Web-based Oil Supply Chain Game

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Abstract

One of the major uses of management games is as a learning tool to improve decisions made under dynamic uncertainty. This paper presents a web-based gaming mode simulation model of a supply chain concerning the procurement and supply of oil. The game mirrors the traditional oil supply chain consisting of Refineries, Storage Points, Depots and Retail Outlets. The computer controls the decisions at refineries and retail outlets, whereas, those for Storage Points and Depots are regulated by the players. The group with minimum total cost after 15-20 simulated days of play wins the game.
The game is highly interactive. Extensive use of web-technology facilitates the game being played by players physically separated from each other but connected through a high-speed Wide Area Network (WAN) or Internet. The game also provides ways of simulating different decision strategy (order-supply strategy) combinations. Debriefing sessions are facilitated by the use of graphs and charts.

Keywords: Decision Strategy; Internet; Management Game; Oil Industry; Supply Chain Management; Web-based game.

1 Introduction

Simulation models are often used to model unstructured social/economic conditions. In complex business situations, the decisions do not follow any particular mathematical order, and hence, the use of random numbers following certain distributions loses most of its justification. In these cases an interactive system where decision values are manually input will be more effective. These systems are called gaming mode simulations and Supply Chain Games such as, THE SUPPLY CHAIN GAME (Horscroft, 1993), COMPUTERIZED NETWORK VERSION OF BEER GAME (Machuca and Barajas, 1997), SUPPLY CHAIN MANAGEMENT GAME (Ghosh and Mahapatra, 1998) are these kinds of simulators.

The above-mentioned games are mostly simple and aim at demonstrating the Bullwhip Effect (Lee, Padmanabhan and Whang, 1997a,b). This condition occurs in supply chains of physical goods because they often exhibit an increasing variability of orders in the downstream direction (i.e., from the retailer to the primary supplier). Thus, the demand creation from the customer to the previous stages exhibits some distortions and disruptions leading to an amplification of orders that in turn causes an accumulation of inventory. This type of condition is called the Bullwhip Effect. The consequences are high inventories as well as stock-outs and unpredictable orders. The games mentioned earlier, demonstrate this by considering one representative of each level in the supply chain, one factory warehouse, one wholesaler, one retailer and one customer. The Oil Supply Chain Game (OSCG) takes a broader view of the system by considering multiple participants each level. This game seeks to demonstrate the dynamic business environment as related to the supply chain in a competitive market. According to Bowman (1963), even if managers are aware of the factors and objective to be considered, and the impact of each factor on a decision, in dynamic environments their decisions are often influenced by the immediate past experience. For instance, if there was shortage the previous day, in most situations, the manager tries to procure more than what is, perhaps, needed. The game helps the managers realize the impacts of such decisions. This also helps them to minimize biases and deviations from optimal decisions.

This game will serve as a useful learning tool for logistics managers and students in logistics or supply chain courses. It is expected to help them make decisions that are less influenced by past experience. Participants will also experience an interesting combination of collaboration and competition between each other while making decisions. With the advent of Internet and web-technologies, there has been an evolution in the design and implementation of network-based games. This game utilizes the Internet for connecting participants, who may be geographically separated, but connected through Local Area Network (LAN) or Wide Area Network (WAN) as required. Participants will also get a feel of real-time data handling and analysis through this game.

2 Description of the Game

The game models a typical oil industry scenario with the market being segmented among four companies. Each company has one Storage Point and one Depot. Storage Points procure oil from Refineries and meet the demand of Depots. Similarly Depots procure oil from Storage Points and meet the demand of Retail Outlets. The game involves 3 Refineries and 4 Retail outlets, all of which do not belong to any particular company and are controlled by the computer. A schematic diagram of the industry structure is shown in Figure 1. The game design assumes infinite capacity of Refineries and infinite vehicles for transportation of oil between different levels. These assumptions help to simplify the problem and have participants focus more on inventory related decisions. Supply policy at Refineries is simple, each order being fulfilled after an inherent delay. Demand pattern at the retail level is probabilistic within a certain range after an initial straight-line pattern. Teams cannot alter the demand pattern in any way.

Eight participants play the game, four at the Storage Point and four at the Depot level. The objective for the players is to control the costs at their levels. Each level incurs costs in the form of inventory holding cost, material cost (oil price), transportation cost and backlog cost. Material cost for Depots depends upon source. Oil at discounted price is available if procured from company Storage Point. Backlog cost is the monetary equivalent of loss of customers and goodwill.

There are a number of other considerations built into the game. First, the quantity of supply available to the clients is in multiples of tankers (for road) or rakes (for rail) capacities. Second, there is an information delay of 1 day, which means orders from customers will be visible to the supplier after a day. Third, the maximum storage capacity for all levels is limited to 200 Kiloliters. Also, there are unit costs and various other constant values used in the game as shown in Table 1.

Constant Name	Value	Unit
Pipe Transportation Cost	0.85	Rs./Kl./Km.
Road Transportation Cost	0.25	Rs./20Kl./Km
Rail Transportation Cost	0.5	Rs./40Kl./Km.
Speed of Pipe	450	Km./day
Speed of Road	220	Km./day
Speed of Rail	245	Km./day
Oil cost	4.5	Rs./Kl.
Oil cost (Discounted)	7.5	Rs./Kl.
Tank Capacity	20	Kl.
Rake Capacity	40	Kl.
Information Delay	1	day
Backlog Cost	1	Rs./Kl.
Max. Storage Capacity	200	Kl.
Total Number of Players	8	people

All players make decisions regarding orders to be placed with a supplier along with the mode of transportation and supply to be made to customers against orders received or order backlog. Information available to the players consists of backlog of orders received from customers, inventory on hand and total cost incurred.

The decision making process of players is supplemented by graphs and tables showing past data. Players can view computer-simulated projections of demand, supply and cost figures. Players also have access to their partner's present data.

A Storage Point and a Depot of same company will play as partner to each other. Total cost of partners will be the performance index of a company. The company with lowest total cost after 15-20 simulated days of play wins the game.

3 Steps of Play

Playing OSCG is fairly simple, although it is assumed that you have working knowledge of computers and Internet. The following is the list of steps for playing the game. Before beginning the game, the facilitator will divide the participants into eight groups and assign each group a company and a level.

- The facilitator will provide an Internet address and will ask you (and all the other players) to connect to that address with the web browser.
- Once you connect to the given web address, you will see the initial screen, as presented in Figure 2. This screen will provide options for viewing the documentation, playing a demo or playing the game.
- You can familiarize yourself with the interface by playing the demo, if time permits, or you can directly start playing the game.
- Once you are ready, you will have to enter your name and select the company and level provided by the facilitator on the initial screen. Then press 'Enter'.

- When all teams have entered their information, you will see the game screen for the first day. This screen has a small map, links for accessing various graphs and charts and fields for entering order-supply details.
- Enter your order details and supply details for the day in the corresponding fields in the right side of the screen. You can track the available time for taking decision with the timer provided below the map.
- When you are done entering values of all the fields, press 'Send' button.
- Once all teams have entered their decisions, the screen changes to the next day.

You will be given ten minutes to make decisions for each simulated day. The game can be continued for as many rounds as possible in the given time available. Fifteen to twenty rounds (days) are recommended for meaningful results.

4 Conducting Oil Supply Chain Game

As the facilitator of the game, you should have basic knowledge about web-servers and web-administration. The game is a collection of web pages, written in HTML, ASP and JavaScript. The web-server should be a Windows NT system with Service Pack 6 and Option Pack 4.0 containing Internet Information Server (IIS 4.0 or higher) that supports ASP. A Perl version of the program is also being developed. Keep all the files in a separate directory under web-root and setup an ODBC connection with the database before conducting the game. A detailed installation manual and facilitator's guide is provided with the game and is also available online at http://www.cae.wisc.edu/ samik/scm/manual/index.html. The files (software) are copyrighted, but free for academic use. Please contact me through email in order to get the files.

In addition to the technical aspects of the game there are a number of other items that you need to insure. First, players should not know at what level other players are making decisions. Second, players should not verbally communicate with other players while playing. All queries should be directed to you. Third, you should not tell participants the number of rounds to be played.

You can change the values of constants if necessary to create realistic business conditions. These constants can be accessed through the web by providing the proper login and facilitator password on the game screen. You can also monitor inventory and cost figures of all players through graphs and charts from this screen. Before starting a new game session, you have to clear the database by removing information from prior sessions.

5 Debriefing

After the facilitator declares the game to be over, participants are given printouts of graphs and/or tables showing their respective inventory, backlog, total cost and cost components until the last round. This information is used for debriefing.

The purpose of the debriefing session should be to identify a decision strategy, which will result in maximum cost-control. For this purpose, the best four teams (two companies that had the lowest total costs) may be asked to discuss their order/supply strategy. The session should also try to find out best co-ordination strategy between a company's Storage Point and Depot. It is possible that the best company did not achieve the least cost at both the Storage Point and the Depot level.

The game can also highlight dynamic business adjustments such as tacit alliance between a Storage Point and Depot or formation of customer loyalty. Participants can discuss whether they have taken part in forming these kinds of adjustments. The participants can also try to identify the 'turning point' of the game, where their costs suddenly increased.

One argument often put forward by game participants is that early on one can find out best Storage Point/Depot combination for ordering and stick to that. They are correct that this strategy could be effective if the system was static, but it is not. The irregularities in the system force players to consider other decision options and failing to do so causes costs to increase substantially. In this context one can also discuss Bowman's Management Coefficient Model (Bowman, 1963), which suggests that managerial decisions might be improved by making them consistent from one time to another rather than by using sub-optimal solutions for each cost-control problem. The model for this case can be developed for the simulation by regressing the game data over reasonable periods.

Another thread of discussion in the debriefing session can be the effect of various assumptions like infinite capacity of Refineries and infinite vehicles for transportation of oil between different levels, on the game. Finite capacity could result in stock-outs and consequential delay in order shipment to the Storage Points. Similarly, finite number of vehicles for oil transportation will also contribute to the transportation delay and can also serve as a 'vehicle scheduling' sub-problem.

The game can also be used for simulating different decision strategy (order-supply strategy) combinations. Some ordering and supplying strategies are listed below:

- Supply Strategies:
  - Supply Judgmentally
  - Supply maximum to the client who has given highest order. Break ties arbitrarily.
  - Supply maximum equal amounts to all clients who have ordered.
  - Fulfill partner's demand up to maximum. Supply others on judgment.
  - Supply maximum to the most loyal customer, i.e. one who orders regularly. Break ties arbitrarily.
  - Supply maximum to the client whose backlog is maximum. Break ties arbitrarily.
  - Supply maximum to the client whose backlog is minimum i.e. Loyalty Generation. Break ties arbitrarily.
- Order Strategies:
  - Order Judgmentally
  - Order only where the distance is minimum.

- Order only to the partner.
- Order equally to two least distance places.
- Maintain single loyalty while ordering.

The facilitator can make each participant adopt particular order-supply strategy throughout the game and then discuss the effectiveness of those strategies. This approach helps the participants appreciate 'situation-wise selection of strategy' while playing the game.

Overall, the debriefing session can be used to demonstrate various aspects and complexities of the supply chain. The simulation can provide the participants with hands-on experience in real-time managerial decision making, which reinforces their theoretical understanding of the subject.

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Note

Images are not included in the pdf. They can be downloaded seperately.

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