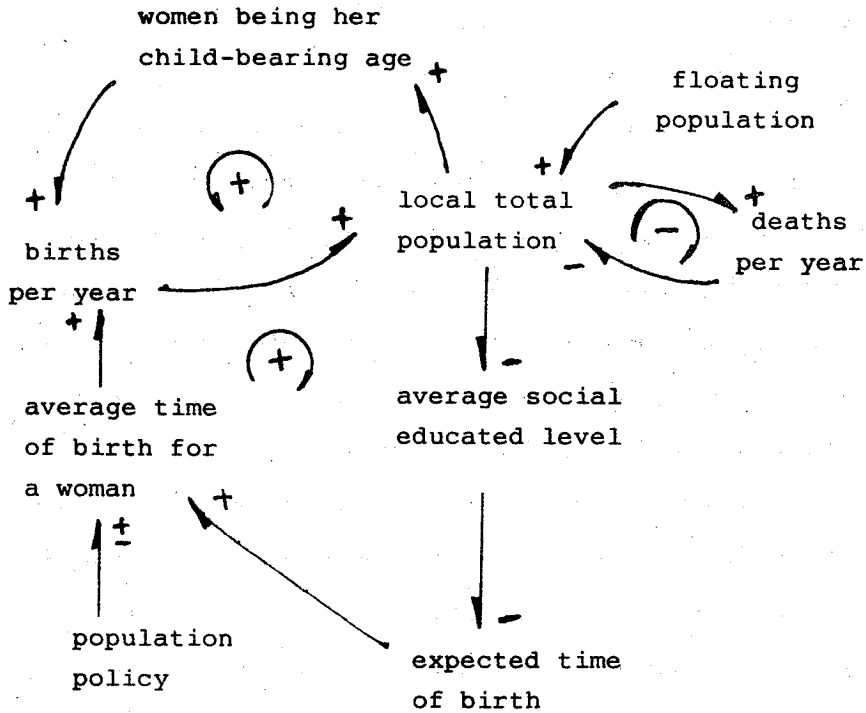


Figure 3. The causal feedback loops in population part

in the employment part of this sector, the changes of local social laborer under the common actions, such as the new social laborer, the student in schools, natural depletion of social laborer and new production fixed capital, are described. The using of the class analysis method in this part is necessary to successfully describe all kinds of channels that students get his employment, to analyse the quality of laborer resource and to evaluate several education development plans. According to the method, total social laborers are divided

into three classes; the first class consists of those who were educated 9 years or less, the second class educated between 9 to 12 years, and the third class educated 12 years or more. Figure 4 shows the causal feedback loops contained in the employment part.

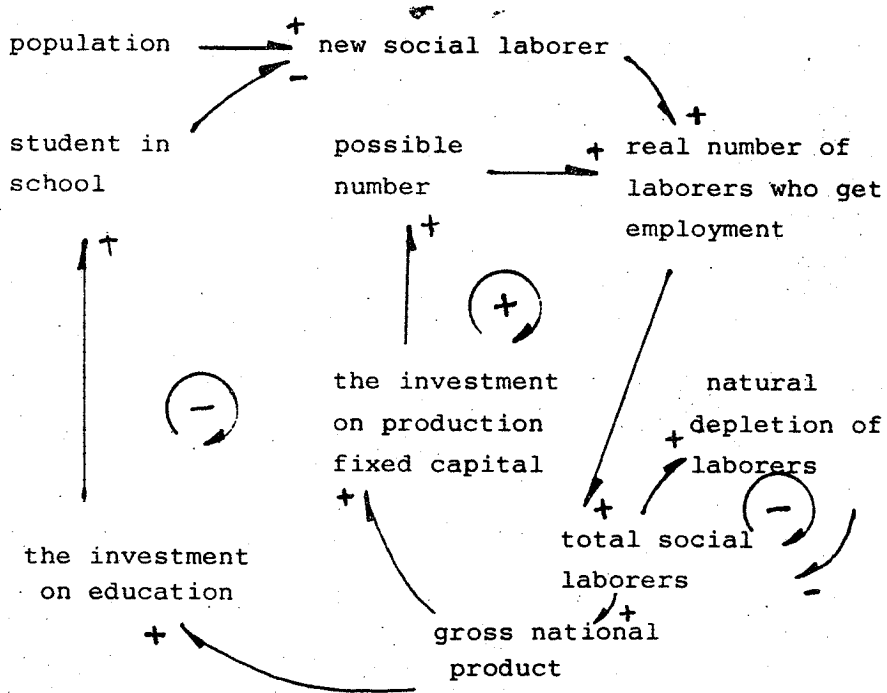


Figure 4. The causal feedback loops contained in the employment part.

2. 3 Social Life Sector

In this sector, a set of indexes closely related with economic, education and social structure are included, such as

gross national product per capita, national income per capita, total expenses in education, the ratio of the expenses in education to expenditure, the average laborer educated years and the university students per ten-thousand person, and so on. Those indexes are used to express local economic and non-economic development situation.

According to the basic principle of the labor value theory, the labor quality factor is considered. The total local laborer resource (L') not only depends on the number of laborer (L), but also depends on the quality of laborer (H):

$$L' = L * H \tag{1}$$

The principle of "less complex labor equal to more simple labor" is used to compute the labor quality factor:

$$H = \frac{\sum_{k=1}^{21} \text{the laborer educated } k \text{ years} * \frac{k}{4}}{\text{the total laborer}} \tag{2}$$

which guarantees, in certain degrees, the unity of number and quality of the laborer in simulation, laying a foundation to evaluate the action of education in the social-economic system. Figure 5. shows the causal feedback loops contained in social life sector.

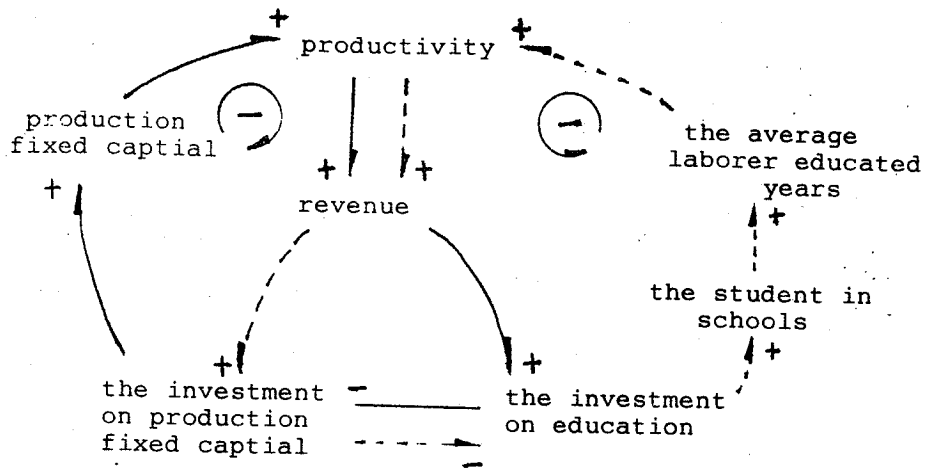


Figure 5. The causal feedback loops contained in social life sector

2. 4 Economic Sector

Analysing economic behavior is the foundation to describe the education development behavior. How much money could be gotten for the future of education development? What proportion could be arranged in all kinds of school? How many special qualified persons are really needed in the future? ... These problems are existing not only in the field of education but also in the field of economic. On the other hand, the increase in economic is more and more deepening on the advances in personal talent and in science and technology, among which one very important factor is education.

In this sector, the production function are revised as following:

$$P = A * L^{\alpha} * K^{1-\alpha} = A * L^{\alpha} * H^{\alpha} * K^{1-\alpha} \quad (3)$$

Here A is a constant, P means product, L' is the input related with total laborer resource, K is the input related with total production fixed capital, α is elasticity coefficient of total laborer resource. Obviously, this revise could reflect directly the relationship between product and the changes of laborer's quality. Figure 6. shows the causal feedback loops contained in the economic sector.

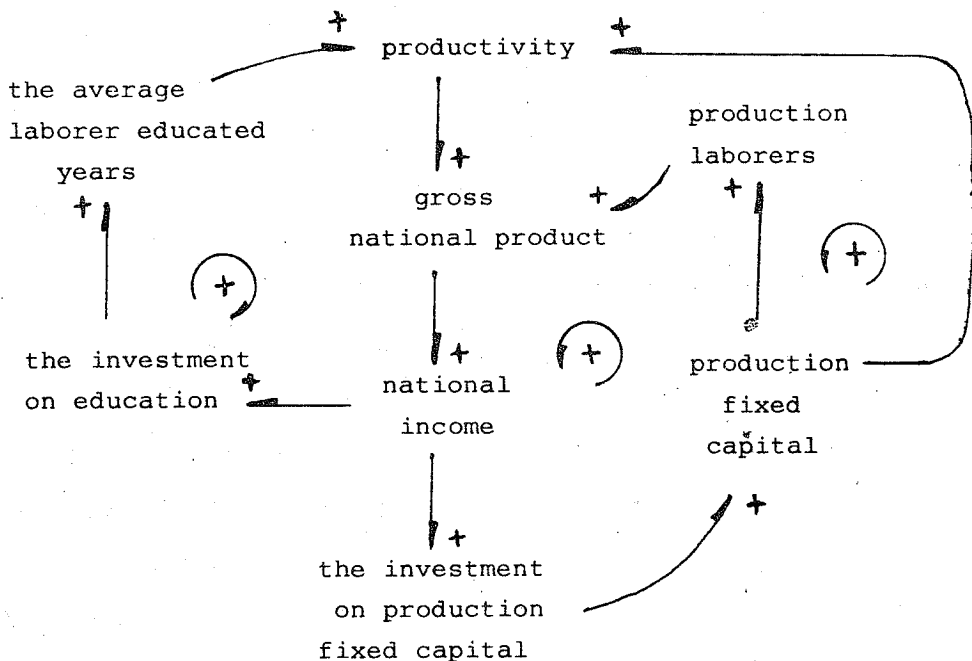


Figure 6. The causal feedback loops contained in the economic sector.

3. STRATEGY AND POLICY ANALYSIS USING THE DYNAMIC MODEL

Based on the local education and social-economic development situation in recent years (Shanghai was considered for the convenience to gather the data), the LEDSPA model,

using DYNAMOIII language, run on the DPS-8 computer in Shanghai Jiao Tong University, from which 730 variables are attained with 90 level equations and 179 rate equations. The simulation time was from 1980 to 2000.

After debugged, the simulation values of main model variables are tallied with the statistical values of relevant variables during the period from 1980 to 1984, which came from "1983 Shanghai Statistical Almanac" and "1984 Shanghai Statistical Almanac". While determining the variables and doing the esnsitivity analysis, that the main variables in the model are quite insensitive and counter-intuitive were found, hence the model's structure is steady and good for long-term (15-20 years or more) foresight.

In order to analyse the influence of Shanghai medium and long term education development goal on the social-economic system, three plans were designed as following:

1) The first plan continued the tendency of Shanghai education development in recent years. The results are: (!) the rate of student getting into senior middle schools reaches 75 percent in 1990 and 92.5 percent in 2000; (2) the university student in schools reaches 160,000 in 1990 and 250,000 in 2000; (3) the laborer educated up to 12 years makes up 57.3 percent of the total social laborers in 2000.

2) The second plan maintained the status at the beginning 1980's and decreased adult education proportion in total

education system. The results are: (1) the rate of student getting into senior middle schools maintains at 37.5 percent;

(2) the university student in schools maintains 76,100;

(3) the proportion of the educated up to 12 years to total laborers maintains around 32 percent.

(3) The last one was designed by comparing with the education level of USA in 1978. The results are: (1) the rate of student getting into senior middle schools reaches 99 percent in 1990 and 100 percent in 2000; (2) the university student in schools reaches 205.7 per ten-thousand in 1990 and 488 in 2000; (3) the laborer educated up to 12 years makes up 90 percent of the total social laborers in 2000. Under the same environment, the simulation results of three different plans were compared with each other. The difference was not obvious at the beginning (1980-1984), and the longer the simulation time, the more obvious the differences among these results.

Figure 7. shows one of the simulation result, while the first plan was put into the model, in which more than ten variables were included, such as, local total population, total social laborer, gross national product, national income, proportions of education expense to total expense and national income, social productivity, average year wage per capita, the educated years of laborer, university student per ten-thousand person, and so on.

1.	1100	1150	1200	1250	1300
2.	725	735	745	755	765
3.	0	1000	2000	3000	4000
4.	0	500	1000	1500	2000
5.	13	14.5	16	17.5	19
6.	0	2	4	6	8
7.	0	10000	20000	30000	40000
8.	0	50	100	150	200
9.	7	8	9	10	11
10.	0	500	1000	1500	2000

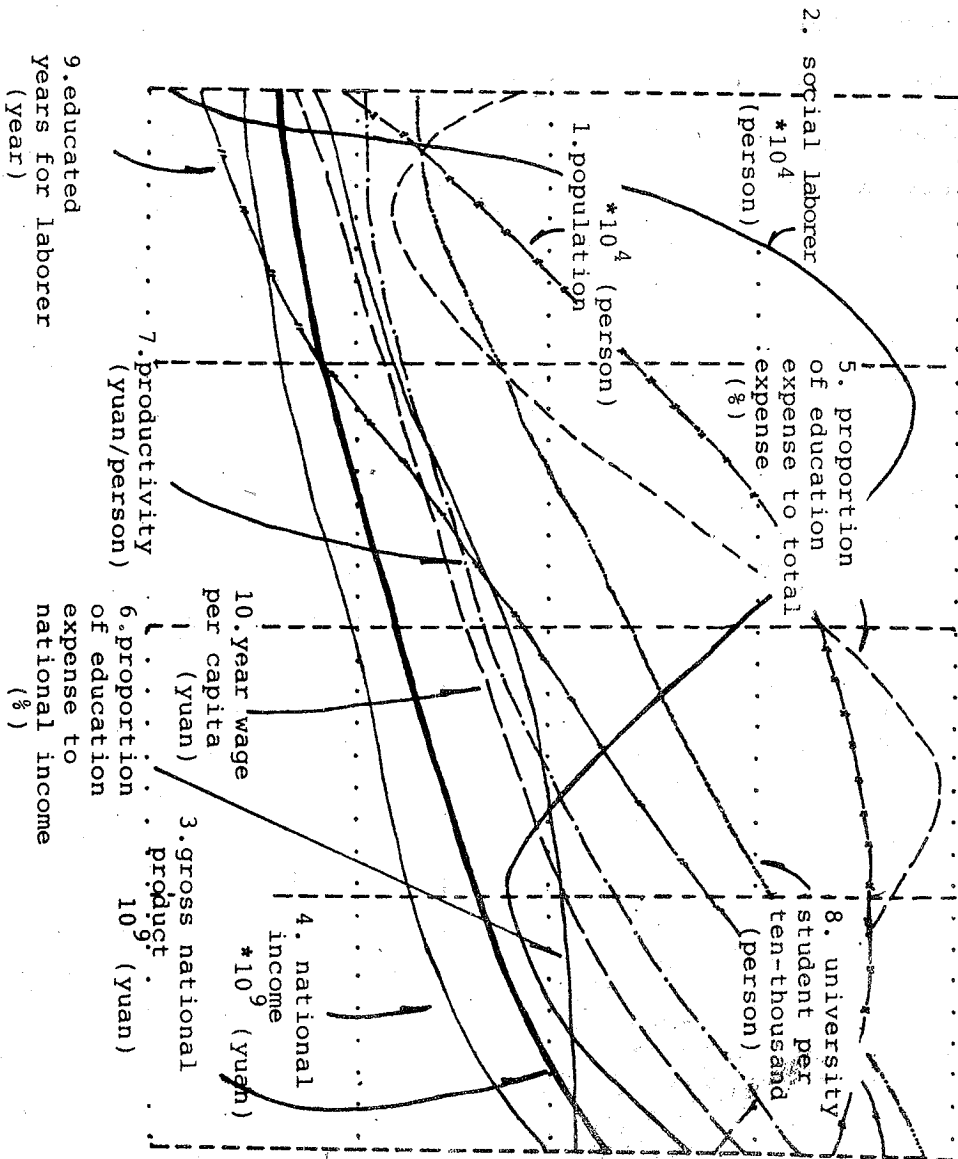


Figure 7. The general behavior of the model

Figure 8 shows another comparing result of three plans on the economic benefit of education investment, where X axis expresses local total education expense, and Y axis expresses local national income. Among three plans, the first plan has best economic benefit than others whether in 1990 or 2000 although the third plan is related with greatest education investment than others and the first is greater than the second, which proved a basic principle in education economic theory by using the quantity analysis method: when education investment suit the needs of the social-economic environment, national income increases along with the increase of education investment, after that goes beyond a limit, national income decreases along with increase of education investment.

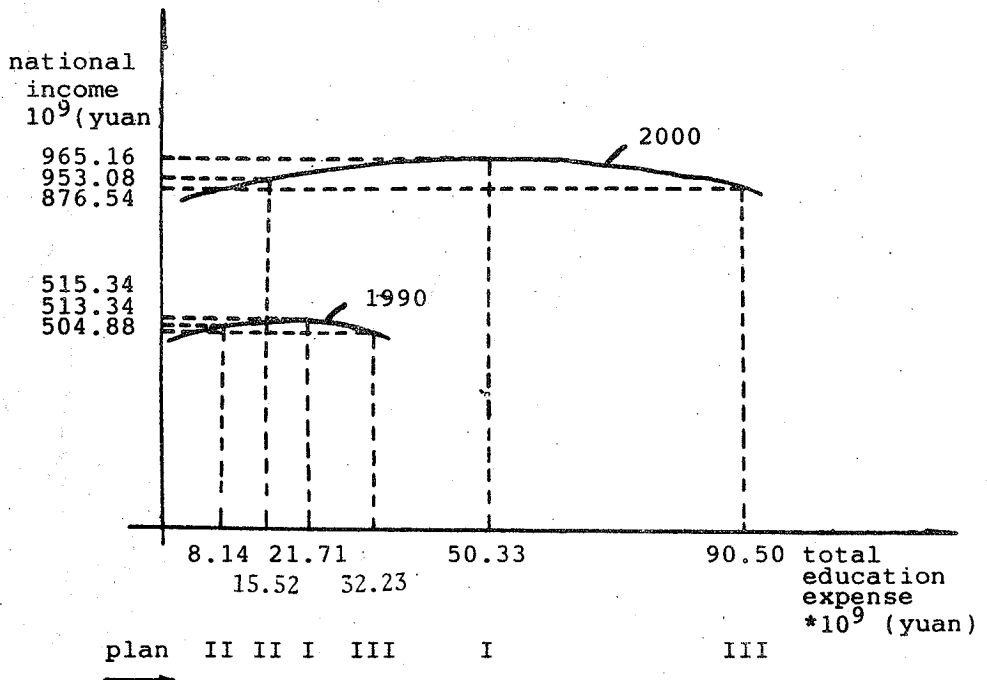


Figure8. The economic benefit of the education investment.

Of course, the economic benefit is only one side of the social benefit of education investment. Except this, the model also computes a set of social-economic indexes for analysing these plans as shown in figure 9.. No plan, according to the data in Figure 9., is always better or worse in all indexes than others, hence there is a multi-object decision making problem. However, the disparities are so great among these plans that the first plan is most appropriate than others can be found by simply comparing with these indexes.

Using the model's data, the contribution of local education development to economic development in Shanghai also could be evaluated, which is useful to appraise three plans too. If the first plan were used to develop Shanghai's education, the contribution of local education development to economic development between 1986 to 1990, 1991 to 1995, 1996 to 2000 would be 21%, 19.5% and 14.15% respectively.

The LEDSPA model gives us rich data to analyse for any purpose. On the other hand, the data analysing is good for taking future steps to perfect the model. Owing to object limitations, there are some problems not discussed here, such as the right rate of the student staying at the locality to the student assigned to other parts of the country, the right distribution of social laborer with different educated years, and so on.

2000		1990		year	2000		1990		year
plans		items			plans		items		
I	6.29%	I	6.02%	average year increase rate of gross national product from 1980 to the year (%)	I	1:3.2	2.6	I	laborer educated 12 years or more : 9 to 12 years: 9 years or less
II	6.25%	II	5.09%		II	1:6.18:14.1	8.32	II	average educated years for laborer (year)
III	5.76%	III	5.8%		III	1:3.0 : 0.47	12.13	III	university student in school per ten thousand (person)
	31475		16665	social productivity (yuan/person)		189.5		18%	proportion of laborer in part-time education to total laborer (%)
	29925		16325			60.5		0.11%	population *10 ⁴ (yuan)
	1409.8		763.8	average year wage per laborer (yuan/person)		488.4		24%	gross national product *10 ⁹ (yuan)
	1454.0		776.1			26.2%		1228.2	national income *10 ⁹ (yuan)
	2376.5		1284.8	average year wage per laborer (yuan/person)		17.7%		504.88	revenue *10 ⁹ (yuan)
	2347.4		1279.9			0%		316.19	expenditure *10 ⁹ (yuan)
	2162.4		1259.5	proportion of education expense to the total expense (%)		1268.5		97.49	
	35.94%		18.37%			1271.9		98.24	
	8.58%		7.54%	proportion of education expense to national income (%)		1280.4			
	4.33%		3.5%			2368.1			
	1.35%		1.43%	total education expenditure *10 ⁹ (yuan)		2357.5			
	50.33		21.71			876.54			
	15.52		8.85	average year increase rate of fixed capital from 1980 to the year (%)		580.08			
	8.42%		8.72%			567.44			
	9.40%		9.47%	average year increase rate of total laborer resources from 1980 to the year (%)		530.07			
	5.92%		8.07%			223.98			
	2.20%		2.46%			223.99			
	1.17%		1.65%			209.24			
	2.61%		2.62%						

Figure 9. A set of social-economic indexes

4. CONCLUSION

Although the LEDSPA model still stays at the beginning, some conclusions, according to the dynamic results, have been obtained:

1) One must pay great attention to the long-term dynamic study in the process of working up the local education development plan, since, judging by the bahavier of model, the differences in the social-economic system are not obvious for the different plans in a short period, which is in cope with the realization about the long education cycle.

2) The development speed in education must keep in step with the increasing speed in economic in order to form a good cycle in the social-economic system. developing in higher or lower speed is harmful for education. According to model's economic benefit analysis, both plan (2) (in lower speed) and plan (3) (in higher speed) in Shanghai's education are disadvantageous for resent years. The author thinks that the following speed in Shanghai's education could be considered:

items	rate (%)		year	
	1980-1990	1990-2000	1980-1990	1990-2000
Average increase year rate of student in higher schools	about 6.9	about 4.5		
Average increase year rate of student in adult part-time higher school	about 9	about 3.7		
Average increase year rate of student in adult part-time senior middle school	about 14	about 3.5		
Average increase year rate of student in adult part-time education under senior middle school	about 26	about -4.9		
The rate getting into full-time senior middle school	about 72.5	about 93		

3) The model behavior analysis show the contribution of local education development to economic increase were 18.92 percent. If Shanghai education were developed by the speed suggested in 2), the contribution could maintain at 19% for next ten years.

4) The analysis about laborer educated level shows that the adult part-time education shall be taken with great attention. If we only develop the full-time education without adult part-time education, the situation that the laborer's educated level is very low along with a very large population will not be changed in expected speed. In addition, excessive investment on higher education will be harmful for the development of local education.

5) In the light of the analysis on the laborer structure, the plan should consider the steady increase of total local laborer resource (L'). All locality with richer laborer resource (L) is not the locality with richer total local laborer resource (L'). Although the laborer resource in Shanghai will decrease during the period of 1986 to 1995 according to the model forecast, the total local laborer resource would steadily increase if the first plan were used. The Situation of Shanghai labor forces sets an important basis for designing the speeds shown in 2), where the speed before 1990 is greater than the speed after. Such study is very useful not only for education strategy but also for other development strategies.

Finally, we must say this model is only one among all kinds of mathematical or non-mathematical models in such research.

There still are many things waiting for us to do. The study on the field of local education development plans is a long term task. As a simulation model of real world, the LEDSPA model will be improved continuously while following the track of practice in working up education plans.

5. REFERENCES

1. Forrester, J. W., The Principles of Systems, MIT Press, Cambridges, Mass, 1969.
2. Xu Zi-yuan, The Method and technology of Forcasting in Humanpower, Shanghai Researchs in Higher Education, No. 8, 1983.