USING SYSTEM DYNAMICS METHOD TO ANALYSE AN ENTERPRISE

Professor Ching T. Yang
Management Shool of Shanghai Jiao Tong University

Ansheng Cao
Management School of Fudan University

ABSTRACT

This paper establishes a system dynamics model to analyse a dynamic productive procedure of an enterprise in Shanghai. The model consists of five sectors, order and supply sector, production sector, material sector, advertising sector and financial sector.

There are many products which the enterprise expects to produce, and in the model these products are transformed into two standard products according to the kind of products. The paper analyses the impacts of some soft factors, such as worker's quality, bonus, advertising etc., on the profit, and also the policy of purchasing materials. The model presents the strategy of how to work out plans between two standard products when the input surpasses the productive capacity of the enterprise.

The model is run by using real initial input values in 1985 and 1986. The results are very close to real situation of the enterprise. The sensitivity test shows that the model is insensitive. So it is adquate to consider that the model is reliable and can be used as basis for dicision making by managers.

I. Introduction

In China, nowadays, computers have been adopted to solve some individual departmental problems, such as finance, production, engineering, etc., but never been tried to analyse an entire enterprise. Lately, the introduction of System Dynamics approach has made possible the structure of a system to be analysed with simulation modeling process. But as long as the manufacturing system of an enterprise, although small as compared with an urban system, is very complicate and many important variables, such as worker's quality, stimulus of bonus, effect of advertising, can not be quantified, managers still prefer to organize production by

their own experience and intuition due to lack of the knowledge of interdependence of factors among and within the different departments.

Thanks to the advancement of System Dynamics disciplines, the knowledge of generic structures has enabled us to construct high-quality models with the aid of Stella Software and Apple Macintosh hardware. This paper, first of its kind in China, attempted to use the generic process to analyse an entire enterprise, has chosen the Shanghai Wireless 16th Factory as the studying object. In the following, table 1 shows the 1985 and 1986 production census.

	1985(RMB)		1986(RMB)	
	product 1	product 2	product 1	product 2
sale's value	5,130,000	19,800,000	5,130,000	19,840,000
material cost	2,900,000	5,100,000	2,600,000	4,400,000
expenditure	1,420,000	5,580,000	1,420,000	5,580,000
interest for loan	199,000	360,650	440,000	773,000
profit	611,000	8,760,000	670,000	9,187,000
total profit	9,371,000		9,857,000	

Tab.1: 1985 and 1986 production census of the factory

The aims of this model are as follows:

1. Completely simulate the whole production.
2. Examine influence of some variables on profit.
3. Analyse the policy of purchasing material.
4. Examine the influence of different assignment of workers between two standard products on profit.

The boundary of the model consists of production of the whole factory. As our production is still mainly organised on planned economy, marketing is not considered and customer's order is put as input for the model. However, with the deeping open policy and present well organised market, it becomes necessary to take into consideration marketing in the model as well.

II. The Structure of the Model

Fig.2 presents the structure of the model.

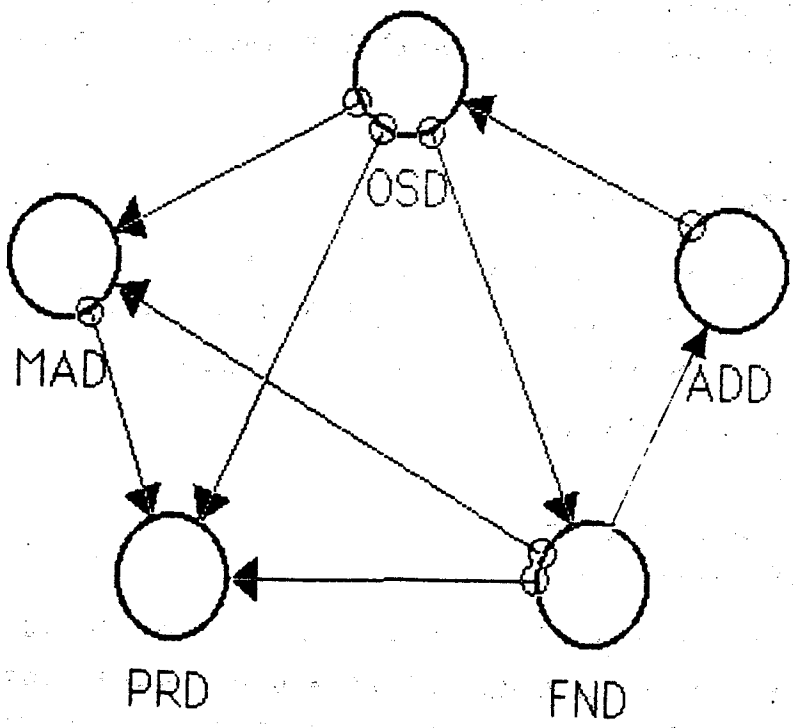

Fig.2: the structure of the model

Order and supply department(O&SD): mainly concerning the input order, inventory of finished products, delivery, and production instruction to production department.
Production department: mainly concerning how workshops receive instruction from O&SD, and organise production.
Material department: concerning how materials are purchased according to customer's order.
Financial department: computing costs, profit, expenditure, sale's value.
Advertising department: concerning how to make advertising.

There are two kinds of product in the enterprise and there exists great difference in cost, profit, input order between the two products. So we use two standard products in the model. This makes the model more complicate and computing works increased. The results from the model, however, are very close to the actual finding, and therefore more useful for manager's decision making.

III. The Testing Process

The model is run by 1985's and 1986's actual input data, NINPUT1=$3.95*10^4$(unit/week), NINPUT2=$9.6*10^5$ (unit/week). The results are showed in Fig.3.

INTRST: interest for loan
PROFIT: total profit
TOCOST: total material cost
TOVAL: total sale's value

Fig.3 shows that the profit slows down at time 26,52, 78(week). This is because materials are purchased once half a year. The factory puts a lot of money in purchasing materials at time 26,52,78 and it makes profit declining.

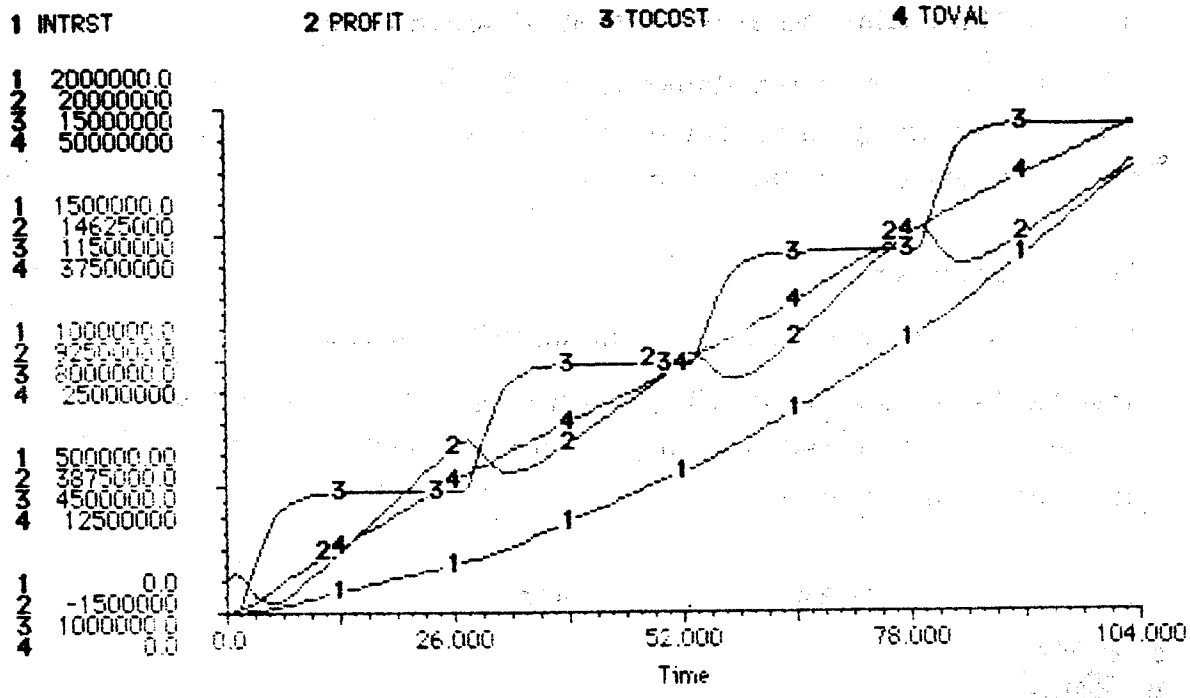

Fig.3 the results from the model by 1985 and 1986 actual input data

Tab. 4 gives the results from the model compared with the actual value.

	1985(RMB)		1986(RMB)	
	actual data	results from the model	actual data	results from the model
sale's value	24,930,000	24,494,684	24,970,000	24,304,800
material cost	8,000,000	7,854,857	7,000,000	6,624,800
interest for loan	559,650	555,414	1,215,000	1,217,658
profit	9,371,000	9,200,634	9,857,000	9,462,300

Tab.4: results from the model compared with actual finding

We see that the results are much coincident.

The sensitivity test shows that the model is insensitive, assuring that the model is reliable and can be used as basis for decision making.

IV. Policy Analysis

1. To examine the material purchasing policy

Now let's assume that the materials are purchased once a month, NINPUT1=$3.95*10^4$, NINPUT2=$9.6*10^5$. Fig.5 presents the results.

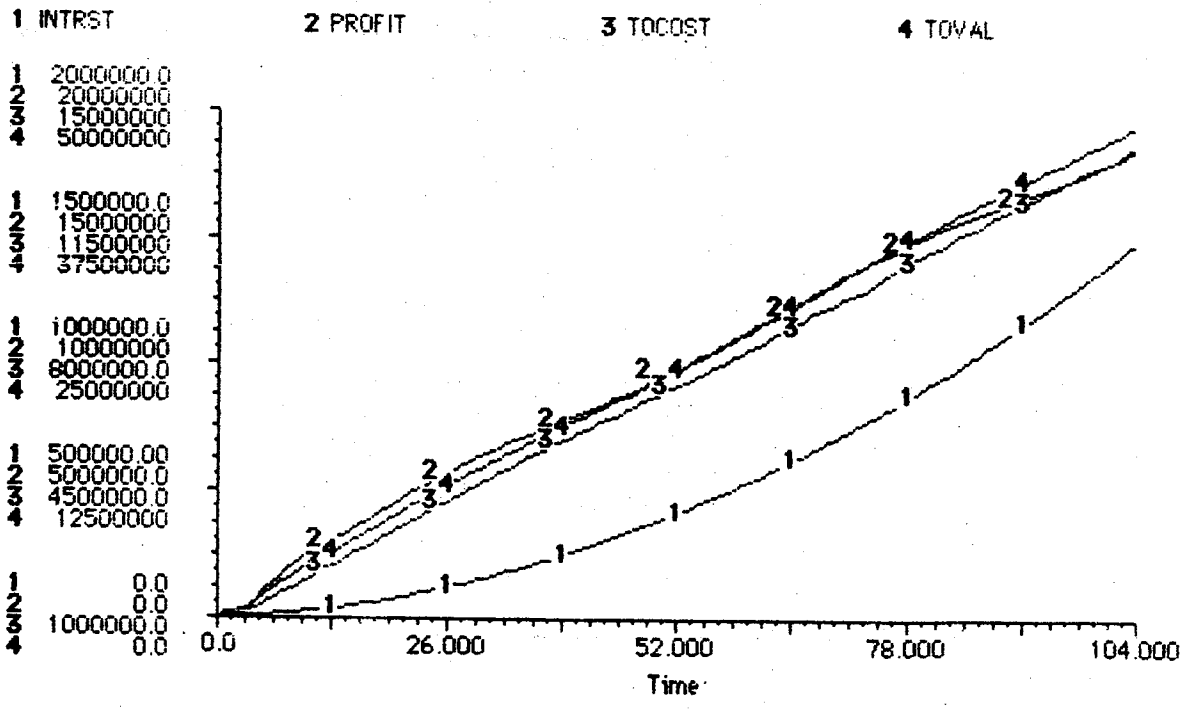

Fig.5: the results of changed material purchasing policy

It shows that the profit is smoother than that in Fig.3. The total interest is RMB 1,494,309 and total material cost is RMB 14,043,024, lower respectively than that in Fig.3. The profit is 18,500,000 which is RMB 700,000 higher than that in Fig.3. So it can be better off if we chose the material purchasing policy

once a month.

2. Effects of raising average productivity per man (APRPM)

Now let's assume NINPUT1=$7*10^4$, NINPUT2=$2*10^6$, and APRPM raises 10%, the results are showed in Fig.6.

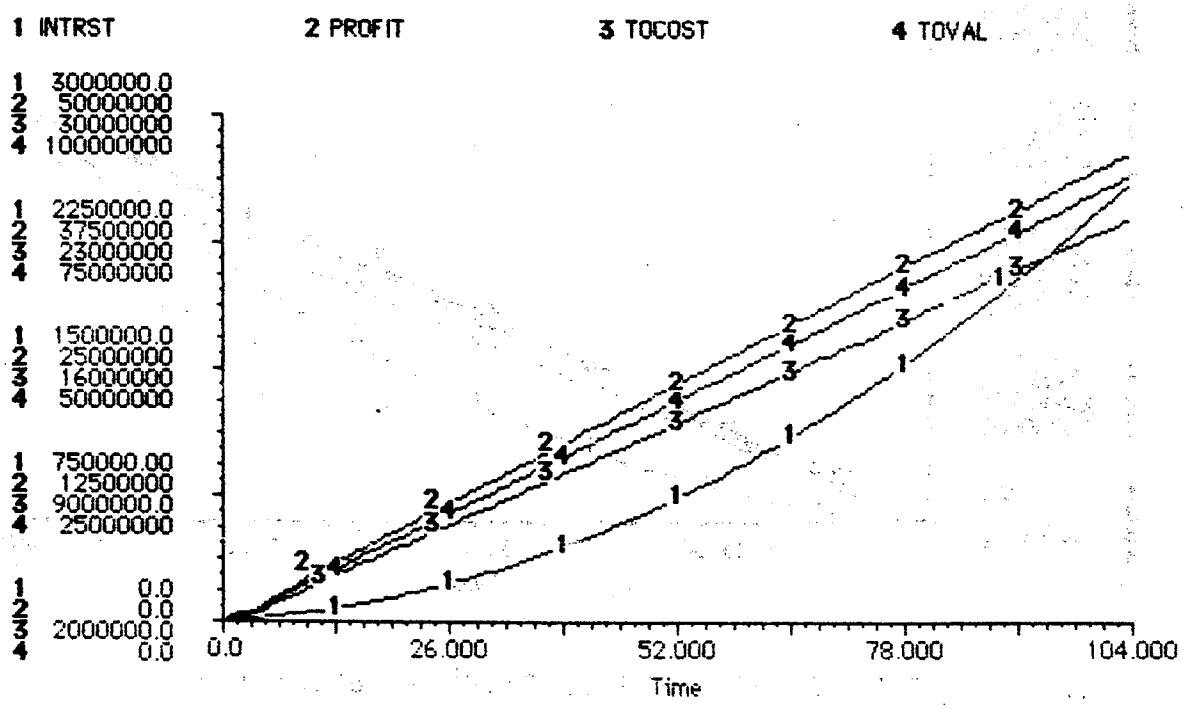

Fig.6: NINPUT1=$7*10^4$, NINPUT2=$2*10^6$, APRPM raises 10%

The end of second year, INTRST=2,616,028, PROFIT=41,244,496, TOCOST=24,478,038, TOVAL=83,123,736.

3. Effects of seeking the equilibrium between two standard products

Let NINPUT1=$7*10^4$, NINPUT2=$2*10^6$. At this time, input exceeds the capacity of the factory's production. The value of desired labour for product 1(DL1) adding desired labour for product 2(DL2) must exceed the maxium labour(MAL). The actual input labour for product 1 (AIL1) and for product 2(AIL2) are now defined as

follows:

AIL1=MAL*DL1/(DL1+DL2), AIL2=MAL*DL2/(DL1+DL2)

The results are showed in Fig.7.

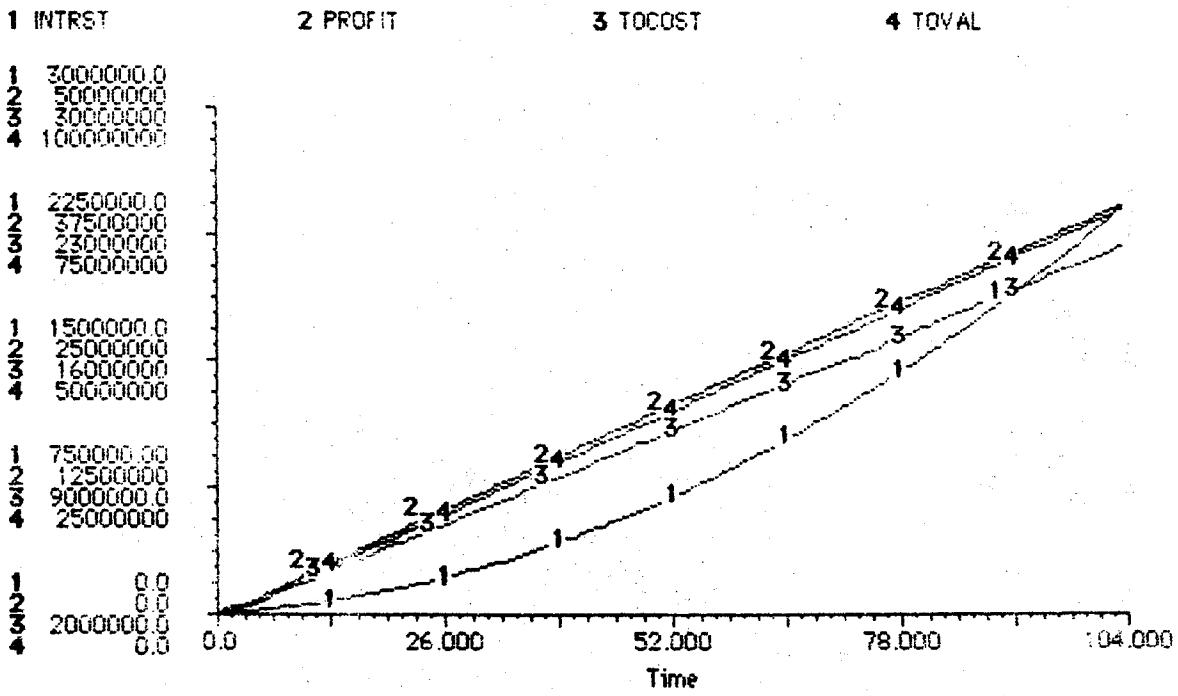

Fig.7: NINPUT1=$7*10^4$, NINPUT2=$2*10^6$, seeking the equilibrium between two standard products

INTRST=2,434,119, PROFIT=35,933,384, TOCOST=22,534,534
TOVAL=75,687,216.

4. Effects of seeking maxium profit

Because the two kinds of product have different profits, we can assign workers with priority to produce the product which has higher profit. Let NINPUT1=$7*10^4$, NINPUT2=$2*10^6$, the results are as shown in Fig.8.
INTRST=2,755,570, PROFIT=44,820,124, TOCOST=25,689,838,
TOVAL=88,050,712.

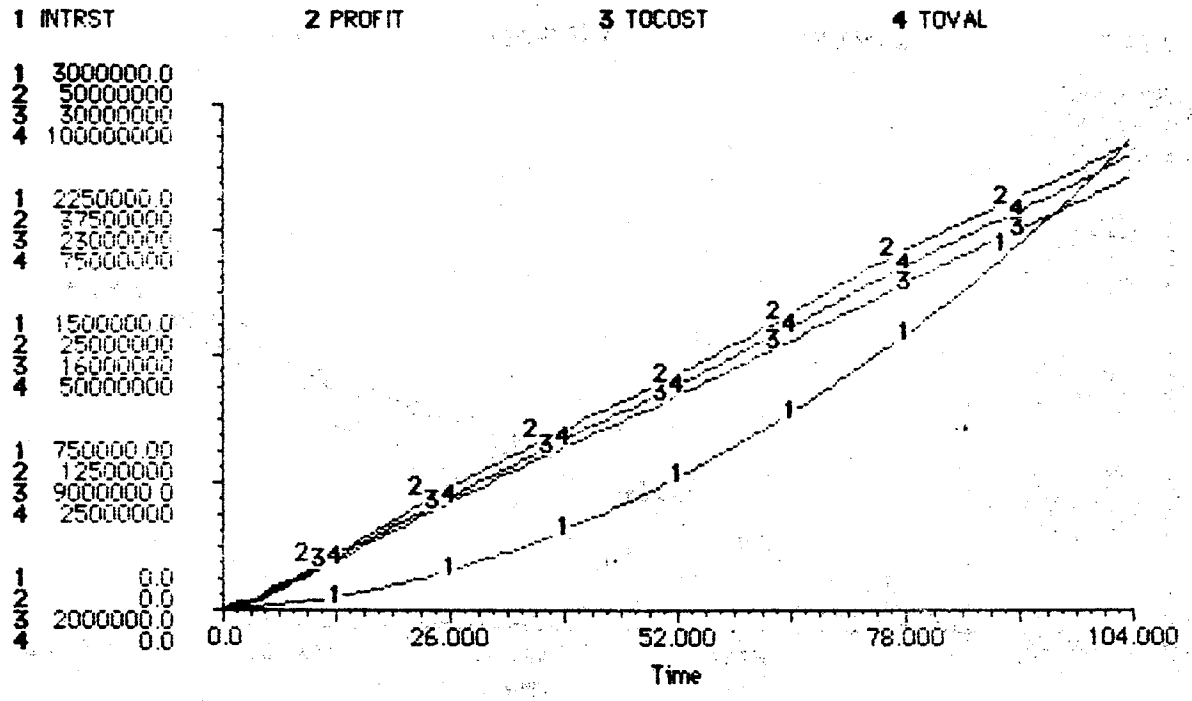

Fig.8: NINPUT1=$7*10^4$, NINPUT2=$2*10^6$, seeking maxium profit

5. Effects of seeking minium cost

If there goes short of capital, the manager's first choice will be making cost minium. So now the workers are first put in producing the product which has lower cost. NINPUT1=$7*10^4$, NINPUT2=$2*10^6$. The results are presented in Fig.9.

INTRST=2,180,858, PROFIT=27,357,354, TOCOST=19,824,566 TOVAL=64,147,956.

Now let's list different results together in Tab.10. We have the following plans(the inputs to every plan are NINPUT1=$7*10^4$, NINPUT2=$2*10^6$):

Plan 1 stands for raising APRPM 10%.

Plan 2 stands for seeking the equilibrium between two standard products.

Plan 3 stands for seeking maxium profit.

Plan 4 stands for seeking minium cost.

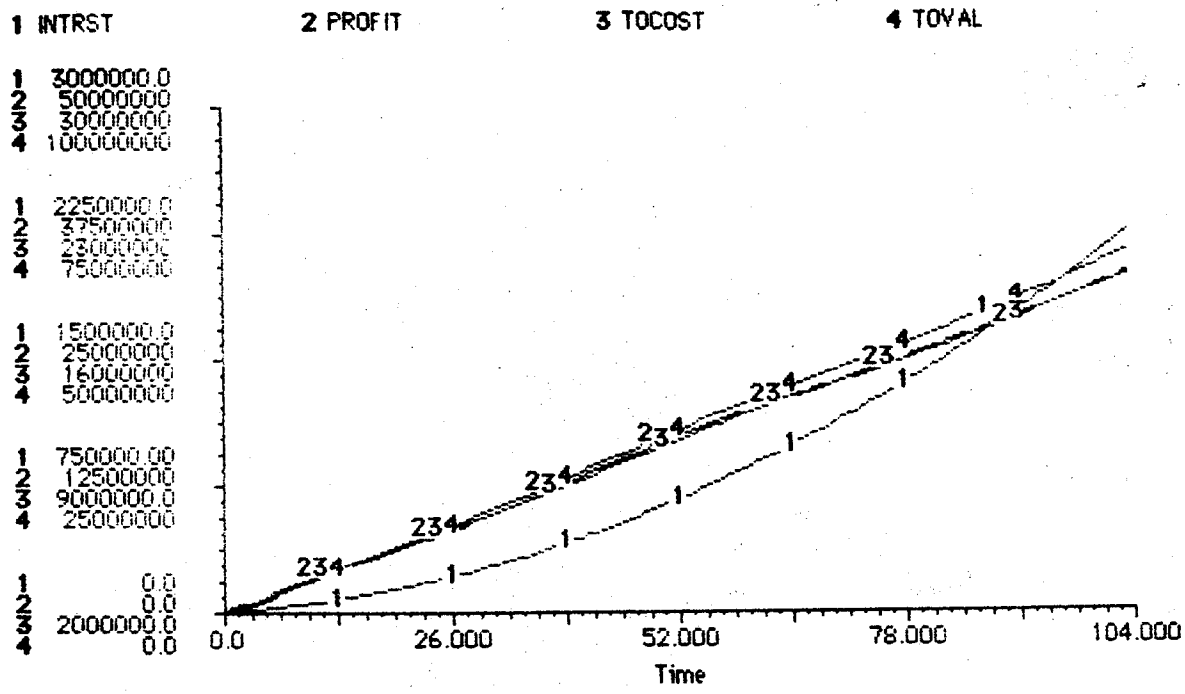

Fig.9: NINPUT1=$7*10^4$, NINPUT2=$2*10^6$, seeking minium cost

	INTRST(RMB)	PROFIT(RMB)	TOCOST(RMB)	TOVAL(RMB)
Plan 1	2,616,028	41,244,496	24,478,038	83.123,736
Plan 2	2,434,119	35,933,384	22,534,534	75,687,216
Plan 3	2,755,570	44,820,124	25,689,838	88,050,712
Plan 4	2,180,858	27,357,354	19,824,566	64,147,956

Tab.10: lists of different plan

The decision maker can chose any one of the four plans according to his own seeking aim.

If the manager has enough capital and wants to seek maxium profit, he will chose plan 3; if he has not

enough capital, he may chose plan 4; if he considers the firm's fame is important (it might be awkward if only one product is produced), he will chose plan 2; if the manager considers firm fame, and making more profit, whereas raising APRPM is possible, he will chose plan 1 as long as the profit minus the cost for raising APRPM is still greater than profit in plan 2.

6. Conclusion

Without lengthy description, we would like to conclude that the model thus developed is suitable and helpful for a manager to run best the business for an entire enterprise.

Reference:

1. Principles of System, Jay W. Forrester

2. Industrial Dynamics, Jay W. Forrester

3. STELLA for Business, HIGH PERFORMANCE SYSTEMS,Inc.