THE IMPACT OF SUPPLY INFORMATION SHARING ON SUPPLY CHAIN COST AND SERVICE LEVEL PERFORMANCE

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ABSTRACT

A simulation model with mixed-integer programming was built to simulate operating activities with and without supply information sharing in a three-level capacitated supply chain consisting of multiple suppliers, one manufacturer and multiple retailers. The simulation results indicate that supply information sharing can significantly reduce total cost and enhance service level of the whole supply chain. The impacts of supply information sharing on the supply chain cost and service levels are heavily influenced by demand patterns and capacity availability.

Keywords: Supply Chain Cost and Service Level, Information Sharing, Simulation

1 INTRODUCTION

Current business competition shifts from individual businesses versus individual businesses to supply chain versus supply chain. Coordinated supply chain management has become the paradigm of modern business operations. Chopra and Meindl [3] claimed that four major drivers, inventory, transportation, facilities, and information, determine supply chain performance. Because information directly affects each of the other drivers, information sharing is a prerequisite for better coordination and planning of supply chain activities.

According to the direction of information flow between supply chain members, information sharing can be classified into two categories: demand-side information sharing and supply-side information sharing. Previous literature already made a wide variety of insightful explorations into information sharing of the demand-side in supply chain, however, research efforts have rarely been made into supply-side information sharing. The purpose of this paper is to scrutinize information sharing from the supply-side and its impact on a multi-level supply chain. A simulation model with mixed-integer programming was built 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 sections present a review of related literature, the research methodology, the proposed research model, and the research hypotheses. Subsequently, we analyze the research results and conclude with a discussion on the major research findings.

2 LITERATURE REVIEW

2.1 Supply Chain Structure

It is almost impossible to include the whole scope of supply chain in academic research. Therefore, it is necessary to construct supply chain structures that are complex enough to be representatives of reality and simple enough to be dealt with for research.

The supply chain concept grew largely out of two-stage models [1].However, a complete supply chain process model should include source, make, and deliver from suppliers to customers [17]. A three-level supply chain that consists of a manufacturer, its immediate suppliers and customers includes these three processes. Therefore，three-level supply chain is a good balance between the closeness to reality and research complexity.

For three-level models, Iyer and Ye [9] and Munson and Rosenblatt [14] are both concerned with serial supply chain, whereas Lau, Huang, and Mak [12] dealt with a divergent supply chain. These studies assume only a single product being distributed in the supply chain. Therefore, multiple products could be a direction for extension.

2.2 The Types of Information Sharing

Research on demand-side information sharing has been highlighted over time [7]. However, what information could be shared from supply side and what the impact would be have rarely been considered. A supply chain faces uncertain market demands for end products from one side and unstable supply of raw materials or components from another side. There is no reason to emphasize one but overlook the other.

Kim, Leung, Park, Zhang, and Lee [11] developed a mathematical model that considers a supply chain consisting of a manufacturer and multiple suppliers to explore how much of each raw material is to be ordered from each supplier under the constraints of capacities of suppliers as well as the manufacturer. They concluded that the manufacturer has to consider its own production capacity, its suppliers' capacities, market demand uncertainty, under-stocking and overstocking costs to reach optimal procurement decision. The limitation is that planning horizon only extends up to one period.

Swaminathan, Sadeh, and Smith [18] analytically investigated sharing supplier capacity information with a downstream manufacturer who orders raw materials from two alternative suppliers differing in cost and capacity to produce a single product. The study showed that although information sharing is beneficial to overall supply chain performance, it can be detrimental to individual members. The findings are only built on a simple two-tier supply chain structure for a single product in a single period horizon.

Lee and Whang [13] indicated that capacity information sharing can contribute to mitigating potential shortage gaming behavior, thereby countering a potential source of the bullwhip effect. Huang, Lau, and Mak [8] indicated that sharing capacity information in a supply chain is essential for integrated planning.

2.3 Supply Chain Modeling Approach

The modeling approaches have basically fell into three categories: analytical models, mathematical programming models, and simulation models.

Analytical models are quite popular in supply chain management field. Such models are effective in providing important insights into information sharing issues. For example, Lee, Padmanabhan, and Whang [13] analytically proved the existence of four sources of the bullwhip effect. Basically, analytical models deal with operational issues under simple supply chain structure and appear in the early literature.

Mathematical programming models are mostly used to formulate strategic issues in supply chain management, such as facility location selection [10], supplier selection [11], global resources deployment [4], and supply chain planning [6].

Simulation approach utilizes computer technologies and programming languages to imitate the operation of a system so that the behavior of the system under specific conditions can be studied. Simulation models describe how a supply chain will operate over time as a function of parameters and policies [16].

Simulation approach has some intrinsic advantages. First, it has greater flexibility that decision makers prefer. Second, it has the ability to replicate and isolate probabilistic functions and activities within a system for specific study. Third, it can be used to explore the impacts of qualitative factors on a supply chain. Fourth, it can be closer to real systems than analytical and mathematical programming models.

The representative discrete event simulation studies that focus on information sharing include those of [5], [7], [20], [22].

Based on our observation of the existing literature, simulation approach is the right choice for modeling complex supply chain structure (e.g. network structure).

3 RESEARCH METHODOLOGY

This paper uses a hybrid approach of computer simulation and mixed-integer programming (MIP). A computer program is 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

We make the following assumptions to simplify the establishment of supply chain model:

1) The supply chain consists of three capacitated suppliers, one capacitated manufacturer, and four retailers.
2) 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.
3) 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.
4) 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.
5) 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.
6) The suppliers are end suppliers; thus they do not need to order raw materials from other suppliers to make their own products.
7) The manufacturer employs MRP system to organize its production activities.
8) Each supplier is the only provider for the manufacturer for one specific raw material, and the manufacturer is the only customer for each supplier.
9) 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.
10) Downstream partners pay for the regular transportation cost, and upstream partners pay for backorder transportation cost.
11) The determination of cost structure: All cost figures are from a real case of a local beverage plant whose supply chain structure is similar to the one we studied. The transportation costs from manufacturer to retailers are $450, $255, $331 and $553 per vehicle, respectively because of different transportation distances; the transportation costs from the suppliers to the manufacturer are $520 per vehicle. The order processing cost of the manufacturer for raw materials procurement is $100 per order and the order processing cost of each retailer for end products procurement is $100 per order also. The production setup cost of the manufacturer is $1000 per setup. The unit inventory holding costs at each period for manufacturer and retailers are $0.03 and $0.04, respectively. Both products of the manufacturer and the raw materials purchased have the same unit inventory holding cost. The unit inventory holding cost for suppliers is estimated to be $0.02. The backorder cost stands for possible loss of goodwill and the potential profit loss due to customer dissatisfaction caused by backorder. After consulting with the plant's supply chain manager, the unit backorder costs paid from suppliers to manufacturer, from manufacturer to retailers and from retailers to market were estimated to be $0.20, $0.30 and $0.40, respectively. Manufacturer's production cost is $34 each unit for both products, respectively, and manufacturer's raw materials procurement cost is $17, which is the same for all suppliers.

3.2 Independent and Dependent Variables of the Simulation

3.2.1 Independent Variables of the Experimental Design

The simulation parameters used in the model as summarized in Table 3.1.

Table 3.1 Simulation Parameters

Variable Name	Label	Levels	Values
Supply-side Information Sharing	SSIS	2	NIS, SIS
Demand Pattern	DP	3	SEA, SIT, SDT
Capacity Tightness	CT	3	High, Mid, Low

1) Supply-Side Information Sharing (SSIS)

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.

2) Demand Pattern (DP)

Three demand patterns representing different combinations of trends and seasonality will be examined. SEA produces demand with seasonality without trend. SIT generates demand with seasonality and increasing trend. SDT generates demand with seasonality and decreasing trend. These demand patterns are generated for four retailers by the following formula.

$$\text{Demand}_{it} = \text{Base} + \text{Slope} \bullet t + \text{Season} \bullet \sin\left(\frac{2\pi}{SeasonCycle} \bullet t\right) + \text{Noise} \bullet \text{snormal}_i() \quad (1)$$

where Demand_{it} is the demand at period t for retailer i (i=1,2,3,4; t=0,1,2,…, 299); Base is the initial demand which is selected to ensure that the average demand for each product during all simulation period is 1000; Slope describes the increasing or decreasing trend of demand; Season represents the magnitude of seasonal variation of demand; SeasonCycle is the cycle of the seasonal variation of demand, and its value is 7 in this study to represent a weekly fluctuation; Noise is the magnitude of random disturbance; snormal() is a standard random function. To avoid the possibility of generating negative demand, we restricted the standard normal random variable to values within the range of –3.0 to +3.0 only.

The characteristics of these demand patterns are summarized in Table 3.2 and Table 3.3.

Table 3.2 The Characteristics of Demand Patterns of Product 1

Demand Patterns	Product 1			
	Base	Slope	Season	Noise
SEA	1000.00	0	200	100
SIT	761.00	1	200	100
SDT	1239.00	-1	200	100

Table 3.3 The Characteristics of Demand Patterns of Product 2

Demand Patterns	Product 1			
	Base	Slope	Season	Noise
SEA	1000.00	0	200	200
SIT	551.00	2	200	200
SDT	1449.00	-2	200	200

3) Capacity Tightness (CT)

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 [2], [21], [22], and [23].

3.2.2 Dependent Variables of the Experimental Design

Cost and service levels have been used as the dependent variables of the experimental design to measure the supply chain performance:

- Total cost of retailers (TCR): the sum of ordering cost (including transportation cost), inventory carrying cost and the backorder cost for the retailers.
- Total cost of suppliers (TCS): the sum of the transportations cost (for backorder delivery), inventory carrying cost and the backorder cost for the suppliers.
- Total cost of manufacturer (TCM): the sum of the setup cost, order processing cost, transportations cost (for backorder delivery), inventory carrying and the backorder cost for the manufacturer.
- Total cost of the supply chain (TC): TCR+TCS+TCM-(backorder cost paid by the manufacturer to the retailers and by the suppliers to the manufacturer)
- The service level of the supplier (SLS): the percentage of manufacturer's orders satisfied by the supplier.
- The service level of the manufacturer (SLM): the percentage of retailer's orders satisfied by the manufacturer.
- The customer service level of the retailers (SLR): the percentage of customer demand satisfied by the retailers; SLR is also the actual external service level performance of the entire supply chain.

3.3 The Simulation Procedure

The simulation program developed by [20] and [22] was used to simulate forecasting, ordering, and supplying activities in the supply chain. Genetic algorithm for general capacitated lot-sizing problem (GCLSP) developed by [19] was modified to solve MIP model for the manufacturer's lot-sizing issue. An interface was built to link these two parts so that simulation parameters could be transferred interactively between them.

4 RESEARCH HYPOTHESES

Four hypotheses will be tested in this study:

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

Hypothesis 2
Demand patterns faced by the retailers (DP) will significantly influence the value of supply information sharing.

Hypothesis 3
Capacity tightness of the manufacturer (CT) will significantly influence the value of supply information sharing.

Hypothesis 4
Demand patterns faced by the retailers (DP) will significantly influence the impact of capacity tightness (CT) on the value of supply information sharing.

5 RESULTS AND DISCUSSIONS

The outputs from the simulation experiments were analyzed by using Analysis of Variance (ANOVA). The selected results are presented in Table 5.1 and Table 5.2. We can see that all the main effects and the interaction effects are significant in terms of total cost and service level at 1 percent significance level. To examine the impact of the independent variables on the dependent variables, Duncan's multiple-range test was performed to rank their performances. The results are presented in Table 5.3 and Table 5.4. The discussions, which centered on the research hypotheses, are presented below.

Table 5.1 Selected ANOVA Results for Cost Performance

Dependent Variables		TC	
Source		F Value	Pr>F
1	SSIS	4756.45	<.0001
2	DP	538.97	<.0001
3	CT	533.70	<.0001
4	SSIS*DP	321.78	<.0001
5	SSIS*CT	553.60	<.0001
6	SSIS*CT*DP	257.16	<.0001

Table 5.2 Selected ANOVA Results for Service Level Performance

Dependent Variables		SL	
Source		F Value	Pr>F
1	SSIS	7048.02	<.0001
2	DP	313.83	<.0001
3	CT	3150.69	<.0001
4	SSIS*DP	298.56	<.0001
5	SSIS*CT	1348.03	<.0001
6	SSIS*CT*DP	236.99	<.0001

Table 5.3 Duncan's Grouping Results of Relative Total Costs

Simulation Parameters	Value	Performance Measures	
		RTC	Rank
SSIS	NIS	150.30	2
	SIS	100.00	1
DP	SEA	100.00	1
	SIT	102.56	2
	SDT	109.08	3
CT	LOW	100.00	1
	MID	101.63	2
	HIGH	106.25	3

Table 5.4 Duncan's Grouping Results of Service Levels

Simulation Parameters	Value	Performance Measures	
		SL	Rank
SSIS	NIS	83.24	2
	SIS	86.67	1
DP	SEA	85.49	1
	SIT	85.01	2
	SDT	84.37	3
CT	LOW	86.46	1
	MID	85.71	2
	HIGH	82.70	3

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

Figure 5.1
Main Effect of SIS on Relative Total Cost (RTC)

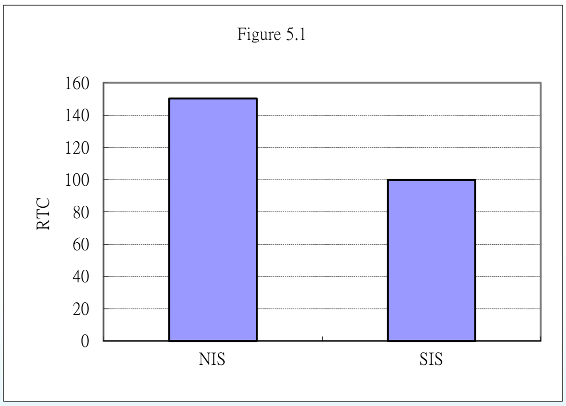


Figure 5.2
Main Effect of SIS on Service Level (SL)

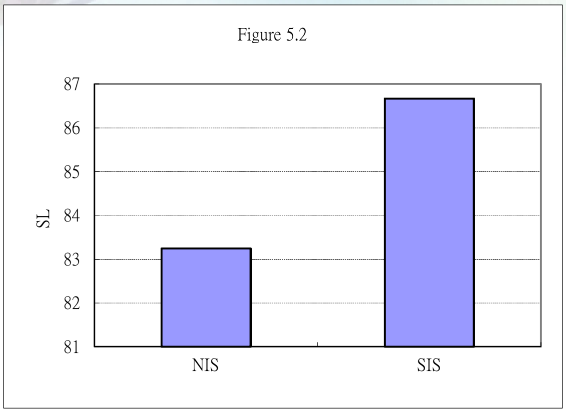


Figure 5.1 and Figure 5.2 show the main effects of supply information sharing (SIS) on the total cost and service level of the supply chain, respectively. The total cost numbers are relative with the minimum being 100. When supply information is shared, the total cost of the whole supply chain is greatly reduced. The total cost saving as a result of sharing supply information is more than 50 percent. Service level of the whole supply chain under supply information sharing is slightly higher than that of no supply information sharing (approximately 3.4 percent). 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 procurement lot-sizes for products backward or by buying substitute products, thus reducing backorders and increasing sales.

Based on these observations, hypothesis 1 is supported.

5.2 The Influence of DP on the Value of SIS

Figure 5.3
Interaction between DP and SSIS on Relative Total Cost (RTC)

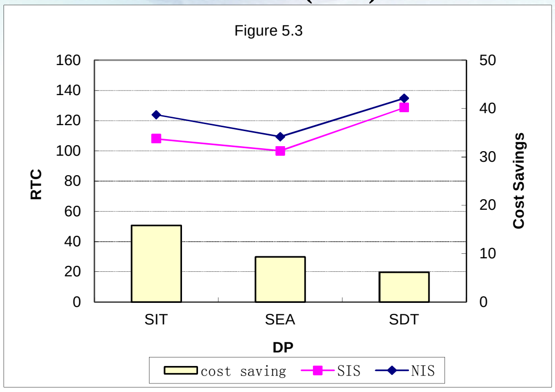
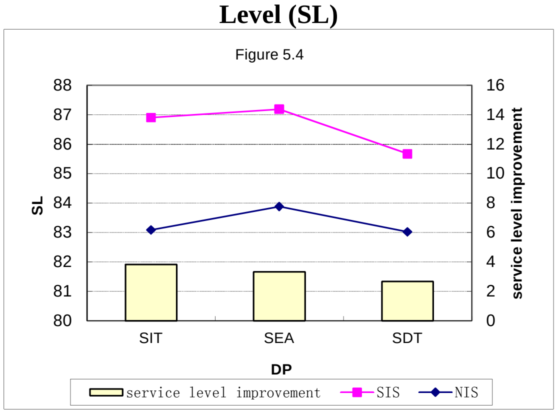


Figure 5.4
Interaction between DP and SSIS on Service Level (SL)



From Figure 5.3, the cost saving that was brought by supply information sharing is decreased when the demand pattern changed from SIT to SDT. Hence, demand trend has an influence on the value of supply information sharing in terms of cost saving.

Figure 5.4 shows that SIS improved service level across all demand patterns. Whether supply information is shared or not, SEA achieves the highest service level, and follows SIT and SDT. In terms of the magnitude of improving the service level, we can see that although SEA achieves the highest SL, the service level improvement under SIT is slightly higher than that under SEA to be the largest. SIS makes the least improvement in the service level under SDT.

When DP= SIT, if there is no supply information sharing, retailers have to rely on inventories accumulated at earlier periods in order to satisfy backorders at later periods. If supply information is shared, taking advantage of this information, retailers can rearrange their purchasing plan by moving orders at later periods to earlier periods. Therefore, supply information can play a key role in reducing backorders.

When DP=SDT, backorders mostly appeared at earlier periods. Even if supply information is shared, retailers cannot move orders at the earliest periods to earlier periods. Therefore, supply information may not be able to reduce backorders too much. That is why service level improvement under SDT is the lowest.

When DP=SEA, the demands faced by retailers have only seasonal up-and-downs without trend. Even though backorders may appear at some periods, they can be quickly filled by additional supply capability at subsequent periods, so backorder will not remain unsatisfied, and additional inventories will not be stored for a too long period of time. Therefore, backorder cost and inventory holding cost may not be too high. When supply information is shared with retailers, they can take initiative action to adjust their purchasing plans by moving the lot sizes backward to reduce possible backorders. As a result, the backorder cost can be further lowered, but the cost saving achieved and service level improvement may not be as high as those under SIT.

Based on these observations, we can see that DP has a significant influence on the value of SIS.

5.3 The Impact of CT on the Value of SIS

To analyze the impact of capacity tightness on supply information sharing, we portrayed the relative total cost (RTC) and service level (SL) of the supply chain for different combinations of CT and SSIS in Figure 5.5 and Figure 5.6.

Figure 5.5
Interaction between CT and SSIS on Relative Total Cost (RTC)

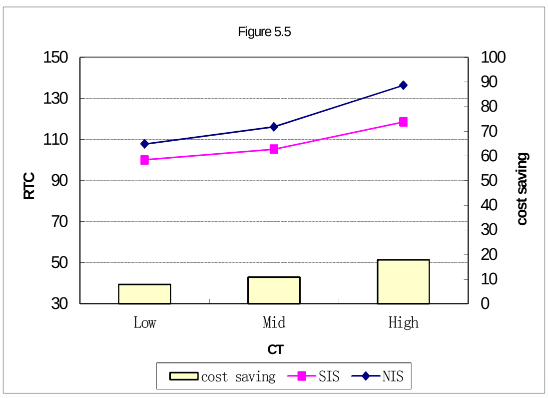
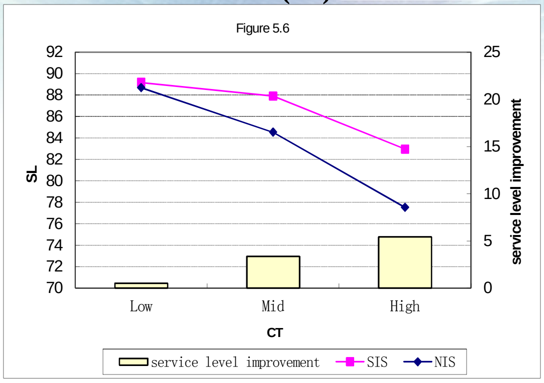


Figure 5.6
Interaction between CT and SSIS on Service Level (SL)



As shown in Figure 5.5, when there is no supply information sharing, the decrease in extra capacity has a negative impact on total cost. The more stringent capacity is, the higher the total cost becomes. Moreover, the increase in total cost is in an increasing rate. When there is supply information sharing, the total cost also increased with the decrease of extra capacity, but in a smooth increasing rate. Hence, the cost saving from supply information sharing becomes larger when extra capacity becomes less.

For the impact on service level, as shown in Figure 5.6, when there is no SIS, the service level declines consistently when capacity tightness ranges from Low to High. When there is SIS, the service level has been greatly improved under CT=High and CT=Mid. However, the service level improvement is not obvious when CT=Low. Therefore, the service level improvement increased with the increase of capacity tightness.

The reason behind these phenomena is that when capacity tightness is low, the manufacturer's production capacity is already sufficient for satisfying the demand from retailers. Shared supply information exerts little influence in reducing backorders through adjusting retailers' procurement plans. In other words, there is not much difference between supply information sharing and no supply information sharing in terms of improving supply chain performance. However, when capacity tightness becomes higher, there is less extra capacity against backorders. Under such circumstance, supply information can be used by retailers to revise their purchasing plans in order to match the supply capability of the manufacturer, thus reducing backorders. Therefore, the supply chain cost and service level were improved in a larger degree. Therefore, hypothesis 4 is supported.

5.4 The Influence of DP on the Impact of CT on the Value of SIS

To examine the interaction effects among DP, 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 demand patterns in Figure 5.7 to Figure 5.12, respectively.

Figure 5.7 Interaction between CT and SSIS on Relative Total Cost (RTC) when DP=SDT

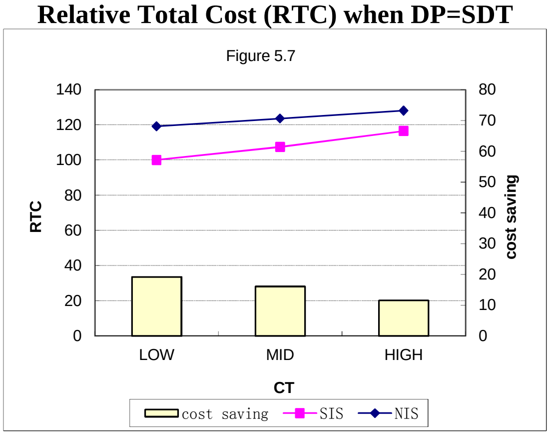
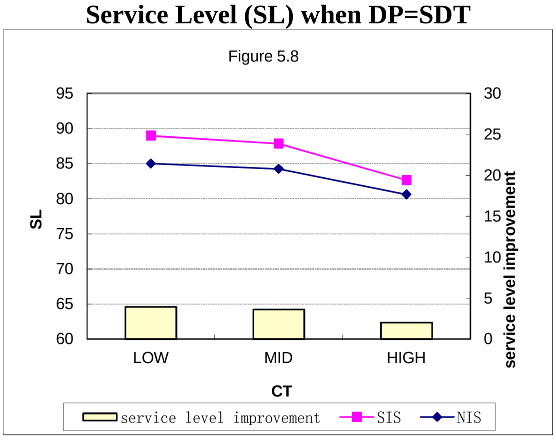


Figure 5.8 Interaction between CT and SSIS on Service Level (SL) when DP=SDT



From Figure 5.7, we know that RTC was decreased greatly across all CT levels through sharing supply information. When there is no supply information sharing, RTC is the lowest when CT=Low, and then it increased slowly with the decrease of extra capacity. RTC increased further when capacity became even tighter. However, when there is supply information sharing, RTC increased consistently in a steeper rate as CT increased from Low to High. The cost saving is decreased with the increase of CT.

Correspondingly, Figure 5.8 shows that the service level reaches the highest level when CT is low, and is reduced to the lowest level when CT is high whether supply information is shared or not. The service level under SIS reduced a little faster than that under NIS when CT ranges from Low to High. Therefore, service level improvement is decreased with the increase of CT.

These observations can be explained by two reasons. First, when demand has a decreasing trend, capacity is lower than demand at early periods. Backorders mainly occur at earlier periods. However, during these earlier periods, even though supply information is shared, retailers have less room to change their purchasing plans by moving purchasing orders to even earlier periods, thus sustaining backorders at a higher level, especially when capacity tightness is high. Second, when capacity tightness is low, supply deficiency is not severe during earlier periods, and capacity at later periods can also be used to satisfy previous backorders. However, when capacity goes tighter, capacity at later periods is not enough to satisfy early backorders. Therefore, the cost saving and the service level improvement under low and middle capacity tightness are higher than those under high capacity tightness.

Figure 5.9 Interaction between CT and SSIS on Relative Total Cost (RTC) when DP=SEA

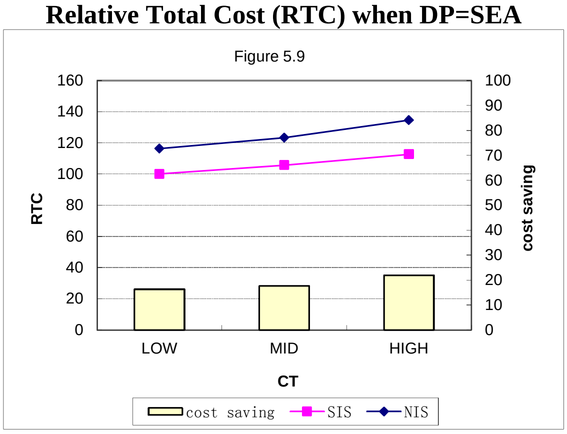


Figure 5.10 Interaction between CT and SSIS on Service Level (SL) when DP=SEA

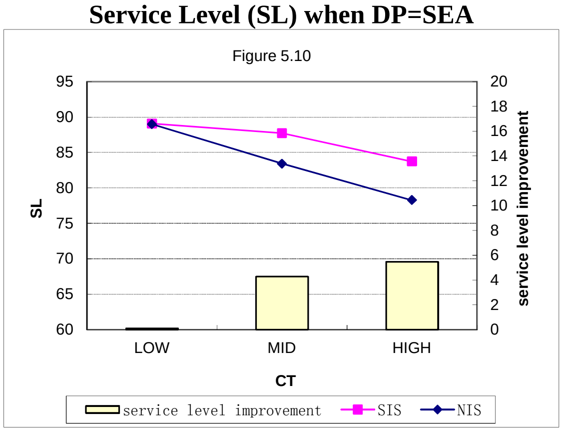


Figure 5.9 shows that when there is supply information sharing, RTC is the lowest when CT is Low, is slightly increased when CT changed to Mid, and continues to increase to the highest level when CT became High. When there is no supply information sharing, RTC grew in a little steeper rate

when CT increased from Low to High. The cost saving is increased with the increase of CT.

As shown in Figure 5.10, when there is supply information sharing, the service level first dropped gradually when CT varies from Low to Mid, then declined a little faster when CT became High. When there is no supply information sharing, the service level declined consistently when CT increased from Low to High. Service level improvement is increased with the increase of CT, but under CT=Low, there is almost no improvement in service level.

These observations can be explained as follows. SEA does not have an increasing or a decreasing trend. Even if capacity becomes tighter, this feature makes backorders be quickly filled by excess capacity at following periods. In addition, by knowing supply information, retailers can move larger-than capacity lot-sizes backward as much as possible. Therefore, the supply chain can lower the total cost and improve the service level in a larger magnitude when capacity is less sufficient.

Figure 5.11 Interaction between CT and SSIS on Relative Total Cost (RTC) when DP=SIT

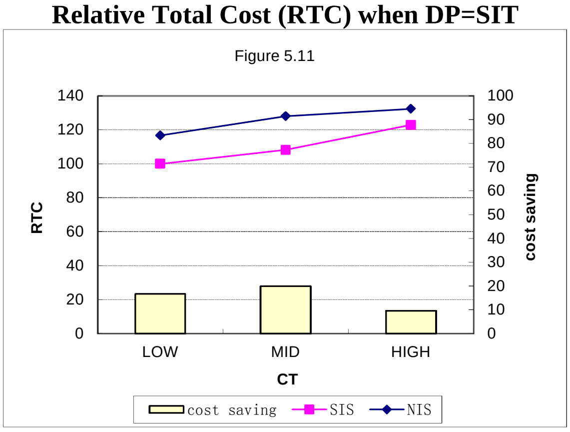
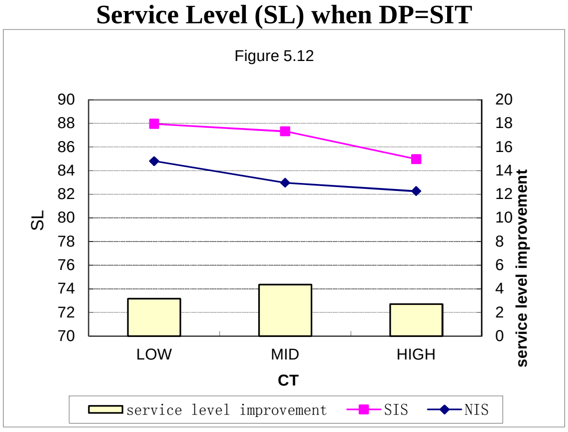


Figure 5.12 Interaction between CT and SSIS on Service Level (SL) when DP=SIT



As shown in Figure 5.11, when there is SIS, RTC was the lowest when CT is Low, increased slightly when CT changed to Mid, and then increased a little faster when CT became High; when there is no SIS, RTC increased gently when CT moved from Low to High. The cost saving reached the highest when CT is Mid and the lowest when CT is High. Figure 5.12 displays the variations of service level across three capacity tightness levels. We can see that the pattern of service level improvement is similar to the pattern of cost savings.

These observations can be explained as follows. Under SIT, backorders are more likely to appear at later periods, and demand is lower than capacity at earlier periods. If capacity tightness is low or moderate, retailers have more chances to move orders at later periods as earlier as possible based on the supply information from the manufacturer. If capacity tightness is high, this order plan revision is highly likely to be impossible. Therefore, the cost saving and service level were improved to a larger extent under low and moderate capacity tightness.

Based on the above observations, the impact of capacity tightness on the value of supply information sharing is significantly influenced by different demand patterns. Overall, these results support hypothesis 4.

6 CONCLUSIONS

Analyses of the simulation output reveal the following important findings.

1) 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.

2) The value of supply information sharing is significantly influenced by demand patterns. Supply information sharing brings more supply chain performance improvement when retailers face demand pattern SEA and SIT than when they face demand pattern SDT.

3) Capacity tightness constrains the potential maximum supply capability of the manufacturer. As expected, capacity tightness greatly influences the value of supply information sharing. The decrease in excess capacity has a positive impact on cost saving and service level improvement. However, caution must be taken in that a manufacturer can adjust its capacity in the long term or for strategic purposes. In this case, the current observation may not be true.

4) There is a significant interaction between demand patterns and capacity tightness. When capacity becomes tighter, SDT and SIT perform worse than SEA. Demand patterns moderate the impact of capacity tightness on

the value of supply information sharing. When DP=SDT or SIT, backorders are more likely to appear at earlier periods or at later periods, and supply information sharing plays a larger role when CT=Low and Mid. When DP=SEA, however, backorders may appear at any periods. The strategy of moving backwards based on supply information can always work even though capacity becomes tighter.

The research on supply information sharing remains in its infancy. The following are some limitations and the possible direction of future research:

1) The manufacturer in the supply chain model decides when and how many to produce through MPS. MPS is determined by planning horizon, frozen interval, and replanning interval. These parameters should have an impact on the supply capability of the manufacturer. Therefore, a study investigating the effect of these parameters on the value of supply information sharing is much needed.

2) The cost structure of a supply chain should have significant influence on the simulation results. Therefore, a possible extension of this research could be an investigation of the impact of different cost structures on the value of supply information sharing.

3) For strategic purpose, a supply chain member could adjust its capacity in the long run. For operational purpose, a company can also change its capacity by overtime or layoff in the short term. In this study, we assumed that capacity is constant during all simulation periods. Therefore, one interesting future research direction is to investigate the influence of non-constant capacity on supply information sharing.

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