

## **A Revised Business Game for Use in Teaching Engineering Economy or Operations Management**

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### Abstract

We report on the use of a revised business game as a supplemental teaching aid in a production and inventory control course in Industrial and Manufacturing Systems Engineering at Lehigh University. The revisions were born out of student evaluations of an original game developed at Stanford and implemented at Georgia Tech and Lehigh. The basic premise of the game remains centered around student teams making periodic decisions regarding the manufacture and sale of a product in a competitive market. However, a variety of the parameters that define the game have been generalized and a number of decisions have been added in order to provide greater realism. Also, the game has been rewritten in C++ with students interacting via the World Wide Web. These structural changes have greatly reduced the time and effort an instructor must expend in executing the game over the course of a semester. It is hoped that these improvements in administering the game will help in its dissemination and use at other institutions as it provides a unique learning experience that can supplement the teaching of engineering economy or operations management courses.

### 1. Historical Perspective of Business Game and Motivation for Revision

Thuesen [1] reported on the use of a computer-based simulation business game (Whitman [2]) in engineering economy courses at Georgia Tech. In the game, teams of students make various decisions regarding the operation of a plant or plants. At the beginning of the game, each competing team has an equivalent net worth, divided among capital assets and cash. Over time, students make decisions regarding their product and its manufacture. The decisions are far reaching, as they include plant expansion and equipment replacement decisions as well as raw material procurement and production scheduling. Additional decisions include product pricing and advertising according to regions, as each team is based in a different geographical location, and product improvement and production process cost control programs. There is also a stock market where shares of each team are traded. There are many influences on a team's stock price, including declared dividends. The team with the highest number of assets is declared the winner after the final period.

The students at Georgia Tech met this game with tremendous enthusiasm (Thuesen [1]). While stimulating their interest in economic decision making, it exposed them to topics of (1) decision making in uncertain environments; (2) operating a competitive company; and (3) relating topics of engineering economy to "actual" decision-making. For three years, the game was utilized in operations management courses at Lehigh University. Motivated by student evaluations and desires

to make the game both easier to execute and more accessible to other interested educators, the game, as described in this paper, was revised and implemented this past semester. These improvements include those in both the execution of the game and in the actual decisions made by teams playing the game. While the changes are substantial, the basic premise of the game remains as it was when originally written: to simulate a competitive business environment in which students can apply and appreciate knowledge acquired in the classroom.

## 2. Overview of Methodological Changes in the Revised Business Game

The revised business game retains all of the decisions that were present in the original game. (For a detailed review of the original game, see Thuesen [1] or Whitman [2].) However, a number of decisions have been added or altered to provide further realism. These changes are described in the following sections. For the sake of brevity, the term “original game” refers to the computer-based simulation business game utilized by Thuesen and the “revised game” refers to the new computer-based simulation business game utilized at Lehigh.

### 2.1 Game Structure

The revised game has no limit to the number of teams that may compete. The game adds a personal touch as each team can select a name for their company.

At the beginning of the game, each company is assigned a plant in a designated location. This location is defined by latitude and longitude coordinates which are assigned semi-randomly, as there is an effort to spread the teams across the entire area. Customers are assumed to be located near each of these plants and thus a company has a strategic advantage when serving customers near its plant, although they are not prohibited from serving customers near other plants.

Companies no longer compete in a fictitious widget market. Rather, they produce and sell wooden CD-racks. This product was chosen for a number of reasons. First, it is a real product that the students can visualize. Second, production of the racks requires only one raw material (wood), which is an assumption made by the game. Third, the product is a semi-luxury item in that people can “live without it” when the economy is not very good (economic parameters provide one driver of demand in the game). Thus, demand is subject to fluctuations outside of the control of the individual companies. Finally, an historical price range for the product is \$20-\$30 (the students learn this when introduced to the game), which is reasonable for this product.

### 2.2 Capacity Expansion and Acquisition

Whereas capacity was previously defined by the number of plants owned, both the number of plants and the number of lines operating in each plant now define capacity. Thus, expansion can occur on two levels. A plant may be expanded by adding production lines. Once a limit of lines (designated parameter) has been reached, expansion can only occur through the purchase of a new plant or plants. The plant must be equipped with lines before it provides operating capacity. Once a plant or line has been selected for purchase, a lead-time (designated parameter) must pass before the capacity is available for use.

Companies purchase a plant and/or line for a designated cost; however, they may choose to finance the acquisition over a number of periods. The interest rate on any loan is a function of the federal prime rate (designated parameter) plus a risk premium (designated number of additional basis points per amount borrowed) based on the size of the loan. In our implementation, the prime rate was assumed to be 6 percent and 0.5 percent was added for each \$10,000 borrowed. It is assumed that a line or plant cannot be utilized until the loan balance is paid.

Finally, it is assumed that lines deteriorate with time. These lines (and thus equipment) may be repaired or replaced over the course of the game.

### 2.3 Stock Market and Trading

The revised game has numerous changes to the stock market and its influence on a company's balance sheet. First, the number of outstanding common shares that a company has on the market is a designated parameter (we assumed 100,000). Trading activity, dividends, the overall economy, and the well being of the company, both in the short and long term, influence share price. It should be noted that it is very difficult for a company to isolate or predict stock share movements with certainty, as with the real stock market.

Second, a team can purchase or sell shares of any company at the market price or enter a limit order. The option to place a limit order was added because students wanted to have more certainty of the stock price when they purchased or sold shares. Shares may still be shorted for cash under the assumption that the shorts are covered in the ensuing period. All insider-trading moves are made public.

Finally, the method in which stocks are reported on the balance sheet has been altered. In the original game, stocks were valued on the balance sheet at their purchase price. Thus, if a stock tripled in value over time, the balance sheet was unaffected until the time of sale when the after-tax cash proceeds were added to cash. While this seems reasonable, it led to extreme difficulties in the final periods of the game because a company had to sell their shares in order to show an increase or decrease in assets from stock market moves. So, at the end of the game, every team would sell their shares, which often led to a stock market "meltdown" due to the influence of heavy selling on share prices. To eliminate this end-of-horizon effect, the assets on the balance sheet are now updated each period according to current stock prices. Therefore, teams do not have to sell their shares in order to reflect any changes in asset value.

### 2.4 Transportation Costs

In the original game, a team is assigned to a geographical region where the company has a market presence. If product is sold in another company's region, a fixed per unit transportation fee is paid. This phenomenon holds true in this game. However, as the plant location is defined by latitude and longitude coordinates, transportation fees are based on actual rectilinear distances.

### 2.5 Backorders and Associated Costs

It is quite possible that companies cannot meet demand. These orders are backlogged and filled at the original order price according to first come first served. After each period, a percentage of these backorders are lost (designated parameter). If an excessive number of customers leave, this affects the appeal of the company's product and will hurt future sales.

### 3. Overview of Technological Changes in the Business Game

The original game was written in Fortran IV (Whitman [2]). Execution of the game required that students submit a page of decisions each week. These decisions were then keyed into a computer and the code was executed. After the simulation was complete, a final report was printed and returned to the students.

Although not a burden to the students in terms of execution (there was a "burden" to the students as they had to make decisions on their own time – not class time – and translate these thoughts onto paper), considerable time was taken by the faculty member or teaching assistant to input the data into the system. As this process transferred written word to computer input, it was prone to error. A number of changes were made to improve administration of the game.

The original Fortran code (in addition to all aforementioned game changes) was rewritten in C++ to take advantage of the benefits of object oriented programming. This code revision allows an instructor to specify game parameters to alter the game according to their own specifications. For instance, the number of shares that a company has on the stock market is a designated parameter.

The most noticeable features in the current execution of the game are in the handling of information and data transfer. The system works as follows. A student team logs onto a web site where they can access confidential company specific data, such as previous decisions and balance sheets. They can also access information available to all teams, such as total asset figures of any company, stock market information and insider trading. While logged on, they can enter their periodic decisions and submit them to the system. After the simulation runs, results are immediately posted to the web. (This process is automated such that the instructor does not have to execute the program.) To keep in touch with the game, the instructor can access the system as an administrator and view the results.

This new system has a variety of benefits. Errors that occurred when transferring decisions to the computer have been eliminated as the instructor has been removed from the process. The system also allows the students to access the system and submit decisions according to their own time frame (available 24 hours per day). Class time is not required to collect decisions or disseminate results as this all occurs online. While not inconveniencing the students, the instructor is essentially removed from the process of running the game and thus is not burdened during the semester. As a final benefit, no paper is used in the new system.

### 4. Student Reaction to Revised Game

The revised game was implemented this past semester in a production and inventory control course. This senior level required course covers a variety of topics including forecasting, inventory control, scheduling and transportation logistics. Thus, the game mapped well into the course content. The

game was introduced in the first week of the semester and ran for 12 consecutive weeks. Ten percent of the course grade was based on the business game – five percent dependent on their team’s achievement and five percent dependent on participation.

As with reported experiences at Georgia Tech (Thuesen [1]), students at Lehigh University thoroughly enjoyed the business game. From a technological standpoint, students were unanimous in applauding the web-based implementation of the system, citing the many benefits stated above. As for the game itself, here is a sampling of typical responses to the game:

“I liked it. I thought it was an easy way to relate class material to a real life situation.”

“I really liked it. It helped me put a lot of what we learned together.”

“I think it was a good addition to the class. I think the part of the game that taught me the most was working with people and making decisions together.”

“I thought it was a good experience. I learned the most from the mistakes we made.”

“It’s actually fun and I like the idea that we are competing.”

Of course, not every comment was positive. Some students stated that they did not apply the methods learned in class to the business game. This is partially by design, as students are not graded on “how” they make decisions, but rather, the simulation determines the outcome of the decisions. Also, the game is introduced in the first week of the semester and thus, the students are forced to “learn by doing” because they do not have all of the tools. Students may “guess” decisions if desired. However, it has been our experience that student teams that apply analytical methods, especially those taught in class, generally perform better in the game. Some students noted that they were very excited about the game at the beginning of the semester but interest “faded” with time. Additional suggestions by the students are noted in the next section.

## 5. Conclusions and Future Improvements

A business game has been incorporated into an operations management course at Lehigh University for the past four years, with a revised web version implemented this past semester. Each year, students were queried through formal course evaluations in order to improve the game for future classes. It was through these formal evaluations that the business game evolved to its present state.

In addition to support for the game and its continuation, students have continually offered suggestions for improvements. This year’s suggestions for further improvements included the ability to purchase *and locate* a plant. While this seems like an innocent change, it would require that teams assign customers to each of their plants. This decision would have to consider both transportation costs as well as levels of customer demand and capacity limits on the plants. Second, it has been suggested that customer locations should be independent of plant locations as all customers are currently assumed to be located near a plant. This would provide further realism with respect to transportation costs. The final suggestion is to allow a line or plant to come on-line for

use before its loan balance has been paid. This reasonable suggestion can be implemented easily. The other two suggestions will be explored further for the next academic year.

For those interested in learning more about the business game, please consult Joseph Hartman's web site at <http://www.lehigh.edu/~jch6/jch6.html>. This page contains information on downloading all necessary files such that any instructor may execute the game. The initial set-up of the system may require local expertise at one's institution of higher learning. However, every effort will be made to make the process of implementing the system straightforward in order to promote widespread dissemination of the game. As the game will continue to evolve, new versions will be made available at this site.

#### Bibliography

1. Thuesen, G. J., "The Use of a Business Game in the Teaching of Engineering Economy," ASEE Annual Conference Proceedings, June, 1988, pp. 1080-1084.
2. Whitman, D. "The Business Game," Technical Report No. 66-11, Department of Industrial Engineering, Stanford University, 1966.

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