

DYNAMIC SIMULATION OF DECISION CRITERIA IN REGIONAL DEVELOPMENT

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ABSTRACT

The aim of this paper is to discuss simulation analysis and decision making criteria in studies of regional development based on systematic sampling of random numbers generated by a spreadsheet using multiple simulations to identify regarding the most advantageous areas to develop investment models within a certain region. For this, the region will be simulated within a matrix and the analysis is carried out by making an initial investment in one of the cells and observing the advantageous results that the investment brings in that point to the entire region during 8 systematic periods. The graphs show results of investing in a specific area of a region and the influence of that investment across the region, growth over time and most important the analysis of the differences of growth over time where it can be seen the associated risk.

Keywords: *Simulation, Regional development, Random numbers, Decision criteria.*

INTRODUCTION

The development of regions is a topic of current relevance, although its origins are not new, it can be seen how the ancient societies established certain criteria for the development of their towns. Looking at historical maps, it is possible to see how certain corridors preserved from ancient times were used for trade between cities. There are also cities where due to the historical value of buildings and monuments, it is not permitted to change them but they are in constant preservation. The same happens with the layout of some streets of old roads that still retain their ancient design today. These areas are impossible to change because they depict a historical architectural heritage.

Looking at historical regional development entails going back to the past in order to understand the "decision criteria" i.e. how construction decisions were made and what influenced them etc. Maps or images can help to show the patterns that dictate regional growth, how the rules adopted at that time gave solutions to development requirements and also how those rules changed with time due to new demands but still keeping some original concepts.

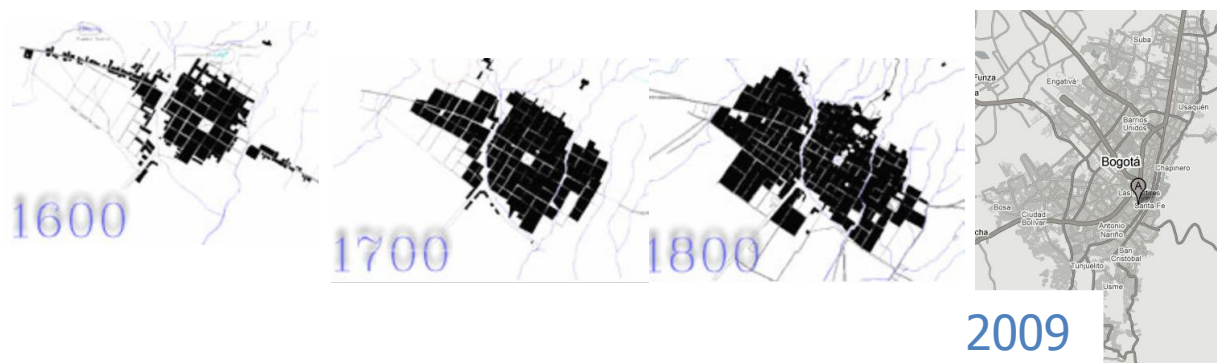


Fig.1. Development of the Bogota city through the years (maps 1600, 1700, 1800 historic Bogota Atlas, map 2009 Google maps)

Due to the randomness of the process of urban or rural development and the various factors involved in (political, economic, cultural, environmental, etc.) designing a model to interpret the behavior of that development, the use of a model that contains the same randomness over time is required. A simulation is used to design and develop a computerized model system or process which conducts experiments in order to understand the behavior of the system and in this case the use of random numbers helps to achieve that understanding. The uniform random numbers (0-1) are the basis for simulation models where stochastic variables are used as tool for generating events such probability (Azarang, Garcia and Mohammad, 1996).

Another important factor in the model for the development of regions is the decisions criteria. Decisions will always be made when investing in any sector or specific project because it is only then that assessment of the quality of development procedures can be reviewed. These decisions criteria are applied to long-term intellectual criteria forming a barrier in the economic, environmental, social, cultural and urban management with regard to technical solutions (Beran, Dlask, 2004: ch. 1, 2)

DESCRIPTION OF THE MODEL

The problem to be solved is to find the point of the best spot in a region for investment, given the circumstances that all points are the same conditions. It is assumed that an investment, in fact correct, well located geographically rather than strong is the main instrument of the benefits of its territory. (Beran V. Dlask D, 2009)

After explaining the problem to be solved is posed the definition of the model, making use of statistical simulation based on systematic sampling of random numbers generated by the spreadsheet. First, the simulation is run with the investment point in one cell and assessed all the graphics and behaviour of that investment, later on it is assessed the behavior in different points in the region.

The region will be simulated within a matrix consisting of 10 rows and 10 columns, each cell within the array contains the same conditions, the matrix is the representation of a region and the analysis is carried out by making an initial investment (with value 1) in one of the cells and observing the development and benefits that the inversion brings in that point to the entire region during 8 periods of time. The expected result is a consequent increase in the starting cell and then in neighboring cells. This could be the representation of the construction of a mall in a neighbor; the initial investment is really high and with the time will bring some benefits to the surrounding areas.

For this case the chosen region is a pretty homogeneous region and it can be assigned the same growth function to each cell within the matrix. However, in the case of a different region with areas demarcated as: a lake, a forest, a residential zone, an industrial zone can be assigned to each zone a different growth function, and therefore the expected results will be different.

It is also necessary in the description of the model, to define what kind of connection each cell has with those around it. In this case, each cell connected directly will influence its neighbors (Fig. 2). When selecting an initial investment point, that point will benefit its neighboring cells in the next period of time, giving them the opportunity for growth and to have profits indirect because that initial investment will force growth in their neighbors. This means that each cell into the region has a direct influence on 8 cells but only with the exception of those cells at the border of the region which influence is on a smaller number of cells.

It is undeniable that the effect of initial investment in neighboring cells, obviously they did not grow at the same rate that the cell with the initial investment, but they will benefit and grow at a lower rate

and the next period of time may provide benefit and growth to its neighbors but at in a lower degree, this growth is inversely proportional to the distance that the cell is from the initial investment, but once completed the 8 periods of time, it is possible to see the benefits throughout whole the region (Fig. 3). One of the fundamental statements of the investment theory is the existence of multiply effects in space and time, this is what most of the cities still preserved today and is one example of the growth.

Land use (inversion)										$I(t)$	=	1
	A	B	C	D	E	F	G	H	I	J		
1	0	0	0	0	0	0	0	0	0	0		
2	0	0	0	0	0	0	0	0	0	0		
3	0	0	0	0	0	0	0	0	0	0		
4	0	0	0	0	0	0	0	0	0	0		
5	0	0	0	0	1	0	0	0	0	0		
6	0	0	0	0	0	0	0	0	0	0		
7	0	0	0	0	0	0	0	0	0	0		
8	0	0	0	0	0	0	0	0	0	0		
9	0	0	0	0	0	0	0	0	0	0		
10	0	0	0	0	0	0	0	0	0	0		

Fig.2. Ratio that each cell with its immediate neighbors. Note that the influence of each cell is only those that surround it

Referring to Figure 3, the cell with the initial investment is E5, through the 8 time periods is seen the change in growth in the region and their respective overall growth. The function $U(t)$ represents the total performance growth in the region which is the sum of every cell within the matrix for every period of time.

It is needed to considerer that the modern evaluation of the success goes far beyond the direct economic benefits; the long-term evaluation of the benefits should include the environment, cultural values and other influences on decision making.

Having made the analysis of the initial investment point, it is obtained a range of possible solutions after running the simulation 30 times on this occasion the graphic shows the values for the best answer to the worst response and the values for intermediate values (Fig.4). Clearly, the greater the number of times a model with random data is analyzed, the better results will more accurately and with greater certainty can make decisions.

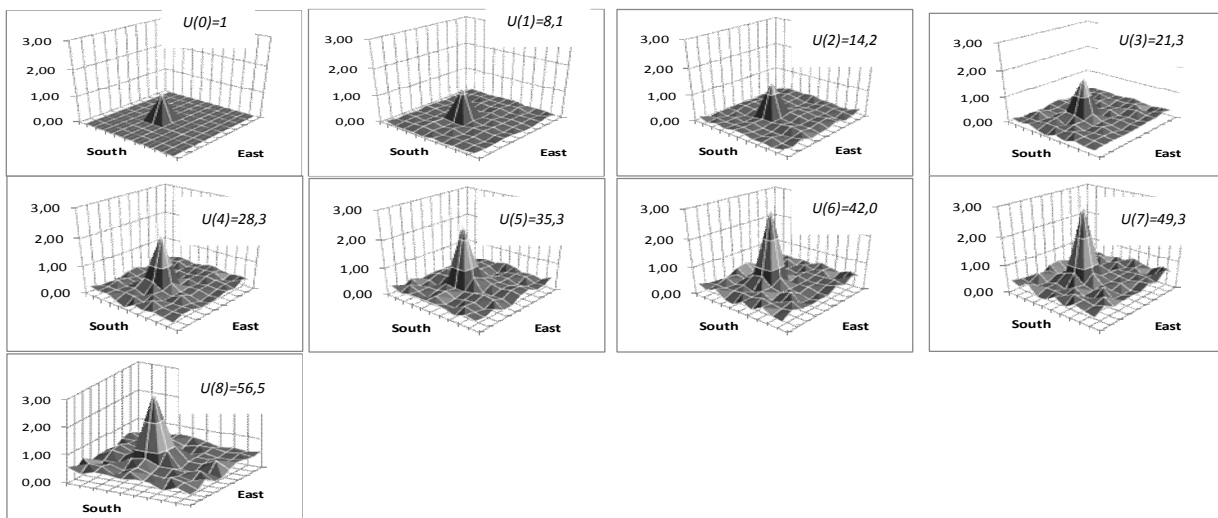


Fig.3. Simulation of the evolution of investment from the initial point E5 through 8 periods with the sum of the total profits in the region

A relevant fact that Figure 4 provides is the range of yields as a consequence of the investment in the point E5. The reason of these changes in the production is because there are many factors that affect the production for the same point of investment, having in mind these ranges can give an idea about what are the values that initial point can offer, it shows the lowest, the highest and the medium values that the model can offer taking the same initial point as reference. It means that for a particular initial point of investment is possible to have an idea of the different ranges of profits for the region during every period of time.

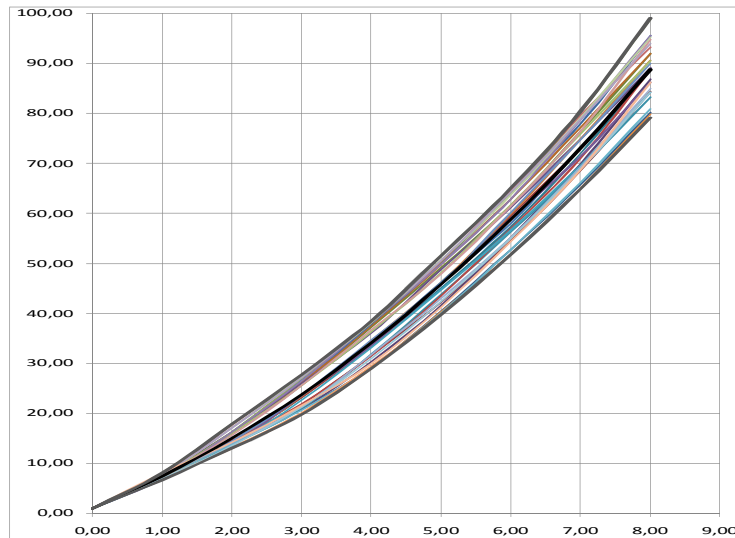


Fig.4. Data range of total regional performance across the 8 periods with initial point E5 through various simulations, here are highlighted with thicker lines corresponding to the graphs with higher values, average and lowest within the different graphs.

PRODUCTION, SPEED AND ACCELERATION

The analysis of the production process gives an idea of the behaviour of the investment in the region and its surroundings, but perhaps more important than the analysis of overall performance graphs in the region, is the analysis of the differences or the rate of change of that performance in each period. This is obtained by subtracting from the overall performance of a period $U(t)$ the performance of the previous period $U(t-1)$, this difference indicates the region's growth over the previous period in unit time t , which ultimately is speed. The equation defining the rate of growth or performance speed in the region is given by Equation 1.

$$\Delta U (t) = U (t) - U (t-1) \tag{1}$$

Making this difference for each time period in each of the cells in the region, it is possible to obtain a graph as shown in Figure 5, but its analysis does not indicate a clear interpretation of results practically seems similar to the graphic of the production, but taking the total figures for the differences across the region and these data are plotted can be quite interesting findings of the graph. The graph of Figure 6, is the representation of the performance speed produced by the investment in the point E5 after 30 simulations investment, as the graph of Figure 4, it can be seen the range of values that can take the performance speed of the region .

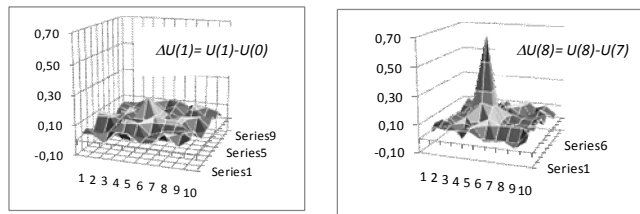


Fig.5. Differences between total performance in subsequent periods showing the speed of development in time for the periods 1 and 8.

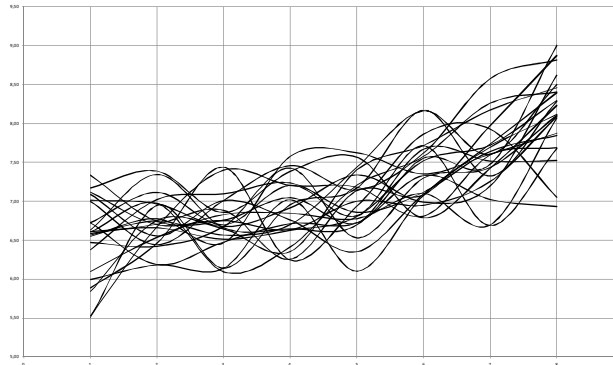


Fig.6. Performance speed graphics for the 8 periods of time with initial investment E5, here are represented 30 simulations for the same point.

From this example it is possible to go even further and not only make an analysis for the speed with which the region is growing but also analyze the variation of that speed. As the same analysis made to determine the performance speed of the region, changes of speed or acceleration can be found through the speed differences between one period and the immediately preceding, as expressed by equation 2

$$\Delta \Delta U (t) = \Delta U (t) - \Delta U (t-1) \quad (2)$$

The acceleration values are indicative of the variation in the speed of performance over time, reaching even some periods of negative acceleration or deceleration in production.

The graphs in Figure 7 show a clear example of total performance, total performance speed and total acceleration along the 8 time periods for investment in the region with the point E5. It is interesting to notice from these plots that while the graph of total performance for the region at first curve shows a completely homogeneous model for the development of region is only indicative of the growth in production over time, but the analysis of the subsequent graphs (speed and acceleration) shows the two curves with large peaks and troughs in its form, even the graph of the acceleration includes negative values. Then are these further analysis where finally show the risk within the model of development of the profits in the region because taking into account only the graph of production, this does not show any anomaly in the curve, but the randomness of the curves for speed and acceleration clearly show the risks of production in the region.

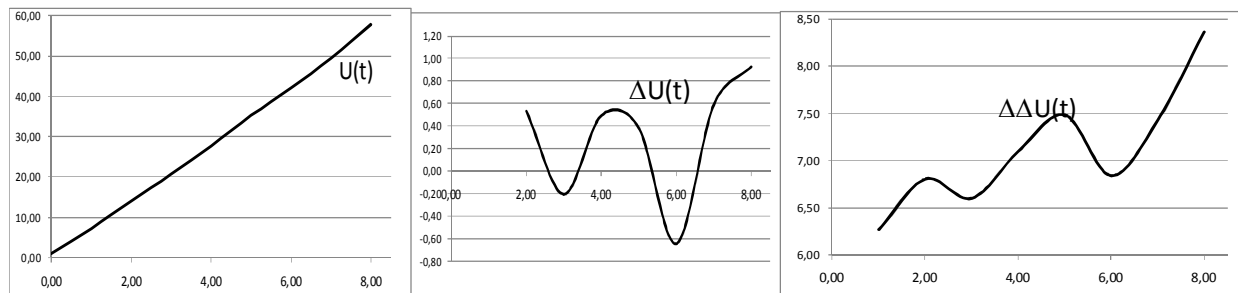


Fig.7. Representation of the performance, performance speed of production and acceleration when is invested in one point within the region.

ANALYSIS OF THE RESULTS WHEN IT IS INVESTED IN OTHER POINTS IN THE REGION

So far it has been only discussed the case of investment in the cell E5, so it has been analysed the behaviour of the model just in one point, but it is also interesting to see the results doing initial investments in different locations within the region. For this case, it is only analyzed the graph 8 where speeds are presented in global production during the 8 periods for each point of initial investment, this chart is taken for analysis because the graph of global performance in the region there are no signs of risk as it was mentioned above.

The investment was made using the matrix of Fig. 2 in the following fields, E5, B3, C6, D9, E2, F4, G7, H8, I10 separately. Analyzing the results is also possible for different tests to find which of the options presented at the end of periods is the best solution in terms of profitability, but also can be deduced from the graphic that in previous periods there are another alternatives that reach a higher return and not always the alternative that at the end of the 8 periods of time gives the highest return is the option which has been showing the best results.

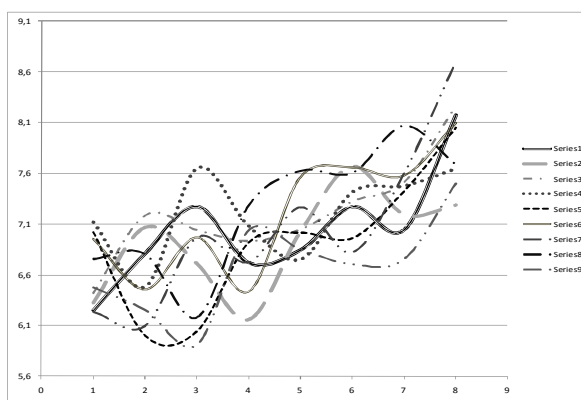


Fig.8. Performance speed using different initial points of investment.

From Figure 8 is important to highlight several aspects:

Watching the behaviour of each graphic is important to note that not always those at the end of the 8 periods have shown a higher rate of speed have taken better performance speeds of past periods.

Sometimes the best alternative is not one that offers the best performance speed in the final analysis for the 8 periods, the performance of graphics displays in some investment decisions very random graphs which translate into higher risks, while others graphics not as good performance speeds, but with a much more homogeneous behaviour, which translates into less risk in that alternative.

CONCLUSIONS

The use of simulation models to help understand the behavior or trend of a development system has increased recently and is a cheap alternative before making an investment in a real model. It also offers an opportunity to analyze more than one scenario for the same price and the assessment of numerous possibilities before making a final decision.

A delicate part of simulations is the criteria or decision rules that are going to run the model because they depend on the model's approach to the real problem and also the precision grade required. In some cases, it is not necessary to consider all variables because some of them do not directly influence the results. Using the example in this paper showing a homogeneous region, simple criteria or decision rules were used for pedagogic purposes with an objective to show results and findings deduced from analysis of graphics portrayed by the simulation given certain parameters. It can be applied to practical situations given the proper information and data.

The simulation as described in general terms can be applied not only for developing regions but also for project management to investigate risks associated with projects

Acknowledgement

This paper is part of the research work MSM 6840770006 "Sustainable Management in construction life cycle" finance by Ministry of Education and Youth and Czech Technical University in Prague, Construction Department.

REFERENCES

- [1] Corporation La Candelaria, Library L. Arango "Historic Bogota Atlas". Bogota, 2000.
- [2] Azarang, Garcia and Mohammad, Simulation and Analysis of stochastic models, McGraw-Hill, Inc.: Mexico 1996.
- [3] Beran, Dlask, Sustainable management for urban, regional and towns development, Prague Academy, chap.1, a chap. 6.2006
- [4] Beran, Dlask, Investment and its influence in the development of regions. Prague Academy, Prague, 2009.
- [5] KOLEKTIV, Sustainable Management for development in life cycle construction, construction companies, and territory, Hypothesis for VZ05, Czech Technical University in Prague, 2005.
- [6] Stephen Wolfram, A New Kind of Science, Wolfram Media Inc.: Canada, 2002.