A MODEL OF SYSTEM DYNAMICS ON FACTORY MANAGEMENT

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ABSTRACT

This paper constructs a system dynamics model which simulates the behavior and the structure of a large radio appliance factory administered by government department in China. Because the factory present focus is orders unfilled and profits reduced, we carry out several policy experiments on the model. The experimental results show that if the factory manager will add sales expense properly and adjust product price in time, orders and profits will been increased to higher level. In addition, the model exposes that there are lack of management systems and policies in state enterprises of China, these problems limit their development.

Input data of the model come from the database of the management information system of the factory. Data are transmitted quickly and accurately. The model is provided with good dynamic state and applied conveniently.

1. INTRODUCTION

There are state enterprises being in a new situation of change and competition in China. Previously, the state enterprises were demend only to completing annual production plan assigned by administration department of government, but now they are required to make their responses to market demand for increasing profits.

Because above-mentioned change have taken place, Beijing State-run Third Radio Appliances Factory which is one of sizeable state interprises is faced with a serious test. The 1986's profits of the factory is not enough of half of the 1985's profits. The primary reason is orders unfilled in 1986. It is seen that the original management systems and policies are not appropriate for new situation and the managers needs to change them.

This paper constructs a model of system dynamics on factory management which is based upon the actual system of Beijing State-run Third Radio Appliances Factory. We carry out simulating operation and experimentation on the model in order to research the factory's management and development and suggest decision basis to the factory's managers. The model name is abbreviated to 'SDFM' .

2. THE STRUCTURE OF SDFM MODEL

There are products structure of variety in the Beijing State-run Third Radio Appliances Factory. Then SDFM model is a multiple product model which is used for researching whole factory system or a single product system. Seeing that the operation of every product system is possessed of the same mechanism, we may describe the operation with a similar structure. Whole factory model is formed by adding these similar structures of all products to gathered part and it contains approximately 1,400 equitions.

For convenience of analysing structure and function of SDFM model, a substitute of whole model is represented by a single product part adding gathered part.

SDFM model consists of several sectors including market and sale, production, financial management and equipment facility sector. The sectors are interconnected by coupling of variables and these interactios of variables construct the feedback structure of SDFM model.

Figure 1 gives a simplified causal-loop diagram of such a factory management model, formaleted using the method of system dynamics. Here backeted i is a product number in the factory. In figure 1, the system consists of five major feedback loops including two positive loops and three negative loops.

The positive loops are;

(1) orders(i)→+backlog(i)→+product output(i)→+delivery(i)→+ income(i)→+total income→+total profit→+investment(i)→+equipment quality(i)→+ product quality(i)→ + credit(i) →+market share(i)→ +orders(i)

(2)product output(i)→+delivery(i)→+income(i)→+total income→ +total profit→+investment(i)→+equipment quantity(i)→+production capacity(i)→+product output(i)

The negative loops are;

(1) order(i)→+backlog(i)→+date of delivery(i)→-credit(i)→+ market share(i)→+orders(i)

(2) orders(i)→+backlog(i)→-increasing sales demand(i)→+total sales expenses→+increasing orders(i)→+orders(i)

(3) total profit→+investment(i)→+ equipment quantity(i)→+

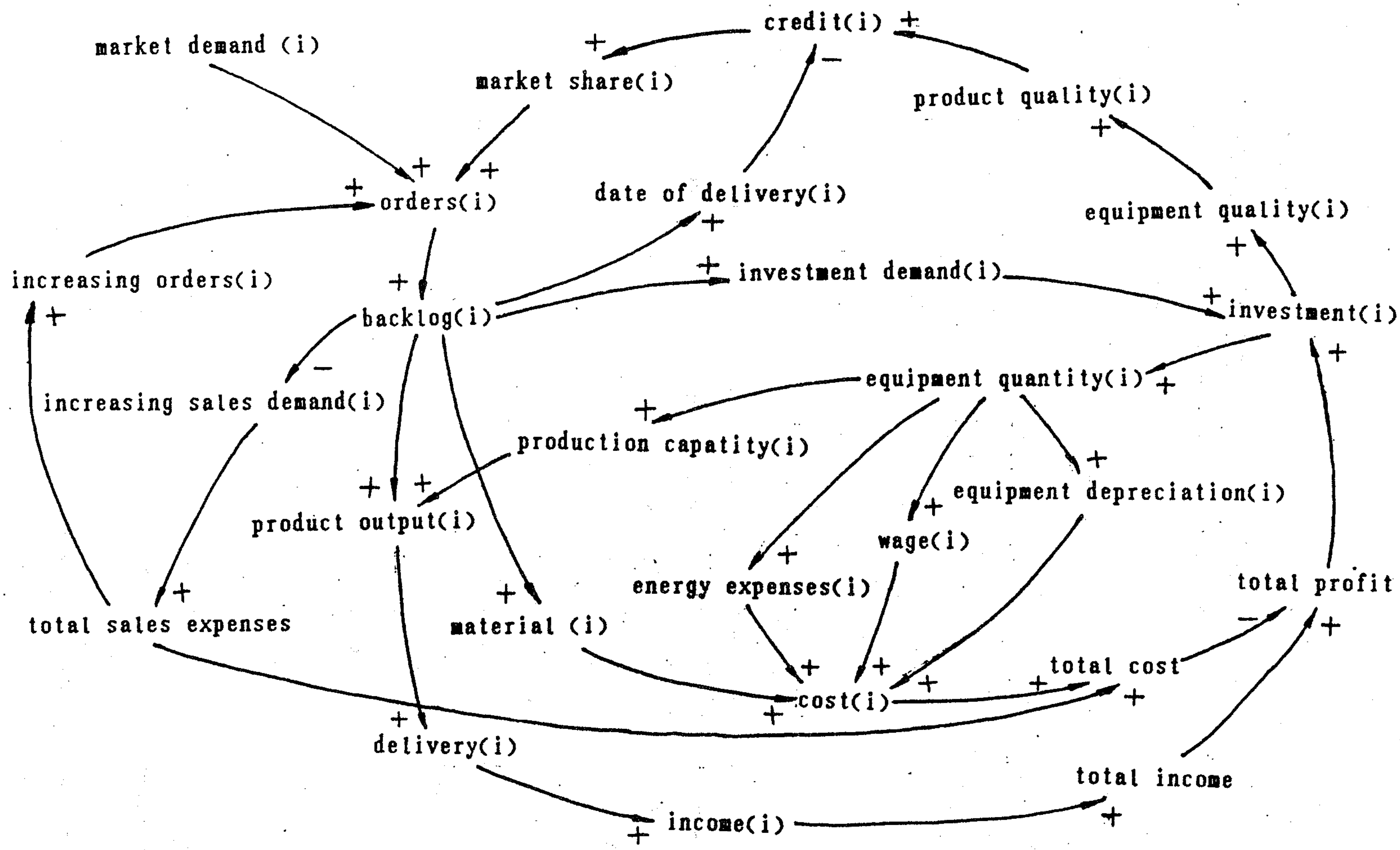

Fig.1. The major feedback loops of the model

$$\left(\begin{array}{l}\text{equipment depreciation(i)}\\ \text{wage(i)}\\ \text{energy expenses(i)}\end{array}\right)$$

→+cost(i)→+total cost→- total profit

While orders are filled, the two positive loops (1) and (2) form good circles which raise production of factory continuously. But in progress of the loops, the increase of production capacity must conform to the increse of orders. In production capacity unfilled, the negative loop ① will restrict production development. In production capacity exceeded, the negative loop (3) will restrict production development. While orders are unfilled, the action of the negative loop (2) could ease their bad influence off.

3. HISTORICAL SYSTEM

The 1986's operation of Beijing State-run Third Radio Appliances Factory has been simulated on SDFM model. Several main output variables such as orders, product output, sales income, cost, profit correspond with the actual date, and their maximum error rate is less than ±8 per cent. It follows that the simulation model is valid.

In the systme operation, value of sales expenses is given zero and the negative feedback loop (2) is on a interrupted state. The system hadn't had approuches to compensate for a loss of orders unfilled so that this state was continued to end of the year. Actually, the factory manager whose idea was influenced by previous management policy almost hadn't paid sales expenses. In addition, the factory manager couldn't invest more money in production because enterprise investment fund had been administrated by government department. From a view of the factory system itself, the positive feedback loops (1) and (2) are interrupted in most conditions. Then, close circle structure haven't been formed on factory management. There is lack of dynamic force on the factory development.Therefore, it is very important increasing factory right of self-control and changing management systems and policies. These changes will form and strengthen factory's own feedback structure according to the principles of system dynamics.

4. POLICY EXPERIMENTS

The structure of SDFM model exposes interaction of demand and supply clearly on factory management in the situation of change. We carry out several policy experiments on the model in order to find approaches of relaxing the tension of orders unfilled and increasing the factory's profits.

The main results of the experiments are as follows;

1) adding sales expenses

We made the policy simulation of adding sales expenses on the model.The action of sales expenses cause orders to increase through a factor of effect. The factor of effect which is a function of the variables including expected orders and surplus market demand is evoluated by statistics and experience. From the experiment result, if sales expenses are increased to a degree which could satisfy demand of increasing sales, orders and profits will been incrased to higher levels. Curves of orders and profits changes which are caused by adding sales expenses are plotted on figure 2 and figure 3.

Figure 2 displays the state change of orders unfilled. Before

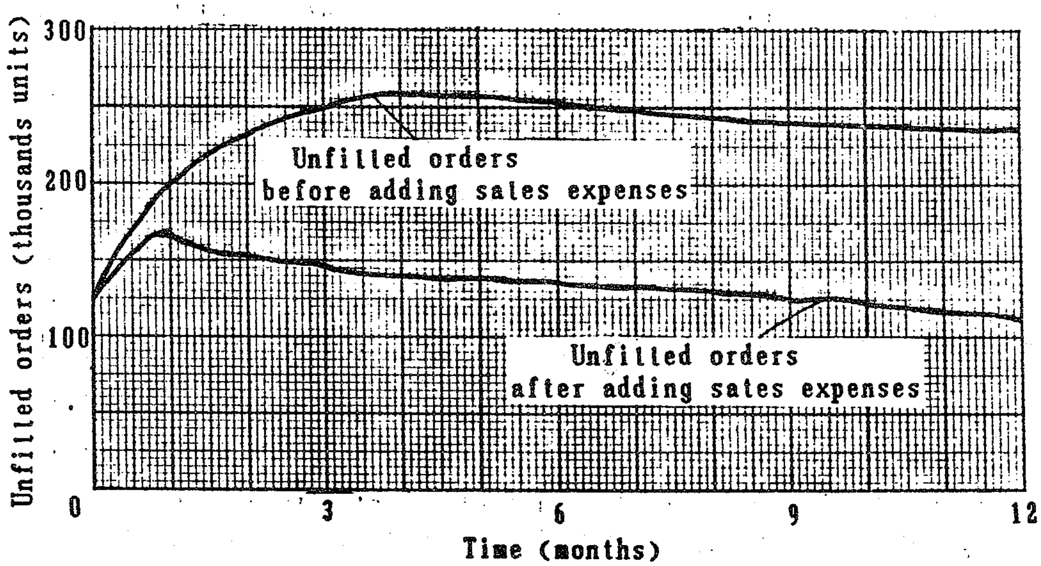

Fig. 2. The effects of adding sales expenses on unfilled orders amount

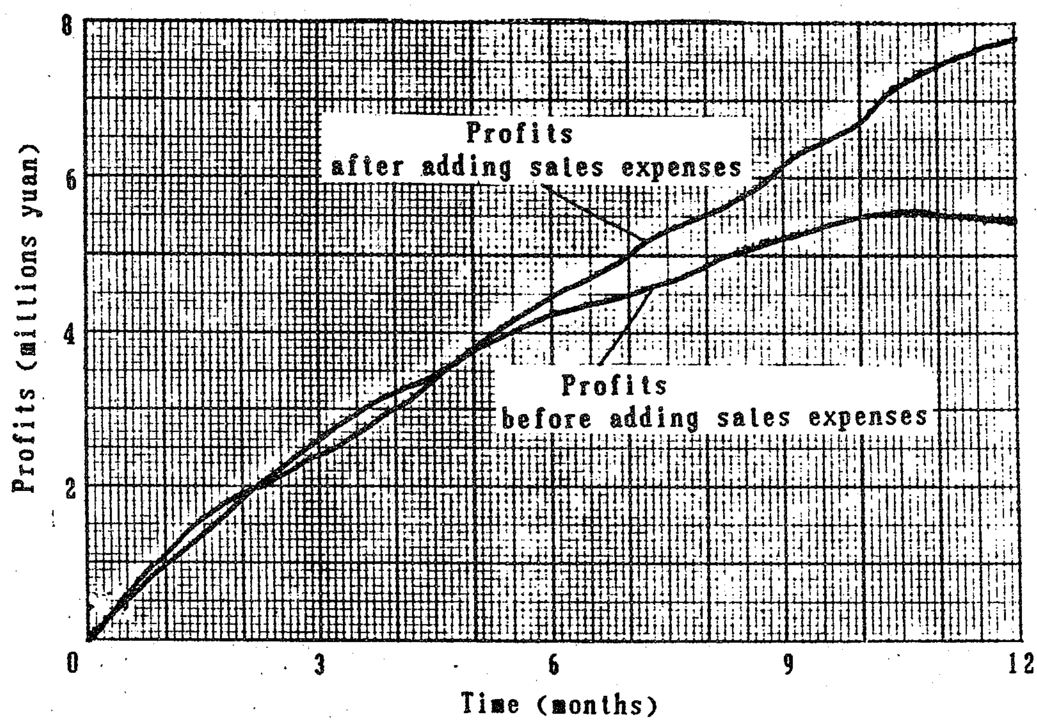

Fig. 3. The effects of adding sales expenses on profits

adding sales expenses, unfilled orders amount was raised to 257 thousands units quickly and was kept in that level. After adding sales expenses, unfilled orders amount is decreased continuously and the state of orders unfilled is relaxed.

Figure 3 displays the change of profits. Before adding sales expenses, final profits were about5.4millions yuan. After adding sales expenses, final profits increse to about 7.8 millions yuan, but sales expenses only add to about 180 thousands yuan.

The conclusion is that we may adopt the approuch of adding sales expenses for the purpose of increasing orders and profits.

2) adjusting product price

According to the general law of change in quantity demanded, if product price is reduced, quantity demanded would be increased but whether producer's profits would be increased isn't certain. Therefore, the questions are in what condition and how many range price reduction is advantageous to increasing both orders and profits. The price reduction experments are made on SDFM model and they are involvod in the interactions of price reduction, market share and profits.

Because different oproducts have different market shares, they need to make the experiments separately. It is found that the profits of the product which is in the higher rate of original market share will decreasw after prise reduction, but the profits of the product which is in the lower rate of original market share could increase after prise reduction. This result is appropriate to the facts of Beijing State-run Third Radio Appliances Factory on which the product in the higher rate of market share is usually good saleable and the product in the lower rate of market share is mostly dull of sale.

The factory's managers provided with two strategy of price reduction. One is that the price is reduced by 5 per cent in equal difference each season and is indicated by 'I' . The other is that the price is reduced by 10 per cent once at beginning and is indicated by 'II' .

Figure 4 displays the profits change of the product which have higher rate of market share (=0.12) in above-mentioned two different strategy of price reduction. It is seen that the final profits (curves I and II) have lower values than original profits (curve 0).

Figure 5 displays the profits change of the product which is dull of sales in lower rate of market share (=0.084). To adopt the strategy 'I' reducing price 5% every season makes the profits value increase by 34 per cent and the result is seen by comparing curve I with curve 0. But, if the range of reduced price is less than 15 per cent, the price reduction couldn't make the final profits change and curve II describes the result which is caused by the strategy 'II' reducing price 10% once at beginning.

3) investment in product quality

We choose the approuch enlarging investment in improving product quality for increading market share. But on conditions of three different investment strength in product quality the changes of market share isn't obvious and is shown on figure 6. It is explained that the approuch don't bring about the effect of action in short term because time delay from investment to market share is

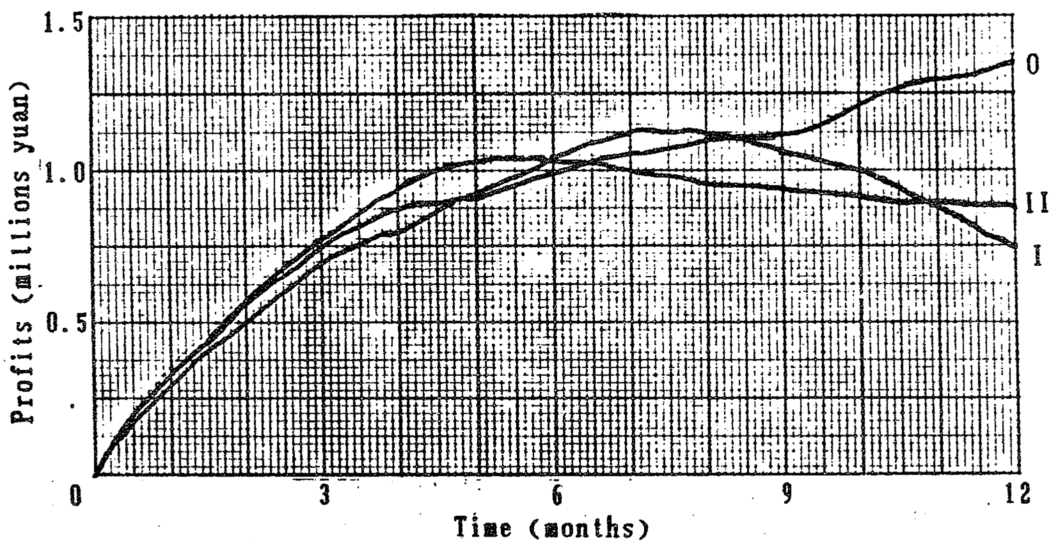

Fig.4. The effects of product reduction in higher rate of market share (=0.12)
Curve 0 ········· Original profits.
Curve I ········· The profits of price reduced by 5% each season
Curve II········· the profits of price reduced by 10% once at beginning

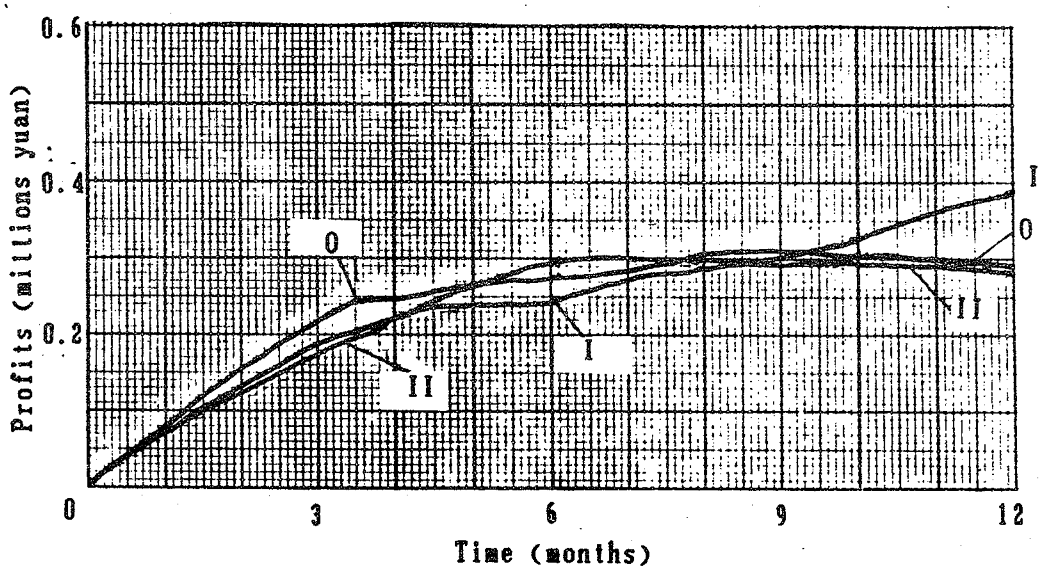

Fig.5. The effects of price reduction in lower rate of market share (=0.084)
Curve 0 ········· Original profits
Curve I ········· The profits of price reduced by 5% each season
Curve II ·········The profits of price reduced by 10%once at beginning

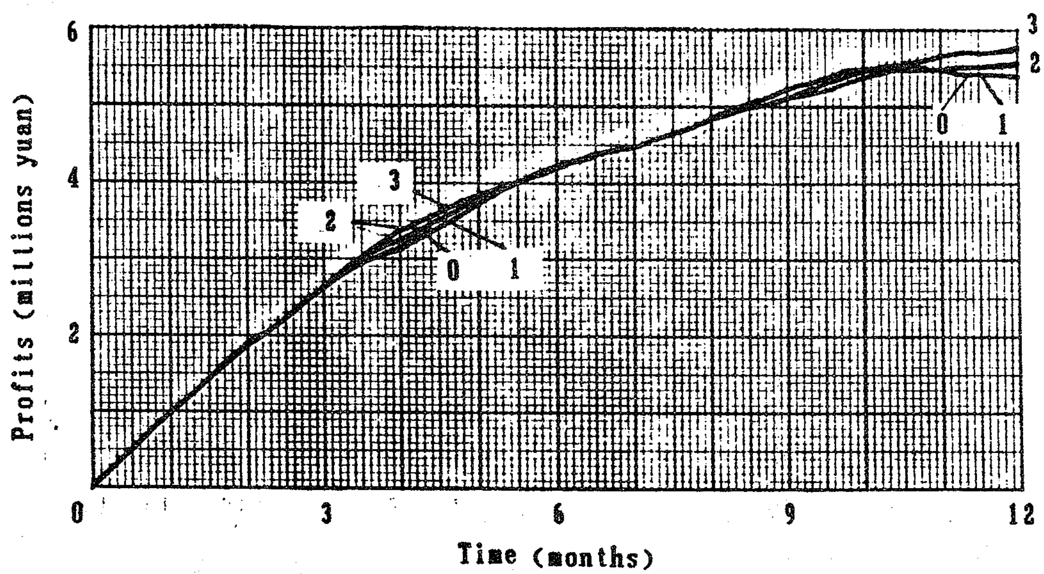

Fig.6. The effects of investment in product quality on profits
Curve 0 ……… Original profits
Curve 1, 2, 3……… The profits on 3 different investment strength

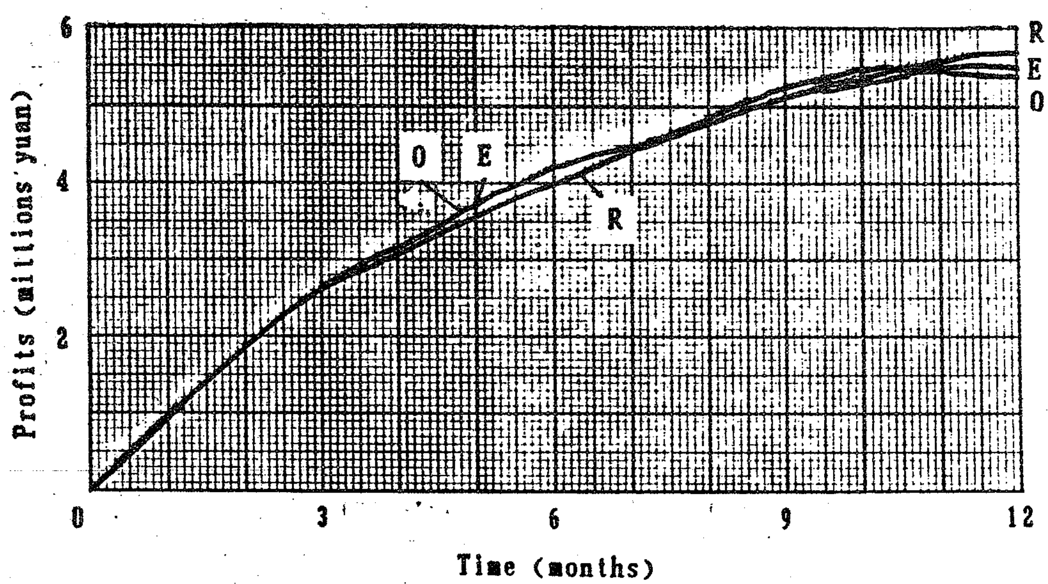

Fig.7. The effects of cost reduction on profits
Curve 0 ……… Original profits
Curve R ……… The profits on reject rate reduced
Curve E ……… The profits on energy use reduced

longer.

4) cost reduction

There are many approuches of cost reduction. For instance, reject rate is reduced by increasing quality control expenses, energy use is reduced by investment in energy conservation, etc. The tests results indicate that their effect to profits rise is very small in short term. Two curves on figure 7 display these small profit changes.

Here other strategy such as adjust inventory which could decrease liquid fund but haven't influence on profits are not discribed one by one.

5. OTHER CHARACTERISTIC OF SDFM MODOL

The model is connecting with the factory's management information system and pick out data from the central database of the management information system through a data index program. This ensure that input data are transmitted quickly and accurately. After the model is constructed, it will follow the factory's actual system in dynamic change and its parameters are adjusted every month. Then, the simulation results of SDFM model may provided many new decision information for the managers of the factory.

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