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A Computerized Futures Market Simulation System

Steven C. Griffin and Paul D. Hummer

Abstract

Classroom gaming can be used to reinforce theoretical and analytical concepts and provide experience in performing managerial functions. A computerized futures market game was developed to provide increased capacity and capability for executing sophisticated trading plans. A marketplace simulation model is used to provide market uncertainties and reduce data requirements.

Introduction

The development and use of computerized classroom games in resident undergraduate and adult extension instruction has become increasingly popular among educational institutions. The Agricultural Economics Department of Oklahoma State University, for one, currently employs five computerized simulation games in its teaching and extension programs.[1,2,3,4,5]

In controlled experiments, Curtis[6] found that business games can be an effective teaching toll for management education. Classroom gaming can reinforce theoretical and analytical functions. This article discusses the structure and successful classroom use of a unique futures market game.

The dramatic price fluctuations of the current and recent past market in agricultural commodities has caused increased interest among students in the workings of the futures markets. Whether an individual will manage a firm seeking to escape the risks of changing prices, or whether he is speculating, hoping to take advantage of those price fluctuations, a study of the role and characteristics of the futures market is important.

Simulated futures trading has long been a part of futures market classwork. Computerized programs relieving the student and teaching staff of some burdensome clerical accounting involved in futures market transactions have been developed for several years.[7,8] A flexible system incorporating the relevant realities of futures trading (i.e., execution uncertainty and price uncertainty) and a variety of market-order types to involve the student in sophisticated trading plans, however, has not been available. The data input, number of market observations required, and high computer operational expenses as the exercise continues make the use of many futures market games cumbersome.

The OSU Computerized Futures Market Simulation System (CFMSS) is a Fortran IV-based computer software package designed as a classroom game and learning tool for teaching and understanding of the operations, functions, and characteristics of commodity futures trading. The computerized system acts as a brokerage house by maintaining customer transaction and financial records, and by submitting user-supplied contract orders into a pseudo-real world marketplace.

CFMSS stresses (1) the capacity for trading numerous commodity groups and contract-months, (2) the capability for handling sophisticated limit and spread orders, (3) the inclusion of a pseudo-real world marketplace for the continuous execution of market orders, and (4) the minimization of game administration time and the amount of card input required.

The primary objective of any computerized commodity trading game is not to make the participants expert commodity traders, but rather to provide a stimulus to encourage the observation of market workings and the digestion of facts and principles which influence the markets and their price levels. (The fulfillment of the primary objective is a step toward gaining expertise in commodity trading.) The OSU system is therefore designed to simulate actual speculator trading of commodity futures contracts on the organized exchanges of the world. The system departs from complete reality somewhat in the simulation of the actual filling of market orders. However, CFMSS uses actual market opening, high, low, and closing prices; and by simulating a continuum of intraday prices, the system provides for realistic "fill" price uncertainty with relative execution certainty, or "fill" price certainty with order execution uncertainty in the use of the various types of market orders. The procedure for simulating "fill" prices which is not present in other futures market games known to the authors is discussed below.

Steven C. Griffin and Paul D. Hummer are former research assistant, and associate professor, respectively, Department of Agricultural Economics, Oklahoma State University.

[1] This article is taken from a more detailed explanation of the futures market simulator given in (3).

The Marketplace Simulation Model

The acid-test of any classroom game or learning tool is its ability to keep interest alive and maintain continuous learning exposure. Relevance to the real world is a basic ingredient which in itself provides a desirable learning catalyst.

It is therefore important that a system portraying the futures market, its functions, and characteristics, maintain close contact with the actual dynamics of the marketplace. While ideally one would prefer minute-by-minute market quotes and executions to replicate exactly the real world, the time involved in the logistics and administration of the system as well as the volume of data required would be prohibitive for large scale instructional use.

The most widely published daily statistics of futures market trading are the market's opening, high, low, and closing prices. These daily price quotes are used in simulating the intra-day market environment by incorporating the use of several random number generators and probability distributions. The "market" price determination technique may be best shown graphically as in Figure 1. It is thus implicitly assumed that intra-day prices exhibit a random-walk pattern between the day's high and low prices.

The procedure begins by calculating the slope of a straight line between the market opening and the market closing prices (the base of the line spans one day of time). A random number generator selects, from a uniform distribution, a number (X) between zero and one. This number, when applied to the horizontal axis, locates a value (A) on the line connecting the opening and closing prices. A second random number generator then selects a second number (T) from a standard normal distribution. This number is multiplied by the sample standard deviation (S) (calculated as the difference between the market high and low, divided by a given divisor; if no divisor is given by the operator in the input, the parameter default = 4) and the product is added to the value (A) to obtain the simulated market price (P).[9] Thus the price (P) is selected from a normal distribution with mean (A) and variance (S^2), i.e., N (A,S^2). The mathematical equation is:

P = (X* (CLOSE-OPEN)) + (T* (HIGH-LOW) ÷ DIVISOR) + OPEN

Several decision rules alter the calculated market price in certain circumstances. For instance, the simulated market price cannot be higher than the market high or lower than the market low. In these cases the market high or low, respectively, becomes the market price. In cases in which the market high is equal to the market close and also equal to the simulated market price, the market order remains unfilled 75 percent of the time (according to the properties of an independent random number generator). This rule is imposed to reflect logically the possibilities of a locked up-the-limit market. Similarly, in cases where the market low is equal

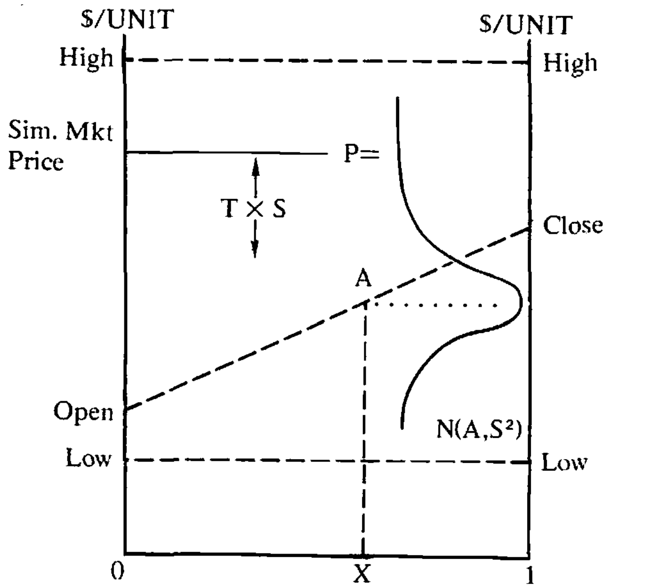

Figure 1 Graphical Representation of Market Simulation Model (Case in which market closes higher than open and both open and close are within the trading range.)

to the close and also equal to the simulated market price, the market order remains unfilled 75 percent of the time, reflecting a no-trading down-the-limit-market. Of course, one can always buy in a market locked down-the-limit, as well as sell in one locked up-the-limit.

In processing of market orders, an "At-The-Market" order will fill at the average of N+1 (N is normally given by the operator; the model has a default parameter of N=3) draws from the market price model, except in the above mentioned special cases. Thus, if any sizeable trading range exists, it is almost certain that an ATM order will be executed since the average of four prices drawn from the trading range will not likely equal the range's high or low. Thus, an ATM order exhibits the characteristic of near market execution certainty at the cost of near price uncertainty. The converse is true for the limit-type order. A limit price order will fill at the limit price if the calculated market price equals or is more favorable[10] to the market order on any one of N+1 successive tries. If the limit price specified by the customer is less favorable than the least favorable market statistic (i.e., the daily market high in the case of a BUY order, or the daily low in the case of a SELL order), then the order is filled at the market statistic. The parameter default number for the allowable number of tries to fill a limit order is four per market order (N+1 = 3+10).[11]

Spreads are filled in much the same way as limit orders. A series of five calculated prices (or "draws") is generated for the first leg of the spread. A limit-price order is then constructed using the first leg's generated market price (one of the five draws) plus the desired spread basis as the limit price. The limit order is then inserted into the general marketplace simulation model with the market information of the second leg's order used as the basic parameters. If this order is filled (the fill price of the second leg must be within its respective

O K L A H O M A   S T A T E   C O M P U T E R I Z E D   F U T U R E S   M A R K E T   S I M U L A T I O N   S Y S T E M

CUSTOMER NAME *** MR. J. P. CUSTOMER   ACCT. NUMBER 1   DATE: 03/26/75

MARKET TRANSACTION REPORT

ROW NO.	IDENT. FIELD	OPENING DATE	ACTION	NUMBER OF CONTRACTS	COMMODITY NAME	MONTH	OPENING PRICE	CLOSING DATE	CLOSING PRICE	PROFIT/LOSS (MINUS COMMISSIONS)
1	AAAA	1/15/75	BUY	1.	WHEAT (SRW)	JULY	$ 3.95750	1/15/75	$ 3.96875	$ 26.25
2	BBBB	1/15/75	BUY	1.	WHEAT (SRW)	JULY	$ 3.95125	1/15/75	$ 3.96875	$ 57.50
5	HHHH	1/15/75	BUY	2.	WHEAT (HRW)	MAY	$ 4.17750	1/27/75	$ 3.85875	$ -3247.50
								TOTAL PROFIT/LOSS CLOSED TRANSACTIONS :		$ -3163.75
									CURRENT CLOSING SETTLEMENT PRICE	PROFIT/LOSS
3	DDDD	1/15/75	SELL	3.	WHEAT (SRW)	MAY	$ 4.19500		$ 3.73500	$ 6900.00
4	EEEE	1/15/75	SELL	1.	LIVE CATTLE	DEC	$ 40.15000		$ 36.22500	$ 1570.00
6	GGGG	1/15/75	SELL	2.	WHEAT (HRW)	MAR	$ 4.19625		$ 3.73000.	$ 4662.50
7	IIII	1/27/75	SELL	1.	LIVE CATTLE	DEC	$ 37.15000		$ 36.22500	$ 370.00
8	$$$$	2/ 5/75	SELL	1.	SOYBEANS	MAR	$ 7.10000		$ 5.46000	$ 8200.00
								TOTAL PROFIT/LOSS OPEN TRANSACTIONS :		$ 21702.50

OPEN POSITION PROFILE REPORT

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	NET
WHEAT (SRW)	0.	0.	0.	0.	-3.	0.	0.	0.	0.	0.	0.	0.	-3.
LIVE CATTLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-2.	-2.
WHEAT (HRW)	0.	0.	-2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-2.
SOYBEANS	0.	0.	-1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-1.

FINANCIAL SUMMARY

TOTAL PROFIT/LOSS CLOSED TRADES	$ · -3163.75
TOTAL PROFIT/LOSS OPEN TRADES	$ 21702.50
BEGINNING CASH AND SECURITIES	$ 21375.50
TOTAL CASH EQUITY	$ 39914.25
CURRENT MARGIN REQUIREMENTS	$ -11800.00
TOTAL SURPLUS/DEFICIT	$ 28114.25

Figure 2 Market Transactions, Open Positions, and Financial Summary For An Individual Trader

trading range) the spread is considered filled at the simulated prices. If the simulated spread basis is equal to or more favorable than the basis requested, the spread is filled at the requested basis (this is similar to the logic of the limit order). If the simulated spread basis for each of the five generated series is less than the desired basis, the order remains unfilled, i.e., the model performs the price and spread generation procedure a maximum of five times in an attempt to fill the order.

Other types of market orders are available to the user of the system. These include stop-loss, stop-loss-close-only, and others. Corrective routines are also available to "make good" any input errors that might have occurred or provide additional market sophistication.

The simulated marketplace model obviously does not necessarily follow the minute-by-minute ticks or trading volumes of the actual market or assume any pattern (other than that generated by a normally distributed random error) in the manner in which the actual market registers its high, low, opening, and closing price statistics. The model is, therefore, not extremely conducive to day trading or scalping exercises, unless of course, the trading day is partitioned into several relevant "mini-days", each having its own price statistics and market orders. The model, does, however, provide for realistic fill price uncertainty or execution uncertainty in the use of the various types of market orders over a period of days or weeks. Thus, the model satisfies the objectives in mind with a minimum of theoretical detraction, loss of realism, and operational cost.[12]

In addition to the normal monitoring of the data processing and diagnostic messages, CFMSS provides three levels of output. The first, shown in figure 2, provides a complete market transaction report of past and current futures market holdings, an open position profile report, and a financial summary for each student or team of students involved in the exercise. The second type of output provides a detailed breakdown by commodity on the activities of the class (figure 3). The third output summarizes the financial status of each account into one

COMMODITY INFORMATION REPORT AND SUMMARY DATE: 03/26/75

COMMODITY NAME	MARKET SYMBOL	NUMBER OF UNITS	MINIMUM FLUCTUATION	MARGIN	COMMISSION	MKT	TOTAL ROUNDS	TOTAL OPEN	OPEN LONGS	TOTAL CLOSED PROFIT	TOTAL OPEN PROFIT
WHEAT (SRW)	W	5000.BU.	0.00125	2500.00	$ 30.00	C	124.	69.	5.	$ -34957.50	$ 11350.00
SOYBEANS	SB	5000.BU.	0.00125	2500.00	$ 30.00	C	53.	70.	12.	$ -27783.75	$ -98268.75
CORN	C	5000.BU.	0.00125	1500.00	$ 30.00	C	30.	7.	5.	$ 11462.50	$ 831.25
LIVE CATTLE	LC	400.CWT.	0.02500	1200.00	$ 40.00	C	119.	72.	7.	$ -7476.00	$ -74340.00
LIVE HOGS	LH	300.CWT.	0.02500	1200.00	$ 35.00	C	27.	32.	32.	$ 1920.00	$ 38355.00
FEEDER CATTLE	FC	420.CWT.	0.02500	900.00	$ 40.00	C	2.	0.	0.	$ 1264.00	$ 0.0
SUGAR	SU	1120.CWT.	0.01000	3000.00	$ 62.00	NY	2.	2.	0.	$ -5477.60	$ 0.0
COTTON	NY	500.CWT.	0.01000	6500.00	$ 46.00	NY	0.	2.	2.	$ 0.0	$ 0.0
PORK BELLIES	PB	360.CWT.	0.02500	1500.00	$ 45.00	C	13.	5.	5.	$ 10827.00	$ 2835.00
SILVER	SI	50.COZ	0.10000	2500.00	$ 30.00	C	34.	11.	6.	$ -6435.00	$ 5105.00
WHEAT (HRW)	W	5000.BU.	0.00125	2500.00	$ 30.00	KC	18.	13.	0.	$ 1791.25	$ -3087.50
SHELL EGGS	SE	225.CDZ	0.05000	1200.00	$ 40.00	C	0.	5.	0.	$ 0.0	$ 562.50
					TOTALS		422.	288.	74.	$ -54865.10	$ -116657.50

WHEAT (SRW) PRICES (MOST CURRENT SETTLEMENT)
MAY $ 3.64000
MAR $ 3.58000
JULY $ 3.58000

SOYBEANS PRICES (MOST CURRENT SETTLEMENT)
MAR $ 5.58000
MAY $ 5.82000
JULY $ 5.87000
AUG $ 5.86000

CORN PRICES (MOST CURRENT SETTLEMENT)
JULY $ 2.90000
MAY $ 2.91000
MAR $ 2.86000

LIVE CATTLE PRICES (MOST CURRENT SETTLEMENT)
JUNE $ 41.40000
DEC $ 39.52500
AUG $ 40.07500
OCT $ 39.37500
APR $ 41.02500

LIVE HOGS PRICES (MOST CURRENT SETTLEMENT)
JUNE $ 43.90000
AUG $ 45.27500
JULY $ 46.27500
APR $ 42.57500

FEEDER CATTLE PRICES (MOST CURRENT SETTLEMENT)

SUGAR PRICES (MOST CURRENT SETTLEMENT)

COTTON PRICES (MOST CURRENT SETTLEMENT)

PORK BELLIES PRICES (MOST CURRENT SETTLEMENT)
JULY $ 64.45000
MAR $ 63.35000
MAY $ 69.52500

SILVER PRICES (MOST CURRENT SETTLEMENT)
JUNE $423.60000

WHEAT (HRW) PRICES (MOST CURRENT SETTLEMENT)
JULY $ 3.63000
MAR $ 3.55000

SHELL EGGS PRICES (MOST CURRENT SETTLEMENT)
MAY $ 42.05000

Figure 3 Total Commodities Traded Report

table (figure 4). All three print-outs are optional in any given execution of the system.

Summary and Conclusions

The CFMSS has been well received by Oklahoma State agricultural economics students in its use as a continuing class exercise for learning about and following the commodity futures market.[13] The system's inherent capacity for handling numerous commodities and contract-months has encouraged students to pursue their varied commodity interests. And CFMSS provides students more realistic futures market trading experiences with respect to order execution uncertainty and "fill" price uncertainty than was possible with any other futures trading game known to the authors. Sophisticated limit and spread orders are also available to the users of the system. The game has been constructed to minimize card input and administrative time, thus encouraging its continued use.

A disadvantage of CFMSS is the incapability of simulating the exact pattern of daily price movements within the market simulator when day trading is the objective. However, this pattern can be approximated by dividing the day into as many "mini-days" as desired and inputting actual market prices more frequently, as has to be done with any other futures trading game. One still has the advantage over other games of simulating uncertainty in order and price fills.

No controlled research technique has been employed to test learning improvement among students using CFMSS. However, instructors have expressed satis-

OKLAHOMA STATE COMPUTERIZED FUTURES MARKET SIMULATION SYSTEM

CUSTOMER SUMMARY REPORT DATE: 03/26/75

ACCT NUM	CUSTOMER NAME	BEGINNING BALANCE	PROFIT/LOSS CLOSED TRADES	PROFIT/LOSS OPEN TRADES	ACCOUNT BALANCE	MARGIN REQUIREMENT	SURPLUS/DEFICIT
1	ADLER C. L.	$ 10000.00	$ 1477.50	$ -1015.00	$ 10462.50	$ 16200.00	$ -5737.50
2	BLACKWELL T. A.	$ 10000.00	$ -1537.50	$ -2250.00	$ 6212.50	$ 30000.00	$ -23787.50
3	BROWN P. A.	$ 10000.00	$ -19577.50	$ 37125.00	$ 27547.50	$ 36000.00	$ -8452.50
4	CHEATAM C. L.	$ 10000.00	$ -3186.25	$ 0.0	$ 6813.75	$ 0.0	$ 6813.75
5	COMPTON A. G.	$ 10000.00	$ 0.0	$ -2010.00	$ 7990.00	$ 3600.00	$ 4390.00
6	DAMRON J. D.	$ 10000.00	$ 536.00	$ 0.0	$ 10536.00	$ 0.0	$ 10536.00
7	FREEMAN M.H.	$ 10000.00	$ 380.00	$ -4600.00	$ 5780.00	$ 2400.00	$ 3380.00
8	GAY D. L.	$ 10000.00	$ -1007.50	$ -3175.00	$ 5817.50	$ 5000.00	$ 817.50
9	JACQUES A.	$ 10000.00	$ 3668.75	$ -662.50	$ 13006.25	$ 1500.00	$ 11506.25
10	JAMES J. W.	$ 10000.00	$ -5477.60	$ -7377.50	$ -2855.09	$ 21100.00	$ -23955.09
11	JAMES L. E.	$ 10000.00	$ 0.0	$ 1230.00	$ 11230.00	$ 2400.00	$ 8830.00
12	JENNINGS R. J.	$ 10000.00	$ -2752.50	$ 4250.00	$ 11497.50	$ 30000.00	$ -18502.50
13	JONES T. K.	$ 10000.00	$ 11368.75	$ 0.0	$ 21368.75	$ 0.0	$ 21368.75
14	LEIRD D. W.	$ 10000.00	$ 0.0	$ 0.0	$ 10000.00	$ 0.0	$ 10000.00
15	MANGELS G. L.	$ 10000.00	$ 2262.50	$ 3900.00	$ 16162.50	$ 2400.00	$ 13762.50
16	MANNERING B. E.	$ 10000.00	$ 4727.50	$ 0.0	$ 14727.50	$ 0.0	$ 14727.50
17	OWENS R. M.	$ 10000.00	$ -7122.25	$ -16216.25	$ -13338.50	$ 33600.00	$ -46938.50
18	PARRISH J. D.	$ 10000.00	$ 0.0	$ 5575.00	$ 15575.00	$ 7400.00	$ 8175.00
19	REGIER D. E.	$ 10000.00	$ 640.00	$ -3250.00	$ 7390.00	$ 7200.00	$ 190.00
20	SCHAFFLER P. P.	$ 10000.00	$ -237.50	$ 10087.50	$ 19850.00	$ 30000.00	$ -10150.00
21	SIMPSON G. S.	$ 10000.00	$ -34525.00	$ -86943.75	$-111468.75	$ 188500.00	$-299968.75
22	SMITH W. L.	$ 10000.00	$ 2644.00	$ -46770.00	$ -34126.00	$ 44400.00	$ -78525.94
23	WAUGH D. E.	$ 10000.00	$ 1390.00	$ -17292.50	$ -5902.50	$ 46000.00	$ -51902.50
24	WOLLENBERG H. D.	$ 10000.00	$ 9086.25	$ 0.0	$ 19086.25	$ 6500.00	$ 12586.25
25	COLLINS G. S.	$ 10000.00	$ 4447.00	$ 10991.25	$ 25438.25	$ 26000.00	$ -561.75
26	MINNICK D. L.	$ 10000.00	$ 3830.25	$ 0.0	$ 13830.25	$ 6500.00	$ 7330.25
27	BONNETT M.	$ 10000.00	$ -25900.00	$ 3856.25	$ -12043.75	$ 25000.00	$ -37043.75
28	FRANZMANN J.R.	$ 10000.00	$ 0.0	$ -2110.00	$ 7890.00	$ 1200.00	$ 6690.00

Figure 4 Financial Position Summary of All Traders

faction that students have gained a clearer understanding of sophisticated limit and spread orders and the application of these orders in developing trading plans. Observed learner achievement has not been possible heretofore under conventional classroom conditions. The learning process was reinforced throughout the semester as students applied theory and techniques learned in class to their own "trading." The competition and discussion between students as a result of the futures exercise added to the learning experience.

Faculty administration time proved to be small, in practice, (and inexpensive, since a non-faculty assistant easily administered the exercise) compared to alternative methods of generating the same level of classroom participation and understanding. Both faculty and students in agricultural economics at Oklahoma State University have termed the system successful in fulfilling its initial objectives.

FOOTNOTES

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9. For example, assume the random number generator selects the value of .75 for (X). If the opening and closing prices are $3.88 and $4.00, respectively, the value for (A) would be 3.97, or .75* (4.00 - 3.88) + 3.88. If the high and low prices are $4.02 and $3.82, respectively, and the selected divisor is 4, then the value for (S) is .05, or (4.02 - 3.82) ÷ 4. Thus, the model has estimated the probability distribution for the market price to be N(3.97, .0025). If the value of (T) is generated to be .8, then the market price is finally determined to be $4.01, or 3.97 + (.8 * .05).
10. Favorable in this sense describes a situation where if the market order was filled at the simulated market price (or basis), the customer's position would be more profitable than a position filled as requested.
11. By manipulating the number of tries allowed and the divisor in the market price equation, the system administrator can dictate the relative market performance of the simulation. System administrators have tended to increase the number of market draws to increase the probability of limit order execution and thereby encourage its more sophisticated use.
12. Day trading is no problem with CFMSS, given the "mini-day" concept and the respective frequent updating of input, as required by any futures trading game. However, the model is presently being used at Oklahoma State University primarily to give students experience in *using economic analysis* to take longer run positions, much as a selective hedger would. Day trading is not as conducive to such economic analysis. Also, day trading by students is discouraged by the instructor-users at OSU because of the desire to keep administrative time and costs to that required by three or four weekly "runs." Students are free to take purely speculative positions with respect to spreads, etc., but an economic analysis justification is required in all cases.
13. The CFMSS system has been incorporated into a senior marketing course (AGEC 4313) and a futures market course (AGEC 4333) at Oklahoma State University for the past two years. Course evaluations by students, and examination results have supported the use of the simulator as a useful learning tool.