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Optimal management of operational risk using a Bayesian Decision Network model.

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1. Abstract

The research represents the extension of a Bayesian Network (BN) model for operational risk quantification into a Bayesian Decision Network (BDN) incorporating decision and utility nodes for the purposes of managing operational risk within a derivatives trading environment. The resulting Bayesian Decision Network can be employed to simulate different operational events under alternative management actions to identify those operational risk management policies under which the expected utility for the organization is maximized.

Industry practitioners in financial institutions are now turning to the problems of quantifying operational risks for the purposes of capital adequacy under the Basel II accord. Much of the proposed approaches to modelling and managing operational risk are still contentious. This research will provide a detailed case study of the application of a new technology, Bayesian Decision Networks, to support the management of operational risk. This will be the first research carried out on modelling operational risk using Bayesian Decision Networks carried out in Australia, in partnership with an Australian Financial Institution. The current literature in this area has a very short history with few current publications. This research will add to the limited extant literature.

2. Background and aims of project

The aim of the project is to present a scholarly case study that describes the development of a Bayesian Decision Network (BDN) model for operational risk (OR) management in a derivative trading environment. This research aims to extend the extant research that has until now focused on using Bayesian Networks (BN) for the quantification of operational risk. A BN developed in previous OR research will be extended to form a BDN with the incorporation of decision and utility nodes. Conclusions will be drawn as to the strengths and weaknesses of the BDN tool in improving OR management in general, and in a derivatives trading environment in particular.

3. Significance and Innovation

Operational Risk in financial institutions, its measurement and management has become a central research topic. Operational risk has been recognized by prudential supervisors and financial executives as representing a critical area of risk management, with severe operational risk events, although rare, resulting in significant losses for financial institutions. The importance of OR is evidenced by the introduction of the new Basel II accord, which requires authorized deposit taking institutions to allocate risk capital for the purposes of covering its operational risk exposures. This is a new area and the tools for quantifying and managing OR has still not reached the maturity of those risk tools used in market or credit risk. A Bayesian Networks (BN) is a tool developed in the field of Artificial Intelligence for the purposes of probabilistic reasoning in domains that contain considerable uncertainty. BNs have now developed into a mature technology suitable for end-user applications. For many years, BN have been applied in areas as diverse as environmental management, medical diagnostics, forensic science, meteorology and engineering. It is only in recent times that researchers

have suggested there application in the modelling of OR (Alexander, 2000). BNs are a technique particularly suited for modelling environments characterized by a lack of relevant, historical data, such as the OR environment. The OR modelling environment does not lend itself easily to the application of traditional statistical techniques, as do the more data intensive areas of market or credit risk. The BN model can be constructed using both observed historical data and expert judgment, to provide a causal model, which incorporates Key Risk Factors, of operational risk event frequencies and severities. The probabilistic random event nodes of the BN can be readily augmented by the inclusion of decision nodes (sets of actions) and utility nodes (sets of payoffs), to create a Bayesian Decision Network (BDN). by the inclusion of decision nodes (sets of actions) and utility nodes (sets of payoffs), the BDN provides a tool to manage a firms OR exposures. (Alexander, 2000). A deficiency with much of the current literature is that BN models for OR are based on contrived case studies. For example, Alexander (2003) (Swaps trading) and Cowell, Verrall and Yoon (2007) (E-Banking systems and Insurance fraud). The recent paper of Adusei-Poku, Van den Brink and Zucchini (2007) provides the first detailed case, set in an actual FX settlement environment.

Our proposed case study will extend previous OR research, which focused on the quantification of OR using BN models, to develop a tool for decision making in the management of OR. The case study will be done in a real, working environment involving derivatives trading, with an industry partner. The novelty of the research is i) a first time study is carried out within the Australian context and with an Australian financial institution partner, ii) OR encountered in a derivatives trading environment is modeled (such an environment has not yet been covered in modelling OR with BNs or BDNs), iii) a BN model for the quantification of OR is extended to incorporate decision and utility nodes for the purposes of OR management to produce a BDN model. This research will add to the current literature, which is small, as evidenced by the relatively short history of publications that existed little, prior to 2000. Other scholarly publications that have discussed the application of BNs to OR in financial institutions include Cornalba and Giudici (2004), Neil, Fenton and Taylor (2005) and Bonafede and Giudici (2007).

4. Description of Approach

The methodology is not the novel feature of this research. Our methodology therefore proceeds in a similar manner as detailed in the extant literature on BN and BDN construction, particularly with regard to OR. Adusei-Poku et al (2007), Cowell et al (2007), and Neil et al (2005) are three prime sources outlining methodology in the OR area. BN development is iterative and requires the identification of i) Random event nodes (these represent the current state of key risk indicators or causal factors), ii) Structure (this represents the causal relationships between factors), and iii) Node Probability Tables (these represent the marginal and conditional probabilities of node states). Each of the above will be identified with reference to the available historical data and expert judgment. Expert elicitation will be carried out using structured and unstructured interviews and formal elicitation methods, references to which are extensive. Cooke (1991) being an early example, and more recently, Cooke and Goossens (2004). Following the approach of Neil et al (2005), we will include as a basic BN component, the risk event ‘frequency’, ‘severity’, ‘total loss’ and ‘process effectiveness’ nodes to provide predictions of total OR losses. The ‘process effectiveness’ node will be further expanded to include causal factors within the derivative trading processes that influence the process effectiveness, and consequently the frequency and severity of OR loss events. BN model assessment will precede using available cross-validation historical loss data, and logarithmic score (LS) metrics as described in Cowell et al (2007). On completion of the BN, decision nodes and utility nodes will then be added to create the BDN. Decision node action ‘states’ and Utility nodes preferences will be determined through interviews with operational risk personal of the industry partner. Formal techniques for the evaluation of BDN are less well developed than for BNs, and the resulting BDN will be assessed using a number of criteria including an elicitation review process, sensitivity analysis and the evaluation of case based scenarios.

References:

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