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Project Portfolio Selection in Public Administration Using Fuzzy Logic

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Abstract

The project selection for portfolio management in the governmental sphere is not associated with project financial return, but necessarily involves public benefits. The literature is extensive for portfolio selection when the financial approach is crucial, but little is discussed about selecting projects from the standpoint of public policies. This paper presents a method for project selection in the area of Information Technology (IT) using a tool to support decision-making based on fuzzy logic. A case study validated the method developed, which consists of: 1) Identification of projects; 2) Association of projects with strategic planning; 3) Categorization of projects; 4) Definition of linguistics variables and fuzzy function; 5) Definition of inference rules; 6) Function calculation; and 7) Portfolio balancing. The paper presents interesting experimental results that show the priority of projects and their success potential. The success is related with qualitative and diffuse metrics applied in a simulator for fuzzy logic.

Keywords: Project portfolio management; Fuzzy logic; Decision making; Information Technology.

1. Introduction

A project portfolio should consider the company's strategic planning and adopt an efficient method of project selection. Because private and public organizations have specific concerns and restrictions, new methods of project selection need to be developed to address these different perspectives. The government's decision-making process is guided by a number of peculiarities such as the existence of

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legal norms, interest groups, media, and all citizens. Therefore, it is very difficult to measure project success using indicators such as cost-benefit or Return of Investment (ROI). Public administrators estimate project effectiveness by using qualitative indicators.

This work presents a methodology of governmental project selection. The methodology uses fuzzy logic with qualitative indicators. The methodology application provides the success potential of projects considering their prioritization.

This paper is organized as follows: Section 2 presents methods of selecting projects. Section 3 highlights the main problems and goals of project selection, and describes a new methodology for governmental project selection using fuzzy logic. Section 4 shows a case study that applies the developed methods and provides results. Section 5 concludes the paper.

2. Related Works

The project selection to build a portfolio is not a simple task, since resources are scarce and the demands of business exceed those limitations. Peng *et al.* (2005) consider project selection as a problem of allocating capital among a number of assets to maximize return on investment while minimizing risk.

Mulcahy (2009) classifies the decision models of project selection into two categories: benefit measurement and constrained optimization. The benefit measurement method uses a comparative approach between projects adopting techniques such as: 1) Scoring models; 2) Economic models; and 3) Cost-benefit analysis. The constrained optimization method uses a mathematical approach, adopting techniques such as: 1) Linear Programming; 2) Integer programming; 3) Dynamic programming; and 4) Multi-objective programming.

The literature presents new methods of project selection using fuzzy logic. Carlsson *et al.* (2007) use fuzzy logic to select projects of research and development (R & D) with the objective of avoiding inaccuracies of return. Qin *et al.* (2009) present mathematical models that use fuzzy logic to improve the expected value of projects. Peng *et al.* (2005) use credibility programming to deal with project selection problem. These articles use fuzzy logic to solve problems about return of investment. Our approach differs from the others mainly by using fuzzy logic to select projects whose qualitative benefits are more relevant than financial returns.

3. Project Selection

An erroneous project selection to compose a portfolio can generate problems such as: 1) Excessive number of projects; 2) Inappropriate projects; 3) Projects disconnected from strategic objectives; 4) Unbalanced portfolio (Qin *et al.*, 2009). In the next section, a new methodology of project selection is presented. It was elaborated to avoid these problems and to provide recommendations to people with decision-making power.

3.1. Methodology of project selection

The Methodology for Governmental Project Selection using Fuzzy Logic (MGPS-fuzzy) developed in this work, extended the macro-processes of portfolio management presented in Mulcahy (2009) and included a fuzzy module.

The MGPS-fuzzy is presented at Figure 1 and consists of the following processes that are executed sequentially: Identification; Association with strategic planning; Categorization; Definition of linguistic variables and fuzzy function; Definition of inference rules; Function calculation; Balancing and prioritization of portfolio.

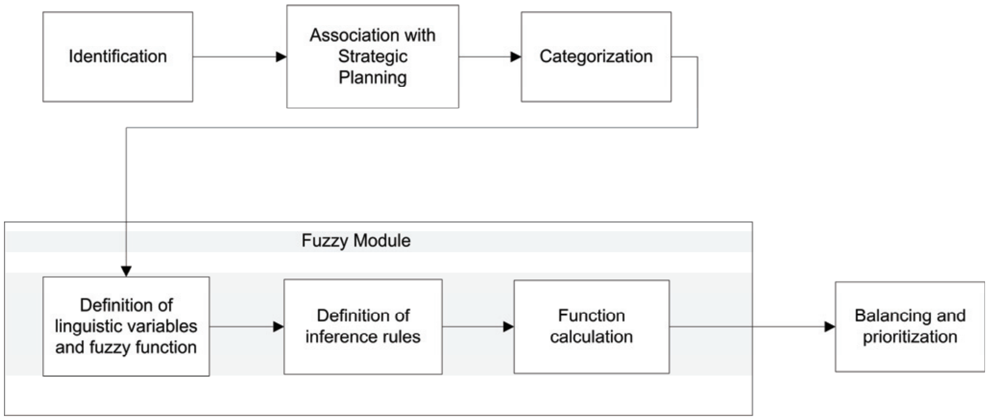

Fig. 1. Methodology MGPS-fuzzy

During the process "Identification", stakeholders define projects in interviews, meetings, or using forms. The project identification follows a bottom-up approach, i.e., it is elaborated by the technical team. During the process "Association with strategic planning", each project identified is associated with actions defined by the institution's strategic planning. In the process "Categorization", projects are categorized into groups of same similarities. Processes "Definition of linguistic variables and fuzzy function", "Definition of inference rules", and "Function calculation" are part of the fuzzy module, which will be detailed in section 3.2.

3.2. Fuzzy module

The fuzzy logic (Zadeh, 1965) is an extension of boolean logic that introduces the notion of sets with partial membership. It is used in many fields where systems must deal with imprecision and uncertainty. With the use of linguistic variables and rules of inference, fuzzy logic provides a mathematical framework capable of representing not only the knowledge of experts as well as the preferences of decision makers in investment projects (Wang & Hwang, 2005).

The fuzzy module in the MGPS-fuzzy consists of three processes that interact strongly: 1) Definition of linguistic variables and fuzzy function; 2) Definition of inference rules; and 3) Function calculation.

In the process “Definition of linguistic variables and fuzzy function”, the values 0 through 10 are associated to each variable to represent a benefit or an importance of a project. The fuzzy function represents the result of linguistic variables correlation. The linguistic variables and the fuzzy function must be defined together with stakeholders.

In the process “Definition of inference rules”, it is necessary to define rules that correlate linguistic variables and fuzzy function to obtain interpretations as follows:

- the more *variable-1* decreases and *variable-2* decreases, the better is the *result*;
- the more *variable-2* decreases and *variable-3* increases, the better is the *result*;
- the more *variable-1* increases and *variable-2* increases, the better is the *result*;

According to the rules described above, *variable-1, variable-2*, and *variable-3* correspond to linguistic variables, which are the inputs to the fuzzy model; and *result* corresponds to the fuzzy function, which is the output of the fuzzy model.

In the process “Function calculation”, the inference rules and linguistic variable values are used for each project recognized at the “Identification” process.

4. Case Study Using MGPS-fuzzy

The methodology MGPS-fuzzy presented in section 3 was applied to a case study in a government company with 500 employees and about 40 IT professionals. The IT area is traditionally composed by subareas of infrastructure and system development. This work focuses on project selection in the subarea of infrastructure. In the following, the methodology is applied.

4.1. Project identification

The identification of IT projects was conducted in three meetings with the infrastructure team and 25 projects were identified as described in Table 1.

Table 1. Identified projects

Project ID	Project name
1	Data security policy
2	Definition of a security and risk management team
3	Definition of a treatment and incident response network computing team
4	Definition of process to start services in production environment
5	Demand management
6	Desktop backup
7	Desktop remote management
8	Distribution of new workstations
9	Infrastructure management
10	Internet access policy
11	Internet link upgrade
12	Link upgrade (MPLS)
13	Migration from 32bits to 64bits servers
14	Password security policy
15	Review of Active Directory
16	Review of CPD environment
17	Review of e-mail
18	Review of firewall
19	Review of network structure
20	Review of service desk
21	Review of Squid
22	Server backup review
23	VoIP
24	VPN establishment for internal access and software factory
25	Wireless network

4.2. Association of projects with strategic planning

In our case study, the interfacing of IT projects with other areas of the enterprise occurs as shown in Figure 2. The client area represents all areas in the enterprise where the projects are strongly linked to strategic planning. The client area frequently demands projects to IT area. Most projects require the development of systems. The system development team requires a subset of projects in the infrastructure to support the demands of communication and storage. The area of infrastructure, in turn, needs to keep and improve the current operational environment. Therefore, some of infrastructure projects related to the strategic planning are mediated by the requirements identified by the system development team. The strategic planning of the case study has generic actions defined to IT area, namely: organize the systems and IT services; build and maintain a reliable public database; organize and disseminate information.

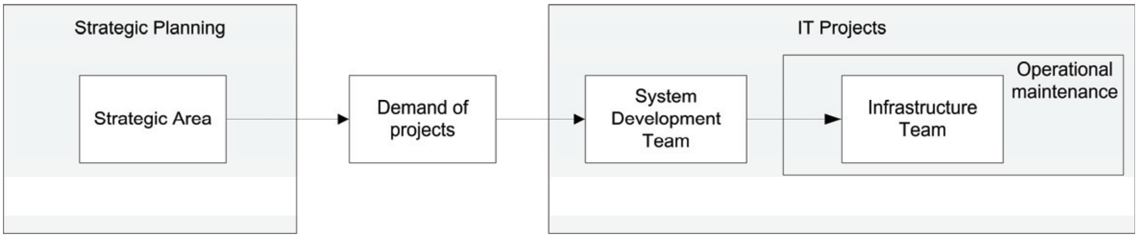

Fig. 2. Association of projects with strategic planning

4.3. Categorization of projects

The categorization of projects will assist the processes of defining linguistic variables and portfolio balancing. In this study, we identified categories according to actions defined in the strategic planning and demands from the system development team, as shown in Figure 2. Table 2 shows the grouping of projects in categories of affinity. The categories represent specific actions to address actions defined to IT area in the strategic planning.

Table 2. Categories identification according to strategic planning

Category	Project ID
Availability of the environment	9, 16, 22
Expansion	8, 11, 12
Improved customer service	6, 7, 17, 20, 25
Innovation	23
New systems (support activities of the development team)	4, 5, 13, 24
Requirement of the laws	2, 3
Security	1, 10, 14, 15, 18, 19, 21

4.4. Definition of linguistic variables and fuzzy function

The linguistic variables were defined by stakeholders based on the benefits or difficulties in project execution. The variables chosen were: cost (given the necessary public investment and annual budget constraint in the IT area); external dependence (assuming that an IT project that interacts with many areas of the company has a greater risk of not succeed); and visibility (assuming that the project impact on users can cause a good impression of the administration). Therefore, in the case study, the cost, the external dependence, and the visibility correspond to linguistic variables; and the project success potential corresponds to the fuzzy function.

4.5. Definition of inference rules

Stakeholders defined the inference rules, establishing a correlation between linguistic variables and fuzzy function, as follows:

- the more *cost* decreases and *external dependence* decreases, the better is the *project success potential*;
- the more *external dependence* decreases and *visibility* increases, the better is the *project success potential*;
- the more *cost* decreases and *visibility* increases, the better is *project success potential*.

Where each variable has the following values and interpretations: External dependence: 0 (good), 10 (bad); Cost: 0 (good), 10 (bad); Visibility: 0 (bad), 10 (good). From these correlations, we constructed 27 inference rules. Table 3 depicts examples of inference rules that will be described in the fuzzy model.

Table 3. Inference rules depicted in the fuzzy model

Cost (input)	Visibility (input)	Dependence (input)	Project success potential (output)
High	Low	High	Weak
Low	High	Low	Strong
Low	High	Medium	Strong
High	High	High	Medium
High	Low	High	Weak
Low	Medium	Medium	Medium

Two important concepts must be considered when inserting or extracting data from the fuzzy model: fuzzification and defuzzification (Shaw, 1998). The fuzzification process interprets the scale of numerical values of linguistic variables to a description apparently informal (Low, Medium, High). This translation is significant because the fuzzy logic helps decision makers where the uncertainty is strongly present.

In the case study, stakeholders defined values for each project presented in Table 1, on a scale of 0 to 10, for each linguistic variable. Table 4 shows the fuzzification of values to informal values *Low*, *Medium*, and *High*; where *Low* represents the values 0 to 3; *Medium* represents the values 4 to 6; and *High* represents the values 7 to 10. The process of defuzzification is the reverse of the process of fuzzification, i.e. it transforms subjective data into numbers. This process will be used in the function calculation process.

Table 4. Fuzzification of values for the linguistic variables associated with each project

Informal Values	External dependence	Cost	Visibility
Low	12, 11, 22, 9, 3, 2, 7, 20, 15, 18, 19, 21	12, 11, 3, 2, 17, 13, 5, 4, 24, 15	12, 16, 22, 3, 2, 25, 13, 5, 4, 24, 10, 14, 1, 18, 19, 21
Medium	8, 25, 6, 14, 5, 13, 17, 24	9, 25, 20, 18, 19, 21	8, 9, 7, 20, 15
High	23, 16, 10, 1	23, 2, 16, 22, 7, 6, 10, 14, 1	23, 11, 6, 17

4.6. Calculation of potential

The success potential of each project was calculated using the tool called Fuzzy Logic Toolbox, available in Matlab (MathWorks, 2012). The simulation model is formed by rules defined in Table 3 and linguistic variables of each project, defined in Table 4.

After these calculations, the results were defuzzyficated, i.e., the terms *Weak*, *Medium,* and *Strong* associated to success potential of each project were transformed into numerical values. The graphs shown in Figures 3, 4, and 5 represent functions defuzzyficated, which correlate each pair of linguistic variables.

Figure 3 shows that *project success potential* increases when *external dependence* decreases and *visibility* increases. Figure 4 shows that *project success potential* increases when *external dependence* decreases, and *cost* decreases. Figure 5 shows that *project success potential* increases when *cost* decreases, and *visibility* increases. The calculation of the success potential for each project is shown in Table 5.

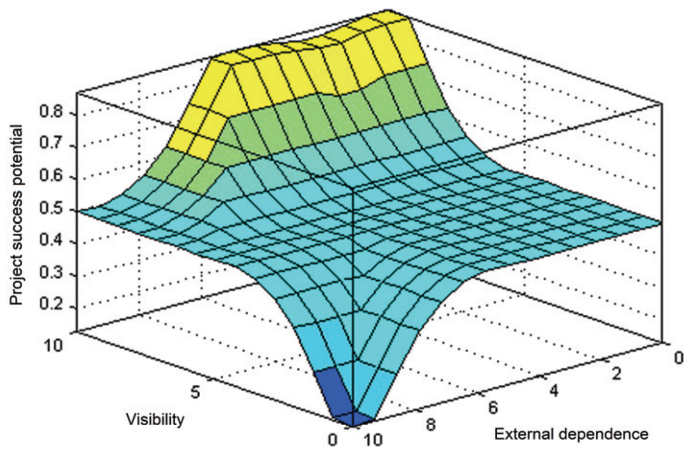

Fig. 3. Visibility versus external dependence

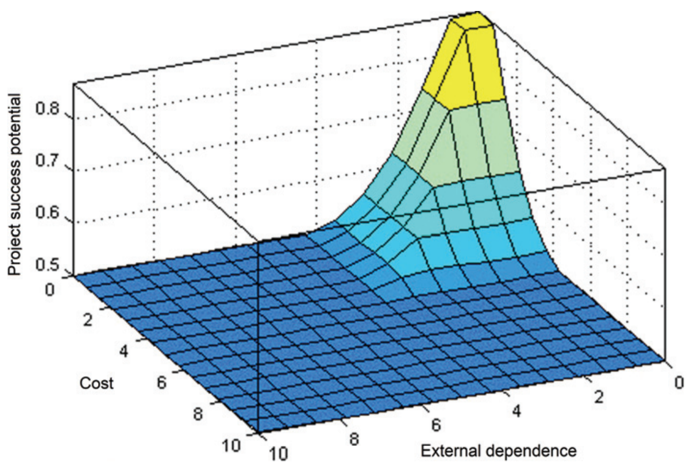

Fig. 4. Cost versus external dependence

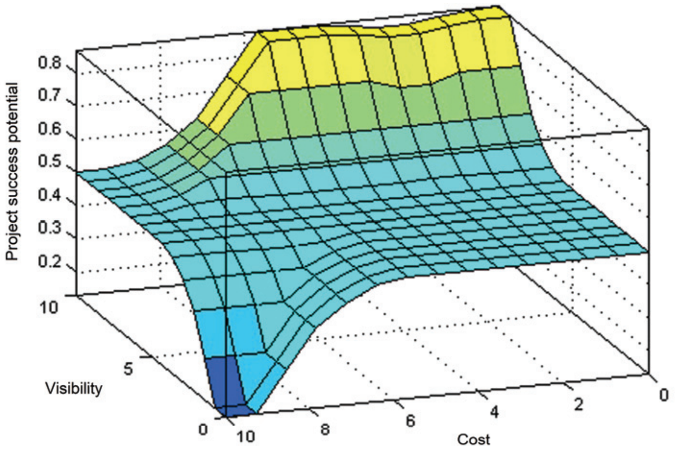

Fig. 5. Visibility versus cost

4.7. Portfolio balancing

In the case study, the portfolio balancing was done by the project prioritization given by different stakeholders. They prioritized projects based on their evaluation of subjective variables, such as availability of human resources and project completion prediction. The list of projects was revised using four priority classes given by three different stakeholders: the infrastructure team, the systems development team, and the manager of user services.

Table 5 presents the final results, where the priority of each project was calculated from the average of different views with weights 3, 2, and 1 respectively to the areas of infrastructure, systems development, and manager of user services. Projects are ranked in decreasing order of priority followed by the project success potential.

5. Conclusions

The project selection to compose a portfolio is not a trivial task. Several variables must be considered, such as the dependence of external areas, the project cost, and the project visibility. In the case study conducted, initially, the IT infrastructure team identified a list of necessary projects. After this survey, projects were categorized according to affinity groups and associated with actions of the company strategic planning. Subsequently, stakeholders defined the linguistic variables, the fuzzy function, and the inference rules for the model. Finally, using the previous information, a simulator of fuzzy logic calculated the success potential for each project.

The methodology developed is a new approach of selecting projects to compose a portfolio using a technique of artificial intelligence, fuzzy logic. The model can help in the decision-making process where uncertainty is strongly present. Our approach considers qualitative metrics because it is applied in the governmental sphere, which must select projects from the point of view of benefits instead of the financial return perspective.

Table 5. Project portfolio

ID	Project name	Project success potential	Priority
11	Internet link upgrade	0.863	1
3	Distribution of new workstations	0.5	1
22	Server backup review	0.5	1
9	Infrastructure management	0.5	1
1	Data security policy	0.5	1
19	Review of network structure	0.5	1
16	Review of CPD environment	0.137	1
14	Password security policy	0.863	2
10	Internet access policy	0.646	2
3	Definition of treatment and incident response network computing team	0.549	2
2	Definition of security and risk management team	0.549	2
17	Review of e-mail	0.549	2
12	Link upgrade (MPLS)	0.5	2
25	Wireless network	0.5	2
24	VPN establishment for internal access and software factory	0.5	2
15	Review of Active Directory	0.5	2
6	Desktop backup	0.646	3
7	Desktop remote management	0.5	3
20	Review of service desk	0.5	3
13	Migration from 32bits to 64bits servers	0.5	3
5	Demand management	0.5	3
4	Definition of process to start services in production environment	0.5	3
18	Review of firewall	0.5	3
21	Review of Squid	0.5	3
23	VoIP	0.5	4

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