Evaluating the Role of "Differential Evolution" Simulation Method in Management Accounting(Case Study)

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Abstract
Limited resources and unlimited needs, makes optimum allocation of resources necessary. This includes labor, natural, capital and management resources. Different methods and techniques have been used for allocation of the so-called. Today, simulation methods have become popular in different sciences. Although using such methods have become widely popular in human, management and accounting sciences since long time ago, it is also proven that utilizing them helps us to make more reliable and optimum decisions. Management accounting is not an exception here. The purpose of this paper is to evaluate a real world example by using a simulation method. Results show that application of simulation methods deliver reliable results and help managers to make better decisions.
Key words: Management accounting, Simulation, Differential Evolution

1. Introduction

In process of decision-making, there are series of uncertain and ambiguous factors and determinants which need to be dealt with. As a result, researchers and scientists concentrated their effort towards achieving efficient methods to predict these variables. Most decisions in economics, finance, industries and other related fields such as banking, insurance, tourism, commerce, financial management, risk management, marketing, investment plan evaluation and etc. are made on a basis which at least one part of it is a reduced value and one or more of its variables are related to future. Decision making is based on prediction because future value of such variables is often not certain. Prediction needs a powerful model which is consisted of two parts: random and specified. Simulation is a way in which a behavior similar to the behavior of the random part of the pattern can be recreated. Therefore, we can have the possibility of achieving reliable prediction with a measurable risk. Utilizing simulation in order to understand the behavior of a system has become increasingly popular and has been paid a lot of attention in last few decades.

2. Study Background and Theoretical Framework

2.1. Definitions of Simulation

Simulation is the demonstration of aspects of a given phenomenon in numbers, figures, codes or forms in a way that it can be easily studied and evaluated (Faghih, 1996:236). In other words, simulation is the repetition of a real world process or system after passage of time. Simulation is closely related to the artificial recreation of the system background with its evaluation in order to achieve some certain conclusions about the functional features of a real system. Simulation, in another perspective, is defined as the examination of a model of a real system (Greasly, 2004).

The term Simulation in dictionaries is defined as “to pretend” or “to understand the truth about something real”. In fact, every model or demonstration of anything, is kind of simulation. The term Simulation is defined in Oxford dictionary as: “a state in which a particular set of conditions are artificially put together in order to study and evaluate something which can exist in the real world (Homeboy and Ruse, 2003:1200).” In Moein dictionary, simulation is defined as “drawing a portrait of someone or something as if it is compatible with its reality” (Moein, 1996:2022).

Simulation, in another point of view, means the creation of unreal environment and using a theoretical model to evaluate the behavior of an organization or a system in real world. The artificial or fake environment is a place identical to the real or virtual place in which the analyst tries to model the real system/organization (Salami, 2003:119).

In general, the term simulation has a wide definition and can be used effectively in various concepts in order to gain an identical result compared to a real world system or process. In other words, simulation is “to model or to study a model in order to gain a deeper understating of a system features (Faghih, 2008:5).”

2.2. Necessity of Simulation

When specific information about a system is needed and there are no available resources, an experimental problem emerges. Although direct experimentation of real world removes the difficulties of appropriate modeling adaptation, it still has some certain shortcomings:

1- It can disrupt the company’s routine operations;
2- If people are an integral part of the system, they may change their behavior due to observations;
3- To achieve desirable model may be excessively time consuming and costly;
4- Real world examination may not allow for replacements;
5- It can be extremely difficult to maintain one identical circumstance for several examinations.

Therefore, according to the above mentioned difficulties and in case of existence of one or more of the following conditions, the researcher must use a simulation method:

1- There is no whole mathematical codification, or, there is no analytical methods to solve the mathematical problem;
2- If the mathematical methods are difficult, simulation seems to be a simple way to solve the problem;
3- People involved are not mathematically eligible to conduct the analytical methods;
4- Apart from estimation of some parameters, a simulated past of the system/process during a certain period of time is desirable;
5- Simulation may be the only solution due to various difficulties in real world examinations and observations;

6- There is a need for time density for long term systems/processes. This difficulty is absolutely resolved in simulation and there is complete dominance over time because the pace of a phenomenon can be increased or decreased willingly (Greasly, 2004).

Accordingly, the necessity of simulation methods becomes even more obvious to us.

2.3. Advantages & Disadvantages of Simulation

Every system and model has certain advantages and disadvantages. As we will see in table below, simulation models are no exceptions.

No.	Points of Strength (Advantages)	Points of Weakness (Disadvantages)
1	It is not a theory, but a methodology for solving problems.	Highly costly and time consuming due to the need for huge amount of information.
2	Efficient application in teaching and training.	If not utilized correctly, can bring false outcomes.
3	Easy to use by managers and analysts.	It is not real and cannot estimate its errors.
4	It is “run” instead of “solved”.	There is a risk of exaggeration of numbers.

Therefore, simulation too, has certain advantages and disadvantages and yet it is one of the most popular tools for scientists and researchers.

2.4. Background of Application of Simulation Method in Financial Fields

2.4.1. Background of Application of Simulation Method in Management

Various studies have been conducted on the utilization of simulation methods in financial management. In this section, we will introduce them briefly. The major studies in the field of financial management are Simulation of Portfolio Outcomes (Geotzmann and Edwards, 1994: 76); Predicting outcome behavior and risk of different debts (Hess, 1994:14); Analysis of outcome rates for real estate investors and property owners (Derieux et al, 2005:21); simulation of Market schedule (Geotzmann et al, 2000:256-264); Helping financial advisors and consultants with their investment recommendations (Kraten, 2007:56); Resolving the Unreliability in multi-criterion decision makings (Momeni and Esmailian, 2006:231-233); Designing Financial Artifacts (Tabrizi, 2003:27).

Regarding production management, various studies have been conducted which the most important ones are introduced here. Simulation Studies for changing the working method and methods of using the capital (Momeni et al, 2005:226-227) and simulation of business administration processes related to purchase (procurement) management of a real company (Azadeh et al, 2006:457). Regarding human resources management, some major studies are: The analysis and evaluation of public sector companies’ organizational relations through modeling line systems in which human factor acts as service provider (Momeni& Sharif Abadi, 2006:12-13).

2.4.2. Background of Application of Simulation Methods in Accounting

Some important studies regarding this topic includes, Utilizing Simulation in order to analyze cost and time of contracted projects (Cenauskas and kumiega, 2008:32 and 16); Utlizing Simulation in order for managers' better understanding of financial concepts (Uhles et al, 2008:82-83); Utilizing Simulation to develop internal system control compatible with section requirements (Borthick and Bowen, 2008:47); Utilizing costing procedure based on activity and costing of life span for large scale planning along with simulation of companies' future (Rodriguez and Emblemsvag, 2007:370); Utilizing simulation in order to develop an efficient costing system (Labro and Vanhoucke, 2007:955-956); Simulation of added value incomes (Piriaei and Farhanian, 2004:237) and Utilizing Simulation in order to Utilize personnel and human resources accounting (Hassan Ghorbani, 2001:21).

In general, simulation is considered to have numerous applications in management accounting concepts and there are several reports of its benefits in subjects like capital budgeting, assets pricing, repair and maintenance, risk and unreliability estimation, etc. However, it is important not to fall for excessive use of simulation and to avoid casual interpretation and ambiguity. Utilizing simulation in order to understand the behavior of a given system is a phenomenon widely marked in last decades. The simulation results provide a basis for recommending different improvements. Systems simulation, today, is one the most efficient tools in the hands of mangers and engineers and can be extremely helpful in their decision makings. This paper presents one the most important uses of simulation in management accounting. In the next section, a real world case followed by our possible simulation solution with its practical results will be discussed.

2. Analysis Methodology

Problems containing absolute optimization in continuous spaces are usually applicable in different sciences. In general, the main purpose of such problems is to optimize the characteristics and features of a system by choosing related parameters. For better understanding, the system parameters are shown in a vector. If the function is a complex non-linear and non-differentiable one, direct searching method will be used as the best possible option (Stom and Price, 1997).

The core of every direct searching method is production of different numbers of parametrical vectors. Once a new generation (Series) of vectors is produced, it should be determined whether the newly produced parameters are acceptable or not. Most standard methods benefit some criterion for such decision makings. According to these criterions, a parametrical vector is only acceptable when it improves the weight of the target function. Despite high speed of these searching methods, it is still possible for them to be trapped in a local optimum point. In parallel searching methods such as Genetic Algorithm and Evolutional Solutions, this problem is inherently avoided. By simultaneously producing multiple vectors, escaping from these local optimum points becomes possible. In general, four different requirements should be considered when using optimization methods:

1- Ability to work with non-differential and non-linear functions;
2- Ability of parallel or simultaneous solving, when functions need complex and numerous calculations;
3- Easy and short operations as well as few number of controlled variables for reaching an optimum point;
4- In different and independent examinations, it shows an acceptable level of convergence towards reaching an optimum point (Ston and Price, 1997).

Differential evolution method is used to solve the problems in this paper. This method is considered to be a new exploratory method to find optimum points of non-linear and non-differential functions in continuous spaces. This is a much faster and more reliable method than others and needs only a few controlled variables. This method can be used in simultaneous (parallel) calculations. The differential evolution method is in fact a direct parallel searching method which utilizes some vectors with D-Dimensional parameter as the population of each generation (D equals to number of decision-making variables). The number of population (NP) remains the same during optimization calculations and primary population vector is chosen randomly and must cover all parameters' spaces equally. In this method, a new vector is produced as the sum of the difference of two vectors added to a new one. This process is called mutation. Then, parameters of the mutated vector are mixed with a predetermined vector – target vector- in order to form the examination vector. If the function value in examination vector is higher than the function value of the target vector, it will replace it in the next generation. Each population vector should be taken as the target vector once; therefore the NP is calculated in every generation. The differential evolution method is designed in a way that it covers all four requirements mentioned earlier (Ston and Price, 1997).

Most optimization problems have Constraints and conditions. The problem of using differential evolution method in solving constrained optimization problems is that by manipulating all population points of each generation, operators could deliver impossible results. There are, however, several ways to overcome this difficulty. After the mutation phase, we may observe band trespassing (upper and lower bands). This can be resolved by using one of the following solutions:

1- In case of any band trespassing, that band (upper or lower) can be replaced with the desired parameter;
2- In case of any band trespassing, that parameter can be randomly produced in the appropriate area using the following formula (Babu and Angira, 2006):

$$\vec{x}_i^{\,j} = lower(x_i) + rand_i[0,1] \times (upper(x_i) - lower(x_i));\ i = 1,\ldots,D$$

D: Number of Parameters (Dimensions)

Using the penalty function is one the common methods in solving constrained optimization problems. This function, as it will is shown in this paper, will convert the constrained problems to unconstrained ones.

$f(X)$:Minimize

$i = 1,\ldots,m\ h_i(X) = b_i$ Subject to:

$g_j(X) \le c_j\ \ j = 1,\ldots,r$

Where the penalty function is used as below:

$$obj(X, W_1, W_2) = f(x) + \left[\sum_{j=1}^{m} W_{1j}\left(h^2{}_j(X)\right) + \sum_{j=1}^{r} W_{2j}\left[\max\{0, g_j(X)\}\right]^2 \right]$$

In this function, W1 and W2 are the penalty coefficients which are usually considered as big numbers depending on the nature of the problem (Edgar and Himmelblau, 1989).

In this study, we have used MATLAB 7 software program in order to solve the problem. This is a highly popular language for solving problems. This program consists of full-fledged calculations, conceptual imagination and programming features which are used when problems and solutions are shown as mathematical symbols. This program has various functions. The main applications of this program are model algorithm, simulation, analysis of simulated data, exploration, specific conceptual imagination and development of engineering diagrams. This program allows its user to solve many problems, especially the vector and matrix ones, easily. It is fast and precise in dealing with complex estimations. The name of this program is derived from the termMatrix Laboratory.

3. Scientific Analysis of The Simulation Method

In order for better understanding of the application of simulation method in management accounting and its mechanism, the following case study is chosen. BitaKhshkbar Kamran Co. has a production line with two products which are called 1 and 2 in here. The demand and production data are presented in below tables:

	Product 1	**Product 2**
Initiation time (hours)	6	11
Initiation cost (US$)	250	400
Production time of each unit (hours)	0.5	0.75
Production cost of each unit (US$)	9	14
Product storing cost (US$)	3	3
Penalty cost for demand Satisfaction (US$)	15	20
Final Price (US$)	25	35

Demand Data

Product	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1	75	95	60	90
2	20	30	45	30

Total production and initiation time in each week is 80 hours. The primary inventory is 0 and must be the same by the end of week 4. Only one product can be produced every week and the production line must be stopped and cleaned in the end of each week. Therefore, initiation time and cost of each product is valid only in a week during which the product is being produced. It is noticeable that no production is run while the production line is initiating. The target is to maximize the overall net profit for all products in all weeks.

Solution: This problem is solved and formulated just like a mixed integer linear program. In order to solve this problem, differential evolution method, explained earlier, is used. The profits are formulated as below:

$$
\begin{aligned}
profit &= (13X_1 - 250)X_9 + (13X_2 - 250)X_{10} + (13X_3 - 250)X_{11} + (13X_4 - 250)X_{12} \\
&+ (18X_5 - 400)(1 - X_9) + (18X_6 - 400)(1 - X_{10}) + (18X_7 - 400)(1 - X_{11}) + (18X_8 - 400)(1 - X_{12}) \\
&- 15\max((75 - X_1),0) + 9\max((X_1 - 75),0) - 15\max((95 - X_2),0) + 9\max((X_2 - 95),0) \\
&- 15\max((60 - X_3),0) + 9\max((X_3 - 60),0) - 15\max((90 - X_4),0) + 9\max((X_4 - 90),0) \\
&- 20\max((20 - X_5),0) + 14\max((X_5 - 20),0) - 20\max((30 - X_6),0) + 14\max((X_6 - 30),0) \\
&- 20\max((45 - X_7),0) + 14\max((X_7 - 45),0) - 20\max((30 - X_8),0) + 14\max((X_8 - 30),0)
\end{aligned}
$$

X1, X2, X3, X4 are respectively the production of product 1 in weeks 1-4.
X5, X6, X7, X8 are respectively the production of product 2 in weeks 1-4.
As mentioned earlier:
X9, X10, 11, X12 are the variables which show if any of two products are or are not produced in each week.
(Xi=1) produced or (Xi=0) Not Produced
Xi= continuous variable for i=1, 2, …8
And paired variables for i= 9-12
The problem contains the following constraints:

$$X_1 + X_2 + X_3 + X_4 \leq 320$$
$$X_5 + X_6 + X_7 + X_8 \leq 125$$
$$(0.5X_1 + 6)X_9 \leq 80$$
$$(0.5X_2 + 6)X_{10} \leq 80$$
$$(0.5X_3 + 6)X_{11} \leq 80$$
$$(0.5X_4 + 6)X_{12} \leq 80$$
$$(0.75X_5 + 11)(1 - X_9) \leq 80$$
$$(0.75X_6 + 11)(1 - X_{10}) \leq 80$$
$$(0.75X_7 + 11)(1 - X_{11}) \leq 80$$
$$(0.75X_8 + 11)(1 - X_{12}) \leq 80$$

The problem contains two types of constraints which are formulated as below:
Minimize:
$i = 1,...,m \;\; h_i(X) = b_i$
Subject to:
$j = 1,...,r \;\; g_j(X) \leq c_j$
The penalty function is as below:

$$obj(X, W1, W2) = f(x) + \left[\sum_{j=1}^{m} W1_j \left(h^2{}_j(X) \right) + \sum_{j=1}^{r} W2_j \left[\max\{0, g_j(X)\} \right]^2 \right]$$

W1 and W2 are the penalty variables with positive weights in this function.
The obtained results after 20 “examinations” are presented in table below:

No. of Examinations	Result or Output
1	1 1 1 1 30 45 30 20 90 60 95 X=75 F= -3160
2	0 1 1 1 30 45 30 20 90 60 95 X=75 F= -2380
3	1 0 0 1 30 45 30 20 90 60 95 X=75 F= -2190
4	0 1 1 0 30 45 30 20 90 60 95 X=75 F= -1615
5	1 1 0 1 30 45 30 20 90 60 95 X=75 F= -2315
6	1 1 1 0 30 45 30 20 90 60 95 X=75 F= -2395
7	0 1 1 1 30 45 30 20 90 60 95 X=75 F= -2380
8	0 1 0 0 30 45 30 20 90 60 95 X=75 F= -1495
9	1 0 0 0 30 45 30 20 90 60 95 X=75 F= -1430
10	1 1 1 1 30 45 30 20 90 60 95 X=75 F= -3160
11	1 0 0 1 30 45 30 20 90 60 95 X=75 F= -2195
12	1 1 1 1 30 45 30 20 90 60 95 X=75 F= -3160
13	1 1 0 1 30 45 30 20 90 60 95 X=75 F= -2315
14	1 1 1 0 30 45 30 20 90 60 95 X=75 F= -2395
15	0 1 0 0 30 45 30

	20 90 60 95 X=75 F= -1495
16	0 1 1 1 30 45 30 20 90 60 95 X=75 F= -2380
17	1 0 0 1 30 45 30 20 90 60 95 X=75 F= -2195
18	0 1 1 0 30 45 30 20 90 60 95 X=75 F= -1615
19	1 1 1 1 30 45 30 20 90 60 95 X=75 F= -3160
20	1 1 1 1 30 45 30 20 90 60 95 X=75 F= -3160

As shown in above table, profit is maximized (Grey Rows) when product 1 alone is produced and amount of production exactly matches the demand. It should be noted that negative symbol of target function is due to the fact that this function is considered a negative one. Hence, the negative symbol must be dismissed in analysis. The problem has been run for 20 times to assure maximum reliability. The maximum amount of profit is 3169 US$ and it is achieved only when product 1 alone is produced in weeks 1-4. The minimum profit is achieved when product 2 is produced in weeks 1-3 and product 1 is produced only in week 4. In this way, the minimum profit equals to 1430 US$. Other combinations deliver a profit between 1430 - 3160 US$. As mentioned before, except 3160 $ profit, other points are considered to be local optimum points and are not our optimum solution. The maximum profit point is called the *Global optimum point*. Hence, the best possible solution to this problem (Global Optimum point) is a point at which the profit is 3160 $.

4. Conclusion and Discussion

It is for half a century that researchers and experts of various sciences are, depending on their specific needs, seriously working with different methods of simulation of real world. Advances in estimation technology have made the use of new findings easy and the pace of the simulation faster. Utilization of simulation methods in financial studies, especially accounting, have been remarkably significant. Utilization of traditional simulation methods such as Monte Carlo imposes certain constraints; therefore utilizing new and cutting-edge simulation methods can be highly effective. In this study, one of the most effective methods of simulation, MATLAB 7 was used. This software program is more popular than other methods for it is faster and more precise in simulating accounting problems, especially management accounting problems like repair and maintenance, inventories optimum level determination, etc. The results show that using modern simulation methods in accounting can deliver reliable results and their application in future works is highly recommended.

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