

Linking Balanced Scorecard to System Dynamics

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Abstract

A Balanced Scorecard is usually based on simple cause and effect relationships. Therefore it is not useful for success-oriented strategic controlling of an enterprises. In the paper it will be shown that cause and effect relationships of various elements described in the literature on the Balanced Scorecard are not suitable for an identification of measures to reach long-term financial success. With the help of system-dynamic causal-loop diagrams this objective could be reached.

A simple cause and effect relationship of some elements, which was taken from the standard work provided by NORTON and KAPLAN, will be used as the basis for the investigation. It will be transferred into a causal loop diagram, particularly in order to make the inadequacies of this concept more transparent. In a second step a system-dynamic model for a simple enterprise will be developed based on this causal-loop diagram. Finally, the comparison and evaluation of short and long-term developments of financial key figures is in the focus of the investigation.

It will be clearly shown that a measure can appear favorable or unfavorable in the short run, on a long-term basis, however, just the opposite effectuation appears. This issue has to be examined with each decision making concerning strategic measures derived from Balanced Scorecards.

1 Balanced Scorecard

The concept of the Balanced Scorecard by KAPLAN and NORTON has become very popular since its first publications came up in 1996. Numerous books and papers have been published by now which examine the concept and which emphasize the opportunities for a success-oriented enterprise control. In particular in the field of Management Accounting and Business Strategy the

concept was often introduced as a control instrument to many enterprises. But what is the reason for the fast spreading of the Balanced Scorecard in business practice? In a first step strategic objectives of an enterprise are easy to identify and to formulate. But how to integrate these strategic objectives to operational processes? What has to be done in the operational field to make sure that these objective will be achieved? Is there an opportunity to link operational measures with strategic objectives? A Balanced Scorecard is often considered as a new concept to translate strategies into operational action.

KAPLAN and NORTON define: "The Balanced Scorecard is a concept for motivating and measuring business unit performance. The Scorecard, with four perspectives -financial, customer, internal business processes, and learning and growth, provide a balanced picture of current operating performance as well as the drivers of future performance".¹

The core elements of a Balanced Scorecard are strategic success factors, which guarantee the survival of the whole enterprise as well as its financial success in the long run. It is particularly stressed out that the Balanced Scorecard does not represent a mathematical number system and no enterprise model. The substantial characteristics of a Balanced Scorecard lie on focusing and parallel illustration of four perspectives: a financial, a customer-oriented, a process oriented and an learn-/growth-oriented. In these perspectives all factors and significant elements which are relevant for the financial success are displayed in one chart.

Through these elements a strategy gets its operational expression. The core idea of a Balanced Scorecard consists of the fact that the financial success of an enterprise in the long run is determined by these factors only. An isolated view and maximization of financial elements lead to a neglect of other elements. In this case the risk of a long-term misguided policy rises.

The illustration of the perspectives of a Balanced Scorecard is given in a specific chart. With that control table the equal role of the four different perspectives is stressed. (fig. 1).²

¹ See Kaplan, R.S. / Norton, D.P. (1996).

² See Kaplan, R.S. / Norton, D.P. (1996, p.9).

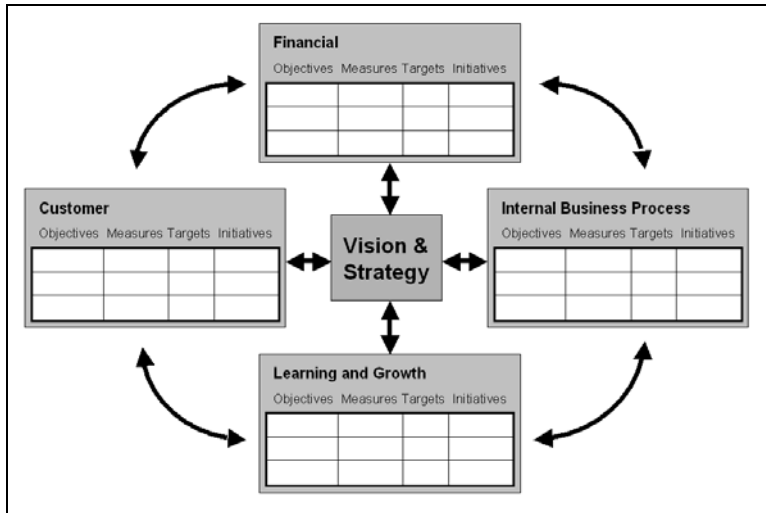


fig.1 Four perspectives of a Balanced Scorecard

KAPLAN and NORTON point out that there are relations between the different elements shown on a scorecard. These affect monetary success variables by cause and effect relationships. Therefore the recognition of single factors and their influence on other variables are very important for a success-oriented enterprise control. To bring strategies to live, measures have to be implemented which guarantee the achievement of strategic goals in the long run. All causal paths from all the measures on a Scorecard should be linked to financial objectives.

In recent times the number of critical papers which determine the lacking usefulness in business practice are increasing. The main problem is derived from the difficulties enterprises have with structuring and linking various elements for the creation of a Balanced Scorecard.

It was shown that suitable elements for measuring a company's strategic success can be identified soon, sometimes through deriving elements from existing performance systems. However, the structuring of the cause and effect relationship using influencing elements often fails because of a high complexity. But to succeed here it is a very important condition for creating Balanced Scorecards which really allow to support the process of strategy-oriented enterprise control.

Once formulated goal elements have to be coordinated with each other. This may be very complicated in case of competitive relationship and when time delays have to be considered. These difficulties are not mentioned in most publications on the Balanced Scorecard. In general, they are not sufficiently analyzed in their meaning for the success of a Balanced Scorecard in practice. The degree of difficulty which results from the high complexity of the developed network seems to have not been sufficiently investigated. A deeper discussion does not take place in the actual literature.

Therefore in this paper the limits and inadequacies of the Balanced Scorecard concept will be illustrated with the help of causal loop diagrams provided by the system-dynamic research. Based on an easy-to-understand example it becomes clear, for which difficulties the literature leaves

questions unanswered and how system-dynamic modeling and simulation can support the process of creating successful Balanced Scorecards in practice.

2 Cause and Effect Relationships in Balanced Scorecards

Strategy is a set of hypotheses about cause and effect. These relationships between cause and effect can be expressed by a sequence of if-then statements. KAPLAN and NORTON give an example to illustrate that:³ “If we increase employee training about products, then they will become more knowledgeable about the full range of products they can sell; if employees are more knowledgeable about products, then their sales effectiveness will improve. If their sales effectiveness improves, then the average margins of the products they sell will increase.” Every measure selected for the Balanced Scorecard should be an element of a chain of cause-and-effect relationships that communicates the meaning of the business unit’s strategy to the organization.

Therefore all Balanced Scorecards should be based on cause and effect relationships, which connect elements from each perspective with a financial variable. The results are complex networks containing a lot of variables and relations. These networks are a compelling condition for the successful use of the concept in business practice.

Cause and effect relationships published exemplarily in fundamental works on the Balanced Scorecard raise elementary questions. Therefore one special and well-known chain will be analyzed in the following and subjected to a critical view.

KAPLAN and NORTON point out a very simple cause and effect relationship of some elements in their basic work to the Balanced Scorecard (fig. 2).⁴

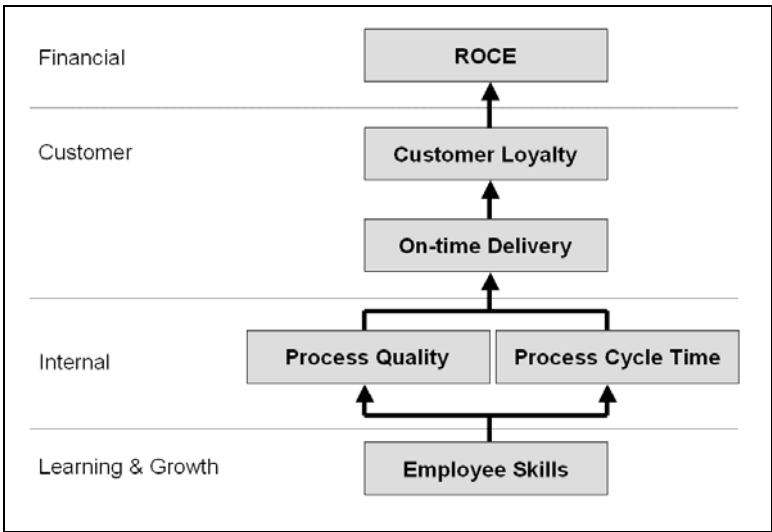


fig.2 Cause and effect relationship within a Balanced Scorecard

³ See Kaplan, R.S. / Norton, D.P. (1996, p.149).
⁴ See Kaplan, R.S. / Norton, D.P. (1996, p.31).

The main purpose is to clarify how a desired increase of the Return on Capital Employed (RoCE) as a strategic goal of the enterprise can be influenced by strengthening employee skills. Therefore in a Balanced Scorecard within the learning-oriented perspective the objective of a high employee skill is formulated. With high employee skills and extensive qualification of the employees process quality and process cycle time can be improved. Process quality can be measured on the basis of a committee ratio. The measurement of process cycle time does not cause any difficulty. High process quality and a fast process cycle time to complete orders are aimed at anyway and therefore these objectives are included in the Balanced Scorecard within the process-orientated perspective.

As result of a short turn-around time the probability of on-time deliveries rises. The same happens when time delays can be avoided as a consequence of a reduced production. KAPLAN and NORTON see the opportunity of an increase in customer loyalty when more and more orders can be completed and delivered on-time to customers.

An objective of nearly all enterprises is to increase customer loyalty. Therefore it is not surprising that on-time deliveries and customer loyalty are important elements in a Balanced Scorecard. Through an increase in customer loyalty a growth in sales and revenues can be achieved. Finally, they will influence profit and Return on Capital Employed (RoCE) in a positive way. In summary the cause and effect relationship of elements presented by KAPLAN and NORTON illustrates the meaning of employee skills on the strategic goal of a maximized financial success.

At first glance the relations and explanations of the authors seem to be without contradictions. The objective of a high employee qualification is an opportunity to contribute to the financial success of the enterprise. Competitive goals or contradictory statements in the argumentation are not immediately evident.

The achievement of the strategic goal will be guaranteed by implemented measures. Based on the relations illustrated in the chain an execution of measures for further education and training courses for employees are easy to justify.

Here further questions have to be raised which are important for an application of the Balanced Scorecard in practice:

- Have all cause and effect relations as a result of this measure been illustrated?
- How strong is the influence of the measure on the financial success of the enterprise?
- When and by which intensity does the desired effect occur?
- Are there any side effects which have not been regarded so far?
- Which role do other variables play in the context of reaching the goal?

3 Causal loop diagram

To answer these questions the same elements and their relation to each other will be examined now with the help of causal loop diagrams from the system-dynamic research. The following illustration shows a translation of the cause and effect chain of KAPLAN and NORTON into a causal loop diagram.

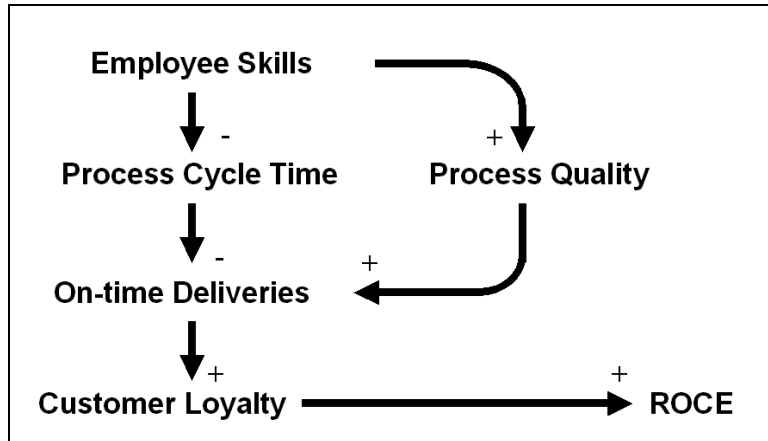


fig.3 Causal loop diagram for Balanced Scorecard elements

The starting point in this figure is the variable *employee skills*. If it is increased, the *process quality* rises as a result. In the reverse case it falls with removing employee's skills.

In another way *employee skills* affect the *process cycle time*. With increasing skills the cycle time falls.⁵ With a decrease in specialized skills the *process cycle time* extends.

Now the variable *on-time deliveries* will be examined. It depends on both *process cycle time* and *process quality*. The number of on-time shipments rises if the realized *process cycle time* becomes shorter or if the *process quality* rises. In the opposite case with lower *process quality* or increasing *process cycle time* fewer products will be delivered. Finally the number of *on-time deliveries* influences *customer loyalty*. Loyalty rises and falls with the number of *on-time deliveries*. The effect of *customer loyalty* on *Return on Capital Employed (RoCE)* is the last relation being examined here. It is the relationship of operating profit to the operationally bound capital. It is accepted that a high *customer loyalty* leads to rising or continuously high repetition purchases. Finally the rising revenue leads to a rising profit. Based on an assumed constant capital the characteristic key figure *RoCE* rises. In case of a falling *customer loyalty* the number of repetition purchases drops too. The declining revenues lead to less operating profit and to a lower *Return on Capital Employed (RoCE)*.

In the next step the measures to increase the employee skills are taken into consideration. With increasing number of trainings the *employee skills* rise. In case of a decrease or an omission of

⁵ As one reason a smaller rate of mistakes or a higher employee productivity is conceivable.

further training it does not rise or it decreases because employees lose the acquired knowledge and skills after a certain time.

Through a closer examination it becomes clear that the cause and effect chain provided by KAPLAN and NORTON leaves a substantial relation unconsidered. All measures with the purpose to increase *employee skills* cause costs for the enterprise. The costs consist of direct training costs as well as costs for the times being away from job. These costs reduce the profit and affect the regarded key figure *RoCE* negatively. The following illustration adds the described relation.

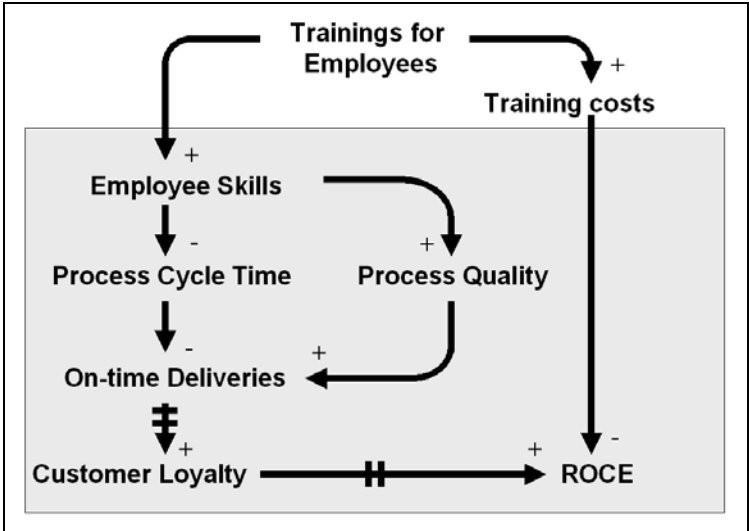


fig.4 Impact of trainings to increase employee skills

In the concept of the Balanced Scorecard substantial and elementary connections remain unconsidered because simple cause and effect relationships are applied. In the example shown opposite developments occur. On the one hand, more revenue and profit can be obtained through increasing education, on the other hand each of these measures causes costs, which reduce profit and RoCE.

With a detailed analysis of this relationships it is remarkable that these influencing variables play an important role. The costs resulting from further trainings immediately affect the profit by 100% in a negative way without any time delays.

However, the desired developments aimed at with more trainings occur usually with a certain time delay. In particular the increase of *customer loyalty* as a result of frequent *on-time deliveries* is noticeable only after a certain time delay, since customers will become loyal when having positive experiences.

High *customer loyalty* gives an competitive advantage only if a repetition purchase is accomplished by the customer. Only at this time the company’s revenue and profit are affected.⁶ Before a system dynamics model can be constructed for the described system a picture with stocks and flows is developed which illustrates the dynamic relations and dependences (fig.5).

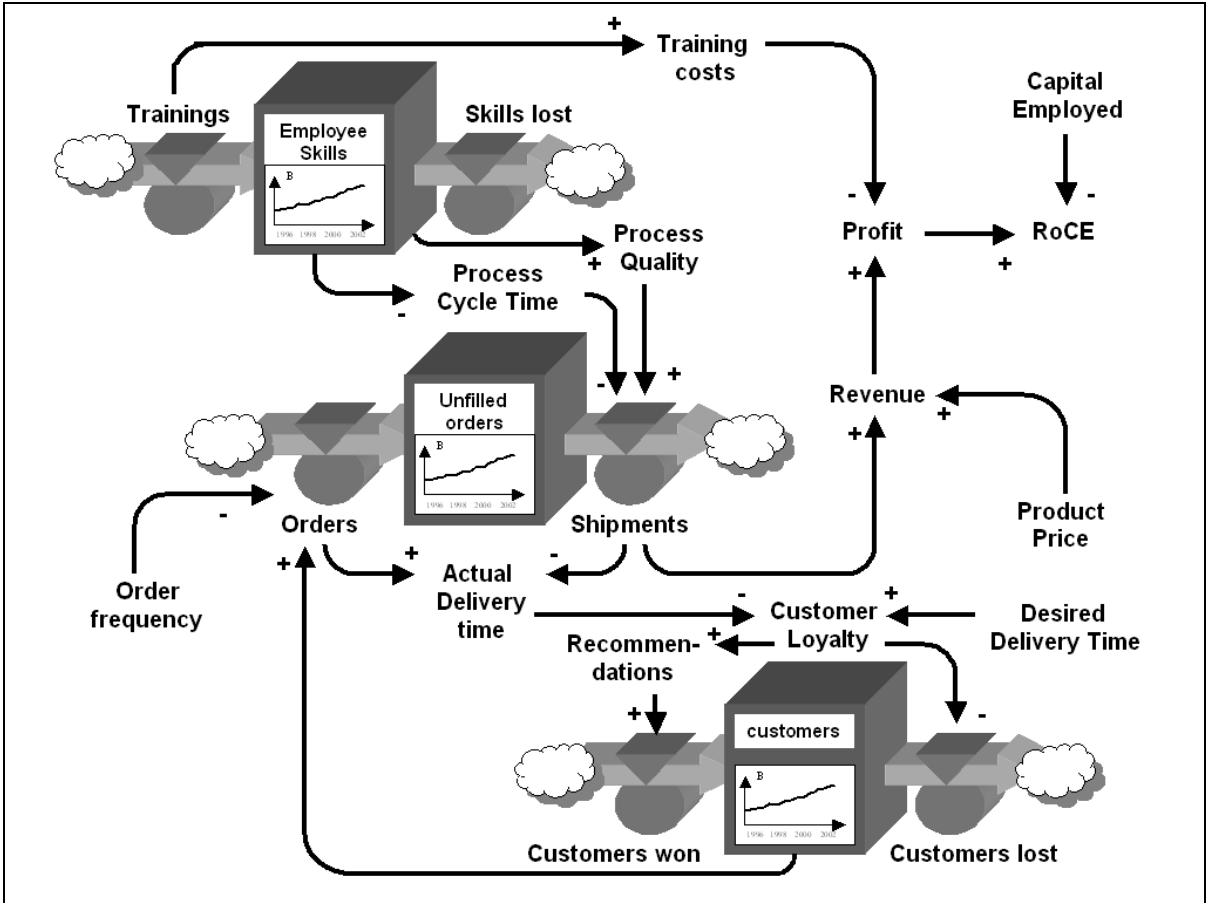


fig.5 Causal loop diagram considering stocks and flows

The starting point is the skill level of the employees. This level rises if new knowledge or skills are gained by the employees resulting from trainings. This growth increases the more, the more trainings will be offered in one period. The skill level will be reduced when employees lose a part of their knowledge and skills in the run of time. This might correspond to reality. In order to keep the skill level constant, the necessity of permanent trainings becomes obvious. Now the *process cycle time* and *process quality* depend on the *skill level*. Considering the causal loop diagram it does not require a further description again.

It has to be noticed that “on-time” expresses a valuation to a reference or a goal value. Therefore in a first step the actual *delivery time* has to be determined and compared afterwards with this de-

⁶ For example a high customer loyalty in the automobile business affects the financial success of the enterprise after some years when a repetitive purchase takes place. In the periods between the purchase processes the effects are not noticeable.

sired goal value. If the actual *delivery time* is shorter or equal to the goal value, an *on-time delivery* has taken place. Otherwise the desired time has not been reached.

A shipment follows an order placed by a customer. Orders are measured per time unit and will be accumulated in the stock *orders in process* or *unfilled orders*. Only through shipment as a result of a completion of the order this stock will be reduced. The *actual delivery time* depends on the number of the incoming orders and on the number of the shipments.

If the number of incoming *orders* rises in case of a constant delivery rate, the *actual delivery time* extends. In the reverse case the *actual delivery time* shortens, if in case of a constant *delivery rate* the incoming orders decrease. If the number of shipments rises in case of constant order intake, the *actual delivery time* shortens.

However, if fewer shipments are completed during a period, the *actual delivery time* rises in the case of a constant order intake. The variable *shipments per time* is now depending on the development of *process cycle time* and *process quality*. The relations were already described in the causal loop diagram. It is assumed that no further variables determine the number of shipments done per period. Restrictions in personnel capacity do not occur.

The *actual delivery time* can be compared now with the *desired delivery time*. Based on this alignment the variable *customer loyalty* formulated by NORTON and KAPLAN is influenced. It rises if the *actual delivery time* is shortened. An unchanged *desired delivery time* is a condition here. In the opposite case it falls, if the *actual delivery time* rises and the *desired delivery time* remains constant. If the customer wishes a shorter delivery time, the *customer loyalty* falls too, if the *actual delivery time* can be not reduced equally.

Next it has to be examined in detail, how *customer loyalty* affects the *Return on Capital Employed (RoCE)* in the long run. Here a certain explanation is necessary because some important intermediate variables were not illustrated in the cause effect relationship of KAPLAN and NORTON. As an auxiliary construction a *customer base level* variable has to be introduced. This is necessary, because the term *customer loyalty* focuses on repetition purchases.

The *customer base* increases if new customers can be acquired and is reduced if existing customers leave for competitors. Here the effect of *customer loyalty* becomes obvious. If it rises less customers decide to leave for competitors. In addition a winning of new customers is conceivable by more recommendations. In the case of a decreasing *customer loyalty* the number of lost customers rises, recommendations will become rarely.

Based on the number of customers and an assumed purchase interval the incoming orders result. The larger the *customer base* is and the shorter the purchase interval is, the more orders arrive. In the opposite case the number of arriving orders falls, if the customers order more rarely or the absolute number of customer has decreased. Only when these new orders are delivered and invoiced after a certain time, they can affect the *revenue* of the enterprise. At this point the transition to the

financial results is given. With the number of *shipments* in one period the *revenue* and as a consequence the *profit* rises or falls. Finally with an assumed constant capital (*Capital Employed - CE*) an increase or a decrease of the *RoCE* results. The examination of the costs resulting from *trainings* completes the description of figure 5. They increase with the number of *trainings*. As consequence of rising costs the *profit* and concomitantly the obtained *RoCE* are reduced.

Looking on the resulting network it becomes clear that an apparently useful measure has to be examined completely in its effects. It has to be paid attention compellingly to a distinction in short-term and long-term effects.

Finally, the following illustration shows how insufficiently the original cause and effect relationship of elements of a Balanced Scorecard explains the underlying system in its complex and dynamic relations. Instead it extracts single variables from the system in a not comprehensible way.

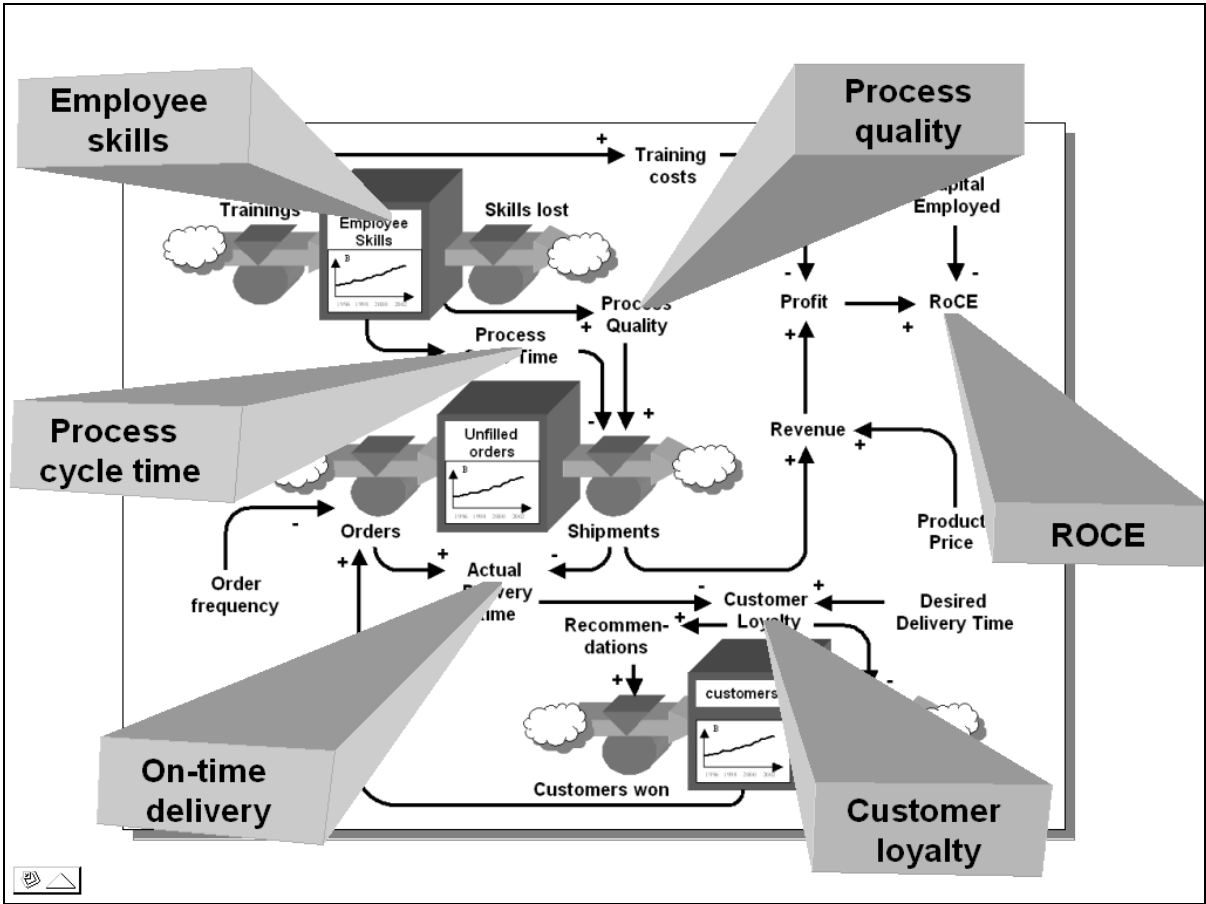


fig.6 Isolation of elements in a Balanced Scorecard

With long-term focus a profit-optimal relationship between the negative effect of *training costs* and positive effects in *revenues* reached by high *customer loyalty* has to be identified. It has to be determined, how extensively further trainings should be accomplished in the company.

4 System dynamics model

This objective is reached by system-dynamic modeling and simulation of the enterprise system. The method allows the quantitative calculation of variable relations with special consideration of time delays. The results obtained by simulation finally help to identify an almost optimal training program for employees.

The following illustration shows the developed model structure.

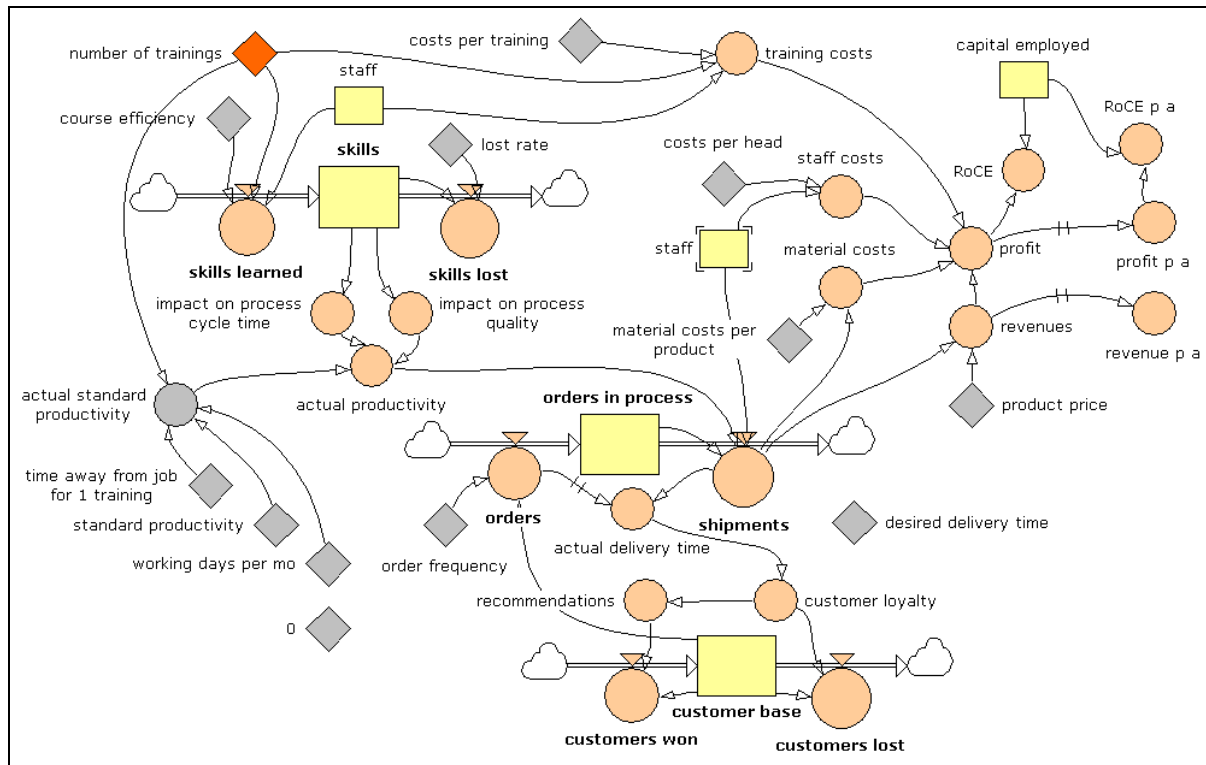


fig.7 System dynamics model

Within the model only a small part of the elements of a real enterprise is shown in detail. Therefore some assumptions have to be made for the enterprise. With these assumptions complex circumstances of reality are simplified. However, for the purpose of the model objective this is not relevant. The substantial assumptions can be summarized as follows:

- The enterprise manufactures one product only.
- Production and delivery to the customers take place within one period.
- The material costs for one product are 375 [\$/product]. They are constant.
- The product price is 1,600 [\$/product]. It is constant.
- The Capital Employed is 30 mio. [\$. It is constant.
- The enterprise employs 15 [head]. There is no hiring or firing.

- The costs per head are 3,000 [\$/head/mo]. They are constant.
- The customer's desired delivery time is 2 [mo] or less.
- The initial orders in process are 850 [product].
- Customers place orders for 1 product every 2 [mo].
- The initial customer base is 2,000 [customer].
- The direct costs of a training are 1,400 [\$/course/head].
- The skills of the staff will be measured by points.
- The initial of staff skill is 10,000 [points].
- Course efficiency is 5 [points/course/head].
- The skill lost rate is constantly 5 % [1/mo] of the actual skill level.
- All workers have nearly the same skills. So an average value can be used.
- All workers have to be trained in an equal way.
- The standard productivity of 1 employee is 5 [product/head/mo] if no trainings take place. It is reduced when trainings take place.
- There is a maximum of 3 trainings per worker and month. More are not possible.
- There is no need to offer any trainings.
- A month consists of 20 working days.
- Each training takes 1 working day and reduces the staff's working time.
- The actual standard productivity considers employee's time away from job.
- In the enterprise there is no administrative or research and development department.
- Any further costs can be ignored for calculating profit.

On the basis of these assumptions it should be examined how many further trainings are to be accomplished monthly to increase *RoCE*. In addition it is interesting to calculate how significantly the costs for trainings influence the *RoCE* in short-term.

In the model it is very important how extensively a change of employee skills affects *process cycle time* and *process quality*. In the model TABLE functions are used for this purpose.

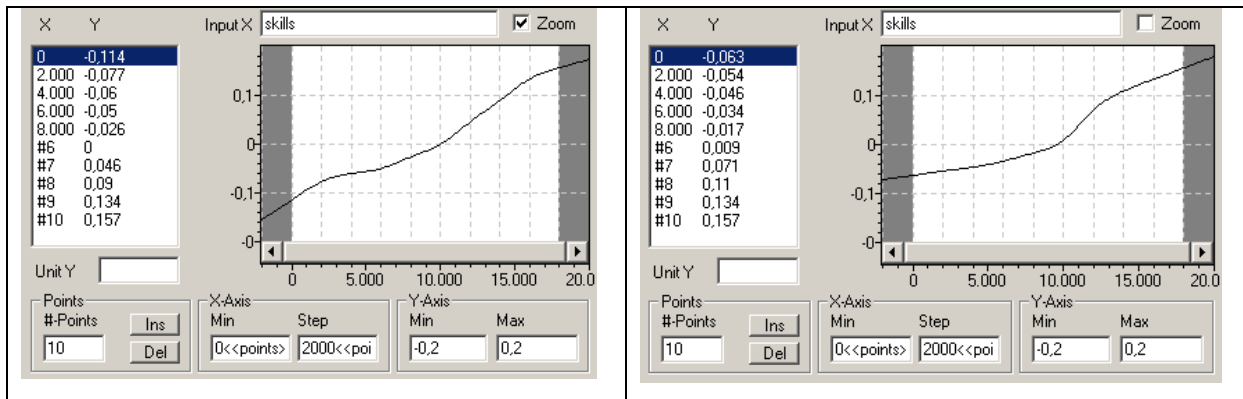


fig.8 TABLE FUNCTIONS: impact on process cycle time (Y) and impact on process quality (Y) depending on skills (X)

At a value of 10,000 [points] the value of the function is about 0 []. If the special skill level rises above, a positive percentage is assigned. For both variables the maximum amounts to about 16% in case of a specialized skill level of approximately 19,000 [points]. However, if the skill level falls below 10,000 [points], the assigned percentages become negative. Using both variables the productivity of the employees can be determined by the following equation:

A1	actual productivity $= \text{actual standard productivity} * (1 + \text{impact on process cycle time} + \text{impact on process quality})$	[product/ head/mo]
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As a result of the positive or negative percentage effects on *standard productivity* an increase or a decrease of the *actual productivity* rises. Additionally, a change in capacity for processing and shipping customer orders follows.

Within the model the *actual delivery time* plays an important role. The number of incoming orders is delayed by 2 periods and set into relation to the value of shipments done. A DELAY function is used in the equation.

A2	actual delivery time $= ((\text{DELAYPPL}(\text{orders}; 2 \ll \text{mo} \gg; 1000 \ll \text{product/mo} \gg)) / \text{shipments}) * 2 \ll \text{mo} \gg$	[mo]
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If the value is smaller than 1, more products are shipped than products were ordered 2 months ago. In this case the *desired delivery time* was achieved. Finally as a result of a multiplication with 2 [mo] the *actual delivery time* is calculated.

The *customer loyalty* as an influencing variable for the development of *customer base* depends on the *actual delivery time*. A GRAPH function is used again.

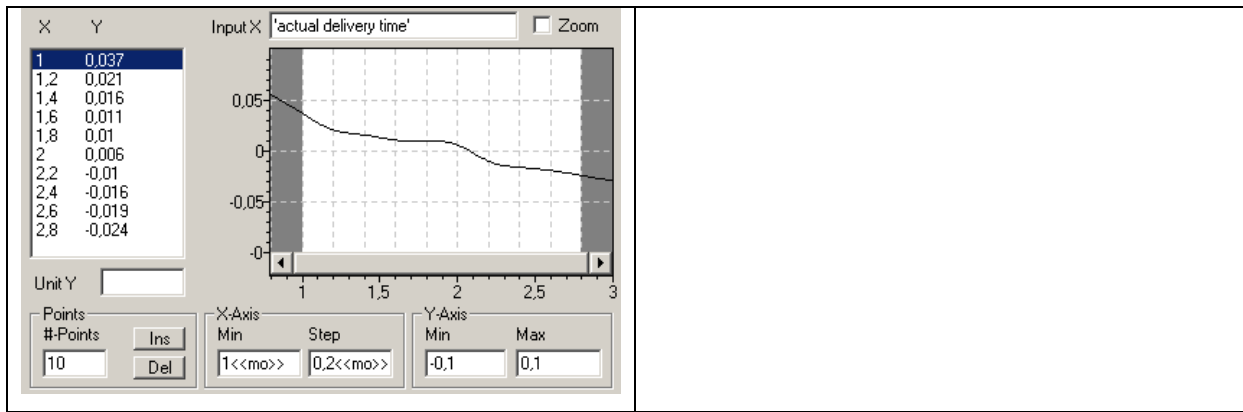


fig.9 TABLE FUNCTION: customer loyalty (Y) depending on actual delivery time (X)

At an *actual delivery time* value of 2 months the assigned percentage is 0 [%]. The shorter it becomes compared to 2 [mo], the more the value for *customer loyalty* grows. With a *delivery time* of about one month the function value is 0.04 [%]. In the reverse case it becomes increasingly negative and with a *actual delivery time* of 3 [mo] the assigned percentage is -0.035 [%].

Any product recommendations and the acquisition of new customers takes place only in case of positive *customer loyalty*. The number of *new customers* is calculated in a simple way as a proportional increase on the existing *customer base*. The value of *customer loyalty* works as a multiplier. Existing customers are lost only if the *customer loyalty* is negative as a consequence of longer delivery times. Their number is determined as a proportional part of the *customer base*.

The exact modeling of monetary success variables as well as other formulated equations is shown in the appendix. Therefore a further description of details of the model is not necessary.

5 Model simulation - reference scenario

For the reference simulation one training per month and employee is assumed in the model. The simulation time takes 4 years. It begins 01.01.2003 and ends to 01.01.2007. The integration step is 1 [mo]. For the evaluation only variables are examined which the original Balanced Scorecard contained. First an analysis of the skill development is shown.

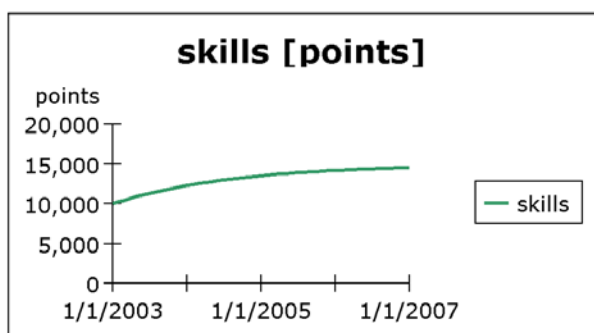


fig.10 Reference run: development of skills

The *skill level* rises continuously from 10,000 [points] as initial value to approximately 14,500 [points] at the end of simulation. That shows that by one training per month more knowledge for employees is accessible than they lose in the same time period. In the next step the effects on *process quality* and *process cycle time* are illustrated.

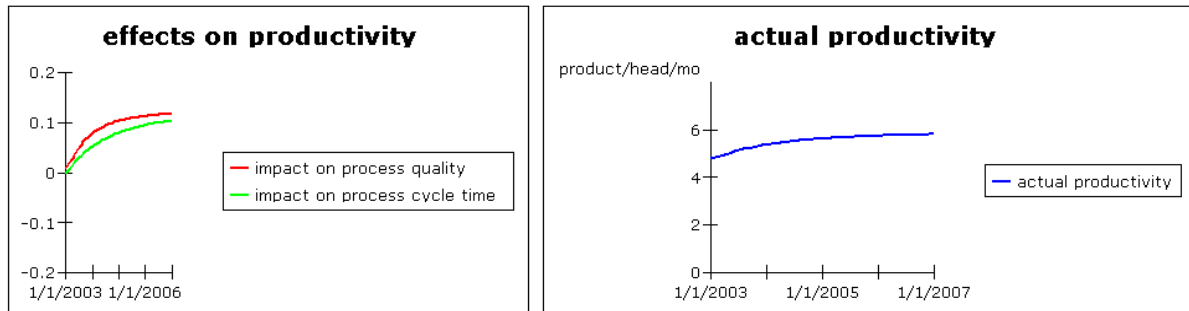


fig.11 Reference run: effects on productivity

Because of the rising effects on *process quality* and *process cycle time* the *actual productivity* increases during the simulation time up to 6 [product/head/mo]. This is an increase of approximately 20 % related to the standard productivity of 5.0 [product/head/mo] over 4 years. In the next figure the actual delivery time is compared to the customer’s desired delivery time.

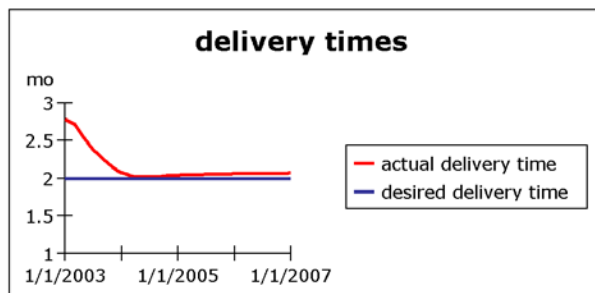


fig.12 Reference run: actual vs. desired delivery time

After a long *actual delivery time* at the beginning of the simulation it reaches the goal value of 2 [mo] soon. However, it does not fall below. Instead it moves at a minimum above the goal value. As a consequence there are a lot of lost customers at the beginning. At the end there are even new customers won by recommendations. That becomes obvious when taking a view on *customer loyalty* and the migration of the customers.

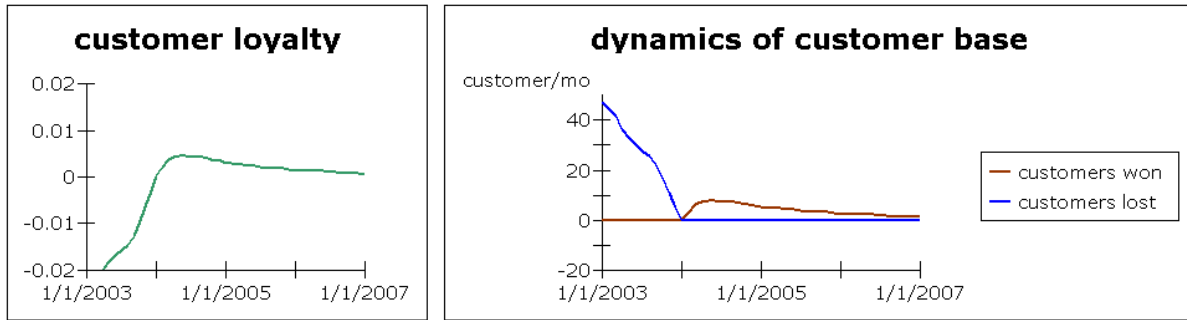


fig.13 Reference run: customer loyalty and dynamics of customer base

Finally the financial variable *RoCE* can be simulated. It is illustrated like the revenue and profit over a yearly horizon. The following overview informs about the results.

Time	1/1/2003	1/1/2004	1/1/2005	1/1/2006	1/1/2007
revenue p a	0.00 \$	14,657,600.00 \$	15,864,000.00 \$	16,366,400.00 \$	16,624,000.00 \$
profit p a	0.00 \$	3,302,225.00 \$	4,225,875.00 \$	4,610,525.00 \$	4,807,750.00 \$

Time	1/1/2003	1/1/2004	1/1/2005	1/1/2006	1/1/2007
RoCE p a	0.00 %	11.01 %	14.09 %	15.37 %	16.03 %

fig.14 Reference run: revenues p.a., profit p.a. and RoCE p.a.

The annual revenue rises continuously during the simulation from 14.6 mio. [\$/yr] to approximately 16.6 mio. [\$/yr]. Similarly the annual profit develops. It rises from 3.3 mio. [\$/yr] to 4.8 mio. [\$/yr]. The RoCE rises due to the constant capital basis from 11.1% in the first year to 16.0% in the year 2006.

The model simulation for the reference scenario shows, that compared to the present situation with monthly employee trainings a certain growth and an increase of the *RoCE* becomes attainable. It proves the suitability of this measure for a strategy initially described in the Balanced Scorecard.

6 Model simulation - scenario 1

In a scenario analysis, the effects of extremely restrictive training politics are examined now by a modified model simulation. The employees will not take part in any trainings because of cost reasons. The simulation time begins on 01 January 2003 and ends on 01 January 2007 again. The integration step is 1 [mo] again.

For the evaluation of the new results they will be compared to those of the reference scenario. First the examination of the skill level development takes place.⁷

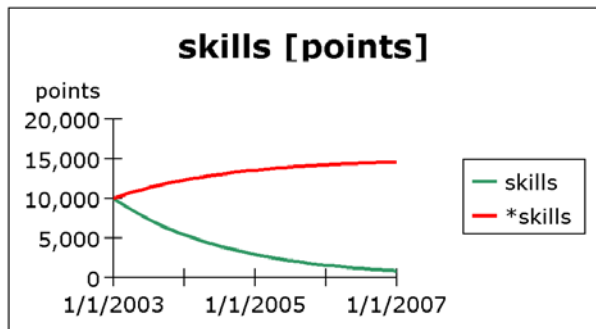


fig.15 Scenario 1 vs. reference run: development of skills

It becomes obvious that the employee's skill level strongly decreases. Compared to the initial value of 10.000 [points] it decreases to about 800 [points]. The employees lose their knowledge and skills but a new acquisition of knowledge does not take place. In the next step the effects on *process quality* and *process cycle time* are examined as a consequence of this drastic decrease.

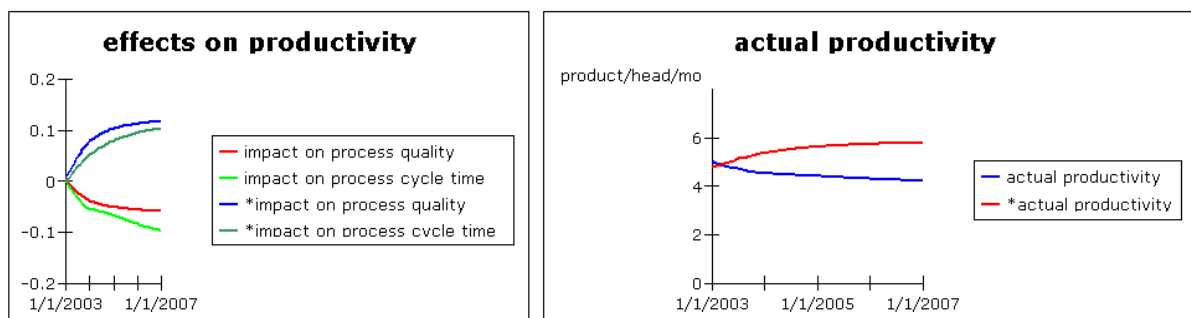


fig.16 Scenario 1 vs. reference run: impacts on productivity

Resulting from the negative effects in *process quality* and *process cycle time* the actual productivity falls within the simulation run to 4.2 [product/head/mo]. In the next picture the *actual delivery time* is confronted to reference scenario's run and to the *desired delivery time* wished by customers.

⁷ The results of the reference scenario are marked in the diagrams with *.

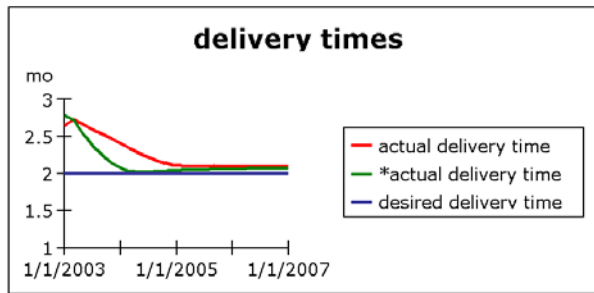


fig.17 Scenario 1 vs. reference run: actual vs. desired delivery time

The long delivery time at the beginning even rises during the first simulation periods and reaches the goal value of 2 months only after approximately 2 years. Here the reason does not lie in a productivity increase, but in a substantial decrease of incoming orders. In this situation the assumed constant personnel capacity can complete the few orders despite a smaller actual productivity within the desired 2 months.

Therefore at first the *customer basis* will be quickly diminished because of a high number of customers lost. In this scenario no new customers will be acquired at all in the result of recommendations. This becomes comprehensive when having a look on *customer loyalty* and *customer base*.

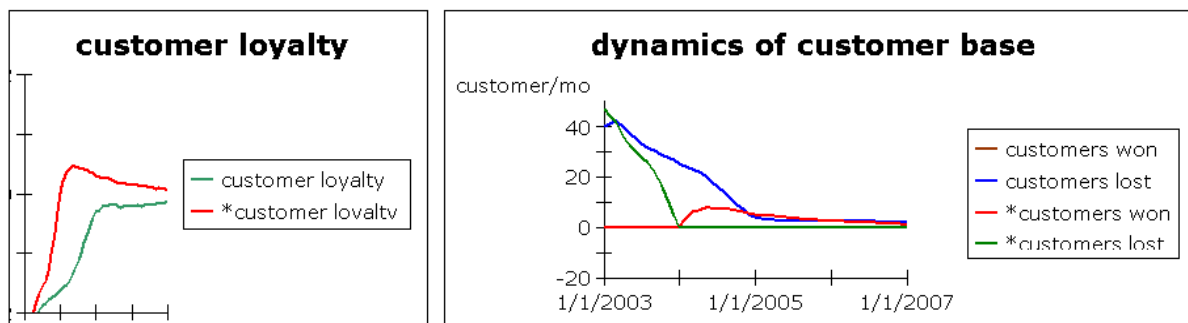


fig.18 Scenario 1 vs. reference run: customer loyalty and dynamics of customer base

Finally the financial goal variable *RoCE* has to be simulated. The following charts show the annual financial results.

Time	1/1/2003	1/1/2004	1/1/2005	1/1/2006	1/1/2007
revenue p a	0.00 \$	13,702,400.00 \$	12,899,200.00 \$	12,574,400.00 \$	12,284,800.00 \$
profit p a	0.00 \$	5,090,900.00 \$	4,475,950.00 \$	4,227,275.00 \$	4,005,550.00 \$
*revenue p a	0.00 \$	14,657,600.00 \$	15,864,000.00 \$	16,366,400.00 \$	16,624,000.00 \$
*profit p a	0.00 \$	3,302,225.00 \$	4,225,875.00 \$	4,610,525.00 \$	4,807,750.00 \$

Time	1/1/2003	1/1/2004	1/1/2005	1/1/2006	1/1/2007
RoCE p a	0.00 %	16.97 %	14.92 %	14.09 %	13.35 %
*RoCE p a	0.00 %	11.01 %	14.09 %	15.37 %	16.03 %

fig.19 Scenario 1 vs. reference run: revenues p.a., profit p.a. and RoCE p.a.

Both *revenue* and *profit* decrease significantly compared to the reference scenario. Instead of 16.6 mio. [\$ /yr] the *revenue* for the year 2006 will be 12.3 mio. [\$ /yr] only. This is a drastic decrease of about 27 %. In the same way the *profit* drops. For the *RoCE* the effects are dramatic. At the end of the simulation period it will have reached a value of 13.3% compared with 16.0% in the reference scenario.

In particular it is remarkable in this scenario that during the first simulated year both the annual *profit* and the *RoCE* are significantly better than the value of the reference scenario. These results might give the impression that shortening employee trainings can be useful and the right way to increase *RoCE*. Here less costs for trainings are clearly in favor of improving *profit* and concomitantly the *RoCE*. The loss of customers due to falling *customer loyalty* does not yet work noticeably. So the conclusion is that decisions like shortening or stopping trainings aligned at short-term notice can be extremely harmful in the long run. Long-term effects have to be examined before any strategic decisions are taken.

7 Model simulation - scenario 2

In a second scenario analysis the effects of an intensive training policy are examined by a further model simulation run. The employees are given 2 trainings a month despite the increasing education costs. The simulation period begins on 01 January 2003 and ends on 01 January 2007. The integration step is 1 month again.

For an evaluation the new results are compared to those of the reference scenario again. First the analysis of the skill level development is made.⁸

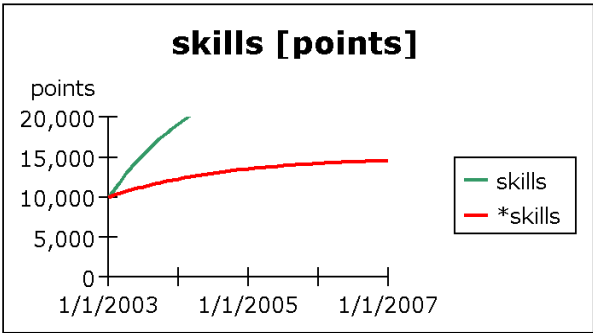


fig.20 Scenario 2 vs. reference run: development of skills

It is shown that the employee skill level rises extremely. In the comparison to the initial value of 10.000 [points] it ends with about 28.000 [points]. The employees lose some skills, but the in-

⁸ The results of the reference scenario are again marked in the diagrams with *.

crease in new knowledge is clearly higher. In the next step the effects on *process quality* and *process cycle time* will be examined as a consequence of this strong increase.

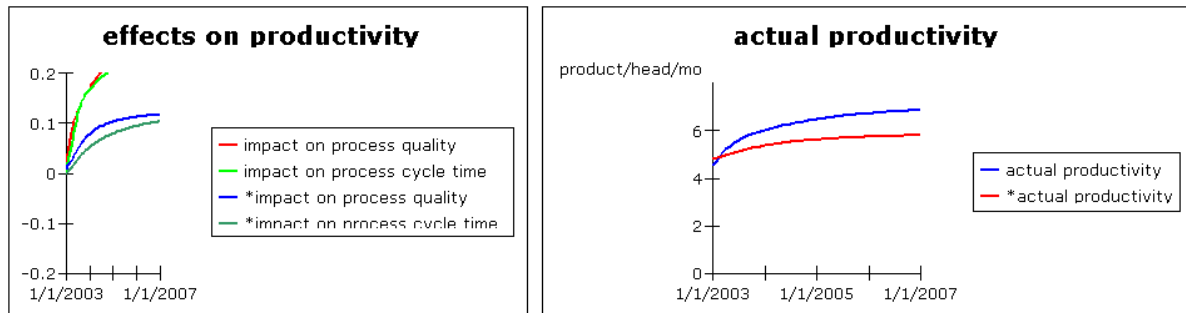


fig.21 Scenario 2 vs. reference run: impacts on productivity

Resulting from the positive effects of *process quality* and the *process cycle time* the *actual productivity* rises within the simulation time to 6.8 [product/head/mo]. This is an increase of 36% over 4 years. In the next graph the *actual delivery time* is shown together with the reference scenario run and the *desired delivery time* for this scenario.

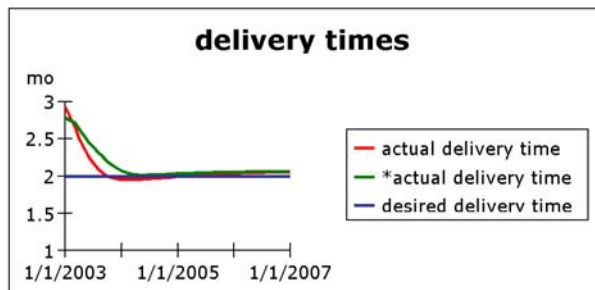


fig.22 Scenario 2 vs. reference run: actual vs. desired delivery time

At the beginning the *actual delivery time* reaches the goal value of 2 [mo] during the first simulated periods and even falls below it. The cause lies in the fast increasing *actual productivity*. The assumed constant personnel can better and faster complete all incoming orders with their high skills.

Therefore only during the first periods customers leave for competitors. After a short time increasing recommendations generate new customers. This becomes obvious when having a view on *customer loyalty* and the dynamics of *customer base*.

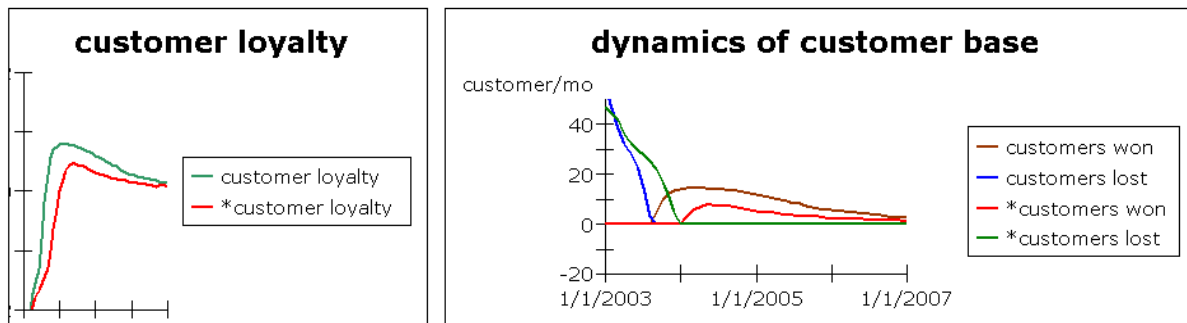


fig.23 Scenario 2 vs. reference run: customer loyalty and dynamics of customer base

Finally the financial key variable *RoCE* is simulated. The following chart shows the annual financial results for the second scenario.

Time	1/1/2003	1/1/2004	1/1/2005	1/1/2006	1/1/2007
revenue p a	0.00 \$	15,662,400.00 \$	18,012,800.00 \$	19,009,600.00 \$	19,548,800.00 \$
profit p a	0.00 \$	1,551,525.00 \$	3,351,050.00 \$	4,114,225.00 \$	4,527,050.00 \$
*revenue p a	0.00 \$	14,657,600.00 \$	15,864,000.00 \$	16,366,400.00 \$	16,624,000.00 \$
*profit p a	0.00 \$	3,302,225.00 \$	4,225,875.00 \$	4,610,525.00 \$	4,807,750.00 \$

Time	1/1/2003	1/1/2004	1/1/2005	1/1/2006	1/1/2007
RoCE p a	0.00 %	5.17 %	11.17 %	13.71 %	15.09 %
*RoCE p a	0.00 %	11.01 %	14.09 %	15.37 %	16.03 %

fig. 24 Scenario 2 vs. reference run: revenues p.a., profit p.a. and RoCE p.a.

The *revenue* rises significantly compared to the reference scenario. Instead of 16.6 mio. [\$/yr] the revenues in 2006 reach 19.6 million [\$/yr]. The *profit* is lower than in the reference scenario but increasing. It reaches 4.5 mio. [\$/yr] now instead of 4.8 mio. [\$/yr]. For the *RoCE* the positive effects become likewise visible. It is about 15% at the end of the simulated time compared to 16% reached in the reference scenario.

For the second scenario in particular it is remarkable that in the first year both the annual *profit* and the *RoCE* are clearly below the value of the reference scenario. This might lead to the opinion that any increase of training activities will decrease *RoCE*. In this scenario the higher training costs affect the profit negatively and, in the result, lower the *RoCE*. The rising *customer loyalty* lead to a strong increase in *revenues* but the additional profits are reduced by high training costs. Therefore it is important to know that long-term successful measures like an intensification of the further training can decrease short-term financial results but their positive effect occurs after a time delay only. The second scenario showed that too many measures may cost more than additional profits can be earned resulting from increasing sales and revenues. So it is recommend to find an equilibrium between the opportunities to obtain additional *revenue* and the necessary costs

to achieve that objective. A system dynamics model can help to find the optimal training program for employees in order to maximize the *profit* and *RoCE* in the long run..

8 Conclusions

In the paper it has been shown that cause and effect relationships of various elements described in the literature on the Balanced Scorecard are not suitable for an identification of measures to reach long-term financial success. Based on single views which ignore time delays and possible feedback loops only one part of the overall effects becomes visible within the enterprise system. Therefore a Balanced Scorecard which is based on simple cause and effect relationships is not useful for success-oriented strategic controlling of an enterprises. To make dynamic relations and dependencies visible requires another method of structuring an enterprise and its elements. With the help of system-dynamic causal-loop diagrams this objective could be reached.

A simple cause and effect relationship of some elements, which was taken from the standard work provided by NORTON and KAPLAN, was used as the basis for the investigation. It was transferred into a causal loop diagram, particularly in order to make the inadequacies of this concept more transparent.

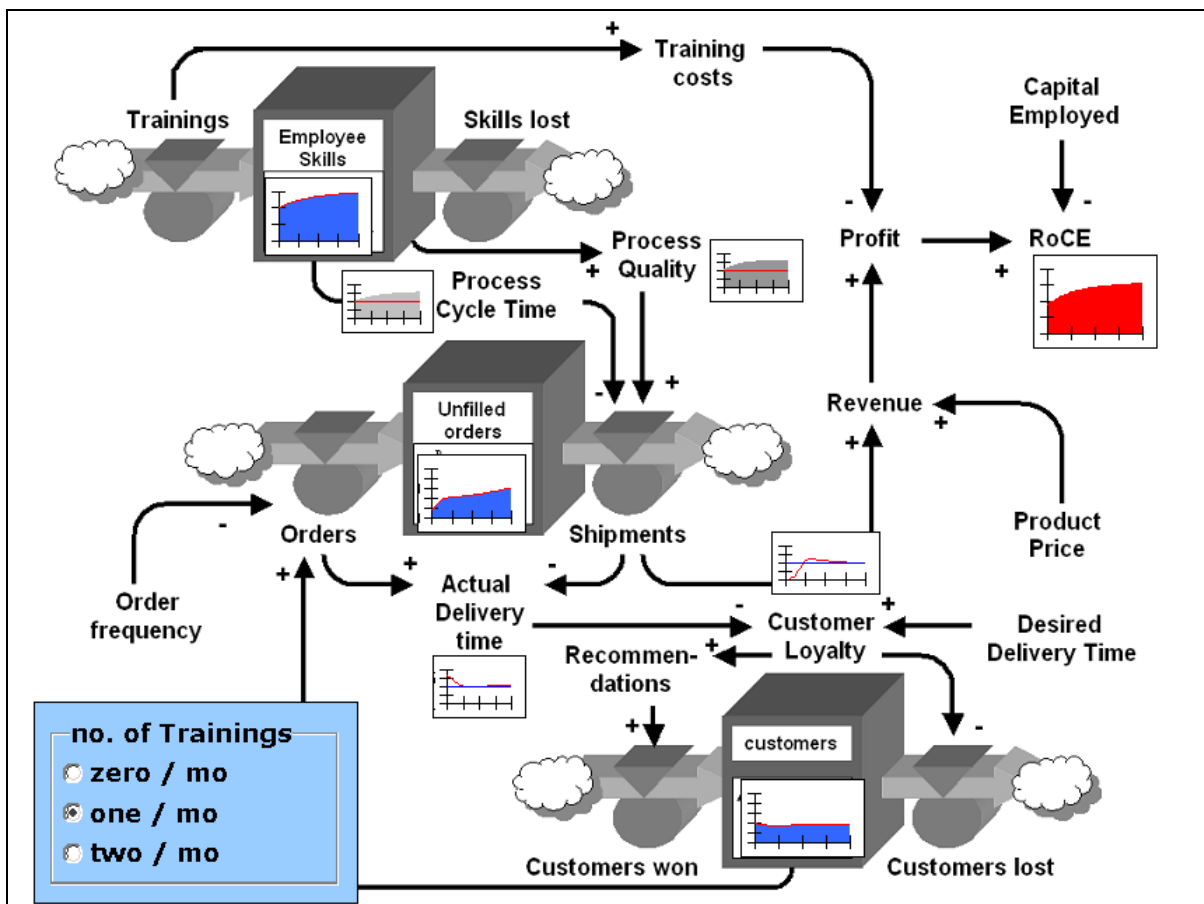
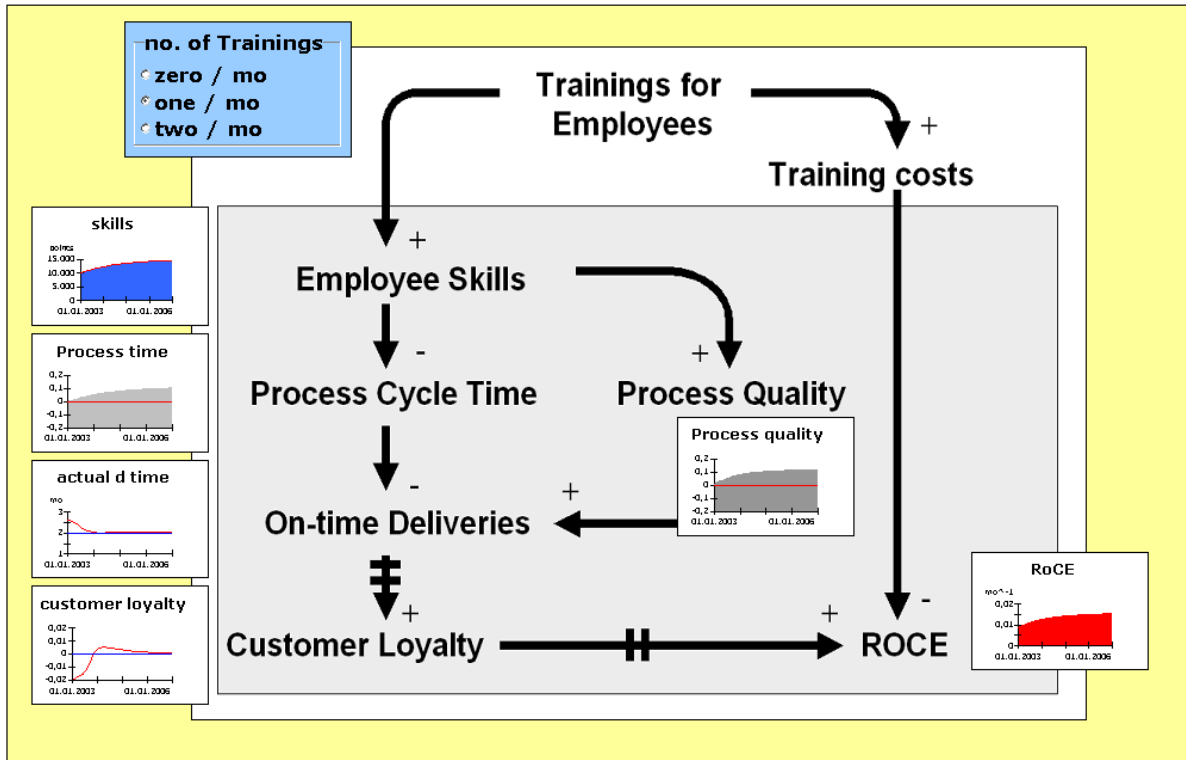
It became clear that within a Balanced Scorecard some elements of the underlying system will be probably isolated. If these elements are used for the evaluation of strategic measures, significant parts of the enterprise system are faded out and possible reactions of these elements will be ignored completely.

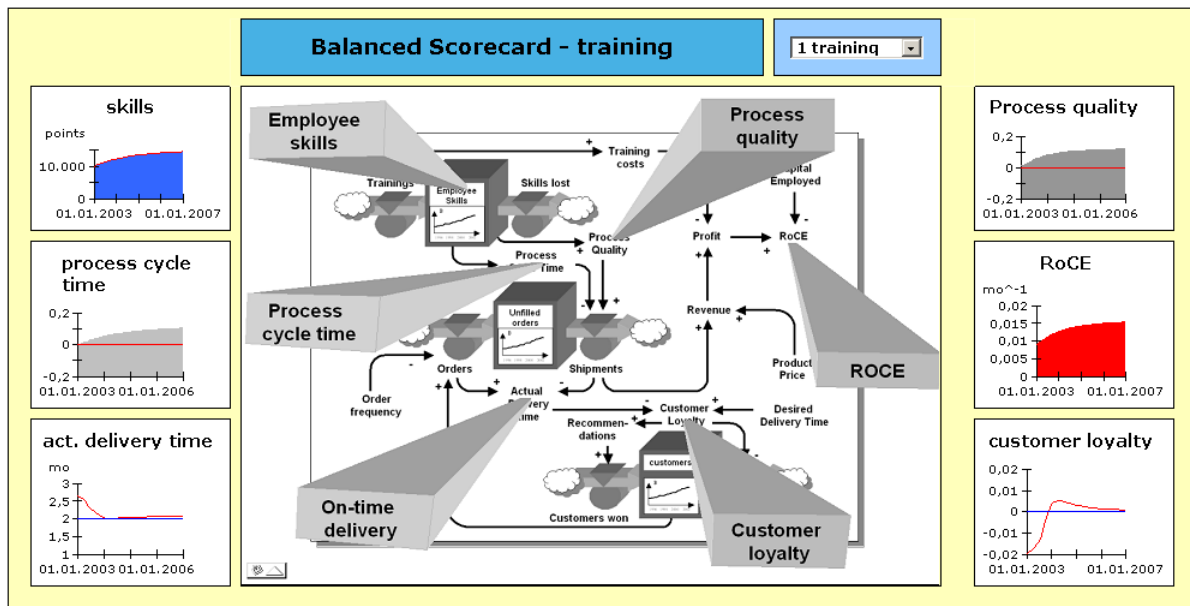
In a second step a system-dynamic model for a simple enterprise was developed based on this causal-loop diagram. With this model the extensive opportunities of quantitative modelling of complex relations within the enterprise system could be shown. Based on some assumptions various simulation runs were presented in order to examine the effects of different activities in employee skill trainings on the financial success of the enterprise.

It could be proven that with the help of the system-dynamic modeling and simulation an extensive analysis of strategic measures can be made examining their effect on the entire enterprise system. In particular the effects on the financial success of an enterprise could be quantified for a long simulation period. Finally, the comparison and evaluation of short and long-term developments of financial key figures was in the focus of the investigation.

It was clearly shown that a measure can appear favorable or unfavorable in the short run, on a long-term basis, however, just the opposite effectuation appears. This issue has to be examined with each decision making concerning strategic measures. For the use of Balanced Scorecards in practice it should be considered concomitantly.

At the end of this paper various opportunities for users are illustrated in a cockpit-like overview to present and analyze the different simulation results. A Balanced Scorecard sheet providing descriptive linkage to the underlying causal-loop diagram may be useful.





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Appendix: Equations of the model

- ◇ $0 = 0,00$
:= 0
- actual delivery time = 2,06 mo
= ((DELAYPPL(orders;2<<mo>>;1000<<product/mo>>))/shipments)*2<<mo>>
- actual productivity = 6,85 product/head/mo
= 'actual standard productivity'*(1+'impact on process cycle time'+impact on process quality')
- actual standard productivity = 4,50 product/head/mo
= 'standard productivity'*(1-(time away from job for 1 training*'number of trainings'/working days per mo'))
- capital employed = 30.000.000,00 \$
:= 30000000
- ◇ costs per head = 3.000,00 \$/head/mo
:= 3000
- ◇ costs per training = 1.400,00 \$/course/head
:= 1400
- ◇ course efficiency = 5,00 points/course/head
:= 5
- customer base = 2.125,59 customer
:= 2000
→ 'customers won'
← 'customers lost'
- customer loyalty = 0,00
= GRAPHCURVE('actual delivery time';1<<mo>>;0,2<<mo>>);{0,037;0,021;0,016;0,011;0,01;0,006;-0,01;-0,016;-0,019;-0,024//Min:-0.1;Max:0.1}}
- customers lost = 0,00 customer/mo
= IF('customer loyalty'<0;customer base*(-1<<1/mo>>)*customer loyalty;0<<customer/mo>>)
- customers won = 3,05 customer/mo
= IF(recommendations>0;recommendations*customer base*1<<1/mo>>;0<<customer/mo>>)
- ◇ desired delivery time = 2,00 mo
:= 2
- impact on process cycle time = 0,25
= GRAPHCURVE('skills;0<<points>>;2000<<points>>);{-0,114;-0,077;-0,06;-0,05;-0,026;0,046;0,09;0,134;0,157//Min:-0.2;Max:0.2}}
- impact on process quality = 0,28
= GRAPHCURVE('skills;0<<points>>;2000<<points>>);{-0,063;-0,054;-0,046;-0,034;-0,017;0,009;0,071;0,11;0,134;0,157//Min:-0.2;Max:0.2}}
- ◇ lost rate = 0,05 1/mo
:= 0,05
- material costs = 385.500,00 \$/mo
= shipments*material costs per product'
- ◇ material costs per product = 375,00 \$/product
:= 375
- ◇ number of trainings = 2,00 course/mo
:= 1
- ◇ order frequency = 0,50 product/mo/customer
:= 0,5
- orders = 1.063,00 product/mo
= CEIL('order frequency'*customer base;1<<product/mo>>)
- orders in process = 2.698,00 product
:= 850
→ orders
← shipments
- ◇ product price = 1.600,00 \$/product
:= 1600
- profit = 389.300,00 \$/mo
= revenues-'staff costs'-'material costs'-'training costs'
- profit p a = 4.527.050,00 \$
= SLIDINGINTEGRATE(profit;12<<mo>>;0<<\$>>)
- recommendations = 0,00
= 'customer loyalty'
- revenue p a = 19.548.800,00 \$
= SLIDINGINTEGRATE(revenues;12<<mo>>;0<<\$>>)
- revenues = 1.644.800,00 \$/mo
= shipments*product price'
- RoCE = 0,01 per mo
= profit/'capital employed'
- RoCE p a = 15,09 %
= 'profit p a'/'capital employed'
- shipments = 1.028,00 product/mo
= CEIL(MIN('orders in process'/1<<mo>>;('actual productivity'*staff));1<<product/mo>>)
- skills = 28.294,85 points
:= 10000
→ 'skills lost'
← 'skills learned'
- skills learned = 1.500,00 points/mo
= 'course efficiency'*staff*'number of trainings'
- skills lost = 1.414,74 points/mo
= skills*'lost rate'
- staff = 150,00 head
:= 150
- staff costs = 450.000,00 \$/mo
= staff*costs per head'
- ◇ standard productivity = 5,00 product/head/mo
:= 5
- ◇ time away from job for 1 training = 1,00 working day/course
:= 1
- training costs = 420.000,00 \$/mo
= 'number of trainings'*costs per training*staff
- ◇ working days per mo = 20,00 working day/mo
:= 20