Performance Analysis of Information Sharing and Order-to-Delivery Processes in a Supplier Hub

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1. ABSTRACT

This paper deals with two models developed to analyze the performance of information sharing and various order-to-delivery processes (ODPs) in a supplier hub. Four suppliers are considered in the models developed for supplier hub. Various ODPs considered in the models are the traditional re-order level process (ROL), the maximum order upto quantity process (MOUQ), the just in time (JIT) delivery process and the commonly used "ordering once in every two weeks " process. The first model takes four suppliers and analyzes the performance in terms of the demand forecast sharing, inventory variations, lead-time, inventory accumulation, and the number of orders placed by the supplier hub to all the suppliers. In the second model the performance is measured with cost parameters, taking two different scenarios with same demand, lead-time, and suppliers. In first scenario all the suppliers follow MOUQ process and in the second the same suppliers follow ROL process. The results give the supplier hub owner and the OEM a better understanding of the various ODPs considered and would help in selecting the best ODP.

Keywords: order-to-delivery process, re-order level, just in time, information sharing.

2. INTRODUCTION

In today's global business arena, competition is marked by volatile demand, decreased customer loyalty, shorter product life cycles, and mass customization. It is important for businesses to gather vital information and act quickly on it. When a number of companies are in alliance, there is a need for collecting accurate, comprehensive and timely information and sharing it with the partners. [8]. This will enable the partners to make decisions based on global information that benefits the entire process. Most of the activities along a supply chain will have an effect on the delivery time of the end product, the important one being the supply of the components by the supplier before assembly. Supplier management, which takes care of the performance of the suppliers and their deliveries, should be given high level of importance to have a smoother supply chain. The type of ODP between supplier hub and the suppliers plays an important role in the delivery time, and the selection of a particular ODP mainly depends upon the location, production and transportation capacity of the supplier, lead-time, and the storage capacity of the supplier hub. Proper selection of a delivery process for a supplier will benefit both the supplier and the owner of the supplier hub which in turn adds value to the overall supply chain and to results in higher service levels between supplier hub and the customer (the OEM for whom the supplier hub works).

The models described in this paper show the management of suppliers and available information by a supplier hub owner in terms of the operations in-between the suppliers and the OEM. Four different ODPs are considered which are commonly used in the present supply chain. Comparing these processes and coming out with a model which would quantify the operational efficiencies of these processes, would be a useful finding for a supplier hub to decide on which process to follow with and the ways to utilize the potential information available. This performance analysis for various ODPS with a supplier hub is modeled in simulation software "Ithink" and the second model is developed in Microsoft Excel.

2.1 Supplier Hubs

The primary aim of any manufacturing company (OEM) is to reduce inventory at its production site, ensuring maximum production efficiency. The concept of "Supplier Hub" is to provide manufacturing support and supply chain solutions to the OEMs. In this case, the supplier management responsibility is given to a supplier hub by which the OEM could concentrate in its core competency. The supplier hub considered manages the suppliers, provides logistics support to the OEM, manages the ODPs of the suppliers, and aims at optimizing the performance of the supply chain.

The supplier hub operator serves as an intermediator, manager, and facilitator of the storage of goods, inventory levels, managing multiple supplies for the OEM.

Traditional ways of supplying materials saw the title of goods transferred upon delivery to the OEM's storage facility. With the supplier hub, the required materials for the future production would be delivered, stored and maintained at a place "supplier hub" close to the manufacturing site. The OEM has to deal with only one supplier, the owner of the supplier hub who in turn manages the suppliers of the OEM. While goods are stored in the supplier hub, the ownership of all materials would remain with the respective suppliers [1].

The supplier owned inventory program is that a supplier hub, which will provide a single source material, provision for the OEM. The streamlining in the supply chain is achieved by the close partnership between the OEM, supplier and the supplier hub owner.

2.2 Information Sharing

In this model, the demand forecast of the OEM is shared with the suppliers and supplier hub on a fortnight basis. Every time the supplier receives an order from the OEM, he also receives updated and initial forecast demand values for the future weeks. For instance, the first day of the first week the supplier receives the following through EDI or Internet.

The firm orders for 3rd and 4th week.

Updated demand forecast for 5th and 6th week

Initial demand forecast for 7th and 8th week

On receiving these forecast details, the supplier works on his production schedule for the first two weeks. This is a process performed two weeks once upon receiving the forecast values from the OEM. The production schedule would be made visible to the suppliers' suppliers who also become a part of the supply chain.

3. FORMULATION OF MODEL

3.1 Suppliers of the Supplier Hub

In the "Ithink" model, four suppliers are considered supplying to the OEM through supplier hub. The types of ODPs followed are discussed here.

The first supplier is an overseas supplier and the lead-time varies between 4 and 13 days. To avoid delivery uncertainties because of the variation of the lead-time, the supplier hub keeps two weeks inventory at its hub for supplier one components. The order quantity is equal to the firm orders received from the OEM. The supplier hub places the orders once in every two weeks.

Supplier two follows the traditional re-order level for delivering components to the supplier hub [3]. This supplier could be situated either overseas or locally placed near to the supplier hub. The ROL strategy is followed by the supplier hub with reference to the inventory level of supplier two components at the hub, the safety stock and the lead-time for the delivery. Orders are placed whenever the inventory at the hub for S2 falls below the ROL.

Supplier three is considered to be a local supplier and follows a Just in time delivery to the supplier hub. The local transport time is very less and delivery is made twice a day. This supplier receives the orders from the supplier hub once or twice a day depending upon the daily requirement of OEM and delivery is made immediately.

Supplier four follows a maximum order up to quantity policy and receives orders from the supplier hub at regular intervals [3] [4]. This supplier could be either local or situated at overseas. The value of MOUQ depends upon the inventory level at the hub on the particular day on which the order is supposed to be placed, and the future demand. The quantity to be ordered is the difference between the inventory level on the ordering day and the value of MOUQ. The value of MOUQ is generally arrived with past performance history or with a simulation with forecasted demand.

3.2 ITHINK-Software

The full model is built with the help of the software Ithink. The Ithink software is designed for increasing the effectiveness of the set of processes by which we render, simulate, analyze and communicate our mental models. Ithink provides a comprehensive set of tools to create any type of simulation model.

3.3 Operations of the Supplier Hub

The supplier hub receives the components on various days of a month and upon receiving, the components are stored in separate places in the hub. The hub places orders to the four suppliers following the various ordering procedures discussed earlier. Based on the lead-time, the components reach the hub. The OEM places order daily twice and it is delivered from the hub depending upon the availability of the four various components. Kitting takes place at the hub by which the four various components from the four suppliers are assembled before being delivered to the OEM. Hence to satisfy every unit of OEM's need, the hub needs one component each from all the suppliers to do the kitting process and deliver one unit to the OEM.

The Ithink model is created to operate the supplier hub operations described above. The production schedules for the suppliers are charted with the demand forecast and firm order values in excel spreadsheet. This excel spreadsheet is linked with the Ithink model so whenever the demand forecast and order quantities are inputted to excel spreadsheet, there will be an update in the production schedule which will be reflected in the Ithink model.

The supplier hub diagram shown below in figure 01, explains the material and information flow that take place in a supplier hub scenario with information sharing. Demand forecast, daily order details, delivery details from the supplier hub to customer and inventory details at the suppliers and supplier hub ends are the potential information shared in the supplier hub model.

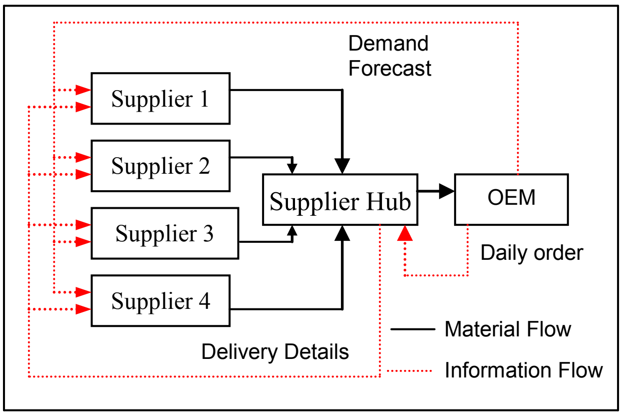


Figure 01: Line diagram of the supplier hub

4. COMPUTATIONAL RESULTS

The model consists of numerous equations for determining the inventory values, production schedules, the back order quantity values, fulfillment rates and other support variables.

4.1 Notations

S1 – Supplier One

S2 – Supplier Two

S3 – Supplier Three

S4 – Supplier Four

IS – Information Sharing

TC – Total cost

ROL – Re-order level

MOUQ – Maximum order upto quantity

ODPs – Order-to-Delivery Processes

4.2 Assumptions

The average OEM demand: 1200

Production capacity for S1 & S2: 1200/week.

Overtime/day = 50 (if needed, based on the forecast)

Production capacity for S4: Min: 100; Max: 150.

Minimum order value for S3 & S4: 50

The model is run for five months (5 * 28 (4 weeks) days with two time steps per day). Initially to start the simulation, the inventory levels at each supplier and the supplier hub are assumed. The demand forecast values and firm orders are inputted to the model and the results are arrived with. Hundred percent service levels are targeted between supplier hub and OEM.

4.3 Analysis of the output values

The demand values (the forecasted and firm orders) are shown in the table 01. The values are shown in different colors. The supplier, from the OEM receives each set of colored values at 15 days interval.

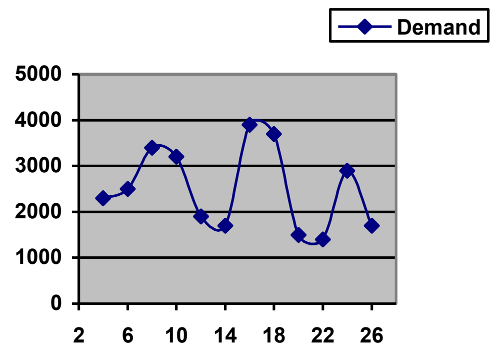
Table 01: OEM Demand Forecast and Firm Orders

Weeks/ Month	Initial forecast	Updated forecast	Firm orders	Received
Week3 (1)	-	-	1150	Week 1
Week4 (1)	-	-	1250	
Week5 (1)	-	1200	1100	Week 3
Week6 (1)	-	1200	1300	
Week7 (2)	1800	1700	1700	Week 5
Week8 (2)	1700	1600	1700	
Week9 (2)	1700	1600	1600	Week 7
Week10 (2)	1650	1700	1600	
Week11 (3)	900	800	900	Week 9
Week12 (3)	1150	1000	1000	
Week13 (3)	900	900	900	Week 11
Week14 (3)	900	800	800	
Week15 (4)	1800	1700	1900	Week 13
Week16 (4)	2000	2000	2000	
Week17 (4)	1900	1900	1800	Week 15
Week18 (4)	1900	1900	1900	
Week19 (5)	600	550	700	Week 17
Week20 (5)	850	800	800	
Week21 (5)	800	900	800	Week 19
Week22 (5)	750	700	700	
Week23 (6)	1400	1300	-	-
Week24 (6)	1500	1500	-	-
Week25 (6)	900	-	-	-
Week26 (6)	950	-	-	-

Table 01, shows forecasted demand and firm orders received by the suppliers from OEM during the simulation period. This demand pattern is shown in the graph 01. From table 01, it is clear that the suppliers, on the first day of the first week, will have an idea of what OEM needs upto 8th week. With the help of these demand forecast and firm order, the suppliers' material requirement planning and production schedule are charted out.

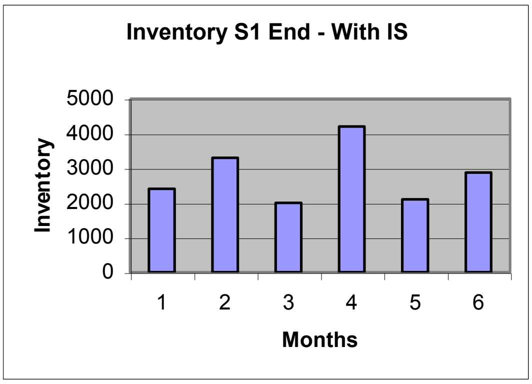
4.3.1 Demand and Inventory Variations

Graph 01: Hockey stick demand pattern considered.



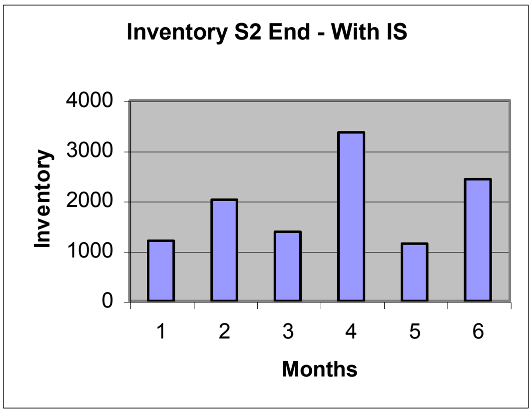
Graph 01 shows the hockey stick demand pattern over a period of 24 weeks (6 months). The hockey stick demand pattern was chosen as it closely matched with the present electronics supply chain demand pattern. Each point in the graph shows two weeks demand.

Graph 02: Supplier one end inventory levels with IS



Referring to Graphs 02, 03 and 04 which show the inventory levels at the suppliers' end with information sharing, if the inventory values at the beginning of each month are taken into consideration, depending upon the future requirement (demand), the levels of the inventories at the suppliers' end changes. For instance, the requirement from weeks 07 to 10 (month 2), table 01 is well above the average demand of 1200. If the corresponding inventories are seen in the graphs shown above, inventory levels follow the demand. Similarly the requirement from weeks 11 to 14 (month 3) is well below the average demand. Corresponding to this period, the inventory levels dip for all suppliers, which could be seen in the graphs. This advantage is leveraged through the possible sharing of demand forecast information from customer to the suppliers well before the actual requirement period.

Graph 03: Supplier two end inventory levels with IS



Graph 04: Supplier four end inventory levels with IS

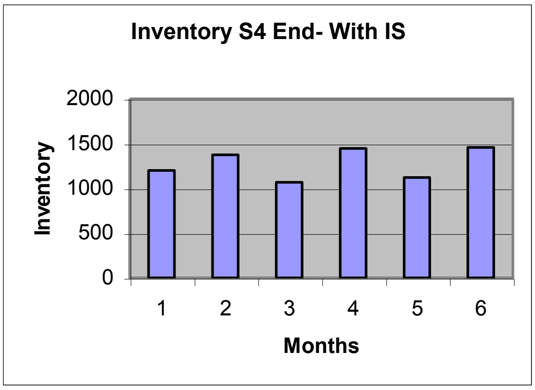


Table 02: Lead-time details for supplier one (overseas)

Months	1	2	3	4	5
Lead-time	10/11/11	5/8/8	5/7/7	3/7/9	8/9/9

* Ideal LT/ Actual for Order1/ Actual for Order2

Table 03: Inventory accumulation for suppliers at supplier hub

Suppliers/ Months	S1	S2	S3	S4
One	152393	27593	9321	35394
Two	125909	41973	10765	38356
Three	139811	27655	13937	32888
Four	124765	44909	11653	47955
Five	114769	27328	10200	33271

Table 04: Ordering details for suppliers from supplier hub

Months	S1	S2	S3	S4
One	2	6	48	6
Two	2	7	50	10
Three	2	5	52	7
Four	2	9	52	10
Five	2	4	47	6

4.3.2 Inventory Accumulations and Ordering Details

From table 03, which gives the value of inventory accumulation for every month for all the suppliers the following are inferred.

The inventory accumulation at the end of each month gives a clear picture in selecting the supplier's delivery process. S1, an overseas supplier with lead time varying between 4 and 13 days, the inventory stored at the supplier hub was more and hence the huge accumulation. The least accumulation is S3's component at the hub. S3 delivered daily twice depending upon the OEM's orders to the supplier hub. This made the hub to carry very less inventory (only safety stock) for supplier three.

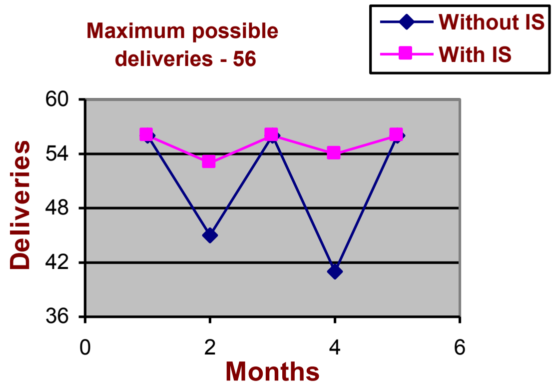
Compared between S2 and S4, the inventory accumulation levels for S2 components are lesser than that of S4. S2 followed ROL and S4 followed MOUQ. The values show that S2 is more effective in terms of inventory accumulation. Also referring to table 04, maximum numbers of orders were placed to S3 all the time, followed by S4 and S2. Though S2 and S4 contribute to the higher fill rates between supplier hub and OEM, S4 incurs more cost because of more inventory storage. In this model, the lead-time for S2 and S4 are different. The second model developed in Excel takes same lead-time for both ROL and MOUQ models and the results are cost oriented which validates the findings of this model.

4.3.3 Lead-time Uncertainty

The inbound logistics to the supplier hub varies between the suppliers because of the different ODPs. Referring to table 02 which shows the lead-time details of supplier one, for month 4, the values show that even though the components were ready for shipping, at the S1 end, with a lead-time of 3 time steps (1 and 1/2 days), there was a delay in both the deliveries (S1 delivers twice every month) because of the non - availability of the ship cargo/air cargo and the element of uncertainty involved in the freight forwarding and customs clearance time. The availability of cargo space was assumed to be only on certain days. If the components arrive with minimum lead-time, then the accumulation at the supplier hub for that particular month will be more and if the components arrive with maximum lead-time, the pipeline inventory time increases which is also a cost for supplier one. For suppliers two and four randomly distributed lead-times are assumed for the model.

4.3.4 Fill Rate Comparison

Graph 05: Fill rate details between supplier hub and OEM.



Graph 05 compares the fill rates achieved between the supplier hub and the customer (OEM) with and without information sharing. Every month was considered with 28 days and with two deliveries per day from supplier hub to customer. Hence 56 deliveries would be the maximum deliveries possible if the customer orders twice on all days. Due to the sudden rise in the demand in two places (2nd month and 4th month), there was a drastic fall in the fill rate on those two months without proper sharing of information. This graph consolidates the effort of the value of information sharing pattern in terms of the delivery service level, in a supplier hub.

The Ithink model developed showed the importance of information sharing and various order-to-delivery processes. Suppliers with long lead-time should follow a process in which they keep a minimum inventory at the supplier hub. Supplier one in the model is an overseas supplier and maintains two weeks inventory at the hub to avoid reduction in service levels between supplier hub and OEM because of delayed delivery.

Just in time delivery is really suitable where the hub has minimum space constraints and cannot accommodate the supplier's components and at the same time supplier has the capacity to fulfill the daily order received from the hub. The decision-making constraints for JIT would be capacity and location of the supplier and space availability of the supplier hub. The location of the supplier near the supplier hub would benefit the supplier in terms of transportation cost, as the number of deliveries is more for JIT process.

The following is a supplier hub model which compares MOUQ and ROL models and analyses the performance the same with respect to the cost parameters and validates the findings of the Ithink model which says that ROL is more effective than MOUQ model.

5. EXCEL MODEL

This model compares the performance of ROL and MOUQ delivery processes. Four suppliers are considered with different lead-time and demand following MOUQ in the first scenario and ROL in the second scenario.

5.1 MOUQ model

The model is simulated to arrive with the optimum value for MOUQ for a given demand pattern, lead-time and ordering days. The model is simulated for 100 days. With a normally distributed demand, constant lead-time and ordering days, orders are placed by the supplier hub to the suppliers to achieve 100 % fill rate between supplier hub and OEM. The orders are placed at regular intervals, i.e. on days known as ordering days. The order quantity is calculated as follows

Order quantity = MOUQ – (Inventory on hand + pipeline inventory)

The total cost for each supplier is calculated as follows.

Total Cost = Holding cost + Handling cost + Ordering cost

5.2 ROL Model

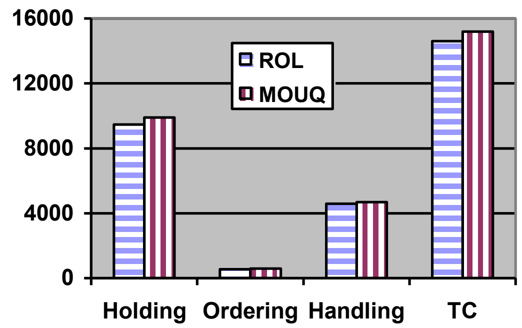
The same excel simulation is run to arrive with the optimum ROL values for the suppliers. The initial inventory levels, the lead-time and the demand pattern are the same values as in the previous case so as to compare the performance. The optimum ROL values are calculated using the formula

*ROL = safety stock + (lead-time *demand during lead -time)*

5.3 Analyzes of Excel Models

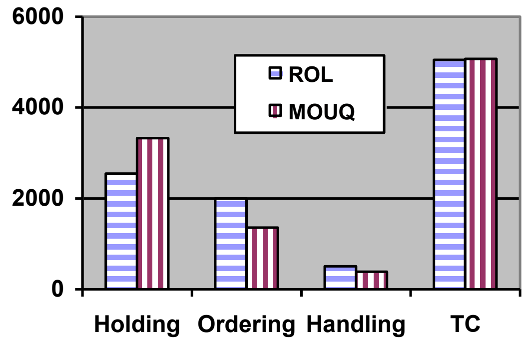
The following graphs show the comparison between MOUQ and ROL models. Referring to graphs 06 – 09, the holding cost, which depends on the closing stock for each supplier's components, is more in case of MOUQ for all suppliers. This shows clearly that MOUQ is less efficient than ROL. The ordering cost mainly depends on the number of orders during the simulation period and the number of orders in case of ROL is more for S2, S3 and S4 and hence higher ordering cost. In the present advancement in IT world, orders are being placed either through Internet or electronic data interchange (EDI). If these IT sources are used effectively, the ordering cost will be very less and in turn reduces the total cost. At the same time, more number of order indicates more number of transportation and hence transportation cost. Since the pipeline inventory is more or less the same, which means the same numbers of components are transported from the suppliers' end to the supplier hub, the transportation cost will be same in both cases. If the transportation cost is calculated on number of deliveries, the distance covered then the location of the supplier with respect to the hub should be considered before selecting the ODP.

Graph 06: Cost comparisons for supplier one.

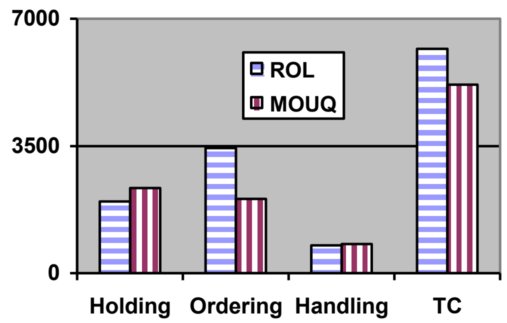


Referring to graphs 10 – 13, closing stock is the accumulation of inventory at the supplier hub during the period (100 days) of simulation. The results arrived with the excel model is similar to that of I think model this accumulation. MOUQ process carries more inventories for all suppliers at supplier hub. The total quantity ordered for all suppliers, in both scenarios is almost same which is because of the same demand considered in both cases.

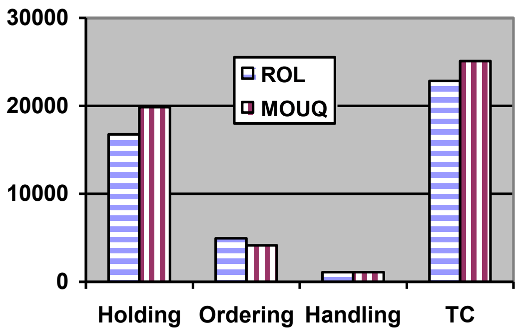
Graph 07: Cost comparisons for supplier two.



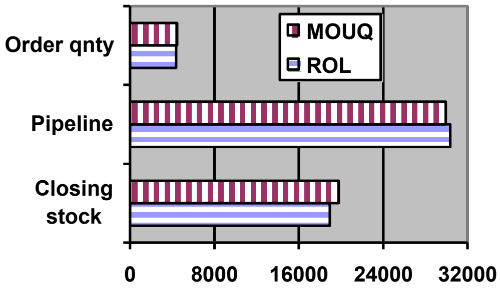
Graph 08: Cost comparisons for supplier three.



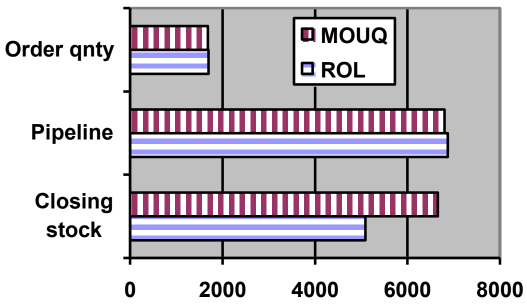
Graph 09: Cost comparisons for supplier four.



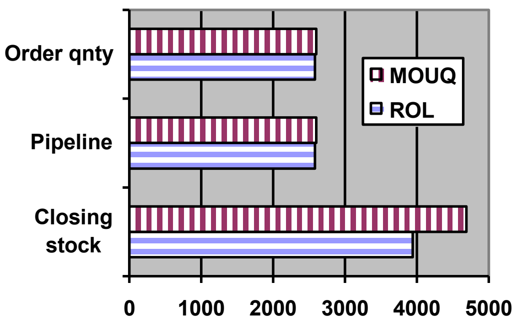
Graph 10: Supplier one – quantity comparison.



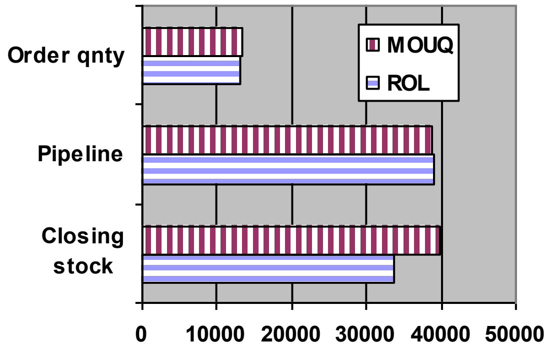
Graph 11: Supplier two – quantity comparison.



Graph 12: Supplier three – quantity comparison.



Graph 13: Supplier four – quantity comparison.



Considering the transportation costs for MOUQ and ROL models to be same since similar type of suppliers are considered, it could be seen that the total cost for suppliers one, two and four are less in case of ROL process showing the re-order level process more effective than maximum order upto quantity process.

6. CONCLUSIONS

The objectives of this work were to simulate a model to analyze the impact of information sharing and the performance of the suppliers following various order-to-delivery processes. The Ithink model clearly showed the value of information sharing with the level of fill rate achieved with shared information during the simulation period. “Information replaces inventory” is a common saying, which is proved in optimizing the inventory levels at the suppliers’ ends. There is an important element associated with the sharing of potential information, which is the level of confidentiality expected from the partners while sharing information. But it is the trust between the parties that is important to realize the benefits of information sharing.

The trade off between ordering cost, inventory holding cost and the transportation cost is the main concern and should be achieved depending upon the facility available in the supplier hub and at the supplier. This analysis shows that the various delivery processes suit the suppliers and supplier hub on a case-by-case basis. The supplier hub should therefore analyze the past performance history of a supplier and its ability to maintain required service levels before deciding on the type of ordering process to be followed.

It could be concluded that ODP plays an important role in supplier management and it decides the delivery time between the suppliers and the supplier hub. The more efficient the ordering process is, the lesser the time for delivery. Particularly in electronics supply chain where the product life cycle is very less, non-delivery of components at right time and keeping more inventories will result in financial loss to the partners along the supply chain. In simple terms both models developed, work towards “delivery to promise”.

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