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SYSTEM DYNAMICS AS A SUPPORT FOR CASH MANAGEMENT EXPERT SYSTEMS

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INTRODUCTION

The following is meant to be an example of the combination of an Expert System (XPS) and a System Dynamics (SD) model in which the farreaching effects of cash management decisions in a complex system of feedback relationships in a company are illustrated.

The great advantage in proceeding this way is to use the results of an Expert System as constants and initials in a System Dynamics model. That means, that the user is enabled to study the results of a static Expert System in a dynamic model.

The mentioned System Dynamics model is created on the background of an ancillary supplier for the car industry. Rather to simulate the real system in a very detailed way the model reduces this real system to the main areas of the company. As in this paper the point of main emphasis is to demonstrate a possible way of linkage of the two systems a short problem definition is followed by the description of the most important feedback-loops in causal-loop diagrams of the System Dynamic model. Subsequently the outcome of a model simulation with it's graphic and tabular results is to be analysed under the aspect of influence of constants and initials originating from the Expert System concerning cash management decisions.

PROBLEM DEFINITION

Expert Systems and System Dynamics models are two seperate and independent methods of structuring and supporting the taking of decisions. Budgeting and financial planing are two of the most important scopes of duty in a company to maintain a needed minimum of liquid resources in general and cash assets in particular. It is most obvious, that cash management decisions contain a great potential of influence on every area of the company. Differentiated by the urgency of financial requirements the Expert System gives a number of proposals for a possible solution to unfavourable financial shortages. On the other hand investment proposals are made to reduce excess liquidity. In order to show the long-term influence of cash management decisions on the feedback formation a special software is necessary which stores the output information of the Expert System.

Before that data can be used as constants and initials in SD equations it has to be processed which means, that the numeric results of XPS have to be indicated to guarantee a correct attachment of proposed XPS decisions and the designations of SD constants.
This function can only be fulfilled if the structure of the SD model complies with the preconditions which were set in XPS, i.e. that every area of the company addressed by XPS decisions is assigned to a corresponding point of attachment in the SD model. As mentioned above both XPS and SD are independent methods for supporting decision making processes. Derived from that fact the necessity arises to verify both systems seperately. Nevertheless the Expert System will only be mentioned graphically to exemplify cash management decisions. The purpose of the following main part of the discourse is to describe the most important points of attachment within the outline conditions of the SD model and to examine the results of the simulation of different starting points.

E X P E R T   S Y S T E M   D E C I S I O N S

Changement of policy of credit raising (c xpsa) = 1E6

Changement of investment policy (c xpsb) = 1

Changement of credit line (c xpsc) = 1E6

Changement of disinvestment (c xpsd) = 0

Changement of personnel policy (c xpse) = 0

Changement of stockkeeping limits (c xpsf) = 1000

Changement of credit repayment policy (c xpsg) = 0.2

Fig. 1: Points of attachment

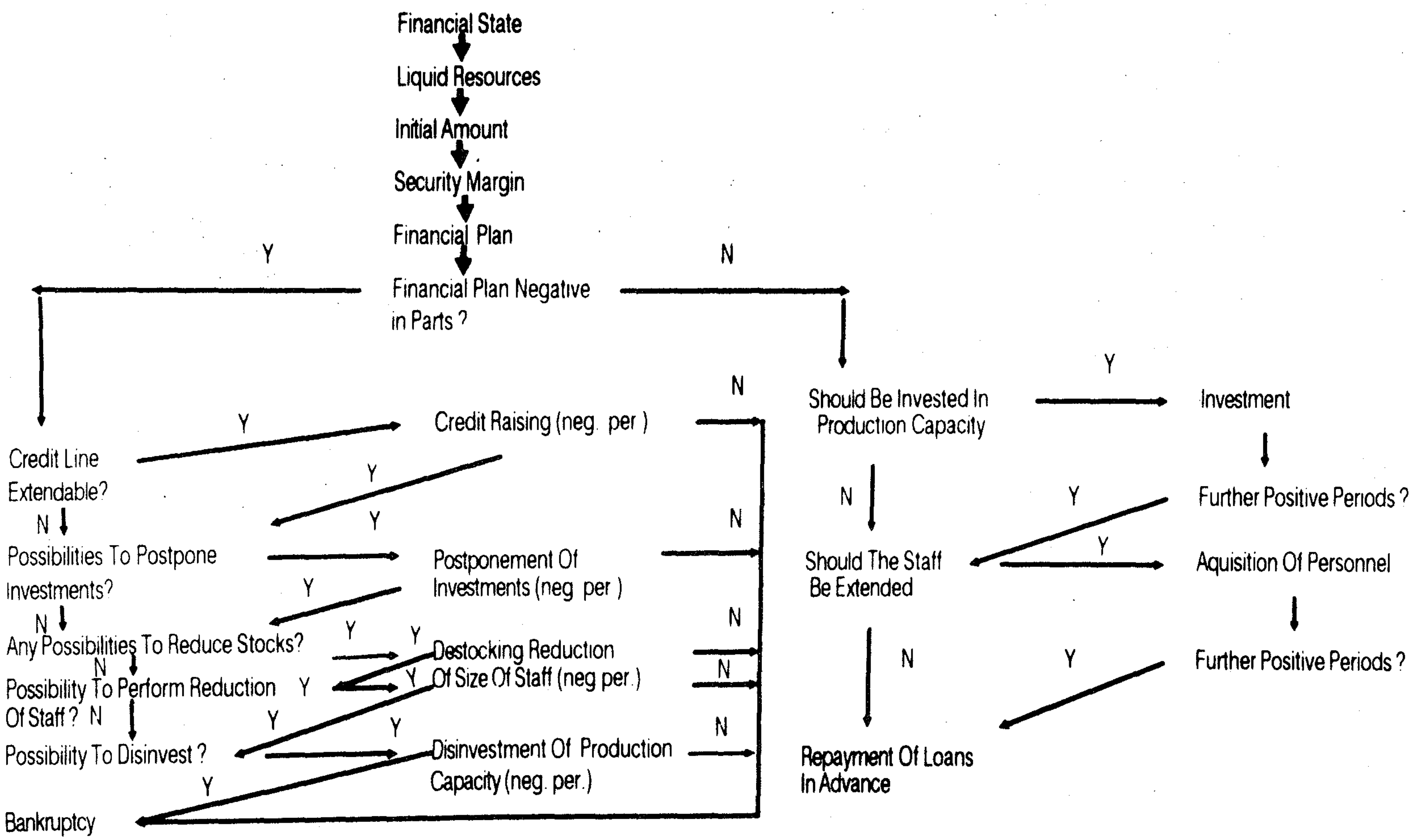

Fig. 2 : Decision Tree

THE MOST IMPORTANT FEEDBACK-LOOPS

The increasing monetary surplus of the period raises the net cash flow and the liquid resources. This influences the difference of liquid resources (dlm = lm - blm). A positive difference leads to an increasing amount of credit repayments. The total of loans and the total of capital decrease and diminish the costs of capital. In the event of a negative difference of liquid resources contributions (Fig. 3) and credit raisings (Fig. 4) will cover the lack. In both cases the capital in total will be raised by increasing equity capital and loans. The capital costs let the costs in total rise, the surplus of the period will descend.

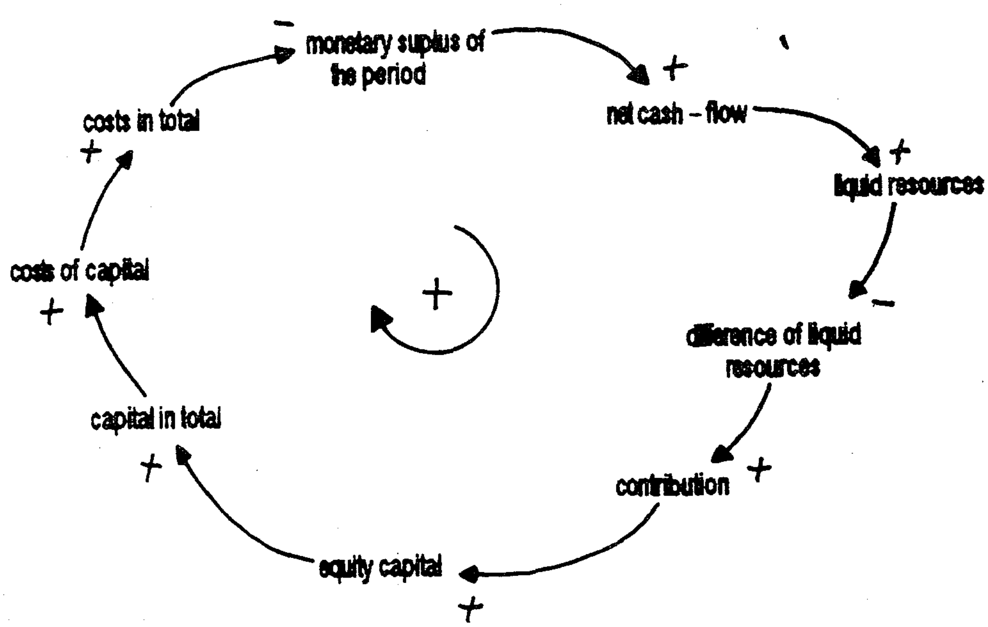

Fig. 3 : Liquid resource contribution loop

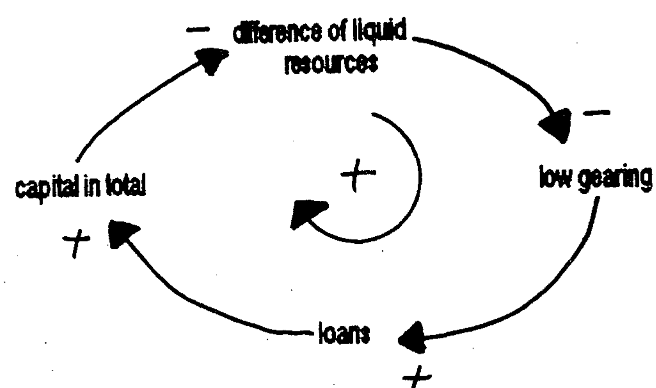

Fig. 4 : Credit raising loop

Investment increases the production capacities and here-with the needed staff. After a certain delay the number of employees will rise as well as the expenditures on personnel. The higher costs diminish the surplus of the period. As explained above this event has a diminishing influence on the capital in total and investment will be reduced. (Fig. 5)

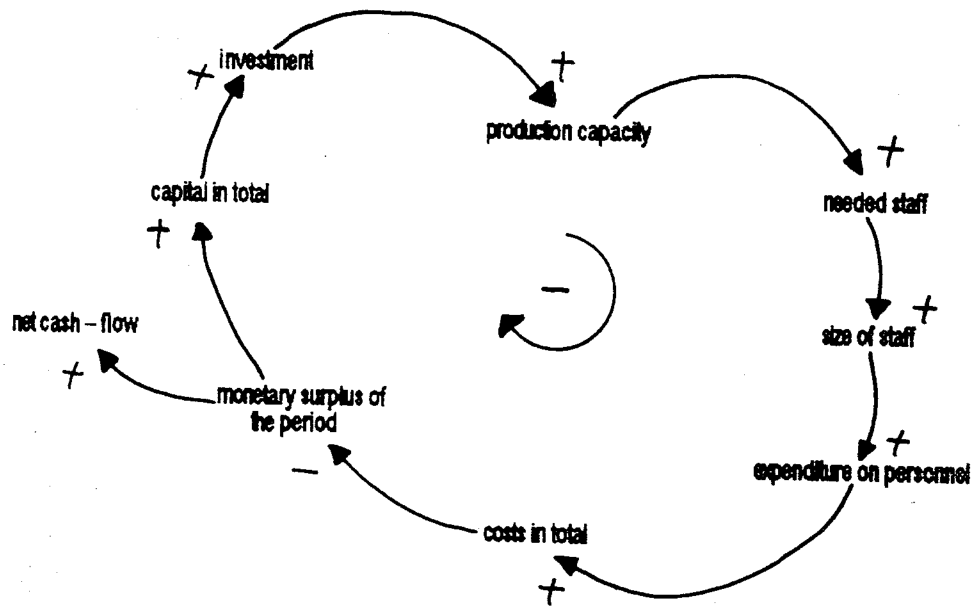

Fig. 5 : Investment effect loop

A second negative feedback loop can be built up starting with higher investment which extends the production capacity. The management is enabled to extend the production. In the same time the costs of production in total will increase and this implies higher costs in total. The monetary surplus decreases and initiates a growth of capital in total. (Fig. 6)

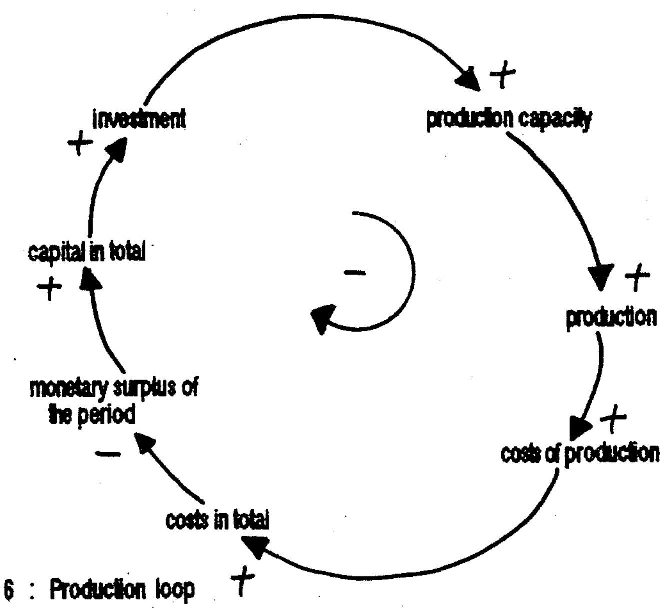

Fig. 6 : Production loop

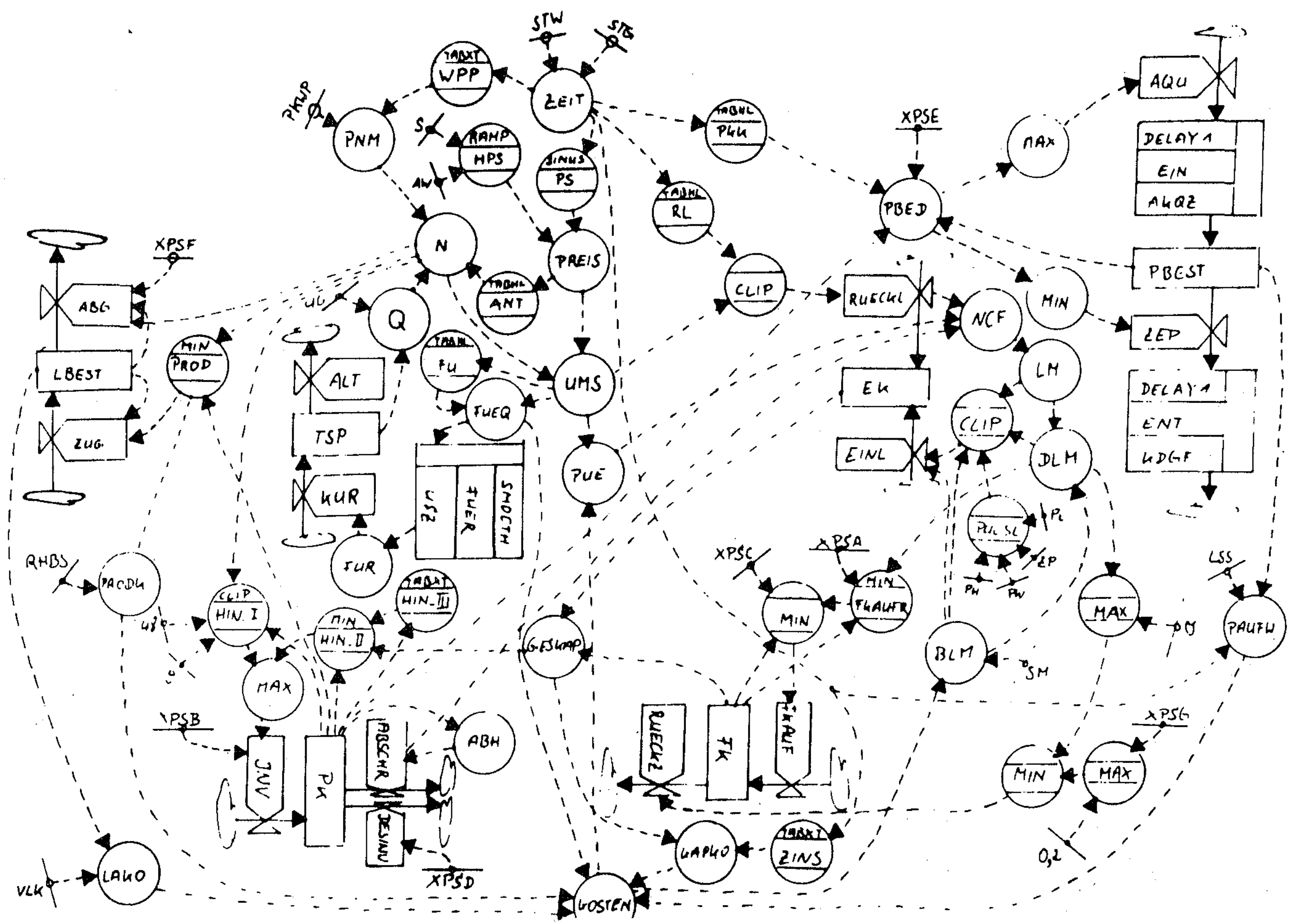

Fig. 7 : Flow chart

area of turnover and demand

pnm =potential demand bec. of changement of market conditions
wpp =increase of production
tw =table ref. pnm
prwp =production in thsd
zeit =period multiplier
stw =start of ramp-fkt. zeit
stg =slope of ramp-fkt. zeit
n =direct demand
ant =price influence on n.k
tant =table ref. tant
ums =turnover in thsd
preis=price per piece
ps =inflation
hps =aux. ref. ps
s =slope of ramp-fkt. hps
aw =start of ramp-fkt. hps

area of finances

pue =monetary surplus of the period
kosten=costs in total
kapko=costs of capital
zins =interest-rate credits
geskap=capital in total
paufw=expenditure on personnel
lss =Rate of wage increase
ek =equity capital
einl =contribution
ph =pulshight
pw =pulswidth
zp =period of first pulse
pi =pulsinterval
rueckl=reserve funds
rl =amounts for res. funds
ncf =net cash-flow
lm =liquid resources
blm =needed minimum of li.re
sm =security margin
dlm =difference of liqu.res.
fk =loans
fkauf=high gearing
fkaufr=rule for high gearing
rueckz=low gearing

points of attachment of XPS and SD

xpsa =ch. of policy of credit raising
xpsb =changement of investment policy
xpsc =changement of credit line
xpsd =changement of disinvestment
xpse =changement of personnel policy
xpsf =changement of stuckkeeping limit
xpsg =changement of credit repayment p.

product area

fueq =research & development quotient
fu =aux. ref. fueq
fuer =r & d rate
fur =aux. ref. fuer
usz =time for transposition
kur =rate of know-how transp
uv =1 - (loss in transp.)
tsp =technical state of prod
alt =product obsolescence
q =quality of products
ug =const. for conversion

area of prduction capacity

pk =production capacity
desinv=disinvestion rate
inv =rate of investions
hin_I=investment rule I
hin_II=investment rule II
hin_III=investment rule III
p =period
abschr=rate of depreciation
abh =aux. ref. abschr.
zk =time constant

area of personnel

pbed =needed staff
pkk =prod. cap. per employee
aqu =rate of aquisitions
ak =aux. ref. aqu
ein =rate of employment
pbest=size of staff
akqz =time for aquisition
zep =pers. to be discharged
ent =dischargements
kdgf =period od notice

area of stocks

lbest=stock of finished goods
prod =production
prodk=costs of production
rhbs =costs of material/piece
zug =stockpiling
abg =destocking
lako =costs of stockkeeping in total
vlk =costs of stockkeeping per unit

Fig. 8 : Explanation

SELECTED RESULTS OF SIMULATIONS

For understanding the results of the SD model it is necessary to explain the different kinds of possible decisions given by the Expert System and acting as constants in the SD model. In case of a negative amount of liquid resources five proposals are made to solve this problem. These are further loans (xpsa and xpsc), cancellation of proposed investments (xpsb), reducement of stockkeeping (xpsf), measures to decrease expenditures on personnel (xpse), and disinvestments (xpsd). On the other hand a number of proposals are given for the utilization of excess liquidity. Those are investments (xpsb), expanding the number of employees (xpse), repayment of loans (xpsg), and depositing money in time deposit accounts, which has been neglected in this model.

In the initial position the following values were set:
xpsa= 1000000
xpsb= 1
xpsc= 1000000
xpsd= 0
xpse= 0
xpsf= 1000
xpsg= 0.2

The results of the simulation can be drawn from the attached plots and verbal explanations.

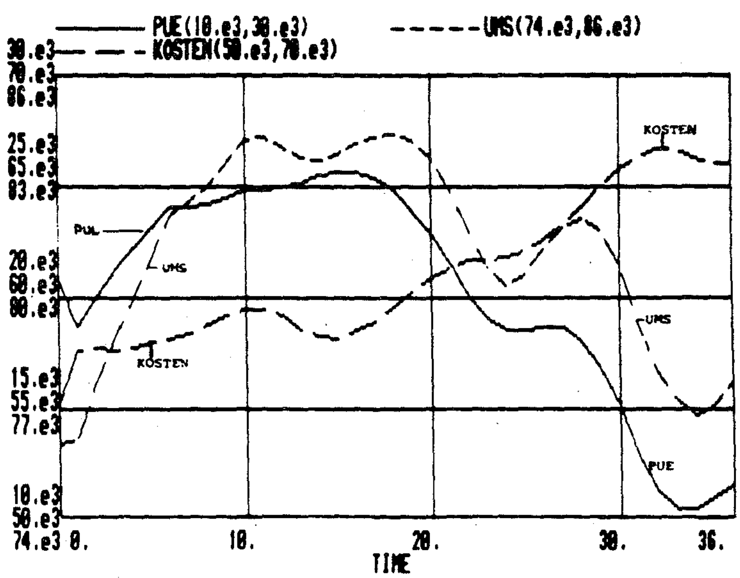

Fig. 9: Plot No.1

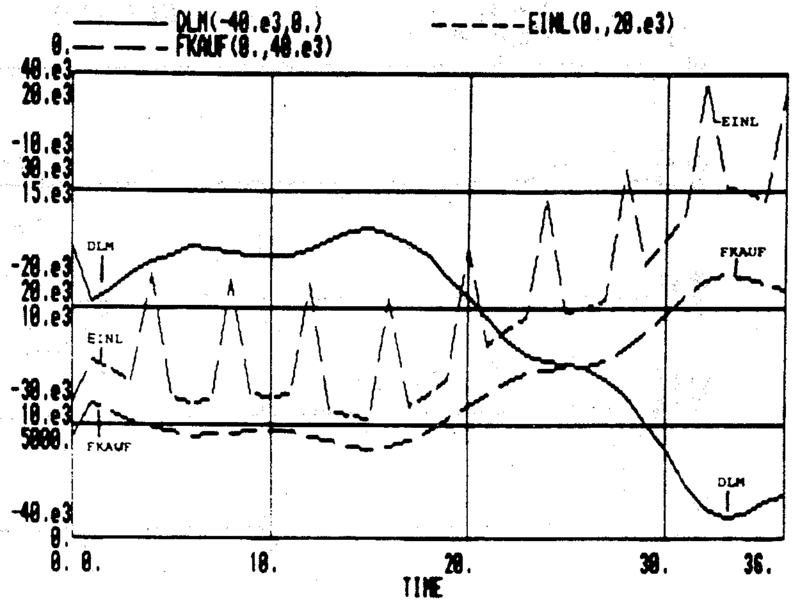

Fig. 10: Plot No.2

In the first scenario the value for investment policy (xpsb) has been changed to 1.1. This causes an additional amount of needed liquidy. There are no impacts on the turnover because only the direct demand and the price influence this variable. As well as investments raising the production capacity they do have an increasing impact on the number of needed employees. As can be seen on the plotted results of scenario No.1 the costs in total rise in the long run (from 55,23e3; 66,09e3 to 55,23e3; 76,3e3). Stocks stabilize at 5648 (former 5304). Number of staff rises from 4768 to 5495 all in period 36.

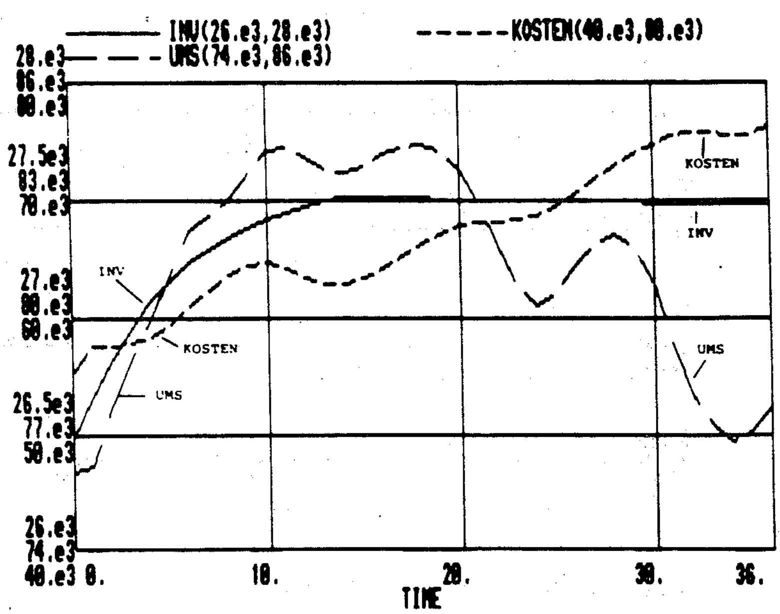

Fig. 11: Plot 1, Scenario 1

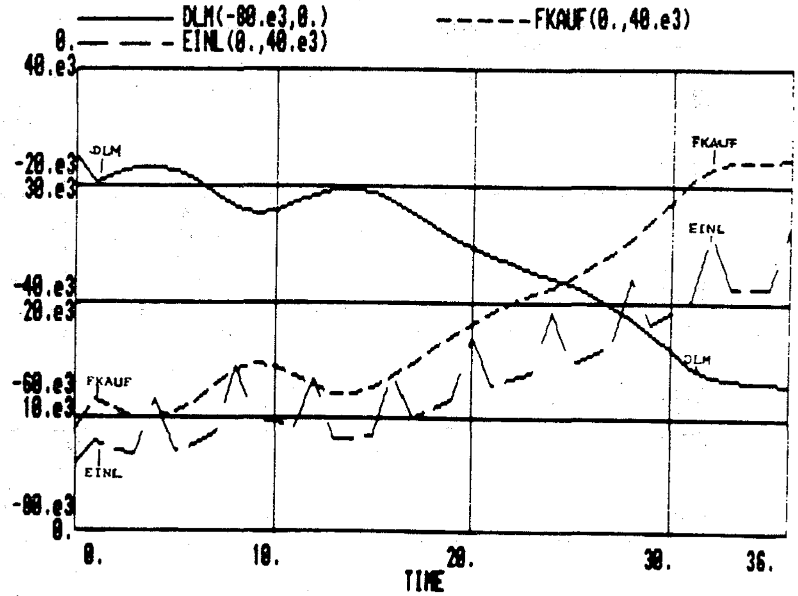

Fig. 12: Plot 2, Scenario 1

In the second scenario xpse (change of personnel policy) has been reduced (-200). This artificial reduction of staff leads to a decreasing amount of costs in the short run but gets almost compensated after bigger wavings until period 36. The production equals the one in the initial simulation from period 19 onwards, in the first 18 periods it is also characterized by greater wavings. The total amount of needed liquid resources as well as the surplus of the period exceed the ones from the original simulation.

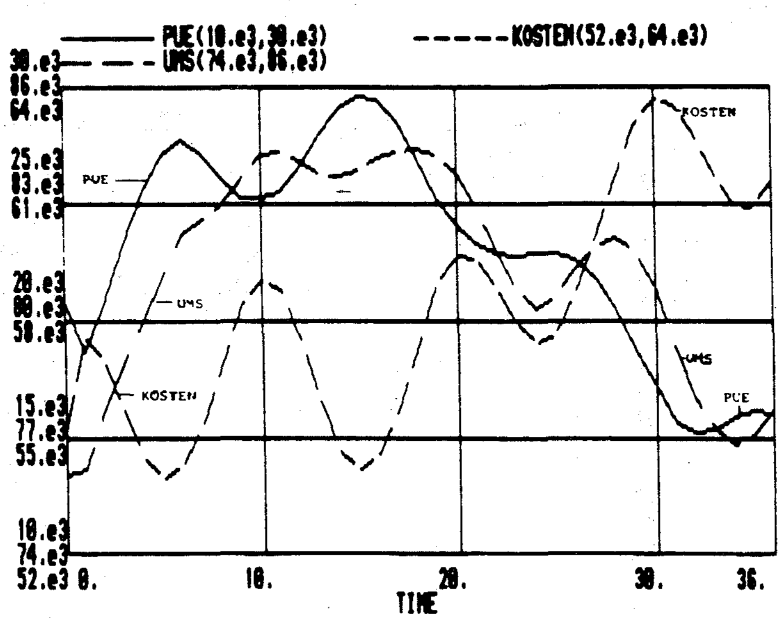

Fig. 13: Plot 1, Scenario 2

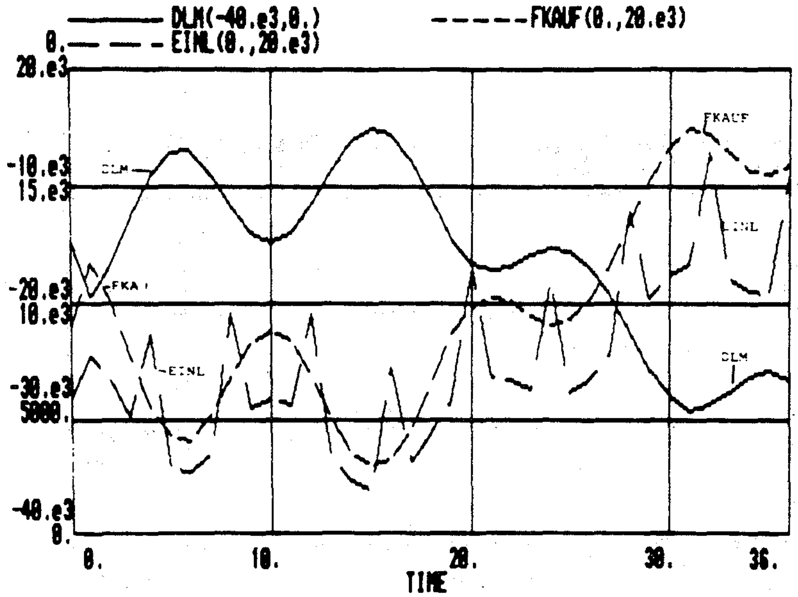

Fig. 14: Plot 2, Scenario 2

Scenario No. 3 illustrates the reduction of xpsf (stock-keeping) from the initial 1000 to a minimum of 10. This decision has no influence on the number of employees nor on the production capacity. The costs in total decline by the amount of stockkeeping costs. The needed liquid resources can be reduced by approximately 20 percent. The analyst should be aware of the fact, that this decision can only be pursued if a direct delivery of finished goods to the buyer can be guaranteed.

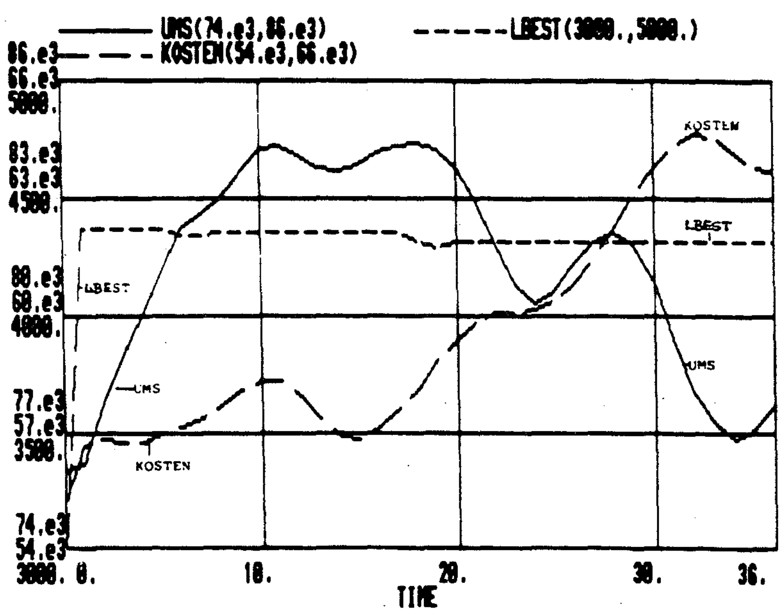

Fig. 15: Plot 1, Scenario 3

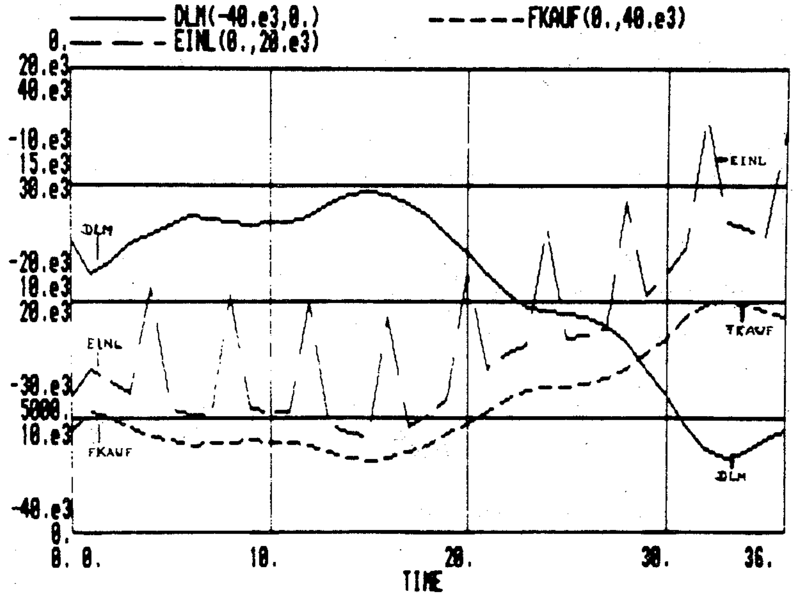

Fig. 16: Plot 2, Scenario 3