

Driving Strategic Risk Planning with Predictive Modelling for Managerial Accounting: A Stochastic Simulation Approach

Abstract

Currently, risk management in management/managerial accounting is treated as deterministic. Although it is well-known that risk estimates are necessarily uncertain or stochastic, until recently the methodology required to handle stochastic risk-based elements appear to be impractical and too mathematical. The ultimate purpose of this paper is to "make the risk concept procedural and analytical" and to argue that accountants should now include stochastic risk management as a standard tool. Drawing on mathematical modelling and statistics, this paper methodically develops risk analysis approach for managerial accounting and shows how it can be used to determine the impact of different types of risk assessment input parameters on the variability of important outcome measures. The purpose is to: (i) point out the theoretical necessity of a stochastic risk framework; (ii) present a stochastic framework for modelling and computing stochastic input variables; and (iii) illustrate how currently available technology has made this stochastic framework easier. The Global Financial Crisis of the last couple of years has re-accentuated the relevance of a concept of risk, and the need for coherence and interrelations between risk theory and areas within management control. Our results show that – evaluated from four simulation scenarios – a company may benefit by developing different optimal risk strategies and then focusing on a few risk performance measures that can be used for decision making.

Keywords: Management control, risk, CIMA, experimental path, computational thinking, Monte Carlo simulation, structural equation modelling.

I. Background

Risk is a relatively new object within economic governance, and although risk has always existed, it has not yet found a proper place in management or managerial control, which reflects its importance. In the real world of business, a risk premium has been used in calculations together with a focused analysis of key areas of uncertainty. Each industry has had to face its own risks and each industry has learned to live with them. But a coherent application of risk within management control theory is still lacking. Within the literature there have been several attempts at treating uncertainty and risk as an economic subject. Both Keynes and Knight wrote on risk and uncertainty, both in 1921, and Arrow focused on the topic in 1984, without it ever finding its way into the theory of management control. Contingency literature (Neergaard, 1998) applies the outside world uncertainty as a factor, but with the caveat that "*In situation of high unpredictability the organization moves from information processing to experimental learning*" (Evans *et.al*, 1986 quoted from Neergaard, 1998).

Risk has been treated as a sort of error or as a lack of data in an information paradigm, and business practices have largely been defined by what EDP systems offered in which the concept of risk did not actually occur. Much is spoken and written about risk, partly because of COSO, Corporate Governance and "The Global Financial Crisis", but in practice there is "*little reported integration between management accounting and risk management*" and "*Risk management may be seen largely as a compliance exercise*" (Collier, Berry and Burke, 2007) or, "*to manage risk*

means, above all, to have available a set of tools or technologies” (Miller *et al.*, 2008). But appropriate concepts, methods and systems for economic management of risk have not yet found their form.

There exist different types of risk for different areas. Within financial accounting, risks are mainly represented by the recognition of provision (accounting) or Contingent liability, for example through fair value measurement which partially includes considerations of risk. Also hedge accounting allows for limited aggregation of mutually offsetting risks. In capital budgeting, risk representation ranges from flat adjustments to cash flows and duration via risk adjusted discount rates to decision tree analysis, stochastic simulation and real options. Within performance measurement, risk is usually represented in form of risk adjusted discount rates or hurdle rates.

Managerial Risk Accounting is concerned with the generation, dissemination and use of risk related to accounting information to managers within organizations to enable them to judge and shape the risk situation of the organization according to the objectives of the organization (Collier *et al.*, 2007). Existing accounting systems are primarily ‘monovalent’ as only a single accounting value (single point estimate) is attributed to a specific object, purpose or decision (Gribbin & Lau, 1996). Risk and uncertainty have normally been viewed by simple techniques for examples ranges of possible values connected to an object, decision tree etc. (see e.g. Drury, 2004 chapter 12). Normally, risk accounting techniques do exist but are in practice mostly restricted to financial instruments as accounting objects and financial institutions as accounting subjects. They include at-risk-measures such as Value at Risk, Cash Flow at Risk or Earnings at Risk. However, surveys have also shown that management accountants are missing relevant risk skills (Collier *et al.*, 2007).

In summary, it can be concluded that the representation of risk and uncertainty in accounting systems is limited in scope and technique as well as dispersed over different systems. As for now, no specialized comprehensive accounting system for the purpose of representing risk organization wide in comparable terms has evolved. Such a system should allow for the representation of risk in accounting terms connected to the goals of the organization such as liquidity and profitability on different organizational levels such as the organization as a whole, business units and projects. Central to this is the configuration of adequate risk measures to capture the risk situation and measures for the capability of the organization to bear risks (e. g. risk capital). These measures should also take into account behavioral and cognitive aspects of judgment and decision making under risk and uncertainty.

This paper is intended to contribute to the discussion of risk management in a managerial accounting setup, by shedding light on what influence risk management and how risk is perceived by users, and to “*make the risk concept procedural and analytical*” (Bhimani, 2009). A partial least square regression model is used as input for building a model, with the purpose to be able to evaluate different risk strategies in a management control setup by using Monte Carlo simulation. Drawing on mathematical modeling and statistics, this paper develops a risk simulation model and shows how it can be used to determine the impact of different types of risk assessment input parameters on the variability of important outcome measures. The paper focuses on building a Monte Carlo simulation model for testing different scenarios, in a perceived and a holistic view. This view is consistent with Collier *et al.*, (2007, p. xxi) statement:

The survey found that the methods for risk management that were in highest use were the more subjective ones (particularly experience), with quantitative methods used least of all. These results suggested a heuristic method of risk management is at work in contrast to the systems-based approach that is associated with risk management in much professional training and in the professional literature.

This study offers several contributions to the risk management accounting literature. Firstly, we document the possibility to design a Monte Carlo simulation model based on a survey on risk management. The significance of risk management is also demonstrated by its direct and indirect impact (through five latent dimensions) on different relationship. Secondly, the paper highlights the importance of a fully integrated approach through four simulation scenarios with different assumptions and policies. Thirdly, the study highlights the intermediate role of future expectations for a successful and holistic risk management framework. Finally, the results also demonstrate the need for more research into the area of Monte Carlo simulation risk scenario based on real data where both facts but also social and psychology elements are included.

In section II we draw on theory for risk management and management control. We present some remarks and ideas of risk management discussion in the managerial accounting literature. In section III we present the simulation model and the input model for the stochastic simulation model. We also outline the structural equation model including the various probability distributions used for all our input variables and together with short comments about the latent variables. In section IV we present the results of the simulation, and in section V we present the discussion and conclusions the study.

Most conceptual research on risk management has until now been based on field studies/case-studies. Much less research has been done in the combination of the conceptual and methodological domains. The combination of the 'conceptual domain' and the 'methodological' domain also supports ideas and comments for the increased use and interest on decision making in risk management environments (Collier *et al.*,2007).

The key research questions in this paper are therefore: *'how can Monte Carlo simulation thinking add value to the discussion of risk management accounting as a quantitative model by increasing 'scope' and 'differentiations' within the conceptual domain, and at the same time increasing the 'precision' with respect to measurement and control within the 'methodology domain'.*

The road for doing this is what Brinberg and McGrath (1985) call an 'experimental path' and in its final stage it will result in a 'study-design', that could be used for future research. Or more specifically, we want to demonstrate how simulation and modeling thinking can both broaden the focal problem by focusing on the purpose of strategic risk management and at the same time improving the technical modeling techniques, introducing items such as stochastic probability distributions, causality and feedbacks for learning in the simulation setup. In the 'experimental path', the main idea is to build a 'study-design' and implement it by using it on a set of events within the 'substantive domain'. The 'empirical' path and the 'theoretical' path are field studies such as case and survey, respectively (Brinberg and McGrath, 1985). Our research framework is shown in figure 1.

The concepts of the Monte Carlo simulation are primarily centred on a certain understanding of causality in a model formulation and design.

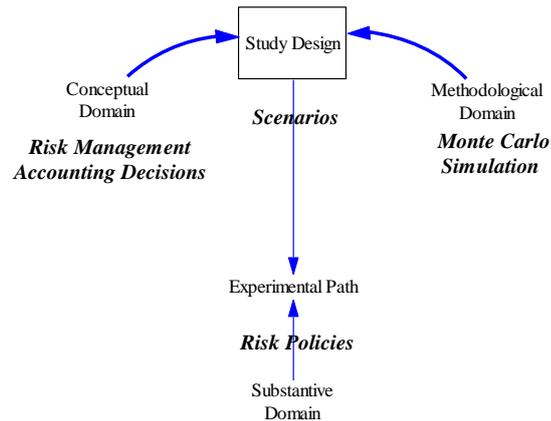


Figure 1: research framework

A model is a concatenation of various experienced causal laws offering a plausible representation and hence explanation for certain behavioural modes. Simulation is therefore, and this is important, not offering any ‘grand theory’; instead each model is a theory by itself. Simulation is concerned with aggregate social phenomena and not individual actions. Due to the level of aggregation aspect, Monte Carlo simulation is closely linked to Simon's (1991) ‘principle of bounded rationality’, which draws attention to the cognitive limitations of the information gathering and processing powers of human decision makers.

II. Risk management and risk control

Risk is an important element in all areas of company management: *“In conjunction with the firm’s owner’s and decision makers’ propensity for risk, the degree of uncertainty that the firm perceives it is confronted with will shape and determine the goals, objectives, strategies and operational activities of the firm”* (Bradshaw, Bui & Hunt, 2006). In ‘Total Business Strategy’ Noy (1998) express the “fourth strategic question” as: *“What is our attitude to risk? What risks, and to what extent are we willing to take?”*

Uncertainty about a situation can often indicate risk, which is the possibility of loss, damage, loss of profit or any other undesirable event. Most decision maker and companies desire low risk, which would translate to a high probability of success, profit, or some form of gain (Goldman, 2002). For example, if sales for next month are above a certain amount (a desirable event), then orders will reduce the inventory, and there will be a delay in shipping orders (an undesirable event). Not only the reduction of risk but also the insight into the assumptions of the model will dramatically improves the quality of the decision maker, in our example, the management accountant. Risk and uncertainty are a part of business decision making and must be dealt with somehow. Formally, risk differs from uncertainty in that that under risk, the probability distributions of variables are known (Hansen & Mowen, 1995). Under uncertainty, the probability distributions are not known.

Risk can be seen as an indirect value-driver (e.g. www.Topdanmark.dk), because risk management may imply a lower interest rate in a DCF model and may reduce the demand for equity (Stultz, 1996). Corporate Governance, in which risk management is an element, is also an important topic for companies listed on the stock exchange. Since strategic uncertainty and risk are furthermore crucial in the choice and the use of enterprise management systems (Simons, 1994; Widener, 2007), it seems obvious when Berry *et al.* (2009) point at *“Control and Risk”* as an *“emerging*

theme" of economic management. In line with a German review (Weissenberg): *"a comprehensive concept on exactly how risk controlling is to be integrated into controllership is yet missing in theory as well as in business practice"*.

The diversity of the risk concept is a problem for risk management which is not diminished by the fact that benefits and costs of risk management are often separated, both in 'place' and 'time'. A degree of interdependence among the various risk factors usually also increases the complexity (Hamberg, 2000). How far the concept ranges is perfectly illustrated by the title of Bernstein's (1996a) article *"The New Religion of Risk Management"*. A 350 year transition from superstition to numbers and facts is outlined, and a diffusion of the concept and its subjectivity is revealed in the title *"Degrees of belief: Exploring uncertainty"* in the last part in his book (1996b).

It therefore only seems natural, that CIMA would sponsor a research project on risk, with a special focus on *"how risk management impacted on both internal controls and on the role of the management accountant"* (Collier, Berry & Burke, 2007). This research material provides a vital foundation for our study. Based on their results, Collier, Berry & Burke modified their framework, so the attitude of risk ("risk stance") became an important factor for risk management together with the size of the company and the external demands through the Board of Directors.

The CIMA survey concludes that risk management is largely *"driven by institutional response to calls for improved corporate governance"* (Collier *et al.*, 2007). The same result as shown by a Spanish study (Dopico, Madrigal & Guzmán). A Danish study with a special focus on strategic risk management (Henriksen & Melander, 2004/2005) revealed that the majority of respondents had or were about to formalize their risk, while a follow-up (Henriksen & Møller, 2010) suggested that reflections on the usefulness are conducted afterwards. Formalities apparently play an important role in risk management; see also COSO and ISO 31000. Our study is focused on the perspective of the economic controller – in other words on the concrete technical management level but with perceived attitude. Since risk by definition is not only a negative phenomenon, but may also be positive, this perspective is also included. The company's ambition level, and hence its "creation risk" (Pontoppidan, 2006), is an often overlooked economic management task which also is sought explicated.

A definition of risk is provided by CIMA (Collier *et al.*, 2006):

'Risk management is the process by which organizations methodically address the risks attaching to their activities in pursuit of organizational objectives and across the portfolio of all their activities. Effective risk management involves: risk assessment; risk evaluation; risk treatment; and risk reporting. The focus of good risk management is the identification and treatment of those risks in accordance with the organization's risk appetite. The enterprise risk management approach is intended to align risk management with business strategy and embed a risk management culture into business operations'.

With a focus on what is actually done in the economic control and management of risk, we base our study on Collier *et al.* (2007) setup shown in Figure 2 with some modifications.

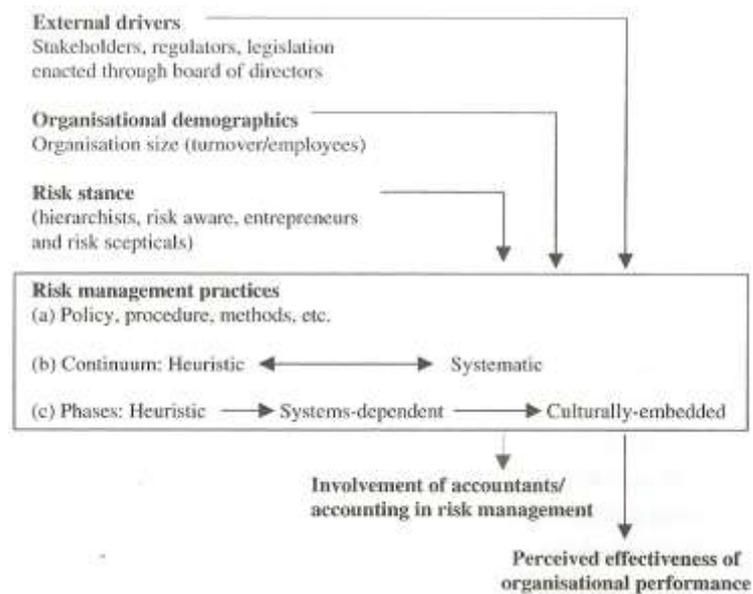


Figure 2: Revised framework for risk management practices in organizations.

Ref: Collier, Berry & Burke (2007)

The modifications are done in relation to Collier *et al.*, (2007) framework and are as follows: “Perceived effectiveness” is omitted in our study as are point (b) and (c) in figure 2 because they fall outside the focus of this study. The company's previous experience with risk is included, in "Organizational demographics", because past psychological experience is generally assumed to affect attitudes (Rosenberg & Hovland, 1960). The perceived satisfaction with the economic performance is also included, as this is assumed to affect risk behavior (Kahneman & Tversky, 1979). "Risk management practices" also examine the elements "Ambition" and "Opportunities". However, we will follow the idea of heuristic methods and the inclusion of ‘soft’ values such as policy and strategy.

After the discussion of Computational Thinking criteria including risk management decision into different types of forecast variables, we will discuss the use of the simulation models in the next section.

III. Building the simulation model

The concept of ‘computational thinking’

Simulation has been used for many years and for many different areas and topics within the social science (Rubenstein, 1981). Many issues within management accounting may actually be stochastic and has also been pointed out in previously literature. This applies, for example the use of probability models in planning (Buzby, 1974), use of multiple values (Chen & Summers, 1977, 1981), choice of subjective probabilities (Chesley, 1975), in budgeting (Ferrera & Hayya, 1970), cost deviations (Gribbin & Lau, 1993; Kottas & Lau, 1978; Liao, 1975), Cost-volume-profit analysis (Jaedicke & Robichek, 1964), depends application of the confidence intervals (Johnson, 1982), the uncertainty in ABC (Gribbin & Lau, 1996), to name just a small fraction of these. To calculate and exploit uncertainty logic, required in reality demands two assumptions both of which are known problems in statistics (see, for example. Yaman, 1964, or Greene, 2000);

- Knowledge or estimation of a probability distribution for any element or design variable in a model, and

- Knowledge or estimation and hence knowledge of the outcome that comes from aggregation, multiplication or division of the various fit-term probability distributions of the individual elements in the first point.

Classical accounting textbooks (e.g., Horngren, Drury, 200z; Foster & Datar 1994; Hansen & Mowen 1995; Kaplan 1998) describe the use of regression analysis to estimate the fixed and variable components of a mixed cost. From historical ordering-cost data, regression analysis provides directly estimate as a probability distribution: i.e., as a normal distribution with given mean and standard deviation. Often the mean of a parameter is used as a single deterministic point estimate. However, regression analysis requires adequate historical data, which is not always available for each parameter or input variable. Also, estimation with regression is either impractical or inappropriate for many input parameters.

However, in Wing (2006) the term “computational thinking” is used to articulate a vision that everyone, not just those who major in computer science, can benefit from thinking like a computer scientist, called ‘computational thinking’. Here is a definition used by the National Science Foundation, Larry Snyder of the University of Washington, and Wing (2010) about what constitutes ‘computational thinking (CT)’:

‘Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent’.

Without going into details, CT describes the mental activity in formulating a problem to admit a computational solution. The solution can be carried out by a human or machine, or more generally, by combinations of humans and machines and by an abstraction. An abstract data type defines an abstract set of values and operations for manipulating those values, hiding the actual representation of the values from the user of the abstract data type. Designing efficient algorithms inherently involves designing abstract data types (Wing, 2010). Computational thinking has already begun to influence many disciplines e.g., algorithmic medicine, computational archaeology, computational economics, computation and journalism, computational law, computational social science etc. Business and data analytics is now used in many different areas both within logistics and managerial accounting (Davenport & Jeanne, 2007). Therefore, using CT for mental or perceived model for risk management based on a structural equation model (e.g. based on a questionnaire) may be obvious. Because risk management is a complex topic building both on intuition and psychological perspectives because of the human factor related to it (Kahneman & Tversky, 1979). Therefore, estimations based on only hard core data is possible, but they could also be completely misleading. And the complex risk system includes elements that are probabilistic by nature, simplifying assumptions and heuristics to forecast future models will only fail (see Tversky and Kahneman, 1974). Therefore, Monte-Carlo simulation is used (Rubinstein, 1981) to analyze the behavior of the various decisions related to risk management.

Shortly about data, test model and PLS

Our starting point and input is based on the result of a survey conducted in Denmark earlier (Pontoppidan & Nielsen, 2010). This result built on an integrated risk concept based on a five-latent variable model, estimated by a PLS regression analysis, designed and tested Smart-PLS (version 2). It is the output from this analysis that is converted and integrated into a quantitative model comprising 25 input variables, five latent variables and correlations.

To get an idea of the relevance or the importance of risk we have asked the responds about how many times they have experienced major risk within the last 5 years. The results are shown in table 1.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid No risk	6	8,2	8,2	8,2
1-2 times	18	24,7	24,7	32,9
3-5 times	12	16,4	16,4	49,3
Several times	33	45,2	45,2	94,5
Not aware	4	5,5	5,5	100,0
Total	73	100,0	100,0	

Table 1: The frequencies of experience of risk

As it shows risk considerations have accrued several times which also indicate the importance of the concept. The basic starting point and inspiration for the survey conducted and on which our simulations model is based, is the work directed by CIMA (Collier, Berry & Burke, 2007, and 2006) and The Public Risk Management Association (2010).

There are different alternatives types of models that represent different natures and directions of epistemic relationships between constructs and indicators (Bollen & Lennox, 1991; Edwards & Bagozzi, 2000). PLS is particularly suited when the analysis is explorative and predictive (Wold, 1980; 1985) which is also the main purpose here by building and using different scenarios. PLS comprise of a structural model and a measuring model. The structural model identifies the relationships among constructs and the measurement model identifies simultaneously multiple relationships between manifest and latent variables. The PLS technique enables an overall assessment of the validity of constructs within the total model (Hair *et al.*, 1998; Wold, 1980). This ability is seen as an advantage over multiple regression and path analysis.

According to Bagozzi and Philipps (1982), a theory should contain three different types of concepts: (a) theoretical concepts that “are abstract, unobservable properties or attributes of a social unit of entity”; (b) some empirical concepts which “refer to properties or relations whose presence or absence in a specific case can be inter-subjectively ascertained, under suitable circumstances, by direct observations” (Bagozzi & Philipps, 1982); and (c) derived concepts, which are unobservable (like theoretical concepts) but “unlike theoretical concepts they must be tied directly to empirical concepts”.

The construct is an operationalization of a path construct using a five variable latent model - named ‘activities & techniques (depending variable)’, ‘procedures & culture’, ‘attitude’, ‘opportunities’ and ‘expectations’. The result of the test (used as input model here) is shown in figure 3.

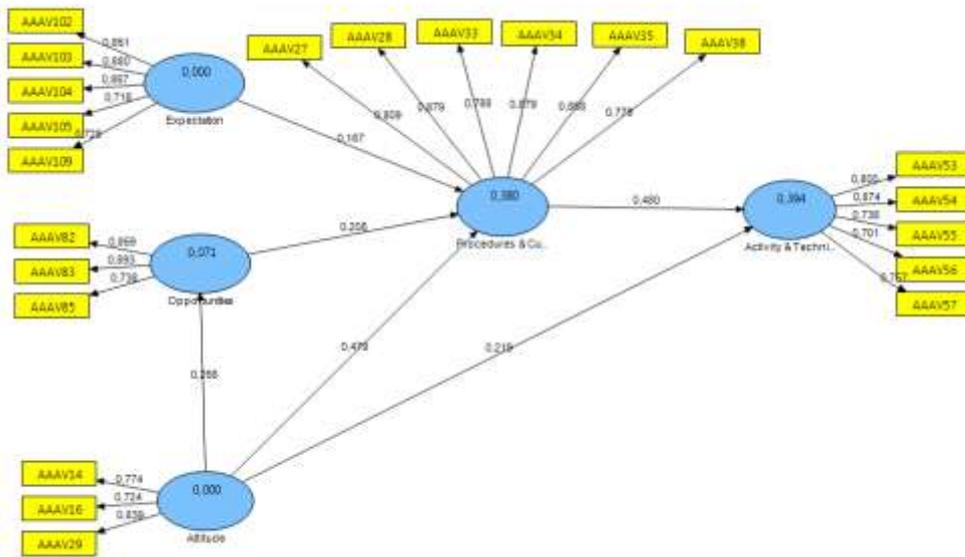


Figure 3: Conceptual Model for Risk Management Control

The realized and conceptual model in figure 3 is, however, not the main point here. Instead, the model is used as input to a Monte Carlo Simulation model (only correlations with $p < 0.05$ are included here).

The model can be expressed using the following three equations:

$$\text{Procedures \& Culture} = f(\text{Expec} + \text{Opportunities} + \text{Attitude})$$

$$\text{Opportunities} = f(\text{Attitude})$$

$$\text{Activity \& Tech} = f(\text{Attitude} + \text{Procedures \& Culture})$$

The demand for both convergent validity and discriminant validity are both within accepted levels. Item loading, together with the average variance extracted AVE captures the convergent validity of each of the measures for constructs that are modelled with values exceeding 0.50 for all constructs (Fornell and Larcker, 1981). Discriminant validity measured as correlations between construct all have values at an accepted level. Each measurement item loads higher on the appropriate construct than on any other construct (Chin 1998; Gefen et al. 2000), providing additional support as to the discriminant validity of the measures.

After obtaining all estimation parameters, fractiles, etc., fitting them to a probability distribution is a fairly difficult problem mathematical- statistical problem (Greene, 2000). Fortunately, this problem can now be handled by various software vendors¹.

¹ The Batch Fit Tool in CB automatically fits continuous probability distributions to multiple data series. The tool lists all of the Crystal Ball continuous and discrete that may be fitted to your data series. The Auto-Select setting will calculate the fits for the appropriate distributions using the appropriate ranking method. For example, the tool will only use the Chi-Square method for fitting to discrete distributions. If the data have a time-series element, trend, or seasonality, the CB Predictor should be used instead of the Fit Distribution functionality. This will not be present in this here. However, often the decision maker has to choose a distribution among the 24 different basic distributions supported by CB. CB also gives good advices for this choice e.g. by examples. Assumptions related to each distribution are obvious one of the most important aspect of using this tool. For

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Attitude

The latent variable Attitude contains significance of risk in the financial management, that risk must be secured, and that the company has clarified the organizational responsibility for risk. Input variables that reflect a "hierarchical" risk attitude according to CIMA's terminology (Collier *et al.* 2007).

Attitudes are relatively stable mental positions, "a combination of beliefs, feelings, and evaluation and some predisposition to act accordingly" (Gleitman, 1995). We categorize attitudes following Adams (1995), utilizing CIMA's terminology (op.cit.). In CIMA's study (op.cit.) risk management was driven by institutional response with supporting procedures & culture having a significant impact; in line with Theory of Planned Behaviour, where Attitudes together with Subjective norms and Perceived behavioural control predisposition behaviour (Weber et al., 2002, www.people.umass.edu/aizen).

The input variables are:

Input variables for attitude
AAA14: The concept of risk attributes important meaning in the company's management control?
AAA 16: Risks must be secured so the budgets can be kept?
AAA 29: Has the company resolved the organizational responsibility for managing the risks?

Table 2a: Variables for attitude

Opportunities

The latent variable Opportunities contains how the company manage their positive risk outcomes, how they measure them and how they include them in their calculations. Following CIMA's attitude categorization this variable indicate a "risk aware" attitude (op. cit.,18, 67). The variable can be understood from a normative perspective, as a wish to comply with external ideas of value creation, conforming with both CIMA's external drivers and to subjective norms in Theory of Planned Behaviour (op.cit.). It consists of three underlying variables:

Input variables for opportunities
AAA82: Measured probability weighted?
AAA83: Compiled using option theory?
AAA85: They are included as a probability weighted?

Table 2b: Variables for opportunities

example the Beta distribution is well recognized in business as a real-life distribution having a wide variety of shapes (in CB given by four parameters: min, max, alpha, and beta) and is much more difficult theoretically than fitting – say a normal distribution (Gribbin & Lau, 1993).

Expectations

Future expectations represent the ability to recognize where to put resources and increased focus. The latent variable expectations includes: increased emphasize on risk controlling, on risk reporting, on involve risk in management control, on managing ambition based on a risk assessment, and that the company will achieve better results, and will be able to fund themselves cheaper.

Based on psychological theory can be argued that expectations - as a kind of information about the future - is an independent factor in the choice of behaviour. (Walls in Birket-Smith, 1998) It can also be argued, that expectations, to a certain extent, overlap intentions and wishes and hence increase the likelihood of a given behaviour. Further it can be argued, that expectations mirror subjective norms, with a "compliance" motif. The variable can be understood from a phase development perspective, as future behavioural intentions in Theory of Planned Behaviour (op.cit.).

The input variables are:

Input variables for expectations
<i>AAA102: At the company's risk management?</i>
<i>AAA103: At the company's risk reporting?</i>
<i>AAA104: In order to incorporate risk in the company's management control?</i>
<i>AAA105: To manage the company's ambitions based on a risk assessment?</i>
<i>AAA109: The company will be able to finance themselves more cheaply?</i>

Table 2c: Variables for expectations

Supporting procedures & culture

This latent variable summarizes the risk management culture and risk procedures of the company meaning risk strategy, risk policy, the extent of risk analysis, risk plans, procedures and systems and of risk reporting. It is represented by its ability to recognize what types of different written documentation and risk techniques are used in the company and for decision makers concerning risk. It corresponds to both a similar variable in CIMA's study (op.cit.) and to 'Perceived Behavioural Control' in Theory of Planned Behaviour (op.cit.).

The input variables are:

Input variables for supporting procedures & culture
<i>AAA27: To what extent has the company established plans, procedures and systems to enable the management of risks?</i>
<i>AAA28: To what extent, does the company work out risk analysis and risk management?</i>
<i>AAA33: The company work out an entire list of business risks inclusive reporting and management?</i>
<i>AAA34: The company has a written and clear risk strategy (e.g. that certain risks must be rejected, reduced or accepted)?</i>
<i>AAA35: The company has a written risk policy (for example, that no risk must bring the company's existence in danger or that risks should be handled in a special way)?</i>
<i>AAA38: We use separate risk assessments / reports?</i>

Table 2d: Variables for supporting procedures & culture

Activities and techniques

The 'activity and techniques' construct is the depending factor in the model, corresponding to one of CIMA's dependent variables "Involvement of accountants/accounting in risk management". CIMA's other dependent variables "performance" is not included in this study.

There is a great deal of discussion about depending variables such as ‘performance’. However ‘performance’ may be different depending on the type of modeling approach and the purpose of the model. In this model the outcome effect is measured in where risk is included continuously for different control activities. Others have used numerical values for performance (e.g. EVA or ROI) or more developed statistical methods for the evaluation. Braam and Nijssen (2004) also offer a good illustration for this. They used three criteria: ROI, a pooled general measure of performance called ‘overall company performance’ and a ‘perceived company performance’. However, the performance of risk management, using these methodologies is likely to be underestimated due to the fact that the risk generates a multilevel performance effect and outcome (Papalexandris *et al.*, 2004). In this study we do not include performance as a variable.

The Input variables are:

Input variables for activities and techniques
AAA53: <i>Included in the company's strategy?</i>
AAA54: <i>Included in the budget?</i>
AAA55: <i>Included in investment calculations?</i>
AAA56: <i>Included in the P & L statement?</i>
AAA57: <i>Included in projects?</i>

Table 2e: Variables for activities & technique

Some primary comments

The conceptual model is convincing and gives food for thought. It shows convincingly how dependant behaviour, in this study, is on attitude but also on supporting procedures and cultures as well as on Expectations and on Opportunities. It gives food for thought because risk, in this study, administratively and explicitly is integrated in management control - contrary to the CIMA study. Risk is explicitly and formally integrated in the MCS (Management Control System), not only in budgeting. It is also interesting, the extent to which the variables are integrated cf. Hamberg (2000).

Both CIMA (2007) and Henriksen *et al.* (2005, 2010) assume a maturity trend, in the management of risk cf. also e.g., Tillinghast -Tower Perrin (2001). Assuming this, it can be noted, that Danish companies have taken up the risk challenge. Seemingly, a phase ahead of the CIMA respondents, has established a solid MSC fundament for further development. A development the “risk aware” variable “opportunities” may be a sign of. The question is how this development will be? It is a possibility that risk will be connected to another management control system e.g., to BSC, such as Kaplan invites to (Kaplan, 2009)². Be it a traditional BSC model or a supplemented one as e.g. Reichmann’s double model (Reichmann, 2009).

Another possibility is the data grounding many companies have in their ERP system (Enterprise Resource Planning), as these systems today make simulation possible to uncover the economic risk in the company. As in this article it is a possibility to construct a PLS model, convert it to a SEM model and then via simulation to uncover the risk sensitivity, the risk Achilles heel of the company (Pontoppidan, 2006).

Bhimani (2009)³ seems to insist on a technification of risk, so risk ‘becomes operational and actionable, because they can be formalised and rendered technical. Making risk (and governance) concepts procedural and analytical enhance their capacity to be managerially actionable’. ”Risk modelling” (Collier *et al.*, Burke, 2002) is the formal and

² *Balanced Scorecard Report*, 2009, Nov-Dec Risk Management and the Strategy Execution System.

³ Bhimani (2009) Risk management, corporate governance and management accounting, *MAR*, 20 (2009) 2-5

rational way to include risk in management control. EDP tools are already in place, but ” In each organization the context of unique circumstances, history and technology had led to different processes of construction of ideas about risk”, cf. that Mikes consider culture as a defining factor for how risk is managed (Mikes, 2009) ⁴. However, the context dependence and subjectivity of risk does not reduce the need for risk modelling, to the contrary. And scenario planning and simulation are relevant tools for putting risk in words and numbers, be it ‘risk considered’ or ‘risk excluded’ situations (Collier et Burke, op.cit).

Uncertainty and unpredictability are components in risk. Hence it is not enough to calculate, judgement is needed too (Adams, 1995) making scenario planning and simulation ideal tools because ‘risk taking, experimenting and learning goes together’ (March, 1994).

But Berry& Collier found little or no evidence of use of statistics in risk aspects of Management Control (Berry *et al.*, 2009)⁵. ‘Yet the relationships between management control and new IT remain underdeveloped both theoretically and practically’. (op.cit.). Collier et Berry (2002)⁶ judged the lacking inclusion of risk in the budgets by means of Scott’s typology (1998), as an incomparability between the rational perspective in the budget and the natural perspective in risk perception, where the management mediate between the two, “containing” risk (op.cit.). Although they found ‘No evidence of any formal risk modelling’ and ‘No managers, in any of the four cases, suggested any calculation or use of probabilities’ (op.cit.), none the less they expressed the belief that ‘a more educated managerial and financial workforce and a greater likelihood that financial managers and accountants would be open to more structured and analytic considerations of risk’ (op.cit.), with ” a more holistic approach with risk being used to aid decision-making”(op.cit.).

Collier, Berry et Burke (2007) categorizes scenario analysis as a basic method while stochastic models and statistical analysis are categorized as technical methods (op.cit.), but they did not find any real use or belief in either of the methods. Computational Thinking (Wing, 2010) can be a way of closing the gap between the need of risk modelling and the actual integration of risk in management control – now it no longer need to be blocked by ”new technologies (were) perceived as cumbersome” (Berry et al., op.cit.).

IV. Simulation Results

This section primarily aims at illustrating the usefulness of the Monte Carlo simulation in relation to assessing different planning and risk strategies given the designed model above⁷.

Monte Carlo simulation refers to the manner in which individual numbers are selected from valid ‘representative collections of input data’ (often historical) so they can be used in an iterative calculation process (Pidd, 1988). These ‘representatives’ are some sort of a ‘frequency distribution’ that is converted to a probability distribution. Monte Carlo Simulation is primarily in used in situations where: the system being studied can be mathematically described by numbers or metrics, which can be either parametric or analytic; the data can be written as some sort of a frequency distribution; the ‘output’ or ‘results’ must accurately represent the input data; the calculated distribution histogram of

⁴ Mikes (2009), Risk management and calculative cultures, *MAR*, 20

⁵ Berry, Coad, Harris, Otley & Stringer (2009) Emerging themes in management control, *The British Accounting Review*, 41

⁶ Collier et Berry, (2002). Risk in the process of budgeting, *Management Accounting Research*, 2002,13

⁷ We have used Oracle Crystal Ball Release 11.1.2.1. (2010), which is an Excel Add-In. Oracle Crystal Ball is the leading spreadsheet-based software suite for predictive modelling, forecasting, simulation, and optimization. Used by 85 % of the Fortune 500 and taught in the top 50 U.S. MBA programs, Oracle Crystal Ball gives unparalleled insight into the critical factors affecting risk, and calculates the likelihood you will reach your objectives.

the 'answer', or 'results' must accurately reflect the input data; and the calculated uncertainty in the 'result', or 'output' must be an accurate measure of the validity of the model (Wright, 2002).

Clearly, any simulation is the product of the specific model structure formulated and the specific initial state specifications used, often referred to as garbage-in, garbage-out in case that the model used is only poorly documented in reality (Ackoff, 1981; Law & Kelton, 1991). The overall idea may be simple with the models at hand: adapt and reduce different strategy scenarios to obtain a satisfactory output (Anthony, 1970; Kaplan & Norton, 2008). The outcome from the simulation should also be used for feedback and learning meaning the ability at any point to know whether the formulated risk strategy does, in fact, work, and if not, why. Still, this discussion is rather a matter of degree of usefulness than a matter of being true or not. Below a few risk management scenarios is described. The risk scenarios in table 2, is inspired from case-studies and surveys conducted by Collier *et al.*, (2007). However, many risk are not objective identifiable and measurable but are subjective and qualitative. Risk is therefore to a considerable extent socially constructed and responses to risk reflect that social construction (Collier *et al.*, 2007). Their results also show that the content of the budgeting was risk excluded, meaning that budgets were normally focusing only on a single point estimates even though risk was included in the process of budgets. Their results also showed that risk is mostly seen as a more holistic and more proactive view, for example by using heuristics and in a managerial perception view instead of quantitative specific models. For management accounting, this means both a focusing on selected performance measures and performance management but also an operationalization of the strategy related to risk (Kaplan & Norton, 2008).

In today's competitive global economy, decision makers (CFO, accountants, and others) are faced with many difficult decisions. Such decisions might involve thousands of potential alternatives each day. An analytical model (based on updated historical data) can provide valuable assistance in analysing decisions and finding good solutions and answers. Models should capture the most important features of a problem and present them in a form that is easy to interpret and use. Models often provide insights that intuition alone cannot. An OptQuest optimization model in Crystal Ball has four major elements (Oracle, 2009):

- An Optimization Objectives—Elements that represents the target goal of the optimization, such as maximizing profit or minimizing cost, based on a forecast and related decision variables.
- Requirements—Optional restrictions placed on forecast statistics for example that the variance of a TD-ABC should below a specific value. All requirements must be satisfied before a solution can be considered feasible.
- Decision Variables—Variables over which you have control; for example, the amount of product to make, the number of dollars to allocate among different investments, or the range of a cost driver.
- Constraints—Optional restrictions placed on decision variable values. For example, a constraint might ensure that the total amount of money allocated among different activities cannot exceed a specified amount.

For many types of risk analysis the histogram can be used to answer the following questions: *i*) What kind of population distribution do the data come from; *ii*) where are the data located; *iii*) how spread out are the data; *iv*) are the data symmetric or skewed; and *v*) are there outliers in the data? With these elements at hand, different scenarios may be formed and executed.

The idea of the input for the four scenarios is chosen to give both a focused and a balanced image of a model perception for risk management in a management accounting and model setup. Identification of risk and uncertainty – as done in the base run setup – may be seen as the first step in good risk management meaning by increasing the insight into the understanding of the potential upside and downside of all those factors which could affect the organization (Collier, *et al.*, 2007). The Institute of Risk Management (2001) operates with four elements: a) risk assessment, b) risk evaluation, c) risk treatment, and d) risk reporting. Because we draw on a survey as input to the model (meaning more general and not company specific assumptions), our results of the simulation scenarios may also be seen in as general circumstances. Heuristic are viewed as models attempt to gain insights methodically on the basis of previous experience. Heuristic methods are designed to efficiently produce ‘good’ although not necessarily optimal, solutions (Weatherford, 2001). This heuristic experience is rooted in: subjective practical experience and observations, conjectured business interrelationships, and business theories related to specific aspects. Bhimani (2009) also point to a ‘quantification’ of risk by saying:

Placing boundaries on risk taking and organizational functioning by identifying acceptable variances from predefined parameters of action is fully part of the definition of management control for most modern organizations.

It is important to distinct between objective measurable risk (e.g. in pricing, customer analysis, currency etc.) and the perception of risk management, which is the topic here (e.g. ways of handling risk, information etc.) and influenced by experience of accidents (Adam, 1995). Individual risk taking represents a balance between perceptions of risk and the propensity to take risks. Prior research shows that we know little about how managers consider risk (Collier *et al.*, 2007). Risk perception is, however, much a cultural process, each with a set of shared values and supporting social institutions being biased toward highlighting certain risks and downplaying others. Socially constructed view of risk seems better to reflect an organisational risk management than rational modelling approaches (Collier *et al.*, 2007).

The base run⁸

The results of the base-run is shown in figure 4 (probability distributions for all input variables are shown in Appendix A together with the parameters for each distribution) supported by statistics to the right in the figure⁹. The cumulative distribution together with level of intervals is shown in the lower part of figure 3.

⁸ All output from the simulations are shown with nominal values. However an easier way for interpretation is to use indexes.

⁹ Simulated 1.000 trials based on Latin Hypercube simulation sampling, which divides each distribution into the specified number of 500 intervals (bins) with Initial Seed Value of 999, which determines the first number in the sequence of random numbers generated for the assumption cells (integer)). Cells in CB may either be: ‘neutral’ i.e. no definition made for any CB tool; an assumption cell where specific assumptions are made for input, a decision cell related to optimization (OptQuest), or as cell for prediction (Predictor) or a forecast cell (normally defined as outcome).

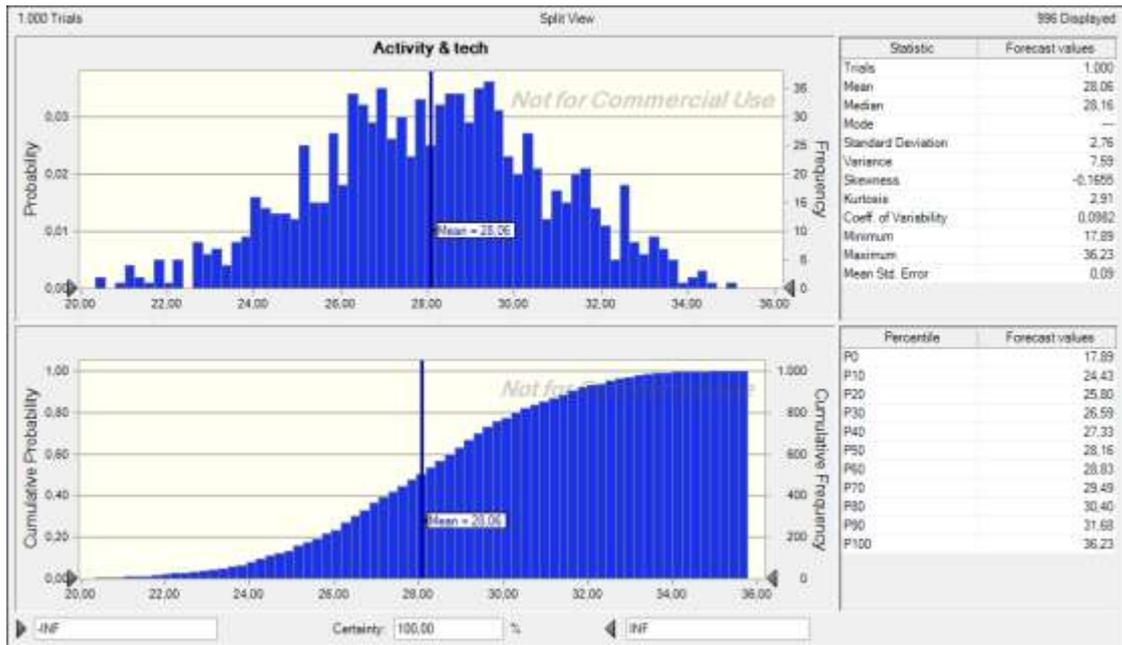


Figure 3: Frequency view and statistics for ‘activities & techniques’ and statistics

The outcome yield important information for the perceived risk. Besides, mean (median and mode) several parameters for deviation from the mean, e.g., std., *skewness* (a measure of symmetry or the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point), *kurtosis* (a measure of whether the data are peaked or flat relative to a normal distribution, e.g., data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails and vice versa), *coefficient of variability*, minimum and maximum values for the variable. These measures may be related to different types of ‘risk’ and may be candidates for changes or testing. The cumulative distribution of ‘activity & techniques’ is shown in the lower part of figure 4, supported by the percentile for the forecast value that could be used explicitly as the level of conservatism. For example, the conservatism at a 90th-percentile level, the data in figure 4 suggests that a value of 31.38 should be used as the bases for this model. On the other hand, a more aggressive and reasonable policy could suggest a value 27.33 at the 30th-percentile level. Companies are seeking to reduce risk and uncertainty; therefore, a benchmark could be to run the model in a clear deterministic setup. Doing this, the absolute maximum for the depending variable in the model, results in a value close to 100 (exact value 106.98). This represent at full-scale model based on correlation between all latent variables of 1.0 (without range values for decision variables) meaning no uncertainty is included. In isolation, all risk initiatives that may increase the correlations between the latent variables and reduce the uncertainty or the stochastic element will also improve the perceived risk management – ceteris paribus (including input variable e.g., AAA16 about the budget).

Selecting the best or the ‘optimal’ combination of policies, and justifying it within the existing benefit/cost framework, is compromised by the inability to quantify the risks within the organization (costs or lost contributions), and the complexities of interaction between different policies, strategy and operational variables in combination. However, a heuristic search may be used for improve the interrelation in the model (Weatherford, 2001) e.g., within the management control area.

For example, a performance measure with a low kurtosis is a potential target for improvement i.e., starting a project to reduce it by getting employees focused and linked to closer reporting or attitude to the depending variable¹⁰.

With the base-run information now at hand there are, however, a number of scenarios and policies that may be at our disposal. Since this concerns risk and uncertainty for a management accounting decision-maker, the question is what could be of interest to look into of the perceived risk model? An interesting thought could be to see how to increase the integration of the different areas in the model (i.e. higher correlation between some of the latent variables).

Scenario two

This scenario is based on the same assumption as the base run, but extended with a search for a reduction of the variance. This iterative process has been studied under several names. It is called a "learning heuristic" by Baumol and Quandt (1964). Others have suggested that the heuristic can be viewed as a representation of 'satisficing' as a limited information search and sequential processing (Simon, 1955). This process has earlier been used in accounting on prices and costs (Dickhaut & Lere, 1983). This means that the level of output is arrived at sequentially in steps.

By using Crystal Ball OptQuest, it becomes possible to focus on specific performance measures and to set targets for these measures under different kinds of restrictions and constraints. There may be several measures expressing different kind of variance in the data. One important measure for risk and simulation studies is the variance of the outcome (depending variable). Based on previous information we will now test the following simple policy:

Maximizing the mean of the outcome (activity & techniques), subject to a requirement that the variance can be reduced by 20 % (meaning equal or less than 6.0)

The performance chart in figure 6 displays the trajectory of the search, meaning the rate at which the best objective value has changed during the course of the search. This is shown as a plot of the best objective values as a function of the number of simulations (solutions). If any requirements have been specified, the line might initially be red, indicating that the corresponding solutions are not feasible according to the requirements. As it can be seen, the decision variables are different depending on the latent variables respectively.

¹⁰ Crystal Ball also informs about specific reports within each tool e.g., Goodness-of-fit, Fitted assumptions, Creating reports and Extracting of data. Statistical assumptions can be seen in the technical part of CB manuals.

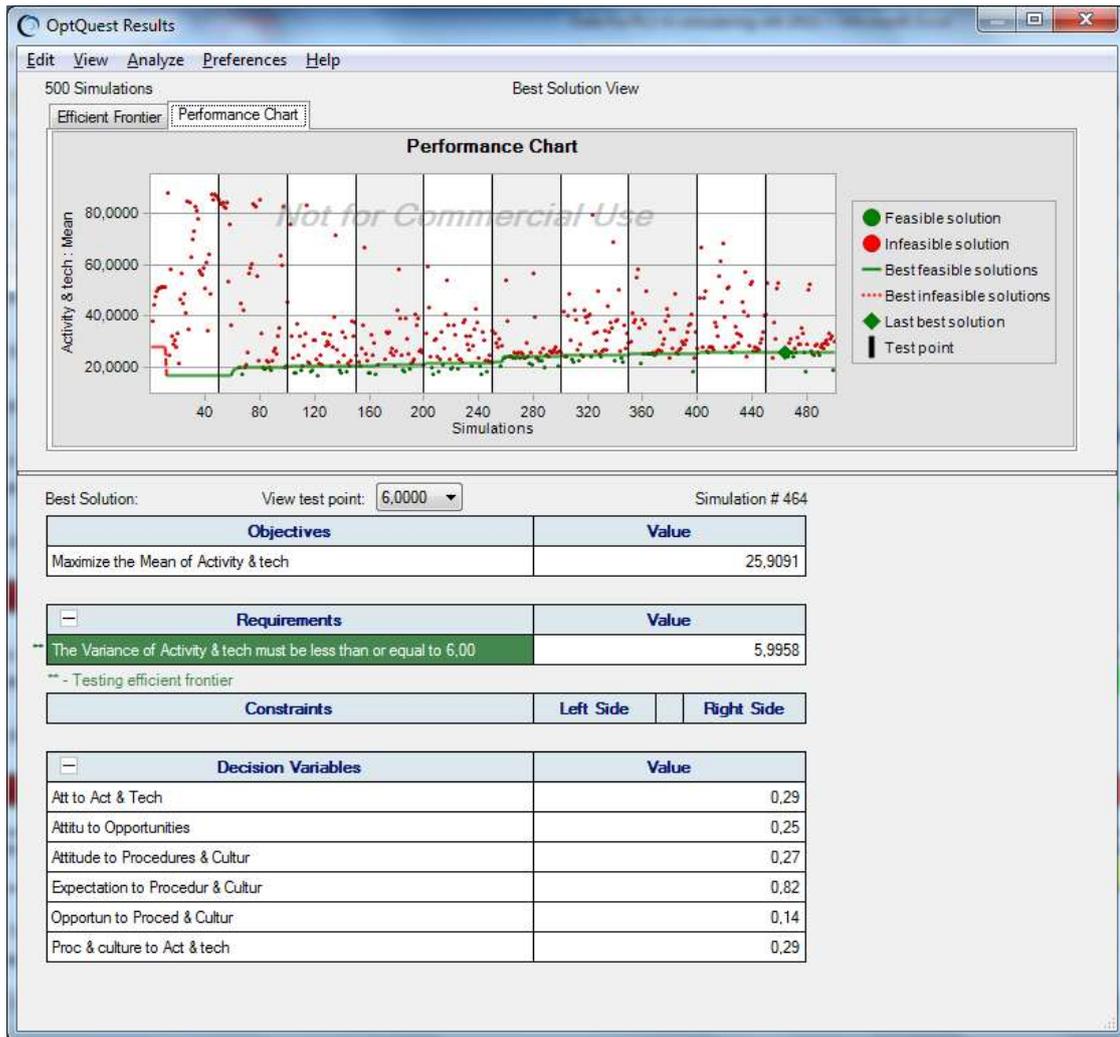


Figure 4: The performance chart and decision variables for scenario two

The OptQuest result shows that it is possible to reduce the variance to a level of 5.98 as the absolute minimum given the imposed restrictions (simulation no. 464). The values of the decision variables are shown in the part of the table ‘decision variables’. If the decision maker wants to reach this target, he/she has to accept a lower mean (now 25.9 against 28.1 in base-run) and also be willing to improve the integration (meaning increasing correlations) as can be seen in lower level of figure 6 (e.g. between ‘expectation’ and ‘procedures and culture’ from 0.167 to 0.82) but at the same time may relax the correlation between ‘attitude’ and ‘procedures & culture’ (from 0.47 to 0.27). The main reason for this is that ‘procedures & culture’ is an important factor for ‘activities & techniques’. Looking into the outcome from ‘activities & techniques’ it also shows that the mean has increased about 3 points indicating a larger benefit. The results of testing the variance against the mean of the outcome is shown in figure 5. OptQuest includes several advanced features, one of which is its ability to automatically perform an Efficient Frontier Analysis. The efficient frontier is a concept in Modern portfolio theory introduced by Harry Markowitz in the 50s. This type of analysis is often used within finding optimal portfolios of different types of investments and assets. If you were to examine all the combinations of investment strategies – or in this case – all combinations of all five latent variables expressing different types of risk strategies, you would notice that each combination of the latent variables (potential portfolio of these) has its own

specific mean on ‘activities & techniques’ and variance of the mean. Points on or under the curve represent the possible combinations of the latent variables. Points above the curve are unobtainable combinations given the particular set of decision variables. The portfolios that lie directly on the curve are called ‘efficient’, and the curve itself is often called the ‘efficient frontier’.

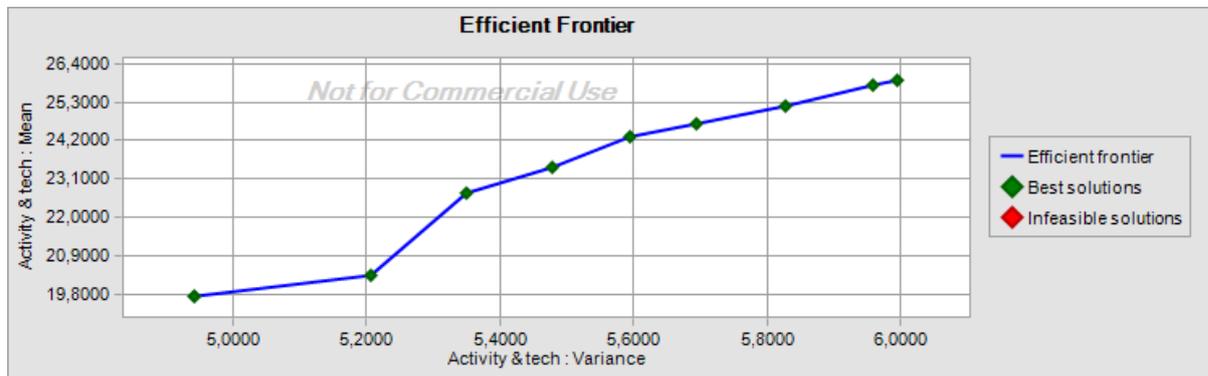


Figure 5: Efficient Frontier between variance and the mean for ‘activities & techniques’

Not uncommon that an increase in the variance implies a larger return in the form of the mean (Brealey & Myers, 1981). However, the form of the graph shows that the increase is specifically increasing between 5.2 and 5.4. OptQuest gives you the possibility to review all combination by looking at the values of the decision variables depending on the preferences for the variance. This means that a company may choose different risk strategies depending on costs and profit (risk aversion). With a lower variance the risk of not meeting the budget is reduced, consistent with the hierarchical attitude in the base case (scenario 1) (Collier *et.al.* 2007).

Scenario three

This scenario is based on the same assumptions as scenarios two, but now the intention is to be able to increase the mean and at the same time increase the demand for kurtosis. An important measure for risk and simulation studies is the concept of ‘kurtosis’. Kurtosis measures the degree of peaked-ness of a curve. It is sometimes referred to as the "volatility of volatility." The higher the kurtosis, the closer the points of the curve lie to the mode of the curve. A normal distribution curve has a kurtosis of 3. ‘

If a distribution is symmetric, the next question is about the central peak: is it high and sharp, or short and broad? You can get some idea of this from the histogram for the output, but a numerical measure is more precise. The height and sharpness of the peak relative to the rest of the data are measured by a number called kurtosis (Kmenta, 1986). Higher values indicate a higher, sharper peak; lower values indicate a lower, less distinct peak. Or putting it another way: increasing kurtosis is associated with the “movement of probability mass from the shoulders of a distribution into its center and tails (Balanda and MacGillivray, 1988).

In figure 6 three distributions are shown, all with a mean of 0, standard deviation of 1, and skewness of 0, and all are plotted on the same horizontal and vertical scale. Look at the progression from left to right, as kurtosis increases.

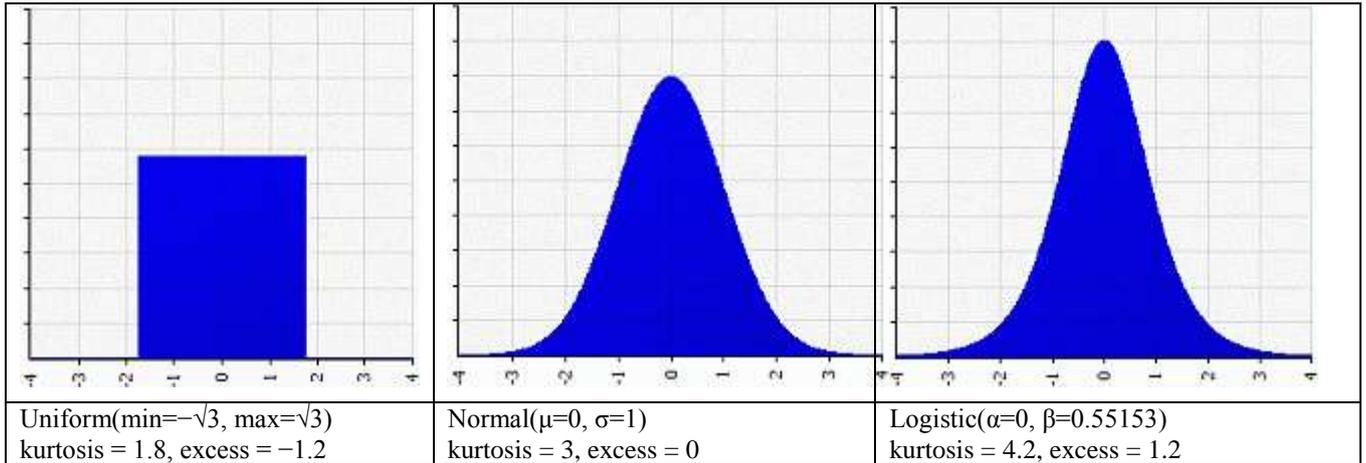


Figure 6: Different kurtosis

Based on previous information we will now test the following simple policy:

Maximizing the mean of the outcome (activity & techniques), subject to maximizing kurtosis

Investment and risk management normally provides investors with performance measures based on some capital market theory. Two of the most popular performance measures are the peak-ness ratio and the information ratio (Bertrand, 2008). Used for risk management, we are searching for an outcome with a high kurtosis (Balanda, 1988).

Distributions with kurtosis values of less than 3 are described as platykurtic (meaning flat), and distributions with kurtosis values of greater than 3 are leptokurtic (meaning peaked). Kurtosis, or peaked-ness, is calculated by finding the fourth moment about the mean and dividing by the quadruple of the standard deviation (Kmenta, 1986):

$$k = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^4 / s^4$$

The result of the simulation is shown in the performance chart in figure 7.

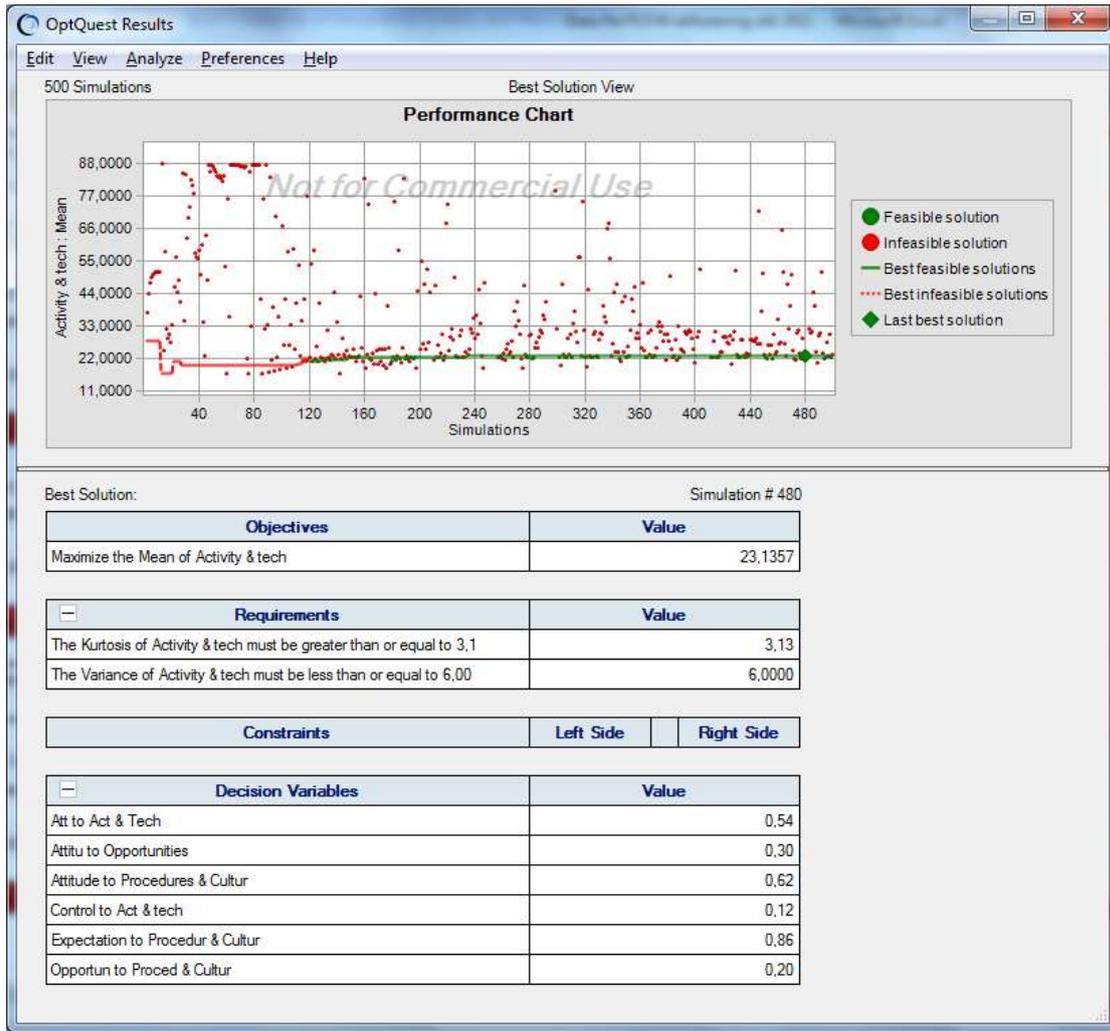


Figure 7: The performance chart and decision variables for scenario three

Decision theory and portfolio theory often include the 3rd and 4th moment, due to preferences for a positive skewness and for avoiding high kurtosis (Bertrand & Protopopescu, 2008; Jurczenko & Maillet 2006; Cambell *et al.* 2010). The scenario changes the correlations radically between both opportunities and expectations to procedures & culture.

Scenario four

This scenario is based on the same assumptions as scenarios three, but now with a demand on a higher integration between attitude and opportunities. The idea is that attitude plays an important role for risk management (Collier *er al.*, 2007). Based on previous information we will now test the following simple policy:

Maximizing the mean of the outcome (activity & techniques), subject to a demand on the integration between attribute and opportunities to at least 50%

The result of the simulation is shown in the performance chart in figure 8.

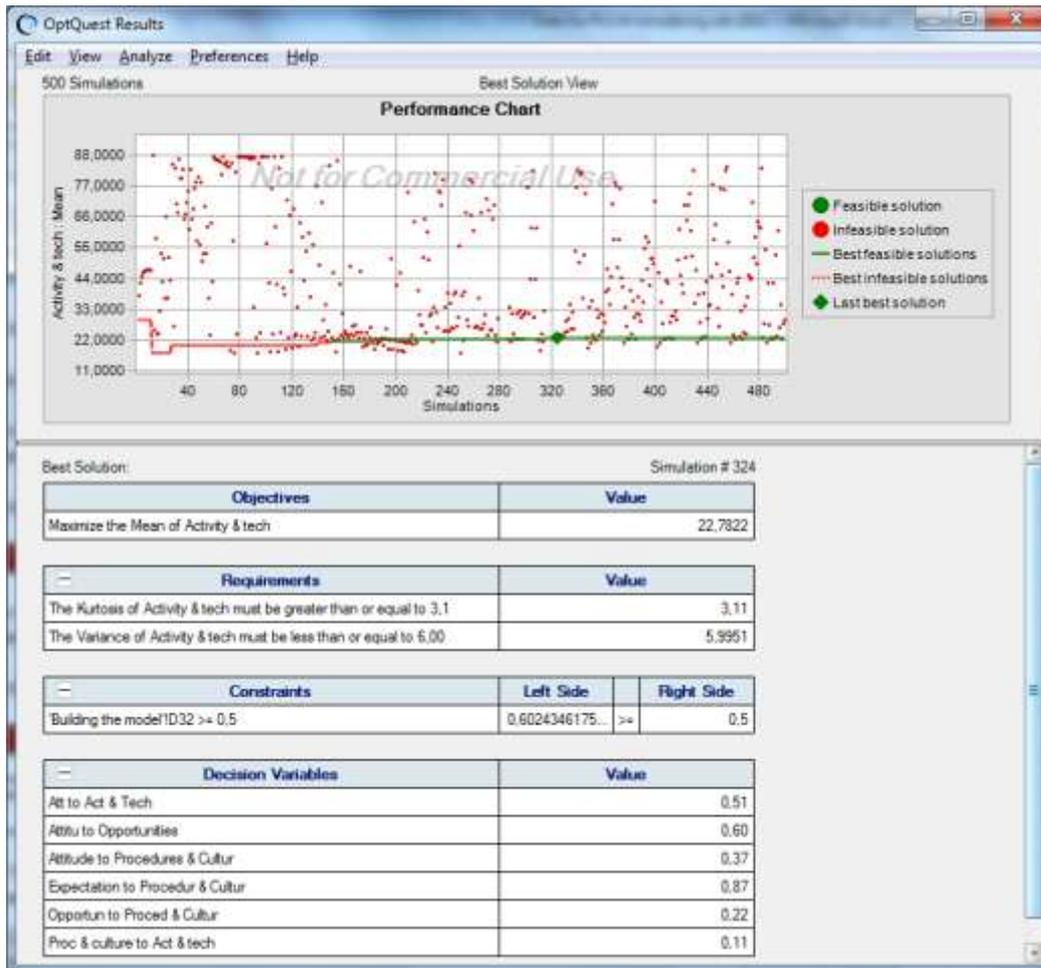


Figure 8: The performance chart and decision variables for scenario four

Under these conditions it can be seen that the relation between attribute and opportunities will at least reach 60%. However, the mean will decrease from 23.1 to 22.8. It also influences the correlations between the rests of the decision variables: for 'Att'(attribute) a reduction from 0.54 to 0.51; for 'Att' to procedures & culture from 0.62 to 0.37; for expectation to procedures & culture from 0.12 to 0.87; for opportunities to procedures & culture from 0.86 to 0.22; and for procedures & culture to activities & techniques from 0.20 to 0.11. The substitutions between different areas are important and must be determined before a company can be sure that implement risk management will succeed. The result of the simulation based on these conditions is shown in figure 9.

The requirement for a higher correlation between attitude and opportunities can be a way of testing a more "risk aware" attitude than the "hierarchical" that describes the base case (scenario 1) (Collier *et al.*, 2007). Following CIMA a risk aware stance should be a weaker predictor than a hierarchical stance (op.cit.). In figure 9 the simulation results based on the optimal solution is shown including the revised cumulative distribution with values and precisions.

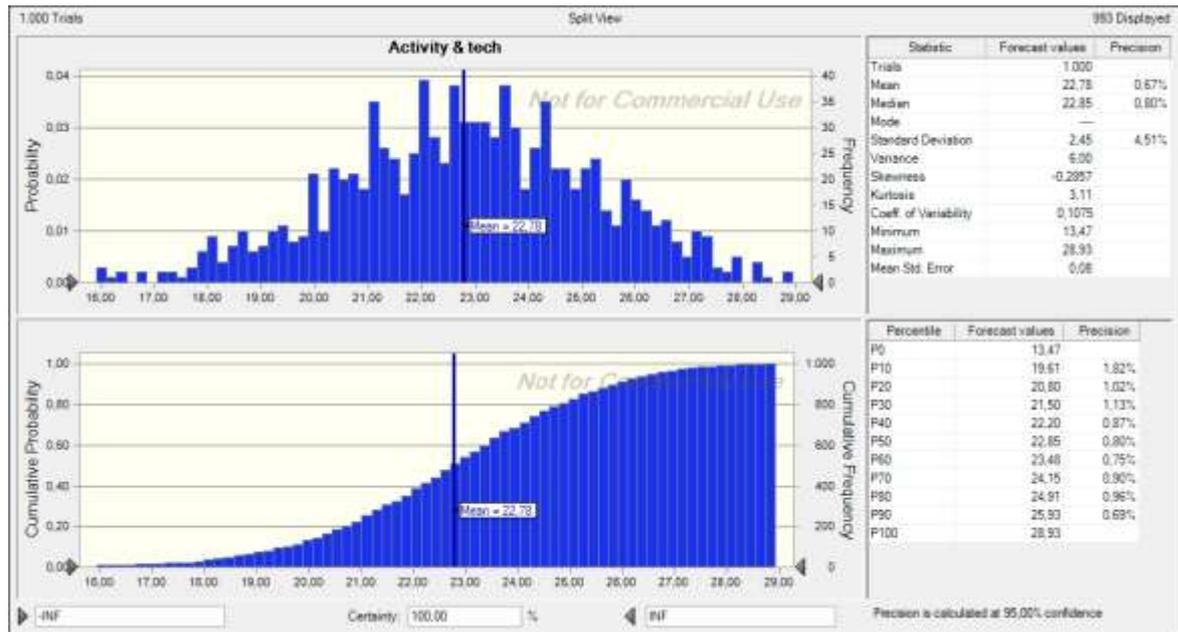


Figure 9: The result of the simulation

Some primary comments

The four scenarios have hopefully illustrated the usefulness of simulation as a tool for adaptation and for risk learning. Not only because relevant variables and their interrelations experimentally can be manipulated to clarify the potentially negative and positive risks (as in the base run), but also for giving insight in the possibility of adapting variables and/ or relations to obtain an acceptable ‘risk landscape’ (as illustrated in scenario 2,3,4).

V. Summary and conclusions

The objective of this study has been to propose and develop a methodical risk analysis approach for managerial accounting (Bhimani, 2009), drawing on mathematical modelling and statistics. By investigating different risk strategies based on a SEM model (PLS) consisting of five latent and 25 manifest variables. We have only focused on a Monte Carlo simulation model based on SEM. The study has been inspired by the result and the direction of future research within risk management for management accountants specifically Collier *et al.*, (2006, and 2007) and Bhimani (2009). In the Collier study future research point to holistic and more strategic oriented model, combined with a heuristic approach while Bhimani calls for risk management to become “*procedural and analytical*”. This paper has given a few important research contributions in relation to these topics.

First, we have pointed out that a Monte Carlo simulation framework is a logical necessity for many risk management topics if the purpose is to make operational. The implementation of a stochastic framework is particularly relevant for risk evaluation for the following reasons. Many risk values (shown as different performance measures) are known to be “formalities,” with which the issue of accuracy is often irrelevant. In contrast, the explicit purpose of simulation is to provide accurate and relevant information to aid controllers and management accountants in logical

decision making. Also many accounting systems were established before the technology to practically implement a stochastic framework was available. In contrast, risk management is developed in an era where a stochastic framework is practically feasible and in line with the concept of 'business analytics'. Besides reviewing the theory of a stochastic risk framework, one major purpose of this paper has also been to show how we can design, use and test different relations of uncertainty. The stochastic framework can be implemented with a minimal amount of mathematical, statistical and computer knowledge. However, it is important still to keep in mind possible technical flaws and limitations related to different software packages. These must, however, be discussed in technical terms.

Second, the output of our simulations has shown that a company may gain a lot of knowing how related areas are correlated. Only in doing so it will be possible to test different scenarios – which may for the individual company – be very different. Important here is to pin point that this study is based on a perception view – not on hardcore numbers derived from accounting or other sources. However, this view is much in line with the recommendations made by Collier *et al.*, (2007).

Limitation in this study is mostly related to how respondents view or perceive the five decision variables: attitude, opportunities, expectation, procedure & culture and activities and techniques. Another limitation is related to the possible range of the decision variables. If and how these may vary must be more clearly defined in a concrete case company, including the economic consequences. This has not been discussed here.

Future research may go in different directions. One direction may be to show that it is a possibility that the risk element can be coupled to another economic management task for example to BSC. Another direction could be the method used in this paper since both data and systems to a large extent already today allows simulation of the company's risk. Maybe combined with a method to manage the uncertain risk as 'focus' in a "balance-and-focus" approach (Ewing and Samuelson, 1998) with a holistic view, where not only numbers but also elements of sociology and psychology are included would be a road; but only further research can tell. As the unpredictable aspect in risk forces a move from pure information processing to experimental risk learning, further research into the possible utilization of computational thinking as a tool in economic management of risk is desirable.

Appendix A: Input variable fit

Attitude construct

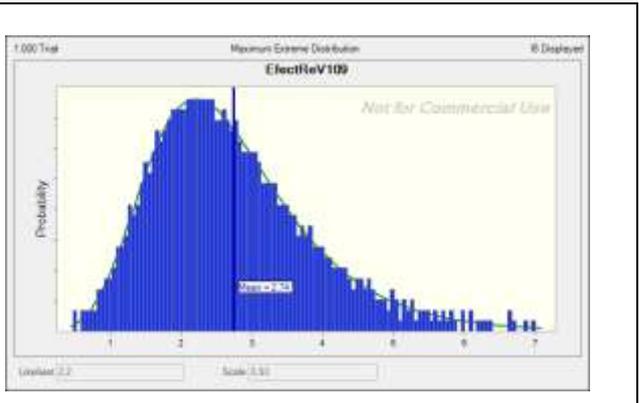
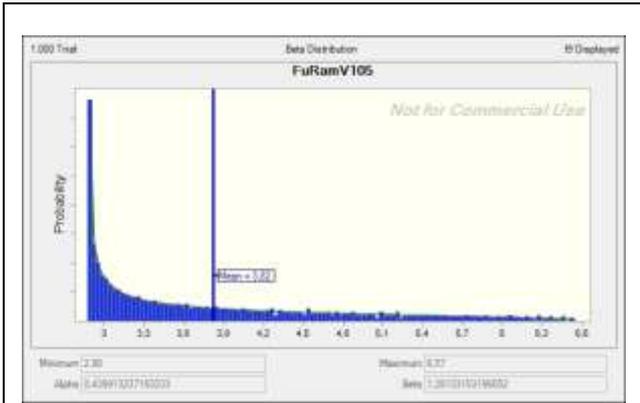
<p>Assumption: ØkonoV14: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>0,6</td> </tr> <tr> <td>Maximum</td> <td>5,04</td> </tr> <tr> <td>Alpha</td> <td>1,23002527</td> </tr> <tr> <td>Beta</td> <td>0,497291574</td> </tr> </table>	Minimum	0,6	Maximum	5,04	Alpha	1,23002527	Beta	0,497291574	<p>Assumption: BudgV16: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>1,49</td> </tr> <tr> <td>Maximum</td> <td>5,21</td> </tr> <tr> <td>Alpha</td> <td>0,80110134</td> </tr> <tr> <td>Beta</td> <td>0,671122964</td> </tr> </table>	Minimum	1,49	Maximum	5,21	Alpha	0,80110134	Beta	0,671122964	<p>Assumption: AnsvarRikV29: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>0,54</td> </tr> <tr> <td>Maximum</td> <td>5,19</td> </tr> <tr> <td>Alpha</td> <td>1,509851196</td> </tr> <tr> <td>Beta</td> <td>0,725887208</td> </tr> </table>	Minimum	0,54	Maximum	5,19	Alpha	1,509851196	Beta	0,725887208
Minimum	0,6																									
Maximum	5,04																									
Alpha	1,23002527																									
Beta	0,497291574																									
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Beta	0,671122964																									
Minimum	0,54																									
Maximum	5,19																									
Alpha	1,509851196																									
Beta	0,725887208																									

Reporting construct

<p>Assumption: VægtV82: Best Fit</p> <p>Minimum Extreme distribution with parameters:</p> <table border="0"> <tr> <td>Likeliest</td> <td>2,73</td> </tr> <tr> <td>Scale</td> <td>1,1</td> </tr> </table>	Likeliest	2,73	Scale	1,1	<p>Assumption: OptionsTV83: Best Fit</p> <p>Logistic distribution with parameters:</p> <table border="0"> <tr> <td>Mean</td> <td>1,9</td> </tr> <tr> <td>Scale</td> <td>0,64</td> </tr> </table>	Mean	1,9	Scale	0,64	<p>Assumption: SandVægV85: Best Fit</p> <p>Minimum Extreme distribution with parameters:</p> <table border="0"> <tr> <td>Likeliest</td> <td>3,03</td> </tr> <tr> <td>Scale</td> <td>1,19</td> </tr> </table>	Likeliest	3,03	Scale	1,19
Likeliest	2,73													
Scale	1,1													
Mean	1,9													
Scale	0,64													
Likeliest	3,03													
Scale	1,19													

Expectation construct

<p>Assumption: FrStyV102: Best Fit</p> <p>Logistic distribution with parameters:</p> <table border="0"> <tr> <td>Mean</td> <td>4,05</td> </tr> <tr> <td>Scale</td> <td>0,44</td> </tr> </table>	Mean	4,05	Scale	0,44	<p>Assumption: FrRaV103: Best Fit</p> <p>Logistic distribution with parameters:</p> <table border="0"> <tr> <td>Mean</td> <td>3,88</td> </tr> <tr> <td>Scale</td> <td>0,51</td> </tr> </table>	Mean	3,88	Scale	0,51	<p>Assumption: FrØkV104: Best Fit</p> <p>Logistic distribution with parameters:</p> <table border="0"> <tr> <td>Mean</td> <td>3,76</td> </tr> <tr> <td>Scale</td> <td>0,52</td> </tr> </table>	Mean	3,76	Scale	0,52
Mean	4,05													
Scale	0,44													
Mean	3,88													
Scale	0,51													
Mean	3,76													
Scale	0,52													



Assumption: FrRiv105: Best Fit

Beta distribution with parameters:

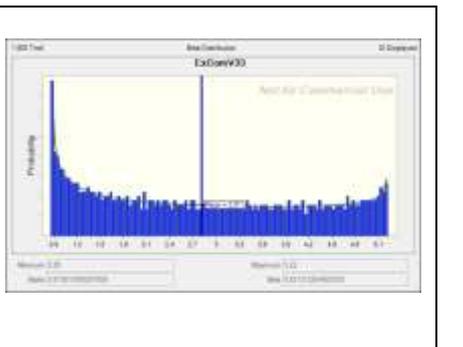
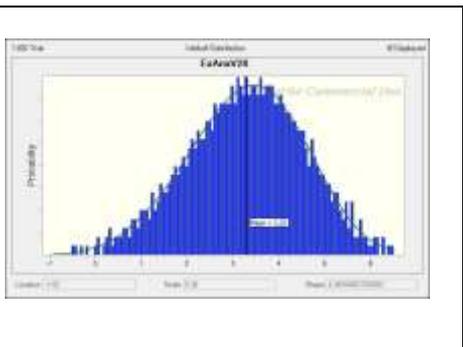
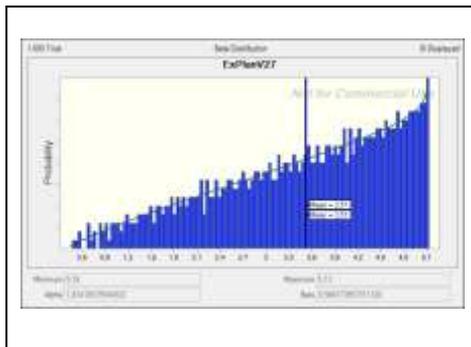
Minimum	2,88
Maximum	6,57
Alpha	0,439913237
Beta	1,281331532

Assumption: EffFinV109: Best Fit

Maximum Extreme distribution with parameters:

Likeliest	2,2
Scale	0,93

Control construct



Assumption: EtablProV27: Best Fit

Beta distribution with parameters:

Minimum	0,39
Maximum	5,13
Alpha	1,834185795
Beta	0,946373957

Assumption: UdabjRikV28: Best Fit

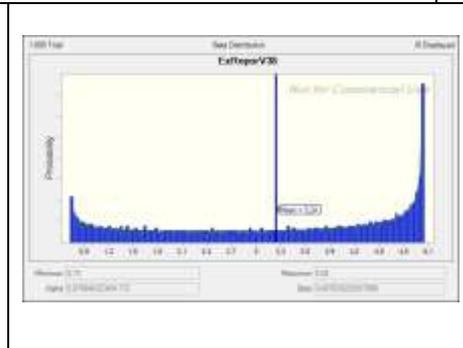
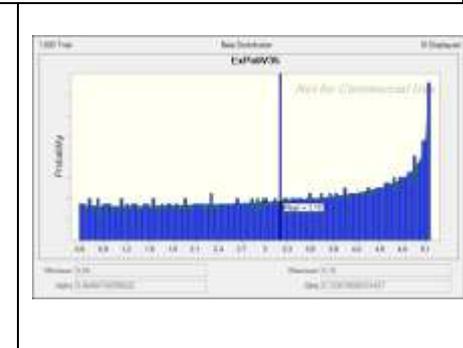
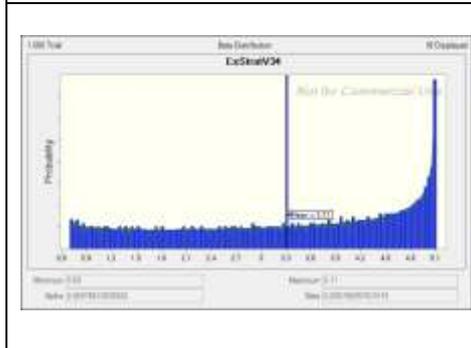
Weibull distribution with parameters:

Location	-1,62
Scale	5,38
Shape	4,36504657

Assumption: SamletOvV33: Best Fit

Beta distribution with parameters:

Minimum	0,85
Maximum	5,22
Alpha	0,67301916
Beta	0,831312265



Assumption: RisikoStraV34: Best Fit

Beta distribution with parameters:

Minimum	0,69
Maximum	5,11
Alpha	0,869786108
Beta	0,600786898

Assumption: SkrifligV35: Best Fit

Beta distribution with parameters:

Minimum	0,58
Maximum	5,16
Alpha	0,964667686
Beta	0,723679866

Assumption: RapporV38: Best Fit

Beta distribution with parameters:

Minimum	0,73
Maximum	5,04
Alpha	0,676646323
Beta	0,487638225

Activities and technique construct

<p>Assumption: VirkStraV53: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>0,26</td> </tr> <tr> <td>Maximum</td> <td>5,18</td> </tr> <tr> <td>Alpha</td> <td>1,782081438</td> </tr> <tr> <td>Beta</td> <td>0,691107601</td> </tr> </table>	Minimum	0,26	Maximum	5,18	Alpha	1,782081438	Beta	0,691107601	<p>Assumption: BudgeV54: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>-0,58</td> </tr> <tr> <td>Maximum</td> <td>5,33</td> </tr> <tr> <td>Alpha</td> <td>3,432628989</td> </tr> <tr> <td>Beta</td> <td>1,137309293</td> </tr> </table>	Minimum	-0,58	Maximum	5,33	Alpha	3,432628989	Beta	1,137309293	<p>Assumption: InvesteV55: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>0,44</td> </tr> <tr> <td>Maximum</td> <td>5,11</td> </tr> <tr> <td>Alpha</td> <td>1,090874131</td> </tr> <tr> <td>Beta</td> <td>0,661761077</td> </tr> </table>	Minimum	0,44	Maximum	5,11	Alpha	1,090874131	Beta	0,661761077
Minimum	0,26																									
Maximum	5,18																									
Alpha	1,782081438																									
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Alpha	3,432628989																									
Beta	1,137309293																									
Minimum	0,44																									
Maximum	5,11																									
Alpha	1,090874131																									
Beta	0,661761077																									

<p>Assumption: ResultopV56: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>0,27</td> </tr> <tr> <td>Maximum</td> <td>5,19</td> </tr> <tr> <td>Alpha</td> <td>1,33073566</td> </tr> <tr> <td>Beta</td> <td>0,797495504</td> </tr> </table>	Minimum	0,27	Maximum	5,19	Alpha	1,33073566	Beta	0,797495504	<p>Assumption: ProjV57: Best Fit</p> <p>Beta distribution with parameters:</p> <table border="0"> <tr> <td>Minimum</td> <td>0,06</td> </tr> <tr> <td>Maximum</td> <td>5,15</td> </tr> <tr> <td>Alpha</td> <td>1,662787831</td> </tr> <tr> <td>Beta</td> <td>0,587356299</td> </tr> </table>	Minimum	0,06	Maximum	5,15	Alpha	1,662787831	Beta	0,587356299
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