

DESCRIPTION OF THE BUSINESS SIMULATION PROCESS USING THE SOLVER ANALYSIS TOOL

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ABSTRACT

Simulation is the process of creating a model of a real system and experiments using this model are made, in order to understand the system's behaviour and/or evaluate the different strategies for the analyzed system.

To illustrate how to perform a simulation, the analysis tool SOLVER was chosen as an analysis instrument and the real system selected was a restaurant that wants to maximize profits in a normal week, considering the supply, the available food, the held quantities and the number of the chefs.

Key words: simulation, solver, analysis tool, business

1. INTRODUCTION

The computer simulation is the process of creating a mathematical-logical model of a real system and performs experiments with this model on a computer. This represents the imitation of a process way of work or a real system and includes generating of an artificial history and its observation, in order to create inferences regarding the functional features of the real system, being used in analyzing the system's behaviour.

Simulation refers to a large collection of methods and applications for imitating the behaviour of a real system, usually with a computer and an appropriate software.

Simulation is a numerical technique of creating the experiments using a digital computer and involves using some type of mathematical and logical relations, necessary to describe the behaviour and structure of a complex real system, over a long period of time. Thus, the following assumptions that underlines the simulation, can be deducted:

- A mathematical and logical model of the analyzed system can be created.
- The analyzed system can be real or theoretical.
- Usually, in order to make the simulation a digital computer is used. Therefore, it is assumed that the system can be described in acceptable terms for a computing system.
- Simulation is a technique of creating the experiments.
- Data regarding the performance of the analyzed system are obtained by execution of a model, thereby generating an artificial history.

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By analyzing the artificial history, inferences regarding the features of the real system's functionality can be made, over a long period of time. The purpose of simulation is to find "something" about the functioning way of the real system.

Simulation is important for the issues that cannot be approached by using mathematics, analytical or optimization methods. Even though, both simulation and optimization and quantitative methods, based on mathematical models, the fundamental difference between these two approaches lies in the role of the decision variables.

For optimization, the values of the decision variables are output data of the model. These values are obtained with a formula or an optimization algorithm, in order to maximize or to minimize the value of an objective function, which shows the performance criteria of the model.

For simulation, the values of the decision variables are input data of the model. By simulation, based on mathematical models, the performance criteria for certain values of the decisional variables, is evaluated. Finally, the option which will lead to the best value of the performance criteria is chosen.

2. THE STEPS OF THE SIMULATION PROCESS

Creating a simulation process involves several steps. In practical applications there is no general procedure for simulation projects, although several general ideas are applicable to all the simulation types. .

The simulation steps are generally following the modeling cycle, but a simulation model is much more complex, because it involves using the computer and statistical analysis. Thus, the most important steps for conducting a successful simulation project are identified and analyzed. These steps can be grouped into four major categories:

- a) The problem to be solved
- b) The simulation model
- c) The simulation experiments

3. THE ANALYSIS OF THE RESULTS

- a) The problem to be solved. The steps in this area are the most important for the simulation project, and refers to the formulation and problem analysis, training the involved persons on the basic principles of the simulation, building the conceptual model, collecting the fundamental data, testing the validity of the conceptual model.
- b) The simulation model. The steps in this area refers to: transposing the conceptual model into a computer model (simulation program), verifying the simulation model, analyzing the sensitivity, validating the simulation model. The validation compares the behaviour of the computer model with the real one, trying to answer to the question: "The right or appropriate model was created?"The verification

aims to evaluate the accuracy of informatic transposure of the conceptual model into the computer one, trying to answer to the question: “The computer model was correctly created?”. To these activities the calibration of the model is added, consisting in mentioning the parameters of the computer model, by adjusting them without changing the structure of the conceptual model. These activities are difficult, because it has to be taken into consideration the fact that the conceptual model resulted from deliberate application of some simplification and idealization operations and the data referring to the real system can be affected by measurement errors, registration errors or may be incomplete.

- c) The simulation experiments. This area refers to the design of experiments and the creation of simulation experiments. By designing the experiments will be set: the number of simulations, the numbers of experiments of each simulation, the initial conditions for each experiment, the length of the “warm up” period necessary in order to bring the artificial system in a stable condition, how to reduce the variation of the results due to the random numbers, etc.

The analysis of the results lies in the statistical analysis of the results (trustful intervals, comparison and evaluation of the decisional alternatives), identifying the best solution and creating the documentation that will include the objectives and the assumptions, the input parameters of the simulation model, the verification and validation of the model, designing the experiments, presenting the results, conclusions and recommendations.

4. ADVANTAGES AND DISADVANTAGES IN THE SIMULATION PROCESS

In the past, simulation was often considered the last technique of solving the decisional problems and only if applying the analytical methods was not possible. Over time, the development of special simulation languages, massive increase of the computer power along with reducing the operating cost calculation and the progress registered in the simulation methodologies have turned the simulation into a tool widely used and accepted in many areas.

The purpose and applicability of simulation is not limited only in assisting some managerial decisional processes. Simulation has important usage in computer aided design, in virtual reality systems for computer games industry, training of professional categories (pilots, surgeons, etc.) or touristic applications.

Generally, the users are attracted by simulation, because it allows the imitation of what happens into a real system or what it is expected for a system which is in a project stage. The output data obtained by simulation can be considered as results that might have been provided by the real system.

Also, by simulation it is possible to create a model of a system or a process without the assumptions imposed by the analytical models.

Compared with optimization models, the simulation models are “executed” and not solved: having a set of inputs and features of the model, it is executed to observe the behaviour of the system it represents. Modifying the inputs and features of the model is structured in several scenarios, which are evaluated by simulation.

The advantages of simulation are the following:

- By simulation policies, operating procedures, decision rules, informational flows and organizational procedures can be explored, without interrupting the activity of the real system.
- The projects for new equipments, equipments’ placement, different transport systems can be tested without involving the resources for their purchase.
- By simulation, the assumptions about how and why some phenomenon may appear, can be tested.
- Time can be compressed or expanded in order to enable the acceleration or to slow an investigated phenomenon.

The interactions between different variables can be observed and may determine the effect of the different variables on the system’s performance.

- The “tight places” can be identified, where the production process, information or materials are delayed excessively.
- Sensitivity analysis such as “What if...?” can be done.
- Simulation can be used to quantify the inherent risk of a system or of an investment decision.
- Being associated with animation to visualize the functioning way of a system, simulation can contribute to increase the deciders’ capacity of intervention, by a large perception of opportunities and by clarification and evaluation of some eventual actions.
- It can be a modality of solving problems for which the analytical or algorithmic solutions are not possible. In addition, the model can be created based on the preferences and decider’s perspective, rather than the modeling specialist, which can be influenced by the existence of an appropriate solution.

Among the disadvantages there are:

- Creating the simulation model needs a special training. It is an art which is learned over time and through experience.
- Simulation doesn’t guarantee obtaining some optimal solutions.
- The simulation’s results can be difficult to analyze. Due to the random nature of the inputs of the simulation model, the results are stochastic variables and statistical knowledge is required for their analysis.
- Simulation can be time consuming and expensive. Reducing the modeling resources and analysis can lead to a simulation model unsuitable for the analysis purpose.
- The quality of the results obtained by simulation depends on the quality of the used data. Collecting data for simulation can be difficult and time consuming.

Modeling and simulation can contribute to the understanding and improvement of a real system. Although a system can be extremely complex, it is good to try to create a model as simple as possible. This is achieved both by defining the boundaries of the analyzed system in order to take into consideration only the essential features in terms of the analysis objective point of view and by defining some simplifying assumptions.

The model can be improved by redefining the limits and relaxing the assumptions. On the other hand, if you are trying to include in the model all the factor and relations, the model could become too complicated to be solved. That's why, it is necessary to make a compromise between the necessity of creating a simple model and easy to solve and the necessity of obtaining through this model a reasonable and plausible representation of the real problem.

The simplest model is the determinist one, because it makes the assumption that all the data of the model are certain. In some situations, this type of model is extremely valuable. In addition, by applying the sensitivity analysis some simplifying assumptions underlying these models can relax and can better understand and interpret the results obtained by solving. The stochastic models are more realistic than the determinist ones. Because these models have at least a variable, described by a probability distribution, most of the time the simulation is used to solve them.

Although initially, the simulation was recommended only if the application of analytical methods was not possible, in time the development of the special simulation languages, the massive increase of the computing power while reducing the operating cost calculation and the progress within the simulation methodologies turned the simulation into an widely accepted and used tool in assisting the managerial decisional processes. However, it should be noted that simulation does not take decision in a place of a manager or a decider. Simulation only provides information and data on which the deciders to develop more fundamental decisions.

Simulation is correct only if the input data are correct and it as credible as trustful is the analyst that made the simulation. In addition, the major involvement of the manager in the modeling and simulation process is very important for the successful application of a model in the decisional process. Also, for a model to be accepted with confidence by the deciders in the decisional process they are involved in, it is necessary the careful verification and validation of the model, prior to implementation.

5. THE DEVELOPMENT OF A PROFIT MAXIMIZATION APPLICATION USING SOLVER ANALYZING TOOL

Solver is an instrument which helps in taking business decisions, it can maximize or minimize the function that we analyze or it can search for a certain value, it can implement constraints which the business must take into consideration.

Solver tool cannot be automatically found in the Excel Menu, it must be installed following the steps: Office button-Excel Options-Add-Ins-Manager: Excel Add-Ins-Go – we select Solver box Add-in-Ok. In Data menu – Analysis appears SOLVER options.

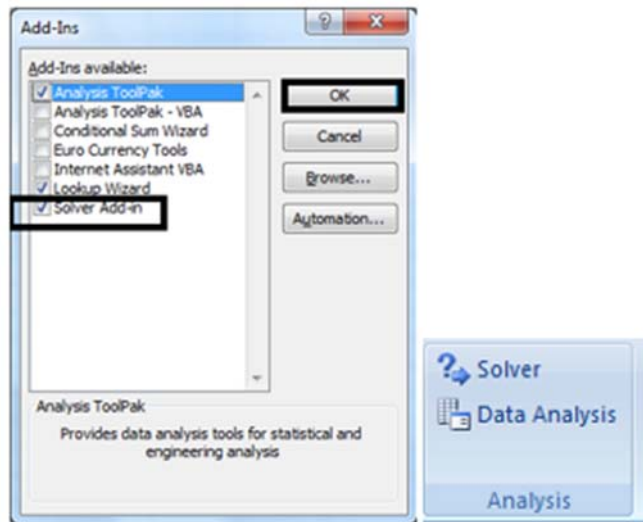


Figure 1: Installing Solver analysis tool

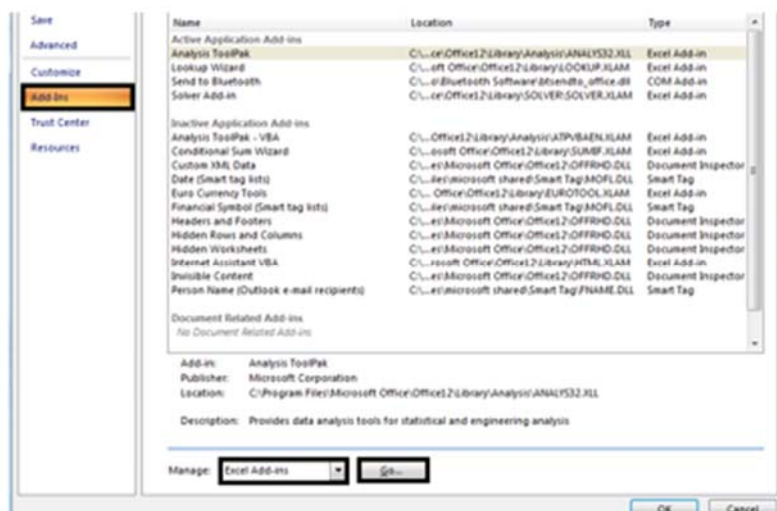


Figure 2: Installing Solver analysis tool

Application: Maximizing the profit in a restaurant.

- 2 decisional variables
- 3 constraints

Decisional variables:

- x_1 = weekly production for a breakfast menu (the number of the portions made)
- x_2 = weekly production for a lunch menu (the number of portions made)
- x_3 = weekly production for a dinner menu (the number of portions made)

z = the profit/week

The objectives of the function:

Maximizing $z = 15x_1 + 35x_2 + 20x_3$

Constraints:

Effective cooking: $15x_2 + 4x_3 \leq 2400$

Food supplying: $15x_2 + 4x_3 \leq 2400$

Specific lunch ingredients: $7x_2 \leq 840$

Specific lunch and dinner ingredients: $7x_1 + 7x_3 \leq 1470$

Non-negativity: $x_1 \geq 0, x_2 \geq 0$ și $x_3 \geq 0$ (non-negativity won't be added in Excel to constraints, because Solver has the options Assume Non-negative, which replaces this constraint).

	A	B	C	D	E	F	G
1	SOLVER: maximizing profit						
2							
3							
4							
5	Decision variables	Breakfast (x1)	Lunch (x2)	Dinner (x3)			
6	Decision values						
7					Total Profit		
8	Objectives function (Profit \$)	15	35	20			
9							
10	Constraints						
11	Actual cooking (minutes)	5	15	4		<=	2400
12	Food supply	2	2	2		<=	700
13	Specific ingredients lunch	0	7	0		<=	840
14	Specific ingredients for breakfast and dinner	7	0	7		<=	1470

Figure 3: Transposing the statement in Excel – modeling the problem

The objectives of the Z function will be reflected into the decisional values from cells B6, C6, D6. In order to perform these calculation, the cells B6, C6, D6 must be transformed into absolute cells and the total profit formula is displayed in E8 cell. Copy E8 cell and paste it into E11:E14 cells.

	A	B	C	D	E	F	G
1	SOLVER: maximizing profit						
2							
3							
4							
5	Decision variables	Breakfast (x1)	Lunch (x2)	Dinner (x3)			
6	Decision values						
7					Total Profit		
8	Objectives function (Profit \$)	15	35	20	=SUMPRODUCT(\$B\$6:\$D\$6;B8:D8)		
9							
10	Constraints						
11	Actual cooking (minutes)	5	15	4	=SUMPRODUCT(\$B\$6:\$D\$6;B11:D11)	<=	2400
12	Food supply	2	2	2	=SUMPRODUCT(\$B\$6:\$D\$6;B12:D12)	<=	700
13	Specific ingredients lunch	0	7	0	=SUMPRODUCT(\$B\$6:\$D\$6;B13:D13)	<=	840
14	Specific ingredients for breakfast and dinner	7	0	7	=SUMPRODUCT(\$B\$6:\$D\$6;B14:D14)	<=	1470

Figure 4: Profit maximization – formulas

We attribute some random values (from the keyboard) for the decisional values (B6=10, C6=100, D6=50). After completion, it is found that the total profit cell is 4650 and the constraints are all satisfied ($1750 \leq 2400$, $320 \leq 700$, $700 \leq 840$ and $420 \leq 1470$). These values satisfy the criteria, but it is not maximized.

	A	B	C	D	E	F	G
1	SOLVER: maximizing profit						
2							
3							
4							
5	Decision variables	Breakfast (x1)	Lunch (x2)	Dinner (x3)			
6	Decision values	10	100	50			
7					Total Profit		
8	Objectives function (Profit \$)	15	35	20	4650		
9							
10	Constraints						
11	Actual cooking (minutes)	5	15	4	1750	<=	2400
12	Food supply	2	2	2	320	<=	700
13	Specific ingredients lunch	0	7	0	700	<=	840
14	Specific ingredients for breakfast and dinner	7	0	7	420	<=	1470

Figure 5: The results displayed by Excel, according to constraints

Changing the decisional values, we can notice that the values are too high and do not fulfill the constraints (the constraint 1 and 3 are no more fulfilled).

	A	B	C	D	E	F	G
1	SOLVER: maximizing profit						
2							
3							
4							
5	Decision variables	Breakfast (x1)	Lunch (x2)	Dinner (x3)			
6	Decision values	45	200	10			
7					Total Profit		
8	Objectives function (Profit \$)	15	35	20	7875		
9							
10	Constraints						
11	Actual cooking (minutes)	5	15	4	3265	<=	2400
12	Food supply	2	2	2	510	<=	700
13	Specific ingredients lunch	0	7	0	1400	<=	840
14	Specific ingredients for breakfast and dinner	7	0	7	385	<=	1470

Figure 6: Changing the decisional values

To maximize the profit and in the same time to respect the constraints, the Solver will be used. Press E8 cell (the cell where the Total Profit is - this has to be maximized).

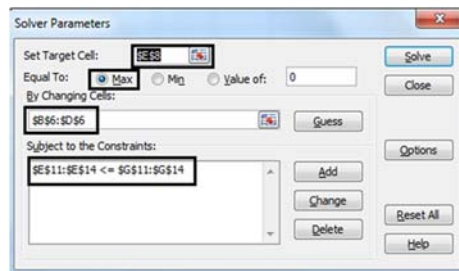


Figure 7: Maximizing the profit according to parameters

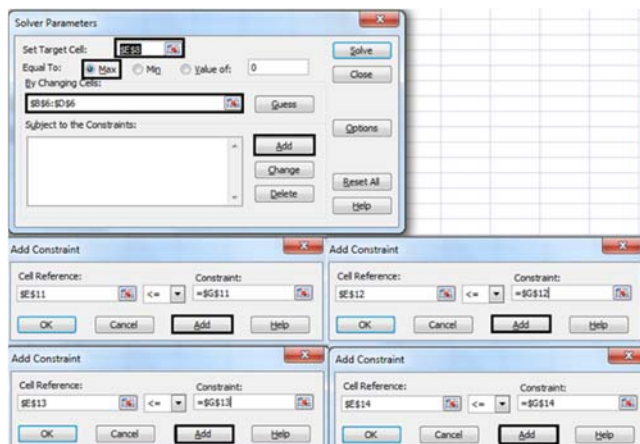


Figure 8: Visualizing all the restrictions to maximize the profit

Considering the fact that all the constraints have the same format, <=, we do not necessarily need to input each constraint separately.

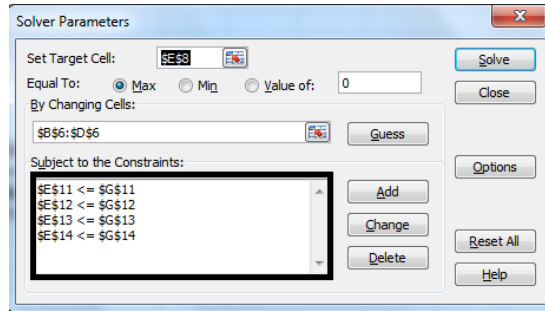


Figure 9: Options – linear model and non-negativity

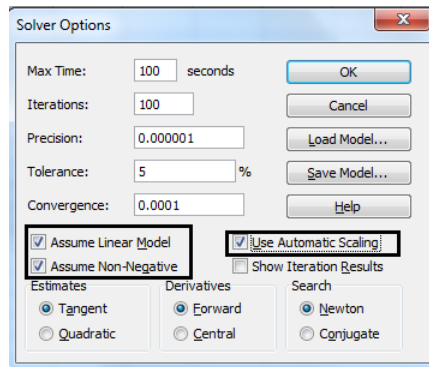


Figure 10: Maximizing the profit according to parameters

In order to maximize the profit of the restaurant, the created model must meet a number of criteria. The model must have a precision of 0,000001, a 5% tolerance, the model must be linear and non-negative.

In figure 10, the profit is maximized according to the constraints. These constraints are: food supplying, the available ingredients, the number of chefs who prepare the food for breakfast, lunch and dinner.

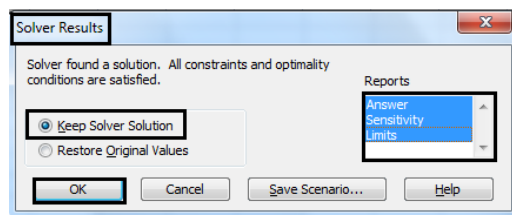


Figure 11: The solution provided by Excel

In figure 11, it is presented the dialog window of the results that we want the Excel to display. In case of this analysis, it is wished to keep the initial analyzed data and creation of the reports, the sensitivity of the results and the limits of truth where the statement fits into.

	A	B	C	D	E	F	G
1	SOLVER: maximizing profit						
2							
3							
4							
5	Decision variables	Breakfast (x1)	Lunch (x2)	Dinner (x3)			
6	Decision values	0	104	210			
7					Total Profit		
8	Objectives function (Profit \$)	15	35	20	7840		
9							
10	Constraints						
11	Actual cooking (minutes)	5	15	4	2400	<=	2400
12	Food supply	2	2	2	628	<=	700
13	Specific ingredients lunch	0	7	0	728	<=	840
14	Specific ingredients for breakfast and dinner	7	0	7	1470	<=	1470

Figure 12: Displaying the results of the analysis made by Excel

In figure 12, it can be seen the results after the analysis was made. In order to maximize the profit, which when the analysis was done, it is 7840, the decisional values must be for breakfast 0, lunch 104 and dinner 210. Breakfast is the least rentable, therefore the conclusion was that the restaurant would be more profitable if the working hours would be from noon until evening and with the ingredients and staff available, would have only lunch menus with a special accent on dinner.

In Figure 12, it can be seen that the effective cooking minutes are totally allocated; the products which the restaurant supplies with are almost totally finished, the specific lunch ingredients are used in a large proportion, and the ones for dinner are completely used.

6. CONCLUSION

In conclusion, Solver analysis tool of the Excel turns to be very useful, easy to use by the less experienced users in analyzing data with Excel analysis tool.

Also, it can be observed the fact that Solver is precise to the reality, the demonstration made in the profit maximization of a restaurant case being a witness of what is said before. It is known the fact that in a restaurant breakfast is not profitable, the customers visiting the restaurants more at lunch (during lunch break at the office or in weekends) and at dinner. Therefore, the proposal presented by Excel in order to maximize the profit was only to prepare lunch or dinner.

7. BIBLIOGRAPHY

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