"Electrifying" Learning: Computerizing the Beer Game

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Abstract: The Beer Distribution Game is one of the most popular ways of introducing managers and students to system dynamics. One of the reasons for this popularity is its success at teaching, on an experiential level, one of the fundamental principles of System Dynamics--that structure causes behavior. It does this in an entertaining and engaging manner. Some players have become so engaged in the experience that they want to explore the dynamics of the game further. Because of this interest computer versions of the game have been developed to accelerate the opportunities to explore the game's dynamics and make it easier to use and facilitate. This paper will highlight some of the features of these games which facilitate learning by individuals or teams.

Brief History of Game

The original Beer Distribution Game was developed at MIT sometime in the early 1960s by the System Dynamics Group at the Sloan School of Management (Jarmain 1963). The game was used to introduce three key concepts of system dynamics; (1) structure causes behavior, (2) the concept and importance of delays, and (3) the concepts of stocks and flows. It has since become the standard way courses in System Dynamics are introduced (Sterman 1992).

The Beer Distribution Game consists of a series of Stocks (Inventory) which must be managed by controlling the flows into and out of these stocks. This control is done by making orders to the positions upstream from your position and filling orders from the downstream positions.

Over the years the game has been refined, improved, and analyzed by many people (see Sterman 1989, Senge 1990; see the annotated bibliography in this paper). Many computerized versions have been developed.

We will explore a version of the game that Innovation Associates and Gould-Kreutzer Associates created in 1991. The game consists of a STELLA™ model attached, via STELLAStack™, to a HyperCard™ interface. It not only captures the dynamics of the Beer Distribution Game but also allows you to quickly change the decision rules of that game to explore the dynamics further. By allowing the user to play this game in both "Simulation" and "Gaming" mode the user is able to recreate the experience of the Beer Distribution Game without having to collect the appropriate number of people needed to replay it. We will then briefly discuss previous other computer-based versions of the Beer Distribution Game.

Electronic versions of the game first began appearing in the late eighties. These games can be divided into two groups. The first group consists of games that are designed to replace the Board Game. They are generally networked and designed to have groups of people play them just as they would in the traditional way, except that instead of sitting in front of a board game they are sitting in front of a computer. The computer

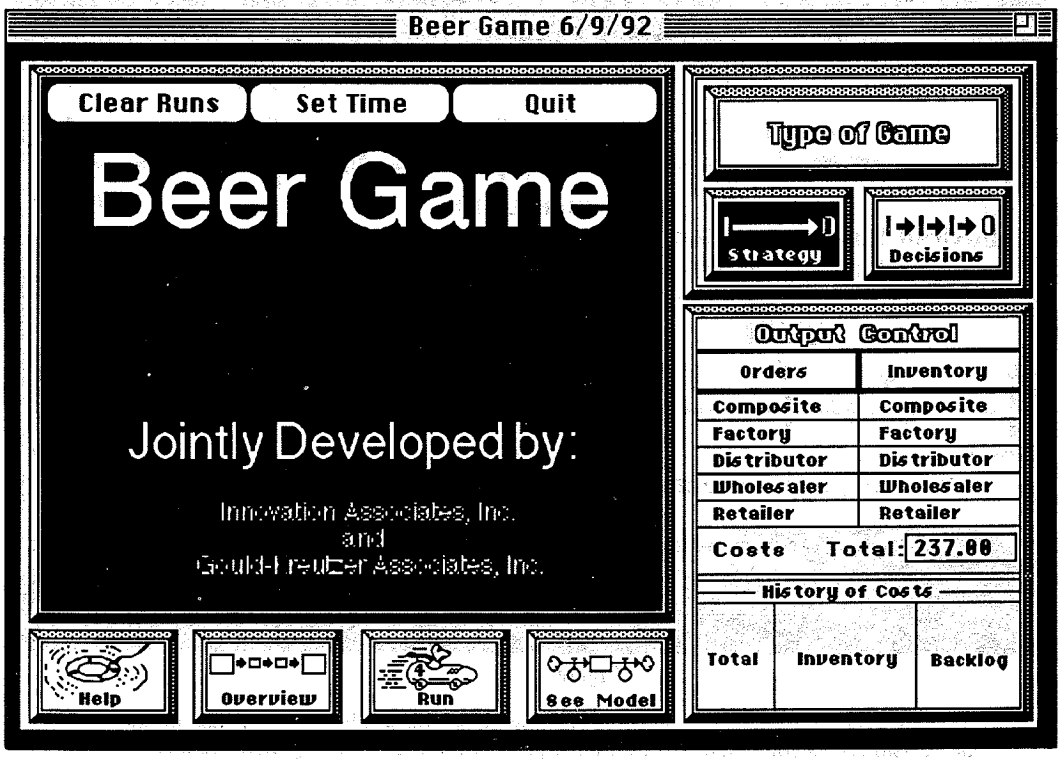
recreates the look and feel of the board game and in addition automatically keeps track of your orders, inventory and backlog, and produces the graphs and tables that are used during the debriefing.

The other style of Beer Game is designed to be played by one person at a time or a small group. They are designed to be used by facilitators to help in debriefing people who have just played the board game or by people who want to explore the dynamics of the game in greater detail but don't have the time or the people to replay the game in the traditional way.

Electronic Beer Distribution Game

The GKA-IA Beer Game allows the model to be played in either simulation or gaming mode. This is done by incorporating the decision rules explored in professor John Sterman's research into modeling managerial behavior estimated from the play of many actual participants (Sterman, J. D. 1989). These decision rules enable you to tell the computer how you want the positions to be played.

The game begins with a simple animation which shows the relationship between each of the positions. From there you are taken to the main control screen. (See figure 1)



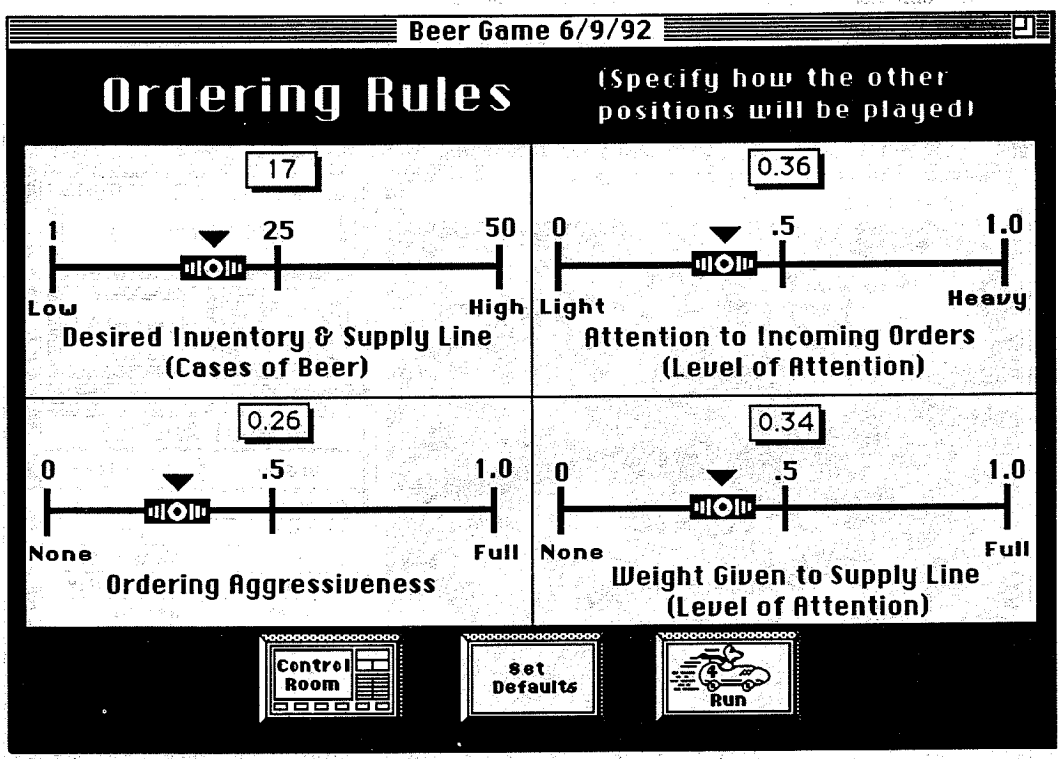
(Figure 1)

This control screen has several features beyond just controlling the flow of the game. These features include context sensitive help, a guided tour, and the ability to explore the actual model that is used to simulate the beer game.

The first thing you need to decide is whether you want to play the Beer Game in simulation or gaming mode. Simulation mode means that you set the ordering rules and sit back and watch the model simulate. All positions will play with the same rules. Gaming mode means that the simulation will stop each week and ask you to make decision as in the manual game. In this mode you must predetermine how the other three positions will play on their own.

Playing in Strategy Mode

Clicking on the "Strategy" button puts the game into simulation mode. It also takes you to a series of screens. The first screen allows you to set weights associated with the decision rules described by Sterman (Sterman 1989). These decision rules focus on typical algorithms people use when they play the game and are shown in figure 2.

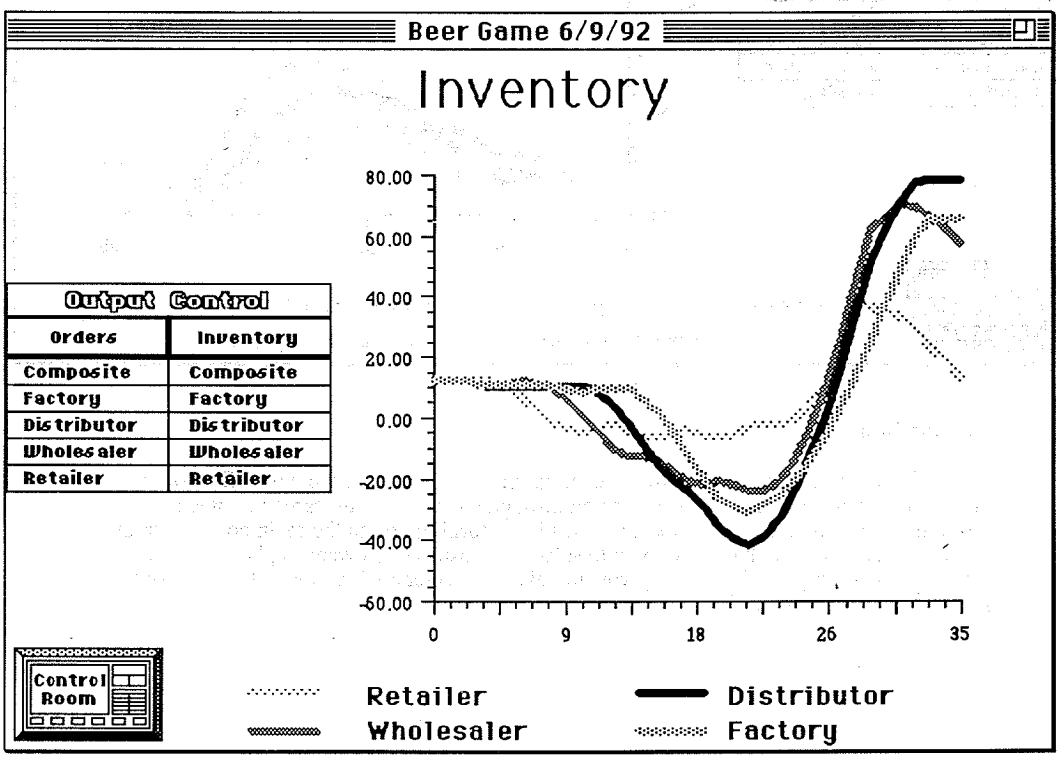


(figure 2)

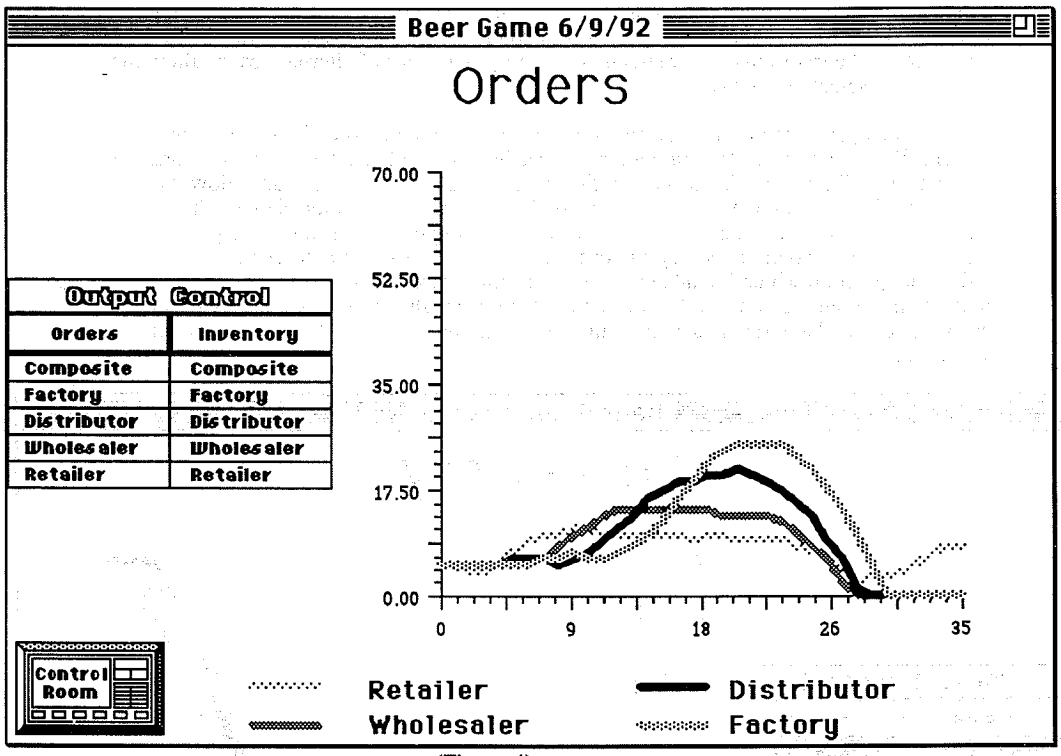
If you were playing the game in Gaming mode you would use this screen to set the decision rules you would want the other positions to use in making their decisions. A default button is included on this screen if you want the positions to behave like the

average player of the game. In Simulation mode this screen is used to set the decision rules for all positions. The next screen allows you to set up the incoming order stream. You can use the traditional order stream, choose from a series of alternatives, or allow the computer to select one for you.

Once you complete the set-up procedures you are returned to the main control screen. You can now run the simulation and see how you did. As the simulation runs the total cost for all positions is updated on the main control screen so you can follow its progress. Once the simulation is finished you have several options for viewing the output. You can look at a graph for the entire team showing all four positions plotted on the same graph for both inventory and orders, or you can look at graphs of each individual position which include the plots of the most recent 4 runs for that position plotted on the same graph (see figures 3 and 4) You can also look at the history of total costs. Once you have finished examining the output you can rerun the model as often as you want.



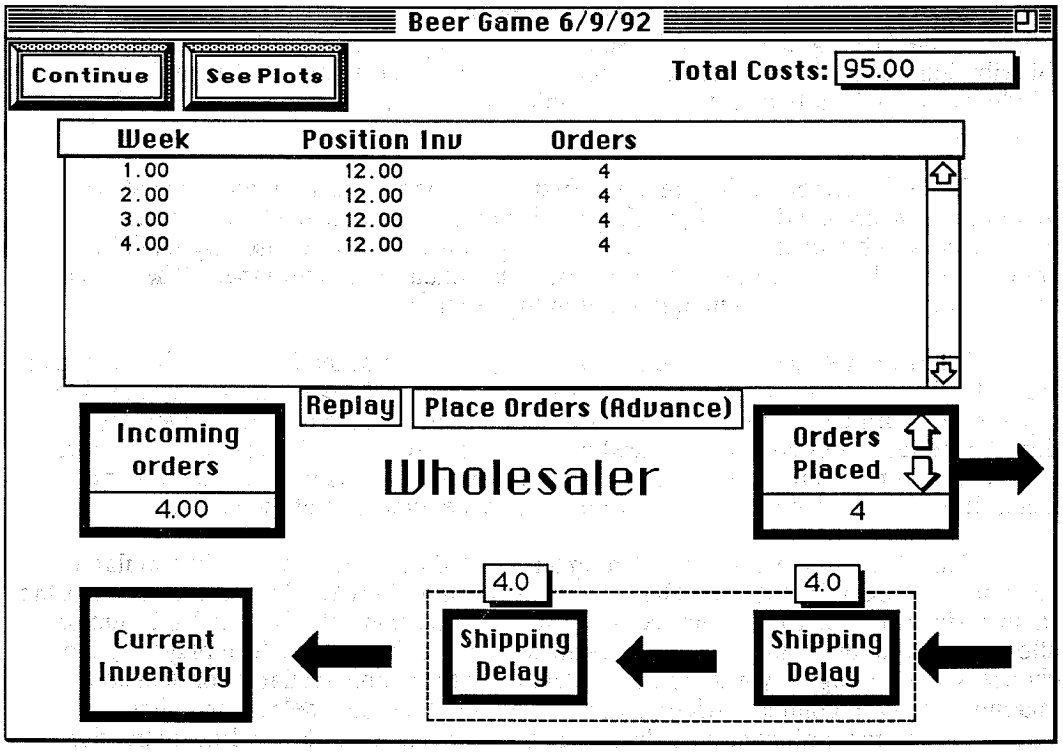
(Figure 3)



(Figure 4)

Gaming Mode

If you want to run the model in gaming mode you click on the word "Decisions" on the main control screen. This takes you through the same set up cards you went through in the simulation mode except instead of returning you to the main control screen you are taken to a card that allows you to select the position you want to play. Once you select the position you'd like to play you are taken to a screen which recreates the board game position (see figure 5).



(figure 5)

This card shows you the same view of the game you get from the board game . It allows you to place your orders (Order Placed) and see what you have coming to you in your two shipping delay boxes. It also keeps your record sheet for you. From this card you also have access to all the plots you had access to in simulation mode.

Once again you can play this game as often as you want in order to explore the dynamics of the Beer Game in greater detail then you'd otherwise be able to do.

Survey of Electronic Beer Games

There are several electronic versions of the Beer Distribution game. Below we describe those of which we are aware.

In February of 1988 Pecos River Learning Center produced the first electronic networked version of the Beer Game. It was written in hyperacid and required one Macintosh per position and one Macintosh for the facilitator. While it was only in black and white it contained sophisticated graphics, animation, and sound effects. For instance if you were playing the retail position a new customer in a different car would drive up each week, honk the horn and place an order. You would then fill that order and place one of your own. This version of the game is extremely fun to play and is very engaging.

The Digital Equipment Corporation Multi-Media Beer Game (VAX Brew) was created in the late eighties and was also designed to replace the board version of the Beer Distribution Game. Its main features include (1) that it is networked, (2) that it uses windows, is graphically oriented, and has animation, and (3) that it runs on a VAX VMS machine.

Digital's version of the game was first used in Japan. Later it was used at DEC World 1990 where hundreds of people participated in an hour and a half learning experience which focused on logistics dynamics. It has since been used by DEC in conferences and with their clients throughout the United States and Japan. They use it mainly in their supply chain integration training programs.

Innovation Associates is currently testing a version of the Beer Distribution Game created in Microsoft Excel™. This spreadsheet version of the game is also designed to replace the board game. One of its main strengths is that all the computer interaction is done be the facilitator so you only need one computer to play it. The computer images are projected onto a projection screen. Everyone in the room is playing on the same team. It has yet to be determined how this affects the dynamics of the game.

The MIT System Dynamics Group has created a management flight simulator version of the Beer Distribution Game developed using MicroWorld Creator™. It has the same basic design as The People Express Simulator (Sterman 1988). The MIT version allows one or more people to play the game or simulate the system. The player(s) can choose which setting they wish to play, select the information available for decision making (locally or company wide), select the length of the time delays, and choose a variety of patterns for incoming orders. The program also includes on-line instruction and help. Like the People Express and B&B Enterprises management flight simulators, the package comes complete with a user's guide and an instruction manual.

Conclusion

The Beer Game is used to introduce three key concepts in systems dynamics. 1) That structure causes behavior, 2) the concept and importance of delays, and 3) the concepts of stocks and flows. Anecdotal evidence from Innovation Associates and Gould-Kreutzer Associates suggests that the GKA-IA Electronic Beer Game does a good job at introducing these concepts and more.

While the game does give players the opportunity to play individual positions in the same way as the board game we do not use or suggest that the various versions replace the board game. In fact we designed our version of the game to deepen learning *after* people have played the manual game. This was in response to "what if" questions often asked after the manual game. The intention was to allow participants to see more rapidly and graphically the impact of different decision rules on performance and to further strengthen notions related to the impact of structure on behavior.

In experiments with this game we divided an executive team up into groups of three and asked them to play with the intention of improving their manual game performance. All had played the manual game some months prior. We asked them to pick a position and play that position while using the default parameters for the other positions.

Participants were able to fully re-engage themselves in the game and recreate the same type of experience they had had previously. One interesting result of this experience was that we discovered that the participants found it difficult to significantly better their manual game performance.

In other experiments with other subjects they were asked to play optimally while the other positions were set to play using the normal defaults. Not surprisingly the overall qualitative and quantitative results did not improve markedly even with one position playing very well. The experiment made evident the fact that an individual playing more optimally while other positions are playing sub-optimally does not improve performance at all. For us this reinforces the maxim that the team needs to learn together how best to play in the system. While these results are intriguing it must be remembered that they are preliminary and were based on a small sample.

The Beer Distribution Game: An Annotated Bibliography Covering its History and Use in Education and Research (Prepared by John D. Sterman)

Forrester, J. W. (1958) Industrial Dynamics: A Major Breakthrough for Decision Makers. *Harvard Business Review,* 36(4), July/August, 37-66

The first article in the field of system dynamics. Presents the production-distribution system as an example of dynamic analysis of a business problem. Reprinted in Roberts (1978)

Forrester, J. W. (1961) Industrial Dynamics. Cambridge MA: Productivity Press.

Contains the material in Forrester 1958 expanded to include additional discussion of policies to improve performance in the production-distribution system. Also includes complete equations for a computer model of the system from which the Beer Game is derived. Describes the results of many policy experiments. Industrial Dynamics is *the* classic work in the field and remains an extremely useful reference and text thirty years after publication.

Jarmain, W. E. (ed) 1963. Problems in Industrial Dynamics. Cambridge, MA: MIT Press.

Contains a description of an early version of the Beer Distribution Game.

MacNeil-Lehrer Report, (1989) *Risky Business - Business Cycles*, Video, Public Broadcasting System, aired 23 October 1989.

Videotape showing students in John Sterman's System Dynamics course at MIT playing and discussing the Beer Game. Relates the game to boom and bust cycles in the real world. Excellent in debriefing the game, and helpful to those seeking to learn how to run the game. Copies available from System Dynamics Group, E40-294, MIT, Cambridge MA 02139.

Mosekilde, E., Larsen, E. R., & Sterman, J. D. (1991). Coping with complexity: Deterministic chaos in human decision making behavior. In J. L. Casti & A. Karlqvist (Eds.), Beyond Belief: Randomness, Prediction, and explanation in Science, 199-229. Boston: CRC Press.

Shows how simple and reasonable decision rules for playing the Beer Game may produce strange nonlinear phenomena, including deterministic chaos.

Radzicki, M. (1991). Computer-based beer game boards. Worcester Polytechnic Institute, Dept. of Soc. Sci. and Policy Studies, Worcester, MA 01609-2280.

Beer game boards in PICT format for Macintosh computers available on disk for $5.00; all proceeds go to the System Dynamics Society.

Thomsen, J. S., Mosekilde, E., & Sterman, J. D. (1992). Hyper chaotic Phenomena in Dynamic Decision Making. *Systems Analysis and Modelling Simulation.*

Extends earlier papers by Mosekilde, Sterman, et al. to examine hyper chaotic modes in which the behavior of the beer distribution system may switch chaotically among several different chaotic attractors (for aficionados, "hyper chaos" exists when a dynamical system contains multiple positive Lyapunov exponents).

Roberts, E. B., ed. (1978) *Managerial Applications of System Dynamics.* Cambridge, MA: Productivity Press.

Excellent anthology of early applied system dynamics work in organizations, including analysis of efforts to implement the results of the model which led to the Beer Game.

Roberts, E. B. (1978) Equations for the Production-Distribution System, in Roberts, E. B. (ed.) *Managerial Applications of System Dynamics*. Cambridge, MA: Productivity Press.
Presents documented equation listing for the production-distribution system based on Forrester (1961), in the DYNAMO computer simulation language.

Senge, P. (1990) The Fifth Discipline. New York: Doubleday.
Excellent non-technical discussion of the Beer Game, and systems thinking principles generally.

Sterman, J. D. (1984). Instructions for Running the Beer Distribution Game. D-3679, System Dynamics Group, MIT, E40-294, Cambridge MA 02139
Explains how to run and debrief the Beer Game, including layout of boards, set up, play, and discussion. Incorporates debriefing notes by Peter Senge. Some people have found this document, in conjunction with the MacNeil/Lehrer video and *plenty of practice*, is sufficient to enable them to lead the game successfully.

Sterman, J. D. (1988). Deterministic Chaos in Models of Human Behavior: Methodological Issues and Experimental Results. System Dynamics Review, 4, 148-178.
The decision rules people use when playing the Beer Game can lead to deterministic chaos.

Sterman, J. D. (1989). Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment. Management Science, 35(3), 321-339.
Detailed analysis of Beer Game results. Examines why people do so poorly in the Beer Game. Proposes and tests a model of the decision making processes people use when playing the game and shows why they do so badly.

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Diehl, E. 1990. MicroWorld Creator™ User's Manual. Cambridge, MA: Microworlds, Inc.

High Performance Systems, STELLAStack, 45 Lyme Road, Hanover NH 03755

Richmond B. M., P. Vescuso, and S. Peterson 1987, *STELLA for Business,* High Performance Systems, 45 Lyme Road, Hanover NH 03755, USA

Sterman, John D. 1988, People Express Management Flight Simulator. Simulation Software and Documentation available from author, MIT Sloan School of Management, Cambridge, MA 02139

Sterman, John D. 1992, Teaching Takes Off: Flight Simulators for Management Education, OR/MS Today, October, 40-44.

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Pecos River Learning Center, Inc. (Joey Wilson 505-989-9101, Amy Edmundson 617-864-0073)

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