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Project Prioritization and Portfolio Performance Measurement in Project Oriented Organizations

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Abstract

The overall performance of project-oriented organizations (POO) relies not only on the successful implementation of one or two large, complex projects that they are implementing but instead on how the entire set of projects is managed. Many POO view successful portfolio project management (PPM) as a competitive advantage and establish a formal PPM system which should ensure that with limited resources and available time, the organization selects the projects that facilitate its success. PPM requires several processes to be run for selecting projects and evaluating their success. The selection decisions, and the periodic project evaluations, are made taking into account the enterprise's business goals and strategies.

The paper presents a project prioritization scheme, including several criteria related to the project opportunity (impact on organization goals, internal rate of return, and fit with long term strategy) and project risk estimations.

Effect of projects prioritization over the project portfolio performance is analyzed. In this regards, the paper provides a quantitative, technical treatment of project portfolio risk analysis, using Success Driven Project Management methodology, with a focus on construction projects portfolio. The applied risk measures are derived from the project portfolio return distribution. It is important to understand how the empirical return distribution deviates from normality. This has led to the development of specific risk measures including value-at-risk and expected shortfall.

The paper concludes with ways to improve project portfolio performance. The case study included in the paper is developed using Spider Project software.

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1. Introduction

One of the main causes affecting the project implementation, in actual economical environment is the lack of financial sustainability of the project’s cash flow, which is achieved only if the cash-in flow is timely made by the sponsor. Otherwise, the internal financial resources of the executing company should be used. But the companies do not have all the times these resources available. The lack of cash during the project progress both at the employer level but mostly at the contractor level leads to delays, penalties and loss of opportunities which are reflected in the health of project and organization, as a whole. Financial crisis led to the temporary cessation of payments or to major delays for interim payments. D. Borge (2001) considers that the unsteady economic conditions make the liquidity risk the least understood and the most dangerous financial risk because it reduces the control we have over existing risks and forces companies to assume other risks which normally they would not like to hold.

Another major cause of the difficulties during project implementation is the unsustainable biding prices. The number of project bids is significantly reducing every year, making the competition to win projects extremely challenging. In order to win the tender, the companies accept a large number of risks, which significantly affect the project implementation, up to their cessation. The biding prices led to a continuing erosion of the project budgets and profit margins of companies. Assign projects to values of 50% of the initial budgets have become a common practice, especially in Eastern Europe (Purnus & Bodea, 2013) and may encounter cases of financial offers below 10% of budgets and initially estimated. The effects that such practices have on the market are deeply negative term, as providers enter into a competition absurd prices. In the short term, companies are not able to implement projects at the tendered prices and reduce significantly the quality of services. In the long term, these practices lead to the bankruptcy.

When projects are selected for implementation, most of the executing organizations use a profit-based criterion applied at individual project level, instead to consider several criteria at the organization level (Tanaka, 1984). Adopting a portfolio management approach, by combining investments where the risks are not closely correlated, variance reduction and a lower risk level can result (Han et al., 2004).

The portfolio reflects the production capacity as well as the development potential of the organization. The portfolio components are programs, projects and other operational activities. These components are prioritized and grouped according to certain characteristics, defining a portfolio structure. The projects’ performance and the portfolio structure determine the portfolio performance.

The paper discusses the concepts of project prioritization and portfolio performance. Using a case study, implemented in Spider Project software, the complex relationship between project prioritization and portfolio performance is explain.

1. Project prioritization, a portfolio management process

Portfolio management ensures that projects and programs are reviewed to prioritize resource allocation, and that the management of the portfolio is consistent with and aligned to organizational strategies (PMI, 2013a). The main processes of portfolio management are the following: the components identification and selection, assessment and prioritization of the components, portfolio monitoring and control (PMI, 2013b). There are different types of criteria (Frame, 2003) which are used to evaluate and prioritize the portfolio components, such as:

- financial criteria;
- technical criteria;
- risk-related criteria;
- resources-related criteria (human resources, equipment etc.);
- contractual conditions criteria;
- experience and other qualitative criteria.

As examples of financial criteria, we can mention: benefit-cost ratio, net present value, payback period, internal rate of return (IRR), weighted average cost of capital, and terminal value. Different works (Flanagan & Norman, 1993; Phillips & Phillips, 2006; Yescombe, 2002; Esty, 2003; Fabozzi & Nevitt, 2006) discuss about the limitations of these indicators.

The steps for developing a quantitative model to evaluate and prioritize the projects are the following:

- Establish the evaluation criteria;
- Establish the score scale for each criteria;
- Establish the scoring method for each criterion;
Calculate the project score for each criterion and the total score.
Establish the project priority based on one single score (single-criteria approach) or total score (multi-criteria approach).

Project prioritization is usually done on the single profit-oriented criteria, rather than consider multiple criteria, both quantitative and qualitative. Another limitation of the existing practices in project prioritization is the deterministic approach. Most of the companies develop financial projections based on the deterministic estimation of project financial performance. For doing that, some basic assumptions are considered, such as: the time frame (the financial projections cover the project implementation period plus three-five years after the project’s completion), capital outlays and financing costs (they include any up-front and ongoing capital needs during the reference period), revenues associated with the project, expenses, and capital structure.

In a probabilistic approach, the financial indicators are considered as being uncertain variables, with discrete probability distributions. Working with stochastic variables leads to the increasing of computational effort. This is why, different solutions to approximate systematic distributions were proposed, such as Pearson-Tukey method. This method represents a three-point approximation solution (table 1).

### Table 1. Quantitative model based on Pearson-Tukey method – an example

<table>
<thead>
<tr>
<th>Evaluation criteria</th>
<th>Weight</th>
<th>Worst case scenario score (18.5%)</th>
<th>Normal case scenario score (63%)</th>
<th>Best case scenario score (18.5%)</th>
<th>Score</th>
<th>Weight Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion 1</td>
<td>20%</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>7.5</td>
<td>1.500</td>
</tr>
<tr>
<td>Criterion 2</td>
<td>15%</td>
<td>0</td>
<td>2.5</td>
<td>5</td>
<td>2.5</td>
<td>0.375</td>
</tr>
<tr>
<td>Criterion 3</td>
<td>35%</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>7.5</td>
<td>2.625</td>
</tr>
<tr>
<td>Criterion 4</td>
<td>5%</td>
<td>0</td>
<td>2.5</td>
<td>5</td>
<td>2.5</td>
<td>0.125</td>
</tr>
<tr>
<td>Criterion 5</td>
<td>25%</td>
<td>0</td>
<td>2.5</td>
<td>5</td>
<td>2.5</td>
<td>0.625</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>7.5</td>
<td>5.250</td>
</tr>
</tbody>
</table>

Success Driven Project Management is a methodology used in project and portfolio planning, performance analysis, control and risk analysis, basing on a series of performance indicators. It integrates the project scope, time, cost, resources and risks and provide useful estimations for the management about the projects execution in order to take timely decisions. Success Driven Project Management includes tools and techniques like Quantity Based Scheduling, Application of Corporate Norms, Conditional Scheduling, Skill Scheduling, Resource Critical Path Calculation, Trend Analysis, Risk Simulation and Analysis and Success Probability Trends. The Three Scenario Approach is a semi-probabilistic risk analysis method used together with the management by trends (Liberzon, 1996). For the initial project and portfolio data (duration, volume of work, productivity, calendars, resources) there are obtained three estimations (optimistic, most probable and pessimistic) which will be used in rebuilding the probability curves for dates, costs, material requirement and financing (Archibald, Liberzon & Souza Mello, 2008). If we define the desired target probabilities we will obtain the desired dates for finishing the project, costs, material requirements and financing. The probabilities to meet the target dates are called success probabilities and they are used to measure the buffer penetration (Liberzon & Souza Mello, 2011).

The three points with the probabilities according to the three scenarios: the point with zero probability for the optimistic scenario, the point with 100 % probability for the pessimistic scenario and the point for which the probability distribution has the maximum value are used to build the probability distribution curve (Fig. 1.a). During the project execution the current probability is monitor by its trend. If the probability trend is negative, than a risk event occurs and preventive or corrective measures are required. If the probability trend is positive, no action is needed.

Unlike the Three Scenario Approach for which there are developed three different scenarios of the project or portfolio, Monte Carlo analysis use only different estimates of the parameters. The risks events and uncertainties are simulated using triggers and conditional branches which are applied in the project or portfolio scheduling depending by a series of user defined probabilities (Kendrick, 2003).

Artificial variable values are generated, using a random number generator uniformly distributed in the interval [0, 1] together with the associated cumulative distribution function. The Monte Carlo method uses the obtained results to extract values from the probability distribution that describes the behaviour of the stochastic variable.
The cumulative probability curve is build similar to the Three Scenario Approach and the probability of the target data is determined (Fig. 1 b).

![Cumulative Probability Curve](image)

Fig. 1. The cumulative probability curve (a) Three Scenario Approach; (b) Monte Carlo simulation

Due to the large number of iterations, the great amount of time for the preparation of input data and the large effort and time for computation, Monte Carlo simulation may be applied on projects or portfolios with a low level of detail. However, this approach will affect the accuracy of the results (Hulett, 2009).

(a) Portfolio performance measurement

A portfolio management methodology defines several portfolio performance criteria. These criteria can be quantitative (turnover, profit, cost reduction, human resource efficiency, reduction in execution time and quality) or qualitative (quality of work, number of accidents in the portfolio; speed of obtaining and using information about different portfolio components). The return on a portfolio of projects is simply a weighted average of the return on the individual projects and the expected value of the sum of various returns is the sum of the individual expected values (Elton & Gruber, 1987).

Portfolio performance criteria address the organization situation as opposed to projects whose interest is the performance of work according to the plan and the satisfaction of investor and beneficiary.

Maximizing the expected portfolio return is considered usually as the most important performance criterion. But this is not the only one goal of an organization. In (Cardo & Wind, 1985; Segev, 1995) the maximization of the expected return for a given level of acceptable risk is consider as a model for business investments evaluation. Han et al (2004) introduce a multicriteria approach, based on the expected value maximization, risk volatility minimization and the investment efficiency maximization.

(b) A case study

The effect of project prioritization over the project portfolio performance analysis is focused on the construction of an industrial logistic park. It consists from five projects which includes warehouses for acquisition and lease and production facilities for light industry and manufacturing. The infrastructure is based on isolated concrete foundations and the superstructure is made of concrete prefabricated pylons and metal frames. The projects are developed for the same investor, the technical design is similar with differences in the size of the facilities, the contractual conditions are identical and the designer and the consulting company are the same for all projects. The contract is turnkey with a maximum guaranteed price. It contains a clause in which the contractor will receive 1,000 Euro bonus per day for each day prior to the contractual finish date and will pay a penalty of 1,000 Euro per day for each day after the contractual finish date. The payment of the works is done after each
phase of the project is taken over.

The portfolio model consisted of 1654 activities, with 85 resources (manpower and equipments), 90 multi-resources, 380 materials, 74 cost components, 25 calendars and 80 cost centres was scheduled according the contractual requirements (Fig. 2).

Using the Three Scenario Approach, for each project was developed three scenarios, taking into account the potential risks and uncertainties. A particular importance was given to the project and portfolio cash-flow. It highlights the maximum amount of expenses the contractor should make. The cash flow for optimistic, most probable and pessimistic scenario at the portfolio level is presented in Fig. 3.

The portfolio performance analysis was made taking into account the following optimization criteria: maximizing the profit (in percent) and the earnings (in currency) and minimizing the costs and the maximum amount of expenses resulted from the cash flow.

Five alternative prioritization schemes were defined. In all the alternatives the computation was made taking into account the limitation of the resources (manpower, equipments and materials). The first alternative considered as the reference assign for each portfolio component the same prioritization level. In the second alternative the component level of prioritization was defined in order to maximize the portfolio profit. The highest priority was
given to those components that have the highest profit. The aim of the third alternative is to minimize the maximum amount of expenses from the portfolio cash flow. The highest priority was given to those projects that have the maximum expenses in the cash flow. The fourth alternative is focused on the maximization of the portfolio amount of earnings. The projects with the highest amount of earnings were given the highest priority. In the fifth alternative oriented on the minimization of portfolio costs, the highest priority was given to those projects that have the highest costs. Changing the level of priority of the portfolio components will allow those projects with high priority to access the needed resources as soon as possible, at the expense of the projects that have lower priority. However, the delays of certain portfolio components will lead in the application of penalties and as result, in the increase of costs and reducing the profit for those components. The prioritization scheme in the five alternatives applied in all scenarios (optimistic, most probable and pessimistic) is presented in the table 2.

Table 2. The prioritization scheme and the level of prioritization

<table>
<thead>
<tr>
<th>Scheme 1</th>
<th>Scheme 2</th>
<th>Scheme 3</th>
<th>Scheme 4</th>
<th>Scheme 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>1000</td>
<td>700</td>
<td>900</td>
<td>800</td>
</tr>
<tr>
<td>Project B</td>
<td>1000</td>
<td>600</td>
<td>700</td>
<td>600</td>
</tr>
<tr>
<td>Project C</td>
<td>1000</td>
<td>800</td>
<td>800</td>
<td>700</td>
</tr>
<tr>
<td>Project D</td>
<td>1000</td>
<td>900</td>
<td>100</td>
<td>1000</td>
</tr>
<tr>
<td>Project E</td>
<td>1000</td>
<td>1000</td>
<td>600</td>
<td>900</td>
</tr>
</tbody>
</table>

Considering the Scheme 1 as reference the target dates for the following parameters were defined: profit, cost expenses, duration and earnings. The corresponding probabilities to achieve the target dates computed using The Three Scenario Approach is presented in table 3.

Table 3. The probabilities to achieve the target dates for Scheme 1

<table>
<thead>
<tr>
<th></th>
<th>Profit</th>
<th>Cost</th>
<th>Expenses</th>
<th>Duration</th>
<th>Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio</td>
<td>76.10%</td>
<td>71.48%</td>
<td>72.90%</td>
<td>72.60%</td>
<td>74.36%</td>
</tr>
<tr>
<td>Project A</td>
<td>80.10%</td>
<td>72.76%</td>
<td>72.07%</td>
<td>76.72%</td>
<td>70.35%</td>
</tr>
<tr>
<td>Project B</td>
<td>72.80%</td>
<td>74.11%</td>
<td>70.83%</td>
<td>72.86%</td>
<td>70.00%</td>
</tr>
<tr>
<td>Project C</td>
<td>76.90%</td>
<td>64.64%</td>
<td>72.94%</td>
<td>69.98%</td>
<td>70.67%</td>
</tr>
<tr>
<td>Project D</td>
<td>74.90%</td>
<td>72.43%</td>
<td>70.34%</td>
<td>71.35%</td>
<td>73.49%</td>
</tr>
<tr>
<td>Project E</td>
<td>75.20%</td>
<td>73.53%</td>
<td>70.53%</td>
<td>75.20%</td>
<td>71.15%</td>
</tr>
</tbody>
</table>

During the computation, for each alternative scheme the probabilities to achieve the target dates were obtained. In order to identify the best alternative scheme, the results were analyzed from two perspectives:

- For each parameter (profit, cost, expenses, duration and earnings) was analyzed the variability to achieve the target dates for projects and portfolio in each alternative scheme
- For each scheme was analyzed the variability to achieve the target dates for projects and portfolio, for each parameter

The variability of the probability to achieve the target dates for profit, amount of expenses, duration and earnings for portfolio and its components in different schemes is presented in Fig. 4.

While at the portfolio level the probability to achieve the target profit has an insignificant difference resulted by changing the level of priority of the portfolio components, project C encountered a decrease of the probability to achieve the profit in the scheme 2 (profit maximization). This should be correlated with the variability of the probability to achieve the target dates for the maximum amount of expenses where the scheme 2 (profit maximization) and scheme 3 (expenses minimization) shows a large difference for project B and Project C. The scheme 2 and 4 (earnings maximization) are also correlated for the probability to achieve the target duration at the portfolio level and project B. The effect of delaying project B in scheme 2 due to the lowest priority to access the
resources is significant at the portfolio level as time as it affects the probability to achieve the target duration of the portfolio. Analyzing the variability of the probability to achieve the target earnings, we find that in both schemes 2 and 4, project B has the lowest values. That means that component portfolio project B is the most sensitive to the resource allocation within the portfolio.

The resource constraint scheduling taking into account the projects level of priority will allow the projects with a high level to use as earlier as possible the needed resources, while the projects with a low level of priority will encounter delays due to the lack of resource. The evolution of the projects will affect also the maximum amount of expenses. That is why the variation of the probability to achieve the target duration and expenses is highly. Analyzing the above variations, we find that the worst scheme is 2, where the lowest priority was gave to the Project A, Project B and Project C. The variability of the probability to achieve the target dates (profit, cost, expenses, duration and earnings) for portfolio and its components during the change of projects level of priority is presented in Fig. 5 and Fig. 6.

Fig. 4. The probability to achieve the target dates (a) for Profit; (b) for Expenses (c) for Duration; (d) for Earnings

Fig. 5. The variability of the probability to achieve the target dates for (a) Scheme 1; (b) Scheme 2
Fig. 6. The variability of the probability to achieve the target dates for (a) Scheme 3; (b) Scheme 4; (c) Scheme 5

Besides the scheme 1 which was taken as reference for our analysis, the scheme 2 (profit maximization) and scheme 4 (earnings maximization) presents lowest probability to achieve the target duration at the portfolio level, even the other parameters has a better probability. The risk of delaying the entire portfolio due to the limited resources is higher than in the other schemes. On the other hand, delaying some portfolio components may reduce the maximum amount of expenses from the portfolio cash flow. This is the case of scheme 3 (expenses minimization) and scheme 5 (minimizing the costs) where at the portfolio level the probabilities to achieve the target dates are reasonable, even the project C encounters lower values for the probability to achieve the target dates for expenses and costs.

It is proved therefore for the analyzed portfolio structure that defining several prioritization criteria may lead to different portfolio performance results. Among the analyzed criteria – maximizing the profit and earnings and minimizing the amount of expenses and the costs, the last two offer more favourable results at the portfolio level.

It is more important in the actual economical environment to analyze the portfolio cash flow and to define a rational project prioritization scheme in order to reduce to financial effort at the organization level. On the other hand, a deterministic approach will not allow to take the best decision in the project prioritization process. It is necessarily to analyze also the risks and uncertainties and using the Three Scenario Approach is a choice, especially in medium and large projects. Once the project prioritization scheme is selected, during the construction phase it is necessarily to monitor the trend of the current probability to achieve the target dates. As time as due to the site conditions the projects needs change, the process of project prioritization is continuous.

(d) Conclusions

The project implementation in actual economical environment requires a careful analysis of the financial sustainability of the project's cash flow, taking into account the effect of resource limitation at the organizational
level. Project oriented organizations need to set integrated project and portfolio success criteria. It is necessary to be able to calculate project and portfolio schedules considering not only resources but also financial and supply constraints. The choice of projects for their inclusion in the Project Portfolio shall be justified by scheduling the portfolio model that includes project schedules and analyzing their impact on the portfolio success criteria. Risk simulation shall be applied basing on the solid resource management foundation and corporate standards for scheduling. The application of simplified models, without considering resource constraints may lead to wrong and dangerous decisions.

The complexity of construction projects and the large number of risk events and uncertainties which may occur before and during their execution make very difficult to evaluate the projects and portfolios using a single parameter. During the execution when most of the risks occurs, the often changes of the projects priorities within the company portfolio will lead to changes in resource availability. The decisions are made mostly based on the company financial capability to sustain the entire effort.

The paper presents the main results obtained during the portfolio performance analysis, based on the following parameters: cost, expenses, profit, earnings and duration of the projects and portfolio and the variation of the probability to achieve the target dates when the prioritization is changed, taking into account the limited resources (manpower, equipments and materials). A particular importance was given to the project and portfolio cash-flow, taking into consideration the maximum amount of expenses the contractor should made. The prioritization schemes took into account five prioritization alternatives. In each scheme, the level of project prioritization was changed in order to obtain the maximum profit, the maximum earnings and to minimize the expenses, the costs and the duration. It was analyzed the variability of the probability to achieve the target date for each parameter (duration, cost, expenses, earnings and profit) for portfolio components during the change of projects level of priority and for each portfolio component it was analyzed the variability of parameter probability during the change of projects level of priority. The resource constraint scheduling taking into account the projects level of priority allow the projects with a high level to use as earlier as possible the needed resources, while the projects with a low level of priority will encounter delays due to the lack of resource. The evolution of the projects affects also the maximum amount of expenses. That is why the variation of the probability to achieve the target duration and expenses is highly. Analyzing these variations, we find the conditions (the projects ranking in the portfolio) which lead to the worst and the best portfolio performance, as it was defined by the parameters took into account.

Starting with this model of portfolio performance, the authors consider that it would be necessary to improve the model, taking into consideration additional parameters, such as: value at risk and cash flow at risk. Value at risk is ‘‘the worst expected loss over a target horizon within a given confidence interval. Value at risk summarizes in a single number the global exposure to market risks and the probability of adverse moves in financial variables’’ (Jorison, 1996). Value at risk shows the potential maximum loss that can happen with any portfolio component, with a certain confidence level over a relevant time period. In order to calculate the portfolio’s value at risk, two factors must be defined: the confidence level and the length of the holding period. In contrast to the value at risk, which is usually applied for short periods of time (days), the cash flow at risk is appropriate for long-term analyses (months, quarters or years) as well. The cash flow at risk is measuring the maximum shortfall of a cash flow within a certain period with a certain probability. Therefore, downside risks can be identified in time and liquidity planning can be optimised.

References


