University at Buffalo School of Management

Supply Chain Game Report

MGO 638: Logistics Management

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Part one: One Region

In the first phase, there is only one region, called Calopeia, with an uncertain demand. The demand data are given for the first two years, and we are going to decide about the inventory management strategies and capacity planning for the next upcoming two years. To plan for the game, it is required to predict the demand for the next upcoming two years. As displayed in Figure 1, the demand trend has a seasonal behavior with no trend. To forecast the demand for the following two years, we decided to use the average demand for each day of the year, based on the data given for each two years. In other words, the predicted demand for each day of the year equals the average demand for the same days in the first and second year. Figure 2 represents the predicted demand for the upcoming years.

- **Inventory Management**

The demand prediction reveals that it is possible to split the demand into quarters and make decisions based on the variations in each quarter. Considering the average demand in each quarter and the continuous review inventory model denoted as (R, Q) model, we modified the EOQ (given in Exp. 1) to set the production plan, safety stock (given in Exp. 2), reorder point (ROP) with a 95% of service level (given in Exp. 3), and capacity planning. The Exp. 1 to 3 give the EOQ, ROP and Safety Stock (SS) formula, where k is the ordering cost, D is the annual demand, H is the holding cost, σ_L is the standard deviation of demand, L is the lead time, μ_L is the mean demand during lead time. Based on the information given, the ordering cost equals to $1500, and the holding cost equals to $200 (H=100+(0.1*1000)). Lead time is subject to the mode of transportation from the factory to the house. 7 days for truck and one day for mail service. In the beginning, we selected truck as transportation mode and 7 days lead time. Also, we considered service level to be 95% to optimize inventory. Making any further increment in service level would incur extra inventory holding cost as buffer inventory (safety stock) will be high.

- **Capacity planning**

Since the decision to increase the capacity takes 90 days to apply, and the average demand in the second quarter was above the current capacity, we decided to increase it up to 40 units per day at the beginning of the game.

- **Transportation Mode**

As given in the problem description, two modes of transportation are available, including mail, with the highest cost but lowest lead time (1 day), and Truck with the far lowest cost but a 7-day lead time. To minimize the expenses of transporting drums from the factory to the warehouse, the cost difference must be calculated for both truck and mail options. If a truck can carry 200 drums and the trip cost is $15,000, the cost per drum would be $75. Conversely, mailing a drum would cost $150, which is double the cost of using trucks. Therefore, it would be preferred to use trucks for transportation, but transportation time and the number of drums per truck must be considered as well. To avoid losing demand, it is crucial to adjust the schedule and track completion while considering mail as the preferable option for transportation. The solution is to use mail when the number of drums is 100 items or less than 100 items. Regarding the transportation mode, the lead time would be estimated as 7 days if truck is selected and 1 day if the mail is set. Table 1 gives the detailed calculations for each quarter.

Our strategy:

As mentioned earlier, our first step was to increase the capacity to meet the average demand of 39/day. We set our EOQ and ROP after computing the values as per the mathematical formula (Avg. Demand, 39/day; Lead time, 7 days; CSL, 95%). Considering that the order quantity was more than 100 units, we opted to ship through trucks. In the second quarter, we expected a rise in avg. demand and adjusted the EOQ & ROP accordingly. Later, we assumed that keeping these figures (EOQ & ROP) would result in extra inventory holding costs as average demand was expected to be 19/day. Hence, quarter 3 to 7, we lowered our figures, EOQ-318 and ROP-234. Lastly, in the 8th quarter, we assumed, as per past demand information, that average demand would be 8 units/day. Hence, we further lowered our figures, as mentioned in the table. On day 1397, we further lowered our figures to order quantity-35 and ROP-5, and switched transportation mode from truck to mail service. It was done to reduce the risk of left over inventory at the end of simulation. We assumed that average demand would be 8 to 15 units/day, and we needed just two days (one day for production and another day for mail shipping).

Conclusion:

At the end of the game, we had managed to accumulate around $5.5 million in cash, but there were some decisions we could have corrected to improve our cash position. For instance, we should have kept the EOQ quantity at 400 units instead of 463 units to minimize transportation costs via truck. Additionally, keeping the ROP figures high would have helped us accumulate inventory at the warehouse and meet customer demand during peak demand cycles. Although we increased factory capacity by 20 units to cater to the average demand of 39 units, we underestimated the increase in demand during peak cycles, resulting in a significant loss of demand during that period. Increasing the ROP figure would have been a good alternative to cope with the spiked demand. Furthermore, during the low demand cycle, we tried to be more conservative in cost savings by varying our EOQ and ROP figures. Instead, we should have kept the same EOQ and high ROP to accumulate inventory to meet the demand during peak times. Lastly, we reduced our EOQ and ROP to 200 and 100 units, respectively, on day 1,348 in anticipation of minimizing the loss of unsold inventory. However, we should have waited until day 1,450 to reduce these figures, resulting in a significant loss of demand and lower cash flows.

Part two: Network Design

In the second part of the simulation, the initial situation is much more complex. This time, we must handle five regions. Among those, four are on the same continent and one is on a separate island, it is Fardo. We have some data about the demand shape of each region. Calopeia remains the same as in the first part with a strong seasonality (Figure 1). For all other regions, demand starts after day 640. Sorange has a demand that continues to grow linearly from day 640 to the end of the simulation at day 143 (Figure 3). On the other hand, Tyran also grows after day 640 but reaches its pick average demand around 30 days later (Figure 4). No trend or seasonality can be identified. The first three region all have an average demand size of 8 drums. The last two regions involved in the simulation are Entworpe and Fardo. In the case of Entworpe, it is caracterized by a highly random demand that only appears with 250 drums demand (Figure 5). Demand appears to be stable after day 670 and we cannot find any seasonality or trend in the long-run average. Finally, Fardo, the isolated region has a demand that is random in both timing and size (Figure 6). At first, it is highly unstable. Eventually, there is no seasonality nor trend and the demand is stable after day 670. In this phase, we are faced with the following decisions: for each region, whether to add additional warehouses and factories, whether to expand the capacity of existing factories, and which regions can be served by each warehouse.

- **Cost calculations**

In this section, the formula and related calculations are given in Exp. 4 to 6 for transportation and holding costs, as well as the profit per drum for three different scenarios. Transportation cost is minimized when full truckloads are used compared to mail. The summary of the results is given in Table 2. As can be seen from Table 2, the profit will be lost by producing and selling products separately on the continent and in Fardo. Therefore, our team decided that products produced in Fardo will only be sold in Fardo, and products produced in continent will be sold in continent.

- **Launching warehouses and factories**

Assuming all demand is satisfied, the profit of launching and not launching new factories in each region is calculated as given in Exp. 7 and 8. By separately estimating the profit of setting up a factory and a warehouse and not setting up a factory and a warehouse in different regions, our team decided to launch a new factory and a warehouse in Fardo. Although Table 3 shows that the profit of setting up a factory in Tyran is higher than that of not setting up a factory in Tyran, there is no need to add additional capacity if the plant is not set up in Tyran, because Calopeia region has 70 drums of capacity per day (31 drums of excess capacity per day) to meet the demand of Tyran region. Meanwhile, because of demand uncertainty, it is better to aggregate demand across different regions. In this case, demand variability can be reduced.

- **Inventory Management Strategy in each Region**

\- **Caleopia**

For Caleopia, we added a factory and a warehouse to meet the daily average demand (D) of 39 drums per day in Caleopia and 41 drums per day from other regions in the continent. It was discussed already that demand in Caloepia has strong seasonality while no trend or seasonality observed in other regions. We used the same periodic review models (R, Q) for calculating EOQ, and ROP in this section. The ordering cost (k) to be $1500 is given in game information, the holding cost (H) calculated as average of same and different regions on continent holding costs from the above cost calculations section which is equal to $209. Thus, using formulae for EOQ calculation from Expression 1 of the first part, we calculate the EOQ for Caloepia to be 650 drums. In the game we set the EOQ round off to 600 considering the freight benefit of transporting by three trucks at a time where each truck can carry maximum 200 drums at a time. The ROP was set to 99999 for Caloepia keeping consistent with continuous production and meeting average daily demand across the regions on continent.

\- **Fardo**

For Fardo, which is an island, must build a factory and warehouse regarding the fact that transporting from mainland to island or vice-versa would not be profitable to meet the daily average demand (D) at Fardo which is 16 drums which starts from 640th day and ends in 730th day.

For calculating EOQ, we are given with the information on an ordering cost (k) of $1500 per drum and holding cost for same region (H) is $207.50 from the information in cost calculations section given above. Using Expression 1 formulae for EOQ it is calculated to 288 drums. Transportation by truck is economically viable here but limited to 200 drums a single trip. So, we set the EOQ for Fardo to 200 drums to meet the demand within island. The optimized service level is 95 percent where z=1.65 and lead time (L) is 7 days for transporting by truck which was chosen. The Standard deviation of demand (sL) calculated is 17 drums. The mean demand during lead time (mL) is equal to average daily demand (D). Therefore, the ROP for Fardo is calculated using the Expression 2 formulae from first part is 187 drums. We set the ROP to 400 drums to meet the demand surge and keep up the buffer stock in hand.

Capacity Planning

To meet the demand across the four regions, there was a requirement to add at least two factories to the continent. Cost of building a new factory would be $500,000 per location or upgrading the capacity of existing factory at Caloepia would take 90 days. Therefore, upgrade the capacity of the existing factory at Caleopia to meet the anticipated daily average demand across the four regions. Also build a new factory and warehouse only for Fardo to meet the demand on the island only. From the above we raised the capacity for Caloepia to 81 drums per day which is the aggregate average daily demand for four regions in continent. For Fardo the capacity was set to 16 drums per day, which is the average daily demand.

Transportation

The transportation across the regions within continent and within the island Fardo was chosen by truck method. The reason for choosing truck over mail was to keep the overall logistic cost economical. Transporting each drum, transporting within the region cost $75, across different regions is $100, and between continent and Fardo is $275. Whereas the transportation by mail for each drum within the same or different regions in the continent is $150. Shipping by mail from island to Continent or vice-versa would be $400 per drum. It is evidently true to choose truck transportation when the lead time is 7 days.

- **Conclusion**

By the end of the game, we had accumulated approximately $21.89 million in cash. However, there is always room for improvement when it comes to increasing our cash position. Based on our experience in the first game, we learned that it is important to maintain consistency in our order quantity (EOQ) and to keep our ROP figures high to handle peak demand periods. While we made a good strategic decision to open a new factory and warehouse in Fardo, we missed an opportunity to establish an additional factory and warehouse in Sorange to accommodate the significant increase in demand that occurred towards the end of the third year. This spike in demand was unexpected, and the previous demand data that we received at the beginning of the game did not account for such peak demands. We were uncertain whether this demand pattern would continue in the future or if it was a temporary phase. Although establishing a new factory would have required a significant capital expenditure of $500,000, we understood it would take 90 days to establish a new factory or increase capacity at Calopeia. By that time, demand may have fallen. Therefore, we decided not to establish a new factory. However, we should have established a new factory and warehouse in Sorange to meet the rise in demand. In conclusion, the Supply Chain Game is a valuable exercise that provides students with hands-on experience in managing supply chain networks. The game honed our skills to make strategic decisions about production, inventory, and transportation, all while considering market demand and optimizing cash flows. Overall, we as a team felt that the Supply Chain Game is an effective tool for developing critical thinking, problem-solving, and decision-making skills in the context of supply chain management.

Appendix:

A. Expressions

$$EOQ = \sqrt{\frac{2kD}{H}} \quad (1)$$

$$Safety\ Stock = z_{0.95} * \sigma_L \quad (2)$$

$$ROP = L * \mu_L + Safety\ Stock \quad (3)$$

Transportation Cost per drum (by truck) = (Cost per Truckload)/ (Truck capacity) (4)

Holding cost per drum = Interest rate*(incremental cost of producing one drum + transportation cost per drum) + holding cost for one drum for one year (5)

Profit for one drum = Revenue - Incremental cost of producing one drum - Transportation cost - holding cost per week - fulfillment cost (6)

Profit of not constructing = Revenue - Cost of increasing capacity (7)

Profit of constructing = Revenue[1] - Cost of building a factory and a warehouse - Cost of increasing capacity (8)

B. Tables

Table 1. Decision parameters in each Quarter of the year

	Quarter 1	**Quarter 2**	**Quarter 3**	**Quarter 4,5,6,7**	**Quarter 8**
Anticipated Mean Demand	39	58	19	19	8
EOQ	463	562	318	318	200 / 35
ROP	380	518	234	234	100 / 5
Trans. Mode	Truck	Truck	Truck	Truck	Truck/Mail

[1] "Revenue" refers to the revenue from day 821 to day 1460, since it takes 90 days to construct a new factory or to add capacity.

Table 2. Cost and Profit calculations for three different scenarios

Origin and Destination	Transportation cost per drum (by truck)	holding cost per year	holding cost per week	Profit for one drum
Same region	$75	$207.50	$3.98	$197.14
Different regions on continent	$100	$210.00	$4.03	$121.81
Between continent and Fardo	$225	$222.50	$4.27	-$204.87

Table 3. Profit of constructing/not constructing new factory in different regions

	profit of constructing	profit of not constructing
Fardo	$581,521.78	-$3,148,749.02
Tyran	$898,978.90	$775,922.62
Entworpe	$351,295.76	$493,278.69
Sorange	$130,694.63	$367,334.43

C. Figures

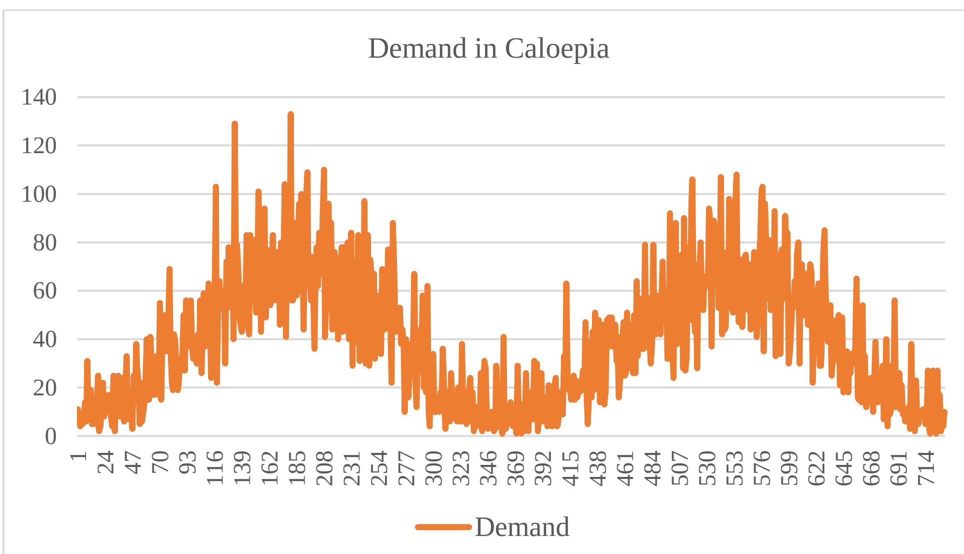

Figure 1. Demand in Caloepia in the first two years

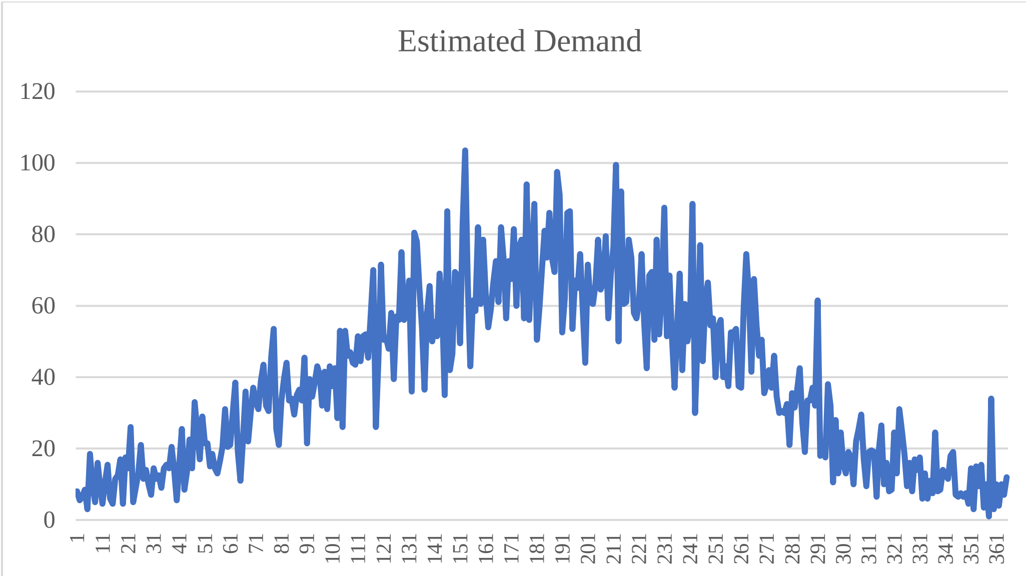

Figure 2. Estimated demand for the 3rd and 4th year of the simulation.

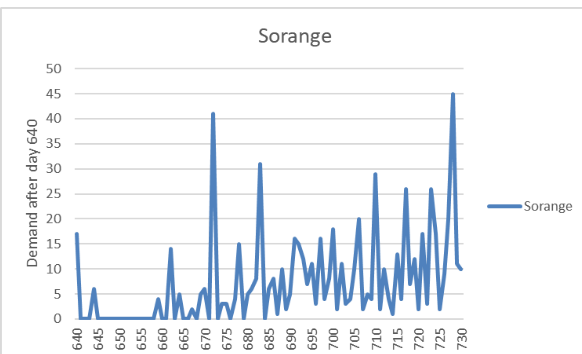

Figure 3. Demand at Sorange

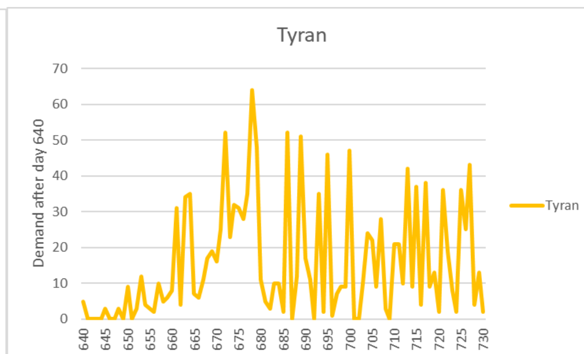

Figure 4. Demand at Tyran

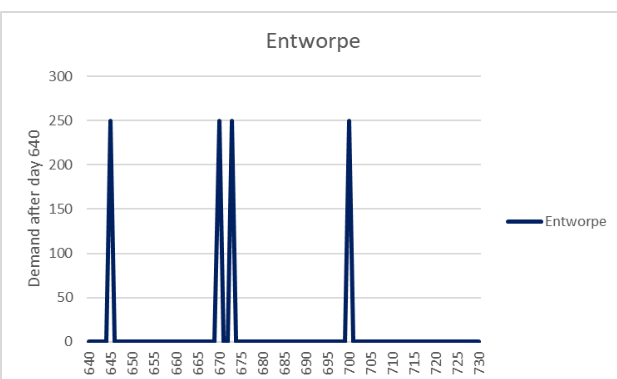

Figure 5. Demand at Entwore

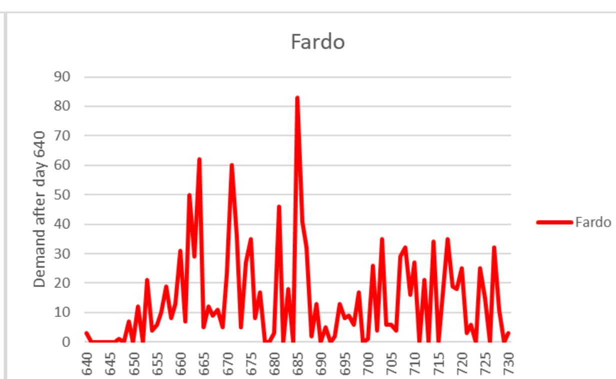

Figure 6. Demand at Fardo