MITIGATING THE WINNER'S CURSE IN THE AUCTION MARKET OF A COMPUTER-ASSISTED BUSINESS GAMING SIMULATION

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ABSTRACT

As an alternative to modeling the market, the problem of gaming it in a simulation by an auction mechanism is addressed. A two-market solution, including both a first-bid market and a best-bid market, is proposed to mitigate the winner's curse, a common affliction of auctions. A computer-assisted gaming simulation with an auction mechanism that incorporates the solution is described. A comparison of simulation results before and after the two-market solution was applied showed an increase in the number of companies founded, and, after initial periods, reductions the winner's curse, the standard deviation of transaction prices within each period, and the volatility of average transaction prices. The increased pedagogical scope of the two-market solution may by itself suffice to justify the extra programming effort that it entails and the additional demands it places on the participants.
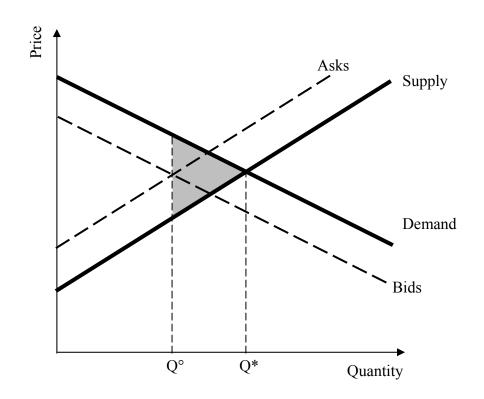
INTRODUCTION

Business gaming simulations have generally incorporated markets by modeling them. In the usual implementation, participants manage virtual firms whose virtual products are sold through a model of the marketplace (Gold & Pray, 2001). In general, the market-demand model allows products with lower prices, higher promotional expenditures, and higher product quality to capture a larger proportion of the market than products less advantaged. These market-demand models have tended to increase in complexity as an increasing number of considerations that affect demand have been incorporated into the models (Cannon, H. M., Cannon, & Schwaiger, 2005; Cannon, J. N., Cannon, & Schwaiger, 2005; Cannon & Schwaiger, 2004; Murff, Teach, & Schwartz, 2006; Teach, 2005), but they suffer from a defect that complexity can never remedy—the models, however elegant they may be, are not real. Real markets have a collective intelligence far beyond any model's ability to capture, because a real market embodies everything the market's participants know, whereas a modeled market embodies only what its developer knows.

An alternative to the modeling approach is the gaming approach, which is to create within the game a means for the companies to sell their products to the participants themselves, either as consumers of the products made or as purchasing agents of other companies that require the products for their own operations, or both. An example of the gaming approach is PROGRESS (Cannon, Yaprak, & Mokra, 1999), which allows for trading among participants but which includes no formal mechanism to facilitate it. In the absence of formality, the marketplace is a bazaar, where "each trader personally examines the offers available, and personally decides on the offers to accept or reject" (Thavikulwat, 2003). The bazaar is a labor intensive mechanism that cannot benefit much from computer assistance.

An auction is a trading mechanism that can benefit from computer assistance. Economists have been analyzing auctions since Vickrey's (1961) seminal work on the subject. Auctions can involve a single seller and many buyers, or a single buyer and many sellers, or many sellers and many buyers. In this last case, the auction is known as a double auction (Friedman & Rust, 1993; Shubik, 2005). Auctions can be continuous or periodic. The continuous auction allows traders to enter and exit at any time; the periodic auction closes and reopens from time to time.

Although auctions have been used extensively in a large variety of settings, from the trading of rare goods and those with widely dispersed valuations (Pinker, Seidmann, & Vakrat, 2003) to the trading of common stocks, commodities, and treasury securities, they remain a complex procedure that can trap the unwary. Klemperer (2004) relates cases when poorly designed auction procedures reduced participation and encouraged market distortions through collusion and predation, and Thavikulwat and Pillutla (2008) has shown that the strategies that participants may employ in a periodic double auction can be quite complex.

Figure 1: Effect of Buyers Shaving Bids

AUCTION DESIGN

A notable defect of auctions is their susceptibility to the winner's curse, which arises when a buyer pays more, or a seller gets less, than necessary to clinch a trade. The possibility of suffering from the winner's curse causes traders to "shave" their offers. Buyers bid less than the product is worth to them and sellers ask more. As a consequence, some trades that could be mutually beneficial are not executed, because buyers bid too little or sellers ask too much. The situation is illustrated in Figure 1, where $Q*$ is the equilibrium quantity give the buyers' demand curve and the sellers' supply curve, but $Q°$ is the actually quantity that will be traded when both buyers and sellers shave their offers. The loss of efficiency is represented by the shaded triangular area of the figure.

The winner's curse arises when the auction requires sealed offers. Thus, one solution is open offers, which unfortunately facilitates collusion and is labor intensive. Another solution is to apply to all trades a uniform *market clearing* price, $P*$, which would be computed to be some combination of the lowest workable bidding price, the highest workable asking price, the highest unworkable bidding price, and the lowest unworkable asking price. Essentially, the market clearing price is computed to be at the intersection of the bids and asks. Presuming that the bids represent the true demand curve and the asks represent the true supply curve, the market clearing price approximates the equilibrium price under perfect competition.

With Friedman's (1960, 1963) notable endorsement, the market clearing price has been used for the auctioning of U.S. treasury securities since 1992 (Garbade & Ingber, 2005). It suffers from two limitations. First, like open offers, it facilitates collusion, which does not have to be explicit to be effective (Back & Zender, 1993). Second, it requires computations that slow down computer responsiveness and reduce transparency.

Our solution to the winner's curse is to allow for two markets, a first-bid market and a best-bid market. In the first-bid market, the supplier submits an invitation asking price that is matched to the bidding price of the highest bidder. If the highest bid equals or exceeds the invitation asking price, the product is sold to the bidder at the invitation price. In the best-bid market, the supplier submits a reserve asking price. If the highest bid equals or exceeds the reserve asking price, the product is sold to the bidder at the price of the bid. Thus, the first-bid market functions like a retail store. Every customer buying the product pays the store's invitation price. The best-bid market functions like a liquidation auction. Every successful bidder pays as bid. Each supplier is free to choose the market for its products. Priority goes to the first-bid market, so the best-bid market is activated only after all workable first-bid transactions have been executed. The process is illustrated in Figure 2, where downward-pointing arrows indicate sales at asking prices and
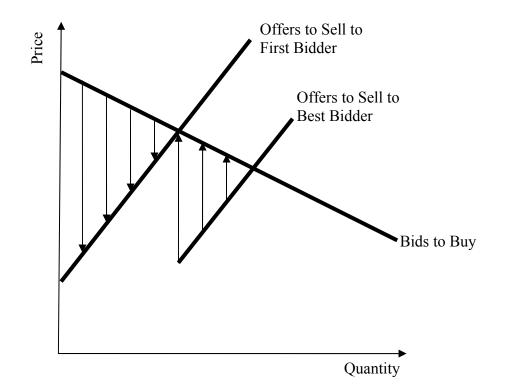
Figure 2: Two-Market Selling Process

upward-pointing arrows indicate sales at bidding prices. Products are traded at many prices, so collusion is difficult; and inasmuch as the transaction price is either the asking price or the bidding price, depending upon the market, price computations are unnecessary—the algorithm is fast and transparent.

The discussion that follows describes the business gaming simulation with a real product market in which the two-market solution to the winner's curse has been included. Data on transaction prices and quantities before and after implementing the two-market solution are presented. Expectations are laid out, results discussed, and suggestions made for future research.

THE GAMING SIMULATION

The simulation is GEO, a local-area-network and Internet-based (Pillutla, 2003) computer-assisted (Crookall, Martin, Saunders, & Coote, 1986) gaming simulation of a global economy that is used in international business and strategic management courses. Each participant goes through multiple lives, each life beginning after the previous one ends. Participants are not assigned to teams that are given simulated firms to manage, as is the case of many business simulations. Rather, they are essentially born into a nation; given an income, as in the popular board game, MONOPOLY; and urged to spend their income to purchase, and therefore consume, the products of the companies that they and their fellow participants have founded and managed. Their scores in the exercise depend solely on their consumption such that those who consume more and do it more evenly receive higher scores. As in everyday life,

consumption depends on how well they spend their income. Income to which everyone is entitled is supplemented by salaries, dividends, and capital gains that each participant gets from the companies with which each is associated.
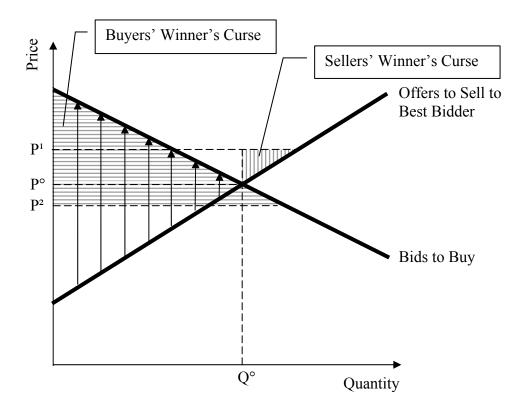
The production of each company is limited, so to expand the business beyond what one company can produce, the participant must found additional companies, generally as subsidiaries of the first successful company. Each participant is able to found up to five companies. This limit of five companies is, for almost every participant, a generous limit, because the more companies the participant founds, the more the participant must keep in control.

Time is clock- and activity-driven (Chiesl, 1990), advancing, when participants are active, at the pace of approximately 40 period a week over the one-semester duration of the exercise. Production occurs at the beginning of each period, followed immediately by the periodic-double-auction sales of the products to consuming participants and to companies purchasing those products as resources for their own production. The periodic double auction is followed immediately by a continuous double auction that extends until the end of the period.

Prior to adopting the two-market solution, products were sold in the periodic double auction only on a best-bid basis, wherein the seller sets a reserve asking price and the products are sold to the highest bidder at the bid price. Under this condition, the buyers' winner's curse is the horizontally patterned area of Figure 3. The area extends past $Q°$, the quantity traded through the periodic double auction, because in the

Figure 3: One-Market Auction

continuous double auction that follows each periodic double auction, some sellers may decide to accept bids that are below the seller's own reserve asking price. Likewise, the sellers' winner's curse is the vertically patterned area of the same figure, considering that in the continuous double auction some buyers may decide to accept best-bid offers that are above the bids that they had submitted.

The situation after adopting the two-market solution is illustrated in Figure 4. As with the one-market condition, the buyers' winner's curse is the horizontally patterned area. The seller's winner's curse consists of two vertically patterned areas. The area on the left represents products sold in the periodic double auction; the area on the right represents products sold in the continuous double auction. P^1 is the highest transaction price across the two areas.

EXPECTATIONS

The rationale for the two-market solution is economic and pedagogical. Economic, because it should improve the efficiency of the market, and pedagogical, because if the market is more efficient, it should be more predictable, in which case participants will have a greater sense of control. Sense of control reduces illusory pattern perception (Whitson & Galinsky, 2008), which should accelerate learning about the simulation and improve performance in playing the simulation, inasmuch as participants enter a business simulation with their own sense of reality, one known to be strong enough to cause them to ignore

simulation characteristics and be oblivious to a substantial programming error (Wolfe & Castroviovanni, 2006; Wolfe & Jackson, 1989).

The participants' sense of control is not directly observable. As a proxy, we substitute the number of companies founded, reasoning that those with a greater sense of control will found more companies. Thus, our first expectation is as follows:
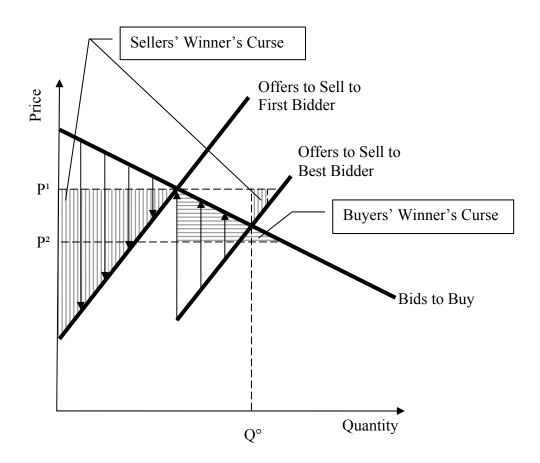
E1: *Participants will found more companies under the two market condition than under the one market condition.*

The underlying demand and supply are likewise not directly observed, so the market's efficiency cannot be computed directly. As proxies for efficiency, we substitute two measures: the sum of the winner's curse for buyers and sellers, and the standard deviation of prices within each period. Thus, our remaining expectations are as follows:

E2: *The winner's curse under the two-market condition will generally be lower than that under the one-market condition.*

E3: *The standard deviation of transaction prices within each period under the two market condition will generally be smaller than that under the one-market condition.*

Figure 4: Two-Market Auction

E4: *Period to period changes in average transaction prices will be less under the two market condition than under the one-market condition.*

We use *expectation* in place of *hypothesis* to distinguish our design-science study from an analytical-science study. As Klabbers (2006) has argued, simulation construction is design science, not analytical science. Whereas the key questions of analytical science are "Is this a valid theory? Is this the right conclusion?" (p. 168) those of design science are "Does it work? Is it an improvement?" (March & Smith, 1995, p. 168). Accordingly, we will not be comparing many instances under one condition with many instances under another. That is an analytical-science approach. Rather, we will compare the last time that the simulation was administered under the one-market condition with a later time, equivalent in the number of participants, when it was administered under the two market condition. We will show that the two-market solution to the winner's curse does work, and that it is an improvement. Having reached that conclusion, we would not subject our students to the evidently inferior one-market experience again just to gather additional data. That is an analytical-science approach. Instead, we will look ahead to the next improvement, and gather data to see if the next change works, that it is in fact an improvement.

RESULTS

The one-market condition involved 170 participants over 482 periods; the two-market condition, 177 participants over 400 periods. The simulation allowed for five products but limited each company to a single product. We chose for comparative analysis the product with the highest volume of transactions, and limited the duration of analysis to the first 133 periods of the exercise, considering that in the two-market condition participants could and did change the economic conditions of the exercise from period 134 onwards. Moreover, we took the first quartile of the exercise, numbering 33 periods, to be initial periods of the exercise that should be considered separately, as results of these periods would be sensitive to misunderstandings and elusive differences in what participants heard when they were briefed for the exercise.

Participants registered themselves into the exercise. The 170 participants of the one-market condition were all registered by period 19, and the 177 of the two-market condition were all registered by period 11. After registration, participants were able to found companies whenever they had secured sufficient financing through either personal savings, company retained earnings, borrowing, alliances, or some combination of these. By period 133, those in the one-market condition had founded 176 companies to produce the simulation's highest-volume product and those in the two-market condition had founded 254
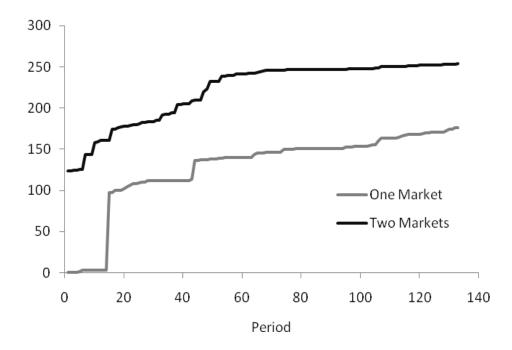
Figure 5: No. of Companies Under Two Conditions

Figure 6: Sum of Buyers' and Sellers' Winner's Curses Under Two Conditions
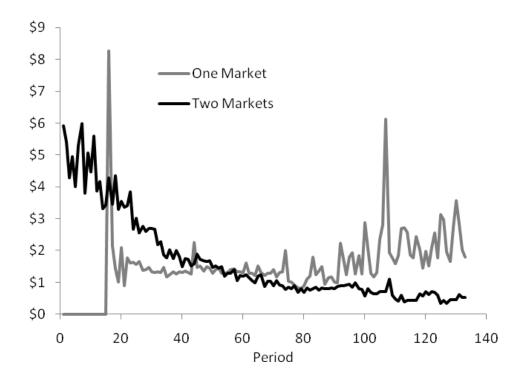
Figure 7: Standard Deviations of Transaction Prices Under Two Conditions
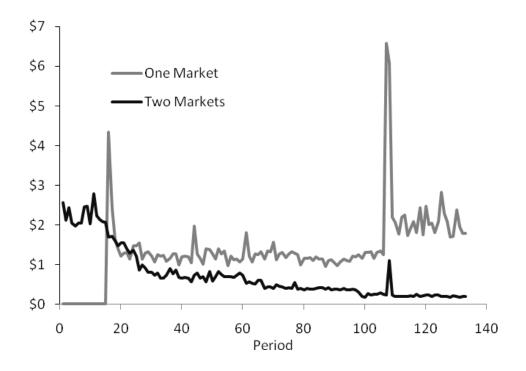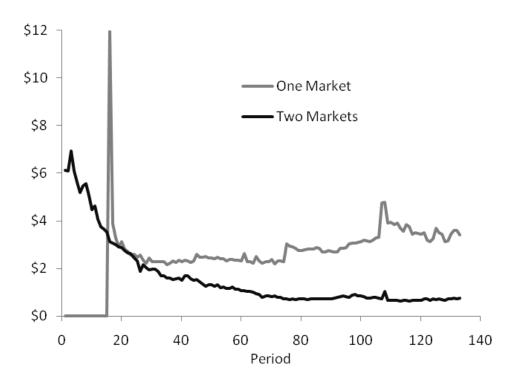

Figure 8: Average Transaction Prices Under Two Conditions

companies to produce those same products, as graphed in Figure 5. The number of companies founded in the two-market condition was 44% higher even though the number of participants in that condition was only 4% more, $\chi^2 (1) = 4.73$, $p < .05$. Accordingly, the results support E1.

The total winner's curses, summing the buyers' and the sellers', per item traded for both conditions are graphed in Figure 6. The total curse for the two-market condition is generally less volatile than that of the one-market condition, and consistently lower from period 54 onwards. Excluding the 33

initial periods of the exercise, the total curse for the two-market condition is $0.6935 per period less than that of the one-market condition, $t(99, \text{2-tail}) = 7.17$, $p < .001$. Accordingly, except for the initial periods of the exercise, the results support E2.

The standard deviations of transaction prices for both conditions are graphed in Figure 7. They are generally smaller for the two-market condition and consistently smaller from period 24 onwards. Excluding the 33 initial periods of the exercise, the standard deviation of transaction prices for the two-market condition is $1.0771 per period less than that of the one-market condition, $t(99, \text{2-tail}) = 12.44$, $p < .001$. Accordingly, except for the initial periods of the exercise, the results support E3.

Average transaction prices are graphed in Figure 8. Average prices form a smoother curve under the two-market condition, so they are apparently more stable. Excluding the 33 initial periods of the exercise, the period-to-period absolute difference in average prices for the two-market condition is $0.0740 less than that of the one-market condition, $t(99, \text{2-tail}) = 3.83$, $p < .001$. Accordingly, except for the initial periods of the exercise, the results support E4.

CONCLUSIONS

Our expectation that the two-market solution would result in participants founding more companies was met, and our expectation that the two-market solution would reduce the winner's curse, the standard deviation of transaction prices within each period, and period-to-period changes in average transaction prices were met after the initial periods of the exercise. We conclude from these results that the two-market solution works. The alternative conjecture, that in the two semesters between the two conditions the administration of the exercise improved sufficiently to account for the difference, cannot be dismissed; so further research will be needed for a definitive explanation.

Even so, the two-market solution expands the pedagogical scope of the simulation by impressing on participants the difference between two kinds of markets. Business-to-consumer markets usually operate on a first-bid basis; business-to-business markets often operate on a best-bid basis. Giving participants a choice of markets amounts to giving them the challenge of learning the difference. This by itself may suffice to justify the extra programming effort that it entails and the addition demands it places on the participants.

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