About Business Risk and Simulation Modelling in Practice

The book aims to be a practical guide to help business risk managers, modelling analysts and general management to understand, conduct and use quantitative risk assessment and uncertainty modelling in their own situations. It is intended to provide a solid foundation in the most relevant aspects of quantitative modelling and the associated statistical concepts in a way which is accessible, intuitive, pragmatic, and applicable to general business and corporate contexts. It also discusses the interfaces between quantitative risk modelling activities and the organisational context within which such activities take place. In particular, it covers links with general risk assessment processes and issues relating to organisational cultures, incentives and change management. Some knowledge of these issues is generally important in order to ensure the success of quantitative risk assessment approaches in practical organisational contexts.

The text is structured into three Parts (containing thirteen Chapters in total):

- Part I provides an introduction to the topic of risk assessment in general terms.
- Part II covers the design and use of quantitative risk models.
- Part III provides an introduction to key ways to implement the repeated calculation steps that are required when conducting simulation, covering the use of VBA macros and that of the @RISK add-in.

The text has been written to be software-independent as far as reasonably practical. Indeed (apart from an assumption that the reader wishes to use Excel to build any models), most of the text in Part I and Part II would be identical whichever platform is used to actually perform the simulation process (i.e. whether it is VBA or @RISK). Thus, although some of the example files use Excel functionality only, and others use features of @RISK, essentially all could be readily built in either platform if necessary (there are a handful of exceptions): One would have to make a few simple formula changes in each case, with the tools presented in this text showing the reader how to do so. On the other hand, in the context of presenting data arising from probabilistic processes and simulation results, @RISK's graphical capabilities are generally more flexible (and quicker to implement) than those in Excel. Thus, for purposes of quality, consistency and convenience, many of the illustrations in the book use @RISK in order to show associated graphs, even where the model itself does not require @RISK *per se*. Thus, a reader is not required to have a copy of @RISK at that point in the text. Indeed, apart from when working with the examples in Chapter 13, there is no fundamental requirement for a reader to own a copy (nor a trial version) of @RISK in order to gain value from the text. In fact, readers who wish to use other implementation platforms for the simulation itself may find many aspects of this text of relevance.

The choice to present both Excel/VBA and @RISK approaches serves a number of purposes:

- Whichever platform is used for the simulation, the core concepts, most of the modelling techniques, and issues concerning process alignment and other organisational challenges are essentially the same. An integrated approach allows a reinforcement of some of the

concepts from different perspectives, and provides a comparison between the possible implementation approaches whilst ensuring minimum repetition.

- Each platform has its own merits, so that in practice, some readers may need one approach whilst other readers would need another. In particular, not only is Excel essentially ubiquitous (and hence the implementation within Excel/VBA involves no additional cost), but also the range of possibilities to use Excel/VBA for risk modelling is larger than is often realised. For example, it is fairly straightforward to create random samples from over 20 probability distributions, and to correlate them. On the other hand, the use of @RISK can facilitate many aspects of the process associated with the building and communication of risk models and their results; in many organisation contexts, its use would be the most effective, flexible and transparent option, with the cost of the required licences generally being insignificant compared to the potential benefits and the investments being made (both in terms of participants' time and in terms of project investment budgets). The visual tools in @RISK also represent very powerful benefits from an organisational process perspective, where there is typically a large variety in the level of understanding of statistics and modelling within groups of participants.

The main content of each Part and Chapter is as follows:

Part I introduces the need for risk assessment, its uses, the general process steps, possible approaches to risk quantification, and the associated benefits and implementation challenges:

- In Chapter 1, we discuss the use of risk assessment in many day-to-day situations as an informal activity that most people conduct naturally, albeit implicitly and informally. We also present some prominent examples of where risk management has failed in business-related contexts. We then discuss some general challenges to the implementation of formalised risk assessment processes, before presenting key drivers of the need for more structured, explicit and formal approaches in some contexts, especially in many business situations. Finally, we present the main uses and objectives of general risk assessment processes.
- In Chapter 2, we cover general aspects of the risk assessment process, including tools to ensure that risk identification is appropriately thorough, the potential objectives and challenges in risk prioritisation, categories of risk mitigation actions, and some other selected process issues.
- In Chapter 3, we present a variety of possible qualitative and quantitative approaches to risk assessment, including their core aspects and relative benefits. We discuss the more demanding requirements of quantitative aggregation or full risk modelling approaches, especially in terms of risk identification and risk mapping. We note the associated challenges when qualitative or non-aggregate approaches are used as a basis for the subsequent development of quantitative models.
- In Chapter 4, we discuss the benefits of full risk modelling approaches, in relation both to risk register approaches to risk assessment, and to traditional static (non-risk) modelling approaches to project evaluation and to general business analysis.
- In Chapter 5, we discuss many challenges in implementing quantitative risk modelling, especially those which relate to issues of an organisational, incentive, cultural, process and communications nature. An awareness of these can be of great importance both to modelling analysts and to senior management who wish to implement risk-based decision-making processes and to install a more risk-aware culture within their organisations.

Part II provides a detailed discussion of the design and building of risk models:

- In Chapter 6, we present the key principles of simulation methods. We also cover the relationships between simulation and other numerical modelling techniques, such as sensitivity, scenario, and optimisation analysis.
- In Chapter 7, we discuss core aspects in the design of risk models. We highlight some important similarities between risk modelling and traditional static modelling, as well as covering some of the key differences. We also discuss issues that need to be addressed in order to align the modelling activities with those of a general risk assessment process, as well as issues faced when integrating risk assessment into existing models.
- In Chapter 8, we cover statistical measures of risk and probability distributions, as well as the general topic of risk measurement using properties of distributions; this has general relevance for the use of distributions as inputs to risk models, and for the interpretation of simulation results.
- In Chapter 9, we describe over 20 distributions and their uses; these are usually sufficient for most practical activities in business risk modelling, and are available both in @RISK and in Excel/VBA. We also discuss the approximation of distributions with each other, and the processes and possible frameworks to select an appropriate distribution to use.
- In Chapter 10, we present methods to create random samples from the distributions discussed in Chapter 9; this is fundamental to readers wishing to use Excel/VBA approaches, whereas it is in-built as part of @RISK's distribution functions.
- In Chapter 11, we discuss the modelling of dependency relationships that are specific to risk models, including techniques such as the use of conditional probabilities, parameter dependencies, scenarios, correlated sampling, time-series modelling and others.

Part III presents practical methods to implement the repeated calculations of a model that is the hallmark of simulation methods. The advantages of presenting this topic at the end of the text include that the core concepts apply to whichever platform is used for the simulation, and that it allows readers to achieve a strong basis in the concepts and understand the possibilities that quantitative risk modelling may offer, without needing to necessarily become involved in the technical aspects of implementation. We initially focus on the "mechanical" aspects of each platform, which are presented in a step-by-step fashion within the context of a simple model. We aim for the early part of the discussion to be largely self-contained, focussing on the simulation process, rather than establishing a tight link into the subject of model design. This part of the text can be read essentially independently to the modelling techniques covered earlier. Nevertheless, in the later parts of the discussion, we do cover more general topics, and make links to the earlier text:

- Chapter 12 presents the use of Excel/VBA. We discuss many aspects of simulation models that can be readily implemented in this approach, ranging from running basic simulations to the creation of flexible ways to store and analyse results, generate correlated random numbers, and increase simulation speed. A template model is provided which contains the core functionality that would be needed in many cases; its use is explained with several example models. Although we show techniques that allow for the creation of reasonably sophisticated approaches to the design of risk models, the running of simulations, and to results analysis, we do not attempt to replicate the functionality of an add-in, such as @RISK. Rather, where such functionality would be complex and time-consuming to implement in Excel/VBA, but is available within @RISK, we take the pragmatic view that

for readers working in a business or organisational context (to whom this book is targeted), it would almost always be more effective to use @RISK in order to access this functionality, in order for them to be able to retain a focus on the core aspect of providing decision support.

- Chapter 13 covers the use of @RISK. By presenting it in the last Chapter of the text, one can create a clearer comparison with Excel/VBA approaches, especially of its relative benefits. These include not only its sophisticated and flexible graphics capabilities, but also tools to rapidly build, experiment with, and modify models, and to analyse the results. In addition, there is a larger set of distributions and parameters available, an ability to control many aspects of the simulation and random number selection, and to create dependency relationships. The Chapter focusses on the core aspects of the software and on the features required to work with the models in this text, as well as being guided by the general modelling considerations that the author wishes to emphasise. Although it covers many topics, it does not intend to be a substitute or alternative to the software manual (which, at the time of writing, is approximately 1000 pages, as a pdf file). Nevertheless, in the latter part of the text, additional features which may be of importance in some specific practical situations are mentioned. These include functionality to fit distributions and time series to data, to conduct optimisation under uncertainty, and to integrate Excel with Microsoft Project. The book was written when @RISK version 6.3 was the latest one available, so that new features may become available in the future (such as when version 7 is released). However, the fundamental concepts in risk assessment, risk model design, and simulation modelling remain largely unchanged as such developments occur, and later software versions are generally fully backward compatible with prior ones, so that it is hoped that this text will nevertheless provide a useful guide to core functionality, even as future versions are released.

Readers who wish to review specific models which use @RISK may install a trial version (if they do not have, or do not wish to buy, a full version). Trial versions are fully functional but time-limited, so that readers should ensure that the installation of any trial is appropriately timed. In particular, readers may choose to read (or skim) all of the text before installing the trial, and revisit relevant parts of the text afterwards. At the time of writing, trial versions are valid for 10 days and are available at www.palisade.com. Readers may contact Palisade Corporation directly who may – entirely at its discretion – be able to extend the duration of a trial. For the purposes of the models used in this text, it is sufficient to download @RISK Industrial; however, some features within this - whilst briefly mentioned in this text - are not required for the example files provided, so that the additional software associated with these features does not need to be acquired (in particular the SQL-related content used for the Library functionality, and Microsoft Project, are not required). Technical aspects of installation and licensing options for @RISK are not covered in this text. Please note that the author is totally independent of Palisade Corporation, and has no control over the availability (or not) of trial versions, so the above is (in theory) subject to change, although trial versions have been available for many years without issue.

As far as possible, we have aimed to present concepts in a logical and linear order, but also to remain practical and to introduce technical aspects only where they are genuinely needed, and not simply for their own sake. Due to the richness of the subject, this has not been possible to do perfectly. In particular, whereas the detailed discussion of simulation concepts, and

definitions of statistical terms is covered in Part II (Chapter 8), on occasion in Part I we make reference to some basic statistical concepts (such as averages or percentiles, or to probability in general), and also show some simulation results. It is hoped that readers will nevertheless be able to follow this earlier discussion; many will no doubt have some (at least limited) experience of such concepts that is sufficient to be able to follow it; if not, of course the option to read first (or selectively refer to) this later Chapter is open to them.