Available online at www.sciencedirect.com
ScienceDirect
International Journal of Project Management 34 (2016) 1460 – 1470
International Journal of Project Management
www.elsevier.com/locate/ijproman

The downside risk of project portfolios: The impact of capital investment projects and the value of project efficiency and project risk management programmes

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Received 25 September 2015; received in revised form 18 May 2016; accepted 21 July 2016

Abstract

This article deals with the economic conditions required from a candidate capital investment project for its admittance within a firm's project portfolio. A stationary stochastic model is used to assess a project's $\tilde{NPV}$ and its impact on a firm's expected profitability and down-side operational risk when measured by its probability of loss and conditional expected loss. In order to lower the firm's operational risk the PMO can devise, assess and implement project efficiency management (PEM) and project risk management programmes (PRM) during the PM phase of the candidate capital investment project; their economic value determines their maximum admissible implementation budgets. When the correlation coefficient between the economic activities of the candidate project and the firm takes a negative value exceeding a threshold value, its addition to the firm's project portfolio will reduce the firm's operational risk while rendering counter-productive the implementation of any effective PRM programme.[1]

Keywords: Project risk; Project operational risk; Down-side risk; Probability of loss; Conditional expected loss; Uncorrelated and cross-correlated projects; Project efficiency management programme; Project risk management programme

1. Introduction

Literature in the field of project management has progressively evolved from single project management (PM) to project portfolio management (PPM) as various authors (Archer and Ghasemzadeh, 1999; Kester et al., 2011; Olsson, 2008; Martinsuo et al., 2014) have held forth the proposition that the single project risks must be incorporated within the PPM process in order to give project managers an overview of the most critical and important portfolio risks (Teller, 2013; Teller and Kock, 2013; Teller et al., 2014). It is argued that such an overview enables project managers to develop relevant project management responses and sufficient planning time and resources to ensure project portfolio success. A further advancement in the management of projects occurred more recently, mainly in large organisations, as a top-down approach was proposed in order to better plan, manage and coordinate all project-intensive work and resources across the enterprise. Enterprise project portfolio management (EPPM) was therefore introduced as a mean of ensuring the alignment of project portfolios to the firm's strategic objectives (Meskendahl, 2010; Rajegopal et al., 2007; Sanwal, 2007), thus further increasing the importance of a top-down management process. Hence, project management processes have gradually migrated from logistical and operational issues to tactical and finally to strategic concerns as the coordination of PM teams was moved up from a Project Management Office (PMO) and hierarchically attached to the Enterprise Project Management Office (EPMO). Such a move occurred as a result of organisations growing in size and spreading geographically. The centralisation of the enterprise's project management overview and control process has allowed the

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[1] The authors thank the reviewers for their pertinent and most helpful comments.

http://dx.doi.org/10.1016/j.ijproman.2016.07.009
0263-7863/00/

implementation of a global and interdependent top-down approach to project management.

The economic evaluation of capital investment projects has followed a similar top-down process. The initial approach to project financial evaluation focused on the probabilistic features such as the expected profitability and operational risk of a single capital investment project. Later on, the scope of project economic evaluation was brought up to that of a firm and its portfolio of projects. In fact, what one could find in many textbooks (Bierman and Smidt, 1988; Bussey and Eschenback, 1992; Copeland and Weston, 1988; Levy and Sarnat, 1994; Shapiro, 2005) and articles (Shapiro and Titman, 1985; Stulz, 1999) on capital budgeting were recommendations pertaining to the critical importance of assessing the impact of single projects on the parent firm's expanded project portfolio. However, no specific rules or assessment methodology were ever proposed or even suggested for actually carrying out such a complex undertaking. It will be the very objective of this article to show the complexity of such an endeavour and to provide closed-form solutions to assess the financial impacts of real-world capital investment decisions. Furthermore, one must recognise the fact that such financial assessments simply cannot be turned over to field project managers for the obvious reason that it is at the highest echelons of the firm, either the PMO or EPMO, that all the relevant statistical and financial information concerning the firm and the candidate project are to be gathered, revised, aggregated and organised in order to make them readily available for strategic and financial analyses. Finally, one must recognise the fact that all strategic and capital budgeting decisions need to be ascertained through a standardised administrative process and a unique evaluation methodology. Obviously, this can only be achieved at the PMO.

Before engaging ourselves in such an endeavour, we need to clarify three issues that have generally obscured the relationship linking a single project's operational risk to that of a parent firm's project portfolio. Indeed, risk analysis techniques dealing with single capital investment projects have, to a certain extent, largely been misleading by limiting the scope of operational risk analysis to that of single capital investment projects as if they were stand-alone projects (Hertz, 1964; Hillier, 1963; Wagle, 1967). However, capital investment projects are rarely stand-alone undertakings as they are usually part of a portfolio of projects that make up the firm. Assessing the operational risk of a single project, although a necessary first step, is not sufficient from a firm's standpoint. Naturally, the project manager will most certainly be concerned with the single project's specific risk given that it is the only type of project risk for which he is responsible and that he can actually control through various risk management strategies such as risk avoidance, risk transfer, risk mitigation and risk acceptance decisions. However, notwithstanding the project's specific risk, it will be the total risk that will ultimately impact on the project's operational risk and that of the parent firm's expanded project portfolio. In reality, top management will be concerned by the project's impact on the firm's total operational risk as it may increase the firm's likelihood of financial distress and its probability of bankruptcy (Shapiro and Titman, 1985; Shapiro, 2005).

Secondly, some financial analysts allege that project risk management is a waste of time and money on the grounds that efficient investors will already have diversified away any of a project's specific risk. Such a rationale indicates a misinterpretation of the nature of what actually is a specific risk. The CAPM shows that rational investors will require a risk premium on securities' non-diversifiable risk as they can eliminate any of their own portfolio's specific risk through efficient portfolio diversification. However, one must understand that an investor's specific risk is not a project manager's specific risk so that removing the specific risk of a security portfolio does not remove that of a project nor, for that matter, that of a firm's project portfolio. Project managers will be as much interested and as rational as security investors when striving to reduce their own specific risk through various project risk management and risk diversification strategies (Paquin et al., 2015b).

The third issue concerns the selection of an adequate risk measure. Security portfolio and project portfolio management differ one from another in a fundamental way. Security portfolio managers seek to minimise their portfolio's specific risk by fractionally allocating a fixed total sum of money among a set of investment opportunities (Samuelson, 1963). The fractional approach differs from the additive approach adopted by project portfolio managers as indivisible projects are wholly and quasi-irrevocably added to a portfolio of projects. As Ross (1999) wrote: "*when an insurance company or a 'swaps shop' opens its doors, it attracts n independent risks; it does not cut up some larger existing risk.*" (p. 332). The difference between a fractional and an additive approach to risk management brings forward the issue of choosing in both contexts an appropriate measure of risk. Historically, the fractional approach has measured risk by the variance of the security portfolio's rate of return; this implies that the greater will be the number of assets within a portfolio, the lower will be the volatility of the portfolio's rate of return, hence its risk, as the law of large numbers applies, according to Samuelson (1963), to averages and not to sums. Hence, diversification strategies concerning security portfolios are to be considered effective only when they reduce the variance of the portfolio's rate of return which then becomes the recommended measure of risk. However, unless the random cash flows of different projects are negatively cross-correlated while complying to certain conditions (Samuelson, 1967), the addition of any project to a firm's project portfolio will inevitably increase the variance of its $N\tilde{P}V$ probability distribution so that no risk reduction can ever be expected.

Moreover, when the project's operational risk is measured by its $N\tilde{P}V$ variance, its upside opportunity and downside risk are considered as equally undesirable. Considering that decision makers are generally risk-averse when facing monetary consequences, they should actually be significantly more sensitive to the chance of a dread event such as the likelihood of financial disaster than to an improvement of the firm's profits (Roy, 1952). Such considerations would imply that the downside financial risk of indivisible and quasi-irrevocable capital investment projects should generate greater concerns to top management than would up-side financial opportunities. Hence, the indivisible and quasi-irrevocable capital investment decision entails that the assessment of project portfolios' operational risk should be tied to down-side risk metrics.[2]

This paper is organised as follows: In Sections 1 and 2, we describe the methodology and probabilistic model used in deriving our main results. In Section 3, we develop the closed-form solution of the Conditional Expected Loss (*CEL*) metric as a measure of the magnitude of any economic down-side operational risk. In Section 4, we derive from the *CEL* metric a simple rule for assessing the impact of project efficiency management (PEM) and project risk management (PRM) programmes for both the candidate project and the parent firm's expanded project portfolio. This will enable us to determining the value and the maximum admissible budget for implementing individually or both the PEM and PRM programmes. In Section 5, we provide a numerical application illustrating how to apply the proposed methodology in a real-life setting and how they can effectively be used to decide on the maximum admissible budgets for the implementation of PEM and PRM programmes. We will also be dealing with the case of a highly negative project-firm cross-correlation exceeding its critical threshold value and making some suggestions as to the strategic implications of PRM programmes under such a critical condition.

2. Methodology and basic model assumptions

Our methodology rests on the development of a probabilistic $N\tilde{P}V$ model aimed at exploring the extent to which a firm can increase its profitability and reduce its operational risk by adding a candidate capital investment project to its current project portfolio, and further improving its economic performance by implementing PEM and PRM programmes during the candidate project's PM phase. Such a phase includes the project design, planning and execution phases also referred to as the candidate project capital investment phase. Our analysis will enable PMO financial analysts to assess the maximum budget that can be allocated to such capital investment cost-cutting PEM and cost-control PRM programmes.

The proposed $N\tilde{P}V$ model complies with a set of four basic assumptions. Firstly, we assume that both the project and the firm's net operating cash flows obey a stationary in mean and variance stochastic process. Stationarity in mean implies that both the firm and the project are operating at a constant level that cannot be augmented without an increase in their respective production capacity, and therefore by further investing in their capital stock. Secondly, we assume that the firm's and the project's net operating cash flows probability distributions describe their respective total risk, that is, the sum of their respective systematic and specific risk. Thirdly, we assume that all cash inflows and outflows of any given capital investment project are discounted at a common systematic risk-determined cost of capital, whether their values are known with certainty or are subjected to random shocks. This assumption is justified by virtue of the fact that there exists a fundamental difference between managing security portfolios and managing project portfolios as exposed above.[3] As a last assumption, we consider that the parent firm and the candidate project's $N\tilde{P}V$ total risk probability distributions are Normal. Such an assumption, derived from the Central-Limit Theorem, holds for most capital investment projects as long as the cost of capital does not exceed 30% (Paquin et al., 2006).

3. Expected profitability and operational risk of a project

3.1. Defining project risk

The definition of risk generally pertains to uncertain events with undesirable consequences. The Project Management Institute (PMI) (Project Management Institute, 2008) defines project risk by the following: *"Project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objective"* (p. 9). This definition puts on an equal footing down-side and up-side project risks for it assimilates risk to uncertain events that may either contribute positively or negatively to the attainment of a project's goals. Hence, any deviations from the candidate project's time, cost, or quality goals will be considered as a project risk. To implement its definition, the PMI proposes (Project Management Institute, 2009) a probability and impact matrix combining, on the one hand, the probability of occurrence of uncertain events and, on the other hand, an ordinal and symmetrically scaled impact metric that indicates the magnitude of the various project opportunities and threats. As a consequence, the higher the expected volatility of a project's uncertain situation, the higher will be the project risk. Such an understanding of project risk ties on to the managerial concept of project control given that volatile situations will be indicative of managerially uncontrolled and/or uncontrollable situations. This is where risk management comes into play with policies and tactics aimed at bringing under control a potentially volatile situation that might jeopardise the success of a project.[4]

The concept of project risk, as defined by the PMI, naturally adopts the project managers' point of view for it is applied during the project's PM phase, that is, as the design, planning and execution activities of a project are being carried out. In contrast, the operations or business phase will only start once the project's end-product will have been delivered and handed over to the

[2] Downside risk measures have been introduced in the every-day practice of security portfolio managers as they have adopted the concepts of Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) to assess the total risk of the security portfolios under their responsibility (Dowd, 2005; Hull, 2010; Jorion, 2006; Landsman and Valdez, 2003).

[3] As each security or homogeneous aggregate of securities are assigned their own beta-determined cost of capital, so does any non-divisible capital investment project for it possesses its own unique beta-determined cost of capital. It follows that any project's cash flows components, whether randomly generated or not, must be treated as an integral part of the project given that all components jointly contribute to the determination of the project's $N\tilde{P}V$ probability distribution.

[4] Considering that volatile and uncertain situations need to be brought under control, Ward and Chapman (2003) have proposed to change the name and emphasis of risk management to that of uncertainty management.

project client. In this article the concept of project risk will apply to the cost components of the PM phase which will limit the analysis to the capital investment phase of a project. Hence, we will measure project risk by its investment cost expected volatility or standard deviation $\sigma(\tilde{I}_R)$. We shall therefore identify as PRM activities all decisions, actions, and programmes that will be initiated and carried out with the intention of reducing the project's investment costs volatility or standard deviation $\sigma(\tilde{I}_R)$. By the same token, we shall identify as PEM activities all decisions, actions, and programmes that will be initiated and carried out with the intention of reducing the project's expected investment costs $E(\tilde{I}_R)$.

3.2. Defining project operational risk

While project risk deals with time, cost and quality variances during the PM phase of a project, project operational risk deals with the economic consequences over the total life of a capital investment project, which covers both of its capital investment and business phases. It is generally assumed in economics that investors are risk-averse; hence, they will, dollar for dollar, always weigh the expected loss of a project more heavily than its expected gain (Roy, 1952). Hence, to be relevant to top management, any project operational risk measure must reflect a project's life-long down-side economic risk.

The concept of project operational risk, as adopted in this article, is defined by two complementary down-side risk measures, one dealing with the likelihood of occurrence of an operational risk, the other one assessing the exposure or economic magnitude of a potential operational risk. To determine the likelihood that a project could be unprofitable we define the probability of loss (PL) as the probability that its random $N\tilde{P}V$ (noted $\tilde{P}$) may become negative:

$$PL = \Pr(\tilde{P} \le 0) = \int_{-\infty}^{0} f(P)\ dP$$

As shown in Paquin et al. (2006) and by virtue of the Central Limit Theorem that the $N\tilde{P}V$ probability distribution of a capital investment project will converge towards a Normal distribution, *i.e.* $\tilde{P} \sim \mathrm{N}(\mu_P; \sigma_P)$ provided the cost of capital does not exceed the 30% mark. Hence, we may assume for most cases that the $N\tilde{P}V$ probability distribution $f_N(P)$ will be normal with an expected value of $E(\tilde{P})$ and a finite standard deviation of $\sigma(\tilde{P})$. The probability of loss of most capital investment projects will then be given by:

$$PL = \Pr(\tilde{Z}_N \le -E(\tilde{P})/\sigma(\tilde{P}) = F_N(-E(\tilde{P})/\sigma(\tilde{P})) \qquad (1)$$

Where $\tilde{Z}_N$ is the $N(0,1)$ standardised random variable and $F_N(-E(\tilde{P})/\sigma(\tilde{P}))$ the cumulative distribution of the probability density of $f_N(\mu_P, \sigma_P)$. This definition of project operational risk corresponds to Roy's (1952) definition of a capital investment project down-side risk. However, when managers are concerned with the exposure or magnitude of a potential loss, one must assess the project's conditional expected loss (CEL) defined by:

$$CEL = \int_{-\infty}^{0} P\ f(P)\ dP$$

Still retaining the assumption that the $N\tilde{P}V$ probability distribution $f_N(P)$ is normal, it can be shown that the closed-form solution of a project CEL is the following:

$$CEL = E(\tilde{P})\,PL + \frac{\sigma(\tilde{P})}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{E(\tilde{P})}{\sigma(\tilde{P})}\right)^2\right) \qquad (2)$$

Eq. (2) shows that the project CEL explicitly depends only on two parameters, $E(\tilde{P})$ and $\sigma(\tilde{P})$, as does the project PL. From Eqs. (1) and (2) one may affirm that project efficiency management (PEM) and project risk management (PRM) programmes will exert mutually independent impacts on the project PL and CEL.

As the PEM programme will improve the project's efficiency (Sundqvist et al., 2014) through a reduction of the project's expected investment cost $E(\tilde{I})$, it will thus increase the project's expected $N\tilde{P}V$ thereby improving the project's profitability and lowering its operational risk. The PRM programme will, on the other hand, exert its influence only on the project's operational risk while leaving its expected profitability unaffected for it will be channelling its effects through a lowering of the project's expected volatility or project risk $\sigma(\tilde{I})$, thus reducing the project's $N\tilde{P}V$ expected volatility $\sigma(\tilde{P})$. Any PEM or PRM programme that will reduce the project's CEL will generate a corresponding cost saving or economic benefit by reducing the project's expected opportunity cost. The reduction of a project's CEL following the implementation of PEM and/or PRM programmes may therefore be directly used to assess the maximum admissible budget for implement either one or both of these cost-cutting PEM and cost-control PRM programmes.

Having proposed the PL and the CEL as project down-side risk metrics, one may inquire about the desirable properties they should possess in order to justify their use. The answer can be found in the theory of coherent risk measure developed by Artzner et al. (1999) which rests on four basic properties.[5] One of these is the sub-additivity property which concerns portfolio risk diversification and which states that portfolio diversification will actually take place if and only if the risk resulting from the combination of two risky projects A and B is equal or less than the sum of their individual risk when considered on their own. This condition implies that a coherent risk measure $\mathfrak{R}(\cdot)$ should comply with the following sub-additivity property, namely that:

$$\mathfrak{R}(A+B) \le \mathfrak{R}(A) + \mathfrak{R}(B)$$

Artzner et al. (1999) have shown that the Conditional Value-at-Risk or $CVaR$ risk measure is a coherent risk measure whatever might be A or B's probability distributions. The CEL being mathematically equivalent to the $CVaR$, it may therefore

[5] These properties are sub-additivity, homogeneity, monotonicity and risk-free condition (Artzner et al., 1999; Dowd, 2005).

be viewed as a coherent risk measure for whatever $N\tilde{P}V$ probability distribution. On the other hand, it can be shown (Dowd, 2005) that the Value-at-Risk or *VaR* risk measure is not a coherent risk measure under all probability distributions unless it is elliptical or normal (Dowd, 2005; Jorion, 2006; Landsman and Valdez, 2003). The *PL* risk measure being mathematically akin to the *VaR* risk measure, this means that it may not be considered as a coherent risk measure under any probability distribution unless it is also elliptical or normal as we have actually postulated for the project $N\tilde{P}V$ probability distribution. Hence, we may affirm that both project *PL* and *CEL* risk measures are coherent risk measures.

3.3. A project NPV probabilistic model

Our analysis utilises a basic $N\tilde{P}V$ model for which the net operating cash flows $\tilde{X}_{R,t}$ and the investment costs $\tilde{I}_R$ of project R are randomly distributed and mutually independent in probability. The proposed basic $N\tilde{P}V$ probabilistic model takes on the following form:

$$\tilde{P}_R = \sum_{t=1}^{n} \tilde{X}_{R,t}(1+k_c)^{-t} - \alpha\ \tilde{I}_R \tag{3}$$

The net operating cash flows and the investment costs are specific to the project and thus are discounted by the project's required rate of return as given by its marginal cost of capital k_c. To determine the random present value of investment costs we assumed that the market salvage value of the asset $\tilde{S}_{R,n}$ was obtained from a constant year-to-year market depreciation rate δ such that $\tilde{S}_{R,n} = \tilde{I}_{R,0}(1-\delta)^n$: Hence, discounting this salvage value one obtains as the present value of investment costs $a\ \tilde{I}_{R,0}$ with $\alpha = 1-\left(\frac{1-\delta}{1+k_c}\right)^n$ and $0<\alpha<1$.

We assume that the probability distribution of the random net operating cash flows $\tilde{X}_{R,t}$ reflects the project's total risk and that the current and future net operating cash flows are depicted by the following discreet stationary in mean and variance stochastic process[6]:

$$\tilde{X}_{R,t} = \mu_{X_R} + \tilde{\varepsilon}_{R,t} \quad ; \ t = 1.2,\ldots,n \tag{4}$$

$$\text{with:} \quad E(\tilde{X}_{R,t}) = \mu_{X_R} \quad \text{given that:} \ E(\tilde{\varepsilon}_{R,t}) = 0 \quad ; \ t = 1.2,\ldots,n \tag{5}$$

$$\text{and:} \quad V(\tilde{X}_{R,t}) = V(\tilde{\varepsilon}_R) = \sigma^2(\tilde{\varepsilon}_R) \ \text{(constant and finite)} \ ; \ t = 1.2,\ldots,n \tag{6}$$

with $\tilde{\varepsilon}_{R,t}$ representing the random shocks or white noise. Under such assumptions one obtains the project's $N\tilde{P}V$ expected value and variance:

$$E(\tilde{P}_R) = E(\tilde{X}_R)\ a_{n\neg k_c} - \alpha\ E(\tilde{I}_R) \tag{7}$$

$$V(\tilde{P}_R) = V(\tilde{X}_R)\ a_{n\neg k_c^*} - \alpha^2\ V(\tilde{I}_R) \tag{8}$$

with $a_{n\neg k_c}$ a constant \$1 end-of-year annuity factor[7] and $k_c^* = (1+k_c)^2 - 1$.

4. Implementing PEM and PRM programmes during the PM phase of project R

A reduction in project R's PL_R and CEL_R can be obtained by a reduction in the project's $N\tilde{P}V$ expected investment cost $E(\tilde{I}_R)$ following the implementation of a PEM programme which will result in an increase in the project's expected profitability $E(\tilde{P}_R)$. As an alternative or complementary managerial process, one might consider implementing a PRM programme whose main objective is to reduce project R's risk or expected investment cost volatility $\sigma(\tilde{I}_R)$ and thereby decrease the project's $N\tilde{P}V$ standard deviation $\sigma(\tilde{P}_R)$.

We shall therefore focus our analysis on the PM phase of project R as project managers aim at successfully implementing PEM and PRM programmes. However, it should appear quite obvious to the PMO project managers that setting the PEM objectives should preceed those of the PRM programme given that the PRM programme should aim at bringing under control and stabilising the investment costs around the expected investment cost goals set earlier by the PEM programme.

4.1. The impact of PEM and PRM programmes on the project's CEL

Project R's CEL_R is given by the following equation:

$$CEL_R = E(\tilde{P}_R)\ PL_R + \frac{\sigma(\tilde{P}_R)}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{E(\tilde{P}_R)}{\sigma(\tilde{P}_R)}\right)^2\right) \tag{9}$$

with $PL_R = F_N\left(-E(\tilde{P}_R)/\sigma(\tilde{P}_R)\right)$

To evaluate the impact of PEM and PRM programmes on the project's CEL_R one must first assess their capacity in lowering the candidate project's expected investment cost $E(\tilde{I}_R)$ and on bringing down the project's expected volatility $\sigma(\tilde{I}_R)$. It will be the responsibility of the PMO project managers to provide accurate estimates about $\Delta E(\tilde{I}_R)$, the impact of the PEM cost-cutting programme, and about $\Delta\sigma(\tilde{I}_R)$, the impact of the PRM cost-control programme. The PMO financial analysts can then directly calculate

[6] We assume that the net operating cash flows are serially uncorrelated with a constant variance (homoscedastic variance). Had we assumed the more general case of serially correlated cash flows throughout time with a heteroscedastic variance, this would had led to an increased $N\tilde{P}V$ variance and consequently to an increase in the project's operational risk (Paquin et al., 2015a).

[7] Mathematically $a_{n\neg k_c} = \sum_{t=1}^{n}(1+k_c)^{-t} = [1-(1+k_c)^{-n}]/k_c$, a constant written with the actuarial notation and standing for the present value of a \$1 end-of-year annuity discounted at the cost of capital k_c over n years.

from Eqs. (7)–(9) the impact of such programmes on the project's CEL_R, that is ΔCEL_R, as the result of a decrease in either the project's expected investment cost $\Delta E(\tilde{I}_R)$, and either as a result of a reduction in the expanded firm's expected investment cost volatility$\Delta\sigma(\tilde{I}_R)$.

4.2. The impact of PEM and PRM programmes on the firm's CEL

Normative economics will always uphold that the introduction of capital investment projects within a firm's project portfolio must be decided on the principle that any project must be admitted on the basis of its own economic contribution to the firm. A project must not be made attractive or subsidised by other profitable projects. The economic rationale of such a principle is to ensure that each project must prove on the basis of its own economic merits its worthiness to the firm. However, necessary conditions are not sufficient conditions so that, even though a project might be profitable on its own, it cannot be accepted and added to the project portfolio solely on a stand-alone basis. The main reasons why stand-alone conditions are insufficient stem from the fact that they do not take into account the interdependence and interaction between the candidate project and the parent firm's project portfolio. More specifically, stand-alone conditions do not and cannot fully account for the total impact of the candidate project on the expected volatility $V(\tilde{P}_{FR})$, hence, on neither the PL_{FR} nor the CEL_{FR} of the firm's resulting expanded project portfolio. To produce such information one needs to obtain financial and statistical information about the candidate project and the parent firm and, most importantly, information about their activities' cross-correlation.

We assume that the firm's random net operating cash flows $\tilde{X}_{F,t}$ probability distribution reflects the firm's total risk and obey a discreet stationary in mean and variance stochastic process such that:

$$\tilde{X}_{F,t} = \mu_{X_F} + \tilde{\varepsilon}_{F,t} \quad ; \quad t = 1.2\ldots, n \tag{10}$$

$$\text{with:} \quad E(\tilde{X}_{F,t}) = \mu_{X_F} \quad \text{given that} : E(\tilde{\varepsilon}_{F,t}) = 0 \quad ; \quad t = 1.2\ldots, n \tag{11}$$

$$\text{and:} \quad V(\tilde{X}_{F,t}) = V(\tilde{\varepsilon}_F) = \sigma^2(\tilde{\varepsilon}_F) \ \text{(constant and finite)} \ ; \ t = 1.2\ldots, n \tag{12}$$

with $\tilde{\varepsilon}_{F,t}$ representing the random shocks or white noise. We also assume that the firm's current and future net operating cash flows are stationary in mean and variance as well as serially uncorrelated. The firm's $N\tilde{P}V$ model basically has the same form and properties as that of the single capital investment project for which the net operating cash flows and investment costs are randomly distributed and mutually independent in probability. We assume that the firm's current investment costs are randomly distributed as a result of incompleted capital investment projects that are consequently subjected to random shocks. The firm's $N\tilde{P}V$ probabilistic model is written as follows[8]:

$$\tilde{P}_F = \sum_{t=1}^{n} \tilde{X}_{F,t}(1+k_c)^{-t} - \alpha \ \tilde{I}_F \tag{13}$$

$$\text{with :} \quad E(\tilde{P}_F) = E(\tilde{X}_F) \ \ a_{n}\neg_{k_c} - \ \alpha \quad E(\ \tilde{I}_F) \tag{14}$$

$$V(\tilde{P}_F) = V(\tilde{X}_F) \ \ a_{n}\neg_{k_c^*} + \ \alpha^2 \ \ V(\tilde{I}_F) \tag{15}$$

The profitability of candidate project R and parent firm F are respectively defined by their respective $N\tilde{P}V's$ expected value, $E(\tilde{P}_R)$ and $E(\tilde{P}_F)$ while their expected volatility is measured by their respective variance, $V(\tilde{P}_R)$ and $V(\tilde{P}_F)$. When the candidate project is added to the parent firm's project portfolio their combined $N\tilde{P}V_{FR}$ expected value and variance will be given by the following equations:

$$E(\tilde{P}_{FR}) = E(\tilde{P}_F + \tilde{P}_R) = E(\tilde{P}_F) + E(\tilde{P}_R) \tag{16}$$

$$V(\tilde{P}_{FR}) = V(\tilde{P}_F + \tilde{P}_R) = V(\tilde{P}_F) + V(\tilde{P}_R) + 2\rho \ \sigma(\tilde{P}_F) \ \sigma(\tilde{P}_R) \tag{17}$$

The interactive effects between project R and firm F are captured by their cross-correlation coefficient $\rho = \rho_{FR} = \rho_{FS} \times \rho_{SR}$ which reflects the statistical cross-dependency between the net operating cash flows' total risk of the firm and the project. Hence, although the parent firm and the candidate project could operate within a same industry their cross-correlation coefficient might still be negative provided that their respective specific risks are negatively cross-correlated and are more important than the sector's systematic risk. Whatever might be the sign of the cross-correlation coefficient, it will add complexity to the relationship linking the candidate project to its parent-firm. The CEL_{FR} of the parent firm and its candidate project will be given by:

$$CEL_{FR} = \ E(\tilde{P}_{FR}) PL_{FR} + \ \frac{\sigma(\tilde{P}_{FR})}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{E(\tilde{P}_{FR})}{\sigma(\tilde{P}_{FR})}\right)^2\right) \tag{18}$$

$$\text{with} \quad PL_{FR} = F_N\left(-E(\tilde{P}_{FR})/\sigma(\tilde{P}_{FR})\right)$$

To evaluate the impact of PEM and PRM programmes on the expanded firm's CEL_{FR} one must first assess their capacity

[8] We still assume that both the candidate project and parent firm are carrying out their business operations in the same industry; hence, both are to the same systematic risk and consequently assessed at the same cost of capital. The following analysis would not be modified in any fundamental way had the candidate project been carried out in a different industry than that of the parent firm. This would simply imply a different systematic risk, and therefore a different cost of capital.

Table 1
Financial variables.

Parent firm F		Candidate project R	
Random capital investment cost ($\tilde{I}_F$)	Random net operating cash flows ($\tilde{X}_{F,t}$)	Random capital investment cost ($\tilde{I}_R$)	Random net operating cash flows ($\tilde{X}_{R,t}$)
$E(\tilde{I}_F) = \$100.0$	$E(\tilde{X}_F) = \$10.5$	$E(\tilde{I}_R) = \$10.0$	$E(\tilde{X}_R) = \$1.0465$
$\sigma(\tilde{I}_F) = \$5.0$	$\sigma(\tilde{X}_F) = \$1.05$	$\sigma(\tilde{I}_R) = \$1.0$	$\sigma(\tilde{X}_R) = \$0.2093$
$(\times 10^6)$	$(\times 10^6)$	$(\times 10^6)$	$(\times 10^6)$

Financial parameters of parent firm F and candidate project R

Projects duration (years) (n)	Assets market depreciation rate (δ)	Correlation coefficient with industry activity ($\rho_{R,S}$)	Marginal cost of capital (k_c)
20 years	0.10	0.75	0.08

in lowering the candidate project's expected investment cost $E(\tilde{I}_R)$ and bringing down the project's expected volatility $\sigma(\tilde{I}_R)$. Again, it will have been the responsibility of the PMO project managers to provide accurate estimates about $\Delta E(\tilde{I}_R)$, the impact of the PEM cost-cutting programme on the candidate project, and about $\Delta\sigma(\tilde{I}_R)$, the impact of the PRM cost-control programme on the candidate project. The PMO financial analysts can consequently determine those project impacts on the expanded project portfolio and then directly calculate from Eq. (18) the impact of such programmes on the expanded firm's CEL_{FR} that is ΔCEL_{FR}, as the result of a decrease in the expanded firm's expected investment cost $\Delta E(\tilde{I}_{FR})$ and/or as a reduction in the expanded firm's expected investment cost volatility $\Delta\sigma(\tilde{I}_{FR})$.

5. A numerical application

The following numerical application will illustrate how the concepts and methodology developed in the preceding sections can actually be applied in a real-world setting. The analysis of the impacts produced by PEM and PRM programmes could be carried out mainly through the lens of the *CEL* risk measure. This choice would be motivated by the fact that it is essentially with economic information that top management can actually determine the financial exposure of the firm's expanded project portfolio as well as the value and the maximum admissible budgets for the implementation of both the PEM and PRM programmes. Nevertheless, we shall give the results in terms of the *PL* so as to provide additional information on the probability of occurrence of such an economic exposure.

5.1. The operational risk of candidate project R

The PMO financial analysts would normally begin the whole project evaluation process by estimating the expected profitability and operational risk of project R. This would enable them to decide if the project is financially acceptable on its own merits.[9] Such an evaluation would rest on the *NPV* methodology and would require information on a certain number of statistical and financial parameters. Table 1 summarises relevant information pertaining to candidate project R and parent firm F.[10]

The operational cash flows and investment costs of candidate project R were assumed to be, on average, twice as much volatile than those of parent firm F. This explains why the coefficient of variation $(\sigma(\cdot)/\mu(\cdot))$ of net operating cash-flows and investment costs of project R were respectively set at 20% and 10% while those of parent firm F were set at 10% and 5%.

Considering these statistical and financial data, the PMO financial analysts would arrive at a project R's expected profitability of $E(\tilde{P}_R) = \$0.53553 \times 10^6$ with an expected volatility of $\sigma(\tilde{P}_R) = \$1.09529 \times 10^6$. From these estimates the analysts would conclude from Eq. (9) that the project's probability of loss stands at PL_R=0.3125 and its conditional expected loss at CEL_R=\$0.5550×10^6, just over half a million dollars.

Let us assume that the PMO requires all capital investment projects to be subjected to PEM and PRM assessments in order to provide information on the potential improvement of all candidate capital investment projects. A complete review of the PM phase of Project R by the PMO project management team has come to the conclusion that an effective PEM programme could reduce the project's expected investment cost by 5%, hence by half a million \$, while an effective PRM programme could reduce the project's expected volatility or project risk by 10%, therefore by one hundred thousand \$. With this additional information the PMO financial analysts set up Table 2.

Table 2 indicates that only the PEM programme would exert a significant impact of nearly 14 percentage points in reducing the project's PL_R while the PRM programme would exert a mere 1.45 percentage points impact. However, what really matters from an economic standpoint is the impact of these programmes on the project's CEL_R. Thus, implementing the PEM programme would improve the project's profitability to $E(\tilde{P}_R^{ER}) = \$1.0225 \times 10^6$ and lower the project's $CEL_R$to \$461,858, a \$93,142 decrease. On the other hand, implementing the PRM programme would lower its expected operational volatility to $\sigma(\tilde{P}_R^{ER}) = \$1.00967 \times 10^6$ and lower the project's CEL_R to \$509,540, a \$45,460 decrease. Finally, implementing in an effective fashion both programmes

[9] This first step must be understood as a screening procedure for there is no economic logic in submitting for acceptance within a project portfolio a capital investment project that is not financially profitable on its own.

[10] Those estimates would normally have been inferred objectively or subjectively from earlier and similar projects. They might also have been generated by statistical simulations.

Table 2
Probability of loss and conditional expected loss of candidate project R with PEM and PRM programmes.

	PL_R	$\Delta\ PL_R$	CEL_R ($\times 10^6$)	$\Delta\ CEL_R$ ($\times 10^6$)
Project R $\tilde{P}_R$	0.3125		\$ 0.5550	
Project R with efficiency management programme $\tilde{P}_R^E$	0.1753	−0.1372	\$ 0.461858	−\$ 0.093142
Project R with risk management programme $\tilde{P}_R^R$	0.2980	−0.0145	\$ 0.50954	−\$ 0.045460
Project R with efficiency & risk management programme $\tilde{P}_R^{ER}$	0.1556	−0.1569	\$ 0.400308	−\$ 0.154692

should lower the project's CEL_R to \$400,308, a \$154,692 decrease.

A critical question that needs to be addressed concerns the maximum admissible budget for implementing the PEM and/or the PRM programmes. The answer is directly obtainable from the information provided by the project CEL_R. The rationale is the following: The total cost for implementing the PEM and PRM programmes should not exceed their own cost savings as measured by their respective reduction in the project's CEL_R. Hence, when taken individually, the budget allocated to the PEM programme should not exceed its cost savings of $\Delta CEL_R^E=$ \$93,142 generated by its implementation, while the budget allocated to the PRM programme should not exceed its cost savings of $\Delta CEL_R^R=\$45,460$. On the other hand, the total admissible budget for implementing both the PEM and PRM programmes should not go beyond their total project cost savings estimated at $\Delta CEL_R^E+\Delta CEL_R^R=\$138,602$.[11] In addition of the benefits resulting from the cost savings due to the investment cost-cutting and cost-control programmes, one must also take into consideration the implementation costs of such programmes by netting them out from the project's expected profitability. For instance, when implementing the PEM and PRM programmes, the project's net value would be given by: $E^N(\tilde{P}_R^{ER}) = E(\tilde{P}_R^{ER}) - PIC^{ER}$ where PIC^{ER} stands for the project implementation costs of both efficiency and risk management programmes.

5.2. The impact of candidate project R on the firm's operational risk

In order to assess the financial impact of project R on the parent firm's expanded portfolio one will require information on the statistical relationship linking them together and, more specifically, information on the cross-correlation between their respective economic activities during their business phase. Table 1 provides the main financial and statistical parameters of the firm's project portfolio. The PMO financial analysts assumed once again that the firm's $N\tilde{P}V$ probability distribution is normal with mean–variance stationary. The firm's investment costs are also randomly distributed due to the fact that the firm is currently implementing other capital investment projects.

Considering the parent firm's current portfolio of capital investment projects and given the current statistical and financial data, the PMO financial analysts estimated that over the forthcoming 20-year period, assuming no addition to the actual capital investment stock, the parent firm's expected profitability should stand at $E(\tilde{P}_F) = \$5.6989 \times 10^6$ and its expected volatility at $\sigma(\tilde{P}_F) = \$5.480276 \times 10^6$. From these results the PMO financial analysts estimated the firm's probability of loss at $PL_F=0.1492$ and its conditional expected loss at $CEL_F=$ $\$2.123464\times 10^6$.

We have already assumed that the firm's correlation coefficient with its sector's economic activities was estimated at: $\rho_{FS}=+0.75$. If the candidate project has the same correlation coefficient with that sector's economic activities then the cross-correlation between firm F and candidate project R will be estimated by their cross-product and will be equal to $\rho=\rho_{FR}=\rho_{FS}\times\rho_{SR}=0.5625$. Table 3 gives the PL_{FR} and CEL_{FR} of parent firm F and candidate project R if the cross-correlation were to drop and move into negative territory.

Results from Table 3 fully support the proposition that a project showing a negative cross-correlation with a parent firm will improve the firm's operational risk whether it is measured by its PL_{FR} or CEL_{FR}. When the cross-correlation coefficient is positive at $\rho=+0.5625$, the firm's expanded portfolio will increase its PL_{FR} and CEL_{FR}. On the other hand, when the economic activities of the candidate project and the parent firm

Table 3
Probability of loss and conditional expected loss of firm and candidate project.

	PL	CEL ($\times 10^6$)
Firm F	0.1492	\$2.1235
Project R	0.3125	\$0.5550

Firm F & project R	PL_{FR}	$\Delta\ PL_{FR}$	CEL_{FR} ($\times 10^6$)	$\Delta\ CEL_{FR}$ ($\times 10^6$)
$\rho_{FR}=+0.5625$	0.1550	+0.0058	\$2.44543	+\$0.32193
$\rho_{FR}=\ 0.00$	0.13234	−0.0168	\$2.02152	−\$0.09998
$\rho_{FR}=-0.1875$	0.12342	−0.02578	\$1,86,785	−\$0.25565
$\rho_{FR}=-0.5625$	0.1038	−0.0454	\$1.5395	−\$0.583964

[11] This amount exceeds the sum of the individual budgets by \$16,092 and therefore is an indication of an interactive effect between the PEM and PRM programmes.

Table 4
Probability of loss and conditional expected loss of parent firm expanded project portfolio with PEM and PRM programmes.

$\rho = +0.5625$	PL_{FR}	$\Delta\ PL_{FR}$	CEL_{FR} ($\times 10^6$)	$\Delta\ CEL_{FR}$ ($\times 10^6$)
Firm F & project R with no efficiency management or risk management programme $\tilde{P}_{FR}$	0.1558		\$2.445430	
Firm F & project R with efficiency management programme $\tilde{P}_{FR}^{E}$	0.1379	−0.0188	\$2.283344	\$ 0.162086
Firm F & project R with risk management programme $\tilde{P}_{FR}^{R}$	0.1536	−0.0022	\$2.403660	\$ 0.04177
Firm F & project R with efficiency management & risk management programmes $\tilde{P}_{FR}^{ER}$	0.1357	−0.0201	\$2.240808	−\$0.204622

are uncorrelated, then both the expanded firm's PL_{FR} or CEL_{FR} are reduced, and even the more so the more negatively cross-correlated they become. Such risk reduction through portfolio addition of independent projects (Paquin et al., 2015b) was to be expected.[12]

Let us, for the time being, limit our analysis to the case of a positive cross-correlation coefficient set at $\rho = +0.5625$. Under such an assumption the candidate project does not seem to offer to the parent firm any great economic prospects considering that although its expected profitability is positive at $E(\tilde{P}_R) = \$0.53553 \times 10^6$ and will therefore increase the firm's expected profitability to $E(\tilde{P}_{FR}) = \$6.2344 \times 10^6$, it remains that it will nevertheless increase the firm's PL_{FR} by a point and a half and its CEL_{FR} by as much as \$321,930. The only way of saving project R would apparently be by implementing the proposed PEM and PRM programmes. Although the expanded project portfolio CEL_{FR} is greater than that of the current project portfolio's CEL_F, *i.e.* $\mathrm{CEL_{FR}} > CEL_F$, one may nevertheless conclude that the additive project portfolio risk diversification process has actually been effective given that $CEL_{FR} < \mathrm{CEL_F} + CEL_R$, thus complying with Artzner's et al. (1999) sub-additivity property.[13]

5.3. The impact of the PEM and PRM programmes on the parent firm's operational risk

The PMO financial analysts will not only need to assess the impact of candidate project R on the parent firm's expanded project portfolio but also assess the impact of the PEM and PRM programmes on the firm's expanded portfolio. These calculations should furthermore enable top management to determine the maximum allowable budget for the implementation and execution of such programmes.

When adding the PEM and PRM-upgraded candidate project to the firm's portfolio the PMO financial analysts has estimated that it should increase its expected profitability to $E(\tilde{P}_{FR}) = \$7.2083 \times 10^6$, an increase that corresponds to the project's expected profitability of $E(\tilde{P}_R) = \$0.53553 \times 10^6$. As for the impact on the expanded firm's operating risk resulting from the addition of such an upgraded project, one finds its expected results in Table 4.

Results from Table 4 tend to confirm those from Table 2 but with some differences. In this example the PEM programme remains the most effective as it succeeds in reducing by 1.88 percentage points the firm's PL_{FR} and by \$162,086 its CEL_{FR}.

One comes to the conclusion that this \$162,086 PEM related reduction in the expanded portfolio's CEL_{FR} is significantly larger than the \$41,777 obtained from the PEM programme. This means that the PEM programme would have had quite a different and greater operational risk impact on the parent firm than on the candidate project *per se*. As for the impact of the PRM programme on the expanded firm, it is still negligible when comparing the firm's PL_{FR} with that of the project's PL_R, as it will be nearly as important on the firm's $\Delta CEL_{FR} = \$41,770$ as it is on the project's $\Delta CEL_R = \$45,460$.

Given the current example, the PMO financial analysts would have been lead to conclude that the impact of the PEM and PRM programmes would have been quite different on the project's operational risk CEL_R, as a stand-alone project than the impact obtained from the firm's expanded project portfolio, namely its CEL_{FR}. This example shows that the PMO financial analysts should always assess the impact of a project and its PEM and PRM programmes on the expanded portfolio of the parent firm's operational risk.

This simple example has showed that when limiting the financial analysis to that of a stand-alone project one obtains biased and unreliable operational risk assessments relatively to the firm. From these results the firm's top management should now be in a position to make a sound decision as to the firm's profitability and operational risk as well as to the economic net advantage of implementing both PEM and PRM programmes before deciding on the appropriate budgets for carrying out these programmes. If top management of parent firm F were to accept the implementation of the PEM and PRM programmes, then each one of these programmes should not exceed their relative contribution to the firm's CEL_{FR}^{ER}. Hence, they could allocate a maximum of \$162,100 for the PEM programme and \$41,800 for the PRM programme; and for both programmes the total budget should not exceed \$204,600.[14]

[12] However, adding an uncorrelated investment project to the firm's project portfolio is generally not an easy task to accomplish while unearthing a negatively cross-correlated capital investment project may prove to be an even more strategically daunting and challenging assignment.

[13] Such a result should not surprise one given those obtained by Paquin et al. (2015b).

[14] This is not to say that they should spend the maximum admissible amount for the implementation of PEM and PRM programmes. In reality, the lower budgets the better.

5.4. The effectiveness of a PRM programme when candidate project R is negatively cross-correlated with the firm

Let us reconsider the statistical relationship linking candidate project R to the firm F and let us see what happens when the cross-correlation between them is set at $\rho = -0.5625$. We have already indicated from the results of Table 3 that the addition of project R to the firm's project portfolio would reduce the expanded firm's operational risk by $\Delta CEL_{FR} = -\$583,964$. From this result one could conclude that project portfolio risk diversification was quite effective.

However, given that the cross-correlation between the candidate project and the parent firm is negative, one may ask oneself whether any successful implementation of a PRM programme under such a condition would contribute to furthering the reduction in the expanded firm's operational risk. Table 5 provides a clear answer to such a question.

Indeed, successfully implementing the PRM programme with a 10% or $\Delta\sigma(\tilde{IC}_{R=}) = \$100,000$ reduction in the project risk will increase that of the expanded project portfolio by $\Delta CEL_{FR} = +\$26,480$. This result therefore shows that the effectiveness of the PRM programme will be critically dependent on the value of the cross-correlation coefficient ρ linking a candidate project to a parent firm. It can be shown that there exists a critical threshold value of $\rho^* = -\sigma(\tilde{P}_R)/\sigma(\tilde{P}_F)$ under which the effective implementation of any PRM programme will become counter productive to the firm given that it will result in an increase instead of a decrease in the expanded firm's operational risk.

In our numerical example $\sigma(\tilde{P}_R) = \$1.095287 \times 10^6$ while $\sigma(\tilde{P}_F) = \$5.480276 \times 10^6$, which gives a critical cross-correlation value of $\rho = -0.19986$, a value much higher than $\rho = -0.5625$. These numerical results are contrary to what project managers normally expect from any PRM programme which aims essentially at reducing and bringing under control the candidate project's risk or expected volatility $\sigma(\tilde{I}_R)$. This unexpected result is a consequence of the reversal of the normally positive cross-correlation to an exceptionally negative cross-correlation coefficient.

These results imply that sufficiently high negative cross-correlated activities of a project with those of a parent firm will convert the project risk reduction advantage into a portfolio risk increase disadvantage. Whenever such an event occurs the parent firm's top management could consider a spin-off or sell-off of the candidate project in order to avoid a conflict of strategic importance from ever developing between the opposing operational risk objectives pursued by the candidate project's PRM programme and that of the parent firm.

6. Conclusion

This article proposed a probabilistic approach to assess the impact of a capital investment project on a firm's expected profitability and operational risk. The operational risk was defined by two complementary down-side risk measures which consisted in considering either the capital investment probability of loss or its conditional expected loss. We showed that both definitions of operational risk possessed a closed-form solution when the project or the firm's NPV probability distribution is normal. These two measures also enabled us to establish a clear distinction between a PEM programme and a PRM programme: As the PEM programme aims at improving the project's expected profitability by reducing its expected investment costs, the PRM programme will aim at bringing under control the project risk by reducing its investment cost expected volatility. While the PEM programme may at the same time increase the project's profitability and reduce its operational risk, the PRM programme can only improve the project's operational risk through a reduction in the project risk. Hence, no profitability improvement can be expected from a PRM programme *per se*. In order to increase the firm's profitability and lower its operational risk top management may improve the firm's financial position by implementing both PEM and PRM programmes within candidate projects's PM phase. However, for this to happen, one needs not only to assess the economic contribution of such programmes to the project's profitability and operational risk but, most critically, extend such financial analysis to the firm's expanded project portfolio. It is shown that such an economic contribution to the project or the firm can be obtained by measuring the decrease in their respective conditional expected loss. These estimates enable top management to determine from the firm's perspective the maximum admissible budget for implementing PEM and PRM programmes during the PM phase of any candidate capital investment project.

Finally, our analysis dealt with the case of a candidate project exhibiting a negative cross-correlation with the economic activities of the parent firm. Such a case is frequently referred to in the literature as an 'ideal project' due to the fact that its

Table 5
Probability of loss and conditional expected loss of parent firm with candidate project under programmes of project efficiency management & project risk management.

$\rho = -0.5625$	PL_{FR}	$\Delta\ PL_{FR}$	CEL_{FR} ($\times 10^6$)	$\Delta\ CEL_{FR}$ ($\times 10^6$)
Firm F & project R with no efficiency management or risk management programme $\tilde{P}_{FR}$	0.1038		\$1.5395	
Firm F & project R with efficiency management programme $\tilde{P}_{FR}^{E}$	0.0882	−0.0156	\$1.377105	−\$0.1624
Firm F & project R with risk management programme $\tilde{P}_{FR}^{R}$	0.1054	+ 0.0016	\$1.565980	+ \$0.02648
Firm F & project R with efficiency management & risk management programme $\tilde{P}_{FR}^{ER}$	0.0887	−0.0161	\$1.396596	−\$0.14354

addition to the firm's project portfolio will always reduce the firm's operational risk whether it is measured by the firm's *PL*or *CEL*. However, applying a PRM programme to a candidate project with a negative cross-correlation will not always prove to be effective; particularly whenever the negative cross-correlation exceeds (in absolute value) a critical threshold value. Indeed, when the cross-correlation coefficient exceeds the threshold value any PRM programme becomes counter-productive relative to the parent firm's operational risk objectives. Such a conclusion runs counter-intuitively to most project managers' *modus operandi* for which project risk management should always aim at bringing under control with ever greater effectiveness the project's risk.

Conflict of interest

None.

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