Maritime Economics & Logistics, 2007, 9, (52–66)

1479-2931/07 $30.00
www.palgrave-journals.com/mel

A Dynamic Replenishment System for Integrating Supply Chain functions

GHAZI M MAGABLEH[1]

[1]Al-Balqa' Applied University (BAU), Amman, Jordan.
E-mail: gmagabl@hotmail.com

An integrated supply chain (SC) model comprising both the warehousing and the transportation functions of the SC is developed that can help to reduce SC inventory levels and total SC costs while maintaining and/or improving customer service levels under dynamic operating conditions. The dynamic replenishment system (DRS) is first defined in the context of a mixed integer programming (MIP) model ('the DRS MIP model'). However, due to the unacceptably long computation times associated with the MIP formulation, a new heuristic algorithm ('the DRS heuristic') is developed to find good, potentially near-optimal solutions to the same static SC problem instances. The performance of the DRS heuristic is subsequently evaluated under dynamic SC conditions with the aid of discrete event simulation. The DRS heuristic is embedded into the ProModel simulation model as a callable subroutine that can be used to make replenishment and transportation decisions throughout the SC ('the DRS simulation model'). Experimental results confirm that operating a SC under DRS simulation model constructs is a win-win relationship for SC partners. The DRS has proven to be able to meet its primary goal of reacting effectively and efficiently to normal and/or non-normal (unplanned, disruptive) SC operations.

Maritime Economics & Logistics (2007) **9,** 52–66.
doi:10.1057/palgrave.mel.9100171

Keywords: Supply chain; integration; simulation; MIP; dynamic replenishment system.

INTRODUCTION

Supply chain management (SCM) has received attention within the logistics community since the early 1980s when it was first introduced.[1] Lambert *et al* (1998) define SCM as 'the integration of business processes from end user through original suppliers that provide products, services, and information that add value for customers'. The coordination and integration of informational and logistical supply chain (SC) elements is critical for achieving effective SCM strategies that produce competitive advantage.

Increased competition constantly drives companies to organise and devise new SC tactics. In fact, many of these new tactics are created to exploit various advantages resulting from the popularity and speed of the internet. It is essential for companies to improve continuously all enterprise activities in order to offer competitive prices and to reach desirable levels of customer service and satisfaction. The success of any company depends on building stronger and more efficient relationships (channels) with its partners. Among others, such relationships can be strengthened by effective warehouse and transportation systems information integration.

A dynamic replenishment system (DRS) model is developed to determine if one or more inventory replenishment-focused decision points can be positively affected by the proposed integrated SC framework. Lack of information sharing between SC partners is an important cause of both fluctuation in and the amplification of order quantities and inventory levels (Hoffman, 2002). The proposed DRS is an integrated model that plans customer goods deliveries based on inventory and backorder levels, customer demand patterns, and available vehicle routes and capacities.

BACKGROUND

With the recent growth and acceptance of the internet, the reemerging view that the customer is in control is changing the requirements for effective SCM. E-commerce and associated business-to-business transaction capabilities have changed the way in which the SC operates. Companies need to make informed, effective decisions based on data from warehouse management systems (WMSs) and transportation management systems (TMSs).

Simchi-Levi *et al* (2000) suggest that many companies take a system-wide approach to SCM, rather than simply focusing on one particular area, such as trying to minimise transportation costs or to reduce inventories. Simatupang *et al* (2002) discuss how increasing competition due to market globalisation, product diversity, and technological breakthroughs stimulate independent firms to collaborate in SCs that allow them to gain mutual benefits. Obtaining these mutual benefits requires integrating the information systems of the extended SC. Furthermore, third-party logistics providers and their pricing may be positively related to logistics performance (Yeung, 2006).

Fawcett and Magnan (2002) state that most of SC integration efforts focus on first-tier suppliers – no one is managing the entire SC from origin supplier to customers. The type of relationship among partners is one of the important things that determine the number of partners and the level of integration in a SC. Chandra and Kumar (2000) state that successful strategic alliances or partnerships must be based on win-win propositions. If mutual benefits are not shared by all partners, the loser(s) will not share their information with other partners, thereby potentially weakening the integrated system.

Simatupang *et al* (2002) suggest that further research is needed to develop methods of matching different segments of customer needs and wants. These methods should be able to take advantage of economies of scale and scope and rapid response to different stages along the SC to compensate for the risks associated with demand uncertainty and inventory obsolescence.

WMSs

WMSs 'enhance visibility of warehouse operations through real-time display and analysis of historical data that allows supervisors to more effectively plan and manage warehouse and distribution activities' (Finkel, 1996). The primary function of a WMS is to assure that sufficient quantities of each product are available for customer consumption when the product is demanded. WMSs contain data such as supplier or customer warehouse inventory levels, key customer ordering patterns, and cross-docking requirements. WMSs can be utilised for order management and consolidation, as well as for comprehending the continually exploding list of products SKUs due to customers' requirements for mass customisation.

While WMSs provide many potential benefits to companies that effectively utilise them, such as labour savings, inventory reduction, space utilisation improvement, and inventory accuracy improvement, WMSs are somewhat limited in their capabilities. First, WMSs manage inventory and warehouses from an operational point of view. According to Faber *et al* (2002), a WMS is only 'a short-term planning, shop floor control system for warehousing and cross-docking (sometimes transport) activities'. Moreover, WMSs are often designed for a specific company's warehouse installation and often cannot be adapted or extended to other locations and/or company facilities. Gripman (1997) suggests that small to medium-sized warehouses may not be able to cost-justify the purchase of a WMS. Finally, simply installing a WMS does not guarantee improved process efficiencies and performance, as a number of warehouse performance metrics exist for which an improvement in the metric may not translate into an overall SC improvement, such as operator and dock-door utilisation (Kiefer and Anovack, 1999).

TMSs

TMSs are software solutions that facilitate procurement of transportation services, short-term planning and optimisation of transportation activities, and execution of transportation plans (Basta, 2002). TMSs store information pertaining to the location of important SC assets such as products or vehicles. During planning and optimisation efforts, TMSs determine the transportation mode(s) and also manage freight consolidation operations and coordinate company shipments, including continuous freight moves (Mason *et al*, 2003). When used in an execution or operation mode, TMSs either directly or indirectly are responsible for carrier load tendering, routing and scheduling, shipment tracking and tracing, and freight payment and auditing (Gilmore and Tompkins, 2000).

The original focus behind the development of TMSs was highway and public transportation problems. TMS connectivity and functionality need to be updated continuously to comply with new technologies, as ‘the challenge is to apply rapidly changing technologies to control, communications, graphics, and processing, taking advantage of emerging standards, to produce a robust and flexible system architecture’ (Baig and Purdy, 1996). Further, TMSs consider transportation routing from the low level ‘traffic’ point of view, rather than from a higher level, logistics perspective. Finally, TMSs are not integrated tools, as they look at transportation management from an operational viewpoint. The benefits anticipated from a truly integrated SC can only be realised when all levels of decision-making technologies (ie, strategic, tactical, and operational) are integrated together (McKay, 1996; Tighe, 1995).

SC event management

Lane (2002) suggests that SC event management ‘offers significantly more insight into major changes in the SC than the established crop of SC solutions’. However, the same author reflects that while event management solutions can identify problems, they offer very few solutions to help SC managers or operation professionals determine the most effective response to the problem (Lane, 2002). Finally, Marabotti (2002) suggests that ‘the greatest pitfall is reacting to [event management’s] elevated tracking ability rather than using it for analysis’. Using event management in a purely reactive, rather than proactive fashion can lead to continual ‘fire fighting’, rather than root-cause analysis and problem resolution.

SC INTEGRATION FUNCTIONS

As the level of integration between WMSs and TMSs continues to evolve, simply having access to the 'right' information does not guarantee that a company will either do something with it, or more importantly, do the 'right' thing with it. Companies must be able to coordinate effectively activities across dynamically evolving SCs in response to constantly changing and increasingly customised market requirements (Sadeh *et al*, 2001). Constantly changing customer preferences make it difficult for companies lacking proper integration and coordination with all SC partners to stay competitive in the marketplace.

Consider the SC in Figure 1. Each box designates a stocking location where inventory is held, while solid arrows designate transportation network connectivity. The circle represents the end goal, an end customer buying a product. While most SCs contain multiple echelons of distribution before the product reaches the end customer, Figure 1 depicts the many interactions/relationships that must be managed to convert raw materials into a finished product in the end customer's hands. Simply having visibility into product status, asset locations, and SC inventory positions does not directly translate into reduced operating expenses. Decision-support tools must be in place to disseminate and process large volumes of SC data, and then provide pertinent information for decision-making assistance.

ANALYSING SCs

Three basic solution methodologies are prevalent in the literature for SC model analysis: optimisation-based models, simulation-based models, and heuristic-based models. Optimisation-based SC analysis approaches suffer from the limitation that they typically consider only average demand under static

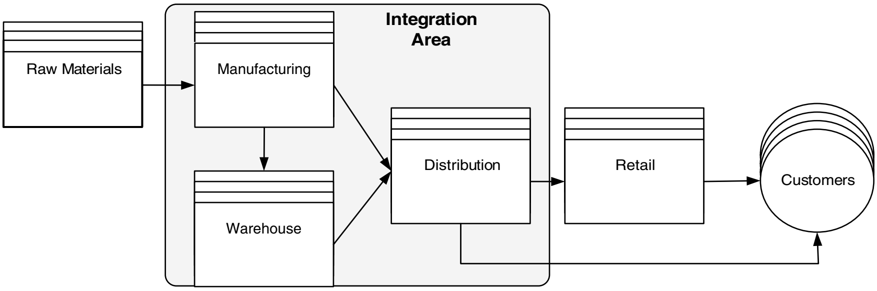

Figure 1: Integrated SC.

conditions. Therefore, the dynamic, stochastic nature of real SCs typically is not captured in these mathematical models.

Conversely, simulation-based solution techniques can accommodate the system dynamics inherent in real-world SCs. A typical SC simulation model is often capable of representing the associated logistics system under study. Given a particular configuration of warehouses, retailers, and so forth, a simulation model can be used to help estimate the costs associated with operating that SC configuration. However, if a different SC execution configuration is considered (eg, a few of the customers are to be served by different warehouses), SC simulation models often must be rerun. Further, simulation analyses often require a considerable amount of time to properly conduct sufficient replications to develop meaningful insights into simulation model outputs.

Given the expertise and time required to properly conduct an SC simulation study, it is no surprise that heuristic-based static models containing some amount of optimisation capability 'account for almost all the network configuration models used in practice' (Simchi-Levi *et al*, 2000). Two strengths of heuristic, static models are their simplicity and intuitiveness. Managers want cost-effective solution approaches that are fast, effective, and easy to use. However, these same managers often want these solution approaches to act as decision-support systems that *recommend* potential actions, rather than decision-making systems that automatically *implement* actions.

Existing research considering the SC as a dynamically changing system is scarce. While some authors have considered SC integration and coordination, few researchers have investigated designing and coordinating the warehousing and transportation functions of the SC based on variable demand. Bertazzi *et al* (2002) present a heuristic algorithm for setting deterministic order up to levels in an inventory routing problem. The problem is to determine, for each discrete time instant, the retailers to be visited and the vehicle's route so that the sum of transportation costs and inventory costs, both at the supplier and at the retailers, is minimised.

Daskin and Coullard (2002) use a Lagrangian relaxation approach for the inventory location problem. In their research, the demand that is seen by a particular DC is a function of the demand at the retailers assigned to the DC. The objective of this formulation is to minimise the sum of order, inventory, and transportation costs. Sha and Che (2006) present a multi-phase mathematical approach for the design of a complex SC network based on the genetic algorithm, the analytical hierarchy process, and the multi-attribute utility theory. Jayaraman (1998) presents a mixed integer programming (MIP) model that simultaneously considers the relationship between inventory management, facility location, and transportation policy in a distribution network design environment.

Chandra (2000) proposes a multi-period, integrated model that plans deliveries to customers based upon inventories and vehicle routes. The model determines the replenishment quantities and replenishment intervals at the warehouse, as well as distribution lots and delivery routes at customer locations. The solution of this integrated problem dynamically determines the capacity requirements of the warehouse. He shows that coordination of customer and warehouse replenishment decisions can lead to cost reductions. Mason *et al* (2003) develop a discrete-event simulation model of a multi-product SC to examine the potential benefits to be gained from global inventory visibility and trailer yard dispatching and sequencing techniques. They examine the benefits that can be achieved by suppliers and warehouses through the increased visibility provided by an integrated system.

Qu *et al* (1999) develop an integrated inventory-transportation system with a modified periodic review inventory policy. In treating the problem as a travelling salesman problem, the authors present a heuristic decomposition method to minimise long-run total average costs, including order, holding, backlog, and travel costs. The decomposition method separates the calculations into two parts: the inventory master problem and the routing subproblem. Results indicate that the heuristic decomposition method performs satisfactorily, leading to a near-optimal solution for the inventory policy and vehicle-routing schedule simultaneously.

Some more theoretical research has appeared recently that considers the problem of allocating multi-product demand to multiple production facilities with finite capacity and load-dependent lead times (Dong and Lee, 2003; Nam, 2001; Gans and Zhou, 2003). Other research proposed frameworks or models based on the functional integration of logistics and SC partnership (Bichou, 2004; Zahurul Islam *et al*, 2005; Robinson, 2006). In addition, Benjaafar *et al*, (2004) vary product demand rates, holding and backordering costs, and service-level requirements in their SC research. However, none of these recent research efforts account for or measure the integration of the SC chain process.

THE PRESENT APPROACH

A number of the previous studies discussed above either examine warehousing or transportation separately, or consider the integration of the two under constraints with somewhat limited practical applicability. Some authors focus on the determination of the number and location of facilities, while others focus on determining the best replenishment policy for a given SC configuration. Although these research efforts cover some aspects of the integrated inventory-transportation SC, the decisions made by the proposed models typically involve either strategic or one-time decisions.

A systematic framework is needed for investigating the impact of sharing WMS and TMS information on SC performance. This framework should be capable of processing qualitative and quantitative information, processing uncertain/dynamic information, and providing flexible, effective solutions quickly. Therefore, the primary objective of this paper is *to develop an integrated* SC *model comprising both the warehousing and the transportation functions of the SC that can help to reduce inventory levels and overall costs while maintaining or improving customer service levels under dynamic operating conditions*.

The primary focus of the paper is on the interaction among SC partners – a focus that covers many aspects of the SC. Specifically, this research investigates the interaction between and the potential advantages that could be gained by integrating and simultaneously optimising the performance of the transportation and warehousing segments of the SC under realistic operating conditions. The ultimate goal of any for-profit company is to maximise profits. Often, this goal can be achieved by decreasing total SC costs and/or increasing customer service levels. Therefore, the decision criteria in this research are based on these two factors. The focus is on minimising total costs (ie, the sum of ordering, inventory, stockout, operation, and transportation costs) in multi-facility, multi-product, and multi-echelon SCs.

The research of Mason *et al* (2003) concentrates on the SC *touch points*, specifically focusing on the interactions between transportation and the warehouse or DC. The present research incorporates the manufacturing/warehousing and distribution echelons of the SC into the analysis to investigate the potential for lower operating expenses. By providing asset visibility and decision-support tools to manage SC relationships, the research findings here demonstrate the possibility of lower inventory levels. The outcome is a ‘win’ for retailers, in terms of lower inventory levels, as well as a ‘win’ for the manufacturer/warehouse, as inventory levels, for both raw material and finished goods, are reduced; consequently, costs should be lowered.

SOLUTION METHODOLOGY

A DRS capable of producing near-optimal solutions to integrated SC inventory and transportation problems is developed. The vision for the DRS is to create a decision-support tool comprising a number of algorithms that can provide SC decision makers with effective replenishment and truck rescheduling guidance in near real-time under rapidly changing SC conditions.

The DRS is capable of accommodating a variety of practical SC-operating conditions, including the existence of both regular and urgent (ie, high priority) orders that may be split between two or more locations. Further, the DRS is capable of changing the destination of transportation assets when appropriate, as well as suggesting process bypassing. All DRS decisions are made by simultaneously considering total SC costs and both time-based and non-temporal customer service levels.

Discrete event simulation models are used to represent each experimental SC under study. For a given SC model, the results produced by standard truck dispatching and localised inventory policies constitute the experimental base case – a SC without any automated, integrated decision support. Simulation is an appropriate tool to study complex, dynamic systems. It can be applied to evaluate decisions, operation policies, and to support managerial decision-making. Assuming that a simulation model for a given system is valid (ie, the conceptual logic of the model accurately represents the system under study), simulating and analysing different scenarios is cheaper and less time consuming than experimenting with the actual system and studying the corresponding results. Simulation models give results within certain confidence levels in which several decisions regarding various possible improvements can be made.

In this research, the DRS receives real-time inventory, demand, and transportation information from SC nodes and transportation carriers *via* the representative SC simulation model. In reality, this information could come from various integrated corporate information systems. Each decision made by the DRS can be viewed as a response to a *decision point* (ie, the question that needs to be answered) using some *decision criteria* (ie, how the question should be answered). The following is list of example decision points:

- Should an order be split across multiple suppliers in light of stockout costs *versus* order splitting costs?
- Should a given shipment bypass one or more locations to reach another location?
- Should any process, such as yard check-in, be skipped in order to meet schedule?
- How much should be ordered of a given product, and from which stocking location?
- Which product(s) should be kept in inventory and in what quantity?
- Should suppliers be asked to send an urgent replenishment?
- Should the unloading priority for a given truck be increased or decreased?

The DRS is functioning as a subroutine call from within the simulation model each time a decision must be made. The data required for DRS decision making are passed from the simulation model to the DRS subroutine. Once the data are analysed using an appropriate DRS decision algorithm, the DRS's prescribed decision is implemented by the simulation model. DRS decision making will occur a number of times over the course of a typical simulation run horizon. One anticipated research result is that the collection of DRS decisions made over time will result in both lower SC costs and comparable (if not higher) customer service levels as compared to the experimental base case of SC *status quo*. Figure 2 presents an overview of the phased research plan.

ORIGINAL RESEARCH CONTRIBUTIONS

The current research extends the existing body of knowledge in two ways. First, segments of the SC that have been traditionally optimised in isolation (ie, warehousing and transportation) are integrated, and then optimised simultaneously *via* the proposed DRS. The DRS is designed to address a number of decision points, some of which have been looked at individually in the literature, others being completely new. The research is also innovative in that no research to date has considered replenishment from all locations in the extended SC simultaneously with the ability to skip certain processes or bypass locations in the event of an important alert message or high-priority task.

In addition, the DRS provides decision support capable of dynamically changing vehicle destinations and comprehending both normal and urgent orders. The DRS also allows for:

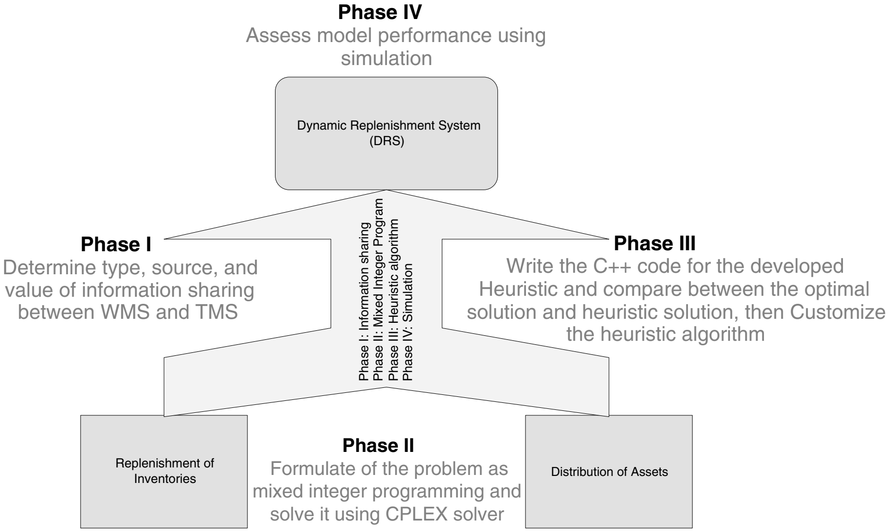

Figure 2: Phased research plan.

- the possibility to fill demand from anywhere in the network;
- visibility into in-transit inventory;
- a capacitated transportation fleet;
- variable location priorities (nearest node, most demanded node, or most important node) for trucks if more than one destination is visited;
- customer demand satisfaction based on time-based service levels for each location.

The SCs considered here are not localised, but represent entire integrated systems. The decisions made by the DRS are not limited to event occurrences or specific points in time (eg, the beginning of each time period). The DRS includes comprehensive decision-making capabilities to address rapid change in demand due to

- sudden changes in marketplace preferences;
- events such as delays, disruptions, and failures as classified by Brandel (2002);
- location-specific safety stock alerts;
- additional alert data such as incidents, improper processes, insufficient resources, and order deletion.

It is hypothesised that the DRS could be easily transferred to almost any multi-facility SC, even on a global scale. Among the most important differences between the DRS in this paper and current integration approaches is the DRS's comprehension of partnerships between warehousing, transportation, and customers that are designed to increase coordination and integration between partners at all levels of the SC. In short, the DRS provides a means for making better, more information SC replenishment decisions taking all pertinent SC information into account.

EXPERIMENTATIONS

It is difficult (if not impossible) for a mathematical model to capture all of the pertinent characteristics of a dynamic environment. As one of the most appropriate tools for studying complex, dynamic systems, discrete event simulation is used to test and evaluate new decision-support strategies and to measure the performance of dynamic systems.

Using designed experiments, both optimisation-based and heuristic-based algorithms are tested, both in isolation and within the simulation model framework, to assess each algorithm's ability to promote lower SC costs when applied to a particular SC problem. Given the absence of any real SC data, experimental test data and distributions were chosen, based on information available in the literature from work cited previously. Sample problem instances were examined by potential DRS component algorithms to assess both solution quality (ie, resulting total SC costs) and required computation time. Additional performance measures, such as inventory levels, order lead times, and lead time variability, backorder level, transportation costs, customer service level, and mutual benefits were also of interest during this experimentation in order to compare the DRS with the experimental base case.

In an attempt to investigate the DRS model's ability to accommodate the important practical considerations, three hypotheses were investigated: (1) DRS model fill rate performance is not affected by changes in inventory replenishment policy parameters; (2) DRS model fill rate performance is not affected by changes in SC network size and the number of SC partners; (3) DRS model fill rate performance is not affected by changes in SC time period (bucket) length.

CONCLUSIONS

An integrated SC model comprising both the warehousing and the transportation functions of the SC is developed to help reduce SC inventory levels and total SC costs while maintaining and/or improving customer service levels under dynamic operating conditions. The resulting DRS considers three main dimensions of information: customer demand, warehouse data, and transportation data. The DRS has proven to be able to meet its primary goal of reacting effectively and efficiently to normal and/or non-normal (unplanned, disruptive) SC operations.

The DRS is first defined in the context of a MIP model. However, due to the unacceptably long computation times associated with the MIP formulation, a new heuristic algorithm ('the DRS heuristic') is developed to find good, potentially near-optimal solutions to the same static SC problem instances. The DRS heuristic requires only 1% of the computation time required by the DRS MIP model to produce good replenishment and transportation decisions that are only 10%–15% above the optimal minimum total SC cost decisions produced by the DRS MIP model, on average.

Given this promising performance of the DRS heuristic in a static environment, it is subsequently evaluated under dynamic SC conditions with the aid of discrete event simulation. After a representative SC simulation model is constructed in ProModel and subsequently validated, the DRS heuristic is embedded into the ProModel simulation model as a callable subroutine that can be used to make replenishment and transportation decisions throughout the SC.

The DRS simulation model interacts with integrated SC systems to plan deliveries to customers based upon SC inventory levels and truck routes. The DRS simulation model continuously determines replenishment quantities, quickly responds to demand changes, and dynamically changes transportation asset destinations as SC conditions warrant. The DRS approach assesses the involvement of many SC partners in each decision and is demonstrated to benefit every location in the SC, rather than just a select few. The potential areas of SC improvement that are possible if the DRS approach is deployed include lead time reductions, increased customer service levels, reduced inventory levels, and reduced total SC costs. On average, total SC costs were reduced 3.5% when traditional SC operations decisions were replaced by the DRS simulation model and its recommended decision outcomes.

Experimental results confirm that operating a SC under DRS simulation model constructs is a win-win relationship for SC partners. As the proposed DRS could be used in either multi- or single-company SC networks, the mutual benefits analysis performed here confirms that no single SC partner stands to reap large benefits from DRS implementation at the expense of one or more other SC partners. In fact, experimental results suggest that every SC partner will experience some type of improvement in their total costs and customer service levels if the DRS was implemented. In addition, transportation costs and order lead times are also reduced for a number of SC partners in the DRS simulation model. Average lead time is reduced by 16.2% due to replenishment options being available from proximal SC locations. However, this decrease comes at the expense of increased lead time variability, primarily due to large fluctuations in the distances travelled between SC locations.

Finally, three separate propositions were made and investigated in an attempt to assess the possibility of DRS implementation in real-world SCs. Analysis of variance results indicated the practicality, flexibility, and implementation functionality of the DRS model, as the performance of the DRS was shown to be unaffected by replenishment policy parameter values, SC network configuration or size (the number of SC partners, and decision time period length).

ENDNOTE

[1] The PhD research this paper derives from; took part in the MEL PhD (2002–2005).

REFERENCES

Baig, A and Purdy, J. 1996: Advanced transportation management system for I-94. *Vehicle Technology Conference IEEE* **45**: 230–234.

Basta, N. 2002: Transportation software market heats up. *Chemical Week* **164**: 34–36.

Benjaafar, S, ElHafsi, M and Véricourt, F. 2004: Demand allocation in multiple-product, multiple-facility, make-to-stock systems. *Management Science* **50**: 1431–1448.

Bertazzi, L, Paletta, G and Speranza, M. 2002: Deterministic order-up-to level policies in an inventory routing problem. *Transportation Science* **36**: 119–132.

Bichou, K. 2004: The ISPS code and the cost of port compliance: An initial logistics and supply chain framework for port security assessment and management. *Maritime Economics & Logistics* **6**: 322–348.

Brandel, W. 2002: *Event Management: The missing link in supply chain services Aberdeen group*. www.aberdeen.com/ab_abstract/2002/08/08020016.htm.

Chandra, C and Kumar, K. 2000: Supply chain management in theory and practice: A passing fad or a fundamental change. *Industrial Management and Data Systems* **100**: 100–113.

Chandra, P. 2000: Dynamic distribution model with warehouse and customer replenishment requirements. *Journal of Operational Research Society* **44**: 681–692.

Daskin, M and Coullard, C. 2002: An inventory-location model: Formulation, solution algorithm and computational results. *Annals of Operations Research* **110**: 83–106.

Dong, L and Lee, H. 2003: Optimal policies and approximations for a serial multi-echelon inventory system with time-correlated demand. *Operations Research* **51**: 969–980.

Faber, N, Koster, R and Velde, S. 2002: Linking warehousing complexity to warehouse planning and control structure: An exploratory study of the use of warehouse management information systems. *International Journal of Physical Distribution & Logistics Management* **32**: 381–395.

Fawcett, S and Magnan, G. 2002: The rhetoric and reality of supply chain integration. *International Journal of Physical Distribution & Logistics Management* **32**: 339–361.

Finkel, K. 1996: How to launch a successful warehouse management system. *IIE Solutions* **28**: 16–20.

Gans, N and Zhou, Y. 2003: A call-routing problem with service-level constraints. *Operations Research* **51**: 255–271.

Gilmore, D and Tompkins, J. 2000: Transport plays key role in supply strategy. *ID Systems* **20**: 16–17.

Gripman, T. 1997: Secret to cost justifying warehouse management systems. *IIE Solutions* **29**: 26–29.

Hoffman, K. 2002: Performance data provides key to continuous improvement. *Global Logistics & Supply Chain Strategies*. http://www.glscs.com/mediakit/glsmedia.htm.

Jayaraman, V. 1998: Transportation, facility location and inventory issues in distribution network design, an investigation. *International Journal of Operations & Production Management* **18**: 471–494.

Kiefer, A and Anovack, R. 1999: An empirical analysis of warehouse measurements systems in the context of supply chain implementation. *Transportation Journal* **38**: 18–27.

Lambert, D, Cooper, M and Pagh, G. 1998: Supply chain management: Implementation issues and research opportunities. *The International Journal of Logistics Management* **9**: 1–19.

Lane, R. 2002: *From Planning to Control: Improving the High-Tech Supply Chain*, Valdero White Paper, http://www.idii.com/wp/valdero-from-planning.

Marabotti, D. 2002: *Supply Chain Event Management, Category, Function or Just another Buzzword*. Silvon Software, Inc White Paper, http://www.idii.com/wp/silvonscem.

Mason, S, Ribera, P, Farris, J and Kirk, R. 2003: Integrating warehousing and transportation functions of the supply chain. *Transportation Research Part E* **39**: 141–159.

McKay, K. 1996: Integrated automatic vehicle location systems. *IEEE Conference* **96**: 230–234.

Nam, I. 2001: Dynamic scheduling for a flexible processing network. *Operations Research* **49**: 305–315.

Qu, W, Bookbinder, J and Iyogun, P. 1999: An integrated inventory-transportation system with modified periodic policy for multiple products. *European Journal of Operational Research* **115**: 254–269.

Robinson, R. 2006: Port-oriented landside logistics in Australian ports: A strategic framework. *Maritime Economics & Logistics* **8**: 40–59.

Sadeh, N, Hildum, D, Kjenstad, D and Tseng, A. 2001: Mascot: An agent-based architecture for dynamic supply chain creation and coordination in the internet economy. *Production Planning and Control* **12**: 212–223.

Sha, D and Che, Z. 2006: Supply chain network design: Partner selection and production-distribution planning using a systematic model. *Journal of the Operational Research Society* **57**: 52–62.

Simatupang, T, Wright, A and Sridharant, R. 2002: The knowledge of coordination for supply chain integration. *Business Process Management* **8**: 289–308.

Simchi-Levi, D, Kaminsky, P and Simchi-Levi, E. 2000: *Designing and managing the supply chain: concepts, strategies, and case studies*. Irwin McGraw-Hill: Boston, USA.

Tighe, W. 1995: Network integrating transportation operations systems, *Sixth International VNIS,* Proceedings. In Conjunction with the Pacific Rim TransTech Conference. pp. 429–435.

Yeung, A. 2006: The impact of third-party logistics performance on the logistics and export performance of users: An empirical study. *Maritime Economics & Logistics* **8**: 121–139.

Zahurul Islam, D, Dinwoodie, J and Roe, M. 2005: Towards supply chain integration through multimodal transport in developing economies: The case of Bangladesh. *Maritime Economics & Logistics* **7**: 382–399.