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The Interactive Effects between Internal and External Resources Constraints on Supply Information Sharing

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Abstract. Demand-side information sharing was explored extensively in supply chain management literature. Research efforts have rarely been made into supply-side information sharing. In this paper, a simulation model with mixed-integer programming was built to simulate operating activities under supply information sharing in a three-level capacitated supply chain. The results indicate that supply information sharing significantly reduces total supply chain cost and enhances supply chain service level. In addition, the impacts of supply information sharing on the supply chain performance are heavily moderated by internal capacity tightness and external resources constraints. The findings provide important reference for supply chain managers to implement supply information sharing to improve decision-making process, reduce uncertainties, and increase visibility in supply chain operations.

Keywords: Supply Chain, Information Sharing, Simulation

1. Introduction

The globalization of business, the innovative requirements in the customer service, the stress on timely and quality-oriented competition, and the availability of cost-effective information technologies are the elements driving business operations. Current business competition shifts from individual businesses versus individual businesses to supply chain versus supply chain.

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Information sharing is a prerequisite for coordinated supply chain operations. Mentzer et al. (2001, p.8) defined information sharing as "*the willingness to make strategic and tactical data available to other members of the supply chain*."

Previous literature already made a wide variety of insightful explorations into demand-side information sharing (Aviv, 2001; Cetinkaya & Lee, 2000; Lau, Huang, & Mak, 2004). However, research efforts into supply-side information sharing are still not enough. In this paper, a simulation model with mixed-integer programming was established to simulate ordering, production planning, and supplying activities with and without supply information sharing in a three-level capacitated supply chain consisting of multiple suppliers, one manufacturer and multiple retailers. The following issues were explored. What are the impacts of supply information sharing on supply chain performance? How do internal and external resources constraints affect the value of supply information sharing?

The rest of this paper is organized as follows. In section 2, we review the related literature. The research models and the research hypotheses are introduced in section 3. Then, the research results were analyzed in section 4. Finally, we conclude in section 5.

2. Literature Review

Different two-stage supply chain structures have been extensively and thoroughly studied in the supply chain information sharing literature. In their pioneering attempt, Lee, So, and Tang (2000) developed an analytical model of a two-stage supply chain that consists of a retailer and a manufacturer, and analyzed the benefit of order information sharing. The results showed that information sharing could provide significant inventory reduction and cost savings to the manufacturer. The retailer obtains no direct benefits from information sharing alone, but gets benefits from lead time reduction. Zimmer (2000) considered a supply chain, consisting of one producer and one supplier, in a Just-in-Time environment where the supply of the component is uncertain due to an unstable availability of the capacity of the supplier, and compared the worst case, where no information exchange between the two parties, with the best case, where all decisions are chosen simultaneously by a central planner. Yao and Dresner (2008) investigated inventory management practices before and after implementing information sharing, continuous replenishment programs, and vendor managed inventory in a two-level supply chain.

Some other research examined the benefit of information sharing under more complex two-level, even three-level, or multiple level supply chain structures. Cachon and Fisher (2000) examined the value of sharing demand and inventory information in a model of one supplier and N identical retailers facing stationary stochastic consumer demand. They compared these two levels of information sharing policy and found that supply chain cost is slightly lower with full information policy than with traditional information policy. The result seems contrary to what they originally expected that significant benefits would appear in the full information policy. The limitations of their model include no capacity constraints, known demand, identical retailers, and single source for inventory. Zhao, Xie, and Zhang (2002) explored the impacts of information sharing and ordering coordination on the performance of a supply chain including one capacitated supplier and four retailers under demand uncertainty. They found that information sharing and ordering coordination significantly influence the supply chain performance represented by total cost and service level, and the influence is considerably moderated by demand patterns and capacity tightness.

Iyer and Ye (2000) established a logistics system where inventory is held at the level of the customers, the retail store and the warehouse managed by a manufacturer, and found that information sharing reduces high inventory costs borne by the manufacturer for promotion support. Hence, retail promotion information sharing makes retail promotions more profitable for the manufacturer than with no promotions at all. But the three-level supply chain in this study does not include the manufacturing process, and they only consider promotion-related information sharing. Munson and Rosenblatt (2001) extended previous quantity discounts research under a two-level supply chain into a three-level chain (supplier-manufacturer-retailer) and explored the benefits of using quantity discounts on both ends of the supply chain. They showed that coordinated quantity discounts decision with upstream and downstream could simultaneously and greatly reduce costs compared to focusing only on downstream.

Lau, Huang, and Mak (2004) conducted a multi-agent based simulation research to explore the impact of information sharing on inventory replenishment in a three-level supply chain structure. The major contribution of this paper is that it tested the impact of information sharing and other simulation parameters, such as demand variance, lead times, capacity and order batch size, over three different three-level divergent supply chain structures which consist of retailers, distributors, and a capacitated manufacturer distributing a single product. This study still has some weaknesses. Firstly, although it includes the manufacturer in the three-level supply chain structure, it merely focuses on inventory replenishment between supply chain members by using simple inventory policy (R, Q). So it does not consider the manufacturer's production planning process. Secondly, it only investigates the scenario in which a supply chain deals with a single product. The impact of information sharing in a multi-product scenario is a more practical situation that deserves to be studied. Wu and Cheng (2008) analytically explored the value of demand information sharing in a three-level serial supply chain and found that the distributor and the manufacturer experience inventory and expected cost reduction because of increased information sharing. The benefit of information sharing was largely obtained by upstream supply chain members. This finding is similar to Ballou, Gilbert, and Mukherjee (2000), Lee, So, and Tang (2000), and Yu, Yan and Cheng (2001). More recently, Arshinder, Kanda, and Deshmukh (2011) indicated that more complex structures that reflect real picture of complex interactions in supply chain should be investigated. Jeong and Leon (2012) expressed a similar point of view.

As commented by Choi (2010), most studies focus on demand-side information sharing. Previous research documented a wide variety of benefit from demand-side information sharing, such as inventory reduction, cost savings, and service improvement. Supply-side information sharing should also improve supply chain performance. Huang et al. (2003) indicated that sharing capacity information of each player in a supply chain is essential for integrated planning. Lee and Whang (2000) suggested that capacity information sharing can contribute to mitigating potential shortage gaming behavior, thereby countering a potential source of the bullwhip effect. By sharing capacity information well in advance, the downstream supply chain partners can coordinate and prepare against possible shortages, and make more practical plans. For example, a manufacturer could make use of its supplier's production or delivery schedule to improve its own production schedule. Its supplier may iron out peaks and valleys of volatile demand. On the other hand, by knowing its supplier's capacity status, a buyer could rearrange its procurement plan to avoid or reduce possible shortage by postponing or advancing its purchase. In case of knowing shortage of finished goods or supply chain resources, deliveries of substitute products should be considered. Thus, the benefits of sharing supply information could be the reduction of missed business opportunities and the enhancement of revenue and profitability by increasing the aggregate sales.

Analytical models which are suitable for relatively simple situations and concepts dominate information sharing research. However, most real-world systems are too complex to allow realistic models to be evaluated analytically

(Law & Kelton, 2000). Compared with analytical approach and mathematical programming approach, simulation approach has some intrinsic advantages. First, simulation has greater flexibility that decision makers prefer. In terms of acceptance, a validated simulation is better than complicated analytical models. Second, simulation has the ability to replicate and isolate probabilistic functions and activities within a system for specific study. Third, simulation models can be used to explore the impacts of qualitative factors on a supply chain. Yet, qualitative factors cannot easily be incorporated into analytical models. Fourth, simulation models can be closer to real systems than analytical and mathematical programming models. With the increasing intricacy of supply chain phenomena, simulation approach would be used more extensively.

3. Research Model

A hybrid approach of computer simulation and mixed-integer programming (MIP) were employed in this paper. A computer program was built to simulate the operations of a three-stage manufacturing supply chain by using C++ and runs on a Dell PowerEdge 4400 server with Linux operating system.

3.1. Basic Assumptions

The following assumptions were made for the supply chain model:

- The supply chain consists of three capacitated suppliers, one capacitated manufacturer, and four retailers.
- The manufacturer produces two functional products in a make-to-stock process, which consume the same key resource and can substitute each other to some extent. Production lead time is assumed to be zero. Capacity absorption rate for both products is equal to one, that is, one unit of product needs one unit of resource to produce.
- Each product needs two components (raw materials), and one of the two components is a common component. The usage rate of all the raw materials for the two products is one.
- The retailers are confronted with uncertain, time-varying customer demands for both products. The average demand for each product is 1000 units at each period. In turn, the manufacturer faces demands from the retailers for replenishing their inventories, so the retailers' average demand for each product is 4000 units at each period. Sufficient initial inventories are provided for each retailer and the manufacturer to avoid not having enough inventories to satisfy demands at the beginning of the

simulation. The manufacturer needs to place orders for raw materials to its suppliers when inventories of raw materials are not enough.

- The lead times of placing orders from the retailers to the manufacturer and from the manufacturer to raw material suppliers are assumed to be zero.
- The suppliers are end suppliers; thus they do not need to order raw materials from other suppliers to make their own products.
- The manufacturer employs MRP system to organize its production activities.
- Each supplier is the only provider for the manufacturer for one specific raw material, and the manufacturer is the only customer for each supplier.
- Transportation lead times from the suppliers to the manufacturer and from the manufacturer to the retailers are assumed to be one period. Transportation capacity of a vehicle is assumed to be large enough for any large order.
- Downstream partners pay for the regular transportation cost, and upstream partners pay for backorder transportation cost.

3.2. Independent Variables of the Simulation

The simulation parameters used in the model are summarized in Table 1.

Tab. 1. Simulation Parameters

Variable Name	Label	Levels	Values
Supply-side Information Sharing	SSIS	2	NIS, SIS
Capacity Tightness	CT	3	High, Mid, Low
Availability of Raw Materials	ARM	4	BH, BL, UnBH, UnBL

Two levels of SSIS such as no supply information sharing (NIS) and supply information sharing (SIS) will be examined. NIS means upstream members do not share supply information with downstream members. SIS means upstream members share supply information with downstream members.

Capacity Tightness (CT) reflects how tight production capacity of the manufacturer is, comparing with the demand it faces. It is defined to be the ratio of the total available capacity to the total capacity needed. It is the reciprocal of capacity utilization. Because we assume the capacity absorption rate is one, that is, one unit of product needs one unit of resource to produce; the total demand to be satisfied is equivalent to the total capacity needed. Therefore, the total available capacity equals the total demand to be satisfied times CT. We assume that available capacity is evenly distributed over all simulation periods. Three levels of capacity tightness, Low (1.33), Middle (1.18), and High (1.05), which correspond to capacity utilization of 75 percent, 85 percent and 95 percent, respectively, are set in the simulation. These CT values are also employed in Zhao, Xie and Leung (2002), Zhao, Xie and Zhang (2002), and Byrne and Heavey (2006).

Availability of Raw Materials (ARM) states the capability of the suppliers to be able to supply raw materials to the manufacturer. Under the circumstance of supply chain management, a manufacturer needs not only to take into consideration its own internal capacity constraints, but also external resources constraints, such as its suppliers' supply capability, in order to have a feasible MPS. Different suppliers may not have the same level of supply capability. Some suppliers have ample resources and others do not. We divide the levels of available raw materials of the three suppliers into four categories such as unbalanced and high availability (UnBH), unbalanced and low availability (UnBL), balanced and high availability (BH), and balanced and low availability (BL). Unbalanced availability means different suppliers have very different levels of supply capability. Balanced availability means different suppliers have approximately the same level of supply capability.

3.3 Dependent Variables of the Simulation

Cost and service level have been used as the dependent variables of the simulation to measure the supply chain performance. Total cost of the supply chain (TC) is the sum of ordering cost, transportation cost, inventory holding cost and the backorder cost for all supply chain members. All cost figures are from a real case of a beverage company whose supply chain structure is similar to the one we studied. The customer service level of the supply chain (SL) is the percentage of customer demand satisfied by the retailers.

3.4. The Simulation Procedure

The simulation program developed by Zhao, Xie, and Leung (2002) and Zhao and Xie (2002) was modified to adapt to the new supply chain structure and setting to simulate forecasting, ordering, and supplying activities in the supply chain. Genetic algorithm for general capacitated lot-sizing problem (GCLSP) developed by Xie and Dong (2002) was modified to solve MIP model for the manufacturer to develop MPS. An interface was built to link these two parts so that simulation parameters and decision variables could be transferred interactively between them. The flow chart of the simulation procedure is depicted in Fig. 1.

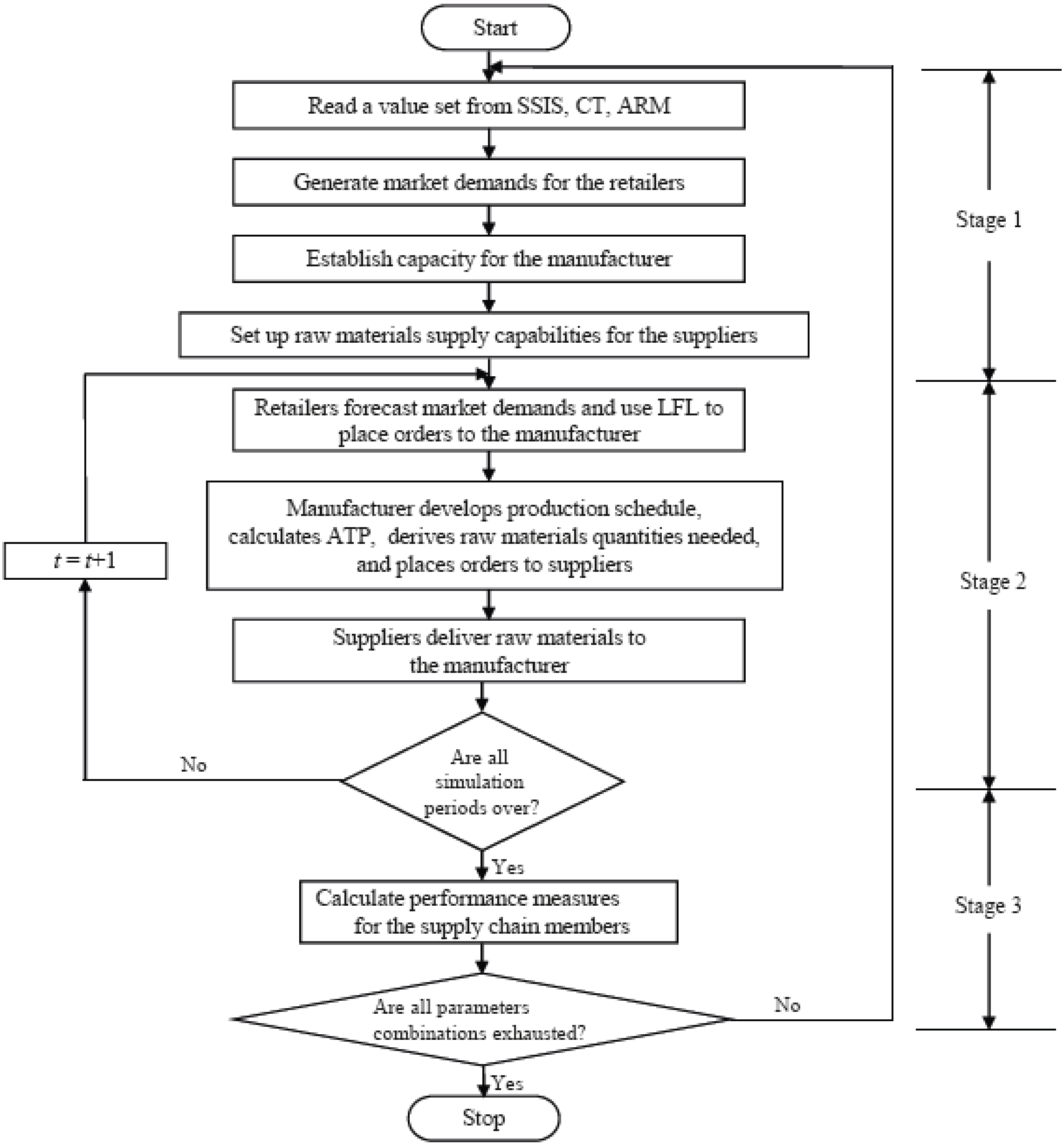

Fig. 1. The Simulation Procedure

3.5. Research Hypotheses

Three hypotheses will be tested in this study:

Hypothesis 1: The supply information sharing (SIS) will significantly improve the performance of the whole supply chain.

Hypothesis 2: The availability of raw materials (ARM) will significantly influence the supply chain performance and the value of supply information sharing.

Hypothesis 3: The availability of raw materials (ARM) will significantly influence the impact of capacity tightness (CT) on the value of supply information sharing.

4. Results and Discussions

The outputs from the simulation experiments were analyzed by using Analysis of Variance (ANOVA). The selected results are presented in Table 2 and Table 3. We can see that all the main effects and the interaction effects are significant in terms of total cost and service level at 1% significance level. The discussions, which centered on the research hypotheses, are presented below.

Tab. 2. Selected ANOVA Results for Cost Performance

Dependent Variables		TC	
	Source	F Value	Pr>F
1	SSIS	4756.45	<.0001
2	CT	533.70	<.0001
3	ARM	341.28	<.0001
4	CT*ARM	999.69	<.0001
5	SSIS*CT*ARM	1348.91	<.0001

Tab. 3. Selected ANOVA Results for Service Level Performance

Dependent Variables		SL	
	Source	F Value	Pr>F
1	SSIS	7048.02	<.0001
2	CT	3150.69	<.0001
3	ARM	436.90	<.0001
4	CT*ARM	1586.87	<.0001
5	SSIS*CT*ARM	652.93	<.0001

4.1. The Impact of Supply Information Sharing (SIS) on the Supply Chain

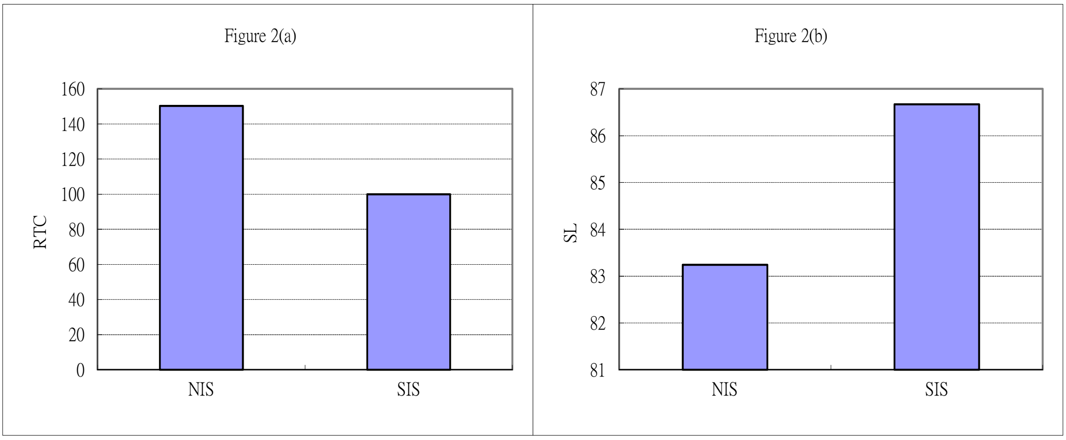

Fig. 2. Main Effect of SIS on Relative Total Cost (RTC) and Service Level (SL)

Fig. 2(a) and Fig. 2(b) show the main effects of supply information sharing (SIS) on the total cost and service level of the supply chain, respectively. The total cost numbers are relative with the minimum being 100. When supply information is shared, the total cost of the whole supply chain is greatly reduced. Service level of the whole supply chain under supply information sharing is slightly higher than that of no supply information sharing. It seems that supply information sharing has more powerful effect on total cost reduction than on service level improvement.

By knowing supply information from its suppliers, the manufacturer can develop a feasible production schedule that satisfies its internal constraints and external constraints, simultaneously. On the other hand, through sharing supply information with the retailers, the manufacturer can reduce backorders cost and transportation cost by selling substitute products to the retailers. Meanwhile, knowing supply information from the manufacturer, the retailers can adjust their purchasing plans by moving the purchasing amounts backward or by buying substitute products, thus reducing backorders and increasing sales. Based on these observations, hypothesis 1 is supported.

4.2. The Impact of ARM on the Value of SIS

To analyze the impact of raw materials' availability on supply information sharing, we depicted the relative total cost (RTC) and service level (SL) of the supply chain for different combinations of ARM and SSIS in Fig. 3.

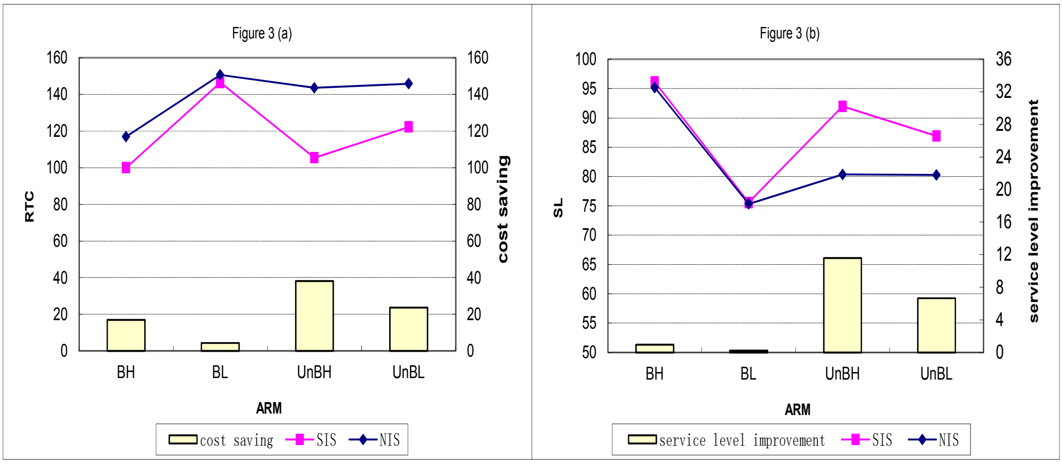

Fig. 3. Interaction between ARM and SSIS on Relative Total Cost (RTC) and Service Level (SL)

Fig. 3(a) shows how the availability of raw materials affects the value of supply information sharing in terms of cost savings. When there is supply information sharing between the suppliers and the manufacturer, RTC is lower than when there is no supply information sharing between them. When ARM=BH, there is a slight cost saving through sharing supply information. When ARM=BL, this cost saving is even slim. However, the cost saving becomes larger when ARM=UnBH and when ARM=UnBL. This is because sharing supply information makes no big difference when all raw materials from the suppliers are very sufficient (ARM=BH) or very insufficient (ARM=BL). When some raw materials from suppliers are sufficient and some are insufficient, the benefit of supply information sharing was revealed. The manufacturer can adjust its raw materials purchasing plan on the basis of shared raw materials supply information so that the production plan can be feasible, thus reducing backorder cost in the manufacturer and inventory holding cost in the suppliers.

Fig. 3(b) shows how the availability of raw materials affects the value of supply information sharing in terms of service level. When there is supply information sharing between the suppliers and the manufacturer, the service level is higher than when there is no supply information sharing between them. When ARM=BH, service level improvement through sharing supply information is trivial. When ARM=BL, there is almost no improvement. When ARM=UnBH, the service level improvement reached the highest. ARM=UnBL narrows this improvement. This pattern of service level improvement is comparable with the pattern of cost saving in terms of magnitude of benefit of sharing supply information under different raw material availability conditions. These observations indicate that when different suppliers have unbalanced supply capabilities for the manufacturer, sharing supply information of different suppliers with the manufacturer can greatly improve supply chain performance.

4.3. The Interaction Effect between CT and ARM

From Table 2 and 3, it is indicated that the interaction effect between CT and ARM is quite significant. This effect reflects the interaction between manufacturer's internal capacity and its external resources constraint. To examine the impact of ARM on CT, we plotted the relative total cost (RTC) and service level (SL) of the supply chain under different combinations of CT and ARM in Fig. 4 (a) and Fig. 4 (b).

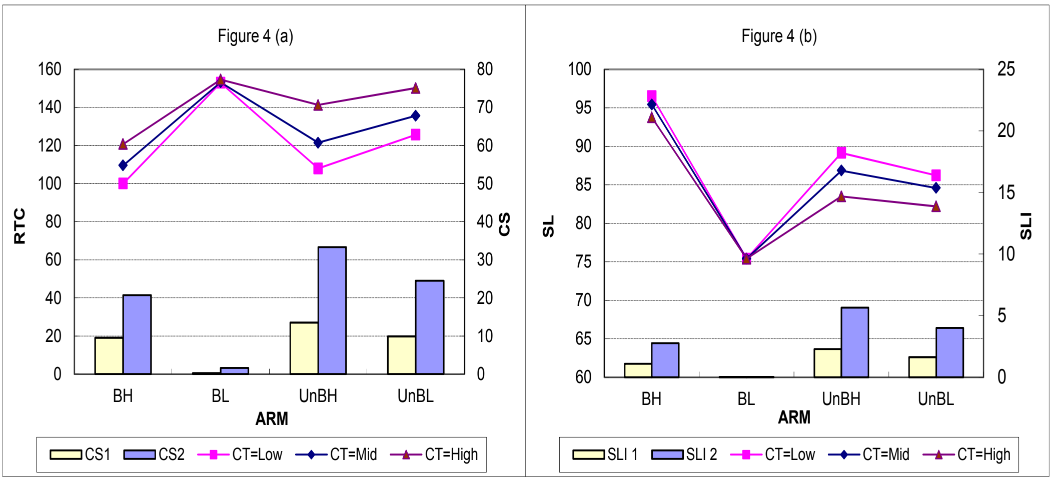

Fig. 4. Interaction between CT and ARM on Relative Total Cost (RTC) and Service Level (SL)

Fig. 4(a) shows that across different degrees of raw material availability, RTC is the lowest when CT=Low, and the highest when CT=High. It also shows the cost savings for CT=Low relative to CT=Mid and High by histograms. CS1 is the cost saving for CT=Low relative to CT=Mid, while CS2 is the cost saving for CT=Low relative to CT=High. It is worth noting that there are almost no cost differences among different capacity tightness when ARM=BL. This is because the supplies of all raw materials are extremely insufficient when ARM=BL; the availability of raw materials becomes a bottleneck constraint for the manufacturer's production planning. Under such circumstance, capacity tightness of the manufacturer makes no difference. For other ARM conditions, there are different degrees of cost savings across different capacity tightness levels. The cost savings of CT=Low and Mid relative to CT=High under ARM=UnBH is higher than the corresponding cost saving under ARM=UnBL. When ARM=UnBH and UnBL, the cost savings across different capacity tightness levels are relatively higher than the corresponding cost saving when ARM=BH. The extent of unbalanced supplies of raw materials under ARM=UnBL is lower than that under ARM=UnBH. This leaves less room for the manufacturer to adjust its procurement plan for raw materials. As a result, the performance improvement under ARM=UnBL is lower than that under ARM=UnBH.

Fig. 4(b) shows that across different degrees of raw material availability, the service level is highest when CT=Low, it is lowest when CT=High. It also shows service level improvement for CT=Low relative to CT=Mid and High by histograms. SLI 1 is the service level improvement for CT= Low relative to CT= Mid, while SLI 2 is the service level improvement for CT= Low relative to CT= High. Under ARM=BH, the service level reaches the highest across each capacity tightness level, then comes ARM=UnBH with a service level in the second highest position, and the service level hits the lowest when ARM=BL. For different ARM conditions, there are different service level improvements across different capacity tightness levels. The service level improvements of CT=Low and Mid relative to CT=High under ARM=UnBH are hiher than the corresponding service level improvement under ARM=UnBL. When ARM=UnBH and UnBL, the service level improvements across different capacity tightness levels are relatively higher than the corresponding service level improvement when ARM=BH. These observations indicate that when capacity is less tight, the manufacturer has more capacity cushion for revising the production plan to cope with the unbalanced supplies of raw materials. Therefore, under ARM=UnBH and UnBL, there is more supply chain performance improvement.

4.4. The Influence of ARM on the Impact of CT on the Value of SIS

To examine the interaction effects among ARM, CT, and SSIS, we plotted the relative total cost (RTC) and service level (SL) of the supply chain for different combinations of CT and SSIS under different raw materials availability levels in Fig. 5 to Fig. 8, respectively.

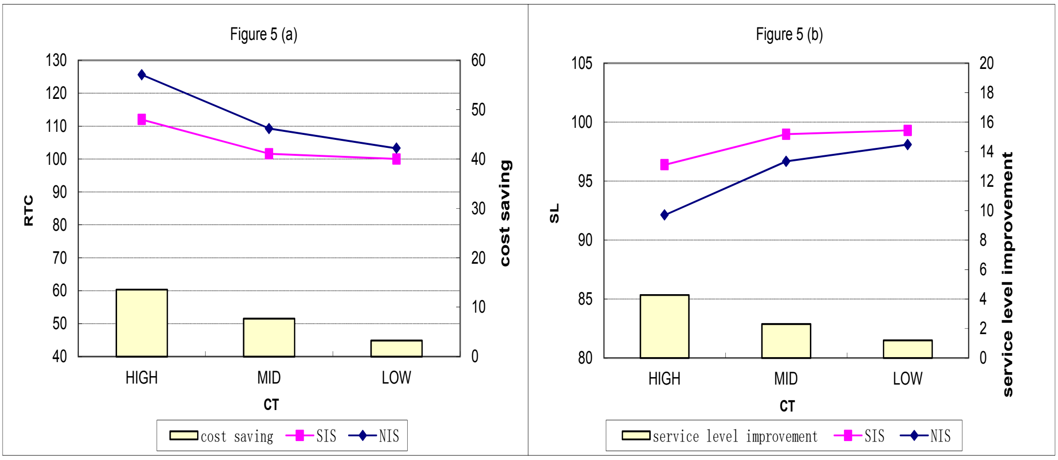

Fig. 5. Interaction between CT and SSIS on Relative Total Cost (RTC) and Service Level (SL) when ARM=BH

When ARM=BH, the supplies of different raw materials are all sufficient. As shown in Fig. 5(a), when there is supply information sharing, RTC is lower than when there is no supply information sharing under all three capacity tightness levels, and the cost savings decrease with CT ranging from High to Low.

As shown in Fig. 5(b), the service level under SIS is higher than that under NIS across all three capacity tightness levels, and service level improvements decrease when CT changes from High to Low. The service level improvements under CT=Low and Mid are far lower than that under CT=High.

Although supply chain performance is the best when CT=Low, sharing supply information only results in a slight performance improvement. When CT=High, the supply chain achieved the worst performance; however, performance improvement is the largest through sharing supply information. A possible explanation could be as follows. When CT=High, the manufacturer almost used up its production capacity. As a result, the manufacturer is very vulnerable to order variation. If supply information is shared, the manufacturer can make use of it to make a better decision about how many of each product should be produced and how many of each raw material should be purchased based on the received orders, thereby reducing backorder cost. When CT=Low, the manufacturer has enough capacity cushion to cope with order variation. Hence, supply information will make a lesser impact on supply chain performance. Therefore, we can infer that when capacity tightness is high and all raw materials are sufficient, sharing supply information is valuable for the supply chain.

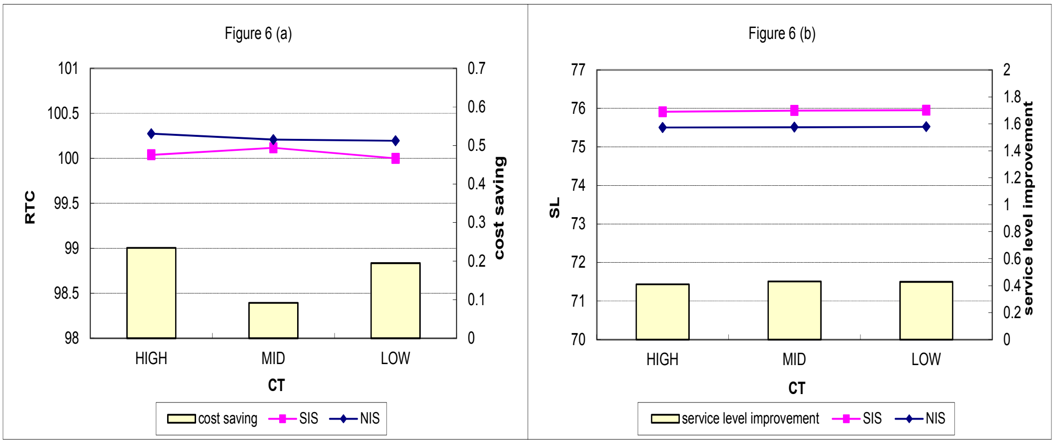

Fig. 6. Interaction between CT and SSIS on Relative Total Cost (RTC) and Service Level (SL) when ARM=BL

When ARM=BL, the supplies of different raw materials are all insufficient. From Fig. 6(a) and 6(b), it is indicated that under low availability of raw materials, sharing supply information makes little difference across different CT levels in terms of total cost as well as service level, and the service level of the supply chain slumped greatly as compared to the corresponding service level when ARM=BH. This is because the lack of raw materials makes the manufacturer unable to generate a feasible production schedule in order to produce enough products to satisfy demands. Therefore, extremely insufficient supplies of raw materials become the bottleneck of the supply chain operations.

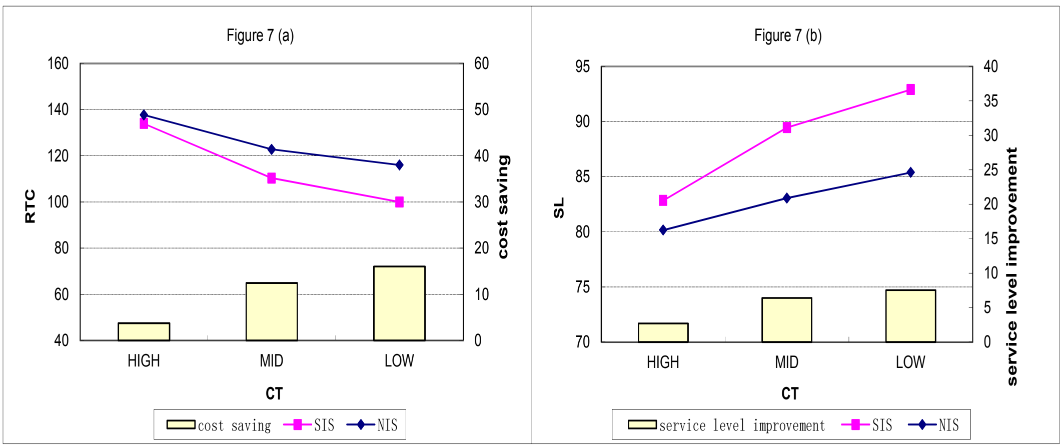

Fig. 7. Interaction between CT and SSIS on Relative Total Cost (RTC) and Service Level (SL) when ARM=UnBH

When ARM= UnBH, the supplies of some raw materials are sufficient, but others are insufficient. As shown in Fig. 7(a), when there is supply information sharing, RTC is lower than when there is no supply information sharing across all three capacity tightness levels, and the cost savings are increased when CT is changed from High to Low. Contrary to the case under ARM=BH, the largest cost saving is achieved under CT=Low, whereas cost saving is the lowest under CT=High. Correspondingly, supply information sharing helps improve the service level across different CT levels as shown in Fig. 7(b). The largest service level improvement is achieved under CT=Low, and the smallest under CT=High.

The reason why performance improvement is better when CT=Low is that UnBH makes some raw materials insufficient for the manufacturer who has to change the production schedule based on shared supply information; on the other hand, extra capacity gives the manufacturer more room to make the production schedule modification possible so that the manufacturer can produce more substitute products to satisfy retailers' demands. However, because of the shortage and the uneven availability of raw materials, the supply chain performance may not be as good as that when ARM=BH.

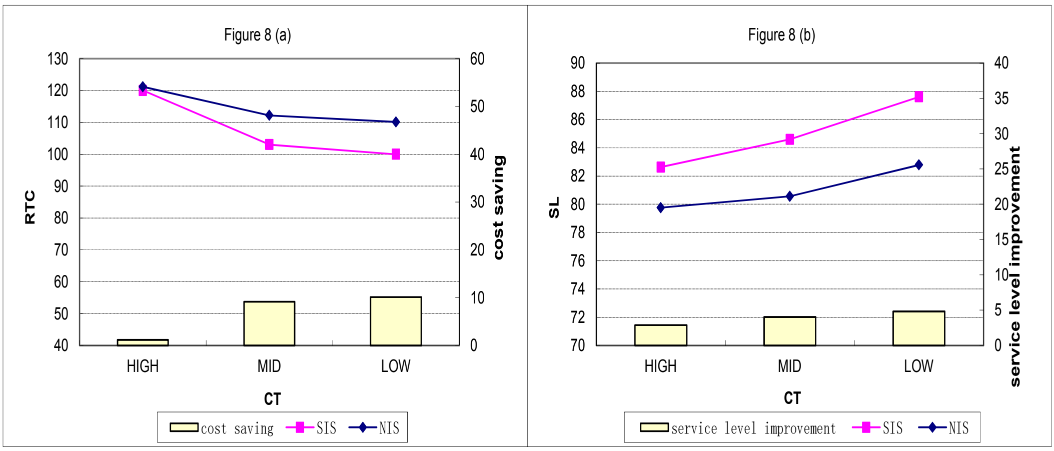

Fig. 8. Interaction between CT and SSIS on Relative Total Cost (RTC) and Service Level (SL) when ARM=UnBL

When ARM=UnBL, the suppliers have unbalanced supplies of raw materials as when ARM=UnBH, but the degree of the unbalance is lower. The patterns in Fig. 8(a) and (b) are similar to those in Fig. 7(a) and (b). Fig. 8(a) shows that when there is supply information sharing, the largest cost saving achieved under

CT=Low is only slightly higher than that under CT=Mid. When CT=High, the cost saving is the lowest. Fig. 8(b) shows the variation of service level across three capacity tightness levels under SIS and NIS. The service level improvement is slightly increased with the decrease of capacity tightness.

From Fig. 8(a) and (b), it can be seen that when ARM=UnBL, the cost saving and service level improvement that were brought by supply information sharing are not as good as their counterparts when ARM=UnBH. This is because the degree of unbalance of UnBL is lower than that of UnBH, and the manufacturer's ability to change its procurement of raw materials is restrained. Stated in another way, UnBL provides less room for the manufacturer to revise its purchasing plan for raw materials. Therefore, the value of supply information sharing under ARM=UnBL is no better than that under ARM=UnBH.

The availability of raw materials restricts the manufacturer’s ability to fulfill and revise the production schedule. Other conditions being equal, a sufficient supply of raw materials always lead to the better supply chain performance. Regarding the interaction between CT and ARM, facing the same availability of raw materials, low capacity tightness always achieves the best performance. When the supplies of all raw materials are insufficient, capacity tightness becomes irrelevant, and the value of supply information sharing is very trivial. When there is unbalanced supply of raw materials, there is more cost savings and service level improvement. That is to say, the value of supply information sharing is increased because the unbalance gives the manufacturer the opportunity to revise its raw materials purchasing plan. Furnished with supply information from the suppliers, the manufacturer can replace insufficient raw materials with sufficient ones to produce the substitute product. Hence, supply information sharing could lead to better supply chain performance. These observations supported hypothesis 2 and hypothesis 3.

5. Conclusions and Implications

Through simulations of ordering, manufacturing, and supplying activities of a supply chain, we investigated the relationship between supply information sharing and supply chain performance, and the impact of capacity tightness and the availability of raw materials on the value of supply information sharing. Analyses of the simulation output reveal the following important findings.

Supply information sharing can significantly reduce the total cost and enhance the service level of the whole supply chain. It causes more cost reduction for the downstream part of the supply chain than for the upstream one. The availability of raw materials has profound effect on the supply chain performance and the value of supply information sharing. Unbalanced supplies of raw materials increase the value of supply information sharing. The availability of raw materials also significantly influences the impact of capacity tightness on the value of supply information sharing. When the availability of raw materials is unbalanced, the value of supply information sharing is increased with the decrease of capacity tightness.

References

Arshinder, K, Kanda, A., & Deshmukh, S.G. (2011). A Review on Supply Chain Coordination: Coordination Mechanisms, Managing Uncertainty and Research Directions. In Choi, T.-M., & Cheng, T.C. E. (Ed.), *Supply Chain Coordination under Uncertainty, International Handbooks on Information Systems* (pp.39-82). Springer-Verlag Berlin Heidelberg.

Aviv, Y. (2001). The effect of collaborative forecasting on supply chain performance. *Management Science*, 47(10), 1326-1343.

Ballou, R. H., Gilbert, S.M., & Mukherjee, A. (2000). New managerial challengers from supply chain opportunities. *Industrial Marketing Management*, 29(1), 7-18.

Byrne, P.J., & Heavey, C. (2006). The impact of information sharing and forecasting in capacitated industrial supply chains: a case study. *International Journal of Production Economics*, 103(1), 420-437.

Cachon, G. P., & Fisher, M. (2000). Supply chain inventory management and the value of shared information. *Management Science*, 46(8), 1032-1048.

Cetinkaya, S., & Lee, C.Y. (2000). Stock replenishment and shipment scheduling for vendor-managed inventory systems. *Management Science*, 46(2), 217-232.

Choi, H. (2010). Information Sharing in Supply Chain Management: A Literature Review on Analytical Research. *California Journal of Operations Management*, 8(1), 110-116.

Huang, G., Lau, J., & Mak, K.L. (2003). The impacts of sharing production information on supply chain dynamics: A review of the literature. *International Journal of Production Research*, 41(7), 1483-1517.

Iyer, A. V., & Ye, J. (2000). Assessing the value of information sharing in a promotional retail environment. *Manufacturing & Service Operations Management*, 2(2), 128-143.

Jeong, I.J., & Leon, V.J. (2012). A Serial Supply Chain of Newsvendor Problem with Safety Stocks under Complete and Partial Information Sharing. *International Journal of Production Economics*, 135(1), 412-419.

Lau, J., Huang, G., & Mak, K.L. (2004). Impact of information sharing on inventory replenishment in divergent supply chains. *International Journal of Production Research*, 42(5), 919-941.

Law, A. M., & Kelton, W. D. (2000). *Simulation modeling and analysis* (3rd ed.). Boston: McGRAW-HILL.

Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Technology Management*, 20(3/4), 373-387.

Lee, H. L., So, K.C., & Tang, C.S. (2000). The value of information sharing in a two-level supply chain. *Management Science*, 46(5), 626-643.

Mentzer, J. T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D., et al. (2001). Defining supply chain management. *Journal of Business Logistics*, 22(2), 1-25.

Munson, C. L., & Rosenblatt, M.J. (2001). Coordinating a three-level supply chain with quantity discounts. *IIE Transactions*, 33(5), 371-384.

Wu, Y.N., & Cheng, T.C.E. (2008). The Impact of Information Sharing in a Multiple-echelon Supply Chain. *International Journal of Production Economics*, 115(1), 1-11.

Xie, J., & Dong, J. F. (2002). Heuristic genetic algorithms for general capacitated lot-sizing problems. *Computers & Mathematics with applications*, 44(1/2), 263-276.

Yao, Y., & Dresner, M. (2008). The inventory value of information sharing, continuous replenishment, and vendor-managed inventory. *Transportation Research Part E*, 44(3), 361-378.

Yu, Z., Yan, H., & Cheng, T.C.E. (2001). Benefits of information sharing with supply chain partnerships. *Industrial Management & Data Systems*, 101(3), 114-119.

Zhao, X. D., and Xie, J. (2002). Forecasting errors and the value of information sharing in a supply chain. *International Journal of Production Research*, 40(2), 311-335.

Zhao, X. D., Xie, J., & Leung, J. (2002). The impact of forecasting model selection on the value of information sharing in a supply chain. *European Journal of Operational Research*, 142(2), 321-344.

Zhao, X. D., Xie,J., & Zhang, W.J. (2002). The impact of information sharing and ordering co-ordination on supply chain performance. *Supply Chain Management: An International Journal*, 7(1), 24-40.

Zimmer, K. (2002). Supply chain coordination with uncertain just-in-time delivery. *International Journal of Production Economics*, 77(1), 1-15.