The use of informational technologies into the cost management

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Abstract
Starting from the importance and role of the information regarding the costs that characterize the decisional process, the purpose of this paper is to present the main tendencies registered in the evolution of the information technology in order to create the information systems that represent the support for the assistance of the managerial decision regarding the costs.
The authors of this paper want to emphasize the moulding instruments, which are an essential part of the managerial process, knowing that mouldiness supposes problem conceptualization and abstraction into quantitative and/or qualitative shapes.
In the case of the mathematical model suggested by the actual paper the variables have been identified and the connections existing between them.
In what concerns the use of information technology we'll emphasize the idea of direct mouldiness into the spreadsheets, regarded as being the most popular information instruments of mouldiness for the final users.
At the end of our work we are going to present the results that we got by using Microsoft Excel Solver as an instrument in those problems regarding costs optimization. We have chosen this information instrument of optimization that generalizes the technique of value as a goal and offers more possibilities of simulation of some parameters that create an optimum situation.
As a principle a problem of cost optimization worked out by Excel endorses the atomization of a linear programme application and that is to reach an optimal solution having the purpose to maximize some results, minimize some effort or of reaching a goal-value desired by the user. Reaching the optimal situation can be done by the automat modification of some parameters which lead to the goal that we wanted, under the conditions of mentioning some restrictions imposed to the model, so that the optimal situation must take into consideration these constraints or restrictions.

Information technologies used in cost management

Cost is one of the most important synthetic indicators that characterizes economic activity and has a crucial role in ensuring the organizations' efficiency and competitiveness. Also, information on costs is an important tool for adjusting, orientation and optimization of the current and further activity and this happens because it occurs in all the activities of an organization.

In these circumstances, cost management plays an essential role in the management system of an organization because, through the cost calculation and results analysis, prepares the forecasts and the control of their achievement, analyzes and explains the irregularities and on this basis provides information and solutions for the board.
Due to the essential role of information on costs in the management process, we believe that modeling is a part of the design of the information - decision-making system.

The success of this activity and the application into production of the developed models decisively depend upon the frame in which it takes place, namely the system analysis. This involves, first, a set of preparatory operations for carrying out the modeling work, and on the other hand some further operations. Only when the mathematical modeling of the economic phenomena, generally speaking, and of costs, in particular, is preceded by a thorough system analysis, and the obtained results are going to be a thorough basis for the decisions' substantiation.

The term "model" is an isomorphic representation of reality to which it creates an intuitive picture, but rigorous too, to show the logical structure of the studied phenomenon.

The purpose of modeling economic processes is the discovery of some links that should legitimate and which, by other means would be very hard to find, or even impossible.

The models used to solve some economic problems, which have taken a mathematical formulation, suppose fallowing the steps of a coherent succession of logical operations called algorithms.

Using the specific algorithms of the constructed model leads to the obtaining of a solution, which will be analyzed in economic terms and will serve as the basis for decisions' substantiation. For this an algorithm must have the following properties:

- Coherent instructions - assumes that the result of an instruction to be retrieved by the following instructions;
- Universality – requires the algorithm to ensure the processing of a large number of the types of problems;
  - Timeness - refers to the time of obtaining the results that should be as small as possible;
- Determinism - requires obtaining a solution with the exception of probabilistic algorithms and the fuzzy (vague) ones;

Economic theory and practice have resulted in economic need for extremely varied models. They can be systematized and analyzed by several criteria.

Thus, *mathematical models* that are part of the abstract models, namely abstract quantitative models are exclusively based upon customized mathematical functions (economic models). They may be:

- *Deterministic* models, based on the application of general laws (postulated that characterize that field in a very general way) leading customized mathematical functions. In these cases random variables are not involved;
  - Statistical models that assume the existence of at least a

relationship derived from the statistical processing of experimental data;

- Stochastic models, meaning the use of random variables in order to describe how the system works. They seek to determine the parameters of static output quantities. Relations thus obtained are considered probabilistic;
- Fuzzy (vague) models, usually reflect a certain property of the studied system, allowing the establishment of the degree of belonging to a certain property;
- Mixed models when we want to notice the use of random variables in order to describe the relations of that system, aiming, on the one hand, determination of stochastic parameters of the output quantities and on the other hand, the mathematical functions.

After the nature of mathematical relations which describe the system's links, models can be linear and nonlinear.

Linear models are the easiest way of approximation of the economic relations due to the fact that both the restrictions and duties are of the Ist degree. The most often used example concerns the linear programming because onto the models which are resolved we can find those relating to costs, that's the reason why we give it our entire attention.

Nonlinear models have as characteristic the fact that both the restrictions and the object function have a higher degree. For example, the square patterns in which the constraints or the object function are of the IInd degree.

Depending on how the time factor is or not taken into account, there are static and dynamic models.

Static models are based on functions whose parameters are independent of the time factor. Decisions based on the solutions offered by these models are valid for a short period of time, but they may be subsequently updated.

Dynamic models are better suited for the most economic phenomena, approximating in a better way reality. They are characterized by time functions.

These patterns can be *stable* when after a disturbance, the response of a system tends to be either to the initial condition, either to a defined state (for example - to adjust prices to meet the conditions of profit) or *unstable* when successive states of an element, at least, are represented by a string of numbers that grows unbounded.

Cost management models and records economic flows, but these operations matter only when they address to the managers and they use them in their decision making process. Once we've identified cost flows there must be a network analysis of the expenses contained within the structure, describing the relations which exist between them and finality.

The first step in the network analysis is the distribution of costs between the incorporated entities, after which it will seek the allocation of their activities and products.

These steps are not difficult to be fallowed if several conditions are fulfilled namely:

- entities have their own means;
- each entity pursues only one activity;
- any of these activities provided by each entity, also has its own means;
- an activity concerns only one product;
- accounting system for recording consumption expenditure allows costs knowledge without ambiguity.

If a certain entity E provides only one activity A, the cost of such activity within the entity is known as soon as the entity's cost is unknown. But it is possible that this activity A results some other costs in other entities too, which emerges from the figure 1.

In this case we must model the cost of A activity, the distributed between the firs and second product, due to which it can be acted upon it.
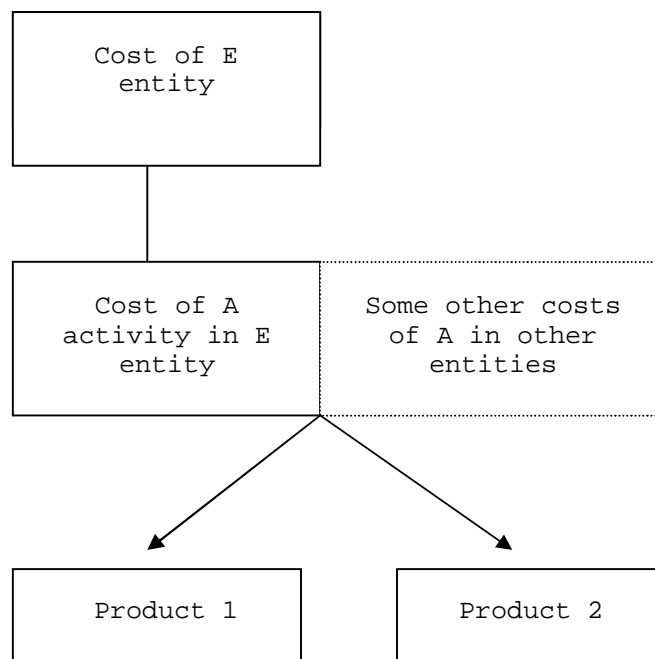
Figure: 1 First graph

If an entity provides more activities, the first problem that appears is to identify the cost of each of them. When each activity can be driven by its own means (personnel or specialized equipment for the A or B activity) knowing the cost is basically simple. When such means are common (e.g. staff attendance of several activities of the entity) we encounter the modeling problem having the same nature as the previous one, but which involves two steps: modeling the cost of the E entity in order that this should be attributable to the activities,

and the modeling of each activity's cost. The figure 2 shows schematically the following s
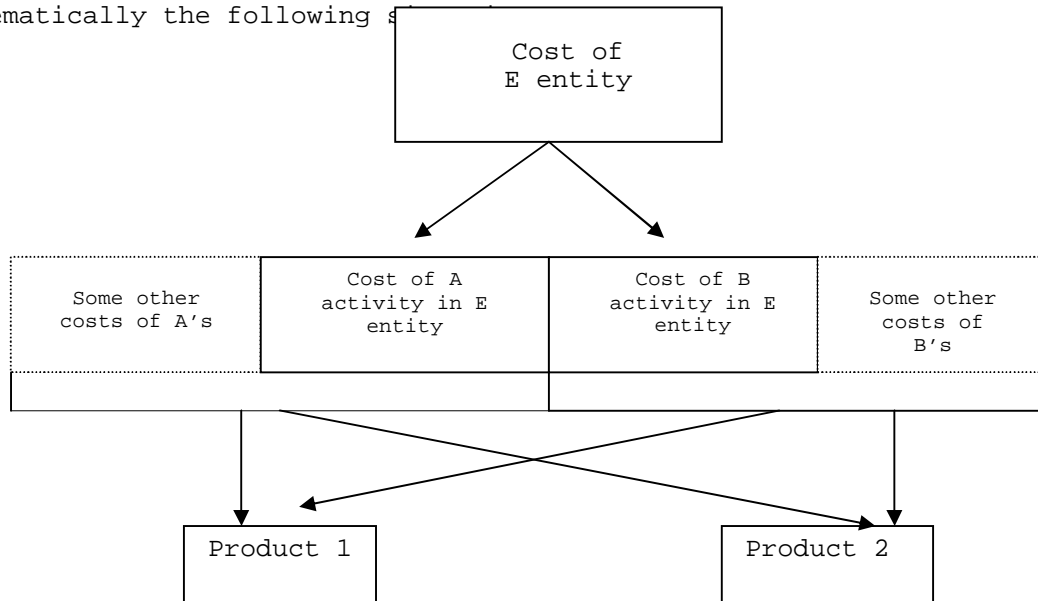
Figure 2: The second graph

Therefore, to model the entities' costs, the first phase is the allocation of consumption that they generate, after which it can be sought for the identification of economic laws which are followed by the costs of the activities produced by the entities. It should be noted that this crucial phase for costs knowledge and mastery raise certain risks. In the attempt to identify them we encounter the issue of costs treatment by grouping them into fixed and variable ones.

In this context, **in order to develop a mathematical model applicable in the field of economic management, we must fallow the next steps.**

1 Knowing the depth of the body is a preparatory nature, dominated by information-specific decision-making methodology, which involves first of all the knowledge of the system objectives and the description of the logic decisional processes.
2 *Develop proper application of the model* assumes the use of a classic modeling tool that should be in a maximum correlation with reality. If this correlation can not be achieved, it can be used either a combination of classical models, or a new model.
3 The model that has been developed facing practice reality and being experimented too;
4 Use of the developed models.

Mathematical modeling seeks, in fact, the determination of certain solutions as much as close to optimal level or even of optimal solutions using:

• Optimization process which involves obtaining the best solution in terms of a specific criterion precisely formulated. In this case, the lack of a better solution, means that the error is zero;
• Heuristic methods which involve the obtaining of some good solutions without claiming that these are the optimum. In these situations it can not be estimated the deviation from the optimum and therefore the error can not be controlled;

- Approximative processes which involve obtaining some solutions close to the optimal solution by means of some successive iteration. In this case the error can be controlled.

Economic and mathematical models applied in the company's activity have as an object the reproduction of some properties of the modeled system (descriptive models) or are models that are to be used for the implementation of some efficient decision rules (normative models). In the most economic-mathematical models descriptive side combines with the normative one.

Modeling through linear programming

Linear programming includes those methods used to solve problems whose model is composed of a system of linear restrictions and an objective function, also linear.
Linear programming problem takes the form of a system of linear equations that characterize an economic process or phenomenon.
Suppose that a company manufactures m products P1, P2, .. Pm, for which n resources are used R1, R2,.. Rn (raw materials, fuel, energy, labor, etc.).
Producing a unit of $\underline{P_i}$ product implies a consumption "a_{ij}" of RJ resource ($i = \overline{1,m}, j = \overline{1,n}$). These consumptions "$a_{ij}$" are known in the literature as technical factors.

Prices for a unit from the resource RJ Prj P_{rj} ($j = \overline{1,n}$). The company has planned to produce from each product quantities q_I ($i = \overline{1,m}$), corresponding to the order received.
Data presented can be systematized in a table form (Table 1):

Table 1

P / R	R_1	R_2	..	..	R_j	..	..	R_n	Quantities planned according to the order
P_1	a_{11}	a_{12}	..	..	a_{1j}	..	..	a_{1n}	q_1
P_2	a_{21}	a_{22}	..	..	a_{2j}	..	..	a_{2n}	q_2
:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:
P_I	a_{i1}	a_{i2}	..	..	a_{ij}	..	..	a_{in}	q_I
:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:	:
P_m	a_{m1}	a_{m2}	..	..	a_{mj}	..	..	a_{mn}	q_m
The price of Rj resources	pr_1	pr_2	..	..	pr_j	..	..	pr_n	

By using the dot-matrix technology, the company's managers can express the following matrix elements:

- technical coefficients (in line with the products and resources in columns);
- price of consumed resources;

- unit cost of products;
- total consumption for the issued order (for the quantities planned to be produced);
- total cost for each product from the issued order;
- overall cost analysis

The following matrices are going to be used:

- technical coefficients matrix

Table 2

	R_1	R_2	..	..	R_j	..	..	R_n	
	a_{11}	a_{12}	..	..	a_{1j}	..	..	a_{1n}	P_1
	a_{21}	a_{22}	..	..	a_{2j}	..	..	a_{2n}	P_2
	:	:	:	:	:	:	:	:	:
A=	:	:	:	:	:	:	:	:	:
	a_{i1}	a_{i2}	..	..	a_{ij}	..	..	a_{in}	P_i
	:	:	:	:	:	:	:	:	:
	:	:	:	:	:	:	:	:	:
	a_{m1}	a_{m2}	..	..	a_{mj}	..	..	A_{mn}	P_m

- vector (matrix column) unit price of each resource:

$$ p = \begin{bmatrix} p_{r1} \\ p_{r2} \\ : \\ p_{rm} \end{bmatrix} $$

With these two matrices can be calculated the unit vector cost of the products Pm. Note:

$$ C_u = \begin{bmatrix} C_{u1} \\ C_{u2} \\ : \\ C_{un} \end{bmatrix} \text{then} $$

$$ C_u = \begin{bmatrix} C_{u1} \\ C_{u2} \\ : \\ C_{un} \end{bmatrix} = AxP = \begin{bmatrix} a_{11} & a_{12} & .. & a_{1n} \\ a_{21} & a_{22} & .. & a_{2n} \\ .. & .. & .. & .. \\ a_{m1} & a_{m2} & .. & a_{mn} \end{bmatrix} x \begin{bmatrix} p_{r1} \\ p_{r2} \\ : \\ p_{rn} \end{bmatrix} $$

The matrix contained into the order (quantities planned to be produced from each product Pi):

$$ Q = \begin{bmatrix} q_1 & q_2 & .. & q_m \end{bmatrix} $$

By the help of this matrix and of the matrix of technical coefficients we can express resource consumption matrix for order execution. Noting this matrix M_r we have:

$$M_r = \begin{bmatrix} m_{r1} \\ m_{r2} \\ \vdots \\ m_{rn} \end{bmatrix}^t \text{ then}$$

$$M_r = \begin{bmatrix} m_{r1} \\ m_{r2} \\ \vdots \\ m_{r\,rn} \end{bmatrix}^t = QxA = \begin{bmatrix} q_1 & q_2 & .. & q_m \end{bmatrix} x \begin{bmatrix} a_{11} & a_{12} & .. & a_{1n} \\ a_{21} & a_{22} & .. & a_{2n} \\ .. & .. & .. & .. \\ a_{m1} & a_{m2} & .. & a_{mn} \end{bmatrix}$$

Starting from the matrix Q we build square matrix Qd (which is diagonally q1, q2, .. qm, and the remaining elements are 0):

$$Q_d = \begin{bmatrix} q_1 & 0 & .. & 0 \\ 0 & q_2 & .. & 0 \\ .. & .. & .. & .. \\ 0 & 0 & .. & q_m \end{bmatrix}$$

Multiplying this matrix by the unit costs' matrix we get the total costs' matrix for each product from the order.
Note:

$$C_p = \begin{bmatrix} C_{p1} \\ C_{p2} \\ \vdots \\ C_{pm} \end{bmatrix} \quad \text{the total cost matrix of each product.}$$

Then:

$$C_p = \begin{bmatrix} C_{p1} \\ C_{p2} \\ \vdots \\ C_{pm} \end{bmatrix} = \begin{bmatrix} q_1 & 0 & .. & 0 \\ 0 & q_2 & .. & 0 \\ .. & .. & .. & .. \\ 0 & 0 & .. & q_m \end{bmatrix} x \begin{bmatrix} C_{u1} \\ C_{u2} \\ \vdots \\ C_{un} \end{bmatrix} \text{ or } C_p = Q_d x C_u.$$

Knowing the total cost of each product we can determine the total cost of the order which we note with Ctc. So,

$$C_{tc} = \begin{bmatrix} 1 & 1 & 1... & 1 \end{bmatrix} x \begin{bmatrix} C_{p1} \\ C_{p2} \\ \vdots \\ C_{pm} \end{bmatrix} \text{ or } C_{tc} = \begin{bmatrix} 1 & 1 & 1... & 1 \end{bmatrix} x C_p$$

We get to the same result if we multiply the unit resources' prices by the quantities of the resources used for the order, i.e. matrixes product:
P(Q*A)=C_{tc}.
In the previous examples unit and total costs have been determined and without imposing restrictions on the resources needed (i.e. it was

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assumed that the company has unlimited resources whose cost they can pay) and it was also considered that there is a firm command of products of the type of P1, P2, Pm ..

These cases are ideal but rarely encountered. Companies are often faced with situations in which their resources are limited, the market study shows that the demand for certain products is limited or the maintaining business relations with certain partners requires the production of some products which, although they are not very profitable, it's necessary.

If the company can get the same products with the same resources and the same technical coefficients (the above examples) but without a firm command and has limited resources (in whole or just in part) we encounter the issue of determining an optimal production plan for the purposes of determining the quantities that are to be made of each product, based upon the available resources so that the production costs should be minimal.

Under these conditions, the model presented in Section 2, the quantities q_i $\left(i = \overline{1,m}\right)$ from the products P_i $\left(i = \overline{1,m}\right)$ are no longer aprioristic determined, but they are to be determined so that manufacturing costs should be minimal.

Being unknown to us we will note them this time with x_i $\left(i = \overline{1,m}\right)$ and

matrix $Q = \left(q_1 \quad q_2 \quad .. \quad q_i \quad .. \quad q_m\right)$ is replaced by matrix

$X = \left(x_1 \quad x_2 \quad .. \quad x_i \quad .. \quad x_m\right)$ which is the size of a series of products introduced into manufacturing at a time. Matrix costs of each product is going to be:

$$C_p = \begin{pmatrix} C_{p1} \\ C_{p2} \\ : \\ C_{pi} \\ : \\ C_{pm} \end{pmatrix} = \begin{pmatrix} x_1 & 0 & .. & 0 & .. & 0 \\ 0 & x_2 & .. & 0 & .. & 0 \\ .. & .. & .. & .. & .. & .. \\ 0 & 0 & .. & x_i & .. & 0 \\ .. & .. & .. & .. & .. & .. \\ 0 & 0 & .. & 0 & .. & x_m \end{pmatrix} \times \begin{pmatrix} C_{u1} \\ C_{u2} \\ : \\ C_{ui} \\ : \\ C_{um} \end{pmatrix} = \begin{pmatrix} x_1 C_{u1} \\ x_2 C_{u2} \\ : \\ x_i C_{ui} \\ : \\ x_m C_{um} \end{pmatrix}$$

and the total cost of a series formed by the quantities x_1, x_2 .. x_i .. x_m from the products P_1, P_2 .. P_i .. P_m is:

$$C_{ts} = \sum_{i=1}^{m} x_i C_{ui} \Leftrightarrow C_{ts} = X C_u$$

This cost should be minimized.
Also, resources being limited, it follows that the matrix's elements that mean their consumption for each series is limited.

If b_1, b_2 .. b_j .. b_n is the maximum level allowed to be available from each resource and R_j and we note:

$$B = \begin{pmatrix} b_1 \\ b_2 \\ : \\ b_j \\ : \\ b_n \end{pmatrix}$$

and the calculation in place of Mr Q's introduce the matrix X, then we obtain the restriction system:

$$\overline{M}_r \le B$$

where $\overline{M}_r = XA$ (A being the matrix of the technical coefficients)

As the quantities x_i $\left(i = \overline{1,m}\right)$ can not be negated $\Rightarrow x_i \ge 0$ $\left(i = \overline{1,m}\right)$

i.e. for matrix X we have the condition $X \ge 0$

Therefore we have the following problem:

$$(P) \begin{cases} \min f(x) = XC_u \\ XA \le B \\ X \ge 0 \end{cases}$$

which is a problem of linear programming.
Problem (P) dot-matrix written above can be presented analytically as follows:

$$\min f = x_1 C_{u1} + x_2 C_{u2} + .. + x_m C_{um}$$

$$(P) \begin{cases} a_{11}x_1 + a_{21}x_2 + .. + a_{m1}x_m \le b_1 \\ a_{12}x_1 + a_{22}x_2 + .. + a_{m2}x_m \le b_2 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_{1i}x_1 + a_{2i}x_2 + .. + a_{mj}x_m \le b_j \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_{1n}x_1 + a_{2n}x_2 + .. + a_{mn}x_m \le b_n \end{cases}$$

$$x_i \ge 0, i = \overline{1,m}$$

Information technologies used for modeling

Currently, information technologies used for modeling enjoy major changes regarding the way in which managers can use computer systems as the support for decision-making process: more and more computers are connected on the network, so that decision support systems can quickly become used goods jointly by the entire organization, organizations can now easily use the Intranet and Internet networks offering high-performance applications to the makers from any point on earth, many organizations develop distributed systems, intranets and extranets, which allow both easy access to data stored in multiple places, and collaboration and cooperation with the whole world; integrated systems are made which exceed even then organization's frame. Managers can make better decisions because they have more precise information.

The type of decision support systems can create interactive interfaces that allow the users to view and process data and models with standard Web browsers by great flexibility, efficiency and ease. Communication between managers and computer and Web can be achieved through a great variety of tools, including cell phones. With these tools, managers can use information and important systems and can cooperate one to the other.

Data Warehouses - and their analytical tools such as Data Mining and Online Analytical Processing (OLAP) have substantially improved access to information within organizations. Support for group decisions continues to improve due to great development and in this way they allow group work at any time and any place. Methods of artificial intelligence help to improve the quality of the decision and they are embedded in many applications: from household appliances to the Web's search engines. Intelligent agents can be used for routine activities, which allows to the makers to devote more time to important activities.

The development of the organizations that learn and knowledge management provide the expertise of the entire organization in order to solve problems anytime and from any place.
A major feature of decision support systems is that they contain at least one model. The basic idea is that the analysis of decision making for the selection of decisional alternatives should be performed on a real model and not on a real system.

Trends in the evolution of information technologies for modeling

We will now present the main trends in the evolution of information technologies for the systems' accomplishment for the management decision support by pointing out the modeling tools that is an essential part of managerial decision-making process.

There are several software products that create and update charts of influence, i.e. a graphic representation of a model which can be used for a model's design, development and understanding. They serve as a framework for expressing the precise nature of the model's relationship and so they help to eliminating elements that are not needed or are not important to be included in the calculation relations.

The most representative are considered to be the following:

- **Analytics performed** by Lumina Decision Systems, Los Altos, CA. Analytics allows the user to describe the model by large blocks representing sub-models of the original model and shows how these blocks affect the model's important outcomes. Each block can then be disaggregated to obtain a more detailed model. Finally, at the last level of decomposition, the variables are assigned values and the problem is solved.
- **DecisionPro** made by Vanguard Software Corporation, Cary, NC. DecisionPro incorporates multiple modeling techniques: linear programming, Monte Carlo simulation, decision trees. After one influence diagram model develop, the model can be solved directly without the need to convert it by a special tool.

- **DATA Decision Analysis Software** developed by TreeAgc Software Inc., Wiliamstown, MA. DATA include influence diagrams, decision trees, simulation models etc.
- **Definitive Scenario** of the Definitive Software Inc., Broomfield. CS'company. Scenario creates influence diagrams that can be integrated into Excel spreadsheets. Also, these charts allow the direct application of the Monte Carlo method to generate the random variables values.
- **PrecisionTree** made by Palisades Corporation., Newfield, NY. PrecisionTree create influence diagrams and decision trees directly into Excel spreadsheets.

For the models' construction and implementation there are available many other systems from software programming languages for the third generation, fourth and fifth to the CASE systems (computer – aided systems engineering) that can automatically generate software. Next we are going to refer to the type of spreadsheet (spreadsheets)systems which are the most popular modeling tools for the final users.

Due to the ease that can be used, many applications in economics, technical, mathematics and other sciences are built on systems of spreadsheets. The best known systems of this type are Microsoft Excel and Lotus 1-2-3.

The current trend is to extend as many applications as possible that can be achieved with the type spreadsheets systems. Thus, to solve specific classes of models instruments of "add-ins" were created, such as for example:

- **Solver** developed by Frontline Systems Inc.., Incline Village, NV, for linear and non-linear optimization;
- **@ Risk** performed by Palisades Corporation, Newfield. NY, for risk analysis by simulation.

Due to intense competition in the software market, the best "add-ins" have been directly incorporated into the latest versions of spreadsheets. That happened to Solver, which was incorporated in Excel.

The spreadsheets system types have become important analysis, planning and modeling tools, because they incorporate a range of financial, statistical, mathematical, functions generating random numbers, etc..

Most systems have interfaces which assure the connection with various databases and other modeling techniques: expert systems, optimization and simulation systems etc..

The spreadsheets system types were developed primarily for personal computers, but they can be executed on large computing systems too. The spreadsheets system types underlying multidimensional spreadsheets systems and OLAP tools.

We will now present the Solver component of the Microsoft Excel program that allows the implementation of some mathematical models used to optimize costs. This component is launched from the Tools sub-menu. If it does not appear in Tools, then to install the Add-Ins select Solver Add-in and then click OK button.

This very strong analysis element uses multiple variables and restrictions which are adjusted to find the optimal solution to solve a problem. Also one can solve:

- problems with obtaining extreme values of some functions.
- problems of linear and non-linear programming.
- problems in programming into the multitude of whole numbers.

The most famous problems in the economy are those that regard **optimization**.

They consist of an **objective function** that should reach an optimum (**minimum or maximum**) and of some **restrictions** (natural limitations of the existing resources: for example, buying products at a time is limited by the amount considered available, manufacturing products is limited by the amount of raw materials held). All the variables involved must be numerically quantified.

This very strong analysis element uses multiple variables and restrictions which are adjusted to find the optimal solution to solve this problem.

Case study: Problem of cost optimization

The problem's goal is to minimize production costs into a company with productive activity, so as not to exceed the budget given for a planned production.
Data can be structured in an Excel spreadsheet with the following structure (Fig. 3):

	A	B	C	D	E	F	G	H	I	J
1		R1	R2	R3	R4	R5	Cu/P	Budget	Q	Ct
2	P1	0.01	16.00	0.32	3.50	21.00	1648889.76	0.00	0.00	0.00
3	P2	0.02	12.00	0.50	3.00	30.00	1398009.00	0.00	0.00	0.00
4	pr	95000.00	85000.00	41218.00	18500.00	10000.00				0.00

Figure: 3 Spreadsheet with optimization calculation

where:

Table 3: The meaning of the spreadsheet's elements

P	Products that are being made
R	Resources used according to the fabrication technologies
pr	Resources' price
Cu/P	Unit cost of each product (e.g. for P_1 product $=B2*B4+C2*C4+D2*D4+E2*E4+F2*F4$)
Budget	budget per product depending on the quantities planned to be produced (e.g. for P_1 product $=B2*I2+C2*I2+D2*I2+E2*I2+F2*I2$)
Q	Quantities planned to be made
Ct	Total cost per product (e.g. for P_1 =G2*I2)

Objective function is placed in J4 cell and represents the optimal cost of production for a planned production. In addition the following restrictions are known:

- the budget for P1 is of 120,000 for a planned quantity.

- the budget for P2 is of 130,000 for a planned quantity.
- the amount planned for P1 0≥.
- the amount planned for P2 0≥.

To determine the optimal total cost, the variables that must be determined are the planned quantities that should be made of each product.

We will use from the TOOLS menu the option Solver. The window with the name Solver Parameters will open (Figure: 4).
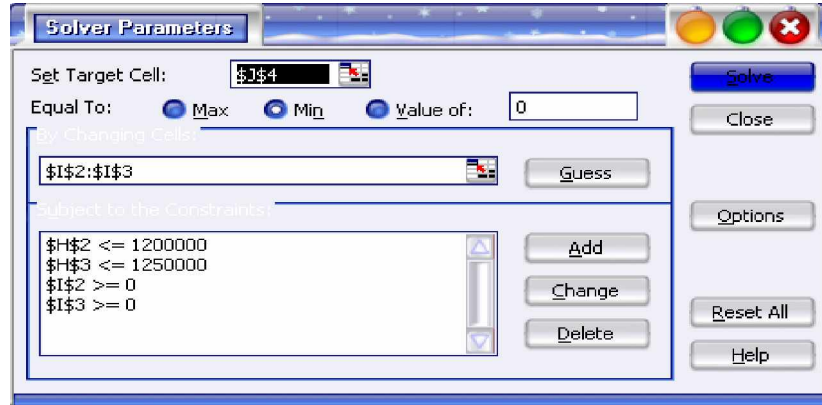

**Figure: 4 Solver Parameters window**

Cell target (Set Target cell) is the total cost, on the min. option. **Specifying variables (By changing cells)** are the amount planned to be produced (Q).

Specifying restrictions: One push the button Add from Solver Parameters and the window Add constraint is obtained.

Restrictions will be written and click Add in order to write the next restriction or OK to return to the Solver Parameters.

After creating all the restrictions, they appear alphabetically in the Solver Parameters window.

Figure 5: Work Options
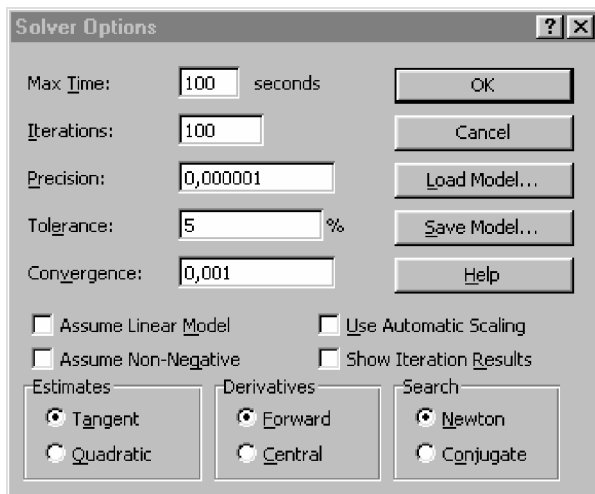
The user can use the following work options (Fig.5):
1. *Max Time* and *Iterations*: establish working conditions. If one of them is reached, iteration stops. For routine cases, default values are sufficient.
2. If accuracy increases over the default, working time increases too.
3. *Tolerance* applies only to full numerical solutions and the it represents the error percentage which is upheld against the exact solution.

4. Estimates, Derivates, Search – using default forms. It refers to linear optimization techniques.
5. Assume Linear Model – allows a faster solving of linear problems.
6. *Show Iteration Results – allows the operation of several combinations of variables, not only to that one leading to the optimal solution.*

By pressing **Solve** from the Solver Parameters window we obtain Solver Results window (Fig.6).
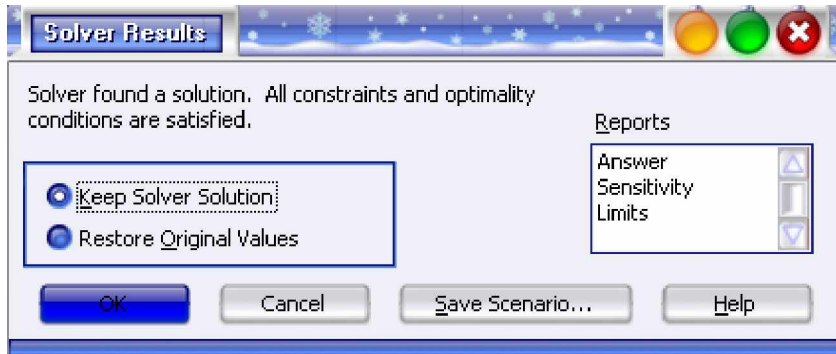
Figure 6: Solver Results Window

From the Solver Results window the user must specify if he wants all those three reports that the solver provides to solve.

The significance of the information of those three reports is:

1 Answer Report shows:
- the initial and final value, for the current values of variables for the objective obtained function;
- initial and final values for variables (the problem's unknowns);
- restrictions' values for the final values of the variables.
2 Sensitivity Report presents the final values of the unknowns and of Lagrange's multipliers.
3 Limits Report presents the objective function's value and the interval in which an unknown can vary; the other ones remain unchanged, without changing the value of the objective function.

If the case of the analyzed problem Limits Reports window is (Figue: 7):

Figure 7: Limits Reports window

The result is:

- Q1 = 29,390 (the amount to be produced from P1)
- Q2 = 27,460 (the amount to be produced from P2)
- Ct for P1 = 48461124467 (total cost P1)
- Ct = 38389965949 for P2 (P2 total cost).

In conclusion, the optimal total cost will be 86851090416.

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