Measures of performance for the portfolio management

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The paper aims to supply some synthetic measures for the assessment of a set of human resources simultaneously involved in a projects portfolio. In particular, on the base of an index obtained by means of the Earned Value Analysis (EVA) and expressing the resource performance on each project of the portfolio, the research offers some performance measures for the generic resource with relation to the entire projects portfolio. Different aggregations that permit to consider different decisional contexts, derived from the Ordered Weighted Averaging operator (OWA), are proposed with the aim to offer a global assessment of the resource. These measures make easier the understanding of the resources performance in the different projects and support the decision maker about the changes to be carried out to improve the performances of the projects. The tool will be implemented into the A.T.I.P.I.CO. platform, that constitutes the final objective of an industrial research project. Finally, the effectiveness of the aggregation operator is shown by means of a numerical example.

Keywords: portfolio management, earned value analysis, OWA operator, human resources

1. Introduction

The present paper aims to offer some performance measures of resources allocated and entangled to a projects portfolio. In particular, these measures of performance regard both the specific resource with relation to a specific project on which he/she is assigned and, since each resource can be simultaneously allocated to more than one project, also the overall resource performance with relation to the entire projects portfolio. This research wishes to supply to the analyst an helpful tool to assess the performance of human resources during the projects execution.
In literature, different measures are proposed to characterize the performance of human resources but not with relation to the project execution phase. In fact, diverse researches propose measures of performances of human resources (workforce, project manager, *etc.*) as drivers during the assignment process of resources to projects, especially to research and development ones. Huemann *et al.* (2007) provide a review on the human resource management and emphasize as the organizations consciously attempt to allocate the personnel to the projects, on the basis of an assessment of what the resources are able to provide. These measures are suggested with relation to aspects as technical skills and other features of the resources (Certa *et al.*, 2008; Certa *et al.*, 2009; Koshijima and Umeda, 2001; Nembhard, 2001).
The measures herein proposed are based on the Earned Value Analysis (EVA). The EVA is a project management tool that supplies meaningful information to the different stakeholders of the projects portfolio.
The basic principle of the EVA has been described in details in the Practice Standard for Earned Value Management (Project Management Institute, 2005), Fleming and Koppleman (2000).
Several researches have proposed the EVA to assess fundamental aspects during the project execution phase.
Vandevoorde and Vanhoucke (2006) provide an overview of the state of art of the EVA, mainly focusing on performance indicators for estimating the total project duration. Lipke *et al.* (2009) propose a method to improve the capability of the project managers for making informed decisions by providing a reliable assessment of the final cost and duration. In order to offer a significant practical contribution to the information system management, Plaza (2008) develops a decision support model to determine both the learning curve and the project duration during the early stages of the project. In particular, the research introduces some formulas to forecast the project duration and a model in which the learning curve is fully integrated with the EVA.
Certa *et al.* (2010) propose a synthetic indicator, that aggregates parameters provided by the EVA, to evaluate the project performance by using a fuzzy inference system. Pajares *et al.* (2011) propose new metrics that combine the Earned Value Management (EVM) and the Project Risk Management for project monitoring and control. Both indexes compare EVM measures with the maximum values that the project should exhibit if it was running under the accepted risk hypothesis.
Chou *et al.* (2010) present a web-based visualized architecture, design and implementation for assessing project performance by integrating the EVA and the database management system (DBMS). Particularly, a probabilistic multiple criteria decision making process is applied to identify the optimal software for developing the

web-based DBMS based on interviews with domain experts and professional engineers. In this case, the EVA serves as a control technique that helps the project managers for the costs monitoring.

Since the information to be handled in order to compute the proposed measures are often hypothesized affected by uncertainty, different researches propose the use of the fuzzy set theory.

Specific applications of fuzzy logic in project management are relatively few in comparison with other application areas. Naeni *et al*. (2011) present an approach to deal the earned value indices with the fuzzy theory. In particular, the Authors propose linguistic terms to measure the earned value and to evaluate its associated indices. Furthermore, in the evaluation and interpretation of the fuzzy indices and estimates they apply the α-cut method. Dweiri and Kablan (Dweiri *et al*., 2006) propose a fuzzy decision making system (FDMS) for the evaluation of the project management internal efficiency by considering as evaluation criteria the project cost, the project time and the project quality and they suggest the use of the Analytic Hierarchy Process (AHP) (Saaty, 2000) to find the relative weights of criteria. Fasanghari and Roudsari (Fasanghari *et al*., 2008) develop a model that integrates the fuzzy set theory and the fuzzy integer linear programming optimization to select the best ICT project.

The herein proposed synthetic measures, based on the EVA, are proposed in order to evaluate the performance of a generic resource with relation to both the specific project and the entire projects portfolio. In particular, the latter is obtained by means of the Ordered Weighted Averaging (OWA) operator. The remainder of the paper is organized as follows: in the next section the proposed measures of performance are described; section 3 is dedicated to the description of an industrial research project addressed to the development of a software platform (A.T.I.P.I.CO.) in which the performances measures will be implemented. Finally, conclusions are drawn in section 4. The present research has been realized with the financial support provided by the Region of Sicily (PO FESR 2007-2013) with relation to the accomplishment of the A.T.I.P.I.CO. project.

2. The proposed measures of performances

As before said, measures herein proposed for the evaluation of human resources performance involved in a projects portfolio, are determined by means of the aggregation of indexes provided by the EVA. The EVA belongs to the EVM defined by the PRINCE 2 (2009) as a technique to measure the scope, schedule and cost performance compared with plans, by comparing the completed products and the actual cost and time taken against their schedule and cost estimates.

The importance to determine aggregated measures in the field of the Project management are stressed by Marques *et al.* (2010). The Authors, by referring to Clivillé *et al.* (2007), highlight as the aggregation models are enable to capture the notion of priorities in the decision-maker's strategy.

The definition of the proposed measures arises from the necessity of some enterprises, belonging to a partnership, that manage a projects portfolio characterized by human resources sharing among projects. Example of enterprises of this type are those belonging to ICT sector, research and development, *etc.* That is, in such contexts, there is the necessity to transversely evaluate the resource with relation to more projects.

It is supposed that ***m*** resources are simultaneously allocated to the ***n*** projects belonging to the portfolio.

As before mentioned, each control account manager of the project *j* evaluates each resource *i* by means of an index provided by the EVA and named Performance Resource Index (PRI_{ij}):

$$PRI_{ij} = \frac{EV_{ij} - AC_{ij}}{EV_{ij}} \tag{1}$$

in which the EV_{ij} is the earned value, that is the planned cost of the work performed and the parameter AC_{ij} is the actual cost of the same work.

It is herein retained that the impact in the global assessment of the resource efficiency has to depend from the features of the project in which the resource is called to operate.

The previous consideration leads to the assignment of a weight w_{pj} to each project, such that:

$$\sum_{j=1}^{n} w_{p_j} = 1 \tag{2}$$

The present paper is non focused on the weights calculation problem and thus the vector of w_{pj} is assumed to be known.

Therefore, the performance of the resource to be evaluated has to be multiplied for w_{pj}, obtaining the following weighted index:

$$G_{ij} = PRI_{ij} \cdot w_{p_j} \tag{3}$$

As mentioned in the introduction, in order to obtain the overall assessment of the performance of the resource *i* with relation to the entire projects portfolio by a global parameter G_i, the use of the OWA aggregation operator is proposed.

2.1 *OWA* operator

This operator allows a remarkable flexibility about the criteria that lead to the resources evaluation and eventually to cluster them into classes each one related to a range of performance.

As described by Yager (2004), the OWA operator returns an aggregated value of *n* starting values a_i by the following expression:

$$F(a_1,...,a_n) = \sum_{j=1}^{n} w_j \cdot b_j \tag{4}$$

where b_j is the j^{th} largest value of the original values a_i and w_j is the weight associated by the analyst to b_j such that:

$$\sum_{j=1}^{n} w_j = 1 \tag{5}$$

The equation (4) can be synthetically expressed in term of vectors by:

$$F(a_1,...,a_n) = W^T \cdot B \tag{6}$$

Where W is the weights vector and B is the vector containing as elements the a_i in decreasing order.

In our case:

$$G_i = F(G_{i1}, G_{i2}, ... G_{in}) = W^T \cdot B \tag{7}$$

The proposed operator is able to reflect different decisional contexts. Namely, it is able to translate the evaluation criteria of the analyst.

If the analyst assigns a greater importance to the positive higher judgments or he/she aims to reward the excellence, as consequence a vector constituted by decreasing weights (w_j - w_{j+1} >0) is used or even the max operator (*t-conorm*) that requires a vector W in which w_1=1 and w_j =0 for $j \neq 1$.

Vice versa, when the analyst desires to be prudent so assigning more importance to the insufficient performances in respect to the others, increasing weights (w_{j+1}- w_j >0) must be applied or even the min operator (*t-norm*) for which w_n=1 and w_j=0 for $j \neq$n.

Instead, if the analyst believes that all the G_{ij} assume the same importance, the OWA operator becomes the simple average operator for which $w_j = \frac{1}{n}$ for $\forall = j$.

3. The proposed measures in ICT software platform-A.T.I.P.I.CO.

A.T.I.P.I.CO. is a project financed by the Department of Production Activities of the Sicilian Region, which the University of Palermo is involved in partnership with some ICT enterprises.

A.T.I.P.I.CO. aims to overcome the limitations of the commercial software platforms, related to the portfolio management, by realizing an innovative software platform that integrates among and within the Project Management Process Groups as well as defined by the PMBOK (2010) and PRINCE 2 standards.
In particular, A.T.I.P.I.CO. focuses on the small and medium enterprises (private and public) that operate in the services supply. The topic of this research fits to the A.T.I.P.I.CO. platform, that requires a tool dedicated to the assessment of the human resources involved in the projects portfolio.

3.1 Numerical Example

In order to highlight as the choice of the aggregation operator translates the analyst objective, a numerical example that simulates the evaluation process of the A.T.I.P.I.CO. platform is shown. A portfolio constituted by 5 projects in which are involved 5 human resources is considered. As before said, the proposed measures for the performance assessment of the resource *i* with relation to the project *j*, are expressed by the PRI_{ij} parameter. The corresponding values are reported in Table 1.

PRI_{ij}	P_1	P_2	P_3	P_4	P_5
R_1	-0.4	- 0.2	0.1	-0.3	0.05
R_2	-0.3	-0.1	-0.05	-0.5	-0.1
R_3	-0.5	0.1	-0.05	0.1	-0.15
R_4	0.1	0.05	-0.3	-0.2	-0.1
R_5	-0.25	0.2	0.15	0	-0.05

Table 1. PRI_{ij} matrix

An information that can be elicited from the previous table regards the eventual presence of columns in which the judgments are characterized by a low or high variability around positive or negative value. This fact could be index of a positive or negative performance of the corresponding project and thus it could drive the analyst to investigate on the causes. In this way he/she can supply useful information to the management and eventually to modify the weight to assign to the project because the corresponding PRI_{ij} values are affected by common external causes.

By assuming the following weights W_{pj} for projects:

[0.3;0.2;0.1;0.25;0.15]

and by applying the equation (3), the weighted indices reported in table 2 are obtained.

G_{ij}	P_1	P_2	P_3	P_4	P_5
R_1	-0.12	- 0.04	0.001	-0.075	0.0075
R_2	-0.09	-0.02	-0.005	-0.125	-0.015
R_3	-0.15	0.002	-0.005	0.0025	-0.0225
R_4	0.003	0.01	-0.03	-0.05	-0.015
R_5	-0.075	0.004	0.015	0	-0.0075

Table 2. G_{ij} indices

As said in section 2, different decisional contexts are hypothesized. They are associated to different values of the weights w_j: decreasing, increasing and equal to $1/n$. In particular, in the first case the weights vector is determined by assuring conditions (8) and (9):

$$[\Delta \cdot n; \Delta \cdot (n\text{-}1); \ldots; \Delta] \quad (8)$$

subjected to the following constraint:

$$\Delta + 2 \cdot \Delta + \ldots \Delta \cdot \mathrm{n} = 1 \quad (9)$$

and it is called *Wdecreasing*.

Similarly, the vector *Wincreasing* is defined by means of:

$$[\Delta; \ldots; \Delta \cdot (n\text{-}1); \Delta \cdot n] \quad (10)$$

and subjected to the same constraint (9).

The values of the three vectors are reported in table 3.

$W_{decreasing}$	$W_{i/n}$	$W_{increasing}$
0.333	0.2	0.067
0.267	0.2	0.133
0.200	0.2	0.200
0.133	0.2	0.267
0.067	0.2	0.333

Table 3. *OWA* vectors

Thus, with relation to the different hypnotized decisional contexts, the overall assessment $G_{decreasing,i}$,$G_{1/n,i}$ and $G_{increasing,i}$ of the resources performance, obtained by the (7) equation, are reported in table 4.

	$G_{decreasing,i}$	$G_{1/n,i}$	$G_{increasing,i}$
R_1	-0.023	-0.045	-0.067
R_2	-0.030	-0.051	-0.072
R_3	-0.013	-0.035	-0.056
R_4	-0.006	-0.016	-0.026
R_5	6.667 E-5	-0.0127	-0,02547

Table 4. G_i vectors

4. Conclusions

The evaluation of resources performance represents an helpful information for the project manager both for the functional manager. In this way they can eventually carry out corrective actions on project team, in order to improve its efficiency and effectiveness.

One of the positive aspect of the proposed methodology is its capability to supply information in a synthetic manner and so easily communicable to all stakeholders. Furthermore, the methodology evaluation process takes into account some objective aspects of projects by means of the EVA and the analyst point of view by means of the OWA operator.

Further research developments could regard the consideration of the uncertainty that affects some factors involved in the assessment process. For example, the assignment process of the project weights could be conducted by means of a Fuzzy Inference System (FIS).

In order to consider the interdependencies existing among the projects belonging to the portfolio, the Analytic Network Process (Saaty, 1996), among the multi criteria decision support methods, represents a valid tool.

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