Accounting & Taxation
Vol. 6, No. 2, 2014, pp. 11-20
ISSN: 1944-592X (print)
ISSN: 2157-0175 (online)

www.theIBFR.org

STRATEGIC IMPLICATIONS OF PROJECT PORTFOLIO SELECTION

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ABSTRACT

This paper evaluates the relationship between corporate strategy and quantitative financial criteria for choosing the optimal set of projects for the Capital Budget. On the basis of the competitive dynamics of the industry and the corporate strategy, different sets of projects should be selected to compose the project portfolio. The choice of the best criteria for project selection is mandatory, even though it is hard to find in both corporate and academic literature recommendation about which criteria should be selected to fit a predefined strategy. In order to evaluate that, this paper analyzed several combinations of risk and return metrics to compare the resultant set of projects and their strategic implications. The results pointed out that while Net Present Value combined with Value at Risk provided the most relevant results in terms of long term value creation, it is important to figure out how different strategies can be best implemented through portfolios selected by other criteria – e.g., fast returns on investment obtained by the Adjusted Payback Period and high profitability based on the Profitability Index or Internal Rate of Return. Such results present a relevant contribution for managers who typically face with the Capital Budget problem.

JEL: G11, G31

KEYWORDS: Capital Budget, Project Portfolio Management, Project Portfolio Strategy, Project Selection, Monte Carlo Simulation, Investment Decision Criteria

INTRODUCTION

The current globalized economy poses the challenges of increased competition among companies, and the mobility of capital and changeability of stakeholders (Bötzel and Schwilling 2000). Companies aim to create sustainable value in order to face such challenges. The long-term market value maximization of a company is the best criterion to equilibrate the tradeoffs among conflicting stakeholders, where value creation can be understood as the increase in a firm's market value, that is, the expectation of present and future cash flow generation (Brigham and Ehrhardt 2007; Hawawini and Viallet 2007). According to Porter (1980), companies competing in high growth industries may establish their position and increase the firm's market value through product development, marketing, innovation, acquisition of new clients, etc. Such companies are focused on growth; therefore, value creation is related to investments that aim for long-term cash flow generation. In addition to growth, if the industry is newly formed or emergent, risk appetite could increase because of the high level of uncertainties about the future. When competing in large revenue industries that are slow growing, companies look for economies of scale, cost efficiency, selective product improvements, retention and acquisition of profitable clients, etc. Value creation is related to efficiency in capital allocation, which means that investments are more selective, risk taking is an important concern, and profitability may be more important than simply growing revenues. On the other hand, if the industry's market is shrinking, or competition is severely damaging profitability, the companies would have to maintain or mitigate the decrease of value. Among the options, companies could change business lines, client segments, divest and capture residual value, etc. When investing in such situations, companies look for short- or medium-term returns; therefore, concerns about investment payback and divestment options may drive the capital budgeting process.

Companies implement their investments through projects that have to be managed in a portfolio structure. Only the most favorable investments have to be chosen, since companies have limited resources. According to Pennypacker and Dye (2002), Chen and Jiang (2004), Almeida and Mota (2011) and Fagerholt et al. (2013), the main problems in project selection and portfolio management include the gap between strategy and investment selection, unprofitability, and unbalanced portfolios in terms of risk, schedule, and size of projects. The first step in facing such challenges is to improve the project selection methodology (Amaral and Araújo 2009).

The selection must consider quantitative financial metrics, such as Net Present Value (NPV), Internal Rate of Return (IRR), etc., and could be complemented by qualitative criteria, such as strategic alignment, company expertise and efficiency in resource allocation (Byrd and Drake 2006). For instance, Cañez and Garfias (2006) evaluated a weighted average model used in a Mexican petroleum company, that comprised four qualitative criteria (alignment with the strategic areas, business impact, time to market, and expected net profitability), and one quantitative criterion (NPV adjusted to risk). Archer and Ghasemzadeh (2000) evaluated a weighted average approach using several qualitative criteria (such as market suitability, resource limitation, and project interdependencies), and quantitative criteria (NPV and project timing). Such models aimed to solve the strategic alignment problem of investment in a qualitative way; however, qualitative judgments could lead to disputable results. In addition to these limitations, their conclusions ignored the intrinsic relationship between the financial criteria and corporate strategy. Although such studies apply quantitative financial criteria to select project for the Capital Budget, they do not present nor discuss the strategic implications of the different resultant set of projects. Thus, the objective of this paper is to evaluate the benefits of the different quantitative financial criteria and their strategic implications for project selection.

LITERATURE REVIEW

One of the most commonly used metrics is the Net Present Value (NPV), which is the sum of discounted cash flows of the project. Present Value is considered to be the metric that is most aligned to long-term value creation, since it measures the amount of present and future cash flows generated by an investment. Two other important metrics are the Internal Rate of Return (IRR) and the Profitability Index (PI). They measure the return of invested capital, that is, capital efficiency. The Payback Period (PBK) consists of the amount of time needed for cash flows to achieve breakeven. It is a measure of how fast the capital returns. Given that the traditional Payback Period criterion ignores the time value of money, Hawawini and Viallet (2007) recommended the Adjusted Payback Period (APBK), which uses discounted cash flow figures instead of non-discounted amounts. According to the same authors, each selection criterion takes into account a different aspect of an investment's cash flow. While NPV "estimates how much the project would sell for if a market existed for it", APBK focuses on how fast the investment delivers return. So, while the latter criterion is favorable for short-term investments, NPV selects high-value cash flows, which usually happens in the long term. The resultant portfolios are different and they support different strategies: fast return versus long-term value creation.

Although return metrics alone can be used to define criteria for project selection, it is important to consider risk components when dealing with relevant uncertainties. For example, Graves and Ringuest (2005) proposed a risk-return approach for selecting project portfolios, combining a metric of financial return (e.g., NPV) and the Gini coefficient as the risk statistic in a dynamic programming model. They claim that their approach is easy to implement, and may be ideal for the selection of Research and Development (R&D) projects. Gustafsson and Salo (2005) implemented another risk-return approach based on Decision Tree Analysis. They maximized the difference between the Expected Value of the return metric (the amount of money of each tree branch multiplied by the probability of achieving the branch) and its lower semi absolute deviation (the sum of the probability of each branch multiplied by the difference of the Expected Value and the branch return).

According to the aforementioned authors, risk may be incorporated directly into the maximization objective function, or indirectly into the interest rate applied to discount cash flows. The composition of the discount rate may include three components: the risk-free rate, the additional cost of capital employed in the project and the additional risk given the cash flow uncertainties (Brigham and Ehrhardt 2007; Cohen and Eschenbach 2006; Hawawini and Viallet 2007). This method involves several complexities, since the third component is difficult to calculate because it represents the uncertainties in future cash flows. Moreover, the use of the third component implies a different discount rate for each project, which complicates project comparison. Another problem with this approach is the lack of historical data to compare the project's discount rate with similar earlier projects (Cohen and Eschenbach 2006, April, Glover, and Kelly 2002). The alternative approach that is implemented in this paper involves the consideration of a risk statistic directly in the maximization formula.

There are three methods to implement this last approach. Better and Glover (2006) showed that the first method maximizes the mean NPV of portfolios, imposing a constraint that the standard deviation of NPV be smaller than a predefined value. The second method involves considering risk as a separate measure plotted on an axis different from that of the return metric, which leads to a frontier visualization as the standard Markowitz frontier. Such approaches are more complex to analyze, because the decision-making process involves complex questions, such as "what is the risk appetite of the company?" and "how much risk should we bear to achieve our strategic goals?" The third method consists of using an indicator that mixes the return metric and the risk statistic; for example, divide the mean of the return metric by its standard deviation, which implies that the company aims for the highest return per unit of risk (Linsmeier and Pearson 1996). Another indicator that mixes risk and return is the Risk-Adjusted Return on Capital (RAROC), which consists of the mean of the return metric divided by its Value at Risk (or Cash Flow at Risk). According to Hager, Roehrl, and Wiedemann (2008), Cash Flow at Risk or CFaR is the "unexpected deviation of the expected cash flow value", which is calculated as the difference (in monetary units) between the mean and the ith percentile of the return distribution. This rule can be applied to any distribution (Holton 2003). The expressions (1) and (2) present these indicators, as discussed in Better and Glover (2006) and Prokopczuk et al. (2007), respectively:

$$SNR = \frac{\mu(X)}{\sigma(X)} \tag{1}$$

$$RAROC = \frac{\mu(X)}{CFaR(X)} = \frac{\mu(X)}{\mu(X) - pct_i(X)} \tag{2}$$

Where:

SNR = Signal to Noise Ratio, the reciprocal of the Coefficient of Variation; RAROC = Risk-Adjusted Return on Capital; $\mu(X)$ = expected value of the distribution of the random variable X; $\sigma(X)$ = standard deviation of the distribution of X; CFaR(X): Cash-flow at Risk of the distribution of X; $pct_i(X)$: i^{th} percentile of the distribution of X (e.g., fifth percentile for 95% of confidence interval); X = any return metric (e.g., NPV, IRR, PI or APBK).

DATA AND METHODOLOGY

In order to analyze the strategic implications of each criterion for project selection, a Monte Carlo simulation model was implemented to compose portfolios from a total of ten projects. These projects' cash flows were based on the projects under evaluation by a Brazilian electric energy company. Even though companies in general have hundreds of projects and the selection process must consider such larger amounts, this paper evaluated a small set of projects in order to test the metrics in all project combinations and to focus on the project selection criteria comparison. The simulation model calculated the return and risk statistics of all 1024 portfolios formed by any combination of the 10 projects. For a larger number of projects, optimization techniques such as mixed integer programming should be used to reduce the processing time (Kitanidis and Philbrick 1999, Dantzig and Thapa 2003).

The structure of the simulated projects consisted of 4 phases: two initial investment phases, the operational phase, and the project closure phase. Each phase presents specific characteristics in terms of revenues, costs, and investments. The definition of the two investment phases was based on the fact that large projects may have a long and expensive feasibility study phase before any investment is made in production infrastructure; this is common, for instance, in electricity generation and mining ventures (Moel and Tufano 2000). Table 1 presents the duration and total investment amounts for each one of the ten projects. For example, Project 1 has 16 months of total duration. Its first investment phase takes 3 months to be completed and invested a total of $ 36.1 million. The second investment phase takes 1 month, in which is invested additional $ 15 million.

Table 1: Duration and Investment of Each Project (Represented on Each Column)

	PROJECT NUMBER									
DURATION AND INVESTMENT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total duration (in months)	16	24	16	13	14	16	16	9	22	26
N_1: duration (in months)	3	4	2	1	3	3	3	1	1	3
N_2: duration (in months)	1	5	2	1	2	2	1	1	2	1
I_1: investment (in $ million)	36.1	40.1	17.4	35.1	7.9	8.7	23.5	20.1	15.1	14.1
I_2: investment (in $ million)	15.0	14.1	55.4	12.7	44.8	24.0	28.5	22.5	22.1	49.3

Each project was considered to have two investment phases: one related to a feasibility study and the second the investment to rollout the project itself. The duration of the first investment phase is presented in the N_1 line, while the investment amount of this phase if presented in I_1. The duration of the second investment phase is presented in the N_2 line, while the investment amount of this phase if presented in I_2. For example, project 1 presents 16 months as total duration. Within this timeframe, 3 months are spent in the first investment phase and another 1 month in the second phase. Total investment amounts were $ 36.1 million and $ 15.0 million in the first and second investment phase respectively.

After the investments, the project starts an operational phase in which generates revenues, costs and it demands maintenance investments. Table 2 presents the detail of revenues, costs, recurrent investments in maintenance and the proportion of variable to total costs. The table also presents the final investment needed when operation finishes and final revenues from selling assets, for example, when a mine or plant is divested. For example, Project 1 presents $ 271.8 million of total revenues and $ 30.7 million of total costs, to be incurred during the 12 months of operational phase. In each month, additional $ 5.1 million is invested in maintenance and additional assets. The project is mostly based on variable costs, which comprises 60% of total costs. In the end of the project, to implement the divestment initiatives, a total of $ 3.1 million (6% of $ 51.1 million of total investments) is needed. Salvage value of selling the assets will comprise $ 24.5 million (9% of $ 271.8 million of total revenues).

The model took into consideration uncertainties in revenues and costs (Hawawini and Viallet 2007). Revenues had two sources of uncertainties (i.e., the number and the price of sales), while costs had one source of uncertainty (i.e., the fixed cost amount). Table 3 presents the intensity of uncertainty, an index that varies from 1 to 4. For example, Project 1 presents high uncertainty in costs and number of sales, and moderate uncertainty in prices. The uncertainty factors are multiplied by random variables to simulate the volatility of the cash flows.

Table 2: Revenues, Costs, and Other Characteristics of Each Project's Cash Flow

	PROJECT NUMBER									
PROJECT CHARACTERISTICS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RB: Revenues[1]	271.8	178.2	245.5	79.3	140.8	136.1	228.5	123.2	120.5	80.6
CB: Cost[2]	30.7	56.3	81.6	45.9	65.9	26.1	43.1	42.2	30.5	53.9
RI: Recurrent investments[3]	5.1	4.3	3.6	5.7	3.7	2.6	0.5	3.0	2.2	7.6
φ: Variable/Total Costs[4]	60%	60%	60%	70%	70%	40%	50%	50%	60%	70%
Final investments as percentage of investment[5]	6%	8%	6%	7%	6%	7%	6%	7%	3%	10%
Revenues at the end of the project as percentage of revenue[6]	9%	17%	10%	10%	10%	17%	12%	24%	11%	14%

[1] Total baseline revenue of the project, in $ millions, for all periods during the operational phase
[2] Total baseline cost of the project, in $ millions, for all periods during the operational phase
[3] Total monthly investments during operation phase (non-investment periods), in $ million
[4] Relation between variable and fixed costs (percentage)
[5] Final investments to end the project (e.g. recovering of a mine landfill after exhaustion)
[6] Final revenues from selling assets

Table 3: Intensity ("α") Factors of Each Cash Flow Component of a Project

	PROJECT NUMBER									
INTENSITY OF UNCERTAINTY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Uncertainty of number of sales	3	1	4	4	4	2	4	3	2	3
Uncertainty of price of sales	2	1	3	2	4	3	4	3	1	4
Uncertainty of costs	4	3	3	3	3	4	1	2	3	4

The table presents factors to determine the intensity of the uncertainty in each cash flow component. In the simulation model, such factors are multiplied by random variables in the model to implement randomness For example, project 1presents high uncertainty for costs (index = 4) and for number of sales (index = 3), and moderate uncertainty for price of sales (index = 2).

All variables from tables 1, 2 and 3 are consolidated into project cash flows, according to expressions (3) to (6). For each month, the cash flow is calculated as the difference between revenues and costs plus investments. Revenue is calculated in expression (3) as the total revenue (Table 2) divided by the number of months from the operational phase (Table 1) and multiplied by two uncertainty factors (Table 3), one for volume and one for price. Cost follows the same logic, but it is calculated in expression (4) using two components: fixed and variables costs. While the Fixed Cost is multiplied by the factor of Uncertainty of costs, the Variable Cost is multiplied by the factor of Uncertainty of number of sales. Investments are basically calculated, for each phase, as total investments divided by the number of months.

$$CF_t = RV_t - CT_t - IV_t \tag{3}$$

$$RV_t = RB \cdot (1 + \alpha_v \cdot u_v) \cdot (1 + \alpha_p \cdot u_p) \cdot \frac{1}{N_3} \tag{4}$$

$$CT_t = CB \cdot [(1 - \varphi) \cdot (1 + \alpha_c \cdot u_c) + \varphi \cdot (1 + \alpha_v \cdot u_v)] \cdot \frac{1}{N_3} \tag{5}$$

$$IV_t = \begin{cases} I_1 / N_1, t \le N_1 \\ I_2 / N_2, N_1 < t \le N_2 \\ RI, t > N_2 \end{cases} \tag{6}$$

Where:

RV_t = revenue of the project in time t; CT_t = total cost of the project in time t; IV_t = investment of the project in time t; RB = baseline of the total revenue of the project; CB = baseline of the total cost of the project; α_v = uncertainty (intensity) factor related to volume of sales; α_p = uncertainty (intensity) factor related to price of sales; α_c = uncertainty (intensity) factor related to fixed costs; u_v = random variable sample related to volume of sales; u_p = random variable sample related to price of sales; u_c = random variable sample related to fixed costs; φ = a constant related to the ratio of variable per fixed costs; N_1 = number of time units of the first investment period; N_2 = number of time units of the second investment period; N_3 = number of time units of the operational phase of the project (project's total duration minus the duration of the investment phases); I_1 = total amount of the first investment period; I_2 = total amount of the second investment period; RI = Recurrent investments (during the operational phase of the project).

The project cash flows were calculated though a Monte Carlo simulation and project portfolios were ranked according to the several criteria in Table 4. The average, the standard deviation and the cash flow at risk of each indicator (NPV, IRR, PI and APBK) were calculated for each portfolio. Then, portfolios were ranked according to maximize or minimize rules. All tested combinations are presented on Table 4.

Table 4: Criteria for Project Portfolio Selection Implemented in the Simulation Model

CRITERIA FOR PROJECT SELECTION	
Criterion 1	Maximize the mean of NPV
Criterion 2	Maximize the mean/CFaR of NPV
Criterion 3	Maximize the mean/standard deviation of NPV
Criterion 4	Maximize the mean of IRR
Criterion 5	Maximize the mean/CFaR of IRR
Criterion 6	Maximize the mean/standard deviation of IRR
Criterion 7	Maximize the mean of PI
Criterion 8	Maximize the mean/CFaR of PI
Criterion 9	Maximize the mean/standard deviation of PI
Criterion 10	Minimize the mean of APBK
Criterion 11	Minimize the CFaR/mean of APBK
Criterion 12	Minimize the standard deviation/mean of APBK

The table presents the composition of each selection criterion. For example, the Criterion 1 consists in maximizing the Mean of NPV. According to this criterion, portfolios are ranked from the maximum to the minimum NPV average. Criterion 2 consists on a combined criterion, since it is the quotient of the Mean by the Cash Flow at Risk of NPV. Risk-return criteria, like 2, 3, 5 and others, are generally calculated by a quotient of the return metric (e.g. mean of NPV) divided by the risk metric (e.g. CFaR of NPV).

RESULTS AND DISCUSSION

Based on the simulations, the 1024 portfolios were ranked for each selection criterion. Table 5 presents the participation of each project in the top eight portfolios selected by each criterion. The conclusions were based on the top eight portfolios instead of the best selected portfolio, in order to mitigate outlier distortions in our conclusions.

For example, project 1 was included in all top 8 best raked portfolios when the criterion of maximizing NPV was applied. But the same project was included in only 70% of the portfolios when the criterion of minimizing the Adjusted Payback Period was applied. Different results were observed for Project 10: it showed up in only 20% of the portfolios ranked by maximizing NPV and it did not show up at all when maximizing IRR or minimizing Payback.

Table 5: Percentage of Participation of Each Project in the Top Eight Portfolios Selected by Each Criterion

	PROJECT NUMBER									
SELECTION CRITERION	1	2	3	4	5	6	7	8	9	10
NPV	100%	90%	30%	10%	30%	100%	80%	60%	100%	20%
IRR	100%	70%	30%	30%	30%	100%	70%	20%	100%	0%
PI	90%	100%	20%	60%	40%	90%	60%	80%	100%	60%
APBK	70%	0%	0%	0%	0%	30%	40%	90%	20%	0%

For example, the top 8 portfolios selected using the NPV criterion were composed basically by projects 1, 2, 6, 7 and 9, in general projects with long term positive cash flows.

The results presented in Table 6 show that portfolios ranked by NPV present long term value creation potential, since the resulting portfolios were composed of long lasting projects with largely positive cash flows. When risk is taken into consideration, the portfolios typically excluded risky projects. Portfolios ranked by the ratio of NPV/CFaR or NPV/Standard Deviation criteria present smaller NPV when compared to the portfolios selected without including risk. This happens because such criteria select projects with high return per unit of risk rather than high absolute return projects, as projects with highest returns may be riskier.

Table 6: Simulation Results for the Project Group under Evaluation by a Brazilian Energy Company

	RETURN STATISTICS OF THE PORTFOLIO			
OPTIMIZATION CRITERIA	**M(NPV)**	**M(IRR)**	**M(PI)**	**M(APBK)**
NPV	708	17.6%	2.9	7.5
NPV / CFaR	577	17.9%	3.0	7.6
NPV / Std	603	18.7%	3.1	7.3
IRR	318	27.3%	4.2	6.0
IRR / CFaR	534	18.4%	3.2	7.6
IRR / Std	492	18.0%	3.2	7.9
PI	363	26.7%	4.3	6.2
PI / CFaR	525	15.1%	2.6	8.2
PI / Std	492	14.0%	2.5	8.7
APBK	294	25.0%	3.6	5.8
APBK / CFaR	225	10.1%	2.0	13.8
APBK / Std	265	9.9%	2.1	11.6

The 10 projects were combined in all 1024 possible portfolios and the portfolios were ranked by the Optimization Criteria (in each line). For the top ranked 8 portfolios by each criterion, the table presents the average of the return statistics (in each column). For example, the cell in the first line and first column is the average NPV of the top 8 portfolios ranked by the NPV criterion. The right adjacent cell (first line, second column) presents the average IRR of the top 8 portfolios ranked by the NPV criterion, and so on.

When evaluating the portfolios optimized by the other criterion, IRR and PI selected portfolios that generate high return on investment, which does not necessarily mean portfolios with large cash flows. Small and very profitable projects may be selected, instead of large and not so profitable projects. Portfolios optimized by APBK focus on short-term returns, instead of long term value creation; this result was as expected. Portfolios optimized using the IRR or PI presented higher APBK than portfolios optimized by NPV, indirectly implying the reduction of the amount of time until the cash flow achieves break even.

To evaluate how general are the conclusions, all simulations were repeated four times using 10 new projects each time. Each new project changed in size (investment amount and schedule), risk profile (degree of uncertainty) and economic feasibility (total revenue and total costs amounts). All above mentioned conclusions were verified on the additional simulations.

CONCLUDING COMMENTS

The choice of projects to make up the portfolio must be aligned with the corporate strategy and the context of the industry in which the company is competing. The researched studies in the literature usually compare only few metrics or frameworks for project selection but do not consider the strategic implications of each criterion. This paper deals with the most common frameworks and criteria for project selection, and also focuses on implementing transparent financial criteria, instead of complex models or "black-box" weighted average criteria.

Comparing the portfolios ranked by each criterion, the relationship between project portfolio selection and corporate strategy becomes evident. The NPV criterion generates portfolios with long term large and positive cash flow streams, which could foster a company's growth when competing in high growth industries. The IRR and PI criteria generate higher return on capital investment, which drive capital efficiency. Such properties are interesting for companies competing in slow growth but large revenue industries, where capital efficiency is required. Interestingly, portfolios optimized by these criteria selected both long term and short term projects. The APBK criterion generated portfolios that were focused on short term returns, which may be required by companies that are competing in shrinking industries or aiming to phase out a specific business line.

The introduction of risk in the selection criteria, combined with NPV, generated portfolios with higher return per unit of risk. Thus, when operating in a critical economic environment, companies should use risk-return criteria to select their project portfolios. It is important to pay attention that risk-return criteria work when the discount rate does not consider the project inherent risk. When the cash flow discount rate considers the project risk, it is suggested not to use a risk return criterion to avoid double counting. The use of only 10 projects was a constraint imposed by the authors to test exhaustively all possible project combinations. For larger groups of projects, it is recommended to employ optimization techniques, even though there would be no guarantee to find the global optimum result.

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ACKNOWLEDGEMENT

This work was supported in part by a grant from the National Council for Scientific and Technological Development (CNPq) under Award number 312033/2009-5.

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