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Do organizations adopt sophisticated capital budgeting practices to deal with uncertainty in the investment decision? A research note

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Abstract

This study examines the impact of uncertainty on the sophistication of capital budgeting practices. While the theoretical applications of sophisticated capital budgeting practices (defined as the use of real option reasoning and/or game theory decision rules) have been well documented, empirical evidence on the factors that affect the importance and use of these sophisticated capital budgeting practices is scarce. I investigate the relation between specific uncertainties and sophisticated capital budgeting practices in 189 Dutch organizations. The empirical results show that sophisticated capital budgeting involves the use of multiple tools and procedures (such as Monte Carlo simulations, certainty equivalents, Game Theory decision rules and Real Option Reasoning). An increase in financial uncertainty is associated with the use and importance of sophisticated capital budgeting practices. Finally, size and industry are also related to the use and importance of sophisticated capital budgeting practices.

Keywords: Capital budgeting practices; Real option theory; Game theory; Uncertainty

1. Introduction

Allocating resources among competing investment projects is one of the most critical decisions made by top management, as it is the means of implementing a firm's strategy (McGrath et al., 2004; Bowman and Hurry, 1993; Hofer and Schendel, 1978). Considerable attention has been devoted to investigating the

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methods and techniques used in evaluating and selecting investment projects (see, for example, Segelod, 1998; Sangster, 1993; and Mukherjee and Henderson, 1987 for an overview) but little attention has been given to the determinants of those choices. There is, however, some limited evidence that firm-specific conditions will influence the efficacy of using sophisticated capital budgeting practices (Chatterjee et al., 2003; Ho and Pike, 1998; Haka, 1987).

The purpose of this paper is to investigate whether there are specific uncertainties that explain why firms use sophisticated capital budgeting practices (SCBP, defined as the use of Real Option Reasoning and/or Game Theory). While theory recognizes that SCBP are essential in dealing with uncertainty, empirical evidence is scarce and mostly anecdotic (Nichols, 1994). Moreover, most empirical literature on capital budgeting practices has solely focused on the capital budgeting decision rule (exceptions are Farragher et al., 2001 and Kim, 1982). Recent literature (Miller and Waller, 2003; Chatterjee et al., 2003) indicates that the sophistication of capital budgeting practices must be considered in a wider context than solely the use of discounted cash flow techniques or the formal analysis of uncertainty. In this study, I empirically investigate the relations between a number of capital budgeting tools and examine whether specific uncertainties affect the importance and use of SCBP among 189 Dutch organizations. To my knowledge, this is the first research project that looks at determinants of the use and importance of Real Option Reasoning, Game Theory and associated capital budgeting tools in the investment process. The empirical results show that sophisticated capital budgeting involves the use of multiple tools and procedures (such as Monte Carlo simulations, certainty equivalents, Game Theory decision rules and Real Option Reasoning). Sophisticated capital budgeting practices appear to augment rather than replace more traditional capital budgeting practices (such as discounted cash flow analysis or the payback criterion). An increase in financial uncertainty (rather than uncertainty in general) is associated with the importance and use of SCBP. In addition, an increase in size is related to the importance and use of SCBP. Finally, particular industries (the financial services industry and the building, construction and utilities industries) appear to find SCBP more important and useful than other industries.

The remainder of this paper is organized as follows. The next section provides a review of literature on uncertainty and capital budgeting practices. Next, the research method and design are described, including the data collection methods and the sample selection. The fourth section provides the results of this study, as well as a discussion of the findings. Finally, some implications for theory and practice are discussed.

2. Literature review

In this section, uncertainty and capital budgeting practices are defined. In addition, the relevant literature on the relation between these two variables is discussed.

2.1. Uncertainty

Uncertainty is defined as the gap between the information currently available and the information required to make the decision (Galbraith, 1973). A condition of uncertainty usually exists in capital budgeting because investment decisions, by definition, involve uncertain outcomes that in the long run are important to firm survival and about which complete information is unavailable (Zhu and Weyant, 2003; Simerly and Li, 2000; Smit and Ankum, 1993).

2.2. Capital budgeting practices

Capital budgeting practices are defined as the methods and techniques used to evaluate and select an investment project (i.e., the decision making role of the accounting system). Capital budgeting practices help managers to select *n* out of *N* investment projects with the highest profits at an acceptable 'risk of ruin'. Literature has generally distinguished among advanced and simple (or naive) capital budgeting practices (Haka, 1987; Haka et al., 1985). Simple or naive capital budgeting practices (such as the payback and accounting rate of return) generally do not use cash flows, do not consider the time value of money and do not incorporate risk in a systematic manner. Advanced capital budgeting practices (such as the internal rate of return, IRR, or the net present value, NPV) are those that consider cash flows, risk, and the time value of money.

Recent theoretical developments in finance (Dixit and Pindyck, 1994; Trigeorgis, 1993; Brennan and Schwartz, 1992) have indicated that these discounted cash flow methods have serious shortcomings in analyzing investment projects when information concerning future investment decisions is not available. The application of Real Options Reasoning (ROR) and Game Theory (GT) principles can be used as analytical tools to evaluate such projects and to support the overall operating and investment strategy (Smit and Ankum, 1993). ROR has its roots in finance literature and frames investment projects in terms analogous to financial options (Miller and Waller, 2003). Option value may stem from the option to postpone, to grow or develop, to stage or sequence, to switch inputs or outputs, and/or to abandon a project (Busby and Pitts, 1997; Trigeorgis, 1993). GT, on the other hand, analyzes how strategic interactions among rational players produce outcomes with respect to the preferences (or utilities) of those players (Ross, 2003). While ROR stresses the value to delay an adoption decision until more information about the investment project is available, GT indicates that firms have an incentive to invest early in case of fear of pre-emption[1] (Zhu and Weyant, 2003; Smit, 2003). A firm runs the risk that another firm may pre-empt it by adopting the investment project first; the 'first-adopter' may eliminate the investment opportunities for all the other firms in that industry (Murto and Keppo, 2002). By integrating ROR with GT principles, firms can make a more complete assessment of strategic option value in an interactive competitive setting (Smit, 2003). For the purposes of this study, sophisticated capital budgeting practices (SCBP) are defined as the application of ROR and/or GT principles.

2.3. Uncertainty and sophisticated capital budgeting practices

The application of SCBP is complicated and conceptually difficult to understand (Bowman and Moskowitz, 2001). Adopting SCBP is thus not without costs: both time and effort must be expended to be able to use them (Miller and Waller, 2003; Busby and Pitts, 1997). In determining the appropriate level of SCBP, organizations will compare the net benefits of capital budgeting methods and tools to their costs. Generally, it is hypothesized that options become more valuable as uncertainty increases (McGrath et al., 2004); in addition, the application of ROR and GT principles may help in determining the trade-off between adopting investment projects early and waiting for more information (Zhu and Weyant, 2003; Murto and Keppo, 2002). Theory thus suggests that SCBP are most valuable in case of high uncertainty; in

[1] ROR may take the preemption effect in account by shortening the 'time to expiration' of the option (Bowman and Moskowitz, 2001). For example, in the case study by Bowman and Moskowitz (2001) on Merck, the firm using ROR set the maximum time to expiration at 4 years because after that, competing products would have entered the market, making entry by Merck unfeasible.

that situation, it is likely that the costs of SCBP are offset by additional gains from successful investment projects.

Similarly, several authors have suggested that different capital budgeting methods and tools may complement each other and/or may provide additional information on how to solve the investment dilemma(s) under consideration (Miller and Waller, 2003; Zhu and Weyant, 2003). A core concept in the ROR literature is that there may be specific uncertainties (rather than uncertainty in general) that affect capital budgeting practices (Dixit and Pindyck, 1994). Also, game theory indicates that specific uncertainties can change the optimal investment criterion (Smit, 2003). Thus, theory suggests that specific uncertainties may need to be analyzed by using different capital budgeting tools (in other words, specific uncertainties have an impact on capital budgeting practices).

Some studies have empirically investigated the impact of specific uncertainties on capital budgeting practices. For example, Haka (1987) concluded that the more predictable a firm's financial markets and competitors are, the more likely that the firm using NPV-methods will outperform a matching firm not using NPV-methods. The predictability of government regulations and the actions of labor unions, customers or suppliers did not have an impact on capital budgeting practices in her study. Ho and Pike (1998) found a positive relation between socioeconomic uncertainty (governmental regulations, actions of trade unions and behavior of financial/capital markets) and the application of risk analysis techniques in capital budgeting practices, and no relation with actions of competitors and customer preferences. Thus, theory as well as previous empirical research suggests that specific uncertainties affect capital budgeting practices; however, empirical evidence on of the relation between specific uncertainties and SCBP is scarce. The previous literature review results in the following hypothesis:

H1. An increase in specific uncertainties is associated with the application of SCBP.

2.4. Control variables

2.4.1. Diversification

An organization's ability to strike options effectively is influenced by its structure (Bowman and Hurry, 1993). An organization will usually have greater strategic flexibility (i.e., it has access to more choices to maximize gains and/or minimize losses) by holding options separately (i.e., by being more diversified). In addition, Schall and Sundem (1980) argue that it is not the level of uncertainty itself that affects capital budgeting methods, but rather the range of risk types across the different projects that a firm considers. When a firm is confronted with heterogeneous projects, the application of SCBP is helpful to distinguish among different types of projects (in terms of uncertainty). This situation is more likely to be present in diversified firms. As such, I expect a positive relation between diversification and the importance and use of SCBP.

2.4.2. Size

Size is also included as a control variable. In general, large firms tend to adopt innovations for decision making (for example, SCBP) to a larger extent than small firms (Williams and Seaman, 2001; Rogers, 1995). In addition, large firms have more at stake and are more likely to have the available resources to use SCBP (Chenhall and Langfield-Smith, 1998; Ho and Pike, 1998). Previous empirical research has indicated that size has an impact on capital budgeting practices (Farragher et al., 2001; Ho and Pike, 1996; Klammer et al., 1991). I expect a positive relation between size and the importance and use of SCBP.

2.4.3. Industry

Finally, some authors suggest that particular industries are more used to the application of real option or game theory analysis; examples include the financial services industry and the high-tech industry (Billington et al., 2003; Zhu and Weyant, 2003), the pharmaceutical industry (McGrath and Nerkar, 2004; Bowman and Moskowitz, 2001; Nichols, 1994) and the extraction industry (see Trigeorgis, 1993; Brennan and Schwartz, 1992). Previous empirical research also suggests that capital budgeting practices differ among industries (Ho and Pike, 1998; Haka et al., 1985; Aggarwal, 1980). Therefore, I expect that the importance and use of SCBP will differ among industries.[2]

3. Materials and methods

3.1. Research design

A sample of 704 large organizations operating in the Netherlands is used for this research project. To select the organizations, three criteria are used: (1) sales have to exceed €25m; (2) total assets have to exceed €20m; and (3) costs for personnel have to exceed €15m. The survey is sent to the chief financial officers of the selected organizations since previous research indicates that the finance department is generally involved in the capital budgeting decision (see Northcott, 1992; Mukherjee and Henderson, 1987). It is expected that these senior financial executives are fully conversant both with the capital budgeting practices as well as with the factors hypothesized to affect the application of SCBP. The data collection process results in 189 (at least partially) useable responses (an actual response rate of 26.9%). Additional tests for non-response bias (i.e., comparing the characteristics and responses for early and late respondents; see Wallace and Mellor, 1988) reveal no particular problems.

3.2. Measurement of variables

3.2.1. Uncertainty

Miller's (1992) uncertainty framework has been used to investigate which specific uncertainties have an impact on capital budgeting practices. Miller (1992) distinguishes among three types of uncertainty: general uncertainties (which affect all companies), industry-specific uncertainties (which affect specific industries) and organization specific uncertainties (which affect one organization). Respondents have been asked to indicate on a 5-point Likert scale (ranging from 1 = unimportant, to 5 = very important) to what extent they consider a number of uncertainties relevant for the intended results of their organization, within the time frame of an investment decision. Factor analysis has been used to verify whether the three uncertainty categories mentioned by Miller (1992) are actually present. Fabrigar et al. (1999) recommend that confirmatory factor analysis (CFA) is likely to be a better approach than exploratory factor analysis (EFA) if there is sufficient theoretical and empirical basis for a researcher to specify a (small subset of) model(s). However, the results for the CFA are considered inconsistent in the sense that

[2] It is notable that, across industries, there are significant differences in uncertainty (Simerly and Li, 2000; Miller, 1992). As such, industry may be just another proxy for the (specific) uncertainties relevant to that industry. I will deal with this issue in Section 4 of this paper.

Table 1
Results factor analysis for Miller's uncertainties framework[a]

Component	INPUT UNC	FINAN UNC	SOCIO UNC	MARKT UNC
Raw material uncertainties	***0.791***	0.042	−0.117	0.045
Input market uncertainties	***0.743***	0.039	−0.047	0.009
Production uncertainties	***0.729***	0.154	0.040	−0.111033
Labor uncertainties	***0.635***	0.153	0.174	0.239
Liability uncertainties	***0.584***	−0.1069	0.159	0.046
Inflation uncertainties	0.051	***0.867***	0.200	0.057
Interest uncertainties	−0.134	***0.851***	0.156	−0.031
Exchange rate uncertainties	0.190	***0.732***	−0.125	0.106
Political uncertainties	0.062	0.114	***0.809***	0.042
Society uncertainties	0.077	−0.003	***0.719***	0.188
Policy uncertainties	−0.009	0.103	***0.692***	−0.278
Competitive uncertainties	−0.094	0.063	0.057	0.838
Output market uncertainties	0.316	0.051	−0.056	0.730
Cronbach's alpha	0.74	0.76	0.62	0.51
N	188	188	184	189

The table presents the results for the factor analysis (eigenvalue > 1) on the uncertainty factors. In addition, Cronbach's alpha and the number of observations are presented. Extraction method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in five iterations.

several variables load on more than one factor. To solve this problem, EFA has been applied. The EFA provides four separate uncertainty factors (eigenvalue > 1) after eliminating four uncertainty variables (natural uncertainties, R&D uncertainties, credit uncertainties and behavioral uncertainties). I label these factors input uncertainty (INPUNCTY), financial uncertainty (FINUNCTY), social uncertainty (SOCUNCTY) and market uncertainty (MARKUNCTY). Considering that these factors are fairly similar to the variables that have been used in previous research (e.g. Ho and Pike, 1998; Haka, 1987), they have been used for this study. The cumulative responses on the questions that load on each factor are used as proxies for each measure.[3] With the exception of market uncertainty, Cronbach's alpha for each of these factors exceeds the lower limit of 0.60[4] (Hair et al., 1998; see Table 1 for details).

The validity of the uncertainty measures is tested using CAPM-β data collected for a small subset of the sample. The survey included a question on 'additional remarks', where respondents could indicate whether they wanted to receive the final results of the study. Based on these data, it was possible to obtain the CAPM-β for 23 listed firms in the sample. CAPM-β is significantly correlated with three uncertainty factors (input, financial and market uncertainty; in all cases $\rho > 0.45$, $p < 0.04$), but not with

[3] For example, the measure INPUNCTY is calculated by summarizing the scores on the questions on raw material uncertainties, input uncertainties, production uncertainties, labor uncertainties and liability uncertainties.

[4] It is noticeable that the Cronbach's alpha for market uncertainty does not exceed the lower limit of 0.60 generally agreed upon (Hair et al., 1998, p. 118). This is probably due to the fact that only two variables (competitive and output uncertainties) relate to this factor. Considering the fact that the inter-item correlation exceeds the 0.30 (another rule of thumb for judging the reliability of a scale), it has been decided to include this variable in the analysis.

Table 2
Results factor analysis for sophistication of capital budgeting practices[a]

Component	Sophisticated capital budgeting practices (SCBP)	NPV capital budgeting practices (NPVCBP)	Naive capital budgeting practices (NAIVCBP)
Monte Carlo simulations	***0.732***	0.117	−0.035
Game theory decision rules (GT)	***0.722***	−0.035	0.185
Real option pricing (ROR)	***0.706***	0.061	0.193
Using certainty equivalents	***0.664***	0.152	0.121
Decision trees	***0.633***	0.116	0.190
CAPM analysis / ß analysis	***0.598***	0.385	−0.263
Adjusting expected values	***0.488***	0.372	−0.089
Sensitivity analysis/break-even analysis	0.037	***0.709***	0.023
Scenario analysis	0.152	***0.703***	−0.080
Adaptation of required return/discount rate	0.010	***0.589***	0.203
Internal rate of return (IRR)	0.047	***0.582***	0.350
Net present value (NPV)	0.087	***0.547***	0.322
Uncertainty absorption in cash flows	0.312	***0.476***	0.033
Payback period (PB)	−0.010	0.150	***0.750***
Adaptation of required payback period	0.194	0.165	***0.701***
Accounting rate of return (ARR)	0.194	0.018	***0.530***
Cronbach's Alpha	0.80	0.70	0.52
N	183	186	187

The table presents the results for the factor analysis (eigenvalue > 1) on the uncertainty factors. In addition, Cronbach's alpha and the number of observations are presented. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in seven iterations.

social uncertainty ($\rho = 0.21$, $p > 0.34$). The results from the correlation analysis provide considerable confidence in the validity of the uncertainty measures used in the study.

3.2.2. Capital budgeting practices

A composite measure is used to proxy for the sophistication of capital budgeting practices. Respondents have been asked to indicate on a 5-point Likert scale (ranging from 1 = never, to 5 = always) to what extent they consider several capital budgeting techniques useful or important in the investment process. Considering the recommendation by Fabrigar et al. (1999), CFA has been used again to verify whether the three capital budgeting practices recognized by theory (naive capital budgeting practices, NPV-capital budgeting practices and sophisticated capital budgeting practices, the latter including ROR and/or GT decision rules) are actually present. The CFA results in the three factors recognized by theory after eliminating one variable (profitability index; see Table 2). Based on the factor analysis, three measures for capital budgeting practices are constructed by summarizing the scores of the questions that load on the relevant factor.[5] The first factor is most relevant for

[5] For example, the score for Sophisticated Capital Budgeting Practices (labeled SCBP) is constructed by summarizing the scores on the questions whether firms find Monte Carlo simulations, GT decision rules, ROR, certainty equivalents, decision trees, CAPM-/β-analysis and adjusting expected values more important and useful.

this research project and is labeled sophisticated capital budgeting practices (SCBP); the other factors are labeled NPV capital budgeting practices (NPVCBP) and naive capital budgeting practices (NAIVCBP). At 0.80, Cronbach's alpha for the SCBP measure exceeds the lower limit of 0.60 (Hair et al., 1998).

The validity of the SCBP-measure is tested by correlating it with a measure for operational risk management practices. Theory and anecdotic evidence (see Miller and Waller, 2003; Billington et al., 2003; Froot et al., 1993) suggest that the use of SCBP should be integrated with other risk management practices. The assumption is that companies that use SCBP will also use other risk management practices to a larger extent in order to integrate risk management practices. The survey included a number of measures that organizations can take to reduce or control risk, including the use of financial instruments, spreading activities or cooperation with other organizations (see Miller, 1992; Shapiro and Titman, 1992). CFA indicates that these operational risk measures load on one factor; in addition, the correlation between a summary measure for operational risk management practices and SCBP is positive and significant ($\rho = 0.27$, $p < 0.01$). The results support the convergent validity of the SCBP-measure.[6]

3.2.3. Control variables

3.2.3.1. Diversification. Respondents have also been asked to characterize their organization as (part of) a single business, (part of) a related diversified organization or (part of) an unrelated diversified organization. The distribution of this variable is mostly in accordance with other research in this area (see Christie et al., 2003). The study includes a dummy variable for diversification which I label DIV (related diversified or unrelated diversified firms, coded 1; single business firms coded 0). The validity of this measure is checked by comparing the responses to more objective information. Based on the data in the 'additional remarks' section of the survey, it has been possible to identify 66 firms and obtain objective information on the number of industries (SIC-codes) in which these firms are operating. The number of industries in which the organization is operating may be considered as a proxy for diversification (see Pennings et al., 1994). The relation between the number of industries in which the firm is operating and the diversification dummy variable is mostly in the expected direction, yet not significant ($p > 0.15$).

3.2.3.2. Size. Three measures for size are included in this research project: total sales, total assets and number of employees of the organization. The Spearman correlation reveals that all indicators for size are highly correlated ($\rho > 0.53$, $p < 0.01$). To correct for skewness, the logarithm of the number of employees is determined (labeled SIZE) and used in the remainder of the analysis.

3.2.3.3. Industry. Finally, respondents have been asked to provide the SIC-codes for the industry in which their organization operates. The industry codes are regrouped to obtain dummy variables for industry. I distinguish among extraction and manufacturing firms (EXTRMFTG), building construction and utilities firms (BUICONUT), financial services firms (FINSERV) and other service firms (NFSERV; non-financial services and government/non-profit companies).

[6] Additional information on this 'operational risk management measure' can be obtained from the author of this paper.

Table 3
Descriptive statistics

	Mean	Standard deviation	Theoretical range	Actual range	*N*
INPUT UNC	15.28	4.05	5.00–25.00	6.00–25.00	188
FINAN UNC	9.46	2.65	3.00–15.00	3.00–15.00	188
SOCIO UNC	9.11	2.52	3.00–15.00	3.00–15.00	184
MARKET UNC	7.60	1.43	2.00–10.00	3.00–10.00	189
SIZE	6.92	1.52	NA	.69–11.16	188
SCBP	12.57	4.86	7.00–35.00	7.00–30.00	183

The table provides the mean, standard deviation, theoretical range, actual range and number of observations for the variables under consideration (excluding dummy variables). INPUT UNC: input uncertainties; FINAN UNC: financial uncertainties; SOCIO UNC: social uncertainties; MARKET UNC: market uncertainties; SIZE: log fte; SCBP: sophisticated capital budgeting practices.

4. Results

4.1. Statistical analysis

The descriptive statistics and the correlation matrix for all of the variables are included in Tables 3 and 4, respectively.

The correlation matrix in Table 4 reveals that several variables appear to be related, yet that multicollinearity[7] is not likely to be a problem. First of all, most uncertainties are correlated at the 10% level ($\rho > 0.129$, $p < 0.08$), with the exception of the correlation between market uncertainty and social uncertainty ($\rho = -0.06$, $p > 0.38$). Also, some uncertainties are correlated with the industry dummy variables (for example, input uncertainty is positively correlated with extraction and manufacturing industry, $\rho = 0.22$, $p < 0.01$ yet negatively correlated with financial services industry, $\rho = -0.22$, $p < 0.01$; financial uncertainty is positively correlated with financial services industries, $\rho = 0.39$, $p < 0.01$ yet negatively correlated with non-financial services industry, $\rho = -0.21$, $p < 0.01$).[8] Size is positively related to a diversification strategy, yet this result is not significant ($\rho = 0.12$, $p > 0.10$). Finally, the capital budgeting practices factors (SCBP, NPVCBP and NAIVCBP) appear to be related ($\rho > 0.22$, $p < 0.01$). This result is consistent with the notion that a combination of tools focuses management attention on different aspects of the investment decision (Childs and Triantis, 1999). It also suggests that organizations *add* new capital budgeting tools to their current practices (i.e., add GT and/or ROR to NPV- and payback practices), rather than *replace* them (i.e., use GT and/or ROR and discard of NPV- and payback practices). This finding is also consistent with the results of Libby and Waterhouse (1996) and Williams and Seaman (2001); they found that the organizational capacity to learn (proxied in both studies by the number of accounting

[7] In addition to the analysis of the correlation matrix, I examined the variance inflation factor for each of the coefficients in the following regression analyses. The results indicate that multicollinearity is not a problem: tolerance values all exceed 0.61 (Hair et al., 1998, p. 208).

[8] These correlations are intuitively correct: for example, input uncertainties (quality of materials and labor uncertainties) are relatively important to the manufacturing industry yet relatively unimportant to the financial services industries; strikes are relatively rare and materials are not used in the last industry. On the other hand, financial uncertainties (exchange rate and/or interest changes) have a large effect on financial services firms, while they have relatively little impact on non-financial service firms (lawyers, consulting firms, etc.).

Table 4
Pearson correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12
1.	INPUNCTY	1.000	0.183**	0.103	0.222***	0.217***	0.008	−0.222***	−0.074	0.006	−0.022	−0.011	0.141*
2.	FINUNCTY	0.183**	1.000	0.182**	0.129*	−0.016	−0.088	0.387***	−0.206***	−0.011	0.078	0.274***	0.279***
3.	SOCUNCTY	0.103	0.182**	1.000	0.010	−0.318***	0.146**	0.125*	0.150**	0.061	−0.055	0.119	0.073
4.	MRKUNCTY	0.222***	0.129*	0.010	1.000	0.068	−0.201***	−0.089	0.131*	0.052	0.036	0.043	0.246***
5.	EXTRMFTG	0.217***	−0.016	−0.318***	0.068	1.000	−0.319***	−0.343***	−0.593***	0.050	0.036	−0.168**	0.020
6.	BUICONUT	0.008	−0.088	0.146**	−0.201***	−0.319***	1.000	−0.143**	−0.248***	−0.116	0.021	0.078	−0.020
7.	FINSERV	−0.222***	0.387***	0.125*	−0.089	−0.343***	−0.143**	1.000	−0.267***	−0.033	−0.134*	0.198***	0.043
8.	NFSERV	−0.074	−0.206***	0.150**	0.131*	−0.593***	−0.248***	−0.267***	1.000	0.052	0.046	−0.020	−0.040
9.	DIV	0.006	−0.011	0.061	0.052	0.050	−0.116	−0.033	0.052	1.000	0.116	0.108	0.131*
10.	SIZE	−0.022	0.078	−0.055	0.036	0.036	0.021	−0.134	0.046	0.116	1.000	0.187**	0.329***
11.	SCBP	−0.011	0.274***	0.119	0.043	−0.168**	0.078	0.198***	−0.020	0.108	0.187**	1.000	0.418***
12.	NPVCBP	0.141*	0.279***	0.073	0.246**	0.020	−0.020	0.043	−0.040	0.131*	0.329***	0.418***	1.000
13.	NAIVCBP	0.185**	0.011	−0.106	0.165**	0.147**	−0.118	−0.054	−0.035	0.097	0.096	0.226***	0.355***

(*), (**), and (***) denote 10, 5 and 1% significance levels (two-tailed), respectively. Explanation of variables: INPUNCTY: input uncertainty; FINUNCTY: financial uncertainty; SOCUNCTY: social uncertainty; MRKUNCTY: market uncertainty; EXTRMFTG: extraction and manufacturing industry (dummy variable); BUICONUT: building, construction and utilities industry (dummy variable); FINSERV: financial services industry (dummy variable); NFSERV: non-financial services industry (dummy variable); DIV: diversification (dummy variable; related and unrelated diversified strategy: 1, single business strategy: 0); SIZE: size (log fte); SCBP: sophisticated of capital budgeting practices (i.e., including game theory and real option pricing); NPVCBP: net present value capital budgeting practices; NAIVCBP: naive capital budgeting practices.

Table 5
Multiple regression results for the impact of uncertainty on the sophistication of capital budgeting practices

Independent variables	Hypothesized effect	Dependent variable: SCBP			
		Model 1		Model 2	
		Standardized coefficient	Significance	Standardized coefficient	Significance
Hypothesis					
(Constant)			0.34		0.00
INPUNCTY	+	−0.065	0.39	0.030	0.70
FINUNCTY	+	0.231	0.00	0.153	0.07
SOCUNCTY	+	0.097	0.19	0.052	0.51
MRKUNCTY	+	0.021	0.77	0.077	0.31
Control variables					
DIV	+	0.078	0.29	0.104	0.16
SIZE	+	0.176	0.02	0.209	0.01
BUICONUT	?			0.174	0.04
FINSERV	?			0.222	0.02
NFSERV	?			0.083	0.34
R^2		0.12		0.16	
Adjusted R^2		0.08		0.11	
d.f.		6		9	
F		3.64		3.47	
Significance		<0.01		<0.01	

Explanation of variables: INPUNCTY: input uncertainty; FINUNCTY: financial uncertainty; SOCUNCTY: social uncertainty; MRKUNCTY: market uncertainty; EXTRMFTG: extraction and manufacturing industry (dummy variable, $N = 81$, base case); BUICONUT: building, construction and utilities industry (dummy variable, $N = 22$); FINSERV: financial services industry (dummy variable, $N = 25$); NFSERV: non-financial services industry (dummy variable, $N = 59$); DIV: diversification (dummy variable; related and unrelated diversified strategy = 1, single business strategy = 0); SIZE: size (log fte); SCBP: sophistication of capital budgeting practices.

systems in place) is an important determinant of changes in the accounting system. Apparently, expertise in one accounting area (for example, capital budgeting practices) provides the capacity to absorb change (i.e., to adopt new capital budgeting practices).

Multiple linear regression, using standardized variables, is used to test the hypothesis stated previously. To correct for the fact that industry may be a proxy for uncertainty, I estimate two models (one excluding, and one including industry dummies). Table 5 presents the results for this analysis.

The hypothesis stated previously is (at least partially) confirmed: the results of the analysis indicate that an increase in financial uncertainty results in an increase in the importance and use of SCBP ($p < 0.10$). The other uncertainties (input uncertainty, financial uncertainty and social uncertainty) are not associated with the importance and use of SCBP ($p > 0.19$). The empirical results thus indicate that an increase in specific uncertainties (more particular, an increase in financial uncertainty) is associated with the importance and use of SCBP.

The results for the control variables are mostly consistent with expectations. The impact of diversification on the importance and use of SCBP is in the hypothesized direction, yet not significant ($p > 0.15$). Consistent with expectations is that larger organizations find SCBP more important and useful than

smaller firms ($p < 0.01$). Finally, capital budgeting practices differ among industries. Firms in the building, construction and utilities industry (BUICONUT) and the financial services industry (FINSERV) find SCBP more important and useful than firms from other industries.

4.2. Additional statistical analyses

To ensure that the previous results are robust, I have used a number of tests to evaluate the assumptions underlying the regression model and to investigate potential data problems. First of all, the results for a regression model using factor scores are similar to the results presented previously. Second, tests for omitted-variable bias and heteroskedasticity (Verbeek, 2000) indicate that these aspects are not problematic and/or do not affect the results. The (lack of an) effect for diversification is also investigated in some depth; however, a more sophisticated measure does not explain the use or importance of SCBP by organizations.[9] Finally, it is possible to run a logistics regression (Verbeek, 2000, p. 179). For this logistics regression, 13 firms that indicate that they use both ROR as well as GT principles either 'sometimes' or more often are classified as 'SCBP-user', while 173 firms that are classified as 'non-SCBP-user' (three firms could not be classified due to a lack of data). The binary measure for 'SCBP-users' is highly correlated with the SCBP-measure previously used ($\rho = 0.53$, $p < 0.01$). Out of these 13 firms, 6 are from the financial services industry; the 'SCBP-users' are generally large and operate internationally. The logistics regression provides similar results to those presented previously in Table 5.[10] Based on these additional analyses, I conclude that my findings are robust.

5. Discussion

Finance and strategic management theory suggest that organizations (should) react to specific uncertainties in the investment decision by adopting SCBP (i.e., ROR and/or GT principles; see Smit, 2003; Zhu and Weyant, 2003; Bowman and Hurry, 1993). The findings in this study are generally in line with this theoretic notion: firms find SCBP more important and useful if financial uncertainties (exchange rate, interest) increase. Social uncertainties (political, policy, society), market uncertainties (competitive, output market) and input uncertainties (quality of labor and materials, R&D output) do not seem to have an impact on the importance and use of SCBP. An increase in specific uncertainties (more particular, an increase in financial uncertainty) is thus related to the use and importance of SCBP.

The analysis also indicates that firms use multiple tools and procedures (such as Monte Carlo simulations, decision trees, ROR, GT decision rules, etc.) simultaneously to evaluate investment projects. This is consistent with the notion that several tools are used to focus management attention on different aspects of the investment decision (Miller and Waller, 2003; Childs and Triantis, 1999). In addition, it suggests that a high level of expertise in the capital budgeting area provides the capacity and willingness to adopt new capital budgeting practices (see also Williams and Seaman, 2001; Libby and Waterhouse, 1996).

[9] An alternative regression analyses using dummy variables for single business, related diversified and unrelated diversified organizations, respectively a measure for the number of industries the organization is operating in, provides similar results (i.e., diversification does not significantly affect the use or importance of SCB).

[10] The only difference is that social uncertainty is negatively associated with the use and importance of SCBP in the logistics regression ($p = 0.04$).

It thus appears that firms add GT and/or ROR to existing capital budgeting practices (such as payback criteria and NPV-decision rules) rather than replace them.

The results for the control variables (diversification, size and industry) are mostly in accordance with expectations; the exception is that diversification is not related to the use and importance of SCBP. Consistent with expectations is that size appears to be related to the use and importance of SCBP. One reason may be that there are economies of scale associated with the implementation of SCBP like ROR and/or GT. A second reason may be that large firms are more likely to implement more complex administrative innovations (Rogers, 1995). Third, size increases complexity which results in the development of more sophisticated integrative administrative mechanisms (Galbraith, 1973). Finally, large firms have relatively greater access to resources to experiment with administrative innovations and participate in extensive networks that result in contacts with change agents internal and external to the firm (Chenhall and Langfield-Smith, 1998).

Also consistent with previous research is that industry has an impact on capital budgeting practices. More specifically, firms in the financial services industry and, to a lesser extent, the building, construction and utilities industries appear to find SCBP more important and useful than the extraction, manufacturing and non-financial services industries. The results indicate that it is more than solely uncertainty that affects the importance and use of SCBP. One reason may be that some industries have characteristics (for example, production type or intensity of competition) that make administrative innovations like GT and/or ROR more suitable to implement (innovation diffusion theory; see for example Abrahamson, 1991). Another reason may be that these industries are used to dealing with uncertainty through option-like analyses (Billington et al., 2003).

Like all research projects, this study has several potential limitations. For example, two of the control factors (industry and diversification) have been measured by rather crude measures. Although the diversification measure has been validated by additional data on the number of industries the organization is operating in, additional research is necessary to verify the impact of these factors on capital budgeting practices. Some other measurement instruments have been adapted in order to explore the relations of interest. For example, the capital budgeting process measure is 'extended' from the instrument used in previous studies (capital budgeting decision rules) to include uncertainty analysis and uncertainty adjustment tools. In case of uncertainty, the instrument has been adapted to capture aspects previously discussed in theory. Although these measures have been validated where possible, further research is necessary along these lines. Finally, the research project relies on perceptions rather than 'hard data'. As a result, we do not know whether the answers on the use of real options are based on using 'actual models' or 'intuitive adjustments' (Busby and Pitts, 1997).

There are a number of possibilities for future research that result from this project. First of all, case studies may reveal how companies use ROR and/or GT to deal with specific uncertainties in the investment project. Second, the relation between industry characteristics and capital budgeting practices may reveal some additional insights. Potential explanations may include the impact of fixed investments in these industries or technology disruptions. A third avenue for future research is the investigation of other organization characteristics (e.g. business unit strategies, reward and incentive structures, distribution of decision rights and financial structure) that have been shown to affect capital budgeting practices and the accumulation and integration of these results in a 'multiple contingency profile'. Another opportunity is to empirically investigate the interrelations between operational, financial and strategic risk management and capital budgeting practices. Such an analysis may reveal which management practices (insurance, capital budgeting, derivatives, etc.) are the most efficient for managing specific uncertainties. Finally, it

may be interesting to see whether SCBP is important for specific categories of investment decisions (e.g. expansion, replacements, mergers and takeovers).

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