A PROBABILISTIC-NETWORK-BASED APPROACH TO INTER-CAUSAL-INFERENCING: A STUDY OF MAPPING STRATEGIC THINKING IN THE INDIAN COMMERCIAL VEHICLE INDUSTRY

ABSTRACT

Researchers interested in understanding strategic behaviour of firms underscore the importance of causal linkage between managerial perceptions about environment and strategic actions a firm adopts. The central tenet of this stream of research is: mind-sets (or perceptions) of managers direct strategic action.

These managerial perceptions can be represented in various forms. Network-based representation of perceptions is one such popular method. There are essentially two broad categories which fall under network-based formalisms: Deterministic formalisms and Uncertainty-based formalisms. The deterministic representations used for the purpose of mapping managerial thinking are termed as Cognitive Maps (and are also known as mental models, mind-sets, managerial frames, and causal models). Probabilistic networks (which can be classified as Bayesian and Non-Bayesian formalisms) are termed as 'belief networks'. In this dissertation only Bayesian formalisms are dealt with. In Bayesian formalisms, individuals perception (belief) about the environment is captured in the form of subjective probability estimates. Also strategic behaviour of firms is studied by converting cognitive maps (mind-sets) into probabilistic networks. A Cognitive map and a Bayesian Network have the same topology. These Bayesian network-based formalisms facilitate belief propagation that essentially deals with updating the existing belief structure in the event of new evidence.

Formally, a probabilistic network is a directed acyclic gr ph with nodes and directed arcs. Any two nodes when connected by a directed arc captures the causal dependency. There are different types of probabilistic networks. The popular forms are: Bayesian belief networks (BBNs), and Qualitative Probabilistic Networks (QPNs). For representation and reasoning under uncertainty, BBNs require precise probability estimates. QPNs, on the other hand, can be used to perform qualitative reasoning, when conditional dependencies among variables are available. In a QPN, a qualitative sign ('+', '-', '0') is attached to each arc, which reflect qualitative constraints imposed on concept nodes like those in a Cognitive Map.

Typically, QPNs are used for situations involving both quantitative reasoning (when information about numeric estimates are available) and qualitative reasoning (when information about numeric estimates are not available). In the second form of reasoning, they have close correspondence with Cognitive Maps. QPNs also facilitate inter-causal reasoning, i.e. reasoning about the relationships among unobserved causes and observed causes in the event of observation of an effect node. Inter-causal reasoning has found wide applications in decision-sciences.

In this dissertation certain intuitive models are developed after observing common patterns adopted by humans while propagating beliefs. A psychological experiment was conducted to study the process of human belief propagation. The main finding here is: humans cluster causes in the form of AND and XOR combinations while reasoning under uncertainty. Formal models are

defined on the basis of these intuitive combinations (AND/ XOR) with the help of certain probabilistic criteria. The proposed intuitive models are generalised for multi-cause nodes. A computer-based model is developed to demonstrate the applicability of representation formalisms (like QPNs) in quantitative belief propagation, and also to demonstrate the usefulness of intuitive-model-based formalisms in belief propagation. The proposed intuitive models were found useful in belief propagation in terms of convergence to approximate values. This methodology is applied in studying the strategic behaviour of two firms (TELCO and Ashok Leyland Limited) from the Indian Commercial Vehicle (CV) industry using the cognitive mapping approach.

The focus of this dissertation with respect to the case study is in trying to explore mind-sets of managers (represented as cognitive maps) which would give additional insights in assessing the distinctly different performance of these two firms. In other words, this study explores the possibility of applying network-based formalisms like Cognitive Maps and QPNs in understanding strategic behaviour of these firms.

The methodology for constructing the cognitive maps of both firms' top management's mind-sets is by representing causal articulations of the top management in the form of a network. The principal source for these articulations are: Annual reports of both companies, and published interviews of the top management during this time period. Concepts represented in the cognitive maps of both firms are then segregated into two dimensions: Temporal (Long Term/Short Term) orientation and Environment (Internal/External) Focus.

Main findings from the fourteen year period study of the two companies are: TELCO had a long term and external orientation in its thinking which enabled it to foresee opportunities cued from changes in the external environment (liberalisation of the Indian economy). However, this external orientation in the mind-sets of the top management resulted in loss of market share in the HCV segment. Ashok Leyland, on the other hand, had an internal orientation till 1993. This had enabled it to penetrate into the HCV segment.

For the latest of cognitive maps of both firms (1993-94), probability estimates were captured through an interview process with the top management. These Cognitive maps (that have probability estimates attached to each node) resemble the formalisms of QPNs. Using the proposed belief propagation algorithm, various scenarios were generated. The motivation here was to explore the following: Given the orientation of the top management of both firms, how would they change their beliefs in a particular scenario. This was done using the computer-based system developed for this purpose.