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Decision analyses – a brief introduction

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Abstract. The decision analyses have been developed in the second half of the 20th century to help managers better deal with the decision making problems they had to face. Evolving from very technical and simple managerial tools, they became today a very wide domain, comprising knowledge, methods and techniques from Mathematics, Statistics, Computer Science, Management and lately GIS. The most important aspect of the decision analyses is the decision making process. Even though, earlier in their development, the goal (the decision) was emphasized, after 1970's the accent was put on *how* a decision should be made. This led to a dynamic development of methods and instruments that could assist the decision makers through the decision making process, so the decision support systems, and later the spatial decision support systems appeared.

Keywords: *decision problem, decision making process, decision support systems, spatial decision support systems*

1. INTRODUCTION

The decision analyses emerged during early twentieth century as a necessity for assisting decision-making in management and economics and are developing rapidly since the mid-twentieth century. They have applications in all areas where there are several factors involved – from economics and management to environmental protection, public administration and territorial planning.

Although they are not yet globally widespread, their practical importance makes them increasingly used and there are ongoing concerns for their improvement and diversification of their applicability.

The aim of the present paper is to briefly introduce these analyses, to present, in general lines, their development and to emphasize their importance and their utility.

In decision analyses, the most used concepts are: *decision-problem* (or just *problem*), *decision-maker*, *decision making process* and *stakeholders*. A *decision-problem* – is a situation in which there is a perceived difference between the current state and a desired state of an individual or group of individuals and in which there are several alternatives and the individual/group of individuals does not know from the beginning the solution for the problem (Sharifi, 2004a). The *decision-makers* are the people entitled to make a decision. They are usually managers, but also, due to the fact that the decision analyses tend to be applied in public administration, the decision-maker can also be the Major of a municipality or other upper level local/regional administrator. In general, any person that has to deal with a great number of needs (of the company or of the municipality) and a lack of resources (financial, human, technical etc.) will become a decision-maker facing a decision problem. The *decision making process* is the sequence of actions and/or events starting from the identification of the decision problem and ending with choosing one alternative, that becomes a solution to the decision problem. The decision making process is a very complex one, so several models have been developed. Some of them are briefly presented in the next section. The *stakeholders* are the individuals and/or group of individuals that are

either affected by a decision or that have a specific interest in a decision problem. In most of the cases stakeholders find themselves in both situations at the same time and are represented by private investors, NGOs, local communities and different social groups. The stakeholders are the ones who influence the objectives in a decision making process.

2. THE DECISIONAL PROCESS AND DECISIONAL ANALYSES

The decision-making process almost always belonged to senior managers, who held a high control over all processes in a company. In other words, the manager had the authority to make decisions at his discretion. Starting in the '70s, this tradition changes and the so-called rational management emerges, the decision is no longer made by manager in an arbitrary way, based on his/her experience and intuition, on the contrary the managerial process integrates elements of mathematics, statistics and the probability theory (Bennet and Bennet, 2008).

The decision analyses began to gain increasingly greater importance with the increase of the amount of data and the development of managerial sciences. Although they essentially are more connected with the management process, however, with the development of GIS technologies, decisions began to be based on objective, transparent and, where appropriate spatial criteria.

In the case of this type of analysis, attention is not focused on the final decision, but on the decision-making process, on the involvement of all stakeholders, on the streamline of the decision-making process, costs reduction, increasing benefits, taking into account resource limitation. In other words, decision analyses consider how the decision should be made and not what decision must be made (Simon, 1979).

The main challenge in decision analyses is the problem structuring (Bosman, 1987) and understanding its characteristics, whether it is a matter of economic or technical problem (Romero and Rehman, 2003). When decisions involve a single solution, the decisional challenge is to implement that solution so the problem is a technical one. But when there are multiple solutions to the same problem, it becomes an economic problem.

Meanwhile, there are two main views on decision making, synthesized as early as 1960's, by Herbert Simon, in his book entitled *The New Science of Management Decisions*. On the one hand, the objective rationality approach is stated - in which is supposed that all aspects and components of a decision problem are known, all the necessary resources to make a decision are in place and, implicitly, all the alternatives can be laid out and the best solutions can be found. This approach is the ideal situation in a decisional process. In reality, however, these cases with such an approach on a decisional problem are extremely rare. So another approach is distinguished, a degree more practical, namely the rational procedural approach (bounded rationality). This gives up on the idea of absolute and focuses on the idea of satisfaction because in practice there is no absolute structuring of a problem, many resources necessary for decision analyses are missing and all decision makers cannot be concomitantly and absolutely satisfied. Furthermore, ideal solution cannot be found, instead satisfactory solution can be developed. This latter approach is the most common in practice.

The bounded rationality approach regarding decision making began to be used and grounded since the early twentieth century. The first fields in which this concept was considered were economics and law. In economics and the related sciences, and in general in any field of activity that involves money, it was and is necessary to make the best decisions possible and as objective as possible, so that the final decision cannot be challenged or subsequently be considered ineffective after implementation. In the field of law and legislative issues also it was and is necessary to make transparent and impartial decisions. So the type of needs led to the theorization of the decision making process. Among the first who grounded the decision making process is Dewey, who, in his work entitled *Logical method and law* (1914) stated that people do not pay enough attention on the actions they undertake, but act based on instinct and routine. This is not always negative, sometime it happens to

be a correct intuition. Often though, people reflect on their decisions beyond the immediate effect, thus they rationalize, argument and motivate an action, a fact, etc.

Therefore there are two types of decisions, some based on intuition and others based on reason. In the latter case, most times has been proven that the best decisions were made under given circumstances. In his work Dewey (1914) greatly emphasise on logic and common sense, seen as an objective way of looking at things and compares the legal situations and, implicitly, those who work in this field with farmers, scientists and mathematicians who use procedures, formula and reasoning to make the best decisions and militate for the adoption of this way of thinking in the field of law, and especially in juridical processes. He ends his paper asserting that the introduction of flexible and experimental logic in the legislative field represents not only a social necessity, but an intellectual one (Dewey, 1914).

The founder of decisional analyses is Herbert Simon, Professor of management at Carnegie Institute of Technology. He wrote numerous papers through which he emphasised the necessity of reasoning and implementation of procedures in decision making in the sphere of economy and in economic organisation and propose different models.

One of his first papers is *Theories of decision-making in economics and behavioural science*, written in 1959. The author starts his paper with a classification of the economy based on the involved actors in macro-economy (when industry and the entire economy are considered) and micro-economy (when individual economic actors are considered), taking into account the economic behaviour in descriptive economy (only describes economic behaviour) and normative macro/micro-economy (which guides the economic decisions towards public policies or the consumer. The latter subsequently became the field of management, being separated from economy and evolving as a separate science. Debating economic theories and problems, especially the theory of consumerism, the management approaches also the issues of decisions and/or satisfying actions. This notion is central in the procedural reasoning approach introduced by Simon. He takes the idea from psychological theory, according to which, the motivation for action is determined by objectives/needs, and actions ends at the moment when the objective/need is achieved/satisfied. In addition, the conditions to satisfy the objective/need are not, by all means, something well defined, but rather they include a certain aspiration level, which is solely adjusted by the experience of individual. Extrapolating this theory, he states that the economic entities do not necessarily have as a goal to maximize profit, but rather to maintain a certain level/rate of profit, to hold a certain market share or to have a certain level of sales. So they will try to satisfy the profit as economic need and not the maximization of profit.

Another novelty of this paper is his vision that the entire decisional process that takes place in the human mind can be implemented through an information technology process, thus a computer can elaborate and follow a decisional process. The advantages of such a programme would be a high number of criteria to be taken into account in making a decision, the increased capacity to generate numerous alternative, high capacity to evaluate the impact of each alternative on the environment to which it belongs. (Simon, 1959)

In another paper from 1979 *Rational decision making in business organizations*, he develops the notion of procedural reasoning, emphasising the fact that in the economic and social spheres, the idea of absolute does not fit in. The is not solution that is absolutely good, there is not situation absolutely known, there is no absolute aspiration level, but all are relative depending on the aspiration level of each individual or economic entity (Simon, 1979).

The bounded rationality approach has several basic principles: (Sharifi *et al*., 2004a)

- Establish the scope and define the problem;
- Establish an aspiration level or matching criteria;
- Use of heuristic research to simplify the problem and extrapolate a single better alternative;
- If no feasible solution is found, then the aspiration level is lowered and the process is repeated;
- After identifying a feasible solution, this needs to be evaluated to establish its rank of acceptability;

- If this is considered unacceptable, the process of seeking solutions is rerun;
- If this is considered acceptable, then this has to be implemented;
- At the final, the level at which the solution corresponds to the needs for future uses needs to be assessed.

3. MODELS OF THE DECISIONAL PROCESS

There is a multitude of models representing the decisional process, the most important being those of Dewey, Simon, Mintzberg and Turban.
Conform to the model of Dewey (1914), the decision making process means answering to the following three questions: (i) What is the problem? (ii) What alternatives are there? (iii) What is the best alternative? This is one of the oldest and simplest model.

The model of Simon (1960) stipulates that there are three stages in the decision process: (i) The intelligence phase (identification of the decision problem); (ii) The design phase (presuppose invention, development, test and analyse possible way of action – new or already developed, resulting in finding some feasible alternatives) (iii) The choice (selection of a certain way of action, resulting in selecting one alternative to become the solution). In the decision making process, when the alternatives are not feasible, the intelligence phase is rerun, if the feasible alternatives are not satisfactory, the process can be resumed either from the design phase or the phase of intelligence. The difference between the two models is that the Simon's model is not seeking to find all alternatives, but only a few, and before choosing one of the alternatives, their feasibility is tested. The model of Simon is based on the sequential analysis of alternative solutions, namely a single solution is studied once, uses the heuristic method of finding alternatives and considers that the final solutions are those that satisfy the proposed (planned) aspiration level, meaning that a problem is solved when there is a satisfactory result. Another model of decision making process is that of Mintzberg (1976). He developed his model based on the practical situations found in some companies and hospitals, when he reached the conclusion that the organisations follow different ways and many times the model followed by them is not a linear one. The principal phases in this model are: (i) identify the problem, (ii) develop the alternatives and, (iii) select a solution. Sometimes, after a problem was identified, it requires a more in depth diagnosis, but other times the organisation goes straight to seeking and filtering a feasible solution or to elaboration of new solutions according to its own requirements.

After the list of feasible alternatives was made follows the validation of the alternatives and the negotiation between the involved decision makers. All these steps could lead to the need to resume the design phase or identify solutions to find a better compromise. Sometimes, after the decision was taken, some organizations must formally confirm the decision (Sharifi *et al*., 2004a).

The model of Sharifi (2004a) is an adjustment of Simon's model with those three phases, only that they are better defined and in more detail, given the fact that Simon's model although original as idea, it became insufficient in the context of technology development and the amount and complexity of information. Therefore, in the intelligence phase we refine steps such as defining the system, searching and scanning environmental data collection mechanisms and understanding the behaviour and system evaluation system behaviour and identify the problem and setting targets and identifying indicators. The next phase, of design, includes the formulation of models, validation, generation of alternative and predicting and quantifying the consequences. In the last phase, for selection, steps are followed to establish the criteria for selection of alternatives, evaluation of alternatives identified in the previous phase, selecting an alternative, performing a sensitivity analysis to see how robust the analysis and final decision is.

4. DECISION SUPPORT SYSTEMS

In terms of operational instruments used in decision analysis, there are two types of decision support systems. Firstly, there are the decision support systems (DSS), with a strong managerial side, enabling decision making and ensuring

transparency of the decision regarding problems of economic and technical type (Fig. 1) and SDSS – spatial decision support systems. In the second case, the decision support systems are combined with GIS tools, enabling detection of rational, objective and transparent solutions to spatial problems (Fig. 2). Spatial decision support systems are most frequently used in the field of urban planning. In this area there are numerous constraints, from those natural (relief, climate, water etc.), to the economic ones (funding, logistics) and the managerial ones (cost efficiency, efficient use of resources, etc.).

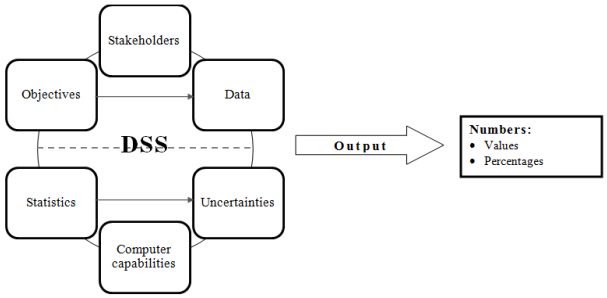

Figure 1. *Decision Support Systems – components and output*

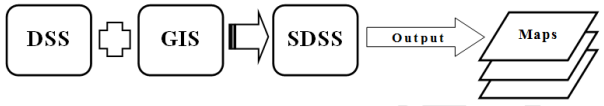

Figure 2. *Spatial Decision Support Systems and their output*

The decision support systems originated in the 1960's, when there were made timid attempts of computer use in managerial decision making. In the 1970's, their use started gaining momentum, computer applications for the managerial support of institutions and companies were developed (customer portfolio management, production support, support for finance, advertising etc.). Beginning with the 1980's, this type of computer systems start diversifying, after a period of approximately 20 years, when the models implemented by these systems were exclusively financial. Thus, in mid 1980's the DSS group is developed with applications in urban planning, and in mid 1990's the web-based DSS emerges (Power, 2004, 2007).

The decision support systems are a type of management support that helps analysts, managers and planners in making decisions. DSS are particularly useful for semi-structured and unstructured problems, which permit an interactive dialogue between system and user. Their main goal is to use the processing power of the computer, but in a user friendly manner, helping the user to explore the problem, better understand it by accessing data and suitable decision models. They are designed for generating and evaluating alternatives to better understand the problem, to increase the negotiating capacity between different objectives and provide decision support.

A scope of DSS is that of assisting certain decision makers, either individually or in group, and not the entire organisation. This allows each individual / group to customize the model according to their needs and requirements and use it in an interactive way. The interaction between actors makes DSS a useful tool in terms of utility and speed of responses. They occur in real time, thus saving time. In addition, high processing power of modern computers enables a dynamic and varied output. Another principle of functioning is to use brainstorming between those involved, so the solutions are satisfactory for all stakeholders.

The spatial decision support systems have been developed to find solutions for decisional problems involving spatial data (SDSS – Spatial Decision Support Systems). They integrate DSS and GIS (Geographical Information Systems) and include analytical techniques and thematic analyses offering the user the necessary framework for the application of decisional processes, which involve the analysis of geographical information. In addition, SDSS is based on georeferenced data, as GIS is based on spatial data (Crossland *et al.*, 1995). SDSS is able to operate with complex spatial problems, offering a common framework for the integration of managerial data bases, for graphic displays, for table reports and for the expert knowledge of decision makers (Densham, 1991).

SDSS are used in two situations: (i) in spatial location problems – where is most suitable to place something (based on the objective set) and (ii) in spatial allocation problems – what is the most suitable usage of a certain place (parcel, building etc.).

SDSS	GIS
• Flexible – assists individual approaches in the decisional process. • It is specifically designed for decision making. • It is designed for semi- and unstructured problem solving. • Flexible in the sense of combining analytic models and databases. • Gives feasible alternatives • It is iterative, integrative and participative • Can also include non-spatial data in analyses	• Supports only cartographic displays. • It has a limited capacity for analysis of geographic information. • It is too rigid for modelling (requires specific data formats, resolution limitations) • Presents deficiencies in analytical modelling techniques • Faces difficulties in designing semi- and unstructured problems

***Table 1**. Differences between SDSS and GIS (Densham, 1991)*

The applications of SDSS are very numerous, ranging from urban planning (e.g. Eldrandaly *et al*., 2003; Sharifi *et al*., 2006; Zucca *et al*., 2008), infrastructure and routing (e.g. Coutinho-Rodrigues *et al.*, 2011; Jankowski and Richard, 1994; Ray, 2007) to agriculture (e.g. Nath *et al.*, 2000), water management (e.g. Makropoulos et al., 2003; Rahman *et al*., 2012; Sharifi, 2003), to environmental issues (e.g. Herwijnen, 1999) – wind farm site selection (e.g. Gorsevski *et al*., 2013), solid waste planning (e.g. MacDonald, 1996; Sharifi, 2004b; Wang *et al*., 2009), to coastal management (Jans et al., 2000; Ruijgrok *et al*., 1999; Uljee, I. And Engelen, G., 2000 cited in Uran and Jansen, 2003), tourism (e.g. Dye and Shaw, 2007; Feick and Hall, 2000) and risk management (Gheorghe and Armaş, 2015).

5. CONCLUSIONS

In their short existence, of about 50 years, the decision analyses proved their utility by helping the decision makers to make better and more substantiated decisions. Evolving from simple, technical solutions implemented to help the managers, they became today very complex systems, capable to deal in real time with various needs of different stakeholders and taking into account numerous factors that affect the decision.

Of course, their development is tightly connected with the development of the technology (computers, software, instruments to collect the data needed), of the methodology and with the problems identified by the practitioners, as they applied the new techniques and they were able to identify the limitations of this type of analyses and/or the limitations of the software developed.

As many (spatial) decision support systems appear and many methods are being improved and developed, a more urge to better knowledge is being perceived. The decision problems are much more complex now compared with the ones from 1960s or 1970s, the decision maker has to face a much larger number of stakeholders, and also the public pressure is more powerful. The manager (of either private or public entities) is not regarded as an absolute centre of power, but a person who is selected by the stakeholders and represents them and their needs, so he can and will be made responsible for every decision he makes and that is affecting the people who invested in him/her. Hence, the accent shifted from the decision that has to be made to the decision making process that became much more transparent.

As any type of new analyses, these ones have also their limitations. One of them is that the decision maker needs to have comprehensive and intuitive software to use, because he/she lacks technical knowledge regarding decision analyses. Also, the stakeholders have to be thoroughly identified and they have to be able to prioritize their needs, to set their satisfaction levels and to establish what they are willing to give up to in order to maintain what they really need. And probably the most important limitation is that, regardless the "help" provided by the (spatial) support systems, the decision maker alone has to make the final decision by choosing one of the designed alternatives.

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