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An agent-based fuzzy cognitive map approach to the strategic marketing planning for industrial firms

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ABSTRACT

Industrial marketing planning is a typical example of an unstructured decision making problem due to the large number of variables to consider and the uncertainty imposed on those variables. Although abundant studies identified barriers and facilitators of effective industrial marketing planning in practice, the literature still lacks practical tools and methods that marketing managers can use for the task. This paper applies fuzzy cognitive maps (FCM) to industrial marketing planning. In particular, agent based inference method is proposed to overcome dynamic relationships, time lags, and reusability issues of FCM evaluation. MACOM simulator also is developed to help marketing managers conduct what-if scenarios to see the impacts of possible changes on the variables defined in an FCM that represents industrial marketing planning problem. The simulator is applied to an industrial marketing planning problem for a global software service company in South Korea. This study has practical implication as it supports marketing managers for industrial marketing planning that has large number of variables and their cause–effect relationships. It also contributes to FCM theory by providing an agent based method for the inference of FCM. Finally, MACOM also provides academics in the industrial marketing management discipline with a tool for developing and pre-verifying a conceptual model based on qualitative knowledge of marketing practitioners.

1. Introduction

Strategic marketing planning is the part of strategic planning that defines the strategies and tactics that form the sequences of activities needed to achieve company missions and objectives, considering the external and internal environments of the company (Byars & Neil, 1987). Strategic marketing planning results in well defined marketing strategies and tactical plans that direct, implement, and control activities. Industrial marketing planning deals with the marketing planning issues of industrial firms (firms that produce industrial products or services), and has been widely implemented to coordinate and control their marketing activities (McDonald, 2002). Formal strategic marketing planning is known to have a positive relationship with the financial and nonfinancial performance of firms, coordinated decision making, and specialization of marketing and distribution activities (Claycomb, Germain, & Droge, 2000).

However, strategic marketing planning is a typical example of an unstructured decision making problem due to the large number of variables to consider and the uncertainty imposed on those variables. Compared with consumer marketing planning, the problems in an industrial marketing context are more complicated due to the differences between the two environments. Webster (1995) argues that industrial marketing planning requires more frequent interactions among the functional departments within the firms to handle supply chain coordination issues with partners (functional interdependence); product, engineering, manufacturing, and technical orientation (product complexity); and management of buyer–seller relationships (buyer–seller interdependence). These differences sometimes become barriers to implementing industrial marketing planning; the literature reports that limited understanding of external macro-marketing environmental forces; poor internal communication within the marketing department and between functions, business units, and management tiers; insufficient details in marketing programs or the implementation plan; and insufficient consideration of buyer–seller interactions are just a few examples of such barriers (Dibb, Simkin, & Wilson, 2008; Turnbull & Valla, 1993).

While there are studies that diagnose the barriers to implementing industrial marketing planning, the literature lacks studies that provide marketing managers with practical tools to support the role of industrial marketing planning in overcoming these barriers. This reflects “the relevance problem” (Tranfield & Starkey, 1998) in industrial marketing planning research. In other words, the literature lacks Mode 2 research (Nowotny, Scott, & Gibbons, 2001) that is multidisciplinary and aims at solving practical problems relevant to industrial marketing managers.

Studies on computerized information systems to support the decision making of marketing managers, sometimes called marketing information

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systems (MkIS), have been conducted as a research stream in marketing since the 1960s (Brien & Stafford, 1968; Cox & Good, 1967; Goretsky, 1983) and can be considered as examples of Mode 2 research in the marketing discipline. Recently, more advanced forms of MkIS that mainly apply the intelligent information systems to solving various marketing problems – including consumer behavior modeling (Martinez-Lopez & Casillas, 2009), service personalization (Chung, Rust, & Wedel, 2009), and marketing strategy development (Li, Li, He, Ward, & Davies, 2011), among others – are proposed to address the relevance problem in marketing. In particular, Li, Kinman, Duan, and Edwards (2000) compare the pros and cons of different types of MkIS for marketing strategy development. They classify the existing information systems for marketing strategy development into six categories: MkIS (in a narrow sense) that mainly aim to provide operational marketing data to marketing managers; decision support systems (DSS) that focus on supporting decision models and data; executive information systems (EIS) that support strategic decision making by CEOs; expert systems (ES) that support experts with a reusable knowledge base; artificial neural network (ANN)-based systems that have strength in identifying transaction patterns of customers; and fuzzy logic-based systems that can handle fuzzy knowledge in the marketing domain. While each type of IS has a unique advantage for supporting marketing strategy development, the common drawback of the contemporary MkIS in supporting industrial marketing planning is the lack of a supporting group knowledge-building process and what-if analysis. As Turnbull and Valla (1993) argue, the integration of knowledge from the different functional departments involved in industrial marketing channels is one of the critical success factors for industrial marketing planning to reflect the buyer–supplier relationships in the planning process. The existence of a large number of variables to be considered for the planning, due to the additional variables relating to the partners, and the uncertainty imposed on the variables require collaborative human judgment to identify core variables and the causal relationships among them. The MkIS in the literature have limitations in supporting both collaborative knowledge building and analysis of the impacts from taking different strategies under foreseen economic circumstances.

This paper aims to propose a fuzzy cognitive map (FCM)-based approach to industrial marketing planning. An FCM-based approach is chosen as it allows easy integration of the subjective opinions of experts in different industrial marketing channels and quantification of the degree of haziness in relationships among the variables concerned, thus providing a systematic what-if analysis to compare different scenarios. An FCM represents domain knowledge as a connected network in which nodes represent major concepts (variables such as communication frequency with partners) and arcs between nodes represent causal relationships and the strength of the causality. An FCM evaluation function allows managers to quantify the impact of a change on an independent variable (the number of branches, for instance) to a monitored variable (the total revenue). Features of an FCM for strategic planning include the easy integration of knowledge from different stakeholders and the existence of a systematic propagation algorithm to track the impact of a change across a planning system.

While FCMs have potential within the strategic business planning realm, they have limitations in supporting industrial marketing planning due to their inherent drawbacks. Firstly, in conventional FCMs, all relationships (which are represented as arcs) are fixed during an evaluation. However, in reality, it is not unusual for changes to occur in some of the relationships when the cause–effects are not certain among variables in modeling phase. For example, it is not certain which variables among “win ratio in bids,” “IT investment of clients,” “number of partners,” and “consulting pipelines” will be most affected by presale activities during modeling, or which can change during the model evaluation. Secondly, FCMs lack a time concept that is crucial in many applications. Therefore, FCMs cannot effectively describe the dynamic nature of the causal relationships among concept nodes. Some causes may show an immediate effect while others may take hours, days, or even years. For example, increasing the number of partners will have an instant influence on the partner management activities but a delayed influence on the total revenue of a company. Thirdly, FCM is not the best solution when the number of nodes and arcs increases exponentially, due to the limited cognitive ability of the human brain. Lastly, one crucial drawback of a conventional FCM is that it is usually not reusable for other problems in a domain. The causal relationships among concepts can be reused to model other problems in the same domain; therefore, it is beneficial to have a mechanism to reuse generic relationships to solve similar problems.

The novelty of this study in solving a practical problem (developing a tool to support marketing planning) lies in overcoming the limitations of traditional FCMs in representing the time lag in the causal relationships among concepts that are common in marketing planning, and increasing the reusability of FCMs so that a marketing planning model can be reused later through the integration of agent technology and the FCM. This study also contributes to the industrial marketing management discipline by providing marketing managers with an intelligent system that can synthesize the qualitative expert knowledge of multiple managers in different divisions for collaborative industrial marketing planning. The proposed approach is tested through a real-world industrial marketing planning problem in South Korea.

This study takes a design science approach (Van Aken, 2005) to produce a novel MkIS that can be used directly by industrial marketing managers. Design science comprises the aim of designing, implementing, and testing a novel solution for managerial problems. Hevner, March, Park, and Ram (2004, p. 726) define the design science method as including the following activities: identification and clear description of a relevant organizational problem; demonstration that no adequate solution exists; development and presentation of novel artifacts (models, constructs, methods, or instantiations) that address the problem; rigorous evaluation of the artifacts enabling the assessment of its utility; articulation of the value added to the domain knowledge base and to practice; and explanation of the implications for management and practice. A novel artifact that addresses the target managerial problems also is known as a design proposition, which corresponds to a causal research model in explanatory science approach (Romme, 2003). A design proposition links a specific intervention to a specific organizational outcome. In the context of this study, the proposed approach based on FCM is considered as a design proposition (intervention) to improve organizational performance (industrial marketing planning).

Following the proposed method, this paper is organized as follows. Section 2 provides the conceptual background regarding FCMs and extended FCMs. Section 3 describes the preliminary design proposition that integrates the agent and the FCM to support industrial marketing planning. In Section 4, the approach is applied to a real world industrial marketing planning problem to determine its feasibility. Finally, Section 5 discusses the practical and theoretical implications of the study and Section 6 concludes the paper.

2. Fuzzy cognitive map

A cognitive map was proposed by Axelrod (1976) to represent social scientific knowledge. A cognitive map model is represented by a signed graph that consists of nodes and edges. A node is used to represent a concept of a domain and an edge a causal relationship between nodes. The direction of an edge represents the direction of a causal relationship, which is also called a feedback. A feedback is positive (negative) if an increase in the first variable leads to an increase (decrease) in the second variable. In order to enlarge the scope of cognitive map applications, several variations of cognitive maps have been introduced in the literature. A fuzzified version of the cognitive map – FCM – was first introduced by Kosko (1986). The FCM incorporates fuzzy causality measures in the original cognitive maps, so it provides a flexible, more realistic representation scheme to deal with knowledge.