Computer Simulation and Learning Theory, Volume 3, 1976

TEACHING INVENTORY CONTROL VIA COMPUTER INTERACTION WITH INCREASING COMPLEXITY

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Submitted for the Third ABSEL Conference
Knoxville, Tennessee

October, 1975

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One of the highlights of last year's ABSEL conference was the demonstration of 3. Ronald Frazer's Inventory Simulation (1). The experiential learning achieved by one of the authors during the demonstration stimulated efforts to add such a package to the teaching of inventory control at Kansas State University. While a different simulation package had been used in the teaching of inventory control at Kansas State, success had been somewhat limited due to its complexity (this simulation will be described later). The addition of an inventory control simulation similar to Frazer's provides the student with an enjoyable but yet meaningful learning experience at a level that does not confuse the student. Also the additional simulation provides a transition between the relatively abstract EOQ lectures and the complexity faced in implementing the EOQ model in the second simulation.

Use and Description of Simulation 1

The students are introduced to an expanded version of Frazer's Inventory Simulation (1) after the instructor has provided a descriptive introduction to inventory control. The students are supplied values for the relevant parameters of the inventory system. They then play the game utilizing simply their general knowledge of the system and "common sense." Their performance, hopefully compared to that of the instructor or that of "the computer," gives them a feel for the complexities involved in inventory control . The original use of the simulation then is to show the need for the development of an inventory control system. Once the students have an inkling about the complexities of inventory control and an understanding of the need for a systematic approach to deal with the relevant uncertainties, the instructors lectures on EOQ become relevant. Once the EOQ lectures are finished, the students are encouraged to use the material provided to develop theft own economic order quantity and reorder point. Subsequently, they are required to play the first inventory simulation game(s) again, this time applying their new knowledge.

As mentioned earlier, the first simulation is an expanded version of Frazer's Inventory Simulation (1). The basic details are the same as in Frazer's simulation:

1) The average number of customers is four (Poisson distribution)
2) Demand averages 50 units/customer/week (normal distribution, standard deviation of 10)
3) Carrying cost of $.05 per unit per week.
4) Order cost of $50, regardless of the size of the order.
5) Stockout costs of $2 per unit plus $50 per unsatisfied customer.
6) Four weeks lead time.

One change in the basic game at Kansas State University is that the initial inventory level is 1400 units rather than 2000 units, since most students would have to wait several weeks before starting the game under the higher initial level.

Another change is that the program at Kansas State *is* written in FORTRAN, rather than BASIC, due to the relative availability and ease of use of the two languages at Kansas State.

Further changes involved the addition of alternative forms of the game:

Version 1: Basically Frazer's Inventory Simulation (varying demand only).

Version 2: Varying lead times as well as varying demands.

The lead time has the following distribution:

3 weeks with probability .2
4 weeks with probability .4
5 weeks with probability .2
6 weeks with probability .2

Version 3: Varying demand, varying lead times, and the possibility of a strike, which keeps in-transit stocks at their current location and postpones orders until the end of a two-week strike. At the beginning of each four-week period the students are notified of the probability of a strike (the product of four random numbers) in the next four weeks.

Each version of the game also gives the players the option of competing against the computer, which uses empirically derived economic order quantities and reorder points. In Frazer's teaching manual (2), he computes an EOQ of 632 units using only the order and carrying costs and suggests a reorder point of 1400 units. The computation of the expected stockout costs is somewhat complex in this situation due to the combination of a varying number of firms coming from a Poisson distribution and each firms demand coming from a normal distribution. However the expected stockout costs can be computed, given a safety stock level, by determining empirically the probability that the actual demand during lead time will exceed the reorder point (mean demand during lead time plus safety stock). Consequently, the procedure used to determine the EOQ was to vary the safety stock level, compute EOQ for each safety stock level, and then to find the level of safety stock that resulted in the lowest total inventory costs over a ten year (520 week) run of the game. The figures thus derived to be used as the computer as, heuristic" are shown in Table 1.

Table 1

	EOQ	Reorder Point
Version 1	698	1189
Version 2	721	1324
Version 3	700	1454

The additions of student competition with ‘the computer” further adds relevance to the teaching of inventory control since students have rarely beaten the computer when the length of the game exceeded 13 weeks. One problem occurs with the use of Version 3, though, since the computer can be beaten if strikes do not occur (they occur infrequently in games of short duration). Therefore, students playing Version 3 are admonished to play for a period of at least 52 weeks. Figure 1 presents a brief example of one run of the game.

Use and Description of Simulation 2

Even the expanded version of Frazer’s Inventory Simulation lacks some relevance, largely due to fact that the expected demand remains the same over time. Consequently a second simulation is used at Kansas State in order to further demonstrate the forecasting aspects of inventory control theory. This simulation was developed by Michael Pohlen at Indiana University (now at Delaware University). It is a FORTRAN program consisting of a series of subroutines, the two most important ones being the DEMAND and ORDER subroutines. The DEMAND subroutine generates the daily demand from a Fourier series, thus requiring the students to consider both seasonal and growth factors in their forecasting techniques. The ORDER subroutine supplied initially orders a set amount each day; the students' task is to replace that subroutine with a better one. Students are required to devise a forecasting routine and to incorporate it into the determination of EOQ and the reorder point. Typically, the class is broken up into fairly good sized groups (5-6 people) and care is taken to insure that each group has at least one student with some programming competency.

The details of the simulation are as follows:

1) Initial daily demand level of 500 units.
2) Initial inventory of 2000 units.
3) Lead time of 6 days, although the students are required to vary this once their order subroutines have been developed.
4) Order cost of $30.
5) Carrying cost of $5 per year per unit.
6) Stockout cost of $3.50 per unit.

The students are to develop an exponentially smoothed forecast of the demand during lead time as well as a forecast for the yearly demand. These become inputs to the EOQ formulas. The students also perform sensitivity analyses on the exponential smoothing parameters, lead time, and the various costs.

The second simulation had been used by itself before the first simulation was developed. The overall reaction of the students was positive, although it was very evident that several students were not willing to put forth the effort to understand what was going into the ORDER subroutine. The addition of the first simulation greatly enhanced an understanding of the second one as well as general motivation.

Course Implementation of the Simulations

The concept of inventory control is a pervasive one, affecting several of the business functions. Consequently the use of the simulations described above has not been limited solely to one course. The two-stage process described above was used in the teaching of Business Logistics. However, the first simulation has also been used in the following courses.

Applications of the Computer in Business--i) the teaching of inventory control and 2) demonstrations of interactive computing. (The initial version of the program at Kansas State was developed jointly by the students and the instructor in this course).

Production Management--the teaching of inventory control

Marketing Research--demonstration of the need for forecasting so as to justify the emphasis on that topic.

Applications of the Computer in Accounting--the teaching of inventory control.

Overall Evaluation

The instructors that have used the simulations have been very pleased with the results. The teaching of inventory control by the traditional lecture-examinations format was regarded as a very sterile approach to the subject. Instead of delivering a lecture on EOQ that was important only because it would have to be regurgitated on an exam, the teachers found themselves delivering lectures that were suddenly relevant to the needs of the students. An increase in the enthusiasm for the area of inventory control on the part of the students was sensed, and greater enthusiasm for the topic area was clearly evident on the part of the instructors. Teacher and course evaluations also improved, although this increase could clearly have been a result of other variables and there is little support for a linkage between more positive evaluations and an increase in the amount of learning taking place.

One side benefit of the use of the first simulation is that students can get a first-hand experience relating to conflicts between different areas of the organization. For example, when a Marketing student suddenly realizes that he is rooting against sales in order to avoid stockout costs, he begins to understand that a firm's marketing and production departments can indeed have conflicting goals.

REFERENCES

Frazer, J. Ronald. Business Decision Simulation: A Time Sharing Approach, Reston, Va: Reston Publishing Co., 1975, pp. 73-76.

Frazer, 3. Ronald. Teachers Manual, Business Decision Simulation: A Time Sharing Approach, Reston, Va: Reston Publishing Co., 1975, pp. 98-107.

FIGURE 1

Example of Interactive Simulation

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TYPE IN A SOCIAL SECURITY NUMBER

[illegible]

INVENTORY CONTROL SIMULATION

WHICH FORM OF THE GAME DO YOU WISH TO RUN?
TYPE 1 IF IT IS THE BASIC GAME, WITH VARYING DEMANDS BUT CONSTANT LEAD TIMES
TYPE 2 IF YOU WANT BOTH DEMAND AND LEAD TIMES TO VARY
TYPE 3 IF YOU ALSO WANT TO INCLUDE THE POSSIBILITY OF STRIKES

3
THERE IS A MAXIMUM OF 10 TEAMS IN THE GAME AT ONE TIME
EACH TEAM WILL START WITH 1400 UNITS OF INVENTORY
THE DEMAND WILL BE THE SAME FOR EACH TEAM
THE AVERAGE NUMBER OF CLIENT FIRMS PURCHASING FROM YOU IS 4.
EACH CLIENT FIRM WILL NEED AN AVERAGE OF  50. UNITS WITH A STANDARD DEVIATION OF  10.
CARRYING COSTS ARE $.05 PER UNIT PER WEEK
ORDER COSTS ARE $50 PER ORDER
STOCKOUT COSTS ARE $2 PER UNIT PLUS $50 PER UNSATISFIED CUSTOMER
THE VARYING LEAD TIME HAS THE FOLLOWING DISTRIBUTION:
     3 WEEKS WITH A PROBABILITY OF  0.200
     4 WEEKS WITH A PROBABILITY OF  0.400
     5 WEEKS WITH A PROBABILITY OF  0.200
     6 WEEKS WITH A PROBABILITY OF  0.200
EVERY FOUR WEEKS YOU WILL BE INFORMED OF THE PROBABILITY OF A STRIKE OCCURRING IN THE NEXT MONTH
IF A STRIKE OCCURS, YOUR IN-TRANSIT STOCK AND YOUR ORDERS DURING THE TWO-WEEK STRIKE WILL REMAIN WHERE THEY ARE
AT THE END OF THE STRIKE, ORDERS WILL BE PROCESSED AND INVENTORY MOVED AS USUAL
NUMBER OF TEAMS

3

DO YOU WANT TO COMPETE AGAINST THE COMPUTER?
IF YOU ANSWER YES, THE COMPUTER WILL BECOME THE  4TH TEAM IN THE GAME
IF YOU ANSWER NO, YOU WILL BE COMPETING AMONG YOURSELVES.

yes

THE PROBABILITY OF A STRIKE IN THE NEXT FOUR WEEKS IS  0.0011670
TYPE IN A TEAM NUMBER AND ORDER QUANTITY, WITH A BLANK SEPARATING THE TWO VALUES, (ONE TEAM PER LINE).
TYPE 11 WHEN THERE ARE NO MORE ORDERS.  TYPE 12 IF YOU WANT TO FINISH THE GAME, IN WHICH CASE IT
WILL RUN FOR FOUR MORE WEEKS.


1 300
11


NUMBER OF FIRMS WAS  2     TOTAL DEMAND WAS   89 IN WEEK NUMBER   1


TEAM  INVENTORY   IN-TRANSIT   CARRYING COST    ORDER COST   STOCKOUT COSTS   TOTAL COSTS

  1      1311        300           65.55           50.             0.           115.55
  2      1311          0           65.55            0.             0.            65.55
  3      1311          0           65.55            0.             0.            65.55
  4      1311        700           65.55           50.             0.           115.55


TYPE IN A TEAM NUMBER AND ORDER QUANTITY, WITH A BLANK SEPARATING THE TWO VALUES, (ONE TEAM PER LINE).
TYPE 11 WHEN THERE ARE NO MORE ORDERS.  TYPE 12 IF YOU WANT TO FINISH THE GAME, IN WHICH CASE IT
WILL RUN FOR FOUR MORE WEEKS.


2 1000
3 650
11


NUMBER OF FIRMS WAS  3     TOTAL DEMAND WAS  154 IN WEEK NUMBER   2


TEAM  INVENTORY   IN-TRANSIT   CARRYING COST    ORDER COST   STOCKOUT COSTS   TOTAL COSTS

  1      1157        300          123.40           50.             0.           173.40
  2      1157       1000          123.40           50.             0.           173.40
  3      1157        650          123.40           50.             0.           173.40
  4      1157        700          123.40           50.             0.           173.40
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