EFFECT ON MARKET PERFORMANCE OF DISPLAYING SUPPLY AND DEMAND CURVES IN A BUSINESS SIMULATION

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ABSTRACT

A design-science study of how participants are affected by displaying market information in the form of supply-and-demand curves was conducted. Expecting that participants with grounding in economics will understand the displays and will use the information contained therein in their price-setting decisions, we hypothesized that the variance of prices should fall more rapidly over the initial periods of the simulation exercise when such displays are present than when they are omitted. Data from a before-and-after study supports the hypothesis, but does not suffice to rule out increased inter-industry competition as an alternative explanation. Nonetheless, the rapidly reducing price variances accompanying the display of supply-and-demand curves suggest that participants solidified their marketing acumen, a testament to their learning and reasoning. Research extending this study to simulations that model product markets mathematically is suggested.

INTRODUCTION

Studies of markets constitute one of the most substantive areas of research in business simulations. Among these studies are many that discuss how markets should be modeled with mathematics (Cannon, Cannon, & Schwaiger, 2009; Cannon & Schwaiger, 2005; Gold & Pray, 2001; Goosen, 2009; Teach, 2007; Wolfe & Gold, 2007) and a few that discuss how markets should be gamed with role-play (Cannon, Yaprak, & Mokra, 1999; Thavikulwat, 1997). Gamed markets differ from modeled ones in that participants play both the buyer and the seller in economic transactions. Thus, when a participant playing the seller sells an item, the participant does not sell to a model that calculates the quantity sold, as would be the case when the market is modeled. Rather, the item is sold to another participant playing the buyer, who makes an independent decision on the price to pay and the quantity to buy. While much useful work remains be done on both kinds of markets, our interest here is to advance to another plane of research on markets in simulations, where studies are scarce, to consider how market information should be conveyed to participants of the simulation.

We are guided by the common observation that visual information can be conveyed in narrative, tabular, and graphical forms. The narrative form, using words, is the most flexible, as words can describe and interpret both qualitative and quantitative data. The tabular form, using numbers, is the most utilitarian, as numbers intended to convey one piece of information can be reworked to reveal other pieces of information. The graphical form, using pictures, is potentially the easiest to understand, a potential realized when the graph takes advantage of visual perception to convey information in a form that fits the way participants have learned to think. We see a close relationship of the graphical form to learning and reasoning, and consider that it should generally be the most effective of the three.

Supply and demand (S&D) curves convey information in graphical form. A staple of economics, these curves may be among the best method of analyzing markets every conceived. They can be used to analyze and explain market models, as Perotti and Pray (2002) demonstrate. Yet, they are rarely used to present market information, probably because much of the information needed to draw the S&D curves is either inaccessible or confidential in everyday-world settings. Inaccessibility, however, is not a limitation to the simulation setting, and confidentiality may be less relevant, considering that the purpose of the simulation exercise is to give participants experience in market functions, and not to increase their personal material well being.

Expecting that simulation participants with grounding in economics understand S&D curves, we hypothesize that when S&D curves are incorporated into a simulation, simulation participants will use the information they contain to set prices that are closer to the market's equilibrium. If so, the variance of prices should fall more rapidly over the initial periods of the simulation exercise when information is presented in S&D curves than when S&D curves are omitted.

We proceed now to show how we use the market information of a business simulation to display S&D curves that aid participants in their decision-making. First, we describe the simulation, its market mechanism, and the market data that it makes available. Second, we describe the study from which we obtain data on the effects of displaying S&D curves, and present data on market performance before and after S&D curves were incorporated into the simulation. Finally, we end with concluding observations.

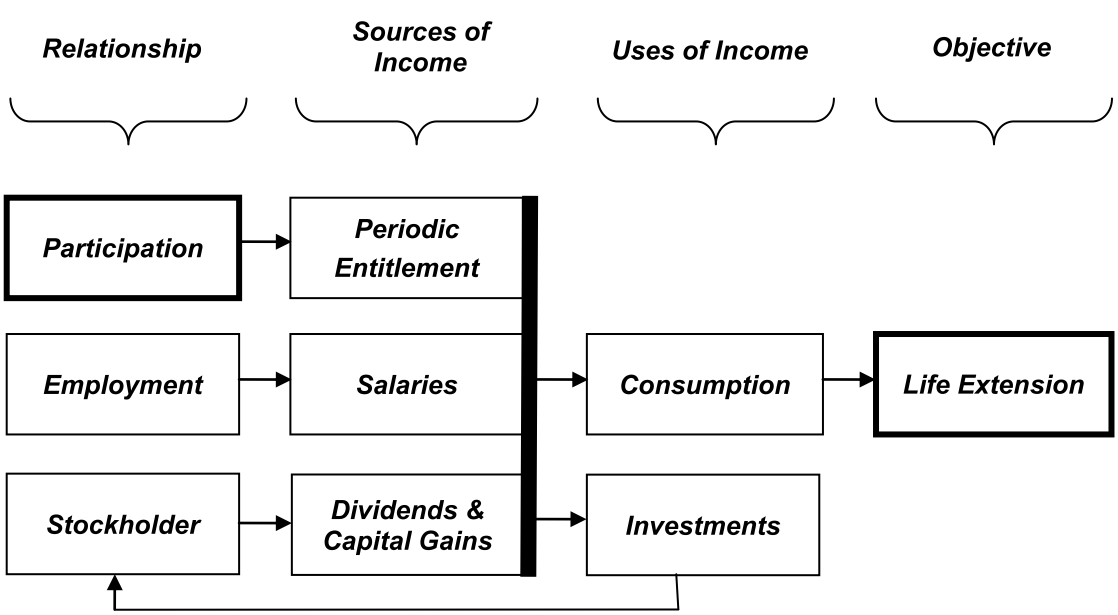
THE SIMULATION

The simulation, GEO, is a computer-assisted (Crookall, Martin, Saunders, & Coote, 1986), Internet-based (Pillutla, 2003), clock-and-activity driven (Chiesl, 1990; Thavikulwat, 1996) simulation of a global economy. Computer-assisted, the simulation enables participants to do much of what they are able to do in the everyday economic setting, namely found companies, trade company shares, hire employees, work for companies, buy resources, market products, and purchase products. Internet-based, the simulation accesses its data directly through the Internet, without requiring a browser. Clock-and-activity driven, the simulation advances from one period to the next depending on the time that has elapsed and on the extent of participant activity. The simulation is administered over the entire length of a semester, with the periods advancing at the rate of about one period every 48 hours at the start and accelerating gradually up to the rate of about one period every 6 hours. The pace slows down automatically during weekends and breaks, when participants are least active, and speeds up on class days, when participants are most active. Unlike many total enterprise simulations (Keys, 1987), this simulation refers to a period simply as a *period*, rather than as a quarter or a year. Like those simulations, production, interest payments, and salary disbursements occur on a batched basis, rather than continuously over the duration of a period.

To enable business activities, every participant receives a beginning balance and a periodic monetary entitlement that the participant may use to found companies, purchase shares, and buy the virtual products produced by the virtual companies that the participants have founded. The incentive for activity arises from a life-cycle-simulating scoring system (Thavikulwat, 2006) whereby participants extend their lives, and therefore increase their scores, by buying products that they are then considered to have consumed. The flow, illustrated in Figure 1, begins with Participation and ends with Life Extension.

As Figure 1 shows, every participant receives a periodic monetary entitlement, for which no work is required. The participant chooses between spending the entitlement on consumption, which extends life, and on investments in company shares, which convey the rights of shareholders, including the right to receive company dividends and to sell company shares. The participant may choose also to accept employment with the virtual companies of the simulation, in which case salaries received from employment add further to the participant's income. Increased income enables increased consumption, which gives rise to a longer life.

Figure 1
Performance Flow Diagram



Participants live multiple, sequential lives. Their scores, for which they receive credit towards grades, consist of the number of cumulative periods by which they have extended their lives.

MARKET MECHANISM

The simulation incorporates three gamed markets: a labor market, a stock market, and a product market. Participants use the labor market to employ each other for three executive positions: manager, purchasing agent, and sales agent. They use the stock market to invest in the companies that they found, and they use the product market to sell their companies' production. S&D curves are displayed for the product market only.

The virtual products of the simulation fall into one of five industries: service, material, energy, clothing, and food. The supply chain of products is shown in Figure 2, together with the value of each product in extending the lives of participants, as scaled in *utils* for each unit purchased. Thus, services, worth 1 util each, are required resources of material and energy companies. Material and energy, worth 4 utils each, are required resources for clothing and food companies, whose products in turn are worth 15 and 20 utils each, respectively.

Companies specialize, such that each company operates within one industry only. The product of any company has exactly the same attributes as the product of any other company within its industry, so all products are undifferentiated industry-specific commodities. Competitive advantage arises from higher production volume, lower fixed cost, and more effective purchasing and sales policies. Companies have higher production volume when they employ more executives and when they have accumulated more production experience. Companies have lower fixed costs when they pay their executives lower salaries. Unlike many total enterprise simulations (Keys & Biggs, 1990), promotion and product quality are not part of the decision set. Companies compete on cost and on their understanding of the market.

Within each period, products are sold in two stages, a batch stage followed by a continuous stage, as diagrammed in Figure 3. The batch stage activates automatically when a period ends. Batch processing takes place in seconds, during which participants are prevented from modifying the decisions that they have submitted. The continuous stage follows immediately, taking place over days at the beginning of the semester and over hours from the middle to the end of the semester. Accordingly, Figure 3 is not drawn to the scale of everyday time, as very little time elapses during the batch stage as compared with the continuous stage.

In the batch stage, companies produce and pay salaries and dividends, followed immediately by a clearinghouse mechanism that sells the products, based on terms of sale set by company sales agents, to consumers and downstream companies based on terms of purchase set, in the case of consumers, by participants seeking to extend their lives and, in the case of downstream companies, by purchasing agents seeking to acquire resources for their companies' production process. Products are sold sequentially, from the supplying company that is first in line to the customer that

Figure 2
Supply Chain of Products

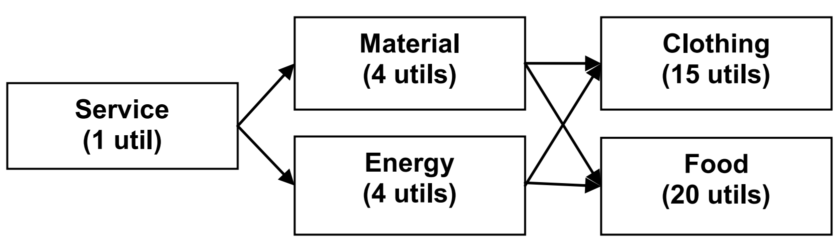


Figure 3
Stages of the Product Market

→ → → → → → → One period → → → → → → →			
Batch stage			Continuous stage
Produce and pay	Retail market	Wholesale market	Bazaar

is first in line, proceeding down the line until the price the seller requires exceeds the price the buyer will pay. Accordingly, the market is not a mathematical model. To the contrary, the market is real (Thavikulwat, 1997).

The market is a triptych of three places: retail, wholesale, and bazaar (Thavikulwat, 2003). Customers decide on quantity and bidding price when they set the terms of purchase. Sales agents decide between retail and wholesale when they set the terms of sale. Those choosing retail set an invitation price at which the product will be sold; those choosing wholesale set a reserve price below which the product will not be sold. The retail market opens first, followed in turn by the wholesale market and the bazaar.

The batch process places customers in line based on bidding price, highest price first. It places suppliers in line based on invitation and reserve prices, lowest price first. When the retail market opens, products are sold from the supplier with the lowest invitation price to the customer with the highest bidding price, at the invitation price. Thus, the customer who bids the highest price pays the lowest price in the retail market. When the wholesale market opens, products are sold from the company with the lowest reserve price to the customer with the highest bidding price, at the bidding price. Thus, the customer who bids the highest price pays the highest price in the wholesale market. The bazaar opens after the wholesale market closes.

In the bazaar, remaining customer bids are made available for acceptance by company sales agents on a first-come-first-served basis. The identity of the bidder is not revealed, and sales agents may not choose to accept any bid

Figure 4
Dialog Panel for Company Selling Services

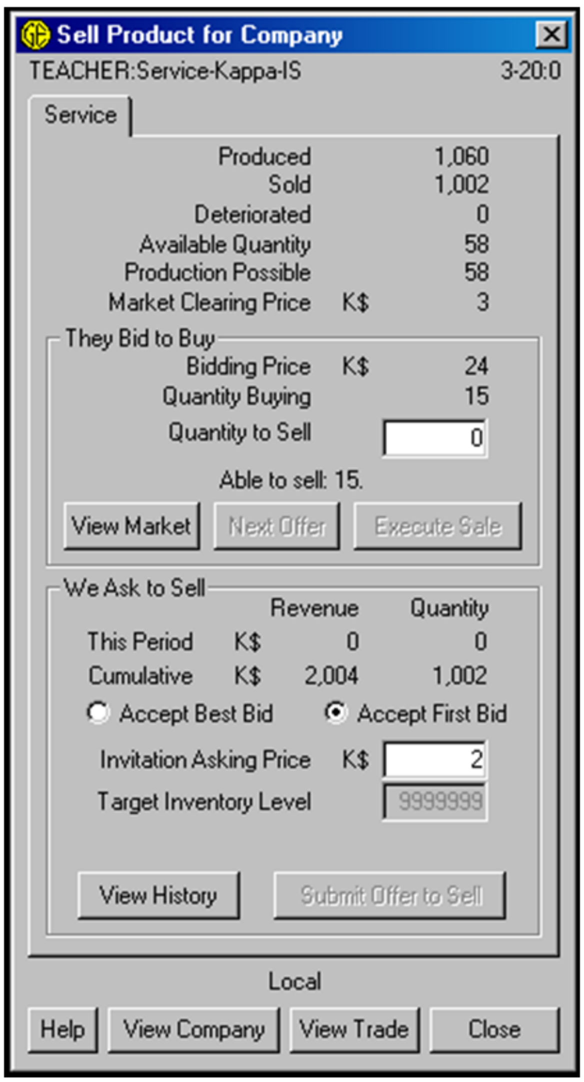
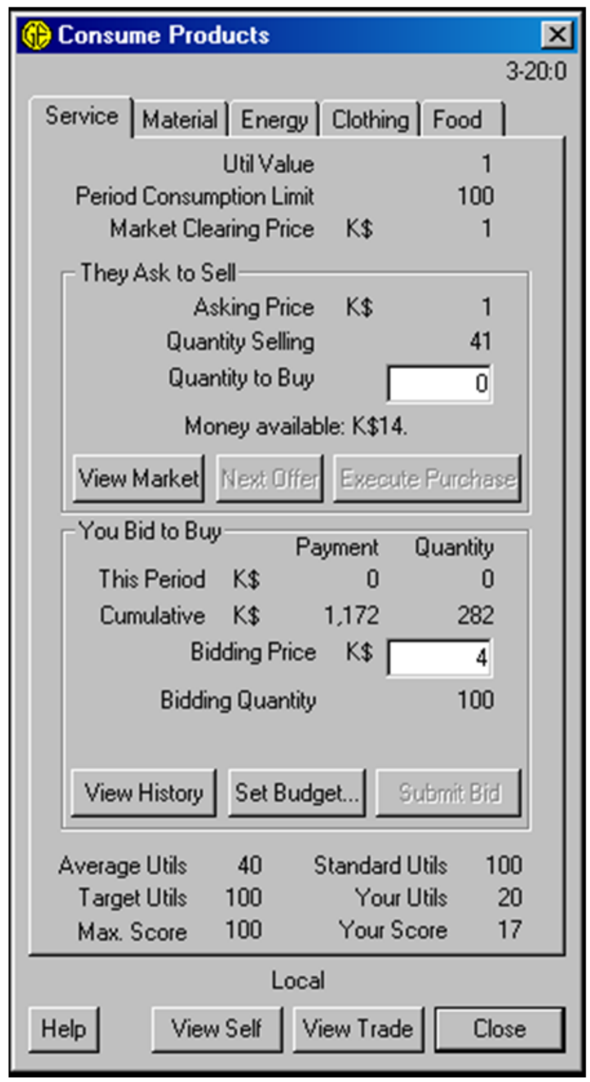


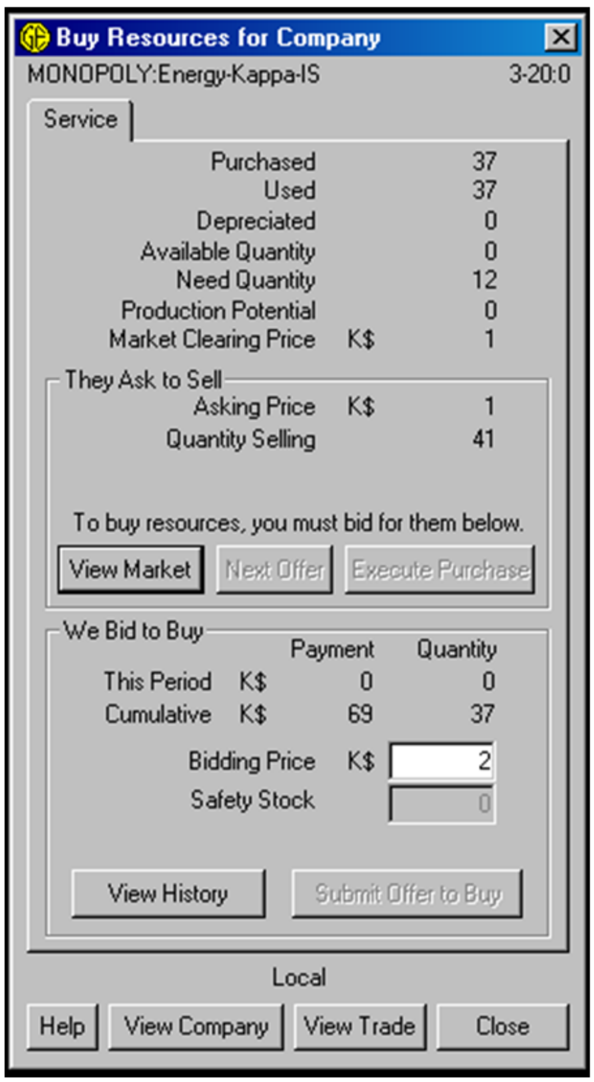
Figure 5
Dialog Panel for Consumer Buying Services



other than the first one in line, which is the one with the highest bidding price. Likewise, remaining sales offers are made available for purchase by customers on the same first-come-first-served basis. The identity of the company that submitted the sales offer also is not revealed, and the customers may not choose to accept any sales offer other than the first one in line, which is the one with the lowest asking price. The asking price can be either an invitation price or a reserve price, as both prices are treated identically in the bazaar. The bazaar closes when the simulation is advanced to the next period, either manually by the administrator or automatically when a preset number of minutes have elapsed, whichever should occur first.

Program dialog panels for a company selling services, a consumer buying services, and a downstream company buying services are shown in Figures 4, 5, and 6, respectively. In Figure 4, the We-Ask-to-Sell area is where the company's sales agent specifies terms of sale, and the They-Bid-to-Buy area is where the company accepts bids in the bazaar. In Figure 5, the You-Bid-to-Buy area is where the consumer enters a bidding price, and the They-Ask-to-Sell area is where the consumer accepts offers to sell in the bazaar. In Figure 6, the We-Bid-to-Buy area is where the downstream company's purchasing agent enters a bidding price. No entry box appears in the They-Ask-to-Sell area, but the company can still participate in the bazaar by raising the bidding price in the We-Bid-to-Buy area. This indirect purchasing procedure encourages purchasing agents to set the bidding price for the long term, as short-term period-by-period manual purchasing is poor policy for purchasing services, because purchases exceeding the quantity needed for the period would be wasteful inasmuch as services cannot be inventoried, and neglecting to purchase services for any period would shut down production in that period.

Figure 6
Dialog Panel for Downstream Company Buying Services



Lainema (2010) distinguishes between simulations that treat time as a batch-processing phenomenon and those that treat time as a continuous-processing phenomenon, arguing that “continuous processing clearly represents a way to broaden the potential learning experiences and therefore a possibility to take the simulation gaming discipline further” (p. 184). We have shown that market mechanism of the simulation used in this study involves both batch and continuous processing, thereby combining the convenience of batch processing with the transparency of continuous processing. Moreover, the mechanism is transaction based, which Teach (1990) two decades ago thought to be highly desirable and prognosticated would eventually become a “real possibility” (p. 115).

DISPLAY OF MARKET DATA

Aggregate and single-transaction market data for every period and itemized data of each transaction have been displayed in tabular and graphical form for some time. Displayed aggregates for the production side include average producer prices, total revenue, units sold, and units produced, as shown in Figure 7. Displayed aggregates for the consumption side include average price per unit, units consumed, and total purchases, as shown in Figure 8. Displayed single-transaction data lists every lot bought, as shown in Figure 9, and every lot sold, as shown in Figure 10.

S&D curves in tabular and graphical form are a recent addition. The curves are constructed from the bids to buy and the offers to sell products. Two panels of curves are supplied, one for the retail and wholesale markets and the other for the bazaar.

Three sequential views of the panel of curves at the opening of the retail market are shown in Figure 11. The first view (A) is of the panel before the Forward button is clicked, the second view (B) is of the same panel after the Forward button is clicked once, and the third view (C) is of the same panel after the forward button is clicked a second time. Essentially, the Backward-Slow/Stop-Forward buttons control animation of transactions in the retail and wholesale markets. Thus, participants are able to see the step-by-step execution of transactions, thereby ameliorating Lainema’s (2010) concern that in batch processing, “processes are hidden and the participants can see mostly the aggregate-level information from the last run period” (p. 178). Here, they see, animated, every step of the batch process.

The panel of S&D curves at the bazaar is shown in Figure 12. The panel contains no animation button, because, at this stage, transactions are immediately processed and the curves are updated whenever a customer changes a bid or executes a purchase by accepting an offer to sell, and whenever a sales agent changes an offer to sell or executes a sale by accepting a bid to buy. The flow of time is con-

Figure 7
Summary Market Data Panel of Production

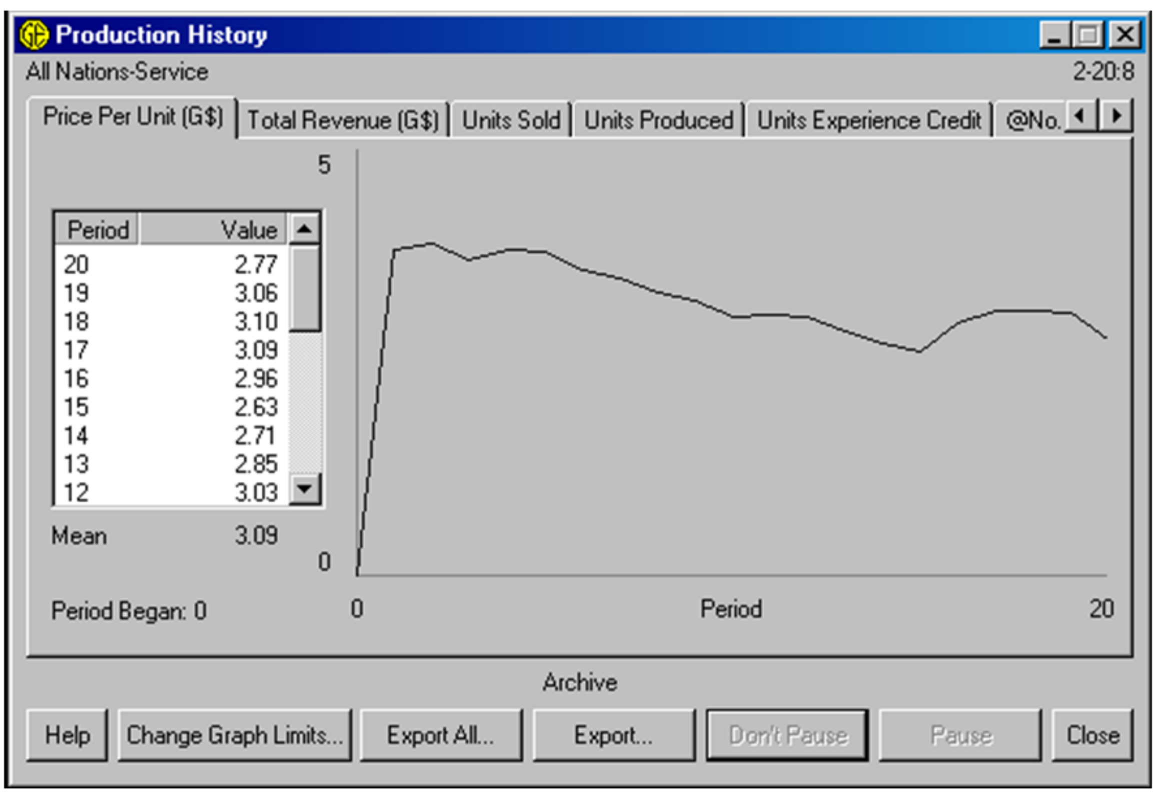


Figure 8
Summary Market Data Panel of Consumption

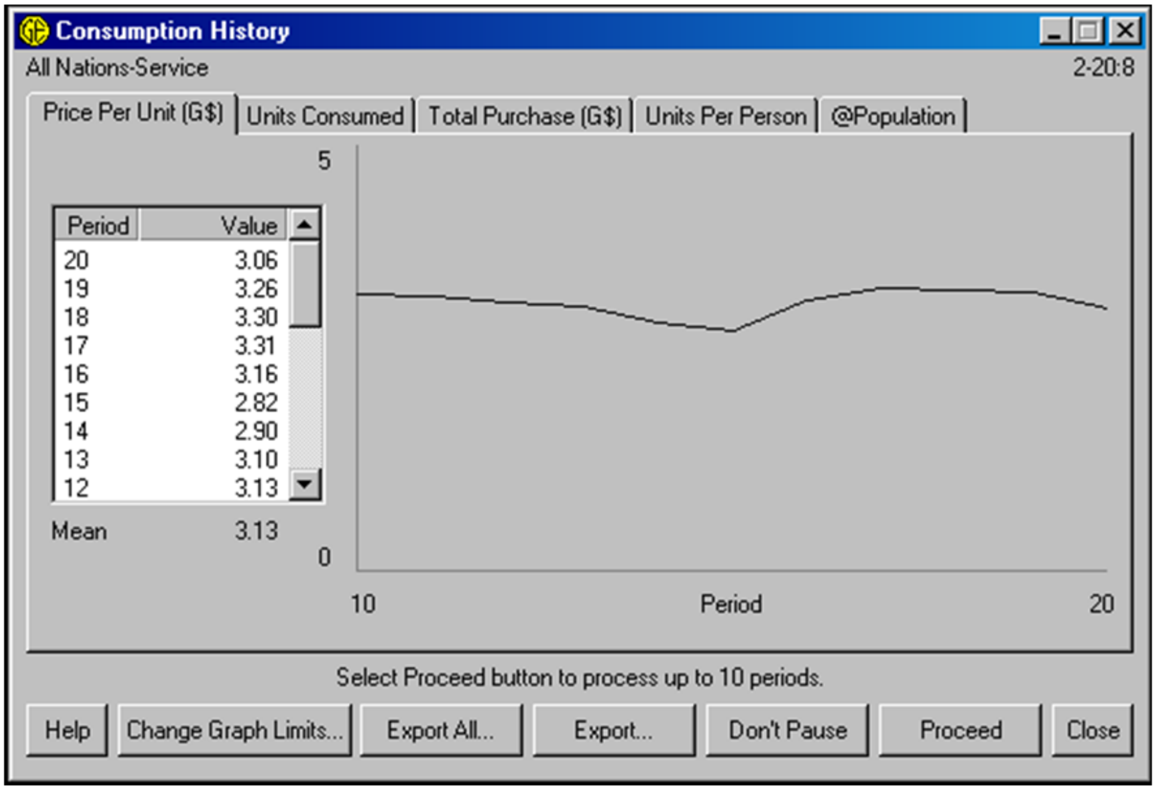


Figure 9
Panel of Single-Transaction Purchases

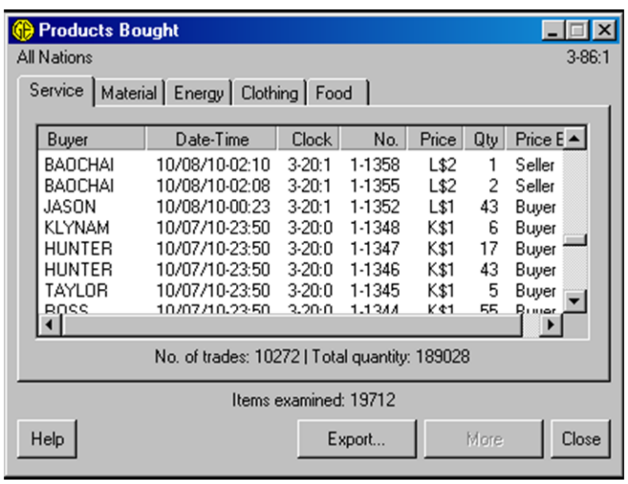


Figure 10
Panel of Single-Transaction Sales

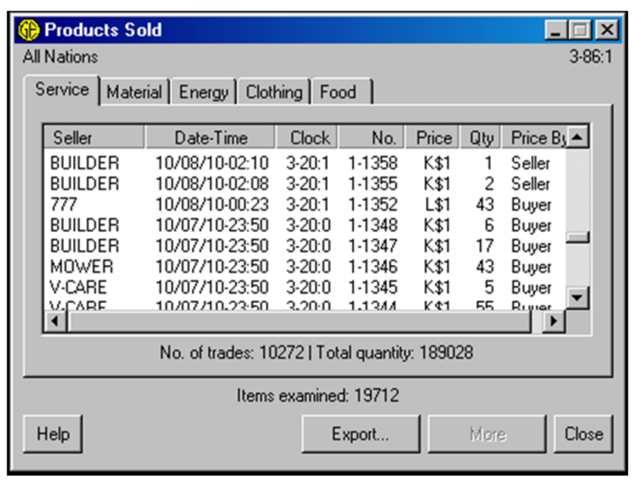
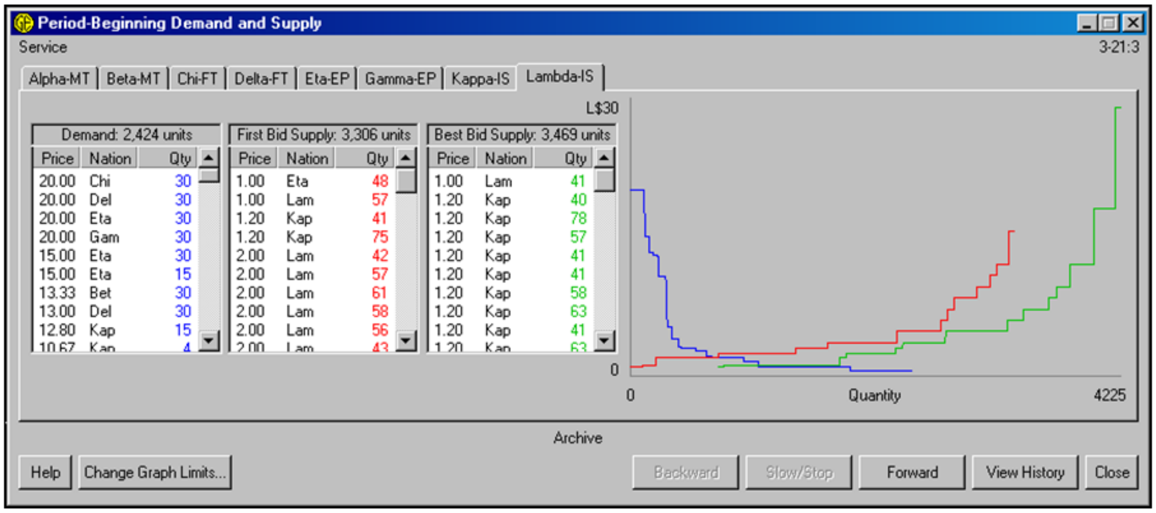
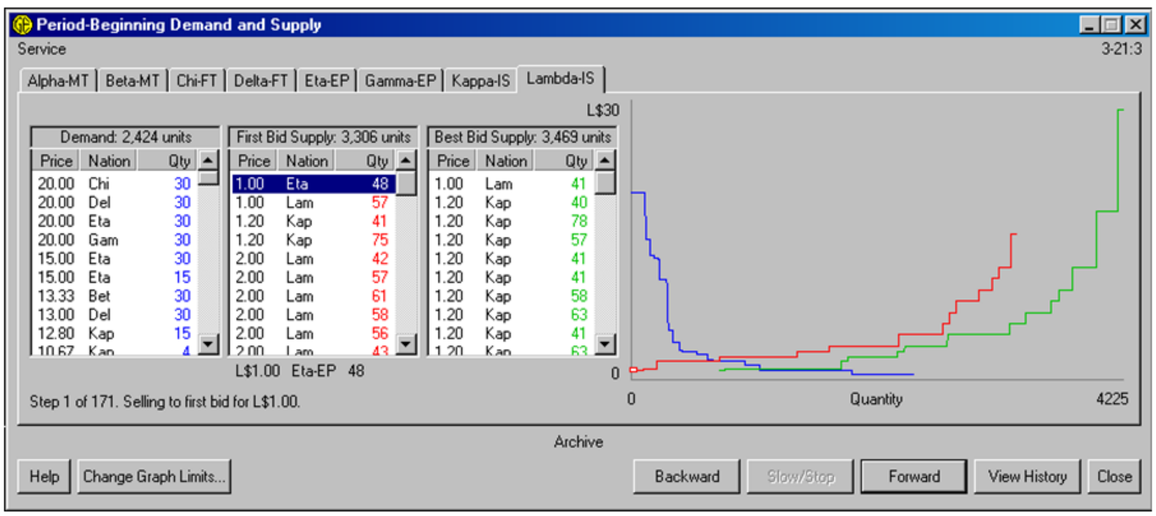


Figure 11
Panel of Supply and Demand Curves at Opening of Retail Market Before Animation (A), After First Step Forward (B), and After Second Step Forward (C)

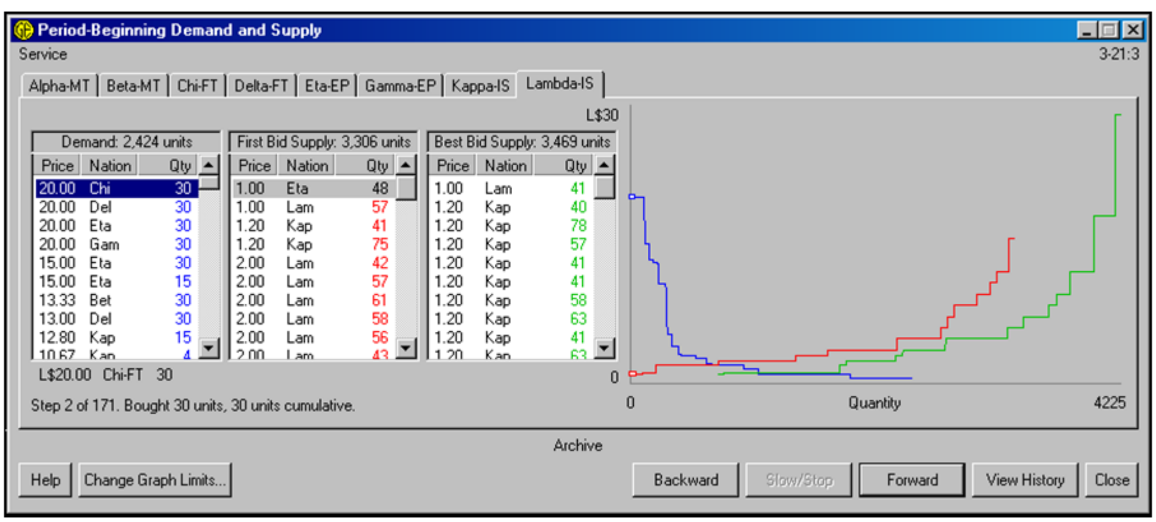
A



B



C



tinuous, so the process is transparent to the participants (Lainema, 2010) and animation would be superfluous.

THE STUDY

Our study is a before-and-after, design-science study, not an analytical-science study (Klabbers, 2006). As such, we are not primarily interested in proving theory, but in establishing workability. We went to considerable effort to incorporate S&D curves into the simulation, so we are interested in knowing whether we have brought forth a real improvement.

We administered the simulation exercise to a population of 142 business students before S&D curves were incorporated into the simulation (BEFORE), and one year later, to a population of 116 business students after S&D curves had been incorporated (AFTER), as shown in Table 1. About 69.4% of the participants across both conditions were upper class business student, a proportion that tended to be higher in the AFTER condition, $\chi^2(1) = 3.632$, $p = .057$.

Under both conditions, the simulation was administered for 200 periods at its usual accelerating pace, with the first 40 period spread over the first half of the semester and the remaining periods spread over the remainder of the semester. Our study is limited to service products of the first 40 periods, because few other products were produced within the first 40 periods and major changes in how the simulation was administered between the two semesters after 40 periods confound the interpretation of data beyond 40 periods.

At the end of 40 periods, the mean number of service companies founded by each participant across both conditions is 1.04, a proportion that did not differ by condition, $\chi^2(1) = 0.186$, $p = .667$; and the mean cumulative number of service units produced per participant is likewise the same for both conditions, $M = 2190$, $\chi^2\ (1) = 0.001$, $p = .997$. In contrast, the mean number of other companies founded by each participant is much smaller in the BEFORE condition, $M = 0.282$, than the AFTER condition, $M = 0.957$, $\chi^2(1) = 30.288$, $p = .000$, a consequence of changes in administrative settings between the two semesters. Increased founding of other companies gives rise to increased inter-industry competition for consumers' disposable income, which should lower the percentage of services units produced that is sold. This reasoning is supported by the data. As shown in Table 1, 57.14% of service units produced were sold in the BEFORE condition, but only 40.89% of service units produced were sold in the AFTER condition, $\chi^2(1) = 5017$, $p = .000$.

Increased inter-industry competition also should lead to lower prices for service products. We find this to be so. Prices fell more rapidly in the AFTER condition, as shown in Figure 13. Except for periods 7 and 8, the differences are all statistically significant, $p < .01$, $t(2700) > 2.576$.

Inasmuch as the participants in both conditions were business students who had taken two or more courses in economics, our hypothesis that the variance of prices should fall more rapidly in the AFTER condition can be tested. The data supports the hypothesis, as shown in Figure 14 by plots of the standard deviations of transaction prices and the F statistics of their variances over the 40

Figure 12
Panel of Supply and Demand Curves at the Bazaar

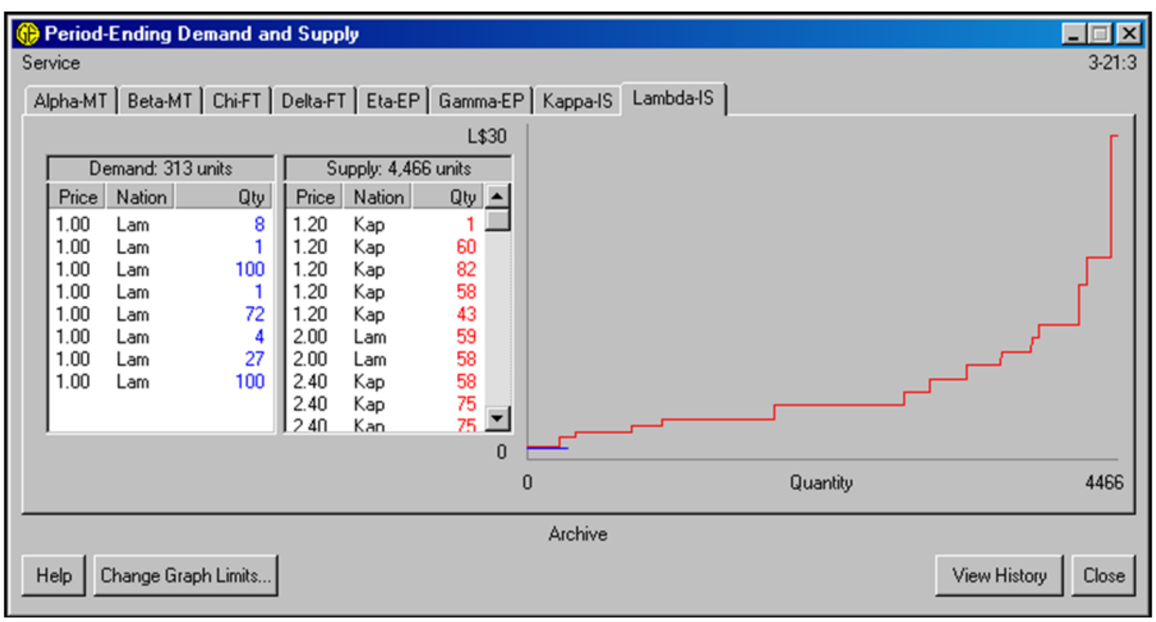
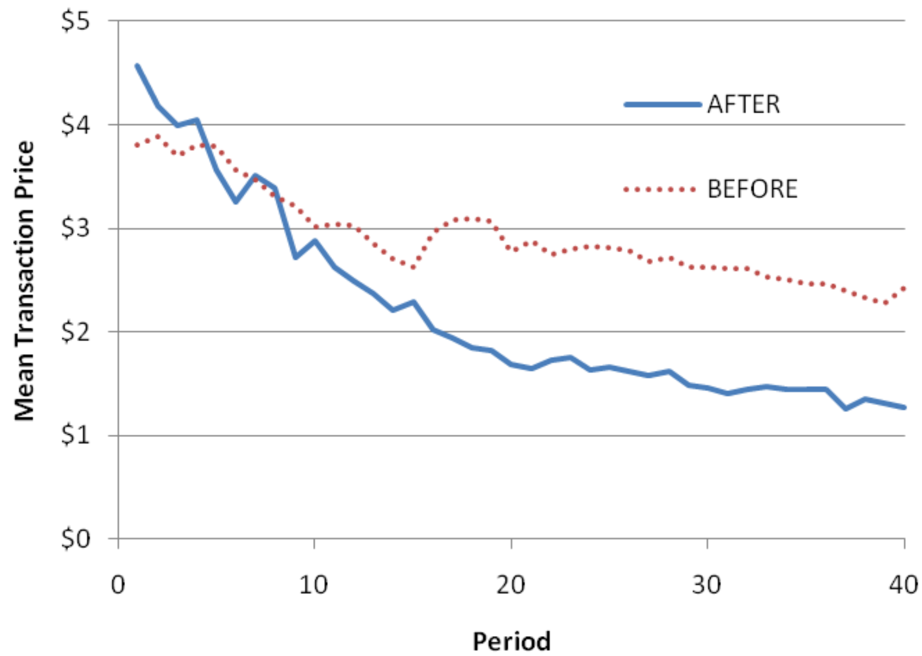
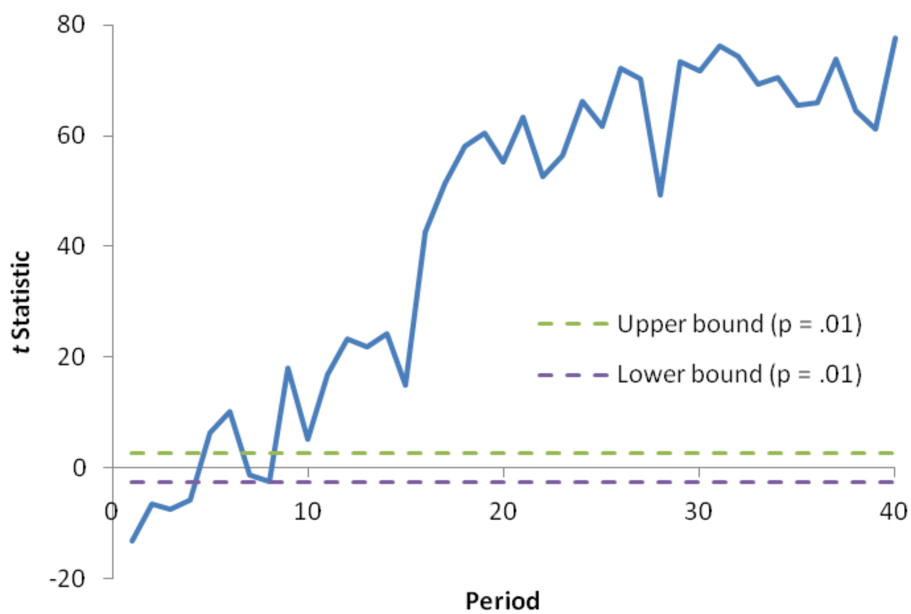


Figure 13
Mean Transaction Prices (A) and t Statistic of Their Differences (B)

A



B



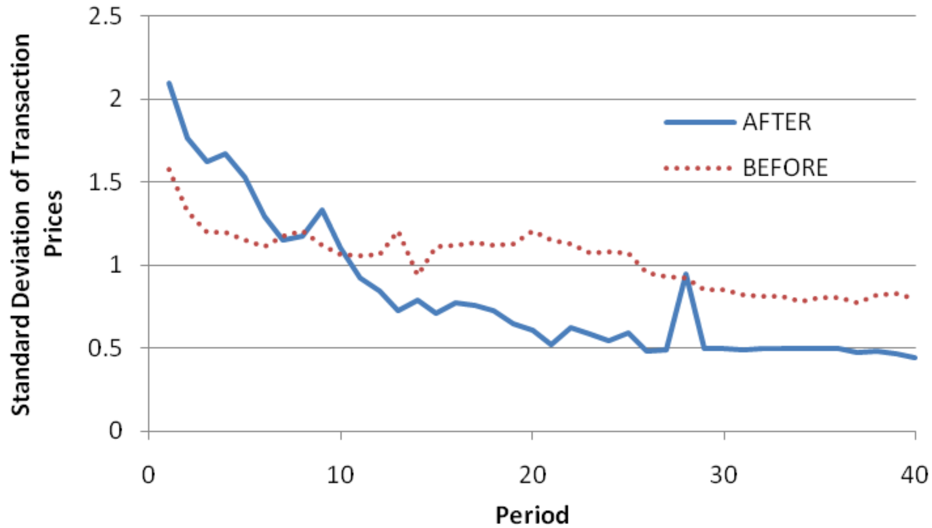
periods of the study. Except for the first 10 periods and an extraordinary dip in period 28 when a consumer made a substantial blunder[1] in the bazaar, the differences are all statistically significant, $p < .01$, $F(1700, 1700) > 1.12$.

CONCLUSION

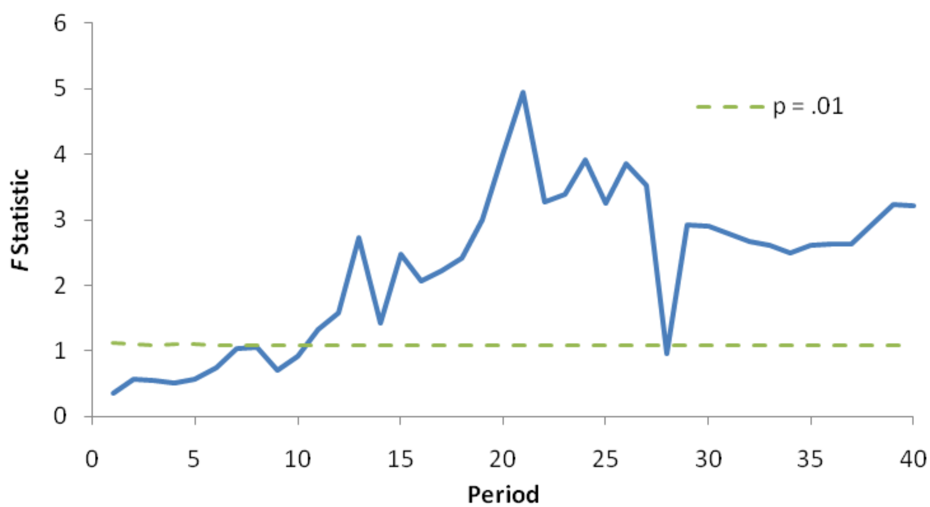
Inasmuch as the data supports our hypothesis that the variance of prices would fall more rapidly when S&D curves are incorporated, the data suggests that a real im-

Figure 14
Standard Deviation of Transaction Prices (A) and F Statistic of Their Differences (B)

A



B



provement has been obtained. The argument could be advanced that a before-and-after study is inadequate, because proof requires a control condition with randomization of participants across conditions. In its absence, the observed rapid fall in price variances could be attributed to other factors that differed across conditions, the most likely being the higher level of inter-industry competition in the AFTER condition that arose because of the difference in administrative setting. The question of causality is of interest, but it cannot be settled by this study.

Settling the question of causality requires an analytical -science study. Here, our focus is less on understanding causality and more on obtaining improvement. More rapidly reducing price variances suggests that participants have solidified their marketing acumen, whatever the nominal cause. We see this outcome as testament to their learning and reasoning, and therefore as improvement.

One way to extend this study is to see if improvement in market acumen can be obtained in a similar manner in the large number of simulations that model markets mathematically. The work would be conceptually and technically challenging, considering that the common way of modeling a product market is a three-step approach: first to compute industry-level demand from an average of firm decisions, then to allocate that demand quantity to the firms, and finally to allocate stock outs from firms with demand quantities exceeding supply quantities to firms with supply quantities exceeding demand quantities (Gold, 2005). This common approach entangles current demand with current supply, so how the process might be represented by S&D

curves is not obvious. A solution should have wide application.

ENDNOTE

[1]Having reached the self-set limit 200 utils, the blundering consumer raised the limit and set the bidding price of services to $23 a unit, when the average sale price of a unit of service was $1.62. The action caused the bid to advance to the front of the line in the bazaar, where the bid was accepted by a company's sales agent. As a result, the company sold to the consumer 2 service units for $23 each, substantially increasing the standard deviation of transaction prices in that period.

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