THE VALUE OF INFORMATION SHARING IN A SERIAL SUPPLY CHAIN WITH CENTRALISED AND DECENTRALISED DECISION

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Abstract: In this paper, we present a simulation based model in order to study the effects of information sharing in a serial supply chain. This chain is multi-product and multi-echelon. Our approach focuses on the study of two shared information simultaneously. The first one is the replenishment leadtime coming from the upstream and the second one is the customers' demand coming from the downstream of the supply chain. Thus, we present four scenarios of information sharing. The demand is supposed normally distributed and the leadtime is random. We develop a cost model consisting of holding, ordering, penalty and transportation costs. The difference of the optimal costs between each studied scenario represents the performance indicator of the information sharing. Two different decisions are considered in our work: centralised and decentralised. The developed model for each studied situation is solved by ILOG CPLEX integrated in a JAVA program. To conclude, the results of our numerical experimentations are analysed.

1 INTRODUCTION

For many enterprises, the supply chain management has become an important element of strategic advantage to gain a competitive edge over their competitors. In the sever competition times, the enterprises want to obtain competition advantage, they must carry on the cooperation with the other echelons in the same supply chain, and try to establish win-win cooperation relationship. The information sharing is the foundation of the cooperation between different links of supply chain, and also is one main origin of the supply chain advantages.

In this context, researches are numerous. The existing works deal with the study of different types of information sharing in different circumstances. Namely, the studied decision and the source of the share, etc. The centralised decision represents the most treated case (Chu and Lee, 2006), (Rached *et al*., 2009). The decentralised decision is treated in (Birendra *et al*., 2007), (Laux *et al*., 2004), (Li *et al*., 2006). However, (Zhao and Qui, 2007) considered simultaneously centralised and decentralised decision. Concerning the provenance of the information to share, on the one hand, many papers have treated the case of downstream information sharing (Agrawal *et al*., 2008), (Hsiao and Shieh, 2006), (Li and Zhang, 2008). On the other hand, (Chen and Yu, 2005), (Jia *et al*., 2007) and (Mehrabi *et al*., 2007) presented shared information which is coming from upstream. However, few papers considered the case of shared information coming simultaneously from the upstream and the downstream (Birendra *et al*., 2007), (Rached *et al*., 2009). The solver CPLEX is used in many recent works including a study of optimisation and the information sharing in supply chains. In (Li and Zhang, 2008) authors present an objective function which includes a cost formulation solved using GAMS-CPLEX. In (Lehoux *et al*., 2007), authors presented seven models aiming to study the value of collaboration between a supplier and his customer.

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To compare and analyse their developed models, they use the solver CPLEX.

According to the above review, we propose to study the effects of two information shared simultaneously upon the supply chain performance with several scenarios and circumstances. The remainder of this paper is organised as follows. Section 2 reviews the structure of studied supply chain and introduces the different studied scenario. Section 3 presents the simulation and analysis results. Finally, conclusions are made in Section 4.

2 STRUCTURE OF STUDIED SUPPLY CHAIN AND THE RESOLUTION METHOD

The supply chain structure in this paper is a four-echelon model Figure 1, which includes several customers, one retailer, one warehouse and one supplier. There are various items of information which can be shared such as inventory level, production capacity, etc. The shared information refers to costumers' demand coming from the downstream of the supply chain and replenishment leadtime coming from the upstream. We assume that the costumers' demand is normally distributed, the leadtime between the supplier and the warehouse is random and the leadtime between the warehouse and the retailer is fixed for all periods.

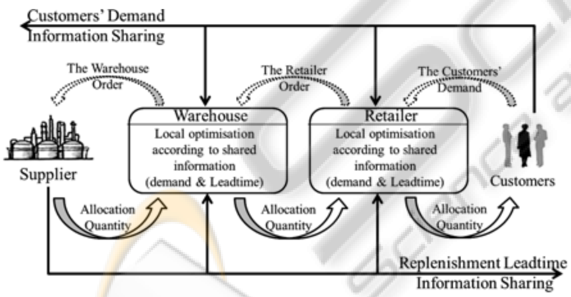

Figure 1: Studied supply chain with information and materiel flows.

We study the sharing of two information simultaneously, which are the demand coming from the downstream of supply chain and the leadtime coming from the upstream.

To investigate the effect of information sharing upon supply chain performance, for each studied decision, four scenarios are designed with respect to the two types of information mentioned above.

In the case of decentralised decision, the retailer performs a local optimisation of its costs before placing their orders. According to this order quantity, the warehouse proceeds to a second local cost optimisation to place an order to the supplier.

According to the centralised decision presented in Figure 2, the four studied scenarios are as follows:

- Case of Replenishment Leadtime and Demand Information Sharing: At the beginning of each period, the decision maker (warehouse) is informed about the exact replenishment leadtime and the customers' demand of the current period. So, he calculates the order quantity witch minimise the total system cost according to the replenishment leadtime and the exact demand of all periods.
- Case of Replenishment Leadtime Information Sharing Only: The order quantity is calculated by the decision maker according to the exact replenishment leadtime and independently of the customers' demand.
- Case of Demand Information Sharing Only: In this case, the warehouse calculates the order quantity according to the exact customers' demand and independently of replenishment leadtime.
- Case of No Information Sharing: The decision maker cannot choose the optimal order quantity according to the replenishment leadtime and/or the customers' demand of each period. So, he uses fixed values of both information for all periods to calculate the optimal order quantity.

3 EXPERIMENTAL RESULTS

In our simulation and in order to study the sensibility and the robustness of our formulation, we use different combinations of replenishment leadtime and customers' demand in each scenario as follows:

- Small leadtime $L_t = [1 \text{ to } 4]$, noted *L1*st;
- Large leadtime $L_t = [1 \text{ to } 12]$, noted *L2*nd;
- High leadtime $L_t = [8 \text{ to } 12]$, noted *L3*rd;
- First mean value of demand (high demand) $\mu = 380$, noted *D1*st;
- Small demand $\mu = 100$, noted *D2*nd;

Medium demand $\mu = 230$, noted *D3*rd.

We use in each simulation the same standard deviation σ =80.

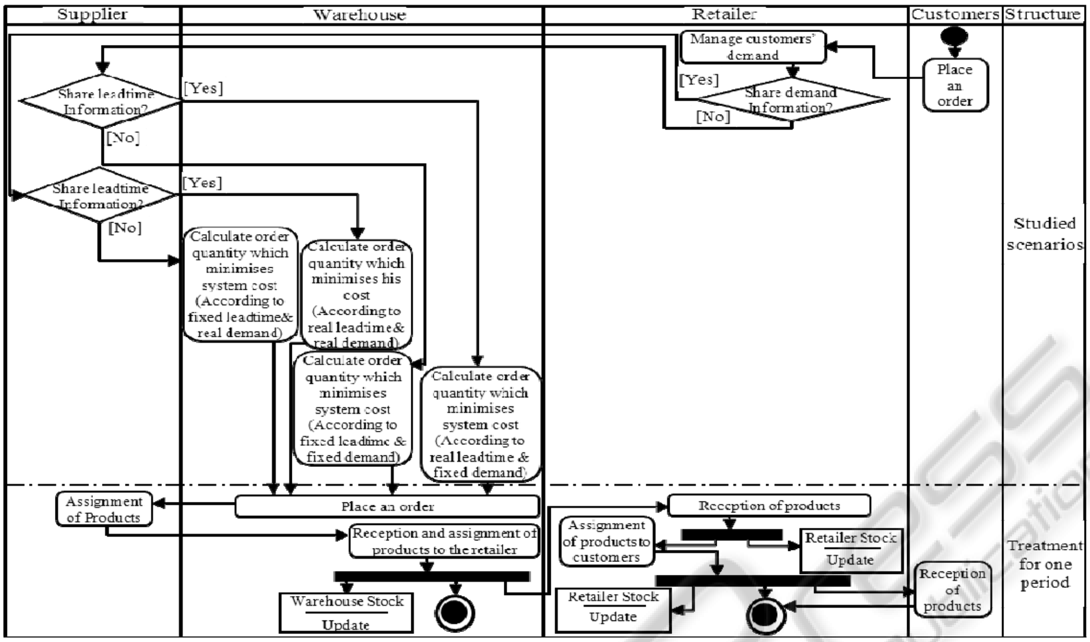

Figure 2: Activity diagram integrating all studied scenarios in a centralised decision.

In our work we deal with the problem of optimisation based on a centralised (Table 1) and decentralised decision (Table 2) using CPLEX.

- IS: Is the case of Information Sharing;
- NIS: Is the case of No Information Sharing;
- DemI: Demand Information;
- LtI: Leadtime Information.

Table 1: Total system cost in centralised decision.

				DemI	
				TSC (10^3)	
				IS	NIS
LtI	$L1^{st}$	$D1^{st}$	IS	5,1347	8,4099
			NIS	6,1216	11,1132
		$D2^{nd}$	IS	3,9821	5,2154
			NIS	4,7612	7,1256
		$D3^{rd}$	IS	4,4782	6,8154
			NIS	5,9373	10,0347
	$L2^{nd}$	$D1^{st}$	IS	5,1277	8,2367
			NIS	7,4385	10,9521
		$D2^{nd}$	IS	3,9482	5,9610
			NIS	4,5659	6,9581
		$D3^{rd}$	IS	6,0274	7,7147
			NIS	6,8416	8,2618
	$L3^{rd}$	$D1^{st}$	IS	7,1639	9,2184
			NIS	8,1374	10,3514
		$D2^{nd}$	IS	4,1132	4,8952
			NIS	4,5173	5,5901
		$D3^{rd}$	IS	3,2467	5,1458
			NIS	3,8962	7,7259

Table 2: Total system cost in decentralised decision.

				DemI	
				TSC (10^3)	
				IS	NIS
LtI	$L1^{st}$	$D1^{st}$	IS	6,2704	10,5806
			NIS	9,2921	12,8980
		$D2^{nd}$	IS	5,2502	6,7198
			NIS	6,4988	7,5044
		$D3^{rd}$	IS	5,9443	7,8265
			NIS	6,3447	10,5558
	$L2^{nd}$	$D1^{st}$	IS	6,9277	9,5627
			NIS	8,8154	12,9171
		$D2^{nd}$	IS	5,2502	7,2198
			NIS	6,4059	8,2461
		$D3^{rd}$	IS	6,2276	8,0747
			NIS	6,7546	8,7996
	$L3^{rd}$	$D1^{st}$	IS	7,8686	9,8018
			NIS	8,4053	11,0514
		$D2^{nd}$	IS	5,3212	6,7635
			NIS	5,8177	6,9859
		$D3^{rd}$	IS	5,2606	7,5315
			NIS	5,9153	9,9776

In Table 1 and Table 2, we present nine values of simulations. Illustrated by the different combinations of ($L1^{st}$, $L2^{nd}$ and $L3^{rd}$) and ($D1^{st}$, $D2^{nd}$ and $D3^{rd}$).For each case we present TSC (10^3) for four scenarios of customers' demand and replenishment leadtime information sharing.

Based on the simulations in Table 1, we study the centralised decision. Regarding the total system cost, the results show an average percentage at 21.12% of reduction of logistic cost in the case of leadtime information sharing compared to the scenario of no information sharing. Whereas the demand information sharing compared to the scenario of no information sharing presents an average of 33.15% reduction of logistic cost.. When the two information are simultaneously shared, we obtain 44.66% of of logistic cost reduction compared to the case of no information sharing. For the decentralised decision illustrated by Table 2, Compared to the case of no information sharing, we can deduce 16.70% and 27.75% of reduction of logistic cost concern, respectively, the case of leadtime information sharing and, the case of demand information sharing. When the two studied information are simultaneously shared, we obtain 38.92% of reduction of logistic cost compared to the case of no information sharing. In the case of no information sharing, the centralised decision presents 12.16% of reduction of logistic cost compared to the case of decentralised decision. Thus, the centralised decision compared to the case of decentralised decision presents a percentage at 16.83%, 18.72% and 20.43% of reduction of logistic cost concern, respectively, the case of leadtime information sharing, the case of demand information sharing and the case of two information shared simultaneously. In the studied circumstances, we can conclude that the information sharing and the centralised decision present an advantage in terms of reduction of logistic cost compared to the case of decentralised decision.

4 CONCLUSIONS

In this paper, we are interested to the evaluating of information sharing in supply chain. We treated in particular the case of multi-product multi-echelon supply chain. We studied the value of information, specially two information shared simultaneously. The firs information comes from the downstream (demand) and the second come from the upstream (leadtime) of supply chain. Moreover, the effect of two kinds of decision has been also studied (centralised and decentralised decision). We used the traditional replenishment policies as a logistic reference cost. The numerical experimentation shows that the information sharing allows reducing the total logistic costs (transportation and storage costs). Moreover, the centralised decision is more beneficial in terms of reduction of logistic cost compared to the decentralised decision.

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