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Management

ADOPTION OF ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT

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ABSTRACT For survival & prosperity in a tumultuous environment, effective supply chain management is essential. Global economic downturn is further growing its significance. SCM is used for enhancing business operations, making them robust, flexible and competitive. A company's performance is measured not just by its size, but by its ability to respond rapidly to market trends with more efficient manufacturing processes, enhanced customer service levels, and ability to take advantage of its SC more effectively to respond to its customers. Making use of the new technologies is one of the ways to achieve excellence. Despite its widespread acceptance as a decision-aid tool, AI has very limited application in SCM. To fully utilise the potential of AI, this paper explores various subfields of AI most suitable for solving practical problems relevant to SCM. In doing so, the paper reviews past record of success in AI in SCM and identifies most suitable areas of SCM to apply AI.

KEYWORDS : Logistics, Supply Chain, Blockchain, AI, ML, Data Analysis.

INTRODUCTION

In an era of rising demand, uncertainty, higher supply risk, and increasing competitive intensity, SC excellence often hinges on organisation's ability to integrate & orchestrate entire spectrum of end-to-end processes of acquiring materials, converting them into finished goods, and delivering to customers. Since such ability can be enhanced by increased visibility across end-to-end SC, many leading-edge organisations have attempted to enrich their information sources & share real-time information with SC partners.

Effective SCM calls for cross-functional alignment and vital role must be played by marketing. In every business enterprise, SC is most important component. The entire SC would be impacted by a hole in SC networks. Task is to decide how to achieve optimization using technological advancements. As well as questions about how it can be applied and questions for future study, we present a SCM framework.

Emerging management philosophy of SCM requires comprehension of complex, interrelated decision-making processes and creation of intelligent knowledge bases crucial for joint problem-solving. To synchronise series of interrelated but different stages of joint demand planning & forecasting processes in SC, an agent-based forecasting system was proposed having capability to predict end customer demand through information exchange among multiple SC partners and learn from past forecasting experience. Subfields of AI such as expert systems & agent-based systems can be useful for dealing with SC's various aspects. Main objectives of this paper are to:

- Identify & characterize AI sub-fields in terms of usefulness for improving SC efficiency.
- Synthesise existing literature dealing with AI's applications to SCM wrt their practical implications & technical merits.
- Develop a hierarchical taxonomy for existing AI literature & categorise according to its SCM application, problem scope, & methodology.
- Discuss future outlook for unexplored AI research in SCM.

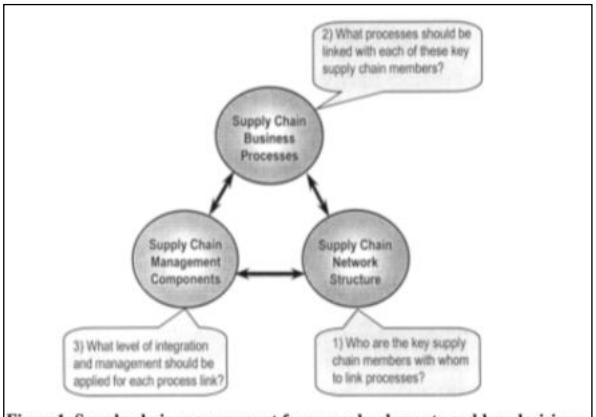

Figure1. Supply chain management framework: elements and key decisions

Major reasons for failure of SC operations are due to a lack of understanding of existence of demand. The stresses on SC are much more severe, and a strong plan and constant measurement for weak ties are needed for management. Global issues are what we have tried to address here as being specific & presenting their solutions. Management may not fully mitigate issues, but preventions can be taken.

PROBLEM SCOPE

The problem scope is categorised according to 3-level decision-making hierarchy:

- Strategic decisions dealing with long-term, executive-level issues such as strategic alliances, facility location, & capital investment.
- Tactical decisions dealing with intermediate term, mid-manager-level issues such as joint demand planning, supplier selection, and inventory planning.
- Operational decisions dealing with short-term, routine issues such as vehicle routing, order picking, and cycle counting.

METHODOLOGY

Several case-studies (involving supply-chains of GSCF members) were analysed to interpret SCM in comparatively better way. Over 90 detailed in-person interviews were performed, documented and scrutinized, lasting from 1-3hrs.

The goal was to emphasize the management of customer-care, procurement, demand management, management of customer relationships, fulfillment of orders, and production & commercialization of goods.

Advertising, logistics, quality control, finance, information technology, manufacturing, and strategic planning are managers of various levels and experiences. 9 separate SCs from 15 different companies were covered by procedure.

AI is known for its ability to think & act like humans and think & act rationally. Thus, wrt these distinctive features, AI is classified into following sub-fields:

- Thinking Humanly-Rough set theory & Artificial neural networks.
- Acting Humanly-ML, expert systems, & GAs
- Thinking rationally-Fuzzy logic
- Acting Rationally-Agent-based systems

Synthesis Of AI Applications In SCM

Here we outline some SCM areas explored for AI applications, identify specific sub-disciplines that are useful for improving SC decisions, and assess their contribution to SC decision-making process.

Inventory Control & Planning

Inventory causes substantial cost since it is an idle resource and required to maintain high levels of customer service. The ability to control & plan inventory at minimum cost can be enhanced with accurate, real-time information about expected customer demands, size & type of inventory at hand, & amount of order cycle time to fulfill

customer orders. However, since this kind of information is usually challenging to assess, predict and obtain, conventional judgment rules based on mathematical models can't reflect actual nature of inventory management.

AI techniques offer a promising new approach to inventory control & planning problems of great magnitude & complexity due to their powerful knowledge representation language capable of capturing inventory patterns throughout the entire SC at all levels of detail. Capturing of such dynamic complexity in an inventory database enables inventory managers to estimate the desirable level of inventory at each stocking point without producing a bullwhip effect.

Transportation Network Design

Class of Transportation network design challenges, that are intrinsically combinatorial and for which optimal global solutions are thus difficult to explore & deploy, are one of the most popular applications of AI to SC. This class of problems include:

- TSP
- Efficient vehicle routing & scheduling problem
- Famous minimum spanning tree problem
- Freight consolidation problem, and intermodal connection problem
- Other related problems: complex road network design, highly advanced gas distribution pipeline network design & its complexity, efficient parking space utilisation, & effective traffic assignment.

Due to combinatorial nature of these problems, GA turns out to be most popular forms of AI techniques deployed to handle various aspects of transportation network design problems. Another technique emerging as increasingly popular meta-heuristic is the algorithm known as **ant colony optimisation**. It is applied successfully to handle well-known network design problems such as TSP, vehicle routing problem & minimum spanning tree problem.

Both GAs & Ant-colony optimisation algorithms belong to class of meta-heuristics applied to wide set of combinatorial optimisation problems with minor modifications to adapt to specific transportation-network design problems. Thus, they're more flexible. However, other meta-heuristics like tabu search, simulated annealing, scatter search, & iterative local search offers similar effectiveness for solving TSP.

Purchasing & Supply Management

Make-or-buy decision is concerned with weighing the options of producing goods internally or purchasing those from external sources to better utilise firm's available resources and focus on core competency. Although make-or-buy seems simple, but it factors into various "what- if" scenarios as described:

- What volume of goods does company expect to produce?
- How much capital investment is needed to produce goods/ services?
- How much risk is involved in developing new products to stay competitive?
- Has the company's target product reached its peak demand or maturity stage?
- Business of the company?
- What is key strength of the company?
- Do the employees have expertise & skill to produce desirable goods?

Due to complexity & dynamics of above scenarios, make-or-buy decision calls for systematic decision-aid tools. This includes an expert system and can aid purchasing manager in a series of strategic & tactical purchasing decisions, while traditional OR techniques can handle only one aspect of purchasing decisions.

Demand Planning & Forecasting

Critical information regarding future demand is crucial basis for firm's capacity planning, workforce scheduling, inventory control, new product development, and promotional campaigns. However, its usefulness & deployment generally depends on its accuracy which ultimately depends on firm's ability to reduce uncertainty & variability in future demand.

Provided future demand's volatile nature coupled with varying degree of uncertainty associated, it has been an unsettling task to develop accurate forecasting techniques. Underlying principle of forecasting technique is that future demand follows pattern of past-demand. Pattern-matching procedure within agent-based system framework, combining human expertise & data mining to predict new product's demand, was proposed. It revealed that wrt forecasting accuracy, dynamic pattern matching outperformed exponential smoothing. Latter relies on historical data, whereas, former effectively utilised multiple agents to capture past, current, and future customer behaviors thus improving forecasting accuracy. Therefore, AI is extremely useful for predicting future demand for products that have not yet been introduced and have no historical demand data.

Order-picking

Order picking affects warehouse productivity as it accounts for largest portion of warehousing operating expenditure due to its labor-intensive operations. Authorities have devised ways to improve order-picking efficiency. This includes computerisation & subsequent automation of sequencing & filling of orders. AI better handles added complexity caused by increasing adoption of value-added services & e-fulfillments due to inherent learning capability.

CRM

Companies should win customers' trust and make them believe it can deliver desired performance. It requires constant communication & building a long-term relationship with customers. Thus, real-time AI-powered CRM is important prerequisite to demand creation that drives SC activities. CRM is referred as business practice intended to improve service delivery, build social bonds with customers & secure customer loyalty by nurturing a long-term, mutually beneficial relationship with valued customers. It increases ROI, reduces churn rate and utilises big data for winning back inactive customers.

E-synchronised SCM

To facilitate coordination & integration, SC partners share information about demand forecasting, joint production, and distribution planning through Internet & electronic data interchange. Abundance of such information in cyberspace provides ground for applying ML techniques such as web mining & text mining to extract new or previously unknown patterns of data regarding customer & supplier profiles, trends in sales, revenue & sourcing and demand fluctuations stored in websites. Discovering knowledge through web mining helps in identifying future customer bases, developing pricing strategies, evaluating trading partners, & increasing revenue.

CONCLUSION

Using customized views, dashboards & KPIs to evaluate SC, monitoring performance of contracts & control complex transactions, Integrating companies for simpler monitoring and partnership management across SC, optimizing logistics by better assets distribution and possibilities to fit loads by saving time, distance & expense, understanding expenses through SC we can develop robust SCM.

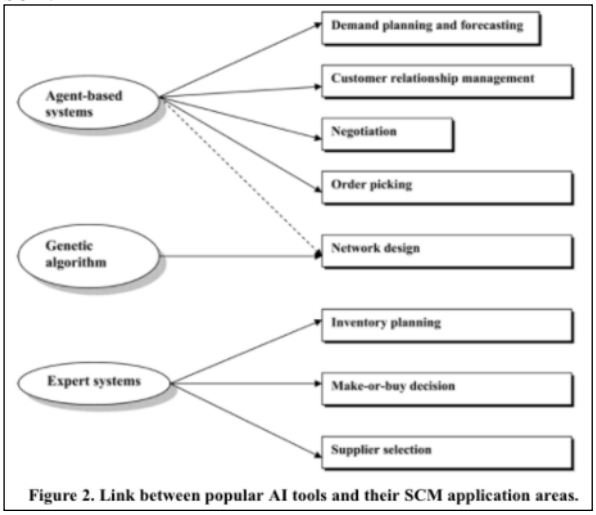

Figure 2. Link between popular AI tools and their SCM application areas.

AI is a useful decision-aid tool helping firms connecting customers, suppliers, & SC partners by facilitating information-exchange among various business-entities. But AI is not fully utilized to solve SC problems whose solutions are either too expensive or difficult to produce due to inherent complexity & ill-structured nature. Recent studies shows AI's great potential for strategic issues involving CRM, outsourcing relationships, strategic alliances among SC partners,

demand planning, & business-to-business negotiations that have often been overlooked by more traditional analytical models. Agent-based systems have emerged as popular tools for tackling various aspects of SC problems. One reason for paucity of AI in SCM is relative youth & broad spectrum of SCM discipline. Other AI challenges in SCM:

Heavy software reliability may lead to wrong decisions if programmed incorrectly.

Not easy to implement and grasp by ordinary decision-makers.

May not work well for handling risk involved in cross-functional & cross-border SC decision environments due to its knowledge acquisition bottlenecks.

AI's Futuristic scope in SCM:
Utilisation of Intelligent agents for real-time pricing & reverse auctioning.

Incorporating game-theory into agent-based systems to understand SC dynamics & form strategic SC partnerships.

Rule-based expert systems to assist logistics outsourcing or contract manufacturing decisions.

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