A Decision Support Framework to Assess Grocery Retail Supply Chain Collaboration: A System Dynamics Modelling Approach

Ghada Elkady, Jonathan Moizer, and Shaofeng Liu

***Abstract*—Supply chain collaboration contributes to improving overall performance through increasing sales, refining forecasts, reducing inventory costs, and improving customer service. In order to be efficient and cost effective, total costs have to be minimized across the entire supply chain. Collaboration efforts run into many practical challenges, both internal and external among small retailers. This paper proposes a framework of retailer supply chain collaboration to identify better understanding of collaboration benefit. A system dynamics simulation modelling approach is used to represent the collaboration effect on the dynamics of this complex system that helps retailer supply chains to obtain maximum benefit of collaborative relationships and reduce the bullwhip effect. This work helps researchers to use supply chain collaboration dynamic modelling to examine how information sharing across a supply chain can result in the identification and prioritization of better order decisions that can be aligned with the retail supply chain's value proposition for further supply chain integration.**

***Index Terms*—Supply chain collaboration, retailer supply chains, system dynamics modelling, ordering policy and decisions.**

I. Introduction

In today's unpredictable and competitive business environment, changes to sales volumes, forecasting improvements, cost and inventory reduction, information accuracy and customer services improvements are not usually attributable to the stand-alone effort of any single supply chain (SC) member. The success of many businesses lies in having efficient and effective SCs, made possible through collaboration among SC partners [1], [2]. Collaboration is defined as two or more companies sharing common planning, management, execution, and performance measurement information [3], [4]. Hence, market demand and customer dynamic needs can create more opportunities for SC players. At the same time, to cope with continuous uncertainty, all SC members need to be innovative and productive, with collaboration between SC partners being present at different SCs levels [5], [6]. SC collaboration activities help to improve the performance of involved members in a structured framework with the aim of maximizing profit through improved logistical services [7]. Despite the promise of collaboration, few retailers have succeeded in creating such partnerships with their suppliers. In order to cope with global and dynamically changing challenges, small retailers should pay more attention to enhancing their SC through collaboration [8]. Sharing up-to-date information leads to reduced lead times and provides high quality products to meet customers' needs [9], [10]. Few research studies have investigated the link between collaboration, supply chain performance, and information sharing among SC partners especially in retail industry. Indeed, published studies that have investigated the more general theme of supply chain performance dimensions are widely reported [11]. The lack of small retail supply chain collaborations has a significant impact on their retailer supply chain overall performance. It has been estimated that approximately three percentage points can be cut from the profit margins of all supply chain partners as a consequence [12]. Moreover, most empirical studies lack a theoretical framework for considering the effects of order policies and collaboration simultaneously on small retail supply chain performance.

This paper proposes a framework of retailer supply chain collaboration (RSCC) to identify better order policies. Order data from 12 US retailers and their distributor have been collected and summarized as a basis for simulation modelling future scenarios surrounding decision options across a RSCC. A system dynamics model is proposed to represent data graphically, and to clarify the collaboration effect on the dynamics of this complex system to help actors within retailer supply chains to maximize the benefits of collaborative relationships and reduce any possible bullwhip effects along the SC. A key contribution of this work is that it advances understanding of the impact of RSCC efforts on performance. This work seeks to help researchers use dynamic simulation models of supply chain collaborations to examine the effect of information sharing on the identification and prioritization of better order decisions, so collaboration strategies and activities can be better aligned with the retail supply chain's value proposition for further supply chain integration. The remainder of this paper is organized as follows: Section II reviews existing literature on supply chain collaboration (SCC). Secondly, Section III describes the characteristics of system dynamics simulation modelling approach. Section IV discusses the retailer supply chain collaboration dynamic modelling. Section V identifies the need for SC collaboration among small retailers. Finally, Section VI concludes the paper with key findings, managerial implications, limitations and future work.

Manuscript received April 20, 2014; revised July 22, 2014.

Ghada Elkady is with the Plymouth University, UK (e-mail: ghada.elkady@plymouth.ac.uk).

DOI: 10.7763/IJIMT.2014.V5.519

II. Literature Review

A. Supply Chain Management (SCM)

SCM is being practiced by many businesses around the world to improve their performance efficiencies, and it has a great wealth of literature and definitions. SCM can be defined as a collaborative effort and a combination of cross-functional teams to provide value-added to customers within various manufacturing, storage, transportation, and retail systems that integrate business function costs [13], [14]. As competition in international markets becomes progressively more dependent upon the quality of goods, information sharing and coordination and collaboration between retailers and distributors has become a key characteristic of supply chain performance [15], [16]. Furthermore, Koha *et al*. [17] illustrated that shared information between partners need to be effective and meaningful to achieve the win-win situations that appear to be crucial for establishing closed relationships among supply chain partners for both business survival and to differentiate customers offerings by providing more valuable products or services than competitors [15]-[18]. Supply chain collaboration assumes that decision-making quality depends on accurate, transparent and timely information, and reduced costs, inventory and demand uncertainty, which ultimately improve the overall supply chain performance [19], [20]. Unpredictable or non-transparent demand patterns have been found to cause artificial demand amplification in a range of settings (also referred to as the 'bullwhip effect') which means that a retailer's orders to their suppliers tend to have a larger variance than the consumer demand that triggered the orders. This leads to poor service levels, high inventories and frequent stock-outs amongst participants in a small retailers SC. Therefore, it is necessary to extend the coordination, collaboration and sharing of up-to-date orders among supply chain members by managing the whole supply chain as an integrated system [21], [22].

B. Supply Chain Collaboration

Supply chain collaboration (SCC) is defined as synergy among SC partners through joint planning and real-time information [23], [24]. Collaboration takes many different forms, including strategic alliances, joint ventures, third party logistics, short- and long-term contracts, partnership sourcing, and retailer-supplier partnerships. Collaboration at the strategic level is concerned with decisions that influence the future direction of the collaborative supply chain performance [25]. In order to facilitate effective collaboration, supply chain partners must understand their role as parts in the system. They must be ready to interact with the other partners in a systemic manner. The SCC efforts can be described as comprising of three different types, namely: collaborative replenishment, collaborative planning and forecasting efforts. Quick Response (QR), Continuous Replenishment (CR) and Vendor-Managed Inventory (VMI) can be categorized as 'replenishment', a Collaborative Forecasting and Replenishment Model (CFAR) as 'forecasting' and Collaborative Planning, Forecasting, and Replenishment (CPFR) as 'planning' effort [4], [26]. CR, inventory replenishment takes place not through orders placed by the retailer, but through automatic orders based on the data of actual or forecasted demand received through Electronic Data Exchange (EDI) [26]. If the CR is vendor-managed, it is called VMI, wherein the supplier determines the time and volume of product delivery while ensuring the full availability of products [20]-[27]. CPFR, proposed in 1998, has been adopted by more than 20% and considered by more than 40% of 120 manufacturers interviewed with retail outlets in Taiwan sell computers, communication equipment [4]. Estimates suggest that those who use the CPFR model will see significant improvements in sales (2-25%), accuracy of forecasting (10-15%), and customer service (0.5-2%). In the retail grocery industry, it is estimated that 30% of the players are simply too small to be considered efficient collaboration targets for the suppliers [4]. It is hypothesized that an overemphasis on expensive collaborative efforts is responsible for overlooking the possibility that small changes in the retail and supplier ordering policy can have a substantial impact on the efficiency of retail grocery supply chains [19], [26], [28], [29]. However, collaboration can be costly, time consuming, and often falls short of achieving performance objectives [29], [30]. In response to these sub-optimal conditions, several other researchers have highlighted the importance of transparent information sharing, joint efforts and investments to improve trust and commitments within SCCs. Moreover, any SC can improve visibility using five important factors namely responsiveness, planning, shared targets, trust and common forecast [26]. The real benefit of information sharing among SC partners it could be argued lies in its effective and efficient use [17], [26], [31]-[34]. Also, due to availability of wider variety of technology and tools, selecting suitable technology to support this becomes a complicated task for collaborating partners.

C. Retail Supply Chains

The retail grocery supply chain differs from other retail supply chains in that many of the products sold are perishable, subject to high prices and demand variability, and require high safety standards [35]. These differences make managing the retail grocery supply chains more difficult. The products in the retail grocery supply chain can be split into two types: perishable and non-perishable. Perishable products include fruits and vegetables with a shelf life depending on the order of the day while non-perishable products include those with longer shelf-lives [35]. Grocery stores make up almost 90% of this number. The 20 largest US grocery retailers account for almost 65% of sales, with their share growing as industry consolidation increases [23]-[26]. Intrinsically, retailers seek to increase sales and market share, to better service their customer base, to hedge against the uncertainties of the market environment, and to obtain economies of scale in advertising and distribution.

D. Models of Supply Chain Collaboration

The growth in numbers of supply chain collaborative models comes from the increasing SC dependencies and complexity at various levels. SCC requires different combination of tasks and resources [26], [28], [29]. Aviv [26] developed a forecasting model focused on the benefits of collaborative forecasting through testing the effect of centralized and decentralized information. Models emphasizing the value of information sharing in demand forecasting accuracy have also been developed [26]-[31]. Within the SCM literature, many conceptual frameworks have been developed to explain the organizational and functional aspects of SCC; whereas, actual mathematical or simulation models have focused mainly on aspects of performance evaluation. Despite these wide ranging efforts, collaboration frameworks have only had limited success at creating more efficient supply chains especially within small retailers [37]. Only a few simulation based studies exist in the literature on the performance analysis of SCC and its benefit to small retail industry. Kim and Oh [20] used system dynamics modelling for instance, to identify the performance of collaborative SCs under three different scenarios: the manufacturer controls the SC, the supplier controls the SC, and in balanced decision making between manufacturer and supplier. A number of other studies have presented system dynamics models to evaluate the performance of supply chain management [2], [19], [26], [28], [35], [38]. Even though the supply chain literature frequently emphasizes the virtues and benefits of collaboration, the issue of collaboration in retail supply chains has not been yet thoroughly addressed for small retailers. Theoretical contributions and empirical studies on collaboration in the small retail industry still have been presented as the main contributions up to now.

III. Research Methodology

System Dynamics is a simulation method that can be used to model complex systemic problems using a combination of quantitative and qualitative techniques. It is based on feedback control theory, using computer simulation technology as its measure [32], [33], [35], [36]. System dynamics modelling can simulate an object system dynamically in order to study and plan future action and corresponding decision-making within an object system. The dynamic system has a certain internal structure and is affected by external conditions. The supply chain being the ‘‘extended enterprise’’ that encompasses vendors, manufacturers/producers, distributors and retailers is characterized within system dynamics by a stock and flow structure for the acquisition, storage, and conversion of inputs into outputs and the decision rules governing these flows [32], [33], [36]. The flows often create important feedbacks among the partners of the extended SC; thus making System Dynamics well-suited as a modelling and analysis tool for strategic supply chain management policy and decision making.

A. Case Study Used in This Research

This research evaluates the impact on performance and efficiency of SCC among small retailers and their distributors. The research attempts to clarify the benefits of retail SCCs through modelling decision making rules within a case study SC. A dynamic model is developed based on actual data collected from case participants. The study was conducted in United State of America. Supply chain managers, store managers, dairy managers, category managers, and executive marketing managers were consulted and interviewed to help build up the structure, parameters and decision rules for an integrated and collaborative SC. Order data from 12 retailers in the 10 different States around USA and their distributor are collected and summarized as a basis for modelling alternative decision rules for collaboration in RSCCs using system dynamics. The selection criteria for the case participants were based on the following: (1) Small retailers need to provide a highly value added products and service to end customer by increasing profit; (2) They had to be diversely located to eliminate geographical specific characteristics. Different states and different cities were used to represent different demographics, educational level, business sophistication and economical attributes; (3) Small order quantities from distributor based on sales forecasting; (4) They had to be financially solvent meaning the selection of retailers with the reasonable credit risk and a viable business; (5) They had to be working in the same market environment; (6) The retailers needed to be similar in size in terms of volume, demand and sales volume; (7) They had to have ease of availability to data; (8) Moreover, they had to stock Chobani yogurt because it is the best-selling yogurt in USA; (9) The yogurt product has sustainable growth from increasing shelf space at retail, geographic expansion and increased in-store promotion activity; (10) Seasonality of product availability, perishability and shelf life.

B. Data Collection Method

Semi-structured interviews have been selected for collecting data from 12 retailers in 10 different states in USA. The interviews allowed the respondent to tell stories, give examples and clarify the problem definition. An initial system dynamics model was built to characterize the problem through discussion with the client teams. This information was supplemented by archival research. Interview questions were designed to focus on the SC participants’ levels of understanding about the real meaning of collaboration with their supply chain partners, through asking them to share any information relating to the aspects of their involvement with other suppliers and distributors of Chobani Blueberry yogurt (6 oz.) in their SC (such as order quantities, sales forecasting, customer demand, inventory management, stock level and promotional strategies, etc.). Moreover, they were asked about how they assess their business relationship with distributors and how they measure the effect of collaboration from their perspective on their level of market share. Specifically, they were asked about the relationships between sharing order information with distributors and competitive advantage, and the collaboration conditions and barriers from retailer’s point of view. From the previous questions during interviews, the research found that most of 12 retailers have the same conceptual understanding of collaboration as a means to contacting their supplier and distributors through just sharing current daily orders. It was noted that they didn’t share any other information about previous orders, future orders, sales forecasting, stock, and inventory management, nor did these small retailers retain historical data for all their ordering. They merely depended on making decisions based on the historical data provided by their distributors.

IV. Model Study

A. Model Boundary and Description

The model represented has been developed based on previously reported supply chain models in the literature, but has been modified and refined to fit the case study in this paper. Also, relevant variables, parameters and feedback loops related to the effect of collaboration have been added to the refined model from the interview findings to provide a fully validated and calibrated case study simulation model. The decision rules are related to the degree of collaboration which is impacted by three variables: number of partners collaborating, average duration they have been collaborating in and their level of involvement measured by relative investment in collaboration-supporting activities. Fig. 1 characterizes the stock-flow structure of this particular supply chain. At the bottom of the figure, there is a stock named Purchase Rate Forecast with a flow named Change in Purchase Forecast. This flow is impacted mainly by Customers Purchase Rate, current level of the Purchase Rate Forecast, and the degree of Collaboration. It also shows the change in the accuracy of the orders forecast on the retailer side based on the sales rate and the customers' demands sides. The key stocks in the model are the distributor inventory, the retailer inventory, and the retailers order forecast. The distributor inventory increases by ordering more units from the manufacturer which is not within the boundaries of this model, and the inventory decreases by fulfilling retailer's orders. The retailer's inventory increases by receiving fulfilled orders from the distributor, and it decreases by selling units to consumers. The retailer's orders forecast stock is mainly dependent on the customers' orders and the depletion of the retailer inventory in relation to the desired minimum levels of retailer inventory. The loops and different variables represent the complex and dynamic interrelations between customer demands, desired inventory levels, orders fulfillment rates, distributor's orders fulfillment ability, distributor own desired inventory levels, and the time to fulfill this desired inventory levels. Three main variables contribute to the effect of collaboration variable: numbers of collaboration partners, duration of collaboration, commitment to collaboration through investment in training and tools. The extent of partner collaboration directly impacts on unit cost, as more retailers collaborate together, more discounted prices can be negotiated as their purchasing power increases. The Retailers orders forecast also get impacted by the effects of collaboration, as it improves the quality of the forecast from the collective intelligence and experience of the different collaborating partners. Revenues are calculated from the sales rate and the unit price, and from revenues and costs, the profits are calculated.

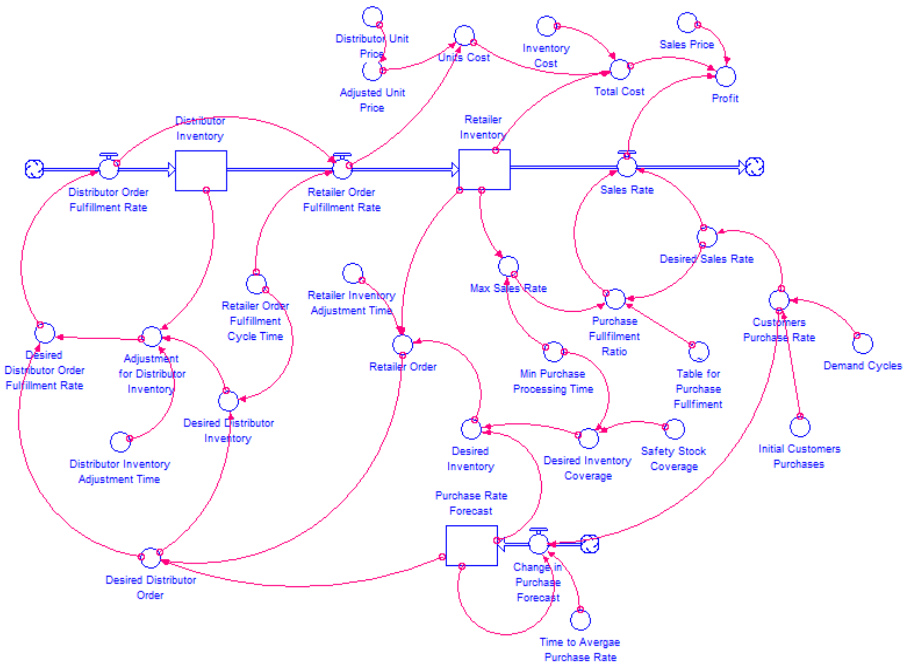

Fig. 1. Flow diagram of supply chain management system before collaboration.

B. Simulation and Analysis of the Model

Fig. 2-Fig. 4 are the simulation results of supply chain management system model before collaboration. Fig. 2 shows that the demand information is enlarged from customer to manufacturer, indicating that a bullwhip effect obviously exists in the supply chain system. In early stages of the system simulation running period, the demand volume of each enterprise in supply chain is gradually increased.

In Fig. 2 Distributor Inventory drops after the first month as it has an initial value of 100 units. Due to the high demand from the retailer, the distributor inventory is optimized as it doesn't accumulate a large volume of units due to the high outflow. Purchase (Retailer) Rate Forecast grows from its initial value and oscillates upwards before exhibiting asymptotic behavior. Retailer Inventory has a cyclic behavior with an overall slight increasing trend. Regards the Customer Purchase Rate, the input is modeled as a sin wave to represent the market seasonality. Sales Rate follows the Customer Purchase Rate behavior, but in the beginning there is a delay or a different in magnitude as the actual sales try to catch up with the customer demand.

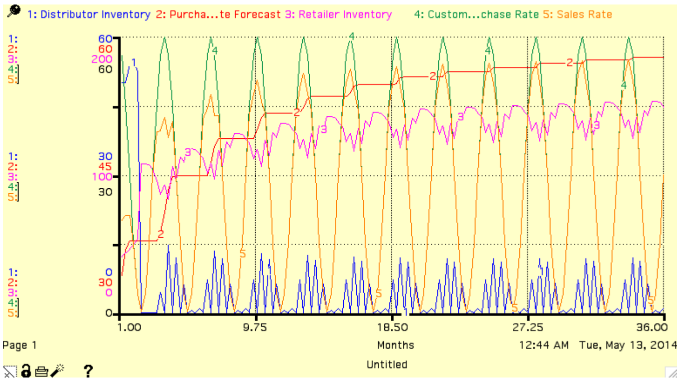

Fig. 2. Simulation result of supply chain management system model before collaboration (I).

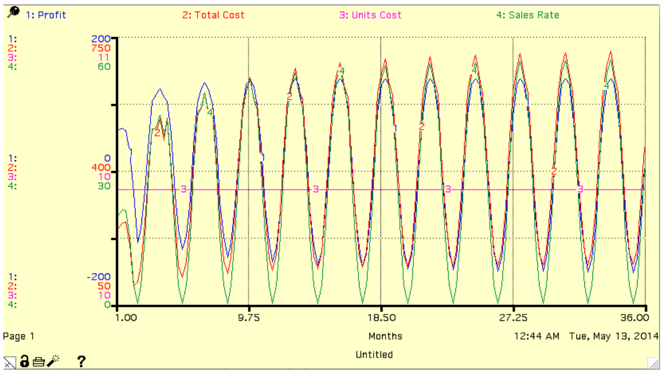

Fig. 3 Simulation result of supply chain management system model before collaboration (II).

If collaboration is incorporated then this can help to improve the performance of a collaborative SC. Fig. 5 incorporates additional notation to represent the (number of) Partners, degree of collaboration by partners through the Average Duration (of partner collaboration), and the (partner) Level of Involvement (with other actors in the SC).

Fig. 3 shows that the effect on desired:

Profit = (Sales_Rate*Sales_Price)-Total_Cost

Sales_Price = 15.48

Units_Cost = Adjusted_Unit_Price*Sales_Rate

Total_Cost = Units_Cost+(Inventory_Cost*Retailer_Inventory)

Sales_Rate = Desired_Sales_Rate*Purchase__Fullfilment__Ratio

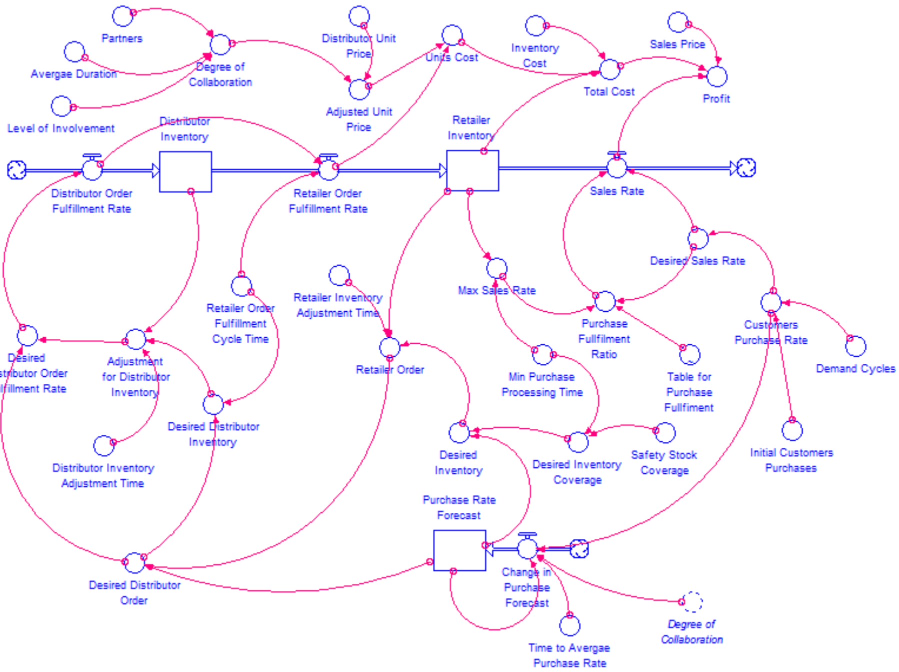

Fig. 4. Stock-flow diagram of supply chain management system before collaboration.

C. Simulation and Analysis of the Model

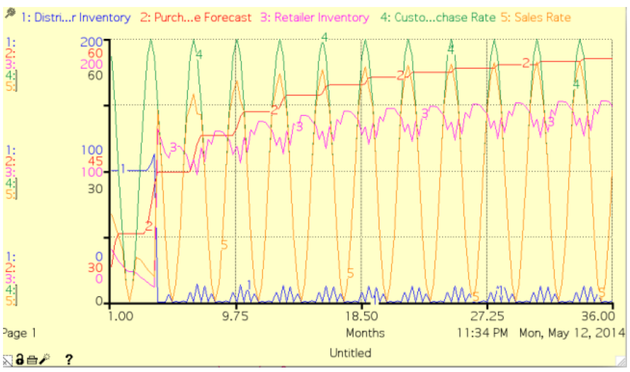

Fig. 5. Simulation result of supply chain management system model after collaboration.

In the figure, Distributor Inventory drops after the first month as it has an initial value of 100 units. Due to the high demand from the retailer, the distributor inventory is optimized as it doesn't accumulate a large volume of units due to the high outflow. Purchase (Retailer) Rate Forecast increases in a classical decreasing rate with an approximate step function over 2 month. Retailer Inventory has a cyclic behaviour with an overall slight increasing trend. Regards the Customer Purchase Rate, the input is modelled as a sin wave to represent the market seasonality. Sales Rate follows the Customer Purchase Rate behaviour, but in the beginning there is a delay or a difference in magnitude, as the actual sales try to catch up with the customer demand. There is no major change to the inventory held across the supply chain between Fig. 5 (after collaboration) and Fig. 2 (before collaboration) as these dynamics are more related to market demand and supply dynamics. The effect of collaboration is very evident though on the month-by-month profitability when comparing Fig. 6 (before collaboration) to Fig. 3 (after collaboration).

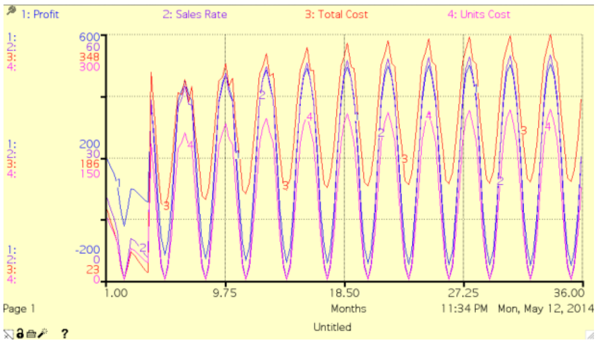

Fig. 6. Simulation result of supply chain management system model after collaboration.

V. Conclusion and Further Research

Collaborative supply chains can cut costs, risks and inventory problems for retailers and their trading partners alike. Small retail supply chain collaboration (SRSCC) reputation blemished by exorbitant costs, complex integration efforts and failure to deliver on its promises. But today, new computing models have dramatically changed understanding of supply chain dynamics. Retailers and their suppliers are increasingly reliant on more touch points domestically and globally to meet their end consumer needs. Consequently, the demand for collaboration across the supply chain has grown. Increasing the flow of better information exchange improves supply chain performance and value.

Present conceptual framework tries to focus on several areas that have not been touched by past research studies. First, past research lacks evidence of positive relationships among small retailers and distributors with collaboration competence and system dynamics modelling success. Therefore, with this framework, it tries to generalize above relationships for other small retailers in the United States in order to meet consumer needs and maximize shelf value. The framework provides the ability to have visibility and collaboration across a grid of connected trading partners which is a critical factor for efficient collaboration between trading partners. The only way they can continue to improve profitability is by increasing their information sharing and synchronization rather than wasting time in excess inventory as the only thing worse than being overstocked is being out of stock. The typical way to avoid out-of-stock situations was to stock up surplus inventory through managing orders across all retail stores. Second, the main determinant of small retailer's collaboration was found through literature and it has not been validated through any empirical work. Further, there might be other factors for collaboration. Therefore, this framework extended existing research to find out above through empirical research. Finally, small retailer's collaboration and performance are severely lacking research efforts. Therefore, this conceptual framework extended existing work to discover determinants for above two concepts of the collaboration with respect to system dynamics modelling and system implementations.

Though this conceptual system dynamics framework contributes to the existing knowledge in a number of ways, it has limitations too, which require future work. There might be difficulties in using one research approach across the framework i.e. quantitative or qualitative. Moreover, there might be difficulties in testing and generalising the framework to all small retailers available in the market and all industry sectors.

In conclusion, this paper mainly discussed the need of supply chain collaboration and system dynamics modelling. The importance of fulfilling research gaps on small retail collaboration is identified through literature review. The significant contribution of the proposed conceptual framework on small retailers supply chain collaboration and its limitations are presented. The study believes that the proposed conceptual framework on SRSCC would guide system dynamics modelling toward business success as a decision support tool with regard to supply chain collaboration.

Acknowledgment

The Authors would like to thank Bozzuto's Inc in United Sates for providing historical data about Chobani Blueberry yogurt regarding their orders and sales.

References

[1] U. Ramanathan, "Aligning supply chain collaboration using analytic hierarchy process," *The International Journal of Management Science*, vol. 41, pp. 431-440, 2013.

[2] M. Caoa, M. A. Vonderembse, Q. Zhangc, and T. S. Ragu-Nathan, "Supply chain collaboration: conceptualisation and instrument development," *International Journal of Production Research*, vol. 48, pp. 6613-6635, 2010.

[3] B. Angerhofer and M. Angelides, "A model and a performance measurement system for collaborative supply chains," *Decision Support Systems*, vol. 42, pp. 283-301, 2006.

[4] S. Min, A. Roath, P. Daugherty, S. Genchev, H. Chen, A. Arndt, and R. Richey, "Supply chain collaboration: what's happening?" *The International Journal of Logistics Management* , vol. 16, pp. 237-256, 2005.

[5] J. Smaros, "Forecasting collaboration in the European grocery sector: Observations from a case study," *Journal of Operations Management*, vol. 25, pp. 702-716, 2007.

[6] S. Naspetti, N. Lampkin, P. Nicolas, M. Stolze, and R. Zanoli, "Organic supply chain collaboration: A case study in Eight EU countries," *Journal of Food Products Marketing*, vol. 17, pp. 141-162, 2011.

[7] T. P. Stank, S. B. Keller, and P. J. Daugherty, "Supply chain collaboration and logistical service performance," *Journal of Business Logistics*, vol. 22, pp. 29-48, 2001.

[8] W. Kessler, L. McGinnis, N. Bennett, Q. Makins, D. Nagao, and N. Bennett, "Enterprise alignment and inertia risks during transformation," *Information Knowledge Systems Management*, vol. 11, pp. 51-168, 2012.

[9] S. Li and B. Lin, "Accessing information sharing and information quality in supply chain management," *Decision Support Systems*, vol. 42, pp. 1641 -1656, 2006.

[10] F. R. Lin, S. H. Huang, and S. C. Lin, "Effects of information sharing on supply chain performance in electronic commerce," *IEEE Transactions on Engineering Management*, vol. 49, pp. 258-268, 2002.

[11] C. Droge, S. K. Vickery and M. A. Jacobs, "Does supply chain integration mediate the relationships between product / process strategy and service performance? An empirical study," *Int. J. Production Economics*, vol. 137, pp. 250-262, 2012.

[12] B. Angerhofer and M. Angelides, "A model and a performance measurement system for collaborative supply chains," *Decision Support Systems*, vol. 42, pp. 283-301, 2006.

[13] M. Cao and Q. Zhang, "Supply chain collaborative advantage: A firm's perspective," *Int. J. Production Economics*, vol. 128, pp. 358-367, 2010.

[14] G. Kumar and R. N. Banerjee, "Supply chain collaboration index: an instrument to measure the depth of collaboration," *Benchmarking: An International Journal*, vol. 21, pp. 184-204, 2014.

[15] R. Anbanandam, D. K. Banwet, and R. Shankar, "Evaluation of supply chain collaboration: a case of apparel retail industry in India," *International Journal of Productivity and Performance Management*, vol. 60, pp. 82-98, 2011.

[16] A. Janvier-James, "A new introduction to supply chains and supply chain management: Definitions and theories perspective," *International Business Research*, vol. 5, pp. 194-207, 2012.

[17] S. C. L. Koha, A. Gunasekaranb, and D. Rajkumarc, "ERP II: The involvement, benefits and impediments of collaborative information sharing," *International Journal of Production Economics*, vol. 113, pp. 245-268, 2008.

[18] C. Glock, "Coordination of a production network with a single buyer and multiple vendors," *International Journal of Production Economics*, vol. 135, pp. 771-780, 2012.

[19] T. M. Simatupang and R. Sridharan, "Benchmarking supply chain collaboration: An empirical study," *Benchmarking: An International Journal*, vol. 11, pp. 484-503, 2004.

[20] B. Kim and H. Oh, "The impact of decision-making sharing between supplier and manufacturer on their collaboration performance," *Supply Chain Management*, vol. 10, pp. 223-236, 2005.

[21] X. Wang and J. Zhang, "Simulation research of the retailer's ordering strategy based on system dynamics," in *Proc. International Conference on Management and Service Science (MASS)*, pp. 1-4, Shanghai, China , 2010.

[22] M. G. Sayed, M. H. Gadallah, R. A. ZeinEldin, and H. A. Wahed, "Analysis of Supply chains using system dynamics simulation," *International Journal of Computer and Information Technology* , vol. 3, pp. 446-449, 2014

[23] T. M. Simatupang and R. Sridharan, "The collaborative supply chain," *International Journal of Logistics Management*, vol. 13, pp. 15-30, 2002.

[24] A. Ullah and S. Ahmed, "Building supply chain collaboration: different collaborative approaches," *Integral Review- A Journal of Management*, vol. 5, pp. 8-21, 2012.

[25] J. A. Bernhard and C. A. Marios, "A model and a performance measurement system for collaborative supply chains," *Decision Support Systems*, vol. 42, pp. 283- 301, 2006.

[26] Y. Aviv, "On the benefits of collaborative forecasting partnerships between retailers and manufacturers," *Management Science*, vol. 53, pp. 777-794, 2007.

[27] U. Ramanathan, "Aligning supply chain collaboration using Analytic Hierarchy Process," *The International Journal of Management Science*, vol. 41, pp. 431-440, 2013.

[28] M. Holweg1, S. Disney, J. Holmström, and J. Småros, "Supply chain collaboration: making sense of the strategy continuum," *European Management Journal*, vol. 23, pp. 170-181, 2005.

[29] U. Ramanathan, "Performance of supply chain collaboration - A simulation study," *Expert Systems with Applications, Expert Systems with Applications*, vol. 41, pp. 210-220, 2014.

[30] G. N. Nyaga, J. M. Whipple, and D. F. Lynch, "Examining supply chain relationships: Do buyer and supplier perspectives on collaborative relationships differ?" *Journal of Operations Management*, vol. 28, pp. 101-114, 2010.

[31] A. Saxena, "Simulation based decision making scenarios in dynamic supply chain," *International Journal of Enterprise Network Management*, vol. 4, pp. 166-182, 2010.

[32] J. W. Forrester, *Industrial Dynamics*, Massachusetts: MIT Press, 1961.

[33] L. Nuo and W. Xiao-Jie, "System dynamics modelling and simulation of multi-stage supply chain under random demand," *International Conference on e-Business and e-Government*, pp. 3306-3309, Guangzhou, China, 2010

[34] C. Low and Y. Chen, "A model measurement system for collaborative supply chain partners," *Journal of Manufacturing Systems*, vol. 32, pp. 180-188, 2013.

[35] P. Wangphanich, S. Kara, and B. Kayis, "Analysis of the bullwhip effect in multi-product, multi-stage supply chain systems - A simulation approach," *International Journal of Production Research*, vol. 48, pp. 4501-4517, 2010.

[36] J. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, New York: McGraw-Hill, 2000, ch.18.

[37] H. Yasarcan, "Information sharing in supply chains: a systemic approach," presented at the 29th International Conference of the System Dynamics Society, Washington, DC, 2011.

[38] R. Anbanandam, D. K. Banwet, and R. Shankar, "Evaluation of supply chain collaboration: A case of apparel retail industry in India," *International Journal of Productivity and Performance Management*, vol. 60, pp. 82-98, 2011.

Ghada Elkady is a PhD researcher Plymouth University, UK. Her research interests are supply chain management with modeling to support business decision making, focusing particularly in the areas of retail management, supply chain collaboration, with system dynamics modeling. She is currently working as a lecturer at the College of International Transport & Logistics, Alexandria, Egypt. Her PhD research examines grocery retailer supply chain collaboration efficiency through using a system dynamics modeling approach. She is a member of Chartered Institute of Logistics and Transport, UK and the International System Dynamics Society.

Jonathan Moizer's research interests include both simulation gaming and its applications in education and training, as well as simulation modeling for learning, insight and prediction. Jonathan is widely published in these fields in addition to the use of computer-based simulation games in educational settings. He is a member of the editorial board for Simulation and Gaming: An Interdisciplinary Journal of Theory, Practice, and Research' and sits on the committee of the European Conference on Games Based Learning.

Shaofeng Liu is a professor of operations management and decision making at Plymouth University, UK. She obtained her PhD degree from Loughborough University, UK, specialising in knowledge and information management for global manufacturing co-ordination decisions. Her main research interests and expertise are in knowledge-based techniques to support business decision making, particularly in the areas of knowledge management, integrated decision support, ERP systems and quantitative decision methods for lean operations, process improvement, resource management, quality management, and supply chain management. She is currently supervising 9 PhD students in above research areas. She has undertaken a number of influential research projects funded by UK research councils and the European Commission. She has published over 100 peer-reviewed research papers including 50 journal articles, 5 book chapters, 48 conference papers, and editorial for 6 journal special issues and 5 conference/workshop proceedings. She is currently an Associate Editor for the Journal of Decision Systems and on the editorial board for the International Journal of Decision Support Systems Technology. She conducts regular review for 4 research councils and 10 international journals.