NEURO-FUZZY MODELING APPLIED IN PROGRAM MANAGEMENT TO INCREASE LOCAL PUBLIC ADMINISTRATION PERFORMANCE

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Abstract: *One of the challenges in local public administration is dealing with an increasing number of competing requests coming from the communities they serve. The traditional approach would be to handle each request as a standalone project and be prioritized according to benefits and budget available. More and more nowadays program management is becoming a standard approach in managing the initiatives of local public administration. Program management approach is itself an enabler for performance in public sector organizations by allowing an organization to better coordinate its efforts and resources in managing a portfolio of projects. This paper aims to present how neuro-fuzzy modeling applied in program management can help an organization to increase its performance. Neuro-fuzzy modeling would lead organizations one step further by allowing them to simulate different scenarios and manage better the risks accompanying their initiatives. The research done by the authors is theoretical and combines knowledge from different areas and a neuro-fuzzy model is proposed and discussed.*

Keywords: Program management, performance management, neuro-fuzzy modeling

JEL Classification Numbers: C61, C63, H83, M29

1. From project to program management

A project is typically defined as the unique set of activities executed according to a plan to accomplish a specific objective in a given budget and time frame complying with certain qualitative and satisfaction indicators set by the project stakeholders. In nowadays context an organization needs to run multiple projects at once. As one can see the traditional project management does not offer a clear visibility on the resource usage across an organization and does not quantify the contribution of a specific project to the overall performance of an organization. Program management is a relatively new practice that is gaining more traction these days in the corporate and public sector environment. Program management forces the organization to manage the mix of resources and methodologies used to run the projects so that one can say in a timely manner up to what degree a specific resource is used and the contribution to the organization's performance towards fulfilling its strategy. A program is a collection of projects that address a strategic objective of an organization. Given the associated costs and impact of such a collection of projects and also considering the benefits and the complexity of the process of balancing workload, the techniques and methods used for program

management are different and need a more complex skillset. Considering the de facto environment in which an organization activates programs can be classified into: programs that allow the organization to continue running its operations, programs that allow the organization to improve its financial performance and programs that allow the organization to innovate and change its shape.
According to an PMI (Project Management Institute) study "62 percent of projects at organizations that described themselves as highly effective in portfolio management met or exceeded expected ROI" (PMI, 2012). While there are differences between portfolio and program management with the last one being focused on keeping aligned projects targeting mostly the strategic objectives of the organizations this is nevertheless an indirect indicator that program management is an important approach for organizations willing to increase their performance. The same study identifies several critical factors for a successful program management implementation. These are: top management support, portfolio governance plan, clear metrics and aligned strategic objectives. To manage a program one might proceed using a flow like the one presented in the graphic below.

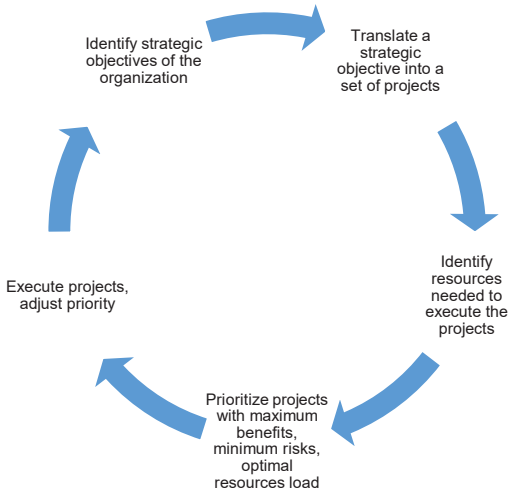

Figure 1: Program management simplified flow

First build the strategy of the organization and set the general objectives so that they:

- Maximize opportunities;
- Minimize threats impact;
- Improve and adjust operational plans to market changes;

While building the strategy the following tools are used: Porter analysis, SWOT analysis and balanced scorecard with an increasing adoption (Niven, 2002). Every line manager will then translate a general objective from the strategy into a set of specific objectives that can be achieved by running a number of projects. In the same stage of the lifecycle project managers are assigned to run projects. To assure consistency of the process and visibility across the organization creating a Program Management Office is desired. In the same stage project managers are assigned to run the projects.

In the third stage the resource pool for each project is established so that all projects from a program have the proper human and material resources to be executed successfully. To do that the program manager together with the line managers performs an analysis to identify operational, financial and human constraints.
In the fourth stage projects are prioritized trying to minimize risks, maximize benefits and maintain a healthy resource usage and workload level. Now is the time to put in place governance plans.
In the fifth stage projects are executed, risks and benefits are continously measured and based on their trends projects are reprioritized and additional resources are allocated. Then the process repeats for the next programs ran by the organization.

2. Performance management in public administration

The performance term is used to describe remarkable results at all levels of an organization achieved inside the environment the organization is operating in and compared to its objectives (Minculete and Olar, 2015). While traditionally the economists focused on measuring performance reffering to efficiency and financial indicators more recent research has focused on assessing the performance of the human resources that run all the activities that make the organization reach its objectives. Measuring and managing performance is a fundamental contributor to the reform of any organization. Highly skilled and up-to-date employees lead to better performed jobs, less complaints, competitive advantage and an increased level of satisfaction for the customers. For public administration the customers are the members of the community, either be it citizens or businesses that pay taxes and use local public services. Performance management in public administration makes no difference for the researchers and can be analyzed from a multidimensional perspective considering economic factors, human resources and even environmental impact and social equity. New public management approach pushed this multidimensional perspective further through its principles by shifting the focus to descentralization in the public sector and focus on the outcomes (Yamamoto, 2003). Descentralization in here means that decision making is delegated to lower levels (units responsible in delivering specific services to the community), bureaucracy is significantly decreased and plans are executed faster. Focusing on the outcomes is the principle that states that what the organizational units deliver and its associated perceived value is what matters, so performance becomes while maintaining and improving economic efficiency.

In this context the public administration traditionally running isolated initiatives, either be it local public services improvements projects or new public services development projects would benefit from moving to program management. Through program management the public administration would be able to better control its resources usage, without scattering them or run into overload situations leading to negative reactions from the community, and maximize the cummulated outcomes of its different initiatives by managing better the correlation between all the factors involved.

3. A neuro-fuzzy model proposal for program management

Fuzzy sets theory has been introduced back in 1965 by Lotfi Zadeh. The challenge raised by this theory is that logic is not purely binary (true and false) and that we can have a set of values representing different degrees of truth and uncertainty. The scope of the fuzzy theory can be applied to solve 2 distinct types of problems: the problems and complex systems for which exact mathematical modeling is not possible and for the problems for which complete evaluation of all solutions is too expensive and the consumer can be satisfied with an approximate solution obtained with a lower cost.

Neural networks have been developed since early 1950, starting from the simple perceptron up to the Widrow & Hoff supervised learning neural network. All of them come in place to help us solve complex problems that need to handle noisy and nonlinear data involving classification, pattern recognition and prediction. The last point is of special interest for this paper as modeling with the help of neuro-fuzzy models allows us to simulate the decision making process in various scenarios. Why we would like to simulate different scenarios? In order to analyze multiple decision paths and their outcome without jeopardizing an entire organization.

For this paper we will consider a program that is made of multiple projects competing for the same resources so not all of them can be executed but only those for which the triad (risks, benefits, resources) is optimal. We will model this into the following objective function:

$$O_p:\{R_p,B_p,W_p\}\text{->}[0,10]$$

Where R_p are the risks associated to a project that is part of a program, B_p are its associated benefits, W_p is the resources usage and [0,10] is apriori established as the output of the function, with 10 as the best solution that can be achieved and 0 as the worst solution.
The aim of this objective function is to minimize risks R_p, maximize benefits B_p and minimize resources usage W_p.

The following fuzzy statements can be presented to describe the desired behavior of the objective function:

- if R_p is low, B_p is high and W_p is low then the project from the program will continue to be executed;
- if R_p is low, B_p is average and W_p is low then the project from the program will continue to be executed;
- if if R_p is low, B_p is low and W_p is low then the project from the program will be stopped from execution;
- if R_p is average, B_p is high and W_p is low then the project from the program will continue to be executed;

- if R_p is average, B_p is average and W_p is low then the project from the program will continue to be executed;
- if if R_p is average, B_p is low and W_p is low then the project from the program will be stopped from execution;
- if R_p is high, B_p is high and W_p is low then the project from the program will continue to be executed;
- if R_p is high, B_p is average and W_p is low then the project from the program will be stopped from execution;
- if R_p is high, B_p is low and W_p is low then the project from the program will be stopped from execution;
- if R_p is low, B_p is average and W_p is high then the project from the program will be stopped from execution;
- if R_p is average, B_p is average and W_p is high then the project from the program will continue to be executed;
- if R_p is low, B_p is high and W_p is average then the project from the program will continue to be executed;

Each of the variables of the objective function needs to be described through a membership function. The perception of these variables and their outcomes by the human brain is nonlinear. According to studies the perception of risks is not linear and once it grows the degree of interest and acceptance towards the risk is decreasing by a potentially polynomial rule (Glimcher et al.,2009). We will use the following membership functions that can be further modeled with the help of Matlab:

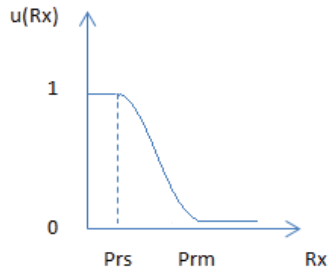

Figure 2: Membership function describing the acceptance of risks

The mathematical representation of this membership function is presented below:

$$\mu(Rx) = \begin{cases} 1, & 0 \le Rx \le Prs \\ 1 - 2\left(\dfrac{Rx - Prs}{Prm - Prs}\right)^2, & Prs \le Rx < \dfrac{Prs + Prm}{2} \\ 2\left(\dfrac{Rx - Prm}{Prm - Prs}\right)^2, & \dfrac{Prs + Prm}{2} \le Rx \le Prm \\ 0, & Rx > Prm. \end{cases}$$

Where Prs is the level of risk from which the risk is actually perceived as a risk and

starts to influence the decision and Prm is the maximum level of risk from which the decident will not continue considerring an analyzed project for execution.

The next one is the membership function describing the acceptance of benefits.

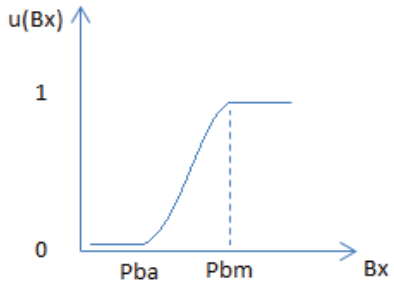

Figure 3: Membership function describing the acceptance of benefits

$$\mu(Bx) = \begin{cases} 0, & Bx < Pba \\ 2\left(\dfrac{Bx - Pba}{Pbm - Pba}\right)^2, & Pba \leq Bx \leq \dfrac{Pba + Pbm}{2} \\ 1 - 2\left(\dfrac{Bx - Pbm}{Pbm - Pba}\right)^2, & \dfrac{Pba + Pbm}{2} \leq Bx < Pbm \\ 1, & Bx \geq Pbm \end{cases}$$

Where Pba is the minimum level of benefits from which an analyzed project starts to be considerred for execution by a decident and Pbm is the maximum level of benefits perceived by a decident.

The last membership function is the one describing the acceptance of workload level.

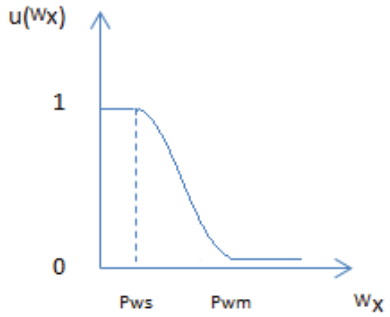

Figure 4: Membership function describing the acceptance of workload level

$$\mu(Wx) = \begin{cases} 1, & 0 \le Wx \le Pws \\ 1 - 2\left(\dfrac{Wx - Pws}{Pwm - Pws}\right)^2, & Pws \le Wx < \dfrac{Pws + Pwm}{2} \\ 2\left(\dfrac{Wx - Pwm}{Pwm - Pws}\right)^2, & \dfrac{Pws + Pwm}{2} \le Wx \le Pwm \\ 0, & Wx > Pwm. \end{cases}$$

This model can be further implemented in Matlab using the Adaptive Neuro Fuzzy Inference System (ANFIS) toolbox and what we will obtain will be the neuro-fuzzy model from the next figure.

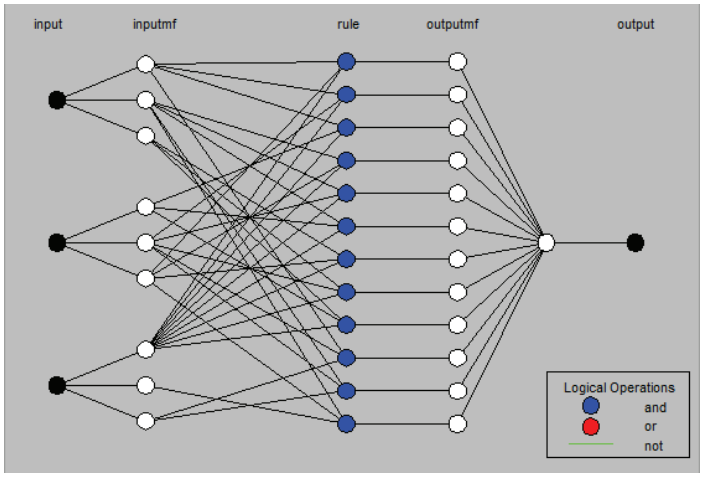

Figure 5: Proposed neuro-fuzzy model architecture

Simulations can then be performed by transforming decisions taken by senior management based on the 3 input variables in approximate numerical thresholds that conduct to a positive or negative decision towards the execution of the projects composing a program.

4. Conclusions

We plan to continue develop this model within future research studies. The model has several limitations as the membership functions used to model the variables are simplified to facilitate implementation and testing into Matlab and not generated through large quantitative analysis and modeling. Still this model is useful to show the utility of neuro-fuzzy models in decision making process when a complex scenario is in place. An advantage of the proposed neuro-fuzzy model is that it can easily be adjusted through training with different sets of data based on the professional expertise of the decision makers.

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