

HUMAN AND AGENT PLAYING THE “BEER GAME”

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ABSTRACT

The supply chain, impacted by production strategies and stock-up or addendum policies, often causes information confusion and forms the bullwhip effect. Instructors were often only able to talk about the various types of strategies and influences imposed by various business performance indexes when lecturing on the supply chain management courses. Although, by developing a ‘beer game’ information system (MIT Forum has its Web-based version), the Northwestern University in U.S. has addressed that the problems of supply chain are solved and whoever interested in supply chain can participate in the beer game and learn about the supply chain through playing. However, the fixed and un-modifiable imitative setup and system parameters that could not be flexibly adjusted by the instructors were indeed the biggest weakness of the game. As the result, this paper has proposed an agent based beer game which enables not only for instructors to set supply chain scale freely or imitate various setups, but also for one to learn much about the supply chain through designing various types of strategies. Besides, by using computer based beer game, it becomes easy to preserve and analyze results and also expected to be shortened the time of learning and playing is greatly shortened.

INTRODUCTION

Due to the rapid internationalization and development of the Internet, economic competition between industries has escalated into competition between supply chains. As a result of this, Supply Chain Management has become a popular area of research in recent years. In Supply Chain Management instruction, teachers have selected from various strategies for each member of the supply chain and only an abstract method can be expressed the effects made by varying operations performance indicators. This makes

teaching material unable to excite student’s interest and make learning performance lower.

Currently, there is a Board-based Beer Game and also a Computer-based Beer Game developed by Northwestern University for problems in supply chain management (MIT Forum also has a Web-based version), which is used as the practice tools for instructors to simulate a supply chain environment. However, the most serious disadvantage of these games is that fixed, unchangeable simulated environments and system parameters limit the teacher’s ability to make flexible strategies for supply chain management. Thus, these tools have the limit to increase various results of supply chain instruction. As a result of the aforementioned, it will be needed a new tool which enables to change parameter settings freely and to add some more strategies easily for learning supply chain management for learning much about supply chain management. This paper proposes an agent-based beer game we call it SOARS Beer Game for solving aforementioned problems.

FEARURES OF THE SOARS BEER GAME

The SOARS Beer Game is a recreated version of Sterman’s “Beer Game” simulation from its original Systems Dynamics implementation to an agent-based simulation using a simulation language SOARS. Like other computer-based Beer Games, the SOARS Beer Game needs some computers for simulating and playing. Compared to the original which is designed as a board game, the SOARS Beer Game is the one which is computer-based and able to show on a display, the model of the SOARS Beer Game is a computer-based and can be seen through a display.

In the SOARS Beer Game, four agents which are decision making entities in an agent-based simulation play a game instead of human players. Like human players do in the original Beer Game, they decide how many beers to order, supply beers that are demanded, and so on. Each agent has a role and all behaving rules, such as ordering beers behavior, supplying beers behavior and so on, are

defined in it. Especially, decision making strategies for ordering beers can be designed similar to human's thinking strategies. This is because in agent-based modeling approach, it is possible to design agent's behaviors based on human's behaviors. There can be agent's strategies as much as human players in the SOARS Beer Game. That is the SOARS Beer Game can be able to simulate the case that various types of human players are playing the original one.

By using an agent based approach to recreate the original Beer Game, the SOARS Beer Game is expected to have some features that both the original one and the computer based one that have already developed do not have. Popular features of the computer based game are as follows;

1. It is expected to shorten the playing time. When you play the original board based Beer Game, all processes have to be done by players. As there are some processes that take much time for processing such as cost calculation, it has a possibility to take a lot of time to finish this game. The computer based Beer Game can do these processes faster and correctly. Processes that players have to do are reduced and the time to play this game decreases as a result.
2. It enables to play with machine players. To play the original board based Beer Game, there must be at least four human players. It is impossible to play it by only one human player, and therefore one who wants to play it needs to find other players and gathers them at the same time and the same place. The computer based Beer Game solves these problems. Usually the computer based one has machine players in it. They are decision making entities and act like players instead of human players and usually have some simple strategies. They are designed to play the game according to these strategies. By replacing human players by these machine players, one can play the game even if there are not enough human players.
3. It is easy to record results. When playing the original board based Beer Game, all records, such as the number of ordered beers, the number of demanded beers, costs and so on, are recorded in some sheets. These days, most of all analyses are done by using computers. To analyze game records by computers, it takes time and is a hard work to input all records to them. If you use the computer based Beer Game, all records are automatically recorded in a computer and some basic analyses will also be done automatically. The computer based Beer Game can help you to analyze and evaluate game records.
4. It is possible to set settings of a game flexible. For example, demands from customers can change easily. In the original based Beer Game, such demands are fixed, but in the computer based Beer Game, demands can be set based on some functions, theories or so on. This enables to use a difficult demand function which is hard to calculate. Environments of a game can be set freely, easily and flexibly as you, who are going to use Beer Game, likes.

In addition to above features, the SOARS Beer Game has features that are as follows;

1. A game can be reproduced as an animation. SOARS has an animation tool which enables to see records as an animation. Almost all computer based Beer Game save records of a game as text records. This is the same also in the SOARS Beer Game. However, differs from them, SOARS can automatically make an animation file from in the form of XML based text file. It enables to see and analyze past games from a graphical view point.
2. More complex strategies can be designed and used. Not only simple strategies but also complex strategies can be designed as strategies of machine players. Examples of simple strategies are as follows;
 - The strategy that numbers of beers that are going to order are the same as that are demanded.
 - The strategy to keep the stock to become a definite value.
 - The strategy that numbers of beers that are going to order are random.
 - Etc...
 In addition to above simple strategies, complex strategies that are as follows can be designed.
 - The strategy that forecast the next demand from past data of demands and use it for ordering beers.
 - The strategy that uses all information that are provided from a game for ordering beers. For example, information on delivery delay can help for deciding how many beers to order next.
 - The strategy that is based on human player's thinking can be designed. For example, it is possible to make a strategy from a questionnaire that is written by a player who plays the Beer Game. By using this strategy, a machine player can act as a human player in a game.
 - Etc...

However, the SOARS Beer Game cannot achieve the goodness that the original board-based beer game has such as a working of shipment etc. By recreating the original board-based beer game on a computer-based beer game, it is true that some disadvantages of the original one may be solved. However, some of the good aspects of the original are lost as well. It is hard to say which one is better.

DETAILS OF SOARS BEER GAME

In computer simulation era, these days, using programming languages such as C, C++, JAVA... is a major way to make computer simulation models. Recently, due to the progress in the agent based modeling and simulation approach, some agent based modeling languages such as SWARM, Repast ... are developed and computer simulation models using them are increasing. Some researchers try to recreate the original board-based beer game by using programming languages and others use agent based modeling languages (Macal and North 2005).

In this paper, the SOARS Beer Game uses the simulation language SOARS (Ichikawa et al. 2007), one of the agent based modeling languages. Features of SOARS are as follows;

SOARS -Spot Oriented Agent Role Simulator- is the new type agent based simulation language which is designed for everyone to make a social simulation model easily. The most important thing about SOARS is that it does not require any knowledge or experience of programming for making a model. Everyone can start to use this without hard study about programming. What you have to do to make a model by using SOARS is to learn basic skills about SOARS. Two or three hours are enough for studying.

SOARS also supports for making a web-based simulation of gaming.

SOARS is the all in one scientific tool for making a social simulation model and a social simulation of gaming.

The reason why we use SOARS is that it satisfies our following requests.

1. There is a tool for Human players to participate in

a simulation.

2. There is an animation tool for viewing results.
3. There is a graph tool for showing results.
4. Do not take much time for construction.
5. Easy to enhance.

SOARS BEER GAME

The SOARS Beer Game is constructed based on the original board based beer game. In the SOARS Beer Game, there are four types of decision making agents and four places for agents to act. Agents in the SOARS Beer Game are taking the place of human players in the original board based beer game. An agent can be the *Retailer* agent, the *Wholesaler* agent, the *Distributor* agent or the *Manager* agent and places are *RetailShop*, *WholesaleFirm*, *DistributeFirm* and *Factory*. The *Retailer* agent act in the *RetailShop*, the *Wholesaler* agent act in the *WholesaleFirm*, the *Distributor* agent act in the *DistributeFirm* and the *Manager* agent act in the *Factory*. There are production lines in the *Factory* and order lines and delivery lines between the *Factory* and the *DistributeFirm*, the *DistributeFirm* and the *WholesaleFirm*, and the *WholesaleFirm* and the *RetailShop*. Beers are produced in

Figure 1
Original Beer Game and SOARS Beer Game

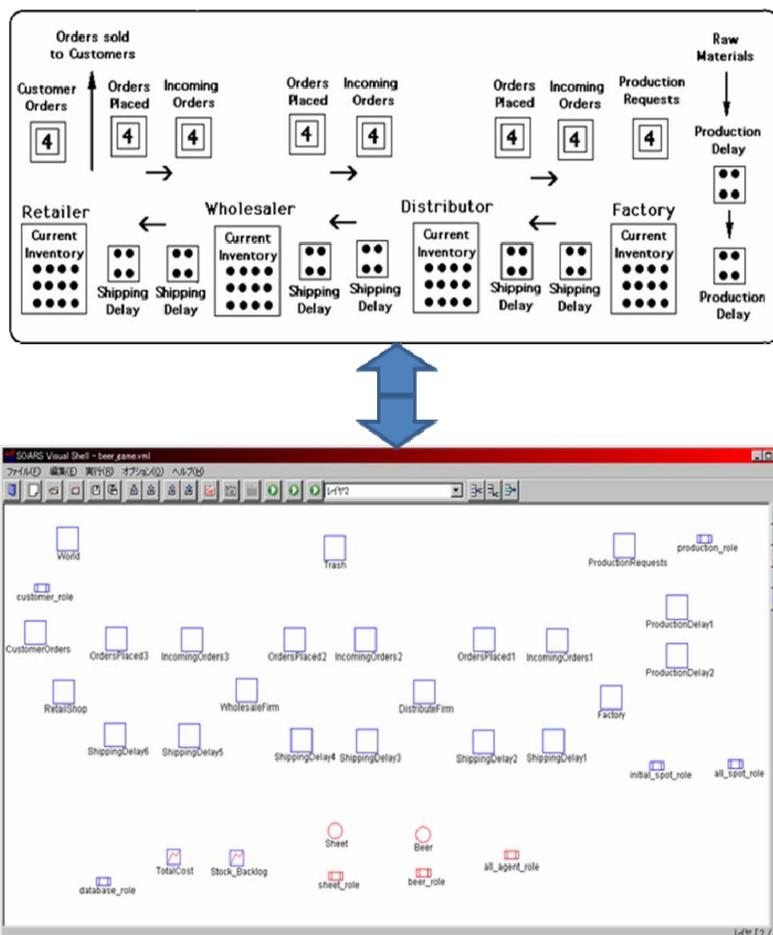
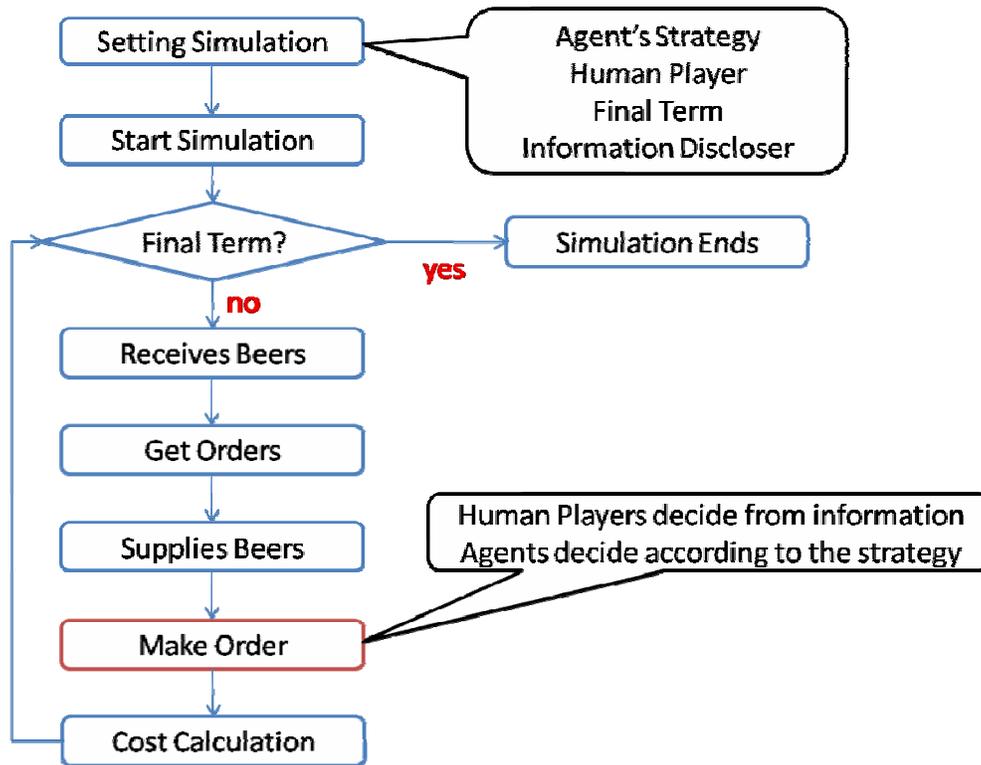


Figure 2
Flowchart of a Simulation



production lines and delivered by using delivery lines. Orders are delivered by using order lines. Production, shipping and order delays have been achieved by preparing these lines.

FLOWCHART OF THE GAME

The algorithm of the SOARS Beer Game is displayed in Figure 2. Users will first set whether there are human players or not. If there are no human players, all agents must be set to have one of various strategies for decision making. Then set the final turn and the information disclosure level and a simulation starts.

The system first determines the current turn, then all places which are scheduled to receive in this turn receive beers. After receiving beers, orders arrive and the number of beers to be supplied in this turn is determined according to the number of stock and backlog of beers (The backlog is the number of beers that are not supplied yet). Then, all agents determine the number of beers to order in this turn using information of places and the strategy they have. Once orders are determined, beers are supplied and a cost is calculated. This cycle is continued until the final turn comes.

AGENT'S DECISION MAKING

Each agent can get information about the place of charge any time. For example, the *Retailer* agent can only get information about the *RetailShop*. Each place has the following information (Basic information).

Table 1
Name and Explanation of Information

Information name	Explanation
backlog	Number of backlog of demanded beers
demand	Number of beers that are demanded
received	Number of beers that are arrived
stock	Number of beers that are remained
supply	Number of beers that are supplied
turn	Present period
total cost	Total of cost that has been cost before

Besides, according to the setting of the simulation, each agent can get information on arrival of beers in the future (Arrival information) and information on stock and arrival of beers of other places (Other information). The relation between the setting of the simulation and the information disclosure is as follows.

Relation between the Setting and Information

Table 2

Simulation Setting	Information
Nothing	Basic information
Only arrival	Basic information and arrival information
All	Basic information, Arrival information and Other information

Table 3
Name and Strategy

Name	Strategy
Nothing	Order only the number of demanded beers
Random	Order randomly between from 3 to 12
Safety	If the stock increases then the number of beers for ordering is the number of demanded beers - 2. If the stock decreases then the number of beers for ordering is the number of demanded beers + 2. Otherwise, the number of beers for ordering is the number of demanded beers.
Human	Human player decides the number of beers of order

The case when the simulation setting is “All” is the same situation of the original board based beer game that players can know all information of beers on the board. All agents decide the number of beers for ordering based on information given according to the setting of the simulation.

AGENT’S DECISION MAKING STRATEGY

Four kinds of sample strategies are prepared in this SOARS Beer Game. Each agent can take one of these strategies and it is not necessary for all agents to take same strategy so that it is possible to simulate by combining various strategies. Strategies that are prepared are as follows; (See Table 3)

If all agents takes one of *Nothing*, *Random* and *Safety* strategy, you can treat this SOARS Beer Game as a simulation model. If one of all agents takes *Human* strategy, it becomes a simulation of gaming model. In changing the number of agents who take *Human* strategy, SOARS Beer Game becomes a simulation model, stand-alone gaming model or multiplayer gaming model. The feature of SOARS Beer Game is to be able to experience the beer game even if the number of human participation is insufficient.

SAMPLE RESULTS OF SIMULATION USING SIMPLE STRATEGIES

In this section, we will give you some simulation results of the SOARS Beer Game. The graph shows the stock of beers of each place.

- Red line: RetailShop
- Blue line: WholesaleFirm
- Green line: DistributeFirm
- Black line: Factory

CASE1

In this case, two agents who are the *Wholesaler* agent and the *Distributor* agent take *Nothing* strategy and others take *Random* strategy. This simulation ends at 50th turn.

Through the whole, stocks of the WholesaleFirm and DistributeFirm are nearly 0 or less than 0, stock of RetailShop is less than 0. Because of strategy that Retailer agent takes, the Retail shop cannot supply enough beers to the world. The factory becomes the result of stocked collecting as a result of using suitably producing.

CASE2

In this case, four human players participate in a simulation. This simulation ends at 32nd turn. In this case, the playing time is about 15 minutes.

Through the whole, out of stock spreads from the RetailShop to the Factory and the result of mass production of the Factory, out of stock is solved from the Factory to the RetailShop.

FUTURE WORKS OF THE SOARS BEER GAME

In the SOARS Beer Game, all agents are designed to decide how many beers to order according to the strategy as implemented. In this basic one that is introduced in this paper, there are only four simple strategies and one of them is used only when a human player participates in a game. To simulate this game with no human players, agents have to take one of other three strategies to decide how many beers to order. Actually, these basic strategies are too simple and not enough, and there should be a lot of strategies. Think about a real world, there must be as many strategies as human players who played this game, and the SOARS Beer Game should have such complex strategies.

Figure 3
Stock of Beers (Case1)

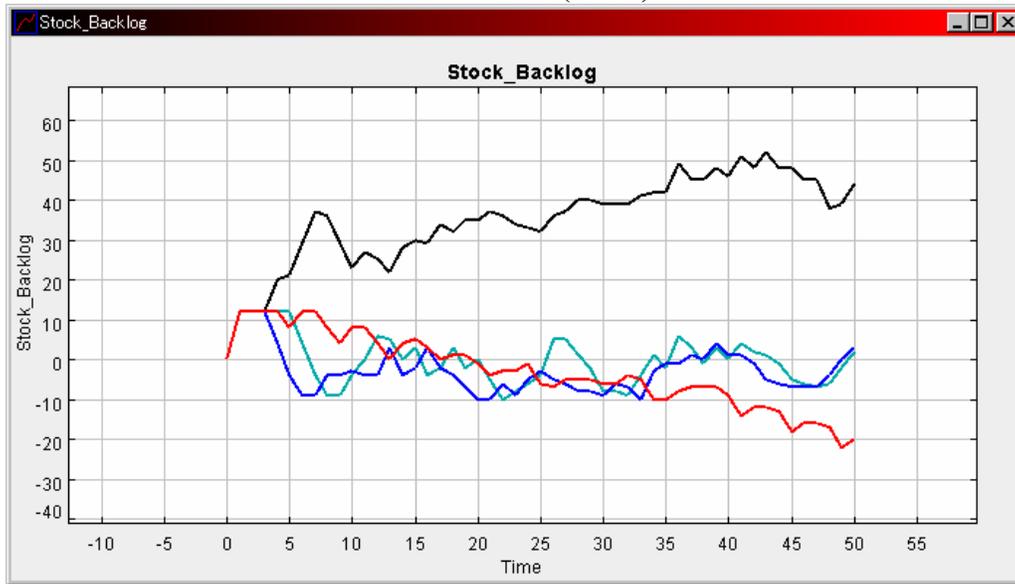
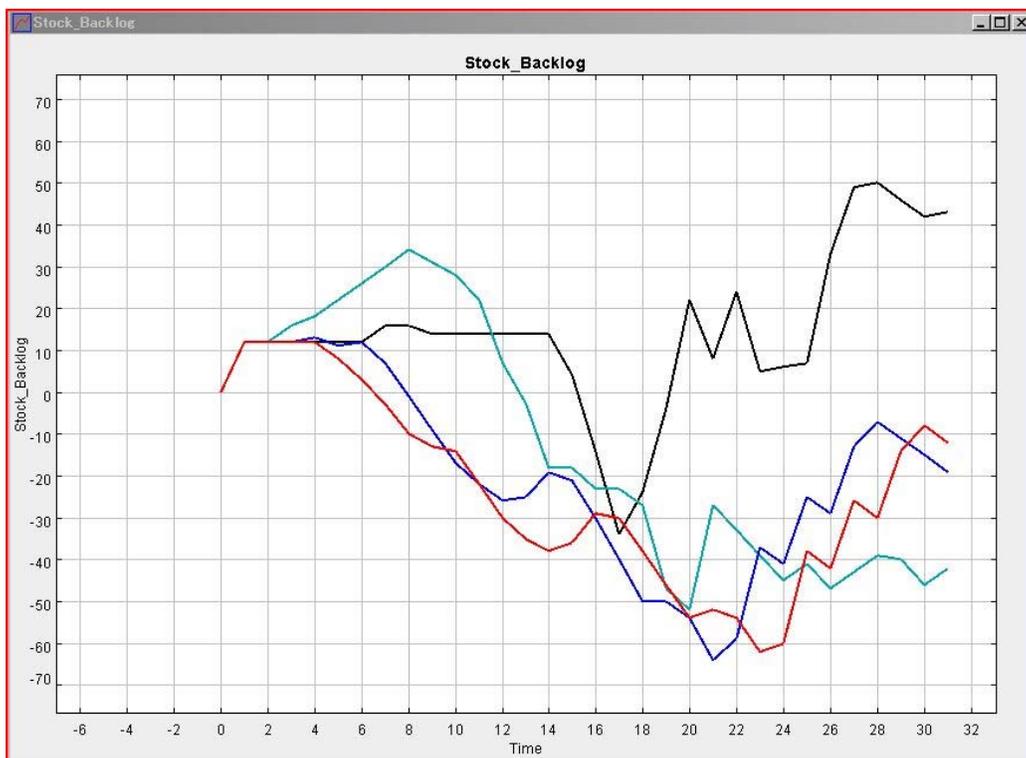


Figure 4
Stock of Beers (Case2)



To make a variety of strategies of this game by a small number of people is a hard work and difficult to cover all strategies of human players who played this game. To solve this big problem, the SOARS Beer Game is designed for everyone to add strategies easily. This enables players who played a game to make strategies which are based on their thinking. As the SOARS Beer Game is made by using the

simulation language SOARS, it is necessary to learn about it for making strategies. But as I described before, SOARS is designed for everyone to use and to make simulation models easily, so it will not take too much time to learn SOARS and to make strategies. This enables a lot of people to have a chance to make their original strategies and they can evaluate their strategies by simulating on the SOARS Beer

Game. Besides, by making others' strategies exist together with your own strategy in the same game, you will be able to know how your strategy works in it, to evaluate your strategy and to get some useful hints to update your strategy. This approach is like *KNOWLEDGE PROGRAMMING IN LOOPS*.

In KNOWLEDGE PROGRAMMING IN LOOPS program, a common environment, a kind of a virtual world, is provided and everyone who is going to participate this program makes some programs that work in it. After making programs, all programs are represented in the save environment and everyone can know how own programs work in it.

Through designing own strategies, it will be expected to learn much more about supply chain management.

Additionally, if the criteria of the quality of the strategy is made (for example, the lesser the cost, the better), the contest, the SOARS Beer Game Contest, can be held like U-Mart Project (Koyama et. al 2007).

U-Mart Project is that the Virtual Markets attract attention of economists, engineers and computer scientists as a novel research topic. The U-Mart Project is a forum for interdisciplinary research using virtual markets. In the U-Mart Project, open experiments are periodically held. Human and machine agents participate in those experiments. Participating strategic-class machine agents can be transferred via e-mail, so that the participants can join the market from everywhere in the world at any time.

Participants design and make their original strategies and compete with others', and finally it can be expected to decide which strategy is the best one, which strategy is the smart one and so on. To archive the above-mentioned, it is necessary to prepare some manuals on how to design and make strategies for an agent of the SOARS Beer Game. For our next actions, our priorities are as follows:

- To make the manuals
- To make some more simple strategies
- To hold a pre-contest

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