Supply Chain Simulations (I)

In this exercise, you will play a simulation game designed to address several important issues in supply chain management. The game simulates a firm that produces and distributes beer. It has a factory, a distribution center, a warehouse, and a retail store where customer demand arises. The retail store orders kegs of beer from the warehouse, which in turn orders from the distribution center, etc. You will be the inventory manager at one location in the supply chain, and your partners will manage the other locations. Your task in each period is to make replenishment decisions, i.e. how many kegs of beer to produce if you manage the factory or how many kegs of beer to order from your upstream partner if you manage a downstream location.

There are two salient flows in the above supply chain. Information (replenishment orders) flows from downstream to upstream, triggering material (beer) flow in the opposite direction (see Figure 1). Both flows are subject to delays. Here is an example. The retail store orders 10 kegs from the warehouse on Monday. The warehouse receives this order on Wednesday. This delay is due to the administrative steps in processing an order. On Wednesday, however, the warehouse only has 5 kegs of beer, so it ships 5 kegs to the retail store and backlogs the remaining 5. This shipment of 5 kegs arrives at the retail store on Friday. This delay is due to transportation. The exact leadtimes for both the information and material flows are given in Figure 1.

This case was prepared by Professor Fangruo Chen, Columbia Business School, and Rungson Samroengraja, a doctoral student. It is inspired by the Beer Distribution Game developed by the Systems Dynamics Group, Sloan School of Management, Massachusetts Institute of Technology. If you have any comments or suggestions, please email to fc26@columbia.edu.

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The customer demand in each period, although unpredictable, has a normal distribution. Moreover, the demands in different periods are independent. Table 1 summarizes the demand parameters.

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>50</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 1. Demand in Each Period (kegs).

Holding costs are assessed at every location for on-hand inventories. Each location must satisfy the orders from its downstream location (or in the case of the retail store, orders from the customers) as much as possible. In case of a stockout, the excess is backlogged. However, a penalty cost is assessed only at the retail store for customer backorders. This reflects the firm’s desire to provide good customer service. Table 2 summarizes the cost parameters.

<table>
<thead>
<tr>
<th>Location</th>
<th>Holding Cost ($/keg.period)</th>
<th>Penalty Cost ($/keg.period)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>Distribution Center</td>
<td>0.50</td>
<td>0</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.75</td>
<td>0</td>
</tr>
<tr>
<td>Retail Store</td>
<td>1.00</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2. Cost Parameters.

The managers at the different locations act as a team, i.e., they have a common goal to minimize the total cost in the system although they each make local decisions. The winning team is the one with the lowest system-wide cost. The prize will be determined in class.
Appendix: How to Play

1) Getting Ready

*Supply Chain Simulations* is an Excel Workbook that models a supply chain with four locations. It requires four computers, one for each location. Each computer must have installed Microsoft Excel Version 8 (Office 97). It is recommended that the computers be arranged from left to right in this order: Retail Store, Warehouse, Distribution Center, and Factory. (Each computer represents a location; and it is possible for a location to be managed by more than one person.)

Each group/location will be provided with a disk that contains the *Supply Chain Simulations* file (SUPCHN.XLS). (This disk will be used later to save results. So please keep it handy.) This file should be copied to each computer. To start the game, simply open SUPCHN.XLS. **Warning!** It is recommended that you close all other workbooks before you open SUPCHN.XLS.

*Supply Chain Simulations* will modify the appearance of Excel by changing the window size and hiding the formula bar, status bar and most toolbars. Don’t worry, when you quit the game, Excel will revert to its previous appearance.

2) The Title Screen

The first screen you see is the title screen. On the left side is the Instructor button. It is for the instructor only and requires a password. The Quit button on the right side is used to exit the game and restore Excel to its former settings. *Please use this button to exit the game. Your former Excel settings may not be restored if you choose to quit Excel before exiting the game.*

Press the Start Game button when you are ready to start the game.

3) Starting the Game

After you press the Start Game button, you will be asked to specify your location. Therefore, your group should decide beforehand who manages which location. You will be asked to confirm your choice. In the next dialog box, you are presented with three options that determine which game will be played. The three options are Management Structure, Demand Information, and Play Style. Under Management Structure, choose Team; under Demand Information, choose Not Transmitted. Choose Training under the Play Style option if you are just learning the game. When your group is ready to play the game, choose the For Real option. *Please have the disk that contains SUPCHN.XLS ready in order to save the results.*

4) Playing the Game

Once the game is started, you will see the main screen. On the bottom are several buttons:

The Proceed Button is used to move from one step to the next and from period to period. The Show History button is used to access the historical data (costs, orders, and shipments). The History screen will be explained in detail under the section “Checking Progress.” The Replay Period and Show Summary buttons are used to help fix any mistakes you might have made in a period. They will be discussed in detail under the section “Fixing Mistakes.” The End Game button is used to end the current game. This will be discussed in detail under the section “Ending the Game.”

The rest of the screen appears differently, depending on the location. Below, we describe the main screen for each location.
Retail Store

Figure 2. The Retail Store Main Screen.

The inventory status (on-hand inventory and backorders) appears in the center of the screen. For the rest of the screen, rectangular boxes are used to represent order information. The box on the left contains the customer order. (It is randomly generated by the computer according to the given demand distribution.) The four boxes on the right indicate the four most recent orders. The labels on the boxes tell you when the orders were placed. There are also three triangles on the screen. They represent shipments. The one on the left is the shipment to the customers. The two triangles on the right represent the shipments in transit from Warehouse. Note that one of the triangles is black, meaning that you don’t know the size of that shipment. If Warehouse always has ample stock, then the two shipments on the right should be equal to the orders in the boxes directly above them.

Playing the game is easy. There is a sequence of instructions specifying exactly what needs to be done. Please follow these instructions carefully. Here is a brief summary of the steps in each period.

Step 1. Outgoing Order – Retail Store informs Warehouse of the order they receive this period.
Step 2. Incoming Shipment – Retail Store receives a shipment from Warehouse.
Step 3. Incoming Order – Customer demand this period.
Step 4. Ship – Based on the incoming order, the current on-hand inventory and the incoming shipment, a shipment is sent to the customers.
Step 5. Advance Orders – Previous orders advance one position.
Step 6. Enter Order – Retail Store places an order to Warehouse.
The inventory status (on-hand inventory and backorders) appears in the center of the screen. For the rest of the screen, rectangular boxes are used to represent order information. The two boxes on the left represent orders from Retail Store. One of the boxes is black, meaning that you don’t know the size of that order. The four boxes on the right indicate the four most recent orders. The labels on the boxes indicate when the orders were placed. There are also four triangles on the screen. They represent shipments. The two on the left are the shipments in transit to Retail Store; the two on the right are the shipments in transit from Distribution Center. One right triangle is black, meaning that you don’t know the size of that shipment. If Distribution Center always has ample stock, then the two shipments on the right should be equal to the orders in the boxes directly above them.

Playing the game is easy. There is a sequence of instructions specifying exactly what needs to be done. Please follow these instructions carefully. Here is a brief summary of the steps in each period.

Step 1. Incoming Order – Warehouse receives an order from Retail Store.
Step 2. Outgoing Order – Warehouse informs Distribution Center of the order they receive this period.
Step 3. Incoming Shipment – Warehouse receives a shipment from Distribution Center.
Step 4. Outgoing Shipment – Warehouse informs Retail Store the shipment they receive this period.
Step 5. Advance Shipment – The shipment sent last period advances one position.
Step 6. Ship – Based on the incoming order, the on-hand inventory and the incoming shipment, a shipment is sent to Retail Store.
Step 7. Advance Orders – Previous orders advance one position.
Step 8. Enter Order – Warehouse places an order to Distribution Center.
Figure 4. The Distribution Center Main Screen.

The inventory status (on-hand inventory and backorders) appears in the center of the screen. For the rest of the screen, rectangular boxes are used to represent order information. The two boxes on the left represent orders from Warehouse. One of the boxes is black, meaning you don’t know the size of that order. The four boxes on the right indicate the four most recent orders. The labels on the boxes indicate when the orders were placed. There are also four triangles on the screen. They represent shipments. The two on the left are the shipments in transit to Warehouse; the two on the right are the shipments in transit from Factory. One right triangle is black, meaning that you don’t know the size of that shipment. If Factory always has ample stock, then the two shipments on the right should be equal to the orders in the boxes directly above them.

Playing the game is easy. There is a sequence of instructions specifying exactly what needs to be done. Please follow these instructions carefully. Here is a brief summary of the steps in each period.

Step 1. Incoming Order – Distribution Center receives an order from Warehouse.
Step 2. Outgoing Order – Distribution Center informs Factory of the order they receive this period.
Step 3. Incoming Shipment – Distribution Center receives a shipment from Factory.
Step 4. Outgoing Shipment – Distribution Center informs Warehouse the shipment they receive this period.
Step 5. Advance Shipment – The shipment sent last period advances one position.
Step 6. Ship – Based on the incoming order, the on-hand inventory and the incoming shipment, a shipment is sent to Warehouse.
Step 7. Advance Orders – Previous orders advance one position.
Step 8. Enter Order – Distribution Center places an order to Factory.
**Figure 5. The Factory Main Screen.**

The inventory status (on-hand inventory and backorders) appears in the center of the screen. For the rest of the screen, rectangular boxes are used to represent order information. The two boxes on the left represent orders from Distribution Center. One of the boxes is black, meaning that you don’t know the size of that order. The box on the right indicates the most recent production schedule. The two triangles on the left are the shipments in transit to Distribution Center. The two cylinders on the right represent beer in different production stages.

Playing the game is easy. There is a sequence of instructions specifying exactly what needs to be done. Please follow these instructions carefully. Here is a brief summary of the steps in each period.

**Step 1.** Incoming Order – Factory receives an order from Distribution Center.

**Step 2.** Outgoing Shipment – Factory informs Distribution Center of the shipment they receive this period.

**Step 3.** Advance Shipment – The shipment sent last period advances one position.

**Step 4.** Ship – Based on the incoming order, the current on-hand inventory and the production batch finishing this period, a shipment is sent to Distribution Center.

**Step 5.** Advance Production – The batch scheduled last period enters the production process. The production batch started last period advances one position.

**Step 6.** Schedule Production – Factory decides how much beer to produce.
5) Checking Progress

You can get an idea of how you are doing by consulting the History and Graph screens. Press the Show History button at anytime except when the game is waiting for you to enter a number. Once you have finished entering a number, you may press the Show History button. From the History screen, you can also access several graphs by pressing the Show Graphs button.

The History screen is explained next. We use Distribution Center as an example; the History screens for the other locations are similar. Note that the numbers on your screen may be different.

<table>
<thead>
<tr>
<th>Period</th>
<th>Dist. Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Starting</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>73</td>
</tr>
<tr>
<td>4</td>
<td>98</td>
</tr>
<tr>
<td>5</td>
<td>97</td>
</tr>
</tbody>
</table>

Figure 6. History Screen for Distribution Center.

<table>
<thead>
<tr>
<th></th>
<th>Starting Outstanding Orders</th>
<th>Order to Factory</th>
<th>Ending Outstanding Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All the orders placed but not yet received</td>
<td>Order placed this period</td>
<td>Starting Outstanding Orders + Order to Factory – Quantity Received</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Holding &amp; Backorder Cost</th>
<th>Cumulative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Holding Cost Rate * if(Ending Net Inventory &gt; 0, Ending Net Inventory, 0) + Backorder Cost Rate * if(Ending Net Inventory &lt; 0, -Ending Net Inventory, 0)</td>
<td>Holding and backorder cost accumulated at Distribution Center</td>
</tr>
</tbody>
</table>

6) Fixing Mistakes

If you should make a mistake entering a number and proceed to the next step, you will have to press the Replay Period button to start the period over from the beginning. It may be necessary for your upstream and downstream partner to press the Show Summary button on their screens to provide you with the information you need to catch up with the rest of the group.
7) Ending the Game

There are two ways the game may end, either you play through a predetermined number of periods or you choose to end the game beforehand by pressing the End Game button.

If you have played through a predetermined number of periods, then you will be asked to insert a disk into Drive A to save results. Once the results are saved, you can either view the History and Graph screens or return to the title screen.

Now suppose you press the End Game Button. If you choose to save the results, then you will be asked to insert a disk into Drive A. Once the results are saved, you can either view the History and Graph screens or return to the title screen. If you decide not to save the results, then you can either view the History and Graph screens or return to the title screen. Finally, if you choose Cancel, then the game will continue.