Département de gestion
des opérations et de la logistique

HEC MONTRÉAL

# OPER20525A.A2019 - LOGISTICS

## Supply Chain Game Part II

Guidelines

### Context:

In “the Supply Chain Simulation Game Part I” we became familiar with the application and “play” a rather simple version of the game in which we made logistics decisions involving only one factory and one distribution center (DC). In Part II, we will face a more complex situation involving different markets and (potentially) a network of factories and DCs.

### Parameters

Part II considers 5 different markets named after their corresponding geographical regions: Calipeia, Sorange, Entworpe, Tyran, and Fardo. As shown in Figure 1, the latter (i.e., Fardo) is particular market, because it is placed on an island. Similar to Part I, our company manufactures and sells **only one product**.

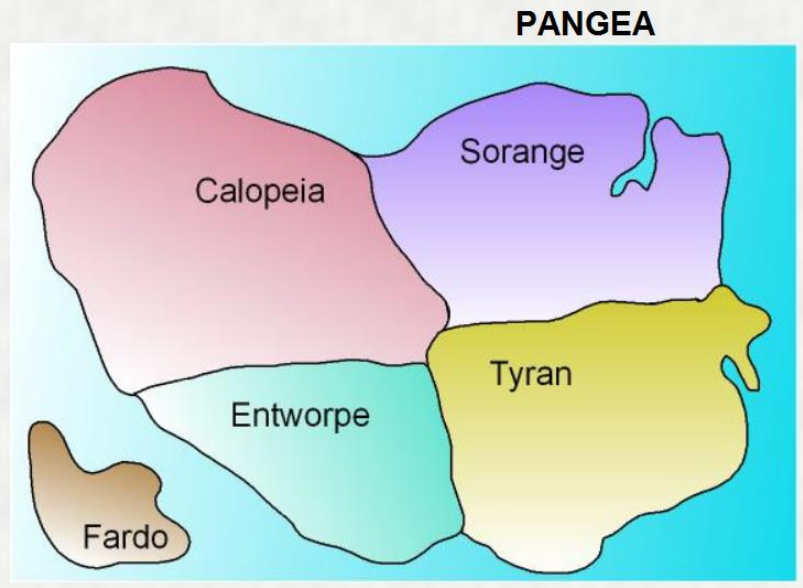



**Figure 1 :** the continent of Pangea

At the beginning of the game, our company has around **$6.8M** in the bank. It is worth noting, that every team will start Part II with the same amount of money regardless of their performance in Part I. It is also worth highlighting that teams are not competing for the market (i.e., the simulation runs independently for each team).

The game starts at day 731. At the beginning, our company has **1 factory** and **1 DC**, both located in Calopeia. The former has a capacity of **70 unit/day**, while the latter has an infinite capacity. During the game, we can build new factories and DCs in any of the reminder 4 regions. However,

we can build only one factory and one DCs in each region. It is important to note that products are delivered to final customers only through DCs.

Similar to Part I, building a new factory takes **90 days** and requires a minimum investment of **$500,000 plus $50,000 per each unit/day of installed capacity**. The investment is discounted from the bank account when the decision is made. The decision of building a new factory can be made at any point of the game, but it cannot be reversed.

**Example 1:** at the very beginning of the game (i.e., day 731) we decide to build a new factory with a capacity of 10 unit/day in the region of Tyran. The new factory will become operational in day 821. The cost of building this new facility is $500{,}000 + 10 \times 50{,}000 = 1{,}000{,}000$

We can increase the capacity of any factory (the original factory in Calopedia or any factory built during the game) at any time. Building new capacity takes **90 days** and costs **$50,000 per each unit/day** of extra capacity built.

**Example 2:** at day 851 we decide to increase the capacity of our original factory in Calopedia from 70 unit/day to 80 unit/day. Building this extra capacity costs $10 \times 50{,}000 = 500{,}000$. The new capacity becomes operational in day 941.

We can also build DCs in any region at any time. Building a new DC costs **$100,000** and takes **60 days**.

**Example 3:** at the beginning of the game (day 731) we decide to build a new DC in the island of Fardo. The new DC will start operating in day 791 and the investment required to build it is $100,000.

The selling price of the product is **$1,450** per unit. The production cost is **$1,000** per unit plus a fixed cost of **$1,500** per batch. The production costs are the same for every factory regardless of its location.

**Example 4:** the DC in Calopeia orders a batch of 100 units from the local factory (the one located in Calopeia). The cost of producing this batch is $1{,}500 + (100 \times 1{,}000) = 101{,}500$

**Example 5:** the DC in Calopeia orders a batch of 100 units from the new factory located in Tyran. The cost of producing this batch is $1{,}500 + (100 \times 1{,}000) = 101{,}500$

When a factory completes the production of a batch, the batch is automatically transferred to a DC. Similarly to Part I, we can use trucks or mail to transport products between a factory and a DC. Trucks have a capacity of **200 units** (but there is an unlimited number of trucks), while mail has infinite capacity. The cost and delivery times depend on the origin and destination of the shipping. Tables 1 and 2 show these parameters.

| Type of transportation | Truck | Mail |
|---|---|---|
| Between facilities located in the same region | $15,000 per truckload | $150 per unit |
| Between facilities located in two different mainland regions (i.e. all but Fardo) | $20,000 per truckload | $200 per unit |
| Between one facility located in the mainland and one located in the island of Fardo | $45,000 per truckload | $400 per unit |

**Table 1:** transportation cost between factories and DCs

| Type of transportation | Truck | Mail |
|---|---|---|
| Between facilities located in the same region | 7 days | 1 day |
| Between facilities located in two different mainland regions (i.e. all but Fardo) | 7 days | 1 day |
| Between one facility located in the mainland and one located in the island of Fardo | 14 days | 2 days |

**Table 2:** transportation time between factories and DCs

**Example 6:** we produce a batch of 100 units in the new factory in Tyran and decide to ship it to the DC located in Calopedia by mail. The cost of the shipping is $200 \times 100 = 20{,}000$ and the shipping will take 1 day to reach the DC.

**Example 7:** in day 800 we complete the production of a 250-unit batch in the factory located in Calopedia and decide to ship it to the new DC located in the island of Fardo by truck. We will need two trucks to load the batch (i.e., $\lceil 250/200 \rceil = 2$). The total cost of the shipment will be \$90,000 ($= \$45{,}000 \times 2$) and the shipment will reach the island of Fardo in day 814.

The customers' orders are fulfilled by the DCs (i.e., there **are not** direct shipments between factories and final customers). An order should be fulfilled in less than 24h. In other words, if a customer places an order and we do not have enough stock (at the DCs or in transit) to fulfilled in less than 24h, the sale is lost. The delivery cost of an order depends on the location of the DC and the customer (see Table 3).

| From / To | Calopedia | Sorage | Entworpe | Tyran | Fardo |
|---|---|---|---|---|---|
| Calopedia | \$150 | \$200 | \$200 | \$200 | \$400 |
| Sorage | \$200 | \$150 | \$200 | \$200 | \$400 |
| Entworpe | \$200 | \$200 | \$150 | \$200 | \$400 |
| Tyran | \$200 | \$200 | \$200 | \$150 | \$400 |
| Fardo | \$400 | \$400 | \$400 | \$400 | \$150 |

Table 3: delivery cost between DCs and customers placed in different regions

**The logistic network**

You can decide how to configure your logistic network. The main two decision here are: i) which factories will supply each distribution center and ii) which distribution centers will serve each market. The first decisions are governed by the factories' "**priority level**" parameters. For each existing distribution center, each factory must define a *priority level* given by integer values ranging from 0 (lowest) to 5 (highest). A DC with a *priority level* of 0 will never be supplied from by that particular factory. On the other hand, supplying a DC with a *priority level* of 5, will be the main destination of the products manufactured in that factory.

**Example 8:** Figure 2 shows the priority parameters for a given factory. In this example we have DCs in every region, but this particular factory only supplies the DCs of Calopeia, Entworpe, and Fardo (note that for the Sorange and Tyran DCs the *priority level* is set to 0). As the Figure shows, the Calopedia is the most important DC for this factory (priority level = 5) while the Entworpe is the least important (priority level = 3)

| warehouse location | shipping method | parameters | | |
|---|---|---|---|---|
| | | order point | quantity | priority level |
| Calopeia | mail: $150.00 per unit, 1 day to ship | 100 | 50 | 5 |
| Sorange | mail: $200.00 per unit, 1 day to ship | 0 | 0 | 0 |
| Tyran | mail: $200.00 per unit, 1 day to ship | 0 | 0 | 0 |
| Entworpe | mail: $200.00 per unit, 1 day to ship | 50 | 50 | 3 |
| Fardo | truck: $45,000.00 per truck, 14 days to ship | 250 | 250 | 4 |

**Figure 2:** example of a factory's "priority" parameter configuration. To set these parameters, click on the factory's icon and scroll down the poping-up dialog box.

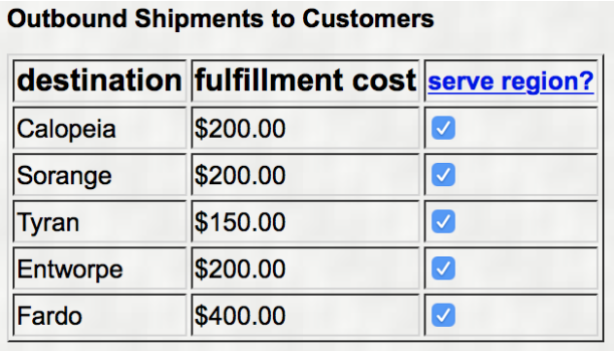
Every time the factory completes the fabrication of a batch, it uses the priority levels to decide which DC to supply next. Starting from the top of the priority list (i.e., the DC with the highest priority level), the factory checks the inventory level (on site plus on transit) for the corresponding DC. If the reorder point (ROP) is reached, then factory triggers the fabrication of a new batch (of size "quantity) for that DC. If not, the factory checks the inventory levels for the next DC in the priority list. The process continues until a the bottom of the list is reached.

**Example 9:** Assume that we have only one factory and 5 DCs (one on each region). Now assume that for our factory the priority levels are those shown in Figure 2. Now imagine that the factory just completed the fabrication of a 50-unit batch for the Calopeia DC. The inventory in transit to Calopeia is therefore 50 units. If the inventory level at the Calopeia DC is less or equal than 50 units, then the ROP is reached. Since the Calopeia DC resides on top of the priority list, the factory will immediately trigger the fabrication of a new 50-unit batch for the Calopeia DC. On the other hand, if the inventory level at the Calopeia DC is more than 50 units, the ROP is not reached. The factory will then move to the next DC in the priority list, Fardo, and check the inventory levels there. If the 250-unit ROP is reached, the factory will trigger the fabrication of a new 250-unit batch for Fardo. If that is not the case, then the factory will scan the inventory levels at the Entworpe DC and decide if a new batch for that DC should or not be triggered.

Priority levels can be change at **any time** during the game (even during the construction of a factory). It is highly recommended to assign different priority levels to different DCs for a given factory. The only notable exception to that rule is the 0 priority level, which can be safely assigned to more than one DC for the same factory.

The second important set of decisions on the configuration of the logistic network is which DCs will serve each market. These decisions are controlled by binary parameters (yes or not) called "output shipment parameters". These parameters that can be adjusted individually for each DCs at **any time** of the game.

**Example 10:** Figure 3 shows the outbound shipment parameters for a given DC. In this example, the DC can serve any of the 5 markets. Now imagine that we do not want to allow the DC to serve the island of Fardo. Then we only need to uncheck the "serve region" box on the third column for the corresponding line of the table.



**Outbound Shipments to Customers**

| destination | fulfillment cost | serve region? |
|---|---|---|
| Calopeia | $200.00 | ☑ |
| Sorange | $200.00 | ☑ |
| Tyran | $150.00 | ☑ |
| Entworpe | $200.00 | ☑ |
| Fardo | $400.00 | ☑ |

Figure 3: Outbound shipment parameter configuration for a DC. To set these parameters, click on the DC's icon and scroll down the popping-up dialog box.

Customer orders are automatically fulfilled from the distribution center with the cheapest transportation costs.

**Example 11:** Imagine that we have two DCs, one in Calopeia and one in Fardo. Now imagine that the current stocks in those DCs are 100 and 50, respectively. Imagine that a customer from Fardo places an order for 75 units. Needless to say, for that order, the DC with the cheapest delivery cost is that located in Fardo (see Table 3). However, since the inventory level at the Fardo DC is not enough to fulfill the order, only the first 50 units will be dispatched from the Fardo DC (at a cost of $7{,}500 = 50 \times 150$). The remining 25 units will be dispatched from the Calopeia DC at a cost of $10{,}000 = 25 \times 400$.

**The demand**

Part II will be played for exactly 7 days and the simulation will span two years of operations. In other words, 14 minutes of "real" time, corresponds to (roughly) 1 day of "simulated" time. The demand for our produce behaves differently on each market (i.e., region). During class session 10, before the start of the game, you will have access to some historic demand data for each region. However, to facilitate the preparation of your strategy, we briefly describe that data here.

**Calopeia**

You will have access to information from the previous two years (day 1 to day 730). By analyzing sales of the last two years (plot demand file) you can forecast the demand for the coming two years (day 731 to day 1460). It is important to mention that the demand data file (plot demand) presents both the sales made and lost sales in the last two years. Once the game is launch, you can access the data on the lost sales through the *lost demand* file.

**Sorange**

For the region of Sorange, the historical demand begins on day 640. The latter means that you will only have access to last 90 days of demand to make your forecasts (i.e., from day 640 to day 730). We know that the demand in Sorange will continue its current trend up to (around) day 1,430. We also know that starting from day 1430 and up to the end of the second year (i.e., day 1460), the demand will linearly decrease down to 0.

**Tyran et Fardo**

In these two regions, the demand has a similar behavior. The historical data for both regions starts on day 640. The data shows that the demand increased during the first month (until day 670) and then it stabilized. We know that the demand will keep stable until (around) day 1,430. Between that day and the end of the second year, we expect the demand to linearly decrease down to 0.

**Entworpe**

The historical data for the region of Entworpe also begins on day 640. The demanded quantities are always 250 units. These 250-unit orders arrive randomly. The data shows that between days 640 and 670, the demand was not stable. However, it stabilized between day 670 and day 730. We expect the demand to remain stable until (around) day 1,430. Between that day and the end of the second year, we expect the demand to linearly decrease down to 0.

Enjoy the game!