SIMULATION MODEL FOR EFFECTIVE SUPPLY CHAIN MANAGEMENT USING ARENA

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ABSTRACT

Supply chain management (SCM) is a major component of competitive strategy to enhance organizational productivity and profitability. Supply chain is essentially a series of linked suppliers and customers where every customer is in turn a supplier to the next downstream organization until a finished product reaches the ultimate end user. In this scenario, two issues have to be overcome namely shrinkage and the bullwhip effect. Computer simulation model can play an important role to identify the problematic areas and indicate possible solutions. Simulation modeling can help the manufacturer to establish supply chain performance and the manufacturer is able make early strategic decisions. A simulation was developed based on information from a paperbased industry. Shrinkage has been identified to occur at the transportation and assembly process module. The bullwhip effect could be seen to occur even at primary supplier as it tries to adapt to the consumer demand fluctuation. Dynamic process simulation allows organizations to study their process from a system perspective, providing better understanding of cause and effect in addition to allowing better prediction of outcomes.

ABSTRAK

Pengurusan rantaian bekalan adalah satu komponen utama dalam strategi persaingan untuk meningkatkan pengeluaran dan keuntungan satu-satu organisasi. Rantai bekalan pada asasnya adalah satu rangkaian antara pembekal dengan pengguna di mana setiap pengguna akan menjadi pembekal kepada organisasi hiliran pula sehingga sampai pada pengguna terakhir. Dalam senario ini, dua isu yang perlu diatasi iaitu kesan pengecutan dan kesan *bullwhip* . Model simulasi komputer memainkan peranan penting untuk membantu mengenal pasti permasalahan dan mencari penyelesaian pada permasalahan tersebut. Model simulasi boleh membantu pengeluar untuk menentukan tahap pencapaian rantai bekalan tersebut dan pengeluar boleh merangka keputusan-keputusan strategik dengan lebih awal. Simulasi yang dibangunkan dengan berdasarkan informasi industri berasaskan kertas. Pengecutan dikesan berlaku semasa penghantaran dan sewaktu proses pembuatan. Kesan *bullwhip* dikesan pada peringkat pembekal utama di mana ketika cuba menyesuaikan dengan pergolakan permintaan pengguna. Proses simulasi yang dinamik membolehkan organisasi meneliti proses daripada perspektif pemahaman tentang sebab dan kesan disamping membantu membuat ramalan yang lebih tepat.

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LIST OF ABBREVIATIONS

CPFR	-	Collaborative Planning, Forecasting and Replenishment
DES	-	Discrete-Event Simulation
FMM	-	Federation of Malaysian Manufacture
OEM	-	Original Equipment Manufacturer
SC	-	Supply Chain
SCM	-	Supply Chain Management
WIP	-	Work In Process
VMI	-	Vendor-Managed Inventory

CHAPTER I

INTRODUCTION

1.1 Background of study

In a today's highly competitive market manufacturer face the challenge of reducing manufacturing cycle time, delivery lead-time and inventory reduction. Every company has its own objectives and its own way of decision making processes, there has been a need for a new mechanism, which help to resolve those conflictions and to integrate process.

In the early 1990s, the phrase "supply chain management" came into use (Yoon Chang, *et al.*, 2002). Supply chain management (SCM) is the integration of these activities through improved supply chain relationships, to achieve a sustainable competitive advantage (Robert, *et al.*, 1999). It is a process integrating/utilizing suppliers, manufacturers, warehouses, and retailers, so that goods are produced and delivered at the right quantities and at the right time, while minimizing cost as well as satisfying customer requirement. The structure considered is the traditional supply chain mentioned by Vieira, G.E. (2001) composed by sources, suppliers, processors,

distributors, retailers and consumers, since one knows that most corporations do in fact adopt this macro-vision (Figure 1.1). In this approach, there exist two types of flows, the information flow, in the upstream direction, that is, customers to suppliers, and the material (products or services), in the downstream direction – suppliers to customers (Slack, *et al.*, 2001).

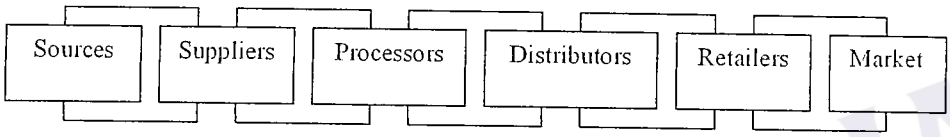

Figure 1.1 : Traditional Logistics Chain (Vieira, G.E., 2001)

Usually, materials flow forward while information and money flow backward in the chain. The goal of supply chain management is to provide maximum customer service at the lowest possible costs. Recent developments highlight the need to manage a company's supply chain integratively and cohesively. These developments include the increased demand for better and faster customer service, globalization of business and competition, and availability of information technology to facilitate information exchange. The concurrence of these factors has demanded and has also enabled companies to manage their supply chains holistically to achieve strategic advantages (Arntzen, *et al.*, 1995).

One can see that such integration has a significant impact on the supply chain performance. Computer simulation can play an important role in this scenario, since it can be used to evaluate the impact of the integration in the chain.

In general terms, this project uses the development of a computer environment in Arena (Rockwell Software Inc.) to aid the responsible for operations to better analyze and test new ways to improve supply chain performance (increase its profitability), under the idea of having all of its chain members collaborating. More specifically, a

simulation environment to allow the study of new technologies to supply chain management, like, for instance, implementation of collaborative planning, forecasting and replenishment (CPFR) ideas. Secondly, the overall project will show that the bullwhip effect can be more easily studied with computer simulation instead of spreadsheets, which can perform very limited analysis of dynamic and stochastic systems like supply chains.

Shrinkage is another big issue in the supply chain management. We have seen many new trends and strategies foster a federated supply chain management to effectively *mask* the distances between suppliers and consumers. Supply chain can be *shrunk* through efficient movement of resources along the three classic dimensions of the supply chain. Larger amount of inventory across larger distances, information exchanged easily through internet-enabled structures, money moved across borders and global partners. Enterprises that rely on global supply chain enhance three characteristics to shrink their supply chains for competitive advantage: visibility, coordination and responsiveness. (Badri Davella, *et al.*, 2007).

In response to the challenge of investigating the supply chain in its entirety, instead of its individual entities, studies using simulation have become more popular in recent years. It also conclude that global behavior of a supply chain can only be assessed by using dynamic simulation.

1.2 Problem statement

Supply chain management is dynamic. Global competitiveness demands international companies to produce and deliver customized products and services fast and efficiently all over the world at low cost and high quality. To achieve this, supply chain process must be effectively synchronized. The problems related with supply

chains are often not simple and easy to understand. It covers is the process of planning, implementing, and controlling the operations of supply chain with the purpose to satisfy customer needs as efficiently as possible. This study is more focus on inventory, logistic, manufacturing process and reducing lead time by improving supply chain delivery. An effective supply chain delivery is very important to capture the market. Coordination and collaboration with partners, which include suppliers, intermediaries, third party service providers, is critical. Beside improving the supply chain delivery, inventory shrinkage and bullwhip effect are the big issues to face it.

Shrinkage is a losing stock through inefficient processes, poor stock accounting or theft and an age-old problem for retailers (Alex Reeves, 2006). Despite the size of the problem, many retailers have little visibility of the full extent of losses, either how much is being leaked or at what point in the supply chain. Typically, there is lack of clarity around physical versus administrative shrinkage, poor unit tracking and known stock accounting issues which obscure true shrinkage levels. Lack of transparency and unreliable data often lie at the heart of the problem. Stock file accuracy though crucial, is frequently compromised by poor systems and process compliance. Furthermore, perceived logistics cost efficiencies, such as good faith receiving, can create additional costs as stores inherit shrinkage from further up the supply chain. Even when the goods have hit the shelves, inconsistent in-store compliance and lax staff behaviour leave many retailers wide open to customer theft, despite significant investment in security technology. A process based review of the entire supply chain is not necessarily the right way to address shrinkage. Instead, a focus on data analytics and forensic accounting, and readiness to see the big picture are key to uncovering the size of the problem, pinpointing the location and dealing with the root causes also mentioned by Alex Reeves (2006).

The four major sources of inventory shrinkage also happen in the retail industry are :

1. Employee theft
2. Shoplifting
3. Administrative errors (e.g. warehouse discrepancies)
4. Vendor fraud

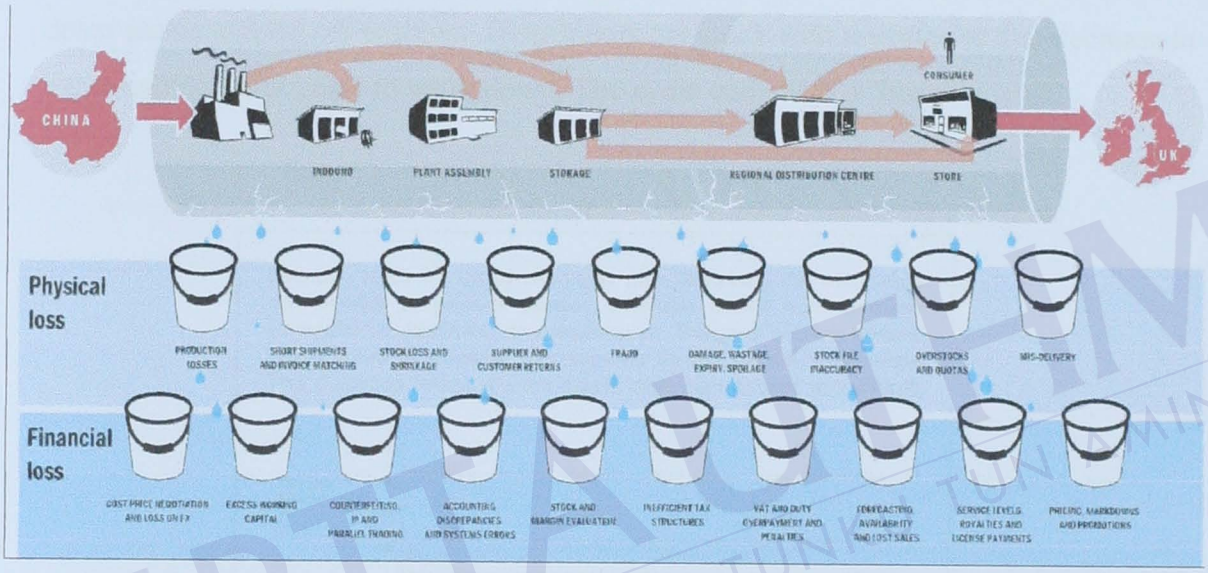

Figure 1.2 : Shrinkage review by Alex Reeves (2006)

Based on discussion with member of Federation of Malaysian Manufacturers (FMM) on 17 March 2008 also explain that shrinkage issue regularly happen in the retail industry in Malaysia. Therefore this project is highly useful to overcome this problem.

In another issue, the Bullwhip Effect is a deformation in information when it goes upstream in the supply chain. More precisely, the demand of the customer is put out of shape each time it goes from a company to another. Assuming the demand of the customer is quasi-constant, this deformation appears through the amplification of the first mini-fluctuations. Demand order variabilities in supply chains are amplified as they move up the supply chain. In other words, when there are multiple levels to supply chain

- supplier, manufacturer, distributor, OEM (Original Equipment Manufacturer) customer and user - the further up the chain, the less predictable are the order quantities.

Companies behave in ways that at first create product shortages and then lead to an excess supply of products. It's a ripple effect, except that for every member of the supply chain, the economic reality is more like the lash of a real bullwhip. Finally, the glut of product is so large that everyone realizes there is too much. Manufacturers shut down plants and lay off workers. Distributors are stuck with inventories that decrease in value and can take years to work down. The cycle ends with a "bust."

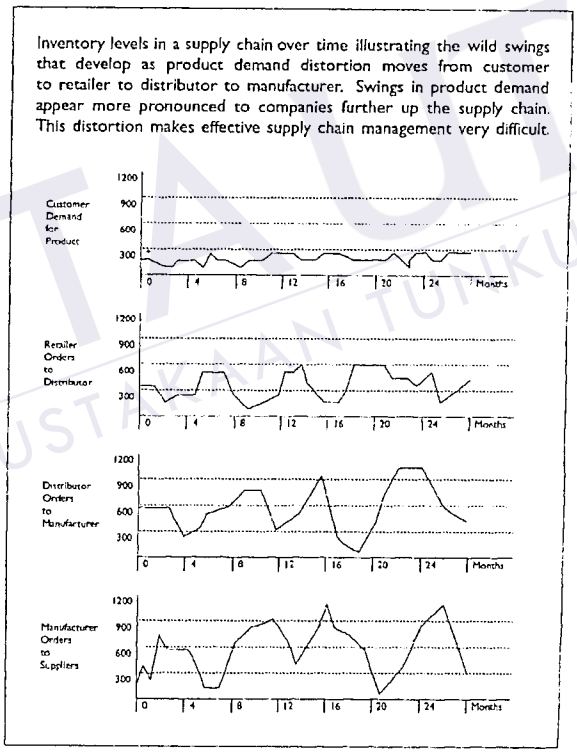

Figure 1.3 : Product demand distortion swings: the bullwhip effect (Michael Hugos, *et al.*, 2006).

Figure 1.3 illustrates how each company sees the product demand and the distortion that causes the problems. Anything that disrupts a steady and orderly supply of product can create a bullwhip effect: a retailer who stops ordering in an attempt to reduce inventory, for example, or delays in material or information that cause backlogs in some parts of the supply chain. A study by Georgia Technical University estimated supply chain problems cost companies between 9 and 20 percent of their overall value in a six-month period. The costs of the bullwhip effect are felt by all members of the supply chain (Michael Hugos, *et al.*, 2006) :

1. Manufacturers add extra production capacity to satisfy an order stream that is much more volatile than actual demand, and/or production schedules are thrown off as the plant scrambles to supply the inflated demand numbers.

2. Distributors carry extra inventory to cover the variability in order levels, which ties up additional funds.

3. Transportation costs increase because excess transportation capacity has to be added to cover the periods of high demand.

4. Labor costs also go up in order to respond to the high demand periods.

5. Retailers experience problems with product availability and extended replenishment lead times, which results in poor customer service and out-of-stocks.

6. During periods of high demand, there are times when the available capacity and inventory in the supply chain cannot cover the orders being placed. This results in product rationing, longer order replenishment cycles, and lost sales due to lack of inventory.

1.3 Objective of study

This study embarks on the following objectives :

1) To reduce the problem that bullwhip effect and shrinkage in supply chain management.

2) To assist decision making in supply chain management through the simulation modeling.

1.4 Scope of study

The scope of study include :

1) To study various models of improve supply chain.
2) To identify real issues in supply chain management in the industry.
3) Verification of the simulation model with the participating industry.

1.5 Significance of study

This study will give another alternative to overcome the issues in supply chain management especially :

1) To make the supply chain management analysis easier by simulation model.
2) To identify the shrinkage issues and bullwhip effect in supply chain.
3) It can be used to reduce inventory cost and then increase industrial productivity.

1.6 Organisation of the thesis

Outline of this thesis is briefly summarized as follows. **Chapter I** presents background of study, problem statement, objectives, scope and significant of the project work. **Chapter II** presents the literature review on the project title which includes background and supply chain management issues, computer modeling study and application the modeling into industry. **Chapter III** present detailed on investigation methodology used for conducting the study work includes problem formulation issues in supply chain management, model description and running the models, then verification process. **Chapter IV** describe the utilization of ARENA software to build and simulate the supply chain model. **Chapter V** discusses and analyze data from the simulation model. The discussion include assessment from the result obtained to overcome the supply chain management issue. **Chapter VI** presents the conclusions and suggestion of the project.

1.7 Summary

Collaboration between suppliers, producers and distributors is crucial in ensuring efficient and effective delivery of products. Many issues and problems were raised. Simulation model has been identified as one of the best tools to help in the understanding of issues in a more holistic manner. This study works aim to facilitate the building of simulation model for supply chain management. Further information about supply chain and the entire factor that contribute in effectiveness of supply chain management will be explained in Chapter II.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The review of published article or journal was important to know more about *supply chain management and the issues that will be happen. Other than that, we can* know what basic theories were used on supply chain management. Several models and software were used as a solution on set of problem relating the supply chain. Beside that, we focus to another way to solve the problem in supply chain management.

2.2 Case study from Ideas for Modeling and Simulation of Supply Chains with Arena.

This paper presents a research project being developed at the Industrial and *Systems Engineering Graduate Program at the Catholic University of Paraná (Brazil).*

The objective is to develop a system to aid professionals from management and logistics areas to evaluate the performance of supply chains through computer simulation. Among the several possibilities for analysis, simulation can allow one to perform detailed studies on the bullwhip effect in supply chains, caused by the demand variation from the point of sale to the suppliers. Two performance measures are of particular interest: average inventory level and service level, both for each stage at and for the whole supply chain. The structure considered in this project is the traditional supply chain composed by suppliers, manufactures, distributors (or wholesalers), retailers and customers. A first version of the proposed Arena simulation models is under development and is presented in this paper.

This paper describes the first version of the simulation models under development. In fact, usually the literature on SC simulation shows very little detail on how to simulate the intricacies inherent of supply chains. Authors mention results, but lack detailed explanations on how they have built the supply chain simulation structure (most of the time this is due to the simplifications made, like "*only one product*", "*one or two SC stages*", or "*no order*, trustworthy, a supply chain simulation model has to consider, at least :

1. Four SC stages: Customers, Retailers (wholesalers or distributors), Manufactures and Suppliers;
2. Different customer demand behaviors;
3. Different product types;
4. For each product type, different bill-of-materials (each product is manufactured from different raw materials and/or components;
5. Minimum production lot sizes;
6. Safety inventory levels;
7. Several retailers and suppliers;
8. Information and material (components or products) flows:
9. Distribution (delivery) lead-times; and
10. Minimum order and delivery quantities.

REFERENCES

A. Gunasekaran and E. W. T. Ngai (2004). "Virtual Supply-Chain Management." *Production Planning and Control*. **15**. 584 – 595.

A. Gunasekaran and Walter W. C. Chung (Eds) (2004). "Special Issue on Supply Chain Management for the 21st Century Organizational Competitiveness." *International Journal of Productions Economics*. **87**. 209 – 212

Alex Reeves, (2006). "Plugging The Leaks." (U.K): Trade brochure.

Arntzen, B.C., Brown, G.G., Harrison, T.P. & Trafton, L.L.(1995), "Global Supply Chain Management at Digital Equipment Corporation."Interfaces, 69-93.

Badri Davella and Vangelis Mavridoglou (2007). "Shrinkage The Expanding Supply Chain." Infosys Technologies Limited.

Banks. J (1998). "Handbook of Simulation Principles, Methodology, Advances, Application and Practice." Canada: Awiley-Interscience Publication.

Banks, *et al*. (2001). "*Introduction to Simulation*." The 2000 Winter Simulation Conference, Atlanta, GA, USA.

Charles C. Poirier. (2004). "Using Models To Improve The Supply Chain." St. Lucies Press, United State of America.

Guilherme Emani Vieira (2004). "Ideas for Modeling and Simulation of Supply Chains with ARENA." *The 2004 Winter Simulation Conference*, Curitiba, PR, Brazil.

John E. Hammann and Nancy A. Markovitch. (1995). "Introduction to ARENA." *The 1995 Winter Simulation Conference*, Pennsylvania, U.S.A.

Jack G.A.J. van der Vorst, Seth Tromp and Durk-jouke van der Zee. (2005). "A Simulation Environment For The Redesign Of Food Supply Chain Network: Modeling Quality Controlled Logistics." *Proceedings of the Winter Simulation Conference*, 1658-1667.

Kelton, W.D., *et al* (2002). "Simulation with ARENA." 4th. ed. New York: Mc Graw Hill.

Kiran, A.S. (1996). "Simulation and Scheduling." Kiran and Associates.

Manivannan S.M, (2006). "Simulation of Logistic and Transportation System." CNF Transportation, Inc.

Michael Hugos and Chris Thomas, (2006). "Supply Chain Management In The Retail Industry." John Wiley & Sons, INC, United Stated of America.

Robert B. Handfield and Ernest L. Nichols, JR. (1999). "Introduction To Supply Chain Management." Prentice Hall, Upper Saddle River, New Jersey.

Seung- Kuk Paik and Prabir K. Bagchi (2007). "Understanding the Causes of the Bullwhip Effect in a Supply Chain." *International Journal of Retail & Distribution Management*. **35**. 308 – 324.

Slack. N., Chambers, S., and Johsten, R. (2001). "Operation Management." 3rd ed Prentice Hall.

Verma, A. K. (2006). "Improving Agility of Supply Chains Using Base Stock Model and Computer Based Simulation." *International Journal of Physical Distribution & Logistic Management*. **36**. 445 – 454

Wikipedia (2002). "Shrinkage Accounting." National Retail Security Survey, University of Florida.

Yoon Chang and Harris Makatsoris (2002). "Supply Chain Modeling Using Simulation." Institute for Manufacturing, University of Cambridge, UK.