Intelligent Agent Framework For Knowledge Acquisition In Supply Chain Management

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Abstract: In the past several years, research targeting the development of automated knowledge acquisition (KA) in terms of the Supply Chain Management (SCM) has notably increased. Numerous methods and approaches have been proposed and used to automate supply chain management involving an intelligent agent (IA). In this paper, the IA approach was employed to facilitate automated knowledge acquisition for SCM decision-making. The study framework is characterized by different levels of knowledge acquisition linked to SCM and knowledge reuse on the basis of the prior supply chain knowledge. The framework presents a new tool for supply chain knowledge management usage.

Index Terms: Artificial intelligence, Intelligent Agent, Automated Knowledge Acquisition, Supply Chain Management, Supply Chain Knowledge.

1 INTRODUCTION

Knowledge acquisition (KA) in Supply Chain Management (SCM) has been deemed as a significant approach for obtaining competitive advantage as knowledge is the core of competitive edge, particularly in the present knowledge economy [1]. More specifically, knowledge acquisition refers to the access and absorption of knowledge (direct and indirect) from different knowledge sources [2]. The initial step begins in knowledge determination in the organization environment and the final step ends with the transformation of knowledge into a useful and useable format [3]. In relation to this, knowledge creation and acquisition are processes that are significant to the organization that is a continuous process for obtaining and maintaining competitive advantage in the midst of environmental changes [4]. In regards to the above, the knowledge-based view of the firm (KBV) views knowledge as stemming from an indispensible resource, making it mandatory for organizations to obtain it from external and internal sources, even from competitors [5]. The view posits that the organization's capability of acquiring and developing knowledge is reflected through various performances [6], and thus, knowledge acquisition improves the whole supply chain performance [7]. Moreover, the premise that the firm requires new knowledge acquisition from suppliers in light of product innovation has been percolating throughout the years, with studies in literature reporting that firm's knowledge acquisition from SC partners is possible via benchmarking, collaboration or join resolution of problems [7] via different ways. These ways involve technical assistance/strategic alliances [8], suppliers' contribution to product development [9] and even via informal relationships [10]. Regardless of the importance of knowledge acquisition to the SC, there are still limited studies concerning the topic. Past studies dedicated to it are limited in focus to knowledge transfer and problem-sharing, including ambiguity, optimization, and mitigation of risks, among others the same studies caliber [11], [12], [13]. The major method adopted by studies in literature to examine knowledge management of SCM is IA [14] and [15], with only some studies developing and proposing knowledge acquisition frameworks. To date, only a few studies ([16],[17] and [18]), have tackled automation of knowledge acquisition in SC, which means there is a dire need to investigate the issue as knowledge acquisition through manual means is still a challenge. This has been linked to the notion of the value of automation in minimizing directed efforts towards knowledge acquisition. Thus, this calls for a framework developed on a repository of SC knowledge acquisition, as recommended by prior researchers. Therefore, this study primarily aims to propose an outline of an inelegant agent framework for automated knowledge acquisition for SCM. The next parts of the paper are organized the following way; the next section of the paper expounds on the issues in knowledge acquisition and their resolution through automated knowledge acquisition to assist the members of SC. This is followed by the review of related studies regarding knowledge acquisition for supply chain management and regarding IA and SCM. Followed by research framework and finally, the last section contains the conclusion and future studies recommendations.

2 AUTOMATED KNOWLEDGE ACQUISITION IN SCM

Knowledge acquisition refers to the generation of knowledge in an ongoing manner from past and current information culled from the environment. In addition, supply chain knowledge may be generated on the basis of social and collaborative processes. Knowledge can be generated using certain processes like action learning entailing problem solving, focusing on required learning, and solutions implementation [19]. In particular, problem solving calls for a strict mindset that is experienced in reductionism and holistic knowledge, detail-focused, and extending boundaries that facilitates assessment. This involves learning from past events, assessment in an organized manner, lessons dissemination and documentation that can be utilized in the future. Following knowledge acquisition, a primary repository has to be created for the knowledge collection to be used in the SC [20] – after which, it is crucial for companies to conduct codification of knowledge in a repository. In this regard, knowledge acquisition in the SC has its basis on each supply flow repository. Also, knowledge acquisition is characterized as a socially complex and interrelated concept [21]. Other

related works [22] laid emphasis on the nature of social interaction when it comes to knowledge acquisition to be used for product innovation in that such acquisition hinges on the knowledge sources interaction. Studies dedicated to knowledge acquisition seem to face several issues that stem from knowledge technology, with several studies reporting combined outcomes, using knowledge assets through knowledge technology functions centralization or IT investments. In relation to this, knowledge techniques in business need to be established for the resolution of problems. The general premise argues that knowledge can enhance businesses [23], thereby making knowledge acquisition a must. This premise, however, has yet to be supported by empirical findings, with the significance being in the case where knowledge is distinguished based on strategy. This begs the question as to the way knowledge is acquired as opposed to if it is to be acquired (yet to be backed by empirical findings). Literature works have tried, time and again, to mitigate the gap by examining knowledge acquisition for certain issues, with the help of human experts and knowledge encoding through a paperless method (via computer). The techniques are notably significant in facilitating effective knowledge acquisition. More currently, empirical studies dedicated to the topic focused on the factors influencing the mandatory knowledge acquisition [24], with several studies focusing on knowledge acquisition risks and issues [25]. Added to this, other authors also investigated the compliance to user's retrieval habits in order to resolve lack of intelligence in the case of traditional retrieval methods, particularly in a large-sized information database [16]. Considering the arguments in literature concerning the importance of knowledge acquisition in the case of SC, it is evident that firm's SC needs knowledge acquisition to facilitate chain members' collaboration. Studies of this caliber, like [26], focused on the examination of knowledge acquisition, sharing and usage that is supply-chain centered, while at the same time keeping abreast of the theoretical underpinning knowledge assumptions including, knowledge is not easily shareable via the chain, each work function in one joint enterprise is ambiguous, and SCM is not capable of innovation. The study also mentioned the issues and called for a knowledge system base to bring about sharing of knowledge. Such system needs to be based on a repository that runs as a storage unit forming categories of knowledge throughout the supply chain length. Needless to say, more studies were urged for the conceptualization of the system and for addressing knowledge-sharing culture, system safety prior to establishment, among other issues. On the basis of the above, it becomes clear that studies dedicated to automated knowledge acquisition in the field of SCM are still few and far between, and what few there are also called for the need to examine technical applications (e.g., [16], [17] and [25]). In particular, [16] conducted an examination of the supply knowledge acquisition in vegetable business, stressing on the resolution of ineffective retrieval outcomes in different database information contexts. On the basis of ontology, the application devolved and was changed to be aligned to the users' retrieval habits and the timings to counter lack of intelligence in traditional keywords retrieval. The authors recommended that future studies determine other methods of risks mitigation in knowledge acquisition. In addition, [17] tackled the representation issues relating to the similar knowledge measures and description of product design through the development of a fuzzy case-based reasoning (FCBR) in extracting product style, facilitating through the use of linguistic variables. The product is then encoded by a vector that consisted of several attributes and the product morphology is developed. The authors brought forward a model of product style extraction with the help of FCBR, normalizing the outcome through Fuzzy Sets. On the basis of their reported findings, the FCBR outperformed other form style extraction models in effectiveness. Moreover, [25] listed a summarized version of the qualitative and quantitative studies that were carried out on knowledge acquisition in SC, and highlighted a few studies that developed a framework for knowledge acquisition and its management. The authors also indicated the lack of studies, qualitative and quantitative, dedicated to the topic. Regardless of the knowledge acquisition significance to SC, there are still scarce studies and papers devoted to it. Past literature on acquisition in SC has also been limited to knowledge sharing and transfer and they were concerned about optimization, mitigation of risks, ambiguity, and other issues.

3 INTELLIGENT AGENT IN SCM

In literature regarding automated supply chain, using agent-based models, authors have conducted several studies that supported the relationship between AI techniques and the enhanced performance of supply chain. In fact, AI and other similar methods have been evidenced to have a key role in enhancing SC performance. For instance, [27] brought forward an integrated framework for agent based on inventory-production-transportation model and SC simulation. The model had four levels that varied from domain modeling to multi-agent systems implementation, with the use of agent-based modeling and distribution simulation theory. In effect, the model consisted of a conceptual agent model that is four-layered, a meta-agent class library as well as a multi-agent platform based distribution simulation. The focus of the framework is to provide a multi-agent class library that users can avail from and a meta-agent that is built on distributed SC platform, facilitating visual and rapid development of agent-based simulation along with meta-agent building blocks. Additionally, the framework focused on the promotion of independent generation of sub-simulation models through their implementation and synchronization in a distributed environment. Based on the findings, the framework is flexible in its various layers, granularities and scalabilities. Similar to the above studies, [28]conducted an analysis of the SC performance with the help of agent-based simulation that was built on SC operations reference model. In this regard, the SC indicators and negotiation approaches are primarily generated for the purpose of local management and one-to-one interactions. Based on the findings, different SC configurations impact the SCOR dynamic performance indicators environment based on a global viewpoint. The authors brought forth a modified traditional SCOR indicator equipped with past knowledge of the network connectivity. Along a similar line of study, [29] proposed an agent-based negotiation

model for automated process of supplier selection, which contained products having synergy effect. The authors adopted a multi-agent system to meet the model objectives and laid emphasis on the proposal of negotiation, its protocol, strategies and the methods of decision making, in the selection of product-supplier environment model. They expected the model to bring about purchasing company-supplier agreements concerning products details, while at the same time delving into their synergy effects. Meanwhile, in a study conducted by [30], an agent-based customer-oriented supply networks model was proposed for the purpose of addressing customer purchase decision-making process and supply network adaptability. They developed their model on the basis of an actual case study in a Columbian floriculture sector. In the same way, [31] presented an agent-based simulation model to address an inventory optimization issue that has various levels in a network that comprised of plant, distributor and distribution units. The authors made use of a mathematical optimization process in their model to facilitate inventory system parameters, with inventories buffing against demand valuation and fluctuations in lead-time. The model comprised of a facility agent monitoring and refreshing inventory, an order agent that saves data in demand-form, sender, receiver and status, and a shipment agent that records data in the shipment quantity form, shipping time, sender and receiver and also a customer agent that takes orders based on the probability relationships. Other studies, like [32] also proposed a supply chain model consisting of distributer, retailer, manufacturer and supplier, with the help of inventory quantity analysis that functions weekly after the orders are placed. The retailers were enabled to perform policy of partial demand satisfaction, where the orders were forwarded to the distributer every week, and the manufacturing agent is enabled to produce raw and completed products through related operations. Meanwhile, the suppliers were deemed as agents with allocated timings for procurement. Learning method was adopted to inform agents on how to differentiate between circumstances and to choose interrelated actions for the maximization of numerical rewards signals and for the achievement of the top effective strategy. They could choose to employ knowledge and optimum actions when adopting and exploring new opportunities for policies enhancement. Similarly, [33] came up with a model that was built on the behavior of farmers, with the help of agent-based simulation within the agricultural supply chain optimization model. The authors considered farmers as smart agents that experimented and observed their environment to cull information on behavior adoption based on the culled information. The findings showed the famers risk effort in such a way that misrepresented delivery from the farmers would result in penalty. This penalty system motivated the farmers to improve delivery. The authors developed the agent interaction model based on the physical distance definition among the farmers, allowing information-sharing. Cases where a farmer was in certain proximity were tested and the remaining farmers boosted their diligent delivery. The lack of such testing would not enable the other farmers to provide optimum deliveries. From the literature reviewed above, it is evident that majority of the studies used IA in SCM and knowledge management to reap the advantages they offer, which include synchronized series of interconnected stages of joint demand planning and forecasting process throughout SC, prediction of end-customer demand based on partners' exchanged information and prior to forecasting, efficient tackling of different aspects of SC (e.g., warehousing, distributed environment synchronization, joint demand planning and inventory control, layered flexibility, granularities and scalabilities, automated knowledge management, inventory problem-solution that is optimized, and production of raw and finished data having operations that transform raw materials to the finished user products.

4 PROPOSED APPROACH

Various phases are integrated into the supply chain that has a direct and indirect contribution to achieving customers' demands and requests [34]. In other words, it encompassed product process, starting from the delivery of raw material and culminating in product delivery to the user and partners impacting the SC including manufacturer, supplier, retailers, transporters, customers and warehouses [35]. The study advocates the RBV theory's premise that firms consist of heterogeneous resources that differentiate the firms from competing firms. The supply chain has to have complex knowledge in considerable amounts concerning the complex environment and the interactions that take place within the organization [36, 37]. In addition, the classification of knowledge in the SCM forms the basis of the processes that make up the knowledge supply chain management [38]. This is why studies in literature have tried to categorize knowledge on the basis of the research framework, following the argument that each SCM function calls for different knowledge types and functions [20]. It should be noted that capabilities that produce, interpret and deploy multi-source knowledge are major drivers of the success of the company, particularly when addressing and leveraging the opportunities in the market [39]. In complementary connection, the SCK forms the initial part of the research framework, with studies focused on it, claiming that the top integral part of knowledge acquisition automation in the SC is the identification of what knowledge is required [40], for storage, recording and reusing in order to develop the application to its fullest [41], for ultimate high value [42] and maximization of the firm's overall knowledge using computer technology [43]. The primary aim of this part is the determination of knowledge on the basis of the functions of SC, in that those that can help other framework parts to cull the accurate and useful knowledge. In the present study, SCK refers to knowledge relating to SC functions of planning and transportation [44], production [45], warehousing [46] as well as delivery [46, 47]. It is also noteworthy that knowledge should be modeled and stored in a knowledge base [48], with the knowledge modeling implemented for actual acquisition of knowledge contributing value to knowledge creation. Aside from this, every SC function possesses knowledge that can assist in decision-making [20]. In this regard, a knowledge modeling is developed to enhance the knowledge basis that eventually facilitates the storage and retrieval of knowledge among the SC partners [49]. Additionally, [50] explained that information and knowledge obtained have to automatically

and electronically recorded and stored for enhanced productivity and optimum acquisition and accumulation of knowledge. It is pertinent for the partners in SC to gather knowledge sources to support their process of making decisions [51], and for this purpose, knowledge acquisition should gather and reuse knowledge form past experiences and cases and from experts knowledgeable on the issues and information [52]. Moreover, in the process of decision-making, it is crucial to gather knowledge based on its types to help SC partners and to develop a repository to obtain knowledge from for self-learning [53]. The knowledge acquisition method should facilitate partners' submission of knowledge/cases in an electronic manner [54], after which they can be categorized in the base to generate and reach informed decisions. Added to this, knowledge acquired should be documented and recorded in an electronic and automatic way to contribute to productivity and enhance acquisition and gathering of knowledge. This study adopted an approach that entails knowledge types of SCM to enhance knowledge acquisition and the knowledge types are categorized based on their supply chain functions. Knowledge obtained from the partners in the SC can be used to promote and enhance innovation and creativity [55]. This calls for addressing knowledge acquisition process by integrating artificial intelligence (AI) in the form of an intelligent agent for the most promising result [56]. An intelligent agent is adopted in this study owing to their role in AI methods and SCM and this covers automated knowledge acquisition that enhances SCM knowledge acquisition. In this regard, there are certain approaches that acquire knowledge in SCM, based on the examined knowledge type. The intelligent agent (IA) requires interaction with supply chain partners through an interface agent, following which the expert agents retrieve the case from the database. The proposed approach for automated knowledge acquisition automation is presented in Figure 1.

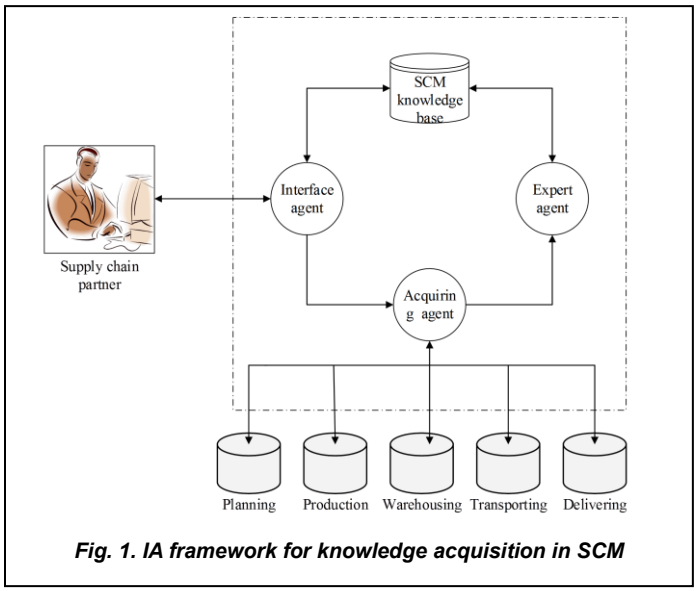

Fig. 1. IA framework for knowledge acquisition in SCM

4.1 Framework Components

The following components constitute IA;

- Interface agent – this forwards the case obtained from the user to the agent, who is responsible for communicating with the both the acquiring agent and the knowledge base. The interface agent brings forth solutions for the SC partner to choose from. Figure 2 shows the process of interface agent.

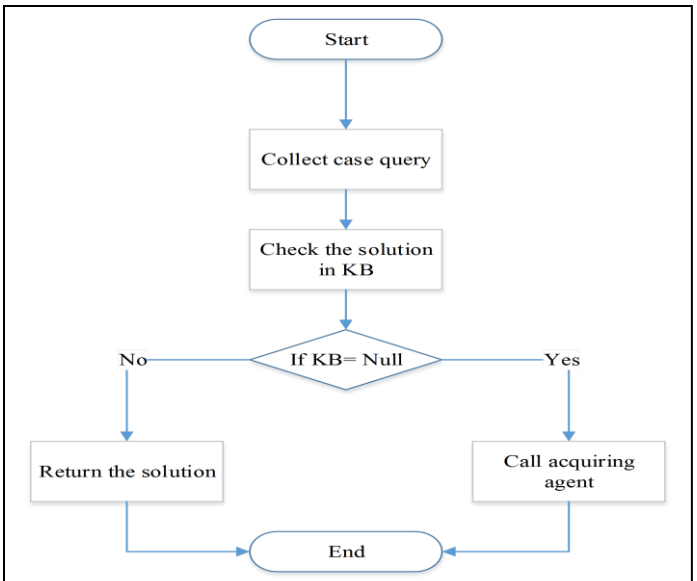

Fig. 2. interface agent flow chart

- Acquiring agent – this gathers knowledge/solutions to address and resolve cases issues that the interface agent relays to him, after which the issues are further relayed to the expert agent. Figure 3 shows the process of acquiring agent.

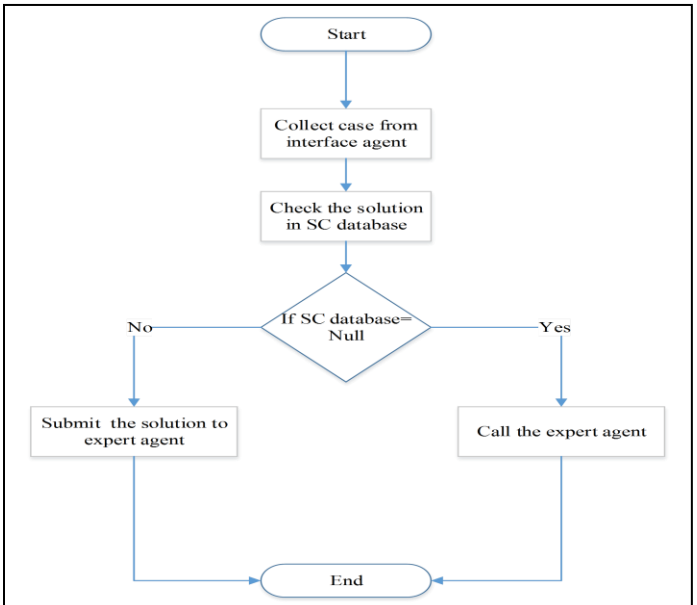

Fig. 3. Acquiring agent flow chart

- Expert agent – the expert agent collects cases from the acquiring agent and stores it in the knowledge base in specific form. Figure 4 shows the process of expert agent.

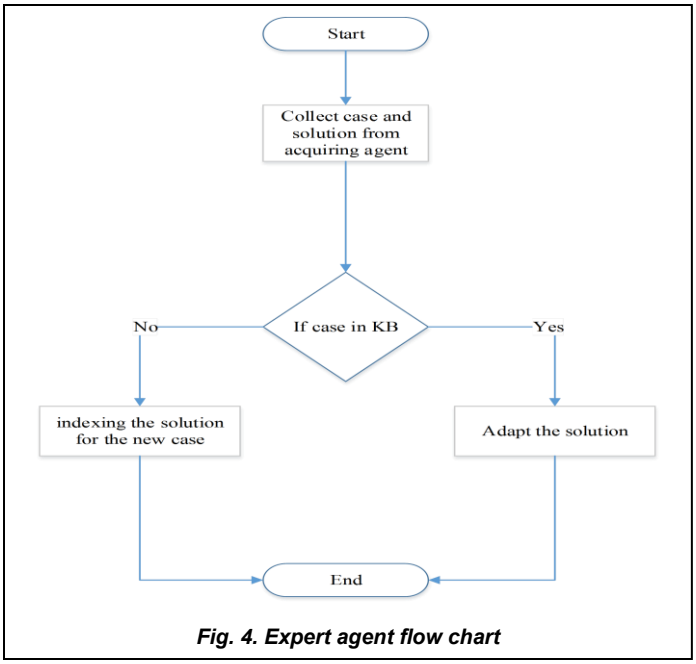

Fig. 4. Expert agent flow chart

5 CONCLUSION

This study proposed a framework for supporting knowledge acquisition. The study contributes by providing insight into the significance of knowledge acquisition in SCM, with the general aim of determining the use of supply chain knowledge. The SCM is inundated with SC knowledge under different knowledge categories. The study also contributes by adopting IA method to acquire knowledge, in the production function of SCM, as such method can accurately acquire knowledge in a timely manner. Moreover, the study also contributes to bridging the gap in literature that calls for more knowledge base and frameworks to describe automated knowledge acquisition in the context of SCM. This study proposed an approach that could lead to avenues and opportunities for development of knowledge acquisition methods that address SCM applications. The study suggests that future research to focus on developing learning algorithms and optimizing problem-solving methods in SCM knowledge acquisition.

6 ACKNOWLEDGMENT

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