International Journal of Business and Management; Vol. 8, No. 20; 2013
ISSN 1833-3850 E-ISSN 1833-8119
Published by Canadian Center of Science and Education

Base Inventory Cooperation Strategy of Multi-parts with Supply-Hub

Li Shuang-yan[1], Zhang De-zhi[2] & Jin Fang-ping[2]

[1] College of Transportation and Logistics, Central South University of Forestry and Technology, China

[2] School of Transportation Engineering, Central South University, China

Correspondence: LI Shuang-yan, College of Transportation and Logistics, Central South University of Forestry and Technology, 410004, China. E-mail: lishuangyan585@sohu.com

Received: June 21, 2013 Accepted: August 5, 2013 Online Published: September 22, 2013

doi:10.5539/ijbm.v8n20p96 URL: http://dx.doi.org/10.5539/ijbm.v8n20p96

Abstract

We investigate two stage supply chain optimization coordination with Supply-Hub operation mode for assembly manufacturing enterprise. Because all parts delivery of all suppliers are integrated at Supply-Hub, all needed parts by the production line are selected, packaged and then sent to the manufacturer by Supply-Hub. We applied queuing theory and basic inventory strategy to model this system and derive the optimization solution for decentralized decision and centralized decision separately. Then coordination inventory strategy is obtained by comparing decentralized decision and centralized decision. Due to inventory risk shifting from manufacturers to suppliers with Supply-Hub operation mode, backorder and holding cost subsidy contracts are used for coordination that incites suppliers to set basic inventories in favor of whole supply chain operation cost reduction. And numerical examples of three suppliers and one manufacturer are given to illustrate the effectiveness of the coordination strategy and the condition to gaining Pareto improving for whole system with the collaborative strategy.

Keywords: supply chain cooperation, base inventory, multi parts

1. Introduction

Assembly manufacturing enterprises assemble variety of parts to be finished product. These part's suppliers have different capacity, location, etc. And thus they delivery capabilities are difficult too. It is very difficult to obtaining all needed parts whose quantity ratio met with assembly Process. The assembly manufacturer production and inventory management will be effect adversely. If there is no coordination between parts suppliers, production halts and some materials accumulation due to out of some parts' stock will become serious phenomenon.

Therefore, it is important to coordinate inventory of parts suppliers for assembly manufacturing enterprise's precedent supply chain management. In order to improve the coordination capacity of various suppliers supply and inventory utility, not only inventory optimization based on economic quantitative methods but also improving the supply chain network structure and operation mode can be used (Li, J. Z., et al., 2011; Ma, S. H., et al., 2009; Peral, T. P., et al., 2011; Buzacott, J. A., et al., 1992).

And in recent years, in order to improve the efficiency and effectiveness of the supply chain further, supply-hub appeared whose function is logistics integrating of upstream supply for manufacturer. Supply-hub integrates different suppliers' inventory operation for manufacturer to realize just-in-time delivery according to real time production (Shah J., 2006; Togar, M., 2008; Guruprasad, P., 2009). Many academic articles indicated Supply-Hub can produce scale benefit and optimize assembling manufacture enterprise's inventory and cooperate logistics operation (Yu, J. H., 2010; Li, J. Z., et al., 2011; Ma, S. H., et al., 2009). Influence for supply chain's optimization after upstream structure changed is explored in literatures (Ma, S. H., et al., 2009; Peral, T. P., et al., 2011; Buzacott, J. A., et al., 1992).

As a coordination organization between parts suppliers and assembly manufacturers, Supply-Hub function concentration and packaging. According to the demand of manufacturers' assembly plan, operators in Supply-Hub select needed parts and package them then delivery to the production line on time. So through the Supply-Hub, integrating suppliers, collaborating Supply logistics operation and parts synchronous supply can be realized. Manufacturers released purchase plan based on rolling time and then suppliers will launch delivery to supply-hub. Supply-Hub operators accept different parts and centralized control arrived parts inventory

(Timmer, J., Chessa, M., & Boucherie, R. J., 2013).

Peral et al. study coordination in a two-stage capacitated supply chain with multiple suppliers (Terekhov, D., et al., 2012). They modeled the manufacturer as a queuing system and suppliers as n different M/M/1 make-to-stock queues. But they didn't consider supply-hub mode. So, we should coordination of the decentralized supply chain with supply-hub and subsidy contract.

Most manufacturing enterprises can't delivery product orders on time because serious backlog of raw materials supply. They have to increased raw material preparation and improve inventory levels. But the cost of finished products will increase too. So how to ensure materials on-line timely without increasing inventory levels are managers headache.

Much attention to inventory control is paid by researchers. A lot of inventory research is resulted such as lead time, the amount of raw material costs and shortages.

An important factor is the delivery of all raw materials or items that will be assembled to finished products to the manufacturing enterprises on time. Timmer et al. studied coordination way for enterprises that repeatedly review their inventories and confront Poisson demand. They analyzed steady cost allocations of the joint costs. If any group of companies has lower costs than the singer companies, then allocations exist and an incentive will be given for the enterprises to coordination. They adopted two enterprises to indicate that the latter strategy has the lowest joint costs. With second strategy, the game theoretical Shapley value and the distribution rule a cost allocation in which the enterprises share the procurement cost and each pays its own holding cost are shown to be stable cost allocations. These results also hold for situations with three enterprises (Timmer, J., Chessa, M., & Boucherie, R. J., 2013).

So there are two coordination strategies can be used. First, the enterprises give their orders together for replenishment if the inventory position jointly equal to a value set in advance. Second, the enterprises reorder when one inventory level of them reaches its reorder point.

Explicitly modeling dispatch decisions with availability constraints of parts, that is important for deal with realistic supply chain problems. A dispatch problem with part availability constraints in a supply chain was considered in (Terekhov, D., et al., 2012). With two production facilities and a incorporate transit facility. Terekhov, D., et al., suggested three mixed-integer programming models and a constraint programming models and the models are compared in an extensive numerical study. If there are no parts shared among the two manufacturers, the mixed-integer programming model based on time-index variables is the best for proving best for problems with short production times while the constraint programming model tends to perform better than the others for problems with a large range of processing times.

Assemble-to-order system subject to multi parts coordination. An assemble-to-order (or ATO) system includes several parts and several products. The time to acquire or produce a part is substantial. A product is assembled only in response to demand. An ATO system combines the elements of assembly and distribution, and resolves both coordination and allocation issues. This makes the ATO systems difficult to analyze, design, and manage. The chapter also discusses one-period models, multi-period models, discrete-time models, and continuous-time models (Song, J. S., & Zipkin, P., 2003). ElHafsi, M researched a pure assemble-to-order system faced with multiple classes' demand and compound Poisson process customer orders. Different parts were to assemble the finished product that is produced in a make-to-stock fashion. The optimal production policy of each part is a base stock dependent with state strategy. And the optimal inventory allocation policy is a multi-level state-dependent rationing policy. They find the optimal average cost rate is more sensitive to order size variability than to order size (ElHafsi, M., 2009). Zhang, X., J. Ou, & S. M. Gilbert also researched an assemble-to-order system too. They examined an assemble-to-order environment involving a short-life-cycle product that is sold in two different configurations, each requiring a unique part that must be stocked in advance. Both configurations of the product are assembled on the same equipment which has limited capacity (Zhang, X., Ou, J., & Gilbert, S. M., 2008). Reiman, M.I. and Q. Wang introduced a multi-stage stochastic program that provides a lower bound on the long-run average inventory cost of a general class of assemble-to-order inventory systems. The stochastic program also motivates a replenishment policy for these systems. They provided a set of sufficient conditions under which replenishment policy, coupled with an allocation policy, attains the lower bound (Reiman, M. I., & Wang, Q., 2012). Xiao, Y., J. Chen, and Lee, C. Y. studied a single-product, single-period assemble-to-order (ATO) model with uncertain assembly capacity. To reduce the risk/cost, the manufacturer may need to assemble in advance. They presented a profit-maximization model that makes optimal inventory and production decisions. They established structural properties of the optimal solutions, and identify the sufficient and necessary condition under which assemble-in-advance strategy should be adopted

(Xiao, Y., Chen, J., & Lee, C. Y., 2010).

2. Supply-Hub Operation Mode

As a coordination organization between parts suppliers and assembly manufacturers, Supply-Hub function concentration and packaging. According to the demand of manufacturers' assembly plan, operators in Supply-Hub select needed parts and package them then delivery to the production line on time. So through the Supply-Hub, integrating suppliers, collaborating Supply logistics operation and parts synchronous supply can be realized. Manufacturers released purchase plan based on rolling time and then suppliers will launch delivery to supply-hub. Supply-Hub operators accept different parts and centralized control arrived parts inventory. The operation process of Supply-hub is shown as figure 1.

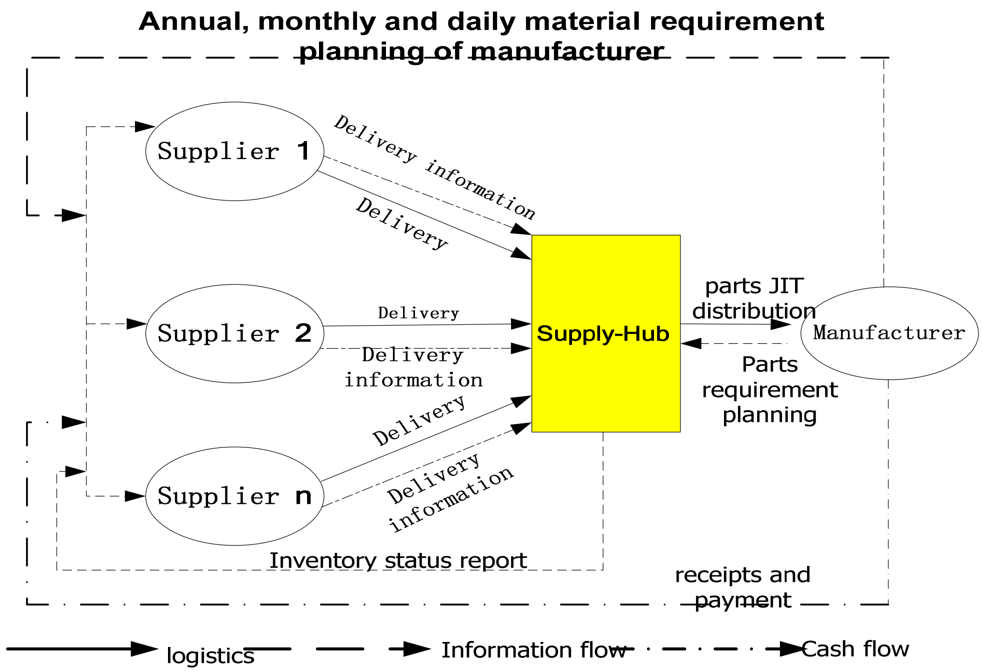

Figure 1. Supply-Hub operation mode diagram

3. Base Stock Policy of Supply-Hub

Two stages Supply chain is considered as a closed loop network, as shown in Figure 2. One Supply-Hub and one manufacturer are in this system. The system operates as follows. Manufacturer makes to order and obtain parts from Supply-Hub but not from suppliers. And n kinds of parts stock are possessed by Supply-Hub and base stock policy is applied to manage inventories in supply-hub. Let s_i be the base stock level of part i for $i = 1, 2 \cdots n$.

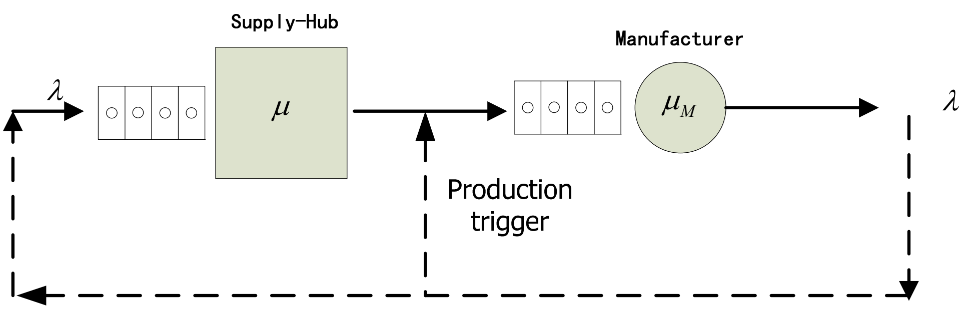

Figure 2. Two phase closed-loop queuing system for supply chain modeling

In the system taken into consideration, the end-customer demands arrive in single units according to a Poisson process with rate λ, where λ equals to 1. And the operation in Supply-Hub is shown as Figure 3. The service times of n servers are independent and identically distributed (i.i.d.) random variables having an exponential distribution with rate μ_i for $i = 1,2 \cdots n$. The manufacturer has also i.i.d. and exponentially distributed service times with rate μ_M. Let ρ_i and ρ_M be the service intensity of part i and the manufacturer, respectively, where service intensity can be defined as the ratio of the arrival rate to the service rate. For the stability of the system, it is assumed that $0 < \rho_i < 1$ for $i = 1,2 \cdots n$ and $0 < \rho_M < 1$.

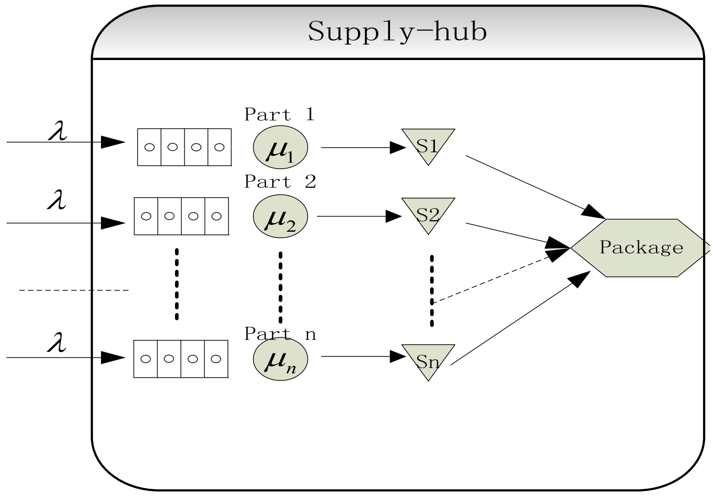

Figure 3. N kinds parts delivery to the Supply-Hub

4. The Centralized and Decentralized Models

4.1 Centralized Model

N parts' base stock level in Supply-hub is decision variables. Let B_i be the backorder cost per unit backordered for part i at Supply-hub per unit time; B_M be the backorder cost per unit backordered at the manufacturer per unit time; h_i be the holding cost per unit inventory per unit time for part i at Supply-hub. And h_M be the holding cost per unit released work-in-process (WIP) inventory per unit time for the manufacturer. In addition to the notation given above, let C_{si} denote the average cost per unit time for supplier i where $i = 1,2 \cdots n$, and C_M denote the average cost per unit time for the manufacturer. Then, C_{si} and C_M can be expressed as followings

$$C_{S_i}(S_1 \cdots, S_n) = b_i E[B_i] + h_i E[I_i] + h_i(\max_{i=1,\cdots n} E[B_i] - E[B_i]) \\ = (b_i - h_i)(\frac{\rho_i^{S_i+1}}{1-\rho_i}) + h_i(S_i - \frac{\rho_i(1-\rho_i^{S_i})}{1-\rho_i}) + h_i \max_{i=1,\cdots n}(\frac{\rho_i^{S_i+1}}{1-\rho_i}), \quad i = 1,\cdots n \tag{1}$$

$$C_M = (b_M + h_M)E[B_M] - \sum_{i=1}^{n} b_i E[B_i] - h_M \max_{i=1,\cdots n} E[B_i] \tag{2}$$

C_M and C_{S_i} can be expressed as a function of $S_1, \cdots S_n$ as given below:

$$C_M(S_1, \cdots S_n) = (b_M + h_M)(\frac{2\rho_M^2}{1+\rho_M^2})\left(\frac{(1+\rho_j)(1+\rho_M^2) - 2\rho_j^{S_j+1}(1-\rho_j)}{2(1+\rho_j)(1-\rho_M)}\right) + \cdots \\ + b_M \max_{i=1,\cdots n}\left(\frac{\rho_i^{S_i+1}}{1-\rho_i}\right) - \sum_{i=1}^{n} b_i \left(\frac{\rho_i^{S_i+1}}{1-\rho_i}\right) \tag{3}$$

Where $j = \arg \min_{i=1,\cdots n} S_i$.

Finally, let C_T be the average total backorder and holding costs per unit time for the overall system. The objective is to minimize C_T .

$$C_T(S_1 \cdots, S_n) = C_M(S_1 \cdots, S_n) + \sum_{i=1}^{n} C_{S_i}(S_1, \cdots S_n) \tag{4}$$

According to [13][14], the unique global optimal solution to the centralized model presented in Eq. (5) is given by

$$S_i^* = \frac{\ln\left(\frac{z^*(1-\rho_i)}{\rho_i}\right)}{\ln \rho_i}, \quad (i = 1, \cdots, n) \tag{5}$$

Where
$$z^* = \frac{\sum_{i=1}^{n} \frac{h_i}{\ln \rho_i}}{(b_M + \sum_{i=1}^{n} h_i)\left(\frac{2\rho_M^2}{(1+\rho_M^2)(1-\rho_M)}\right)\left(\frac{(1-\rho_j)^2}{1+\rho_j}\right) - b_M - \sum_{i=1}^{n} h_i}$$

$j = j^*$, $j^* = \arg\min_{j \in J} C_T(S_1 \cdots, S_n)$, $S_j = \arg\min_{i=1,\cdots n} S_i$, $j = 1, \cdots n$. $j^* = \arg\min_{i=1,\cdots,n} \rho_i$

4.2 Decentralized Model

In decentralized decision-making model, every member of supply chain is to minimize his unit time costs. In most of practice, the basic stock level is decided by corresponding parts supplier. So the decision maker is suppliers.

$$Min \ \ CH_{S_i} = (b_i - h_{M_i})E[B_i] + h_i E[I_i] + h_{M_i} \max_{k=1,\cdots n}\left(\frac{\rho_k^{S_k+1}}{1-\rho_k}\right) \tag{6}$$

When $i \neq k$, $k = \arg\max_{k=1,\cdots,n}\left(\frac{\rho_k^{S_k+1}}{1-\rho_k}\right)$, the unique global optimal solution is Eq. (7).

$$\tilde{S}_i^o = \frac{\ln\left(\frac{-h_i(1-\rho_i)}{(b_i + h_i - h_{M_i})(\ln \rho_i)\rho_i}\right)}{\ln \rho_i} \tag{7}$$

When $i = k$, $k = \arg\max_{k=1,\cdots,n}\left(\frac{\rho_k^{S_k+1}}{1-\rho_k}\right)$, then $h_{M_i}(\max_{k=1,\cdots n} E[B_k] - E[B_i]) = 0$

$$S_i^o = \frac{\ln\left(\frac{-h_i(1-\rho_i)}{(b_i + h_i)(\ln \rho_i)\rho_i}\right)}{\ln \rho_i}, \ i \in \{1, \cdots, n\}$$

Because $0 < \rho_i < 1$, $\ln \rho_i < 0$, $S_i^o > \tilde{S}_i^o$, so $k^* = \arg\max_{k^*=1,\cdots,n}\left(\frac{\rho_{k^*}^{\tilde{S}_{k^*}^o+1}}{1-\rho_{k^*}}\right)$

$$S_i^o = \begin{cases} \dfrac{\ln\left(\dfrac{-h_i(1-\rho_i)}{(b_i + h_i - h_{M_i})(\ln \rho_i)\rho_i}\right)}{\ln \rho_i} & i \neq k^* \\ \dfrac{\ln\left(\dfrac{-h_i(1-\rho_i)}{(b_i + h_i)(\ln \rho_i)\rho_i}\right)}{\ln \rho_i} & i = k^* \end{cases} \tag{8}$$

4.3 Supply Chain Coordination

Comparing the centralized solution given in Eq. (5) with the decentralized solution given in Eq. (8). If $S_i^* = S_i^o$ for all parts, supply chain is coordinated. Otherwise, a coordination mechanism should be investigated between supplier i and the manufacturer. If $S_i^* < S_i^o$, for part i, a coordinating contract has to decrease the base stock level of supplier i. On the other hand, if $S_i^* > S_i^o$ for part i, the manufacturer should design a contract to encourage supplier i to choose a higher base stock level than decentralized solution.

So for supply chain collaboration, manufacturers should compensate inventory and backorder partial cost for suppliers whose decentralized solution do not equivalent to system centralized solution. And backorder and holding cost subsidy contracts is investigated to coordinate the supply chain.

In the backorder cost subsidy contract, the manufacturer pays the i the supplier $\alpha_{B_i} b_i$ per unit backordered, where $0 < \alpha_{B_i} < 1, i \in \{1,\cdots,n\}$. Then, after the subsidy, the average cost function per unit time for supplier i is modified to Eq. (9)

$$C_{S_i}^{B}(S_i) = \begin{cases} (1-\alpha_{B_i})b_i(\frac{\rho_i^{S_i+1}}{1-\rho_i}) + h_i(S_i - \frac{\rho_i(1-\rho_i^{S_i})}{1-\rho_i}) + h_i(\max_{k=1,\cdots n}\left(\frac{\rho_k^{S_k+1}}{1-\rho_k}\right) - \frac{\rho_i^{S_i+1}}{1-\rho_i}) & i \neq k^* \\ (1-\alpha_{B_i})b_i(\frac{\rho_i^{S_i}}{1-\rho_i}) + h_i(S_i - \frac{\rho_i(1-\rho_i^{S_i+1})}{1-\rho_i}) & i = k \end{cases} \quad (9)$$

Similarly, in the holding cost subsidy contract, the manufacturer pays the i th supplier $\alpha_{H_i} h_i$ per unit inventory at the i th supplier per unit time, where $0 < \alpha_{H_i} < 1, i \in \{1,\cdots,n\}$. Then, after the transfer payment, the average cost function per unit time for supplier i is Eq. (10)

$$C_{S_i}^{H}(S_i) = \begin{cases} b_i(\frac{\rho_i^{S_i+1}}{1-\rho_i}) + (1-\alpha_{H_i})\left[h_i(S_i - \frac{\rho_i(1-\rho_i^{S_i})}{1-\rho_i}) + h_i(\max_{k=1,\cdots n}\left(\frac{\rho_k^{S_k+1}}{1-\rho_k}\right) - \frac{\rho_i^{S_i+1}}{1-\rho_i})\right] & i \neq k \\ b_i(\frac{\rho_i^{S_i+1}}{1-\rho_i}) + (1-\alpha_{H_i})h_i(S_i - \frac{\rho_i(1-\rho_i^{S_i+1})}{1-\rho_i}) & i = k \end{cases} \quad (10)$$

After calculation, the value of α_{B_i} and α_{H_i} is as

$$\alpha_{B_i} = \begin{cases} 1 + \frac{h_i}{z^* b_i(\ln \rho_i)} & \text{if } S_i^* < S_i^o, i \neq k^* \\ 1 + \frac{h_i}{b_i} + \frac{h_i}{z^* b_i(\ln \rho_i)} & \text{if } S_i^* < S_i^o, i = k \end{cases} \quad (11)$$

$$\alpha_{H_i} = \begin{cases} 1 + \frac{z^* b_i(\ln \rho_i)}{h_i} & \text{if } S_i^* < S_i^o, i \neq k^* \\ 1 + \frac{z^* b_i(\ln \rho_i)}{h_i + z^* h_i(\ln \rho_i)} & \text{if } S_i^* < S_i^o, i = k \end{cases} \quad (12)$$

5. Numerical Example

A supply chain with three suppliers and a manufacturer is considered in numerical examples. There are 5 groups of parameters. The parameters are taken from [13] partially and given in the Table 1. Decentralized solution and centralized solution are depicted in Table 2 and Fig. 4 for suppliers 1, 2, 3. S_i^* presents the centralized solution S_i^o and decentralized solution. As we can seen from Table 2 and Figure 4 that average total costs per unit time of centralized system is always lower than the one of decentralized system. And we find that the cost of supplier will decrease while Manufacturers will not alwaysafter backorder and holding cost subsidy contracts.

Table 3 presents result after backorder and holding cost subsidy contracts. CP(%) is defined as the competition penalty as the percentage increase of the decentralized system over the backorder and holding cost subsidy policy system according to the average total costs per unit time. So whether Pareto improvement after coordination can be find out. “YES” or “NO” in the last column mean there is Pareto improvement or not.

We find that the cost of supplier will decrease while Manufacturers will not alwaysafter backorder and holding cost subsidy contracts. When $CP_M\%$ is negative value, manufacturers interests is damaged and no system Pareto improvement. In this simulation examples, the third suppliers to improve effect is the best.

Table 1. The data set (input parameter)

No.	***Service intensity***				***Holding cost per unit inventory per unit time for part i at Supply-hub***			***Holding cost per unit released work-in-process (WIP) inventory per unit time for the manufacturer***	***Backorder cost per unit backordered at Supply-Hub and manufacturer per unit time***			
	ρ_1	ρ_2	ρ_3	ρ_M	h_1	h_2	h_3	h_M	b_1	b_2	b_3	b_M
1	0.51	0.8	0.82	0.84	5	1.01	3.73	9.74	59.72	92.62	96.95	302.15
2	0.83	0.61	0.81	0.59	3.54	4.36	3.64	11.54	85.38	81.67	92.68	370.94
3	0.62	0.71	0.86	0.71	3.08	4.72	3.16	10.96	81.59	85.64	69.54	386.73
4	0.73	0.78	0.86	0.67	1.86	2.3	3.44	7.6	79.24	66.45	65.39	532.44
5	0.9	0.88	0.62	0.56	4.67	1.27	4.85	10.79	87.56	91.43	81.52	403.74

Table 2. The centralized and decentralized solutions

No.	S_1^*	S_2^*	S_3^*	S_1^o	S_2^o	S_3^o
1	0.935	8.854	10.611	3.216	19.656	16.098
2	19.304	4.974	16.426	16.793	5.4326	14.879
3	5.285	8.5623	25.543	6.335	8.07	20.285
4	11.334	15.447	29.091	11.376	13.082	19.359
5	37.561	29.356	4.706	27.809	32.862	5.468

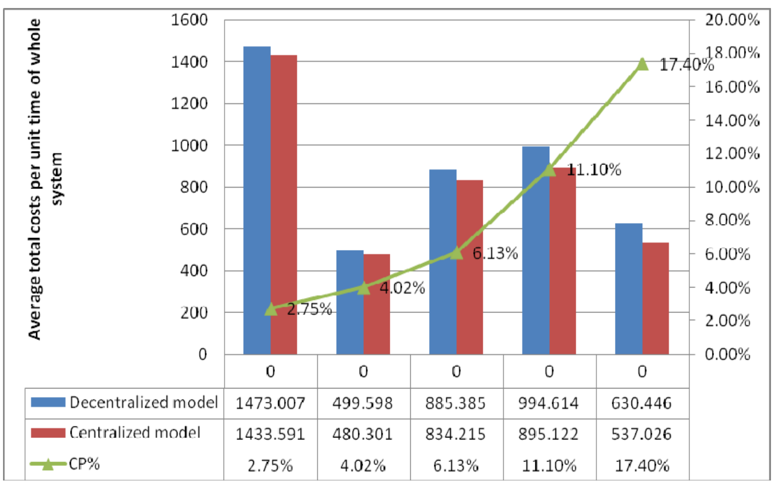

Figure 4. System performance comparison between centralized and decentralized models solutions

Table 3. The competition penalties for the suppliers and the manufacturer under the backorder and holding cost subsidy contracts and the contract parameters

NO	α_{B1}	α_{B2}	α_{B3}	α_{H1}	α_{H2}	α_{H3}	$CP_1(\%)$	$CP_2(\%)$	$CP_3(\%)$	$CP_M(\%)$	Pareto improving
1	0.817	0.893	0.689	0	0	0	126.348	90.436	49.456	-0.104	No
2	0	0.205	0	0.383	0	0.279	41.56	9.392	26.702	-3.489	No
3	0.394	0	0	0	0.161	0.558	20.544	13.141	80.747	1.802	Yes
4	0.013	0	0	0	0.448	0.779	3.433	60	202.962	5.015	Yes
5	0	0.357	0.318	0.654	0	0	114.912	13.464	16.397	3.2643	Yes
average value							61.3594	37.2866	75.2528	1.29766	

6. Conclusion

This paper investigates Supply chain coordination of the assembly manufacturer with Supply-Hub operation modes. All parts delivery of all suppliers are integrated at Supply-Hub. And needed parts on the production line are selected and packaged and sent to the manufacturer by Supply-Hub. The system is modeled as continuous queue and interarrival times of the manufacture are derived using an approximate distribution. Through the comparison, it can be seen that the average total costs per unit time of centralized system is always lower than the one of decentralized system. And the system with certain parameters can be coordinated by backorder and holding cost subsidy contracts. And these coordinated contracts are Pareto improving for whole system.

Acknowledgements

This work was financially supported by the talented person Foundation of Central South Forestry University of Science and Technology, Hunan Province Colleges and universities Scientific Research Projects (No. 12C0435). And the work was supported by Academic Exchanges to Lancaster University of UK by Central South University of Forestry and Technology.

References

Barnes et al. (2000). *On the strategy of Supply Hubs for cost reduction and responsiveness*. The Logistics Institute-Asia Pacific Report, Georgia Institute of Technology and National University of SingaPore.

Buzacott, J. A., Price, S. M., & Shanthikumar, J. G. (1992). Service level in multistage MRP and base stock controlled production systems. In Fandel, G., Gulledge, T., & Jones, A. (Eds.), *New Directions for Operations Research in Manufacturing* (pp. 445–463). Springer, Berlin. http://dx.doi.org/10.1007/978-3-642-77537-6_26

ElHafsi, M. (2009). Optimal integrated production and inventory control of an assemble-to-order system with multiple non-unitary demand classes. *European Journal of Operational Research, 194*(1), 127–142. http://dx.doi.org/10.1016/j.ejor.2007.12.007

Guruprasad, P., & Chen, Z. L. (2009). Joint cyclic production and delivery scheduling in a two-stage supply chain. *International Journal of Production Economics, 119*(1), 55–74. http://dx.doi.org/10.1016/j.ijpe.2009.01.007

Li, J. Z., Ma, S. H., Guo, P. L., & Liu, C. L. (2009). Supply chain design model based on BOM- Supply Hub. *Computer Integrated Manufacturing Systems*, *15*(7), 1299–1306.

Ma, S. H., & Gong, F. M. (2009). Collaborative Decision of Distribution Lot-sizing among Suppliers.

Ma, S. H., & Gui, H. M. (2009). *Based on supply chain coordination of drive technology and management: principles and applications.* Huazhong university of science and technology press 2009.

Peral, T. P., & Füsun, U. (2011). Coordination in a two-stage capacitated supply chain with multiple suppliers. *European Journal of Operational Research*, *212*(1), 43–53. http://dx.doi.org/10.1016/j.ejor.2011.01.018

Reiman, M. I., & Wang, Q. (2012). A stochastic program based lower bound for assemble-to-order inventory systems. *Operations Research Letters, 40*(2), 89–95. http://dx.doi.org/10.1016/j.orl.2011.12.001

Roshan, G. (2001). Collaborative Scheduling Model for Supply-Hub Management. *The 3th Asia Engineering*

Conference, 32–39.

Shah, J., & Goh, M. (2006). Setting Operating Policies for Supply Hubs. *International Journal of Production Economics*, *100*(2), 239–252. http://dx.doi.org/10.1016/j.ijpe.2004.11.008

Song, J. S., & Zipkin, P. (2003). Supply Chain Operations: Assemble-to-Order Systems. Elsevier.

Terekhov et al. (2012). Solving two-machine assembly scheduling problems with inventory constraints. *Computers & Industrial Engineering, 63*(1), 120–134. http://dx.doi.org/10.1016/j.cie.2012.02.006

Timmer, J., Chessa, M., & Boucherie, R. J. (2013). Cooperation and game-theoretic cost allocation in stochastic inventory models with continuous review. *European Journal of Operational Research, 231*(3), 567–576. http://dx.doi.org/10.1016/j.ejor.2013.05.051

Togar, M., & Simatupang, R. S. (2008). Design for supply chain collaboration. *Business Process Management Journal*, *14*(3), 401–418. http://dx.doi.org/10.1108/14637150810876698

Xiao, Y., Chen, J., & Lee, C. Y. (2010). Optimal decisions for assemble-to-order systems with uncertain assembly capacity. *International Journal of Production Economics, 123*(1), 155–165. http://dx.doi.org/10.1016/j.ijpe.2009.07.012

Yu, J. H., & Ma, S. H. (2010). Comparative Research on Col laborative Supply China Based on Distributed VMI and Supply Hub. *Industrial Engineering and Management, 15*(1), 39–45.

Zhang, X., Ou, J., & Gilbert, S. M. (2008). Coordination of stocking decisions in an assemble-to-order environment. *European Journal of Operational Research, 189*(2), 540–558. http://dx.doi.org/10.1016/j.ejor.2007.05.047