Risk classification of projects in EU operational programmes according to their S-curve characteristics: A case study approach.

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Abstract – Project portfolios of EU programme organizations typically contain hundreds or even thousands of diverse projects, carried out by public or private organizations each being at a different level of organizational project management maturity. As a result an embedded risk exists regarding the allocation of funds to potential project organizations which could lead to high opportunity costs from not being able to fully utilize the programme’s available funds. Spotting early signs of underperformance is crucial for programme managers in their decision making concerning the implementation of potential corrective actions, or reallocation of funds. Reduction of this type of risk can only be achieved by monitoring the cost progress of each project against its approved budget.

This paper presents a methodological framework applied to a real case study where projects can be classified according to the shape of their S-curve in a way that provides a strong indication about their final performance.

Keywords - Programme management, Project S-Curves, European Programmes

I. INTRODUCTION

The European Union (EU) in its effort to materialize its commitment to economic and social cohesion within Europe, funds a large number of projects at member states through the establishment and operation of regional and sectoral programmes. Almost 23,000 such projects have being funded in Greece in the years between 2000 and 2006 grouped in 24 operational programmes, with a total budget of 25 billion euros. Each of these programmes is divided into a number of main lines of action, called axis, which identify its strategic priorities, which are further subdivided into sub programmes called measures that include a number of similar projects. Each programme is managed by a specifically established organization called Programme Management Authority (PMA).

According to Turner [8], a programme is defined by as a temporary organization in which a group of projects are managed together to deliver higher order strategic objectives not delivered by any of the projects in their own. Thus the main objective in a programme is the delivery of a strategic objective, totally different of that of a project portfolio where the main issue is the efficient management of resources and risk ([7], [9], [10]). Programmes themselves do not deliver individual project objectives. They create benefit through better project organization (i.e. improved coordination, effective knowledge transfer and resource utilization) and better alignment of the projects with the requirements, goals and culture of the master organization ([7], [11]).

For member nations the exploitation of EU programmes it is important because they constitute a considerable driver for economic and regional development, contributing to GNP growth and providing employment. Thus, a key priority of national authorities through the corresponding PMA is the absorption of as large portion of the available funds as possible.

The PMA is responsible for managing the operational programme, the implementation of the operation inclusion procedures, and the monitoring of the progress of the programme’s projects mainly with regard to the eligibility of the expenses and the rate of absorbing the allocated budget per project.

Excluding a small number of programmes / sub programmes concerning large scale infrastructures, which are project specific driven, the rest of the EU programmes and especially those including ‘soft’ actions (i.e. education, training, employment, entrepreneurship, etc.) include large number of projects.

Potential beneficiaries of each programme, both in the public and private sector submit their proposals, following a public call for expression of interest. Projects are approved by the PMA after a selection and evaluation process, according to a top down approach, where a total budget is set for each measure along with a ceiling on the budget for each potential project. Approved projects must be completed within specific time, at the agreed budget with no trade offs between duration, cost and quality being allowed.

In the case where projects do not consume their agreed budget and/or not fulfilling their scope the PMA can reallocate part of or the entire budget to other beneficiaries in the same or other actions or sub programmes. Achieving a high rate of absorption of the available funds is one of the main objectives for any PMA and for national economy. Therefore monitoring of the projects’ cumulative cost is essential in identifying situations that may present a risk with respect to not consuming significant part of the budget allocated to them.

PMA operations are currently supported by a dedicated integrated information system (IIS) that provides information at different levels of detail extending from aggregate national figures down to sub-project level. Although IIS is very well structured, and it holds a vast amount of information, its design and functionality conforms to the typical characteristics of a management information system rather than a decision support system ([5], [6]). With regard to the information needed for man-
In this paper we present a methodology for classifying projects of a programme with respect to their performance regarding the absorption of the available budget, which is based on the widely accepted empirically established behavior of the project cost life-cycle [1], [4].

The methodology is tested on real data drawn from a EU operational programme in Greece, leading to conclusions that show the applicability of the proposed approach.

The rest of the paper is structured as follows: In the next section we present a formal description and mathematical notations of the proposed methodology. In section 3 we describe the application of the proposed methodology to the case of the Operational Programme Education and Initial Vocational Training (OPEVIT) of the 3rd Common Support Framework (CSF) and provide a set of demonstrative results regarding its applicability and versatility to EU Programme management. Section 4 presents the conclusions and suggestions for future research.

II. THE PROPOSED METHODOLOGY

A. Mathematical formulation of the S curve

The proposed methodology is based on the principles of project management [1], [4] and on time series forecasting [3], [2].

Without loss of generality as it will be shown later, it can be assumed that the cumulative cost for the project of a programme follows the well known S curve.

The formal description of the curve is the one proposed by Mavrotas et al. [12], modified here so that it also reflects cases where the total expenditures at the end of the project does not reach 100% of the committed budget.

\[ Y(T) = \frac{1}{1 + e^{-a(T-T_0)}} \]

Both the domain and range of the function are normalized values of time and expenditures as follows: \( T \) denotes the project elapsed time, normalized to a \([0,1]\) scale, and is defined as the ratio of the elapsed time to the overall project duration:

\[ T = \frac{\text{Time from Start}}{\text{Project duration}} \]

and \( Y(T) \) is the cumulative public expenditure (i.e. programme funds) at time \( T \), also normalized to a \([0-1]\) scale as follows:

\[ Y(T) = \frac{\text{Project expenditures at time } T}{\text{Total Budget}} \]

The values of the parameters of the logistic function \( a \) and \( k \) determine the curvature and the slope of the curve giving a variety of shapes that could describe the project’s accumulated cost as it is shown in Fig. 1 of the next section. The maximum slope of the curve occurs at the point \((1/a, 0.5)\) therefore for a value of \( a = 2 \) the curve is symmetrical having its maximum slope at the middle of the project’s duration where 50% of the budget has been consumed and as a increases the maximum slope moves to an earlier time. Thus high values characterize projects where the corresponding cost curve starts rising soon after their approval, while small values correspond to projects the activities of which have a late start. Parameter \( k \) denotes the steepness of the curve. High values correspond to high escalation rates of the project’s cost and therefore activities, while lower values correspond to smoother curves.

So, the specific shape of the S curve reflects the characteristics of the specific programme, the maturity of the projects selected by the PMA, the experience of the project organization, and the way specific projects are managed. It is easily verified that the modified logistic curve (1) has an upper limit equal to 1 as \( T \) approaches infinity. However at the end of the life cycle (\( T=1 \)) the percentage of the budget that has been consumed by the project, which is called absorption ratio, is defined as:

\[ \text{Project absorption ratio: } Y(1) = \frac{1}{1 + e^{-a(1-1)}} \]

Hence the proposed formulation allows to model for the cases where projects of a programme do not cover 100% of their budget within their normal duration as it is often the case.

The normalization of the time and cost variables in the proposed mathematical formulation is necessary because similar projects can be characterized by comparable S-curves regardless any differences in their budget and duration. Also it can handle extensions in project duration and changes to the project’s budget that could take place during their life cycle.

B. Using S-curves for programme monitoring and control

S-curves is a common tool for monitoring and controlling project time and cost through the earned value analysis. Their use in programme management is multi-fold. They can be used to help programme managers to:

1) Establish norms of acceptable cost vs. time patterns for the programme’s projects so that deviations from the norm can be early spotted and investigated.

2) Identify distinct progress patterns for programmes or sub-programmes depending on the characteristics of the programme and the nature of the projects included in it.

3) Forecast the expenses for a sub programme or the entire programme, through the aggregation of the fitted S-curves of the projects it contains, thus leading to a more efficient management of the programme’s budget.

4) Analysis of S-curves for different programmes or groups of projects or project organizations could also pro-
provide useful information in clustering programmes / subprogrammes or project organizations according to parameters that define their fund absorption pattern.

In the following section, we will demonstrate how the analysis of the S-curves can provide valuable information in developing a control method for identifying potentially risky projects with regard to meeting their budget objectives.

III. CASE STUDY APPLICATION

A. Description of the sample data

The Operational Programme of “Education and Initial Vocational Training” (OPEIVT) is one of the 24 Operational Programmes of the 3rd Common Support Framework (CSF) for Greece. Its overall budget amounting to 2.8 billion euros for the 2002 – 2006 period is used to fund approximately 2,000 projects classified in 5 axis of action, and many sub-programmes.

A sample of 177 projects selected based on two criteria: a) budget over 100,000€ and b) being completed or close to completion from the following five sub-programmes concerning Higher Education, where the project organizations were HE Institutes:

- a) Expansion of Higher Education
- b) Upgrade of Academic Libraries
- c) University-Industry Liaison Offices
- d) Enhancement of Industrial Training
- e) Upgrade of HE Curriculum

The total budget of the projects in the sample amounts to 262.5 million euros.

B. Classification of projects based on their S-curve

The various projects within a programme exhibit different behavior with respect to their progress pattern which affects the rate of absorbing the programme’s funds committed to them. Although similarities in the project’s scope, the nature of subprojects within each project, and comparability of deliverables tend to align the programme’s projects on the same pattern regarding the timing of expenditures, other factors such as the effectiveness of the project management team, the experience and maturity of the project organization, the size of the project, and other project particularities introduce variations in the individual project S-curves.

Since a major objective of a PMA is to ensure the maximum utilization of the programme’s budget, a classification of the corresponding S-curves of the projects of the programme according to how well and at what pace consume the funds committed to them, could provide indications about projects that are underperformers and therefore can be considered as risky.

Is such a classification possible and can it provide reliable indications?

The shape of the S-curve (1) depends on the values of the $a$ and $k$ parameters. The value of the parameter $a$ or $k$ for a specific project is considered to have a “low” or “high” value depending on whether it lies above or below the corresponding median value of all projects. Thus each project is judged not to a preset standard but relative to the performance of the rest of the projects within a programme. The use of median is necessary to avoid the influence of extreme cases (i.e. project with very low performance).

The median values of the two parameters divide the set of the projects in four quadrants: The upper right (UR) quadrant (high $a$, high $k$) can be classified as the one representing projects that show an ideal behaviour with an early start and a steep slope, achieve almost 100% of their budget. The reverse situation is shown in projects classified in the lower left (LL) quadrant (low $a$, low $k$), where the projects have a late start and a smooth almost linear progress that end up well behind their budget. The upper left (UL) quadrant (high $a$ low $k$) represent projects with a fast start but slower progress at the later stages than projects in the UR quadrant, while the lower right (LR) quadrant (low $a$, high $k$) includes projects with a late start but an aggressive progress at the last half of the project cycle.

Fig. 1 illustrates the results of the application of the Four Quadrant S-curve classification model to the 35 projects contained in the subprogramme “University-Industry Liaison Offices” of OPEIVT. The diagram in each quadrant contains the S-curves of the corresponding projects.

C Relationship between classification of S-curves and project performance

The classification system that was demonstrated in the previous section will be of a practical value only if it is proved that it is related to the performance of the projects in terms of meeting their budgets.

Table I shows the distribution of the 177 projects in the sample, into quartiles, according to the budget absorption ratio they achieved at completion.

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Min (%)</th>
<th>Max (%)</th>
<th>Total Budget(€)</th>
<th>No of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th</td>
<td>95,21%</td>
<td>100%</td>
<td>52.745.985,7</td>
<td>44</td>
</tr>
<tr>
<td>3rd</td>
<td>88,66%</td>
<td>95,21%</td>
<td>82.463.061,9</td>
<td>44</td>
</tr>
<tr>
<td>2nd</td>
<td>80,63%</td>
<td>88,66%</td>
<td>85.416.524,7</td>
<td>44</td>
</tr>
<tr>
<td>1st</td>
<td>6,6%</td>
<td>80,63%</td>
<td>44.579.488,2</td>
<td>45</td>
</tr>
</tbody>
</table>

The top 25% projects achieved an absorption ratio higher than 95%, while half of the projects were over 88,66% and 75% of the projects absorbed more than 80% of their budget.
To test the hypothesis, whether the classification of the projects according to S-curves is related to their performance as it is measured by the budget absorption ratio, the values of parameters $a$ and $k$ of the fitted S-curves for each of the 177 projects in the sample were estimated, producing the following distribution statistics:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Min</th>
<th>25% Quartile</th>
<th>Median</th>
<th>75% Quartile</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>0.78</td>
<td>1.47</td>
<td>1.61</td>
<td>1.73</td>
<td>2.11</td>
</tr>
<tr>
<td>$k$</td>
<td>2.02</td>
<td>2.91</td>
<td>3.74</td>
<td>5.59</td>
<td>11.35</td>
</tr>
</tbody>
</table>

The projects were classified according to the Four Quadrants (UR, UL, LL, LR) Classification Model, and the classification results were compared against the performance of the projects as they are presented in table III.

<table>
<thead>
<tr>
<th>Performance Quartile</th>
<th>S-Curve quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UR</td>
</tr>
<tr>
<td>4th</td>
<td>81%</td>
</tr>
<tr>
<td>3rd</td>
<td>19%</td>
</tr>
<tr>
<td>2nd</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td></td>
</tr>
</tbody>
</table>

The data in table III show a strong relationship between the S-curve classification and the budget performance of each project. All projects with S-curves in the UR quadrant have a budget absorption ratio above the median and 81% of them are in the top 25% percentile with respect to budget performance. Exactly the opposite picture is shown for projects with S-curves in the LL quadrant, where almost all of them perform below the median level. Between the two intermediate classes, projects in the UL quadrant perform better than those in the LL right.

Pair wise statistical tests of equality of means for the comparison of the mean absorption rate between the 4 classes of S-curves confirm the previous conclusions, as shown in Table IV.

Thus the four classes of the S-curves are directly associated with the performance of a programme’s project, and can be used to order the projects of a programme based on their performance as follows:

I. Projects with a fast start (high $a$) and sharp growth (high $k$)
II. Projects with a fast start (high $a$) and slow growth (low $k$)
III. Projects with a slow start (low $a$) but sharp growth (high $k$)
IV. Projects with a slow start (low $a$) and slow growth (low $k$)
IV. CONCLUSIONS

Monitoring the rate of public expenditures for programmes financed by the EU is one of the most critical factors for the PMAs, in reducing the opportunity cost of not utilizing available funds, since the objective of the EU programmes is to maximize social and economic benefits for the beneficial country.

EU programmes on soft actions like education, entrepreneurship, employment etc. follow a top-down approach in allocating available funds to selected projects. These types of projects, in contrast with hard projects, do not have a predictable pattern of expenditures that follows the completion of specific deliverables at discrete times, and expenditures can be considered as occurring continuously.

Empirical analysis of a specific case study based on historical data for five sub programmes of a sectoral Operational Programme for Education and Initial Training in Greece shows that an analysis of the project’s S-curves can provide useful information to PMAs in their effort to find efficient methods for project monitoring.

Estimation of the S-curve parameters for the projects of a programme can be used to classify the projects in categories based on expected performance, and help in identifying projects that could present a risk to the programme.

Further research using multicriteria analysis or clustering techniques can be carried out in order to investigate the existence of any causal relationships between the classification results of the project’s S-curves and parameters that characterize the project and/or programme organization such as the size of the project, the type, size and maturity of the project organization, the nature of the project, the project selection process, the administrating PMA team etc.

Furthermore, the results of the S-curve classifications could be explored for defining programme envelope curves that establish a range of acceptable variations in the pattern of absorption of funds within a programme or part of it. Projects that follow a trend leading outside established limits are flagged for review since they present a risk to the programme.

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REFERENCES