A Study on the Chain Restaurants Dynamic Negotiation Games of the Optimization of Joint Procurement of Food Materials

Hung-Teng Chang

Department of Information Management, Yu Da University of Science and Technology, Taiwan, R.O.C.

ABSTRACT

In the era of meager profit, production costs often become an important factor affecting SMEs' operating conditions, and how to effectively reduce production costs has become an issue of in-depth consideration for the business owners. Especially, the food and beverage (F&B) industry cannot accurately predict the demand. It many cause demand forecast fall and excess or insufficient inventory pressure. Companies of the F&B industry may be even unable to meet immediate customer needs. They are faced great challenges in quick response and inventory pressure. This study carried out the product inventory model analysis of the most recent year's sales data of the fresh food materials for chain restaurants in a supply chain region with raw material suppliers and demanders. Moreover, this study adopted the multi-agent dynamic strategy game to establish the joint procurement decision model negotiation algorithm for analysis and verification by simulation cases to achieve the design of dynamic negotiation optimization mechanism for the joint procurement of food materials. Coupled with supply chain management 3C theory for food material inventory management, we developed the optimization method for determining the order quantities of the chain restaurants. For product demand forecast, we applied the commonality model, production and delivery capacity model, and the model of consumption and replenishment based on market demand changes in categorization and development. Moreover, with the existence of dependencies between product demands as the demand forecast basis, we determined the appropriate inventory model accordingly.

KEYWORDS

Multi-agent, Joint procurement, Game theory, 3C theory

1. INTRODUCTION

As it is difficult to accurately predict the demand, higher demand uncertainty will be accompanied with increasing costs of forecast errors of the firms. The reason for the difficulties in forecast of the future is that the market is characterized by uncertainty, complexity, and competition. These three characteristics make many firms unable to grasp the market demand conditions, resulting in too many inventories to cut sales prices or insufficient inventories to fail to grasp the favorable opportunity to make money. The three characteristics of the market are fair to each firm on the market. Any firm that can make the three characteristics more transparent can have more business opportunities to reduce losses.

This study applied the game theory in multi-agent joint procurement decision model negotiation algorithm to find out the relatively better order quantity of a certain raw material for chain restraints participating in the joint procurement and achieve the goal of lowering overall operating costs by way of negotiation. We further introduced the concept of 3C theory to use the

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commonality model, production and delivery capacity model, and the model of consumption and replenishment based on market demand changes for categorization and development of market demand forecast to help companies improve forecast accuracy, and reduce their "guesswork" cost.

2. LITERATURE REVIEW

Regarding the MAS negotiation mechanisms, the most influential one is Contract Net Protocol, which is derived from outsourcing tendering procedures of companies and organizations. Proposed by Smith [1] in 1980, the protocol is to solve problems and conflicts through multi-agent cooperation and negotiation mode by simulating the tendering procedures of enterprises. According to the mechanism of Contract Net Protocol, through the publication of contract information, the multi-agent integrates resources and behaviors for the common goal. Issues including the sub-task assignment of agent playing the role of the manager, information communication between various agents, the bid evaluation model of participating agents and the formation of competition and cooperation models are important topics of Contract Net Protocol. Regarding the application of Contract Net Protocol, Cantamessa [2] analyzed the agent behavior model by distributed artificial intelligence and distributed cooperation, and used the Contract Net Protocol to analyze the mode; in this model, if an agent has a demand, other agents that can satisfy the demand will compete by bidding. Finally, the agent sending out the demand will evaluate the bid according to time, cost and other factors to formulate the final decisions. The design of the agent bid evaluation model is the major research topic. Through the design of relevant variables, the agent decision-making model can generate better system performance and respond to the elasticity of real situation [3].

According to the findings of David [4], no company can satisfy the demand on resources for production from within itself and no company can resist the environmental pressure by its own force. Therefore, labor of division will come naturally in between companies based on specialty, and companies will depend on each other, develop with each other to form a community of gains and losses. In related studies, joint procurement has been widely recognized as a feasible method to effectively reduce production costs. Operating entities of the same nature can achieve the goal of cutting price by increasing order quantity through joint procurement. The meaning of joint procurement is to summarize the demands of companies in the same industry or affiliated companies to place orders with the supplier to collectively change the original market structure and win the influencing power to change market price mechanism, so that the goal of cutting procurement price by "increasing order quantity" can be achieved. [5]

However, in joint procurement, some problems that participants of joint procurement may not be able to address effectively, such as how to determine the joint purchase cycle, whether the negotiated and agreed batches and order quantities in the purchase cycle can achieve the maximized and relatively high profits. Kaspi and Rosenblatt [6-7] proposed two study reports of the testing of different heuristic algorithm, suggesting the optimal solution obtained by using RAND procedure proposed by Kaspi and Rosenblatt is better than the solutions found by using algorithms proposed by other scholars (for details, see Goyal [8], Brown [9], Goyal and Belton [10], and Silver [11]). Unlike the methods proposed by the aforementioned scholars, we applied the game theory in multi-agent joint procurement decision model negotiation algorithm to find out the relatively better order quantity of a certain raw material for chain restaurants participating in joint procurement.

In the study of the behavior of the decision makers, the game theory is different from economics and behavior sciences. When the decision-making behaviors of the decision makers have direct, mutual impact, the choice of one party will be affected by the choices of other parties while other parties will be affected by the choice as well. This is the basic feature of applying game theory in decision making and equilibrium problems [12]. The game theory has the following two basic assumptions:

2.1. Rationality assumption

If a decision-maker can consistently make decisions in the pursuit of his objectives, then the decision maker is regarded as rational. The objective of rational decision-maker is to pursue the maximization of his or her individual payoffs. Some very weak assumptions regarding how rational decision makers should behave can prove that there is a certain way to grant utility values to various possible results of his concern to allow his choice to maximize his own utility [13-14].

2.2. Intelligence assumption

If either play of the game knows what other players know about the game and make inferences of other players regarding the situation, the player is called as intelligent. When rational and intelligent decision makers affect each other, their problems will be analyzed together like an equation. Such an analysis is the just the majority of the game theory [13-14].

The complexity of decision-making problems, and the speed, reliability, flexibility, openness and re-configurability requirements of addressing such problems of the supply chain management make it impossible to solve with a single agent. It requires the coordination of multiple agents with knowledge and tasks of different fields to support the supply chain decision making process. MAS (Multi-Agent System) consists of multiple agents to realize the overall function or purpose by the collective activities consisting of the problem-solving activities of the agents and the interactive activities of agents. Meanwhile, each independent agent realizes its own function and purpose during the interactive process [15]. Therefore, for the coordinated, distributed and integrated requirements of the decision-making problems of the supply chain management, MAS technology can be applied in study. MAS system uses the distributed and cooperative agents to solve the problems of various nodes. It has its own purposed, knowledge and ability. Agent can be human, software or intelligent system. The agents of the MAS system can coordinate their behaviors to jointly solve the complex problems [16]. In the working environment of MAS, a coordination agent can be designed to coordinate the work in between groups and reduce the conflicts. Through the information exchange of multiple agents, collective negotiation and decision making can be realized to get the most satisfactory answers of the problems. Therefore, MAS system provides an effective way for the research and development of complex supply chain decision making support systems.

The collaborative decision-making system of supply chain is presented by the hierarchical decomposition and sharing of decision making activities. Based on joint orientation, multiple agents committed to sharing the computation activities form the federation defined as the following equation with four unknown quantities:

Agent_federation (manager, intra_agent, extra_agent, constructor)

The above equation includes a manager (as the federation management agent), a few infra_agents (≥ 0) and extra_agents (>0) with corresponding communication support functions. The manager administers the coordination of the federation in a centralized way while no communication is made in between infra_agents and in between extra_agents. The infra_agents belong to the manager, which can directly assign tasks to infra_agents. The extra_agents belong to other managers and they are temporary members of the federation. The manager can assign tasks to extra_agents after consultation with them [17-18].

Developed by Lucent Technical Corporation, 3C theory is the basic theory for the realization of global supply chain management and the basic theory for the planning and realization of global resource plan. The basic concepts and values of commonality model is to achieve the goals of reducing development costs, simplifying resource managements, lowering inventories and providing more diversified products to customers through expanding the use of “common materials or resources” strategy and product combination planning. In expanding the use of “common materials or resources”, there are two major aspects, namely, modular design and the design for assembly and maintenance. The basic concepts and values of the production and delivery capacity model is that production capacity, supply capacity or delivery and transportation capacity of companies of the supply chain have constraints by applying the TOC (Theory of Constrain), and the adjustment and distribution of all resources are made with such constraints. This is basic spirit of TOC. The production and delivery capacity model is characterized by the upper limits of materials and production capacity demand. [19] Whether material and production capacity can meet the commitment to the customer should be taken into consideration when placing the order. Hence, it is a realistic model to reduce delivery delays caused by lack of inventory or lack of production capacity to enhance customer satisfaction. The functions designed according to the production and delivery capacity theory, we can lower the risk generated by material shortage and excessive commitment to customer orders. The basic concepts and values of the model of consumption and replenishment based on market demand changes are to realize the mechanism to purchase materials before being demanded through real time market information combined with market demand replenishment model, and thereby lowering inventory levels, reducing fund reserves and discount losses of inventory products. [20] The core of the model of consumption and replenishment based on market demand changes consumption is the “market demand forecast model” because one of the causes of inventory is wrong procurement behavior. The reason of wrong procurement is usually caused by mistaken assessment of market demand. The consumption material replenishment model is characterized as the material planned production is based on the real demand changes of the market with a focus on consistency with market demand to lower inventory to minimize business operational risks [21].

3. RESEARCH METHOD

In this study, in a supply chain region containing the raw material suppliers and demanders, we applied the 3C theory in collaborative replenishment management, and the game theory in the joint procurement mechanism to establish a multi-agent joint procurement negotiation model for analysis and verification by using the simulation case to provide a reference for the selection of business negation strategy.

The research architecture is as shown in Figure 1, the research methods and steps are elaborated as follows:

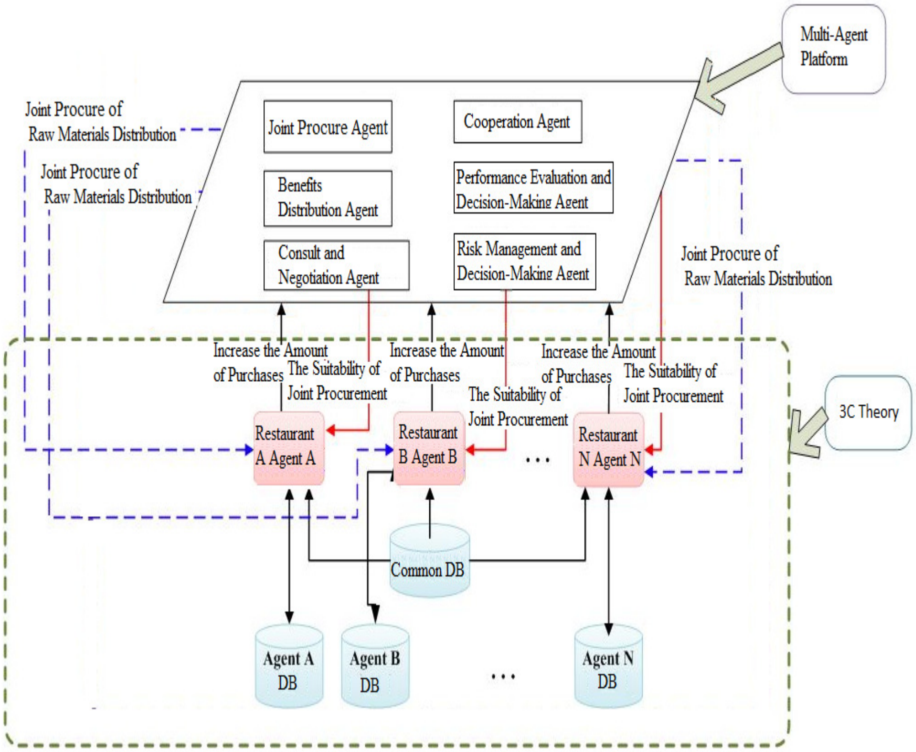

Figure 1. Chain Restaurants' Food Materials Demand Forecasting and Joint Procurement Negotiation MAS Framework

Step 1: According to the 3C theory, to establish the purchase quantity algorithm for food material inventory management with profit maximization as the goal; to establish the forecasting and estimation system of raw material demand for various restaurants based on the data of previous order quantities. By referring to the order strategy, the recommended procedure of "order policy option model" is as shown in Figure 2, the steps of the procedure are elaborated as follows:

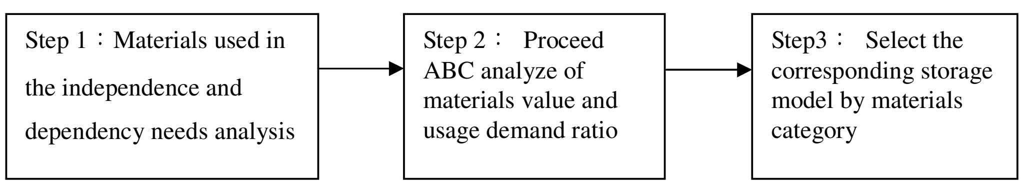

Figure 2. Order Policy Option Model

Step 1-1: Part use independence and dependency demand analysis

1.To decide the material demand forecasting in the inventory system
2.Independent demand: demands on different items are unrelated to each other
3.Dependent demand: the demand on the item comes from the demands of other items

Step 1-2: To conduct ABC analysis of the value and use demand rate of various parts.

When resources are limited, we need to make the most effective use of limited resources to control inventory. According to Pareto theorem, we should concentrate on the most important inventory items. It is impossible to provide a model or fully control each product. ABC categorization may be carried out first.

Step 1-3: To select the corresponding inventory models according to the food material categorization.

As fresh food materials can easily decay, coupled with shelf life considerations as well as the differences in purchase and acquisition, the inventory models should be selected according to specific characteristics. It is assumed the lead time of material m from the supplier to the factory is LT_m.

1. For A category product or B category product of COMI >= 0.5, "S-s order control system" is applied as shown in Figure 4:

(1). Time between purchase can be acquired by using the following equation: $TBP_m = EOQ_m / RBOM_m$

(2). "Order-Up-to-Level": S $= OUT_m = RBOM_m \times TBP_m + SS_m$.

(3). Safety inventory (s) = SS_m = average daily sales volume $\times LT_m +$ $Z_\alpha \times \sigma_m (\alpha = 0.05)$

(4). Material m's order point: $OP_m = RBOM_m \times LT_m + SS_m$.

(5). Once the order time comes, order by referring to the then inventory and the subtraction of EOQ (Economic Order Quantity) by the then inventory.

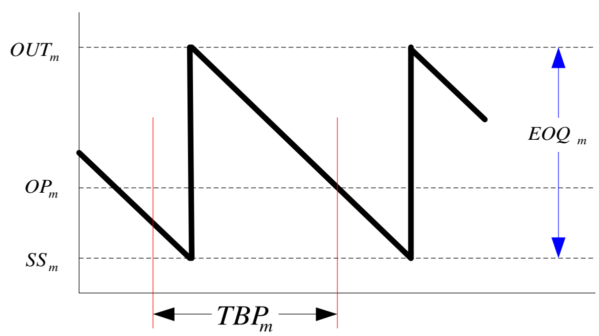

Figure 3. Regular Order Model

2. For B category product with COMI < 0.5 or C category product, "regular quantitative order model" is applied: when the inventory drops to the order point, the order of EOQ will be placed.

(1). $EOQ_m = \sqrt{\dfrac{2RBOM_m K}{H}}$

(2). Reorder Point: $ROP_m = RBOM_m \times LT_m + SS_m$.

3. For B category product with COMI < 0.5 or C category product, "S-s order control system" is applied.

(1). Maximum inventory (S) = $RBOM_m \times TBP_m$.

(2). Safety inventory (s) = SS_m = average daily sales volume $\times LT_m + Z_\alpha \times \sigma_m (\alpha = 0.05)$

(3). Re-order point: $ROP_m = RBOM_m \times LT_m + SS_m$.

Step 2: Use dynamic strategy game to establish the joint procurement decision model negotiation algorithm for joint procurement from raw material suppliers.

The method is as elaborated as follows:

Step 2-1: Formulate negotiation strategy

The satisfaction and expectation of each chain restaurant is the major factor for the success of bargaining negotiations. Therefore, only by understanding the preferences and expectations of players, can we participate in bargaining negotiations in the mentality of players. It seems that different chain restaurants have subordinate relationships; they have to cooperate to get greater profits. Next, we developed the analysis framework of negotiation strategy according to past negotiations between various chain restaurants as shown in Figure 4.

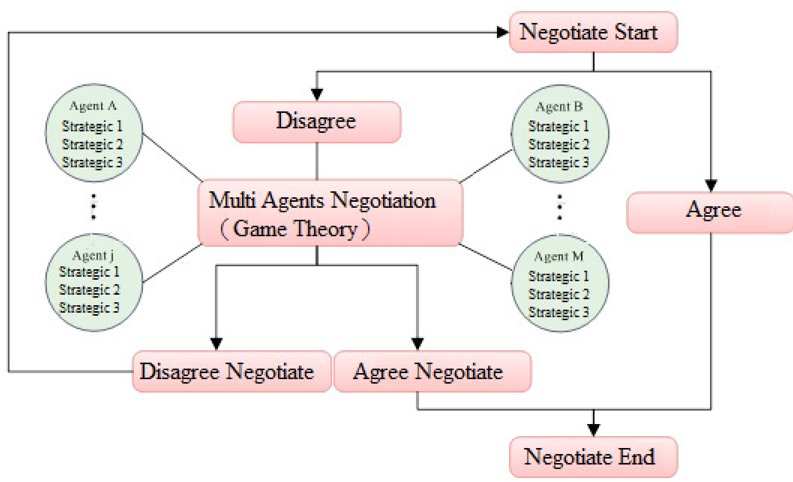

Figure 4.Negotiation Strategy Framework

After each chain restaurant has conducted strategic negotiations with each other, we summarized by the proposed coordination agent model to ensure each chain restaurant to achieve the final cooperation goal, expecting to get the optimal strategy combination of maximum compensation.

Step 2-2: To apply game theory in joint procurement decision model negotiation algorithm.

1. Chain restaurant inventory model, incremental order revenue model and the model of applying negotiation decision games in incremental order revenue model are illustrated as shown below:

(1). $(Q_{ijt}, s_{ijt}, S_{jit}, R)$ Inventory model is applied as the chain restaurant inventory model, where

A. Q_{ijt} is the average forecast demand of chain restaurant i on product j at time t in the following inspection cycle R, $Q_{ijt} = \sum_{t=t+1}^{t+R} \tilde{D}_{ijt}$

B. s_{ijt} is the safety inventory of product j of chain restaurant i at time t at 95% service level, $s_{ijt} = z_{0.025} \times \rho_{ijt} \times \sqrt{R} = 1.95 \times \sqrt{(\sigma_{ijt+1}^2 + \sigma_{ijt+2}^2 + ... + \sigma_{ijt+R}^2) / R-1} \times \sqrt{R}$

C. S_{ijt} is the maximum inventory level of product j of chain restaurant i at time t at 97% service level, $S_{ijt} = Q_{ijt} + 2 \times \rho_{ijt} \times \sqrt{R}$

D. R is inspection cycle

(2) Incremental order revenue model of chain restaurant i at time t
$NPV_{ijt} = (P_{ij} - (1+h_{ij})C_{ijt}) \times Q_{ijt}^P - C_{ij}^F - C_{ij}^T - C_{ij}^S \times \max\{0, Q - IP_{ijt-1} - Q_{ijt}^P\}$, where,
A. h_{ij} is the Holding Cost Rate of product j for chain restaurant i
B. C_{ijt} is the unit purchase cost of product j for chain restaurant i
C. $C_{ij}^F, C_{ij}^T, C_{ij}^S$ is the fixed cost, transportation cost and shortage cost of product j for chain restaurant i
D. IP_{ijt-1} is the initial inventory level of product j for chain restaurant i at time t
E. Q_{ijt}^P is the order quantity of product j for chain restaurant i at time t,
where, $Q_{ijt} + s_{ijt} \le Q_{ijt}^P = \max\{Q_{ijt} + s_{ijt} - IP_{ijt-1}, 0\} \le S_{ijt}$

(3) Apply the negotiation decision making game in incremental order revenue model

$$NPV_{ijt}^G = P_{ij} \times \Delta Q_{ijt} \times E[P(Q > Q_{ijt}^P)] - C_{ijt}^{new} \times (1+h_{ijt}) \times \Delta Q_{ijt} + (C_{ijt} - C_{ijt}^{new})(Q_{ijt}^P + \Delta Q_{ijt})$$

A. ΔQ_{ijt} is the incremental order quantity of product j for chain restaurant i in the negotiation decision making game at time t

B. C_{ijt}^{new} is the new order cost of product j for chain restaurant i at time t

C. $E[P(Q > Q_{ijt}^P)]$ is the normal distribution model's expected value of $Q > Q_{ijt}^P$ probability of product j for chain restaurant i in the negotiation decision making game at time t,

where, $E[P(Q > Q_{ijt}^P)] = \Delta Q_{ijt} \times N(Q > Q_{ijt}^P)$, the normal distribution model of chain restaurant i is $N(\overline{Q}_{ijt} = \sum_{t=1}^{R} \tilde{D}_{ijt}, \overline{\sigma}_{ijt} = \sqrt{(\sigma_{ijt+1}^2 + ... + \sigma_{ijt+R}^2)/(R-1)})$

2. Negotiation game strategic rules (Supply > Demand):

(1)To calculate the incremental order quantity ΔQ_{jt}

(2)To send the incremental order information to various chain restaurants
(3)For chain restaurants, according to the extra-procurement revenue model, NPV_{ijt}^{G} , to calculate the tolerable maximum incremental order quantity ΔQ_{ijt} .

(1)To establish the list of players of the negotiation game
(2)To establish the cooperative federation compensation matrix of each player according to the player list as follows:

To determine the dominator by order and the rest members are allies.

A. If $\Delta Q_{ijt} \leq \Delta Q_{jt}$, to calculate the compensation of the dominator i $NPV_{ijt}^{G}(\Delta Q_{ijt})$, and the remaining incremental or quantity $\Delta Q_{jt}^{R} = \Delta Q_{jt} - \Delta Q_{ijt}$, move to Step (C); otherwise, suppose $\Delta Q_{ijt} = \Delta Q_{jt}$, to calculate the compensation of the dominator i $NPV_{ijt}^{G}(\Delta Q_{ijt})$, then the return matrix of the dominator i against allies of the cooperative federation is $(0,...,NPV_{ijt}^{G},0,...,0)$, move to Step (E).
B. To select the dominator k from the cooperative federation into the negotiation game, if $\Delta Q_{kjt} \leq \Delta Q_{jt}^{R}$, to calculate the compensation of the dominator k $NPV_{kjt}^{G}(\Delta Q_{kjt})$, and to calculate the remaining incremental order quantity $\Delta Q_{jt}^{R} = \Delta Q_{jt}^{R} - \Delta Q_{kjt}$, move to Step (D); otherwise, suppose $\Delta Q_{kjt} = \Delta Q_{jt}^{R}$, to calculate the compensation of the dominator k $NPV_{kjt}^{G}(\Delta Q_{kjt})$, and the add the compensation matrix of the dominator i against allies of the cooperative federation $(0,...,NPV_{ijt}^{G},\Delta NPV_{kjt}^{G},0,...,0)$, move to Step (E).
C. To select the next dominator k from the cooperative federation to join into the negotiation game, repeat Step (C) until $\Delta Q_{jt}^{R} = 0$, move to Step (E).
D. To select the next dominator k from the cooperative federation to join into the negotiation game, repeat Step (C~D) until all the cooperative allies are selected as dominators, move to Step (F).
E. To select the next dominator according to the list of game players to establish the negotiation game, repeat Step (A~F), until all the game list players are selected as dominators to complete the construction of return matrix.

(1) Look for game equilibrium optimal solution

A. From the established compensation matr4ix, to select the game combination of maximum compensation as the starting point from the dominator i (starting with 1).
B. To proposed the corresponding cooperative strategy, and compare whether the compensation of the dominator k is the optimal and acceptable cooperative strategy. If it is, move to Step (D); otherwise, the dominator k proposes the suggested cooperation combination and move to Step (C).
C. According to the cooperative strategy proposed by the dominator k as shown in Step (B), the dominator is to evaluate whether to accept or not, if so, move to Step (D), otherwise, the dominator is to propose the next new cooperative strategy according to the suggestion of the dominator k before moving to Step (B). If the optimal cooperative strategy cannot be found after continuous negotiations, this stage will be ended and move to Step (E).

D. According to the obtained optimal cooperative strategy, to select the next dominator k, repeat Steps (B~C). After all the cooperative allies are negotiated, the final optimal cooperative strategy is the optimal solution, and move to Step (E).
E. In order, to select the next dominator i, repeat Steps (A~D) until all the players on the list have completed the negotiations to get the optimal solution as the equilibrium solution of the negotiation games.
F. To select from all optimal strategy combinations the one of the highest total compensation as the optimal solution.
G. According to the obtained optimal cooperative strategy, to carry out order and calculate the order purchase.

4. RESULTS AND DISCUSSION

According to the aforesaid 3C collaborative replenishment management model and joint procurement decision model negotiation algorithm, we analyzed the sales data of the case chain restaurants in recent one year. The data of the first nine months are the training data for product inventory model and the sales data of the last three months are the testing data for the product inventory model. We applied the model in the analysis of the most representative, perishable packages of fresh meet category of food materials of high unit price and large consumption. The three materials are all independent materials, the data and computational results are as shown below:

Table 1. Product TOP Data and BOM Table

		BOM		
Product	TOPP	Material A (g)	Material B (piece)	Material C (slice)
A package	1,088	300	1	1
B package	1,299	400	-	1
C package	3,750	400	1	-
D package	271	-	-	2
E package	116	-	3	-
F package	6,524	600	-	-
Cm(NTD)		0.25	60	30
Coefficient of losses (U)		10%	1%	2%

Table 2. Material Demand Rate Table

Material	Material A (g)	Material B (piece)	Material C (slice)	Total
MRPm	8,452,200	5,705	3,222	
RBOMM	5,871,600	4,125	1,429	
Inv worst	2,113,050	342,276	96,657	2,551,983
Inv best	1,467,900	247,500	42,867	1,758,267
COMI				0.373223176

Table 3. ABC Analysis and Order Model Selection

Material	Material A (g)	Material B (piece)	Material C (slice)
ABC categorization	A	B	C
order policy	regular quantitative order model	regular quantitative order model	S-s order control system

Table 4. Order Policy Analysis

Material	Material A (g)	Material B (piece)	Material C (slice)
Holding Cost (NTD)	0.02	6	3
Purchase Cost (NTD)	1000	1000	1000
LTm(year)	0.002777778	0.087	0.035671
TBPm(year)	0.261006766	0.568535244	1.366103009
EOQm	1532527.324	2345.20788	1952.02459
OUTm	1597767.324	2436.874547	1983.777923
OPm	81550.6635	82.5582	31.75333333
SSm	65240	91.666667	35.62

Note: SSm=average daily sales volume (95% service level, estimated Shortage Rate<2.5%).

Table 5. Comparison of Ending Inventory

	Item	RBOM	MRP
Material A	Holding Cost	5347.625	6224.336
	Filled Rate	1.219	1.003
	Shortage Rate	0.22%	2.85%
	Improved Rate	13.95%	
Material B	Holding Cost	1886.376	2403.259
	Filled Rate	1.358	1.107
	Shortage Rate	0.56%	0.88%
	Improved Rate	18.53%	
Material C	Holding Cost	1067	1763
	Filled Rate	1.115	1.759
	Shortage Rate	0.12%	0.48%
	Improved Rate	35.02%	

Regarding A material, through computation, we suggested that quantitative ordering inventory control system should be applied. Compared to the traditional MRP inventory control system, it can be apparently found that the suggested quantitative ordering inventory control system is better in terms of inventory replenishment and holding quantity control. Based on the statistical results as shown in Table 5, it can be apparently found that the suggested quantitative ordering inventory control system has far lower holding costs as compared with the traditional MRP inventory control system. The performance of inventory shortage control is far better than the traditional MRP inventory control system; the inventory replenishment rate can be 1.219 times.

Regarding B material, we suggested that quantitative ordering inventory control system should be applied. Although it has poorer performance in inventory shortage control as compared to the traditional MRP inventory control system, its overall performance can be at 95% customer service level. Based on Table 5, the suggested quantitative ordering inventory control system is better than the traditional MRP inventory control system in inventory holding control, and the inventory replenishment satisfaction rate can be 1.358 times.

Regarding C material, we suggested that S-s order control system should be applied. Based on Table 5, its performance is better than the traditional MRP in terms of inventory holding cost and shortage rate, and the inventory replenishment satisfaction rate can be 1.115 times.

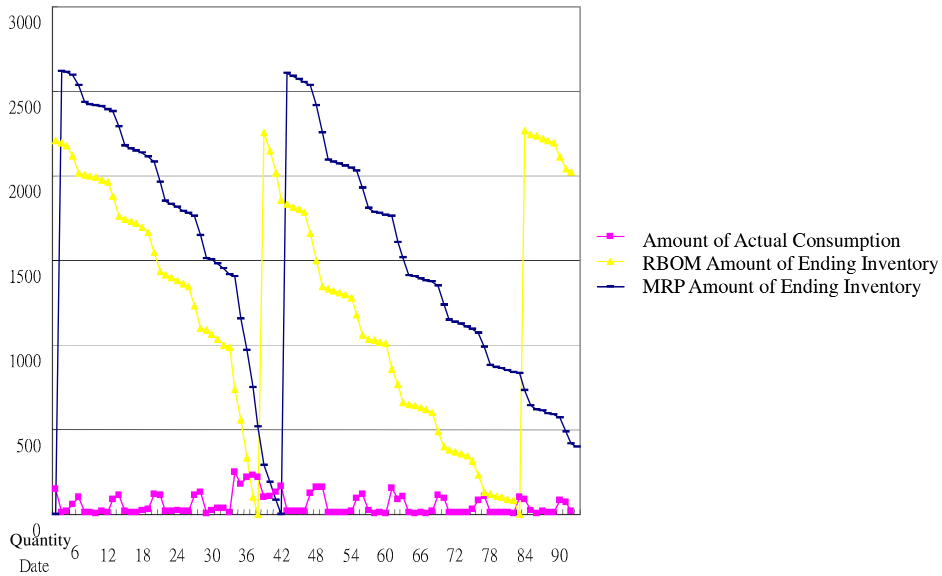

Figure 5. Comparison of Average Ending Inventories of Materials

Through joint procurement and supply chain management computation, improved rate for the purchase of A material is 13.95%, 18.53% for B material and 35.02% for C material. It can be learnt from Figure 5, the average end of term inventories of the three food materials have been significantly improved.

The system after actual execution of the agent system is as shown in Figure 6:

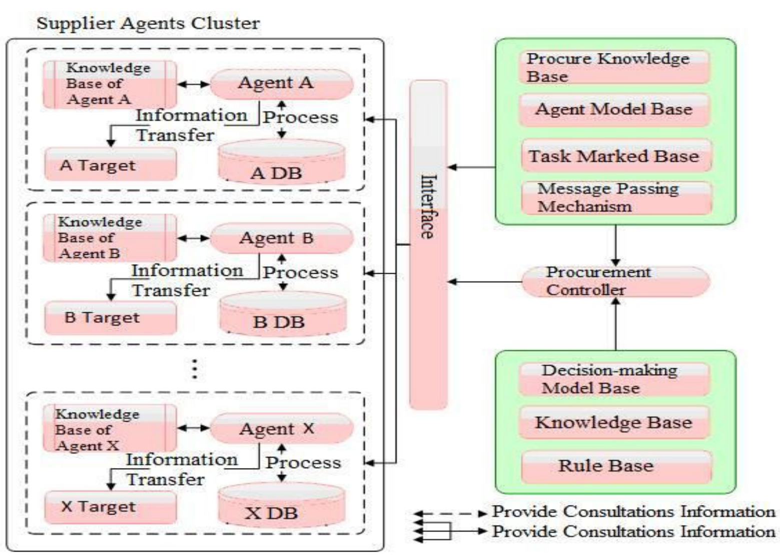

Figure 6. Purchase Agent System

The specific functions of purchase agent introduced as follows:

1. Interacting with user by interface agent.

2. By existing enterprise information systems interface communicate with original information system.

Databases and their associated functional modules described below：

1. Purchasing Knowledge Base: It contains the task decomposition methods and the conflict resolution among different Agents' targets, intentions and Inference engine. To storage the purchase-related knowledge, through the interface and procurement controller interact with business knowledge base.
2. Agent Model Base: To store the use of agent models and task identity base, include query agent, matching agent, negotiations agent, orders agent, and evaluation agent.
   (1) Query Agent: According to requirements by users' inquiries, combined with internal information base, knowledge base, as well as query the information needed by user.
   (2) Matching Agent: According to business purchase proposal and supplier proposal calculated matching level for automatic matching, and submitted the higher degree of matching to negotiations agent.
   (3) Negotiations Agent: Based on the internal knowledge base, rule base interacting with supplies web service, complete the negotiation.
   (4) Orders Agent: According to demand of users' orders, making orders to suppliers order processing web service online and immediate.
   (5) Evaluation Agent: According to the procurement process, combined with corporate strategy related to the evaluation base policies (rules) for the evaluation of suppliers one by one, individually rated, and added to the enterprise knowledge base, ready for the later transaction reference.
3. Task Identity Base: To store the sets of task identity, combined with agent model base, decomposed procurement task into each sub-task, and assign to corresponding agent.
4. Information Delivery Mechanism Base: To store agents' information delivery mechanism; under the coordinated control of purchasing agent, often involved multiple Agent to process of solving a problem, its requires coordination and dispatch of these Agent, and need to communicate between different agents, achieve interoperability information, information delivery agent is used to complete this task.
5. Inference Engine: Based on decision model, select the relative purchasing strategy (rules) from the enterprise knowledge base and rule base, evaluation strategies (rule) to construct the procurement Knowledge base of e-procurement agent, then assigned the task of procurement under the procurement strategy (rules), according to the evaluation policy (rules) have been trading off companies evaluate and rate each, adding to the knowledge base and update corporate procurement knowledge base and rule base through the interface or controller, provide a reference for future purchases.

5. CONCLUSION

With the fresh food materials of the chain restaurants as the example, we forecast product demand by using the commonality model, production and delivery capacity model and the model of consumption with market demand changes for classification and development. Moreover, with the existence of dependencies between product demands as the demand forecast basis, we determined the appropriate inventory model accordingly. By integrating the dynamic strategy game, we established the joint procurement decision model negotiation algorithm, and used the simulation case for analysis and verification to achieve the design of the dynamic negotiation optimization mechanism for the joint procurement of food materials. By using the proposed method for inventory management, we can indeed effectively reduce inventory quantity, inventory cost, and thereby enhancing the customer service satisfaction level.

REFERENCES

[1] Reid G Smith, (1980) “The contract net protocol: High-level communication and control in a distributed problem solver“, *Computers, IEEE Transactions on,* Vol. 1000, No. 12, pp.1104~1113.

[2] Marco Cantamessa, (1997) “Hierarchical and heterarchical behaviour in agent-based manufacturing systems“, *Computers in Industry*, Vol. 33, No. 2, pp.305~316.

[3] Simon Case, Nader Azarmi, Marcus Thint, & Takeshi Ohtani, (2001) “Enhancing e-communities with agent-based systems”, *Computer*, Vol. 34, No. 2, pp. 64~ 69.

[4] David J Teece, (2010) “Business models, business strategy and innovation”, *Long range planning*, Vol. 43, No. 2, pp. 172 ~ 194.

[5] Yu-Teng Chang, Chih-Yao Lo, Pin-Chang Chen & Ruei-Chi Tang, (2011) "Research on the Development of Web-based Joint Procurement Information Systems", *International Journal of Digital Content Technology and its Applications*, Vol. 5, No. 9, pp. 134 ~ 144.

[6] Moshe Kaspi & Meir J Rosenblatt, (1985) “The effectiveness of heuristic algorithms for multi-item inventory systems with joint replenishment costs”, *International Journal of Production research*, Vol. 23, No. 1, pp. 109 ~ 116.

[7] Moshe Kaspi & Meir J Rosenblatt, (1991) “On the economic ordering quantity for jointly replenished items” *International Journal of Production Research*, Vol. 29, No. 1, pp. 107~ 114.

[8] SK Goyal, (1974) “Optimum ordering policy for a multi-item single supplier system“, *Operational Research Quarterly*, Vol. 25, pp. 293~ 298.

[9] Brown R.G. (1967) “Decision rules for inventory management, Holt, Reinhart and Winston“, *New York*, pp. 50-55.

[10] SK Goyal & AS Belton (1979) “A simple method of determining order quantities in joint replenishments for deterministic demand“, *Management Science*, Vol. 25, No. 6, pp. 604 ~ 604.

[11] Edward A Silver, (1976) “A simple method of determining order quantities in joint replenishments under deterministic demand“, *Management Science*, vol. 22, No. 12, pp. 1351~ 1361.

[12] Xiaofang Zhang & Wei Zhu, (2012) "The Study on Food Quality Supervision using Collusion Game Model", *International Journal of Advancements in Computing Technology*, Vol. 4, No. 4, pp. 283 ~ 293.

[13] Yingxue Zhao, Shouyang Wang, TC Edwin Cheng, Xiaoqi Yang, & Zhimin Huang, (2010) “Coordination of supply chains by option contracts: A cooperative game theory approach“, *European Journal of Operational Research*, Vol. 207, No. 2, pp. 668 ~ 675.

[14] Jinshi Wei & Hongjie Lan, (2011) "Establishing Food Traceability System based on Game Theory from the Perspective of Retailers", *Advances Information Sciences and Service Sciences,* Vol. 3, No. 6, pp. 107 ~ 114.

[15] Ai-Ping Li, Yan Jia, & Quan-Yuan WU, (2007) "A Study on Organizational Knowledge in Multi-Agent System", *Journal of Convergence Information Technology*, Vol. 2, No. 1, pp. 61 ~ pp.65.

[16] Yanzhong Li, Zhixia Jiang, Pinchao Meng, Weishi Yin, & Jun Li, (2013) "A Collaborative Optimization Method for Solving Multi-objective Programming Problem", *International Journal of Advancements in Computing Technology*, Vol. 5, No. 1, pp. 809 ~ 817.

[17] Scott A DeLoach, Mark F Wood, & Clint H Sparkman, (2001) “Multiagent System Engineering”, *International Journal on Software Engineering and Knowledge Engineering*, Vol. 11, No. 3, pp. 231 ~ 258.

[18] Michael Wooldridge, Nicholas R Jennings, & David Kinny, (2000) “The Gaia Methodology for Agent-Oriented Analysis and Design”, *Journal of Autonomous Agents and Multi-Agent Systems*, Vol. 3, No. 3, pp. 285 ~ 312.

[19] Chun-Ta Lin, Chih-Yao Lo, & Chia-Hsing Lin, (2008) “Apply 3C Theory in Spare parts Management in Mobile Phone Industry”, *Journal of Applied Science*, Vol. 8, pp. 2874 ~ 2880.

[20] Ayako Kawai, (2012) "Effect of Structural Coordination on Supply Chains Controlled by Manufacturing Planning and Control Systems", *International Journal of Engineering and Industries*, Vol. 3, No. 3, pp. 84 ~ 93.

[21] Jiawang Xu, (2013) "Multi-objective Operation Model for Supply Chain with Uncertain Prices Based on Fuzzy Sets and Robust Optimization", *Advances Information Sciences and Service Sciences,* Vol. 5, No. 2, pp. 320 ~ 327.