Automated Knowledge Acquisition Framework for Supply Chain Management based on Hybridization of Case based Reasoning and Intelligent Agent

Mohammad Zayed Almuiet[1]
Center for Artificial Intelligence Technology
Faculty of Information Science and Technology
Universiti Kebangsaan Malaysia
Bangi, Malaysia

Maryam Mohamad Al-zawahra[2]
Department of Software Engineering
Faculty of Prince Al-Hussein bin Abdullah II of Information Technology, Hashemite University
Zarqa, Jordan

***Abstract*—Throughout the past few years, there has been notable research effort directed towards developing automated knowledge acquisition (KA) in order to automate knowledge acquisition in Supply Chain Management (SCM) applications. Several methods utilized for the automation of supply chain management involved Intelligent Agent (IA) and Case-Based Reasoning (CBR). This paper used both approaches to bring about automated knowledge acquisition in order to assist decision-making in SCM applications. With the arrival of a new case, prior cases are retrieved from the database and the potential solutions are laid down. After the completion of acquisition, case and solution outcome are analyzed and evaluated according to function similarity. Finally, after evaluating the new case along with the problem details and the chosen solution, the case is retained in the database for issues that will arise in future applications.**

Keywords*—*Knowledge acquisition; supply chain management; supply chain knowledge; case-based reasoning; intelligent agent component

I. Introduction

In the field of Supply Chain Management (SCM), knowledge acquisition (KA) has been touted as a major approach in gaining competitive advantage because knowledge forms the heart of competitive edge in the current knowledge economy [1]. Knowledge acquisition is described as the knowledge access and absorption, both direct and indirect, from the sources of knowledge [2]. It begins with the determination of knowledge in the surroundings of the organization and culminates with the knowledge transformation into a format type that can be useful to the organization [3]. In this regard, both the creation and acquisition of knowledge are processes that are crucial to the organization that should be ongoing to maintain competitive advantage in the face of dynamic changes in the environment [4]. In relation to this, the knowledge-based view of the firm considers knowledge as a product resource that is indispensible to the point where it is a must for organizations to obtain knowledge from within and from external sources, like rival organizations [5]. This view also assumes that the relative ability of the organization to acquire and develop knowledge is manifested in different performance variations [6], and hence acquiring knowledge enhances the performance of the whole supply chain (SC) [7]. The argument that the firm needs to acquire new knowledge form suppliers regarding product innovation is not a new one with the reviewed literature indicating that the knowledge acquisition of the firm from its partners in the SC can be carried out through benchmarking, collaboration or joint problem solving [7], through technical assistance or strategic alliances [8], involvement of suppliers in product development [9], and through informal connections [10]. Despite the knowledge acquisition importance to SC, studies that are dedicated to it are still scarce. Prior studies that tackled the subject have been confined to exploring transfer of knowledge and problem-sharing such as, ambiguity, optimization, risks mitigation, and the like [11-13]. The top method utilized by prior studies in knowledge management of SCM involved CBR and IA [14, 15], with only a few studies creating and bringing forward a framework of knowledge acquisition. In fact, as yet, to the best of the researcher's knowledge, from prior literature, only two [16] and [17], have addressed the automation of acquiring knowledge in SC and thus, this indicates the need to examine the issue as currently, it remains a challenge to manually acquire knowledge. This may be related to the premise of the automation value in mitigating knowledge acquisition directed efforts. A framework is therefore needed that is built on a repository used for supply chain knowledge acquisition, as evidenced by the urging from prior authors whose works are dedicated to the topic.

Accordingly, the present study aims to provide an outline proposed hybrid CBR and inelegant agents for automated knowledge acquisition of production function of SCM. The rest of the paper is organized as follows. The first part of this paper elucidates on KA problems and issues and how they can be solved by developed automated knowledge acquisition approach in assisting SCM members. The second part of this paper will provide an related studies concerning knowledge acquisition in supply chain management, followed by part three which explains research framework and proposed approach displayed in part four. Part five discusses the experimental results. Part six presents the research conclusion with recommendations for future studies.

II. Related Studies on Automated Knowledge Acquisition in SCM

Knowledge acquisition is mainly described as the production of knowledge continuously from prior and new information gathered from the environment. Added to this, the supply chain knowledge may be created based on processes (social and collaborative). According to [18] knowledge can be produced through specific processes including, action learning involving solving problems, concentrating on the learning that is required, and implementation of solutions. More specifically, systematic problem solving requires a disciplined mindset well-versed in reductionism and holistic knowledge, focused on details, and extension of boundaries that work towards underpinning the assessment. This entails learning from past experiences, organized assessment, disseminating and recording lessons that can be later utilized. After the acquisition of knowledge, a main repository for it should be developed to collect for the supply chain as explained by [19]. They contended that companies should carry out knowledge codification in a repository. They showed that knowledge acquisition in the supply chain (SC) is based on each repository in the supply flow. Similarly, knowledge acquisition refers to a socially complex and interlinked concept [20]. Other authors like [21] focused on the social interaction nature in acquiring knowledge for the purpose of product innovation. According to them, knowledge acquisition in innovation depends on the interaction with the sources of knowledge.

Knowledge acquisition studies appear to be burdened by different labors that are categorized under knowledge technology. Several works have tried, with combined outcomes, to employ knowledge assets via centralization of knowledge technology functions or IT investments. When encountering business phenomenon, knowledge techniques have to be determined to resolve issues. According to the general premise, knowledge can result in enhanced businesses [22] and as such, it is pertinent to acquire knowledge. Such premise has to be supported by empirical findings, and it would be more significant if knowledge is differentiated on the basis of strategy. The question then arises as to how to acquire knowledge rather than whether to acquire it–this needs empirical support.

Prior studies attempted to minimize the above mentioned gap by investigating knowledge acquisition for a specific issue by taking assistance of human experts and knowledge encoding in a computer format. Evidently, the techniques are important for the effective acquisition of knowledge. In current empirical studies, knowledge acquisition, with some focusing on the factors that affect the required knowledge acquisition [23], while others examined the issues concerning knowledge acquisition risks [24]. Some others examined the adherence to the retrieval habits of the user to resolve lack of intelligence in traditional methods of retrieval, especially in a database information that is considerably large [16].

Judging from the debates, arguments and discussions on the knowledge acquisition importance in the SC context, it is clear that the SC of the firm has to acquire knowledge for ease of collaboration with the chain members. In this regard, [25] examined the supply chain-oriented knowledge acquisition, sharing and use, while keeping the following issues on theoretical underpinning assumptions of knowledge; knowledge cannot be shared easily throughout the chain, every work function in one join enterprise lacks clarity, and SCM lacks the ability to innovate. The study touched upon the issues and called for the need of a knowledge system platform to facilitate knowledge sharing. The envisioned system has to be based on a repository, which functions as a storage that forms knowledge categories throughout the supply chain. More studies were called for to be carried out to conceptualize the system and to address issues including knowledge-sharing culture and the safety of the system before it can be established.

In the above background, studies that examined automated knowledge acquisition in the SCM are still scarce and what little there is laid emphasis on the scarcity of technical applications (e.g., [16], [17] and [24]). More specifically, the vegetable supply chain knowledge acquisition was examined by [16], within which stress was laid on its application to rectify unsatisfactory retrieval results in various situations of database information. Based on ontology, the application underwent devolution and was modified to be consistent with the retrieval habits of the users as well as their timings in order to make up for lack of intelligence in the traditional keywords retrieval. The authors called for future studies to identify other ways that can be used to minimize the risks in acquiring knowledge in this context. Additionally, [17] delved into the ambiguities in representation, the attributed description and similar knowledge measures in product design by developing a fuzzy case-based reasoning (FCBR) in product style extraction, assisted by linguistic variables. This was followed by the encoding of the product by a vector comprising of several attributes, and the development of product morphology. The authors proposed a product style extraction model using FCBR, after which the outcome was normalized using Fuzzy Sets. Based on their obtained findings, the FCBR was revealed to be more effective in comparison to other product form style extraction models.

In relation to the above studies, [24] furnished a summarized outline of the qualitative and quantitative studies dedicated to knowledge acquisition in SC and found few studies that developed a knowledge acquisition framework and its management in this context. The authors also revealed the lack of qualitative and quantitative studies dedicated to the topic. Despite the knowledge acquisition importance to the SC, studies and works dedicated to the topic are still lacking. In fact, prior knowledge acquisition researchers in the SC have been confined to transfer and sharing of knowledge related issues such as optimization, risks mitigation, ambiguity and the like.

A. *Case-Based Reasoning in Automated Knowledge Acquisition*

Information coordination and sharing was enhanced in [11] through the adoption of CBR characteristic and multi-agent, in the presence of different supply chains to rectify the uncertainties that are rife in demand. The authors illustrated that the use of the joint system of CBR and multi-agent base coordination succeeded in the enhancement efforts and generated optimum outcome for the SC rather than using CBR on its own. Meanwhile, both CBR and intelligent agent were combined together in a study conducted by [26]. Individually, intelligent agent is utilized for the exchange of bargaining offers, while CBR is utilized for the efficient retrieval of suitable case from the database. The authors' hybrid approach re-uses prior successful cases to be solutions to new issues encountered by the enterprise and to provide effective adaptation algorithms to align the case suitability to new negotiation contexts. Moreover, in [27], the authors brought forward an integrated framework based on multi-agent collaboration and CBR process, in what became known as the MACESCM system to provide flexibility and extensible solution for addressing arising uncertainties in the SCM and for building an extensive multi-agent system. Such extensive system is used for the understanding, management and in reaching informed decisions for the mitigation of SCM breach and disruption. Similarly, [28] used a combined version of CBR and multi-agents to rectify complexity in SC cost of inter-organization management. They found their approach to be success in enhancing competitive ability and to resolve current issues in the SC cost management. Meanwhile, [29] integrated integer programming, fuzzy set theories and CBR to assist in supplier selection and used fuzzy parameters in the model.

The CBR approach was also employed by [30] in their quest to develop auto-immunization knowledge acquisition level directed towards system performance improvement and towards conducting timely exploration of intelligent system. The weakness of the model is its nature complexity that involves increased number of cases and lack of efficiency in decision-making [31]. A study of the same caliber was conducted by [32] to look into the amelioration of abnormalities in the SCs of manufacturing. The author's study framework was a combination of case-based reasoning, with prior decisions used in current decision-making, to enable learning capability of the agent, while considering integration issues in order to make use of add-on module to legacy systems. Also, [33] proposed and illustrated a novel supply chain method combining four collaborative cost management (CCM) phases and CBR procedures with fuzzy inference model. The method was proven to be successful in enhancing the traditional similarity assessment and it obtained top optimum cases to solve new issues with. The authors provided new information set definition on the CCM problem and emphasized on CBR self-learning in this context to make sure that the selected case solution is the top one, which could ultimately achieve collaborative effect value of CCM.

Furthermore, a real-life case-based action study was carried out by [34] using an integrated analytical model that combined quality function deployment and analytic hierarchy process method for the evaluation of the performance among suppliers. The effectiveness of their technique was demonstrated via different validation processes (i.e., focus groups, business outcomes and statistical analysis results). The findings indicated that enhanced supplier performance outcomes positively affect client organization performance in light of their business and operations.

Added to the above studies, [35] brought forward a method that combined three supporting perspectives, which are multi-agent systems, fuzzy logic and case-based reasoning, a rare combination in one framework. The authors conducted an exploratory case study directed towards an office furniture firm to illustrate the value and effectiveness of their study framework. They used their framework to evaluate the supply offers based on customers' preferences, generating alternative products in stock-out cases, and facilitating a collaborative environment among agents that represent different supply chain entities. Specifically, the authors proposed fuzz case-based reasoning (F-CBR) approach was successful in mitigating overload of information through the systematic case organization. On the basis of their findings, unsatisfied customer, information overload and high uncertainty are the top issues in the SC. Nevertheless, their system did not include functions of inventory management and negotiations of agents and while they examined the case description and case retrieval cases of CBR, the rest of the phases were excluded (e.g., case retaining, case reusing, and case revising).

A similar study was conducted by [36], where a case-based supply chain strategy analysis model was proposed to generate cases oriented on various factors that were involved in the SC process performance evaluation. For the proposed model, Java language was used in its design with a platform that is independent, secure, robust and features that are object-oriented. The study made use of K-Nearest Neighbor algorithms for the determination of similar cases from the database repository and calculated the performance strategy of SCMS. The model's weakness is the inefficient access of K-NN algorithms, in retrieving similar cases. When the number of cases increased and the case base increased, the system tended to slow down.

On the basis of the above reviewed literature, several studies made use of CBR in SCM and knowledge management owing to its many benefits that include; facilitation of adaptive negotiation strategy between buyers and sellers in SCM, enhancement of traditional similarity assessment and obtaining top cases to tackle new issues, enabling the agent's learning capability, while keeping the integration issues into account for the employment of add-on module to legacy systems, and tackling amelioration of abnormalities in the SCs manufacturing and improving the knowledge acquisition performance auto-immunization process.

B. *Intelligent Agent in Automated Knowledge Acquisition*

Several studies were conducted in the topic of automated supply chain through the use of agent-based models, which eventually supported the relationship between AI techniques and supply chain performance. In SC performance enhancement, AI techniques have a major role and other methods can be based on them. In this regard, [37] proposed an integrated framework for agent built on the inventory-production-transportation model and the simulation of SC. There were four levels to the model that ranged from domain modeling to multi-agent systems implementation, using the agent-based modeling and distribution simulation theory. a conceptual agent model with four-layers, a meta-agent class library and a platform of multi-agent based distribution simulation. The framework was directed towards furnishing a multi-agent class library for the users and meta-agent based distributed platform for SC, which made it possible to visually and rapidly develop the agent-based simulation, coupled with meta-agents s the building blocks. In addition, the framework was directed towards the promotion of independent building of sub-simulation models by implementing and synchronizing them in a distributed surrounding. The authors found the proposed integrated framework to be flexible in different layers, granularities and scalabilities. Along with the above studies, [38] analyzed the performance of supply chains using agent-based simulation based on SC operations reference model. SC indicators and negotiation techniques are largely developed for local management and one-to-one associations. The authors indicated various SC configurations effects the dynamic SCOR performance indicators environment based on a global point of view. The authors proposed a modified traditional SCOR indicator with prior knowledge of the connectivity of the network.

Meanwhile, [39] brought forward an agent-based negotiation model to automate supplier selection process, with the model containing a series of products with synergy effect. The authors used a multi-agent system to achieve the objective of the model and stressed on the negotiation proposal, negotiation protocol, negotiation strategies and the decision-making methods in the product-supplier selection environment model. Their expectation was that the model facilitates purchasing company-supplier agreements on the details of products, while exploring products synergy effects. A similar study was conducted by [40], where an agent-based customer-oriented supply networks model was brought forward to tackle customer purchase decision-making process and adaptability of the supply network. The model was built based on a real-life case study from a floriculture sector in Columbia. An agent-based simulation model for multi-leveled inventory optimization problem was also proposed by [41] for a network consisting of plant, distributor and distribution centers. The model used a mathematical optimization process that was directed towards inventory systems parameters, and inventories were employed to buff against demand valuation and lead-time fluctuations. Specifically, the model consisted of a facility agent monitoring and refreshing inventory, an order agent saving data in the form of demand, sender, receiver and status, as well as a shipment agent recording data in the form of shipment quantity, shipping time and sender and receiver, and finally, a customer agent obtaining orders on the basis of probability relations.

In [42] study, four layered supply chain (distributer, retailer, manufacturer and supplier) was proposed, using an inventory quantity analysis after every week following the placing of orders. In this case, retailers were able to perform policy of partial demand satisfaction in modeling, with the orders sent to the distributer on a weekly basis, whereas the manufacturing agent can generate raw and finished products, consisting of operations that did so, and the suppliers were considered as agents, with designated procurement timings. The study made use of learning method to instruct agents to distinguish between situations and to selected connected actions in order to maximize the numerical rewards signals and achieve optimum strategy. They had an option to use knowledge and optimum actions in adopting and exploring novel avenues of opportunities and to enhance policies. Along a similar line of study, [43] developed a model on the basis of farmer's behavior by agent-based simulation encapsulated in an agricultural supply chain optimization model. The authors deemed farmers as smart agents performing experiments and observing the surrounding areas for information in order so that they may adopt behavior on the basis of the information obtained. The authors revealed the presence of risk effort factor among farmers in that with misrepresented delivery, the farmers will be penalized. The penalty system boosts the efforts of the farmers to enhance delivery and the agent interaction model was developed according to the physical distance definition among farmers, enabling them to share information. In situations where a farmer in a particular distance has been tested system-wise, then the rest of the farmers diligent delivery is boosted, but without such testing, the other farmers would also exert low efforts in providing optimum deliveries.

On the basis of the above reviewed literature, it can be noted that several studies employed IA in SCM and knowledge management because of the many benefits it provides. Such benefits include its synchronization of a series of interlinked stages of joint demand planning and forecasting processes in SC, its capability to predict end-customer demand on the basis of exchanged information among partners in SC, and before forecasting, its efficiency to tackle various SC aspects including warehousing, joint demand planning and inventory control, distributed environment synchronization, flexibility in many layers, granularities and scalabilities, automation of knowledge management, optimization of inventory problem solution and generation of raw and finished data with operations that realizes the transformation of raw materials to end-products.

III. Conceptual Framework

The current study is built on two premises. Support for each premise from literature has been highlighted in the previous sections. First, the researcher assume, in this research, knowledge types of supply chain management is essential bases to enhance a knowledge acquisition. The knowledge types are categorized based on supply chain function which is planning, production, warehousing, delivering and transportation. Second, in supply chain management, the knowledge acquired from supply chain partners impact is likely to enhance innovation and creativity [44]. Hence, it is essential to address knowledge acquisition by combination of two techniques of AI namely: Intelligent Agent (IA) and Case-Based Reasoning (CBR) to reinforce optimal results [26]. The study chooses to draw from those applications because they cover both the AI techniques and supply chain management. This is to include automated knowledge acquisition that may enhance acquired knowledge in supply chain management in food manufacturing firm context. This aspect is limited to those techniques that are expected to have an optimal result in acquiring the knowledge in supply chain management and are specific to the knowledge types being studied. When CBR and IA combine, the IA starts with collecting the supply chain partner query through interface agent and then interact with other agents (Acquiring and expert agent) to retrieve the case from data base (cases base). The CBR start with cases (knowledge) collection from supply chain partners and match the solution for such cases.

The current study focuses on developing automated knowledge acquisition in the supply chain management perspective about the following: supply chain knowledge modelling, knowledge acquisition and combination of cased based reasoning with intelligent agent to get optimal result. In brief, the combination of these two pieces of techniques is incorporated into a proposed approach for acquiring the correct knowledge. Fig. 1 depicts these premises.

This research adopts the following concepts in the conceptual framework that is being proposed:

- Supply chain knowledge: In the context of this research the SCK represents the relevant knowledge of the supply chain management environment in a given firm. This is conceptualized by the supply chain partners and its functions which firm can perform to either optimize their knowledge or adapt them to emphasize and achieve knowledge acquisition through appropriate tools.
- Knowledge storage: In the context of this research the knowledge storage represents the modelling supply chain partners' knowledge's based on the supply chain functions.
- Applied Artificial intelligence techniques: In the context of this research the combination of AI techniques clarifies the relevant techniques of the artificial intelligence that is proposed by frameworks relevant to the knowledge acquisition, Supply chain management, and knowledge management aspects. For example, combination of intelligent agent with case based reasoning. Such combination may also come in the form of adherence to acquire the right knowledge at critical time.

The supply chain comprises of the different phases that directly and indirectly contributes to the achievement of the request of customers [45]. Hence, it covers product process beginning from the raw material to delivery of product to the user, the partners that impact the supply chain like manufacturer, supplier, transporters, retailers, customers and warehouses [46]; this is relate to RBV as the theory claims that firms consists of heterogeneous resources that contribute to the differentiation of the firm from its rivals. All that is relevant to the supply chain has abundant and complex knowledge because of the complex environment and the exchanges that are inter-organizational [47, 48]. Additionally, the knowledge classification in supply chain management is the basis of the processes that take place in knowledge supply chain management [49]. Hence, prior researchers have attempted to classify knowledge on the basis of their research framework. Each function of the supply chain management requires different types and function of knowledge [19]. Another essential point, capabilities of generating, interpreting and deploying the multi-source knowledge are key drivers of company success, when responding to the market opportunities [50].

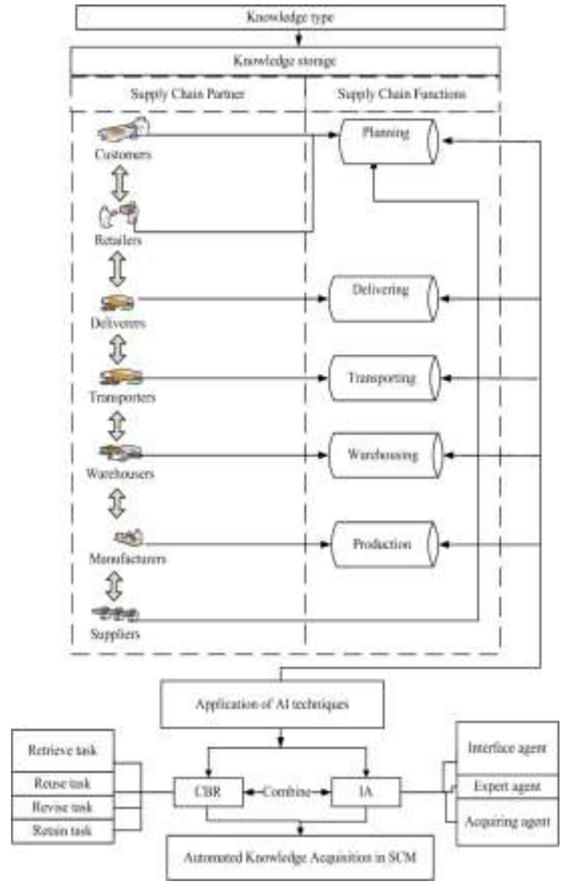

Fig. 1. Conceptual Framework.

Complementary to this, the design of SCK makes up the first part of the research framework. According to several related studies the best of automation of knowledge acquisition attempts in the SC should concentrate on; identifying relevant knowledge [51], that is to be recorded, stored and reused for their optimum application advancement [52]; that would result in the highest value for the organization [53]; and that would maximize the overall knowledge of the firm via the help of computer technology [54]. The major goal in this part is to identify knowledge based on SC functions, which can assist with other parts of the framework to obtain the right knowledge. In the context of this research, SCK is a knowledge that relates to the SC functions which are: planning [55], transportations [55], production [56], warehousing [57], and delivery [57, 58] as mentioned earlier.

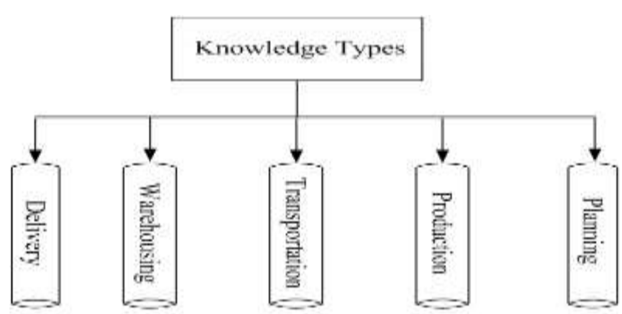

Fig. 2. Knowledge Modelling.

More importantly, knowledge is needed to be modelled and stored in the knowledge base [59]. The knowledge modelling applied to actual knowledge acquisition can be invaluable to creating knowledge. Besides, each function in supply chain has its knowledge that helps in the process of making decisions [19]. A knowledge modelling (see Fig. 2) is created to develop bases of knowledge that assist SC partners to store and retrieve knowledge [60]. In addition, the information and knowledge acquired should be recorded automatically and electronically [61], in order to improve productivity and help knowledge acquisition and accumulation.

The SC partner must obtain knowledge sources to reinforce their decision making [62]. Moreover, to help the partners in reaching a reasonable decision, knowledge acquisition should accumulate and reuse knowledge from prior cases and experts who are capable of providing significant suggestions [63]. In the decision making process, it is vital to obtain the relevant knowledge on the basis of the type of knowledge. It is considered efficient if the knowledge acquisition method assists the SC partners in their decision making. At the same time, information and knowledge obtained from the decision-making process can be kept in a repository and used by partners and decision makers in their self-learning [64]. The method of knowledge acquisition should have functions including; knowledge or cases from the partners that can be submitted electronically [65], the submitted knowledge can be categorized in the knowledge base in an automatic manner, and finally, the decision can be generated. In addition, the information and knowledge acquired should be recorded automatically and electronically to improve the productivity and help knowledge acquisition and accumulation.

IV. Proposed Approach

The present research adopted an approach involving knowledge types of SCM for knowledge acquisition enhancement. The types of knowledge are divided according to the supply chain function production. In the SCM, knowledge obtained from the supply chain partners' effects will likely improve innovation and creativity [44]. Thus, it becomes crucial to tackle knowledge acquisition through the combination of artificial intelligence (AI) (i.e., intelligent agent) and case-based reasoning (CBR) to achieve the most optimum outcome [26]. These applications are used in the study owing to their involvement in AI methods and SCM. This includes automated knowledge acquisition that can work towards improving acquired knowledge in the SCM in the food manufacturing context. Therefore, specific techniques are focused on in knowledge acquisition in the context of SCM that are specific to the types of knowledge examined. The combination of CBR and IA entails the latter's query of supply chain partners via an interface agent, after which acquiring and expert agents play a role in retrieving the case from the database. Meanwhile, the CBR begins with knowledge collection from the supply chain partners and matching cases to obtained solutions. The proposed approach to automate knowledge acquisition in the SCM's is displayed in Fig. 3.

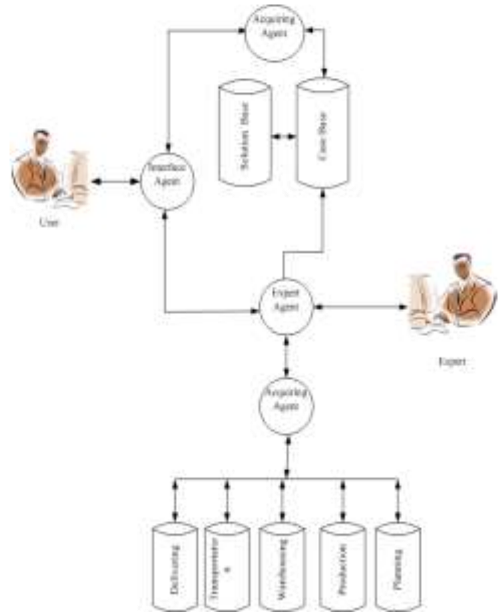

Fig. 3. Automation KA Approach.

A. *IA component*

- Interface agent–The interface agent relays the case to the agent from the user, with the former being responsible to communicate with the acquiring agent and the expert agent. In addition, the interface agent proposes solutions to both the agents.
- Acquiring agent–the acquiring agent obtains knowledge or solutions to rectify issues in cases that the interface agent forwards to him.
- Expert agent–the expert agent helps the acquiring one by consulting with experts to provide case solutions.

Fig. 4 demonstrates shows the basic steps of intelligent agents components that used in this study. The role of intelligent agents are collecting cases and submitting a case from agent to other agent based on responsible of each agent.

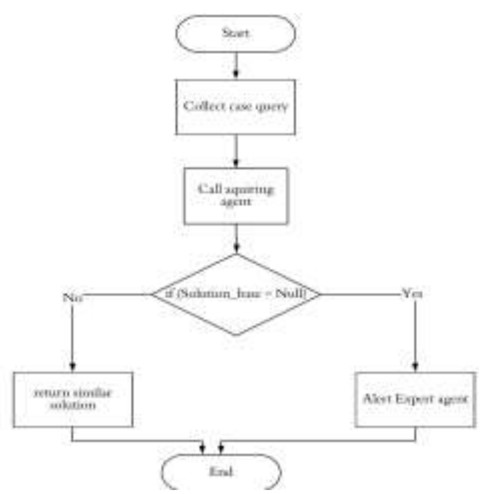

Fig. 4. Flow Chart of Intelligent Agents Components.

B. CBR Component

- Case retrieval–the case retrieval searches for past cases from the database that mimics the current case. Case retrieval from the proposed system involves several steps presented in Fig. 5.
- Case indexing–SCM actual activities like production entail preferences and limitations that may only be defined in an imprecise manner like name, price, quality, quantity and the like. An index is created to implement the CBR system, with the feature selection designed on the basis of the production enhancement contents. This may be exemplified by the following; products can be indicated in the following categories, P1, P2 and P3, and quality can be indexed as good, poor or excellent, whereas quantity can be indexed as quantity size as numerical values as displayed in the Table 1. On the basis of the indices, cases can be placed into groups based on problems and this assists in timely retrieval of similar cases.
- Similarity and Recommended Solutions -this study used the CBR-AI in order to enhance the performance of KA approach rather than solely using end-to-end system. The proposed approach was verified in order to generate satisfactory results by testing cases through experiments. The researchers then compared between the features of the current cases to the case attributes (case base). If the prior case base has similarities that equals or nearer to the knowledge type (case) requirement number, then 100% similarity value may be achieved. The similarity value is calculated according to local and global similarity [66] as displayed by equations 1, 2 and 3.

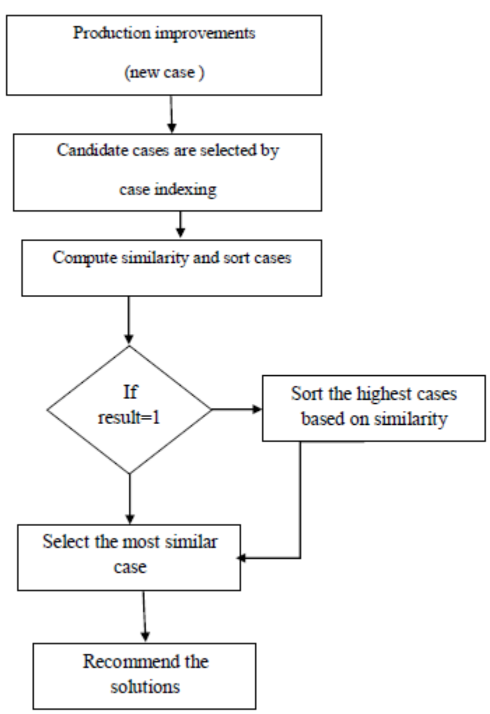

Fig. 5. Case Retrieval Flow Chart.

TABLE I. CASE STRUCTURE

Case Attribute	Case Value
Product ID	Integer
Quality	Text
Quantity	Integer number
Price	Integer number

The entire retrieved cases using case indexing are categorized based on similarities, and the case that had the highest similarity is considered as the one that matches the current case–which means the current problem mimics the case base. In cases, where there is more than one case base, then the highest similarity cases will be categorized on the basis of their utility values of case results. In this regard, the case with the best problem payoff is chosen as the case that matches the current one and after its selection, the solution and outcome are documented for future cases adaptation.

$$\text{sim (xi, yi)} = \begin{cases} 1, & \text{xi} = \text{yi} \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

$$sim\ (xi, yi) = \begin{cases} 1, & if\ xi \leq yi \\ 1 - \frac{|xi - yi|}{|max(xi, yi)|}, & otherwise \end{cases} \tag{2}$$

$$sim\ (xi, yi) = \frac{\sum_{i=1}^{n} wi * sim(xi, yi)}{\sum_{i=1}^{n} wi} \tag{3}$$

Where,

- n denotes the number of case attributes
- xi denotes the new case attributes
- yi denotes the case base attributes
- sim (xi; yi) denotes different attributes similarities between xi and yi
- wi denotes the weights, wi ∈[0; 1]

Regarding the local similarity calculation between the current case and case base, the system conducts a comparison between the first value of knowledge type to the value on the first column in the case base – this is conducted for each feature. However, the SC partner does not need to articulate each feature, in which case, query bias is employed, where the distinct SC partner feature is compared to the column of the case base. For the calculation of the local similarity, Equation 1, 2 and 3 are used and after such calculation, the global similarity is calculated using neighborhood approach (refer to Equation 3).

V. Experiment

For the purpose of the experiment, several procurement cases were acquired from the food company and the study ran simulations for outcome evaluation. The study used a case study as an example to demonstrate the approach's effectiveness. The primary aim of the experimental analysis is to determine the performance of the integrated CBR-IA and to gauge the similarity of the approaches. Under this section, the evaluation is based on new case of production (refer to Table 2).

TABLE II. NEW CASE

Product name	Quantity	Quality	Price
P101	1000	Good	3000

Aligned with the production staff's new procurement requirement, in the acquiring step, the hybrid CBR is employed to assist agents in obtaining invaluable knowledge. In this particular problem, the author retrieved four candidate cases along with their contents (see Table 3). The candidate cases are ranked based on their relative similarity values (refer to Table 4). The similarities result is displayed in Table 5.

There are four candidate cases in the above table, and case 1 was found to have the highest similarity and was thus chosen as the case that best matched the current case. The experimental outcome illustrated the efficiency of the approach to acquire the top most similar cases compared to an approach without the hybrid.

TABLE III. CANDIDATE CASES RETRIEVED BY CASE INDICES

	Product name	Quantity	Quality	Price
Case 1	P101	1000	Good	300
Case 2	P100	1000	Excellent	3000
Case 3	P100	100	Good	600
Case 4	P102	100	Poor	3000

TABLE IV. SIMILARITIES OF CANDIDATE CASES

Case	Similarity
Case 1	75%
Case 2	50%
Case 3	25%
Case 4	25%

TABLE V. SIMILARITIES FUNCTIONS RESULTS

Attribute	Equation used	Wight	New case	Case 1	Local similarity	Case 2	Local similarity	Case 3	Local similarity	Case 4	Local similarity
Product ID	1	1	P101	P101	1	P100	0	P100	0	P102	0
Quantity	2	1	1000	1000	1	1000	1	100	0	100	0
Quality	1	1	Good	Good	1	Excellent	0	Good	1	Poor	0
Price	2	1	3000	300	0	3000	1	600	0	3000	1
	$\sum_{i=1}^{n} \mathrm{sim}(xi, yi)$				3		2		1		1
	$\sum_{i=1}^{n} wi$	4			4		4		4		4
	$\frac{\sum_{i=1}^{n} wi*\mathrm{sim}(xi,yi)}{\sum_{i=1}^{n} wi}$				3/4=75		2/4=50		1/4=25		1/4=25

VI. CONCLUSION

In the tested proposed hybrid approach, the prior successful case solution is reused to solve a current issue encountered by the firm. The approach provides effective adaptation algorithms to ensure that the case is appropriate to solve the new procurement case. It makes complete use of the entire potential knowledge acquisition processes. In sum, the proposed hybrid CBR approach is effective as a framework to support knowledge acquisition. The contribution of this study is that it offers the understanding of knowledge acquisition invaluable to supply chain management, and the general view by determining the inevitable use of supply chain knowledge. The supply chain knowledge of different knowledge types exist in the supply chain management context. This study contributes by using CBR and IA techniques in knowledge acquisition within the production function of supply chain management. The study delves deeper by integrating CBR and IA techniques to acquire the right knowledge at right time. More importantly, this study contributes by minimizing the gap identified in literature relating to absence of knowledge base and frameworks describing the knowledge acquisition automation in supply chain management. The proposed approach of this study may pose as a step closer to the development of an approaches addressing knowledge acquisition in the supply chain management applications. Future work can examine other applications of SCM like planning, delivery and transporting that may call for more developed learning algorithms and optimization methods for problem-solving.

REFERENCES

[1] M. Z. Almuiet, J. Salim, and J. Yahaya, "Automated Knowledge Acquisition in Supply Chain Management," International Journal of Trend in Research and Development (IJTRD(vol. 5, 2018.

[2] M. Z. Almuiet and J. Salim, "Knowledge flow in supply chain manufacturing: Case study in food manufacturing firm," Procedia Technology, vol. 11, pp. 463-470, 2013.

[3] M. Z. Almuiet and J. Salim, "From a Literature Review to a Conceptual Framework for Automation Knowledge Acquisition in Supply Chain Management," Journal of Theoretical & Applied Information Technology, vol. 64, 2014.

[4] W. Chen, X. Zhang, C. Peng, and L. Xu, "Supply Chain Partnership, Knowledge Trading and Cooperative Performance: An Empirical Study Based on Chinese Manufacturing Enterprises," 2012.

[5] N. Seyyedeh and F. Daneshgar, "What Drives Organizations To Share Knowledge With Their Supply Chain Partners?," in ECIS, 2010, p. 167.

[6] T. H. Kim, J.-N. Lee, J. U. Chun, and I. Benbasat, "Understanding the effect of knowledge management strategies on knowledge management performance: A contingency perspective," Information & management, vol. 51, pp. 398-416, 2014.

[7] Q. He, A. Ghobadian, and D. Gallear, "Knowledge acquisition in supply chain partnerships: The role of power," International Journal of Production Economics, vol. 141, pp. 605-618, 2013.

[8] H. Zhang, C. Shu, X. Jiang, and A. J. Malter, "Managing knowledge for innovation: the role of cooperation, competition, and alliance nationality," Journal of International Marketing, vol. 18, pp. 74-94, 2010.

[9] S. Najafi Tavani, H. Sharifi, S. Soleimanof, and M. Najmi, "An empirical study of firm’s absorptive capacity dimensions, supplier involvement and new product development performance," International Journal of Production Research, vol. 51, pp. 3385-3403, 2013.

[10] C.-C. Lee, F.-S. Tsai, and L. C. Lee, "Parent control mechanisms, knowledge attributes, knowledge acquisition and performance of IJVs in Taiwan service industries," The Service Industries Journal, vol. 31, pp. 2437-2453, 2011.

[11] O. Kwon, G. P. Im, and K. C. Lee, "MACE-SCM: A multi-agent and case-based reasoning collaboration mechanism for supply chain management under supply and demand uncertainties," Expert Systems with Applications, vol. 33, pp. 690-705, 2007.

[12] R. I. MOGOȘ and P. L. SOCOLL, "Knowledge Management and Intelligent Agents in an E-Business Environment," International Journal of Economy Informatics, vol. 1, pp. 19-22, 2008.

[13] C.-C. Huang and S.-H. Lin, "Sharing knowledge in a supply chain using the semantic web," Expert Systems with Applications, vol. 37, pp. 3145-3161, 2010.

[14] K. Al-Mutawah, V. Lee, and Y. Cheung, "A new multi-agent system framework for tacit knowledge management in manufacturing supply chains," Journal of Intelligent Manufacturing, vol. 20, p. 593, 2009.

[15] D.-J. Wu, "Software agents for knowledge management: coordination in multi-agent supply chains and auctions," Expert Systems with Applications, vol. 20, pp. 51-64, 2001.

[16] W. Sun, "The Ontology Driven Approach to Vegetable Supply Chain Knowledge Acquisition System," in Semantics, Knowledge and Grid, 2008. SKG'08. Fourth International Conference on, 2008, pp. 26-33.

[17] H. Xiaodong, W. Jianwu, S. Fuqian, and C. Haiyan, "Apply fuzzy case-based reasoning to knowledge acquisition of product style," in Computer-Aided Industrial Design & Conceptual Design, 2009. CAID & CD 2009. IEEE 10th International Conference on, 2009, pp. 383-386.

[18] M. S. Raisinghani and L. L. Meade, "Strategic decisions in supply-chain intelligence using knowledge management: an analytic-network-process framework," Supply Chain Management: An International Journal, vol. 10, pp. 114-121, 2005.

[19] K. Hafeez, E. Rodiguez-Falcon, H. Abdelmeguid, N. Malak, and P. Training, "Knowledge Management in Supply Chains," in ICSTM, 2000.

[20] Y. Liao and E. Marsillac, "External knowledge acquisition and innovation: the role of supply chain network-oriented flexibility and organisational awareness," International Journal of Production Research, vol. 53, pp. 5437-5455, 2015.

[21] H. Parker, "Knowledge acquisition and leakage in inter-firm relationships involving new technology-based firms," Management Decision, vol. 50, pp. 1618-1633, 2012.

[22] A. Norang and S. Nooshin, "Identifying different methods for creating knowledge from lessons learned in project oriented organizations," Management Science Letters, vol. 6, pp. 19-24, 2016.

[23] I. A. Diugwu, "Building Competitive advantage of small and medium sized enterprises through knowledge acquisition and sharing," KCA Journal of Business Management, vol. 3, pp. 102-120, 2011.

[24] L. Ma and F. Nie, "A study on risk of knowledge management for the supply chain in mergers and acquisitions: An empirical analysis in Yangtze River Delta of China," in Management of Engineering & Technology, 2009. PICMET 2009. Portland International Conference on, 2009, pp. 1649-1658.

[25] D. Jie and Z. Shuangyi, " Study on supply chain: oriented knowledge acquisition, sharing and utilization ." 2006.

[26] F. Fang and T. Wong, "Applying hybrid case-based reasoning in agent-based negotiations for supply chain management," Expert Systems with Applications, vol. 37, pp. 8322-8332, 2010.

[27] S. Garg, S. Srinivasan, and V. Jaglan, "Multi-agent collaboration engine for supply chain management," International Journal on Computer Science and Engineering, vol. 3, pp. 2765-2773, 2011.

[28] J. Fu and Y. Fu, "Case-based reasoning and multi-agents for cost collaborative management in supply chain," Procedia Engineering, vol. 29, pp. 1088-1098, 2012.

[29] F. Faez, S. Ghodsypour, and C. O’Brien, "Vendor selection and order allocation using an integrated fuzzy case-based reasoning and mathematical programming model," International Journal of Production Economics, vol. 121, pp. 395-408, 2009.

[30] K. Zhao and X. Yu, "A case based reasoning approach on supplier selection in petroleum enterprises," Expert Systems with Applications, vol. 38, pp. 6839-6847, 2011.

[31] C. Wu and D. Barnes, "A literature review of decision-making models and approaches for partner selection in agile supply chains," Journal of Purchasing and Supply Management, vol. 17, pp. 256-274, 2011.

[32] M. Giannakis and M. Louis, "A multi-agent based framework for supply chain risk management," Journal of Purchasing and Supply Management, vol. 17, pp. 23-31, 2011/03/01/ 2011.

[33] J. Fu and Y. Fu, "Analyzing the effect of collaborative cost management in supply chain by case-based reasoning," JSW, vol. 8, pp. 367-374, 2013.

[34] P. K. Dey, A. Bhattacharya, W. Ho, and B. Clegg, "Strategic supplier performance evaluation: A case-based action research of a UK manufacturing organisation," International Journal of Production Economics, vol. 166, pp. 192-214, 2015/08/01/ 2015.

[35] A. Jahani, M. A. Azmi Murad, M. N. bin Sulaiman, and M. H. Selamat, "An agent-based supplier selection framework: Fuzzy case-based reasoning perspective," Strategic Outsourcing: An International Journal, vol. 8, pp. 180-205, 2015.

[36] D. Surjeet and A. Vijay, "Analysing Supply Chain Strategy Using Case-Based Reasoning," Journal of Supply Chain Management Systems, vol. 1, 2012.

[37] Q. Long and W. Zhang, "An integrated framework for agent based inventory–production–transportation modeling and distributed simulation of supply chains," Information Sciences, vol. 277, pp. 567-581, 2014/09/01/ 2014.

[38] K. Medini and B. Rabénasolo, "Analysis of the performance of supply chains configurations using multi-agent systems," International Journal of Logistics Research and Applications, vol. 17, pp. 441-458, 2014/11/02 2014.

[39] C. Yu and T. N. Wong, "An agent-based negotiation model for supplier selection of multiple products with synergy effect," Expert Systems with Applications, vol. 42, pp. 223-237, 2015/01/01/ 2015.

[40] C. M. Solano-Vanegas, A. Carrillo-Ramos, and J. R. Montoya-Torres, "Conceptual Framework for Agent-Based Modeling of Customer-Oriented Supply Networks," in Risks and Resilience of Collaborative Networks, Cham, 2015, pp. 223-234.

[41] Y. Chu, F. You, J. M. Wassick, and A. Agarwal, "Simulation-based optimization framework for multi-echelon inventory systems under uncertainty," Computers & Chemical Engineering, vol. 73, pp. 1-16, 2015/02/02/ 2015.

[42] A. Mortazavi, A. Arshadi Khamseh, and P. Azimi, "Designing of an intelligent self-adaptive model for supply chain ordering management system," Engineering Applications of Artificial Intelligence, vol. 37, pp. 207-220, 2015/01/01/ 2015.

[43] H. Ge, R. Gray, and J. Nolan, "Agricultural supply chain optimization and complexity: A comparison of analytic vs simulated solutions and

policies," International Journal of Production Economics, vol. 159, pp. 208-220, 2015/01/01/ 2015.

[44] M. Sambasivan, S.-P. Loke, and Z. Abidin-Mohamed, "Impact of knowledge management in supply chain management: A study in Malaysian manufacturing companies," Knowledge and Process Management, vol. 16, pp. 111-123, 2009.

[45] H. Carvalho, S. G. Azevedo, and V. Cruz-Machado, "Agile and resilient approaches to supply chain management: influence on performance and competitiveness," Logistics research, vol. 4, pp. 49-62, 2012.

[46] S. Chopra and P. Meindl, "Supply Chain Management: Strategy, Planning, and Operation," simulation, p. 20, 2018.

[47] L. mingxia, "The Analysis on Collaborative Knowledge Creation in Supply chains ", 2006.

[48] I. Zouaghi, "Tacit knowledge generation and inter-organizational memory development in a supply chain context," Journal of Systemics, Cybernetics, and Informatics, vol. 9, pp. 77-85, 2011.

[49] S. Sudhindra, L. Ganesh, and K. Arshinder, "Classification of supply chain knowledge: a morphological approach," Journal of Knowledge Management, vol. 18, pp. 812-823, 2014.

[50] B. S. Fugate, C. W. Autry, B. Davis-Sramek, and R. N. Germain, "Does knowledge management facilitate logistics-based differentiation? The effect of global manufacturing reach," International Journal of Production Economics, vol. 139, pp. 496-509, 2012.

[51] X. Wang, A. Chused, N. Elhadad, C. Friedman, and M. Markatou, "Automated knowledge acquisition from clinical narrative reports," in AMIA Annual Symposium Proceedings, 2008, p. 783.

[52] B. A. Beatrice, E. Kirubakaran, and V. Saravanan, "Knowledge acquisition and storing learning objects for a learning repository to enhance E-learning," in Education Technology and Computer (ICETC), 2010 2nd International Conference on, 2010, pp. V2-234-V2-236.

[53] O. M. Arango, J. R. C. Armenta, I. A. P. Quiroz, J. G. Gonzalez, M. A. M. Benitez, and H. R. Gomez, "A MODEL FOR CONCEPTUALIZING THE KNOWLEDGE IN SUPPLY CHAIN RELATIONSHIPS. CASE STUDY: MANUFACTURING SMEs IN THE," European Scientific Journal, ESJ, vol. 10, 2014.

[54] R. Nemani, "The role of computer technologies in knowledge acquisition," Journal of Knowledge Management Practice, vol. 11, pp. 1-11, 2010.

[55] S. Wadhwa and A. Saxena, "Knowledge management based supply chain: an evolution perspective," Global Journal of e-business and Knowledge Management, vol. 2, pp. 13-29, 2005.

[56] U. Fischer and D. Stokic, "Organisational Knowledge Management in Manufacturing Enterprises-Solutions and Open Issues," in Challenges and Achievements in E-Business and E-Work Contents: International Conference, 2002.

[57] K. E. Samuel, M.-L. Goury, A. Gunasekaran, and A. Spalanzani, "Knowledge management in supply chain: An empirical study from France," The Journal of Strategic Information Systems, vol. 20, pp. 283-306, 2011.

[58] A. Done, "Supply chain knowledge management: A conceptual framework," IESE Business School2011.

[59] T. Rantapuska and O. Ihanainen, "Knowledge use in ICT investment decision making of SMEs," Journal of Enterprise Information Management, vol. 21, pp. 585-596, 2008.

[60] C. Chandra and A. Tumanyan, "Ontology driven knowledge design and development for supply chain management," in IIE Annual Conference. Proceedings, 2004, p. 1.

[61] C. Gracia, X. Binefa i Valls, P. Casanovas, E. Teodoro, N. Casellas, N. Galera, M. Poblet, J. Carrabina Bordoll, M. Montón i Macián, and C. Montero, "Legal knowledge acquisition and multimedia applications," in International Workshop on Knowledge Acquisition from Multimedia Content, 2007.

[62] A. Ajay and M. Maharaj, "Effects of Information Sharing within Supply Chains," Proceeding to SACLA, 2010.

[63] V. F. d. A. Barros, I. Ramos, and G. Perez, "Information systems and organizational memory: A literature review," JISTEM-Journal of Information Systems and Technology Management, vol. 12, pp. 45-63, 2015.

[64] N. B. Yahia, N. Bellamine, and H. B. Ghezala, "Modeling of Mixed Decision Making Process," arXiv preprint arXiv:1203.5452, 2012.

[65] H. Yu, "A knowledge based system for construction health and safety competence assessment," 2009.

[66] I. Watson, "Case-Based Reasoning is a Methodology not a Technology," in Research and Development in Expert Systems XV, London, 1999, pp. 213-223.