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De Marco A.*, Bozzo R.**, Rafele C.*, Guida R., Grimaldi S.****

** Department of Management and Production Engineering, Politecnico di Torino, Corso Duca degli Abruzzi 24 10129 - Torino – Italy (alberto.demarco@polito.it, carlo.rafele@polito.it, sabrina.grimaldi@polito.it)*

*** Corporate Risk Manager, Comau S.p.A., Via Rivalta, 30 10095 Grugliasco (Torino) – Italy (riccardo.bozzo@comau.com)*

**** VP-Head of PMO, Comau S.p.A., Via Rivalta, 30 10095 Grugliasco (Torino) – Italy (roberto.guida@comau.com)*

Abstract: In increasingly complex and competitive markets, effective Risk Management practices are considered of upmost importance to deliver value in Project Portfolio Management systems. However, there is little literature and methodologies available to evaluate the effectiveness of Risk Management at the Project Portfolio level. This precursory study contributes to filling this gap through the definition of a set of indicators to measure the effectiveness, performance and ability of Risk Management processes to create value in Project Portfolio management. Based on the analysis of real project data from a large Project Portfolio of a major project-based company working in the automation industry, this study proposes a framework of six different Risk Management Key Performance Indicators. With reference to logs of both closed and open risks, the framework allows to measure at any point in time during the project execution the effectiveness of the Risk Assessment process to help project managers respond to threats, seize opportunities, and forecast future risks. Validation of the proposed framework has been achieved both through empirical analysis and expert interviews. The set of indicators is proposed as a valuable metrics to help Project Portfolio Managers improve their risk analysis and decision making standards and methodologies.

Keywords: Risk Management, Project Portfolio Management, Risk Analysis, Key Performance Indicators

1.Introduction

Projects are complex, market demanding and highly competitive. In this context, Project Management standards, skills, tools and techniques are used to meet project requirements and deliver performance targets.

However, companies that are already mature in Project Management are still struggling to improve their results and to create value at various levels of governance that value is perceived, pursued and managed. In a multiple project environment, it is possible to distinguish between value to be pursued by project and portfolio managers.

The value to be pursued by Project Managers during project execution is to deliver result according to the contract requirements, identifying the risks that could prevent the result and planning\implementing the adequate risk response actions to counteract them (De Marco and Thaheem, 2014).

The value for Portfolio Management is to make sure that investments, new contracts and projects globally maintain the expected level of results and the original alignment with the strategic objectives defined in the corporate strategic plan.

Both project and portfolio managers, in order to deliver a higher level of benefits to the organization, may need to move a step ahead to improve business results. In particular, growing in those field where the most projects inefficiencies have been identified.

Among the above factors, inaccurate Risk Management has been identified as one of the primary causes of project's failure in more than thirty percent of cases (Project Management Institute, 2016). This means that a growing in the Risk Management culture may bring an important additional value for organizations.

One of the main challenges for Companies therefore lies in leveraging value generation by integrating the risk model in the business processes with the aim to support decision making and not just as a control tool.

Value Management and Risk Management could be considered in fact as complementary processes that, when employed properly, ensure that objectives are identified and fully understood, potential uncertainties are anticipated and suitable responses are implemented through the concrete application of good decisions taken at all Company levels.

Risk Management plays therefore a pivotal role to preserve the chain of value for companies at all levels of application and the corporate risk function is responsible to define and implement an effective framework for the management of all risks, deeply integrated with the

business activity and aligned with the strategic goal of the company.

Stated that (1) inaccurate Risk Management is one of the main causes of project's failure and that (2) a positive relationship between Value Management and Risk Management exist, could we assume that a better Risk Management framework will drive a greater company maturity? Will it produce a measurable increase in the company performance and, eventually, on profitability and predictability of the business?

This study moves towards this direction through the definition of some performance indicators to measure Risk Management effectiveness and its relationship with potential company's results improvements.

2. Pertinent Literature

2.1 Project Risk Management

The positive effects of Project Risk Management have widely been recognized in literature (de Bakker et al., 2011) and several studies confirm that effective project risk management is key to project success (Mu et al., 2009; Raz et al., 2002; Ropponen and Lyytinen, 1997).

Project risk management aims at reducing the likelihood of project failure as it involves the analysis of the objective functions of the project in their interaction with the project variables (Sanchez et al., 2009).

The term risk is different from issue: issue refers to things already happened that are currently impacting objectives, while identified risks may impact on objectives only if the organization is not able to manage them proactively and timely.

Risk can also be viewed as having a positive effect, placing side by side threats and opportunities, with the assumption that threats are the negative implication of risk and opportunities are the positive one. Both threats and opportunities should be considered in the process of risk identification and analysis (Ward & Chapman, 2003).

Project risk management enables an organization to limit the negative impact of uncertain events and to reduce their probability of occurrence, while simultaneously aiming to capture opportunities (Petit, 2012).

The project risk management process is generally consisting of four steps: (1) identifying project risks, (2) performing qualitative and quantitative risk analysis, (3) planning risk responses and (4) monitoring and controlling risks (Project Management Institute, 2013a).

According to literature, planning and implementing proper risks responses could be considered within the Risk Management process the most critical step, since the effectiveness of responses will directly determine whether risk exposure increases or decreases on the project (Hillson, 1999).

Considering the two-dimensional meaning of the term risk (negative/positive), a number of alternative strategies are available to address threats or opportunities, including avoidance, transference, mitigation, and acceptance (Project Management Institute, 2013a).

2.2 Portfolio Risk Management

Risk management discussions in project contexts have usually focused their attention on handling risks in single projects. For companies that are focused on managing several projects/investments at the same time, control risks in that multi-projects environment means to integrate risks at the portfolio level instead of considering the single projects separately (Artto et al., 2000).

A project portfolio is defined by the PMI as a collection of programs, projects, or operation managed as a group to achieve strategic objectives (Project Management Institute, 2013b).

Portfolio risk management allows the organization to handle risks in a better manner than would be possible if project risks were considered independently from one another (De Reyck et al., 2005).

Portfolio risk management permits an aggregated view on risks and transfers knowledge about risks between projects, creating a sort of lesson-learned (Olsson, 2008).

According to Olsson (2008), benefits of a portfolio risk analysis could be summarized in three main aspects: (1) improvement of project risk management effectiveness thanks to experience and feedbacks obtained adopting a portfolio perspective, (2) optimization of performance through the identification of common risks and trends within the portfolio, (3) enhancement of internal organization across a better planning and coordination.

A conceptual framework that link formal risk management at project level with the integration of risk information at the portfolio level have been proposed by Teller et al. (2014) (Figure 2.1), in order to investigate their impact on project portfolio success.

Teller et al. (2014) findings support the following claims: (1) there is a positive relationship between a formal risk management process and project portfolio success, (2) project risk management is necessary but not enough for the success of a project portfolio and that (3) the integration of risk information is extremely significant for highly dynamics portfolios that operate in turbulent environments.

In literature it is possible to find few evidences on how to incorporate risk management into project portfolio management (Project Management Institutes, 2013b; Sanchez et al., 2008) and there is very scarce evidence about how to evaluate risk management effectiveness at project and portfolio levels.

3. Methodology

Based on real project data collected from a project risk register portal of a large Project Portfolio of Comau SpA,

a leading project-based company working in the automation industry, this study defines, validates and tests some Risk Management Key Performance Indicators (KPIs) to quantitatively evaluate: (1) the value created by Project Risk Management on managing individual projects, and (2) the value created by the application of project Risk Management on the portfolio's results. Results in this context might be referred to profitability, predictability of projects/portfolios outcomes, and customer satisfaction.

The process is as follows. First risk data are collected from the case company Risk Management log system. Then, KPIs are defined. Finally, the KPIs are validated via expert interviews and case study applications at both the project and portfolio levels (Sanchez et al., 2010).

Risk data used for the analysis are collected from 208 projects over a one-year period starting late 2015. Both threats and opportunities are taken into consideration.

This process of collecting risk data during this work is split into four main activities: (1) creating a list of projects with an active risk register, (2) collecting information for these projects, (3) gathering all project risk registers, (4) aggregating all data into a single spreadsheet.

4. Key Performance Indicators

The Risk Management KPIs are defined according to three key aspects: (1) category of analyzed risks (threat or opportunity), (2) status of analyzed risks (close or open), (3) KPI type (current or forecast). The defined KPIs are summarized in Table 1 and given a short definition below. The acronyms used to define the KPIs are explained in the Appendix.

The Response Effectiveness for Threats (RE_{Thr}) indicator aims at providing an estimation of the extent to which the implemented risk response strategy has been effective to respond against threats. This indicator is expressed as the ratio of the sum of the monetary impacts of closed not realized threats over the sum of both closed realized and closed not realized threats. Here, a threat is intended as realized if it cannot be considered any longer a risk, but an issue. A threat is not realized due to the success of the response implemented or for other reasons out of control of the risk owner. The greater the RE_{Thr}, the more the chosen response strategies have brought the good results expected at the time these were planned.

The Response Effectiveness for Opportunities (RE_{Opp}) indicator provides an estimation of how much the response strategies implemented have been effective to seize opportunities. This indicator is the ratio of the sum of current monetary impacts of opportunities closed realized to the sum of both opportunities closed realized and closed not realized. An opportunity is realized if it cannot be considered any longer a risk, but a materialized event. An opportunity is not realized due to the failure of the implemented response or for other reasons not depending from the project. This KPI brings together the positive events (materialized opportunities) with the negative ones (not materialized opportunities) and it may vary from 0 to 1; the greater is RE_{Opp} the more the chosen response strategies have brought the good results expected at the time they were planned.

Table 1: KPIs defined

Key Performance Indicator	Acronym	Formula
Threats Response Strategy Effectiveness	RE_{Thr}	$\frac{MI_{TCNR}}{MI_{TCNR} + MI_{TCR}}$
Opportunities Response Strategy Effectiveness	RE_{Opp}	$\frac{MI_{OCR}}{MI_{OCR} + MI_{OCNR}}$
Combined Response Strategy Effectiveness	RE_C	$\frac{MI_{TCNR} + MI_{OCR}}{MI_{TCNR} + MI_{TCR} + MI_{OCR} + MI_{OCNR}}$
Threats Mitigation Effectiveness	ME_{Thr}	$\frac{MI_{TCR}(0) - MI_{TCR}(T)}{MI_{TCR}(0)}$
Threats Response Strategy Effectiveness Extended	RE_{Thr} Ext.	$\frac{MI_{TCNR} + (MI_{TCR}(0) - MI_{TCR}(T))}{MI_{TCNR} + MI_{TCR}(0)}$
Expected Risks Impact on Consolidated Margin at Project Completion	EMV_C	$\frac{EMV_{Opp} - EMV_{Thr}}{Rev \times CM_{\%}}$

The Response Effectiveness Combined (RE_C) indicator considers both threats and opportunities together. This indicator estimates the extent to which the response strategies implemented have been effective against threats and to take opportunities. This KPI integrates two positive events (not realized threats and realized opportunities) with total closed risks. Similar to previous KPIs, the greater is RE_C the more the implemented response strategies have led to good results in the overall risk management process (combining threats and opportunities management).

The Mitigation Effectiveness for Threats (ME_{Thr}) indicator gives an estimation of how much the mitigation actions are effective to reduce the impact of possible threats on the project objectives.

This indicator considers only those threats with a mitigation response strategy and no other risk response strategy (avoidance, transference, acceptance) is taken into account.

The $MI_{TCR}(0)$ is the monetary estimation of the impact of risk that precedes the definition of the response strategy. Instead, the final estimation of the risk monetary impact at the time when it is closed is the $MI_{TCR}(T)$, which generally includes two factors: (1) cost incurred to mitigate the risk and (2) the residual risk monetary impact.

The difference between the initial estimation of the risk monetary impact (t=0) and the final estimation of the risk monetary impact (t=T) is named as ΔMitigation.

It is important to remark that ΔMitigation could be both positive and negative. If ΔMitigation >0, it shows a global positive result from the risk response actions implemented, meanwhile less than 0 corresponds to two different possible causes: (1) the risk response action did not generated the expected results and/or (2) the response strategy of mitigation has been affected by external events.

The greater is ΔMitigation the more effective have been the actions of mitigation. In other words the greater is the difference between $MI_{TCR}(0)$ and $MI_{TCR}(T)$ more the PM Team has succeeded to reduce the threats impact even if the threat was finally realized.

The *Extended* RE_{Thr} proposes the integration of the RE_{Thr} indicator with the ME_{Thr} indicator. This indicator tells whether the implemented response strategies have been effective against threats.

It consists of three terms: the sum of the monetary impacts of threats closed not realized; the sum of the monetary impacts of threats closed realized at the beginning of the project minus the current monetary impacts of threats closed realized at the time these are closed. These latter term only includes those threats that have been assigned by the PM with a response strategy of mitigation, excluding therefore all those threats classified with a response strategy of avoidance, transference or acceptance. The peculiarity of this indicator is combining RE_{thr}, which measures the ability of closing threats as not realized, and ME_{thr}, which takes into account for the reduced impact value of the threats from the time these have been identified to the time these occurred.

The Expected Monetary Value Combined (*EMV*$_C$) indicator, which considers both threats and opportunities, provides a forecast of how much open risks could impact on project profit. Differently from the other KPIs analyzed, EMV_C handles open risks (both threats and opportunities), considering their Expected Monetary Value and not their current Monetary Impact. With a positive indicator the project margin could increase from now to the end of the project; a negative indicator means that a portion of project margin could be eroded. EMV_C is a valuable contribution to estimating project cost at completion and the future impacts of project risk on final cost. However, a negative value of the EMVc KPI alerts on the need to further strengthen risk responses to reverse the portfolio profit erosion forecast.

The risk response effectiveness indicators defined in here measure the ability to identify project risks (known unknowns). The extent to which unknown risks (unknown unknowns) may also impact on the project outcome and value generation is measured by comparing the monetary values of the threats and opportunities realized with the margin variance. If margin variances are higher that the value of risks realized, this means that risk is poorly managed.

5. Application

The proposed indicators for a portfolio of 63 projects, are computed and listed in Table 2. The 63 projects, randomly picked from a complete dataset of projects carried out by the case company, are all EPC contracts for the turn-key provision of industrial automation systems. They all have similar characteristics, number of stakeholders and project risk profile. The results are representatives of an average, balanced project portfolio.

To protect confidential information of the case company, all data reported have been modified via an unknown constant factor.

The portfolio proves effective in risk mitigation. In fact the overall ΔMitigation is positive, which indicates, on average, the effectiveness of risk response actions taken by Project Managers. However, the EMV_C is negative, which indicates a likely reduction of estimated profit.

The RE_{Thr} indicator, which estimates the extent to which the risk response strategy has been effective to resolve threats, is close to 72% and can be used by Portfolio Managers as a tool to set profit targets. In fact, if the effectiveness to close threats is improved, profit margin is increased. This means that if RE_{Thr} would be set to reach a higher target, the relative margin would raise. And this would be even greater if RE_{Opp} target is also increased. Similarly, a higher level for the combined RE_C would result in a greater margin relative to revenues.

Table 2: Project Portfolios Overview

Nr Projects	63
Avg. Completion	65%
Tot Revenues	628,760
Tot Current Margin	69,574
Tot Current % Margin/Revenues	11.07%
MI tcnr	11,422
MI tcr	4,477
Miocr	4,518
Miocnr	2,097
EMVthr	5,391
EMVopps	1,248
Delta EMV	-4,143
MItcr(0)	5,921
Mitcr(t)	4,351
Delta mitig	1,570
Re thr	71.8%
Reopp	68.3%
Rec	70.8%
Methr	26.5%
Re thr EXT	74.9%
EMVc	-6.0%
Expected % margin at completion	10.4%

To better show the validity of the identified set of indicators, the projects are also assigned to two different subportfolios by whether projects have a Percentage of Completion (POC) less or greater than 65%, which is the average weighed POC for the overall portfolio of 63 projects. This value is picked as a threshold to form two sub-portfolios in order to better validate the KPI model by testing the intuition that late risk identification and consequent counteractions may be a cause of lower percentage of success and to provide for the evidence that more recent projects, that have been started after training and sensitizing Project Managers and Senior Managers on the need for increased Risk Management practices, are reaching greater success realization.

Table 3 shows the two project sub-portfolios characteristics and Table 4 reports the calculated KPIs for the two portfolios.

All data provided are modified from the original real values to keep confidentiality according to non disclosure agreement with the case company Comau SpA.

Table 3: Project Portfolios Overview

Value	Old Portfolio	New Portfolio
Number of projects	35	28
Average % of Completion	89,24%	32,34%
Aggregated Revenues (K/EUR)	359.875	268.885
Total Current Margin (K/EUR)	35.021	34.553
Average Current Margin (%)	9,73%	12,85%

Table 4: KPIs Application to Project Portfolios

KPI	Old Portfolio	New Portfolio
RE_{Thr}	0,697	0,793
RE_{Opp}	0,681	0,687
RE_{C}	0,693	0,75
ME_{Thr}	0,294	0,051
RE_{Thr} Ext.	0,733	0,812
EMV_{C}	-4,18%	-7,75%

The proposed KPIs could be affected by two main factors: the POC of individual projects and number of identified risks. Figure 1 reports the value of each proposed KPI for the two portfolios.

From the analysis of results, it can be noted that both portfolios have rather similar KPIs except two indicators, namely: ME_{Thr} and EMV_{C}.

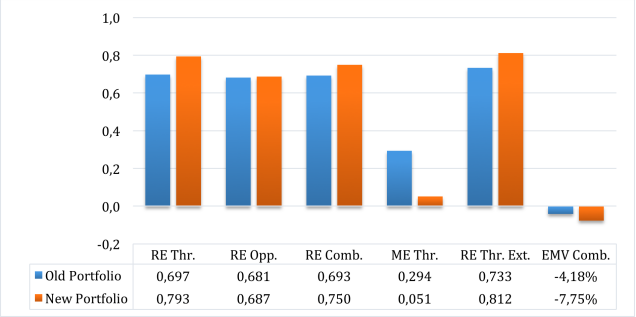

Figure 1: KPIs Application at the Portfolio Level

The Old Portfolio proves a greater ME_{Thr} indicator: this may be due to a greater number of closed threats. However, the New Portfolio has few mitigated threats due to the lower POC of its projects (32,34%) than the Old Portfolio.

As per the EMV_{C} indicator, this may be justified by a greater number of open risks in the *New Portfolio*, which provides for a more complete result rather than in the *Old Portfolio* where there are more closed risks.

6. Conclusions

Effective management of project and portfolio risks plays a pivotal role in creating value. To this end, this study proposes a set of Risk Management KPIs to evaluate the performance of Risk Management processes within a project-based organization. The set of KPIs for a portfolio of projects is defined and applied to real data from a case company of the automation industry. In particular, KPIs have been determined for a portfolio of 63 projects to develop automation plants for the automotive industry.

The KPIs framework has been validated by a panel of industry experts.

The application of the proposed KPIs set could lead to several benefits for the organization: increase the risk management culture, improving the risk management process, and create a risk knowledge base.

The set of KPIs could also be used to set performance targets at the portfolio level. Increasing the effectiveness of risk mitigation actions would lead to a greater portfolio profit and facilitate both Project Managers and Portfolio Managers to accurately identify and proactively prevent threats and pursue opportunities.

Results obtained by the present study encourage future research in the definition of appropriate thresholds for the KPIs in "performance areas" (i.e. healthy zone, alarm zone, failure zone) and definition of a methodology to integrate predictive KPIs such as the EMV_{C} into available cost and time estimate at completion methodologies (De Marco et al., 2017).

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Appendix. Risk Management KPIs Acronyms

Value	Acronym
Sum of the Monetary Impacts of Threats *Closed Not Realized*	MI_{TCNR}
Sum of the Current Monetary Impacts of Threats *Closed Realized*	MI_{TCR}
Sum of the Monetary Impacts of Opportunities *Closed Not Realized*	MI_{OCNR}
Sum of the Current Monetary Impacts of Opportunities *Closed Realized*	MI_{OCR}
Sum of the Monetary Impacts of Threats *Closed Realized* at t=0 (response strategy: *mitigation*)	MI_{TCR} (0)
Sum of the Current Monetary Impacts of Threats *Closed Realized* at t=T (response strategy: *mitigation*)	MI_{TCR} (T)
Delta Mitigation	$\Delta\ Mitigation$
Sum of the EMVs of *Open Threats*	EMV_{Thr}
Sum of the EMVs of *Open Opportunities*	EMV_{Opp}
Delta EMV	$\Delta\ EMV$
Project Revenues	Rev
Current Margin %	$CM_{\%}$
Current Margin	CM