Target-Budgeting for Research & Development

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Abstract

The concept which in the past has been applied to Research & Development (R&D) of technology-intensive companies has in recent times proved inefficient. The concept of classical business administration, which mostly applies to mass production oriented firms, is not suitable for the R&D of technology intensive companies so that a new concept will have to be found. This basic assumption was at the starting point of the „Company of the Future" (COF) project, a joint effort of European and Japanese companies and universities. COF is sponsored by the European Commission as an ESPRIT project in the TBP (Technologies for Business processes) domain and various Japanese bodies including JRIA and MITI.

COF ventures to reform and transfer concepts of classical business administration to make them applicable to R&D environments.

Keywords

Target budgeting, Research & Development

1 BACKGROUND AND ROOTS OF THE NEW CONCEPT

The decision on the right amount of the R&D-Budget is difficult, as experience has shown, and it is done in various ways in different cultures and industries. For example German companies choose scientific techniques whereas Japanese firms prefer face to face consultations of the decision makers. This is one of the results from an European-Japanese research project.

To solve the problems of R&D-Budgeting independently of cultural influences, an EDP-based innovation oriented finance and budgeting tool for R&D will be developed. The focus lies especially on high-tech companies.

It is the aim of this paper to develop a budgeting method according to the ideas of Target-Costing. The new method deducts the maximum R&D-Budget from the market and therefore,

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looks at it from the customer side. In developing this special budgeting technique requirements of everyday work will be taken into account, to increase the acceptance in the future.

Starting point of these considerations is the realisation that the classic management theories, strongly influenced by optimisation of mass production, can only be used for R&D of high-tech companies within certain limits. For example, due to the fact that only classic data like profitability, depreciation and other finance measures have been used, many promising innovations in the past have been stopped, even before they could be put to economic use. Supporters of innovation have to argue against qualitative and strategic considerations. On the other hand they have to argue with vague forecasts, and therefore often loose against easily calculated investments in new machinery and installations which show a certain Return of Investment (ROI).

2 CONCEPT OF AN INNOVATION ORIENTED TARGET-BUDGETING SYSTEM

In response to the problems described above concerning actual R&D-Budgeting procedures the aim of this chapter is to develop a multi-stage process to derive the value of R&D and R&D-Budgets.

2.1 Central notion of Target-Budgeting

The aim of this concept is to develop an EDP-based tool for the planning and controlling of R&D activities in high-tech companies. The model formed for this purpose will give the opportunity to calculate the future value of R&D activities for the company. This is necessary to avoid a backward and competition oriented budgeting. Central notion of the new Target-Budgeting is to look at the R&D-Budget not as an input, but as a result or better output, which is therefore calculated from the expected revenues in the future.

To keep the connection to strategy, a structured strategy development as well as the description of reference numbers has to be implemented in the whole process, which will be described in one of the following chapters.

Based on the chosen strategy the turnovers for current and future product generations are forecast, using a statistical simulation model. To achieve this, an EDP-based Delphi-Method is conducted to gain the relevant internal and external information about the company. As a possible setting for the analysis Porter's concept of the five competitive forces can be used which allows a systematic testing of feasible parameters on the micro-level.

An overview of the product and project classifications used on the different technology S-Curves for calculating the Target-Budget is illustrated in Figure 1.

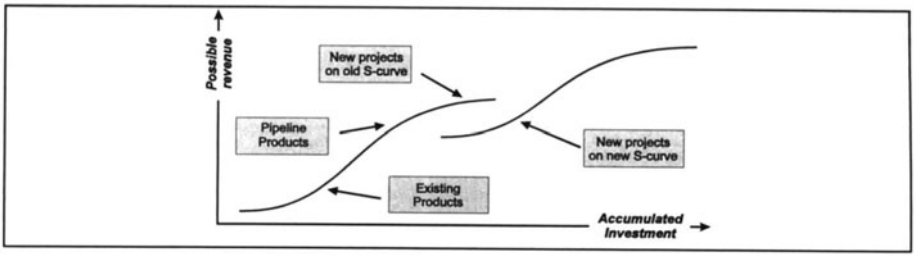

Figure 1: Technological roots of the individual project and product categories.

2.2 Innovation-Target and Innovation-Gap as central reference figures

The data compiled with the EDP-based Delphi-Method is managed in a data-base. The data is offered to the other software-modules in the necessary edited form. On the basis of the data-base-system the operation figures **innovation-target** and **innovation-gap**, which try to describe the future technological situation of the company during a given time period, are derived.

The **innovation-target** is calculated as the inverted value of the product life cycle of certain product groups. If for example a product group has an average product life cycle of four years the resulting innovation-target is 25%. This means, in a very static sense, with a fixed product life cycle and turnover distribution in this product segment a company has to generate 25% of their turnover with innovations. This is necessary because 25% of products responsible for turnover in this segment retire every year.

If the innovation-target is met, the company is as fast as the average competitor. If the company wants to take over the technological leadership, this implies among other things a shortening of the duration of the product life cycle. This means that the innovation-target grows respectively. Assuming that the life cycle in the described segment is shortened from four to three years, the company must generate annually 33% of its turnover in this product segment with the help of innovations. Consequently, the duration of the product life cycle becomes a central strategic variable within the budgeting model. The life cycle duration and related variables thus can be used to install a modern controlling system focusing on financial as well as non-financial measures.

The **innovation-gap**, as the second important variable of the model, results from the difference between the feasible future turnovers and the targeted turnovers, which are given by strategic decisions from top-management. An idealised course of the turnover with innovation-gap is shown in Figure 2.

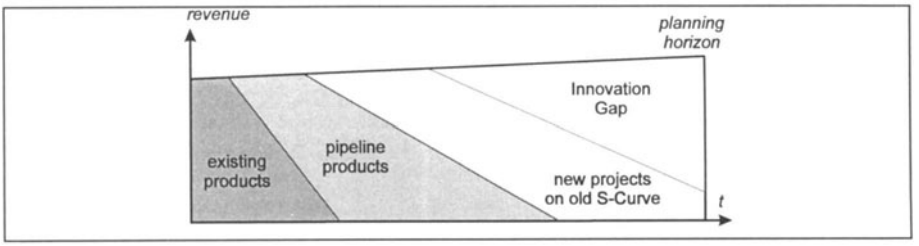

Figure 2: Course of revenue on the basis of the selected specification.

Future turnovers are calculated on turnover forecasts for the already existing products, the pipeline products and the potential turnovers of new projects based on old technology. For the time being the existing products are still able to generate the necessary turnovers. Corresponding to their life-cycle the turnover will decrease over the following years until no turnover can be generated anymore. Of course it is possible that there will be sales after that particular year, but to illustrate the idea of the concept a static market behaviour is assumed. Provided a correct planning beforehand the present pipeline products will be able to close the turnover gap in the next years. However, with a steady product life cycle assumed these turnovers will also fall to zero.

Aim of the model is to prepare a R&D-Budget which allows to close the resulting turnover gap with new products in the future. For this reason the Target-R&D-Budget for the pipeline products and the new projects on old the S-Curve has to be determined.

2.3 Determination of the Target-Budget

After the determination of the core ratios of the budgeting model the maximum R&D-Target-Budget as central figure is derived from the figures innovation-target, innovation-gap and the discounted expected turnover with the help of a mathematical financial model. The fundamental proceeding of determining the R&D-Budget is shown in Figure 3.

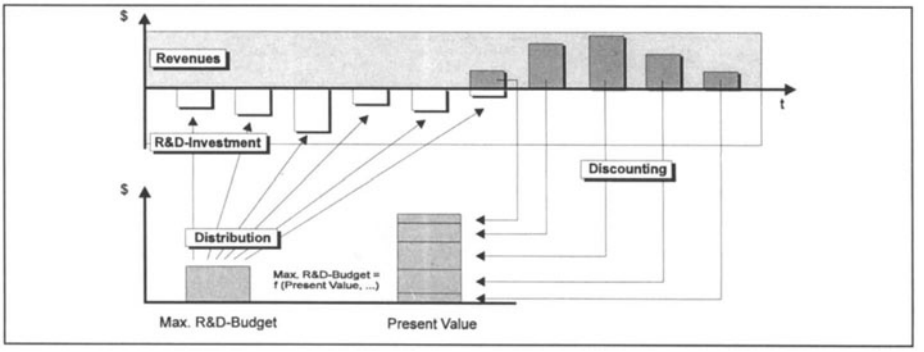

Figure 3: Proceedings to determine the R&D-Target-Budget in general.

The determination of the Target-Budget is based on the ideas which under the name of Target-Costing found their way into production and manufacturing. While in the Target-Costing concept the target costs are derived from the highest possible price, the Target-Budgeting concept calculates the Target-Budget on the highest feasible turnovers. A simplified comparison of both principles shows Figure 4.

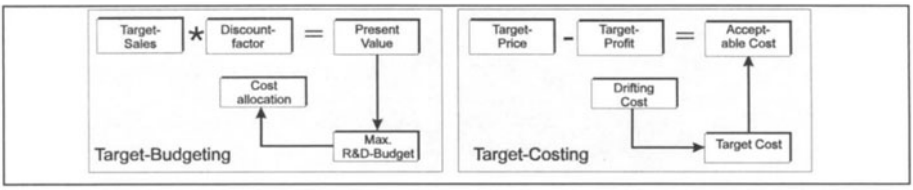

Figure 4: Target-Budgeting vs. Target-Costing.

The determined Target-Budget is allocated to internal and external projects considering the financial and conditional capacity constraints. For this it is important to determine the correct R&D costs. The required information for the distribution can be gained using a process-oriented cost system. This process cost system is among other things necessary, since the classic systems of cost accounting can only inform insufficiently about project development related costs. Traditional methods of cost accounting allocate the overheads to the cost centre and apply them in product calculations on the basis of reference figures, which as a rule illustrate the real origin of costs insufficiently. Provided that for example the overheads are allocated on the basis of the cost of material, the materials handling overheads increase or decrease, if the value of the material changes.

In conclusion it can be said that conventional methods of cost accounting can not describe the origin of cost adequately. An overview over the basic idea for the application of the **Flexible Innovation Accounting System (FIAS) process-oriented R&D accounting** will be given in a later chapter.

The determination of the R&D-Budget does not end with the calculation of the maximum budget. The total budget must be allocated to the different product and project classifications of the respective business product areas. After the calculation of the individual R&D-Budgets per category the different budgets have to be allocated to the single R&D activities using an activity based cost accounting system.

2.4 Examination of resources

To connect the described budgeting process with other activities of the company, control systems corresponding with the single steps of the budgeting model have to be included. For example in one of the first steps it has to be checked, if the forecast liquidity of the company to finance the corresponding R&D activities is sufficient for the next years. If the financial resources are insufficient in the first round, a new definition of the chosen strategy is necessary. Furthermore it has to be checked whether the financial requirements can be met with other financial resources.

As a next step the relevant resources corresponding to the information from the process-oriented cost accounting are allocated to the different R&D projects based on the data forecast. On the other hand it has to be checked, if the human resources which are available to the company are sufficient in quality and quantity to initiate and conduct the different processes. If the internal resources are not sufficient, a make-or-buy decision must help to solve the resource problem. For example it has to be checked if some parts of the activities can be outsourced.

If a buy-decision is not conductible due to strategic reasons, the business strategy referring to the resources has to be re-orientated. In case of sufficient human resources within the company, it has nevertheless to be checked, how far single activities can be outsourced to external institutions or companies. This is true if their research is more efficient or the activities are neither critical nor crucial technology components. For all make-or-buy decisions it has to be considered that they are in line with the chosen strategy or that a buy decision limits future alternative courses of action for the company. For example it has to be checked whether they are irreversible in the short or medium-term, i.e. whether the company can leapfrog a technology generation or not.

2.5 Multi product case

Since the single product case cannot be found in practice it is necessary to describe the multi product case. As a first activity within the budgeting process the product spectrum has to be analysed. Since the duration of the product life cycle is a major variable of the whole concept the different products and projects have to be classified accordingly. Afterwards the feasible sales and cost of the different products and projects have to be forecast. To calculate the value of the different activities the information has to be consolidated. As a next step the external and internal information which is not directly related to the forecast sales and cost must be integrated. After having calculated the different maximum R&D-Budgets the individual project related budgets can be distributed.

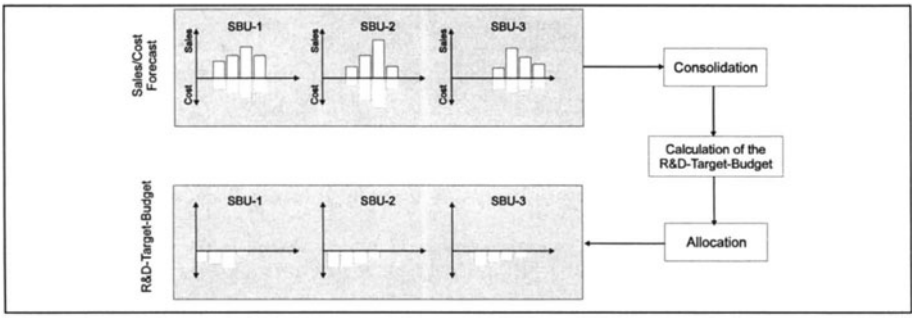

Figure 5: Merge and distribution of the R&D-Budget.

A more detailed description of the whole budgeting procedure is given in the following chapter.

3 PROCEEDINGS FOR DERIVING THE TARGET-BUDGET

The Target-Budget for research and development is determined within a multistage process. The subprocesses themselves are conducted sequential or parallel if possible. Figure 6 summarises the single steps which will be explained in more detail on the next pages.

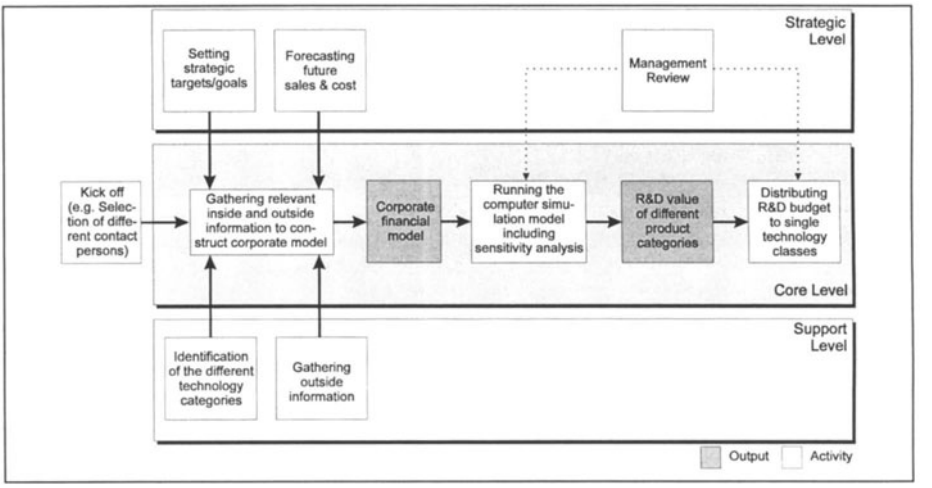

Figure 6: Proceedings for defining the target-budget of R&D activities.

3.1 Determination of data

Starting point for the definition of the budget is a kick-off meeting, where, besides the determination of the process-owner for the budgeting process, contact persons for the following modules are selected. It is intended that the process owner is responsible from the beginning of the whole process to the point where the R&D-Budget is calculated and distributed.

As one important activity the relevant information for the different input variables of the budgeting model have to be gathered. This implies among other things the setting of strategic targets. As mentioned above, the targets are determined by the corporate management using a structured way of finding the strategy with the help of a hierarchically organised decision model. Particularly it has to be checked if the information is available in a data base or whether it has to be newly generated or updated.

As the result of this process the corporate management determines for example, whether the company should strive to become the leader in selected product segments of technology or if it is more appropriate to select the strategy of being the first-follower. With this information and the defined products and projects of the product segment the contact persons are

subsequently interviewed. According to the information needed this will be done using a printed or an EDP-based questionnaire.

Since the environment within the company is not the only important factor for the products and projects, external experts have to be interviewed about the individual subjects. Important information are for example future development on the macro-level like national and international rates of inflation and growth or trends in technology etc.

Not every contact persons will have complete information referring to the different products and projects in one product segment and therefore they can only be interviewed about selected activities within their special segment. For example the central R&D department can only give information about projects but not about products.

On the other hand sales managers are better qualified to give product-information. The question who has the relevant know-how about which product or project must be answered at the kick-off meeting and depends on the situation. With the help of an EDP-based Delphi-Method the different contact persons are asked in form of a question-answer course to obtain the data needed.

The Delphi interview itself has to be conducted most carefully, because any further calculation of the R&D-Budget strongly depends on the quality of the data derived. Figure 7 shows the proceeding used.

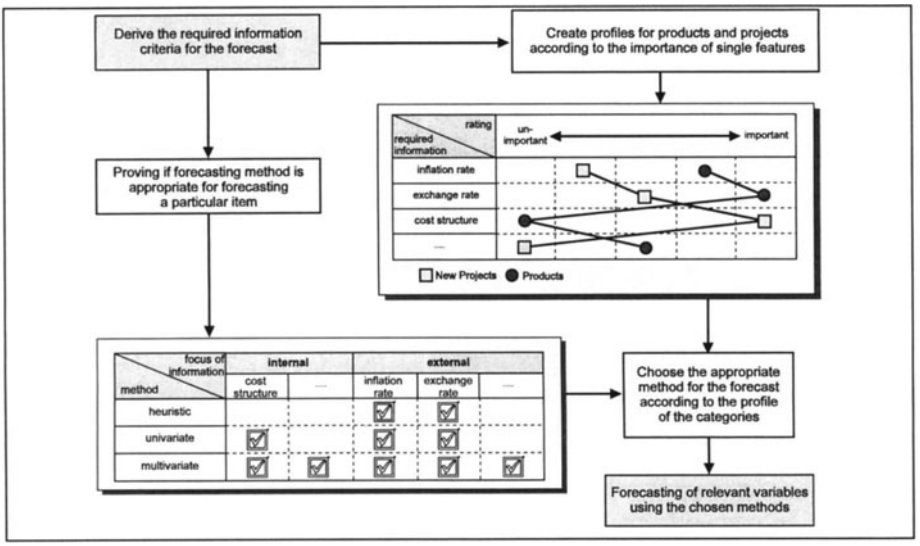

Figure 7: Process to find the appropriate forecasting method.

Due to the heterogeneous character of the different variables not all of them can be obtained with the same forecasting procedures. Therefore, as a first step suitable methods of interviewing for the individual groups of variables have to be identified. Usually the forecasting methods are categorised in heuristic, univariate and multivariate.

Heuristic methods are used if the gathering of data is to expensive and to time-consuming. Known methods are for example the Scenario-Technique or the analogy conclusions. Univariate forecasting methods are those which for example determine the future sales based on only one independent variable. A weakness of these methods is to be seen in the fact that **time** is the only independent variable. Known methods in this area are exponential smoothing or autoregressive methods. Multivariate Analysis methods try to forecast the value of the dependent variable based on changes of the independent variable. They implicitly consider causal relations which is a major advantage of those methods. A common method is for example the Multiple-Regression-Analysis.

First of all the determination of the optimal forecasting procedure starts with the determination of the necessary variables for which the information is needed. On this occasion a distinction between company endogenous and exogenous or between internal and external variables has to be made. The latter distinction includes inflation rate, exchange rate, economic rates of growth etc. On the other hand variables describing the company situation could be for example internal information about cost structures.

After the determination of these variables an examination to what extent each forecasting procedure is suitable to forecast the different variables has to be carried out. Due to the focus of every single method it is impossible that specific methods can forecast all variables. At the same time for each product and project category the importance or unimportance of every single variable for the specific forecasting must be examined. The appropriate method for single R&D activities will be chosen according to the obtained profile and the suitability of the forecasting procedures.

3.2 Data processing

The analysis of the necessary information is to be done within the framework of the whole system. The basis for this evaluation will be an EDP-based risk- and sensitivity-analysis. These methods should supplement the actual capital budgeting. This means that these supplements attempt to integrate the permanent uncertainty of R&D activities in the decision making process. For example they can help to show the effects of uncertainty on the relevant decision variables.

The **risk-analysis** in particular helps to derive a probability distribution respectively a riskprofile for the target variable for example the net present value of an investment from a subjective probability distribution of uncertain input data of the capital budgeting. The sensitivity of the calculated value according to the change of the input data can be examined with the **sensitivity-analysis**.

The **Delphi-Method** developed in the fifties by the RAND Corporation in the United States was originally a method for finding ideas, creating opinions and forecasting based on a questionnaire. The target group are selected experts. The survey is carried out in various steps. Main point is that the single questions will be presented to the participating experts in order to identify deviations or changes. In the second round the result of the preliminary round will be presented. This is necessary because the single interviewee can compare its decision with the opinions of the other experts and after the comparison he can change his statement. According to experiences the results will be stabilised already after the second round, so that only in exceptional cases a third round will be necessary.

3.3 Data Evaluation

In general it should be first evaluated which variables should be included in the financial model of the company. Variables which are irrelevant for the evaluation need not be further analysed. Therefore free capacities should be invested in the evaluation of reliable outputs of other variables. First indicators of the importance of each variable can be derived by means of a sensitivity-analysis.

Sensitivity describes the overall effect or influence that a change in an assumption of a single independent variable produces in the result of a particular dependent forecast variable. Thus the **sensitivity-analysis** helps to identify exogenous variables with a high impact on the endogenous variable. It serves thus to separate important from variables with lower importance.

Before running the analysis the results of a conducted **risk-analysis**, or other methods of capital budgeting, must be available since it is only a tool to support the others.

Computing the analysis for different variables leads to the relationship depicted in Figure 8.

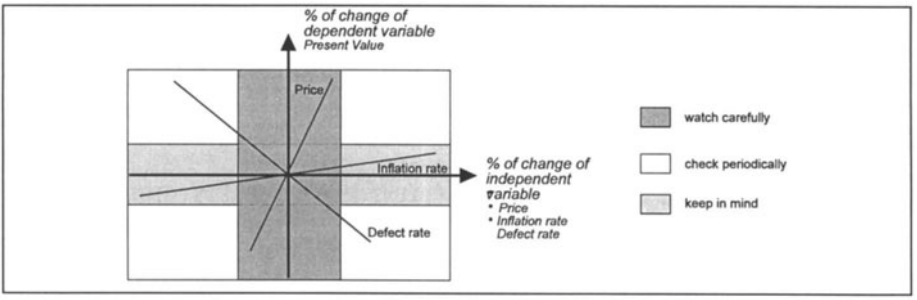

Figure 8: Sensitivity-Analysis.

If the change of an independent variable has a minimal influence on the value of the dependent variable the curve in the diagram is relatively flat. The steeper the slope of the curve the higher the impact of the independent on the dependent variable. In the present case there is a differentiation of three cases. According to the available capacity the variables of the first category (**watch carefully**) must be included in the model. While the variables of the second category (**check periodically**) increase the information of the model the variables of the third category (**keep in mind**) are not of significant importance and can be neglected for a first descriptive model.

Variables with a high slope can be interpreted as value drivers, i.e. it is very important to have a closer look, since a small change has an enormous impact on the target variable. Thus, according to the slope of the single lines it is possible to rank the different independent variables according to their importance.

After generating the data it is to be edited statistically. This process is important because otherwise no clear prediction for a majority of the variables can be drawn. For instance for a Risk-Analysis a respective probability distribution has to be defined.

A simple method to derive the distribution is the so called three-point-estimation. According to this method, people are asked to estimate for each single variable three values, a pessimistic, a realistic and an optimistic value. After using this method to derive the necessary distribution and density functions they can be used for the Risk-Analysis mentioned above.

Risk analysis for a capital investment aims to derive a probability distribution (**risk profile**) of the project's evaluation criterion (**Present Value, ROI, etc.**) from subjective probability distributions of the uncertain key input factors.

Out of two investments, one is clearly better than the other if it offers a greater probability of achieving any given level of return on investment. As pointed out it is necessary to select at random sets of the independent variables and to repeat some steps of the process several times. Therefore the Monte-Carlo-Simulation-Method is an appropriate tool. Figure 9 shows the Risk-Analysis concept used in this model:

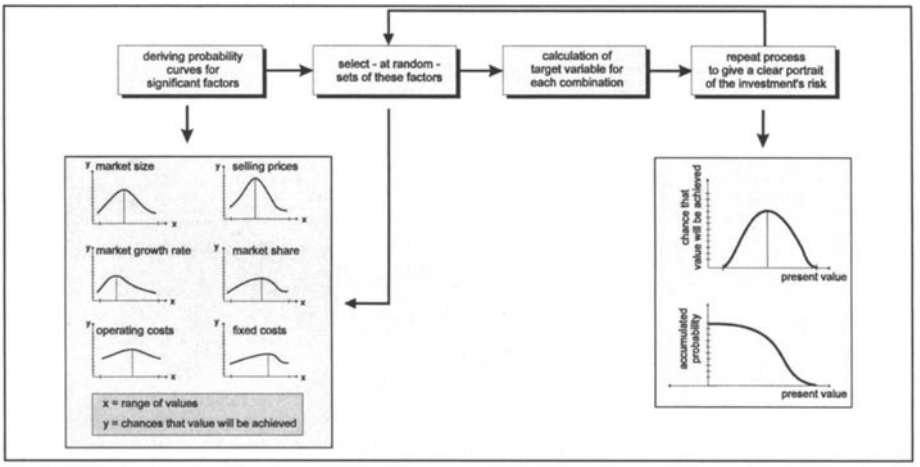

Figure 9: Procedure for the Risk-Analysis.

3.4 Data administration

The EDP-based capital budgeting model mainly uses three software programs. Microsoft Access provides the data base, which is used to administer the diverse external and internal data. Moreover it is used to generate data by means of the Delphi-Method. An interactive graphical user interface (**GUI**) has been developed to facilitate the input of the interviewees for their various estimations.

The main module of the capital budgeting model is based on Microsoft Excel which manages all relevant calculations for the determination of the Target-Budget. The module also

includes the relevant data of the data base in an edited form. For simulation of different scenarios and for risk- and sensitivity-analysis, Excel uses the software Crystal Ball. Crystal Ball is a forecasting and risk-analysis tool which offers the possibility of simulations. Unlike classical calculation programs Crystal Ball offers the possibility to allocate probability distributions to specific cells. Deriving the probability distribution of the dependent variable in the model Crystal Ball uses the well-known Monte-Carlo-Simulation.

4 INTEGRATED PROCEDURE TO DERIVE THE MAXIMUM R&D-TARGET-BUDGET

After having described the single activities within the R&D-Budgeting process it is necessary to explain the connection of the single modules described above.

The main subprocesses of the R&D-Budgeting procedure are arranged around the core of the concept.

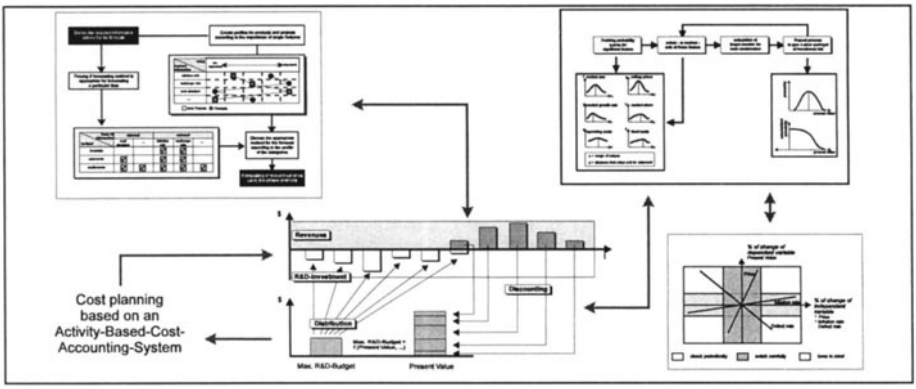

Figure 10: Integrated procedure to derive the maximum R&D-Target-Budget.

The sales forecast, as the basis for all other calculations is to be conducted at the beginning of the whole process. The result from this activity is the input data for the subprocess covering the **risk-analysis** and the **sensitivity-analysis**. One of the main purposes of this module is to separate important from variables with lower important and to evaluate the data from the sales forecast. The aggregated information from this procedure is the input for the calculation of the single R&D-Budgets. Based on these budgets a process oriented R&D cost accounting system helps to allocate the budgets to single research and development activities.

CV of Prof. Dr. M. Perlitz

Prof. Dr. M. Perlitz, born in 1943 in Saarbrücken, studied Business Administration at the University of Saarland. In 1971 he did his doctorate in economics. After gaining his professorship in 1978 he was initially active as assistant lecturer before teaching Business Administration in 1980. Since 1991 he has been professor at the University of Mannheim with special emphasis on International Management. He is co-editor of the European Business Journal and the Business & the Contemporary World. He has written more than 80 essays and published 14 books on topics such as International Management, Strategy Management and Innovation.

CV of Dipl.-Kfm. Randolf Schrank

Randolf Schrank was born in Großburgwedel, Germany, in 1967. He studied Business Administration and graduated from Mannheim University in 1993 after having pursued parts of his studies at the University of Toulon, France, and the Graduate School of International Management in Phoenix, USA. He gained practical experience at Deere & Co., Germany and South Africa and in a consulting project in the telecommunications industry. His research focuses on controlling and performance measurement in R&D.

CV of Dipl.-Wirtsch.-Ing. Klaus Schug

Klaus Schug was born in Seeheim-Jugenheim, Germany, in 1966. He is assistant to Professor Dr. M. Perlitz at the Centre of European Economic Research in Mannheim. With Deutsche Lufthansa AG, Siemens AG, both Germany, and Arrow Electronics, USA, he gained first practical experience. He worked as a free-lance collaborator for Andersen Consulting GmbH. His research focuses on Technology Management, Process Reengineering and Value Based Management.