Large-scale, Long-term and Virtual Experimental Environments for Electronic Markets

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Introduction

Theory testing is as important as theory building in a nascent field like Electronic Commerce (EC). While there is a small but growing body of theoretical models of EC, the literature on empirical testing of beliefs, assumptions and models of EC is sparse, primarily due to difficulties in collecting relevant and detailed data from the field. Experimentation can provide a valuable alternative to EC field research. In spite of well-known problems of external validity, carefully designed experiments can let researchers observe and record EC phenomena which would be virtually impossible to capture in the real world. As an alternative to empirical field research, we present Experimental Digital Economy (EDE), a technological environment for creating a virtual electronic market, and a methodology to test market mechanism related propositions and to understand dynamics of a controlled digital economy. Using this technology infrastructure along with suitable incentives and rules for market agents, we explore the effectiveness of various market mechanisms (e.g., posted prices and auction systems) for digital products involving information and software goods.

Experimental Economics and Electronic Markets

Experimental economics has made significant progress in testing and creating new economic theories by recognizing the role of incentives and by creating simple but real markets in laboratory environments. The main advantages of using such experiments are replicability and control (Davis and Holt 1992). Experimental economics deals with systems involving multiple relationships, rather than addressing a problem in isolation from its environment, within which phenomena of interest are likely to be observed. Starting with Chamberlin's (1948) experimental study, experiments on market organization and competitive equilibrium seek to test theories of exchange that can be formulated in terms of aggregate supply and demand in a market.

Another stream of research methodology that is relevant for studying phenomena in electronic commerce is related to computational economics (e.g., Kydland 1996). By constructing and calibrating a model economy, a researcher collects a set of data which reflects the real-world economy or businesses and which is otherwise not available due to the complexity of real business environments. Along similar lines, Barua, Chellappa and Whinston (1998a, b) created a "quasi-naturally occurring" electronic market where buyers and sellers trade real digital products (information and software goods) using an electronic transaction instrument which is valuable to both parties. For example, during the 1998 Spring semester, there were 18 companies in the electronic market. The company members were students from the Business school, Computer Science and EE departments at the University of Texas at Austin (UT Austin). There were over 80 buyer groups (over 250 individual buyers) spread across different courses at UT Austin, University of Southern California and Monterey Tech, Mexico City. These buyers had to complete multiple projects on computer networking, Internet related business, intranets, etc., as a part of their course. They were allowed to buy information and software from the sellers, and to use the products in their projects.

It is important to note that while experiments in economics use imaginary goods (e.g., a piece of paper with specified cost, Smith 1962, 1964, Plott and Smith, 1978) with fixed buyer values and seller costs, real products created by the sellers are traded in our experimental market. While the simpler but more precise setting in experimental economics is suitable for testing well-developed economic theories, our setting reflects the complexity of real electronic markets to better understand and observe phenomena of interest.

In the exploratory studies conducted by Barua et al. (1998a, b), no explicit experimental controls were used. The focus of these studies was on the feasibility of creating a real electronic market within an educational setting through the deployment of software applications, buyer and seller incentives, and transaction rules, and on the ability to observe and record market dynamics. For example, over a period of three semesters, our market setting provided deep insights into both methodological challenges and business issues in electronic environments. We observed patterns of success emerging in our experimental markets involving the creation of trust, early visibility, focused "push" strategy, customization, bundling complementary products, and product quality

and content signaling (Barua et al., 1998b). In this ongoing research, we build upon the previous studies by moving closer to laboratory experimentation through the use of specific experimental controls. We have redesigned our experimental environment to enable such controls (e.g., based on the experimenter's choice, one set of buyers can only access a market with posted prices, while other buyers are presented with an auction institution).

Ongoing Analysis and Anticipated Contributions

Two of the critical issues facing sellers of digital products involve the choice of a selling institution and the uncertainty surrounding the quality and fit with buyers' requirements of a product. We examine three broad institutional arrangements: fixed posted prices (referred to as posted offer auction in experimental economics), posted prices which can be changed dynamically, and auctions. Given the zero marginal cost property of a digital product, buyers' willingness to pay is a critical determinant of the realized price of the good. A seller will use an institution which helps extract the maximum willingness to pay from the buyers. An institutional arrangement where a seller can change posted prices by observing the buyers' purchasing behavior should allow sellers to charge prices close to the buyers' willingness to pay. On the other hand, if posted prices are not allowed to change, a seller may be far off from a buyer's willingness to pay in either direction.

More specifically, we test the following propositions:

$|P_e - P_d| > |P_e - P_a|$, and $|P_e - P_t| > |P_e - P_d|$, where P_e is the competitive equilibrium price, P_d is the average price of a posted-price market with dynamic price updates, P_a is the average price of an auction market, and where P_t is the average price of a posted-price market with no dynamic prices updates. The supply curve of this market institution can be captured from costs and prices stored in the business transaction module of our database, which logs changes of product and price information. Using a proxy measure for reservation price and quantity, the demand curve can also be determined. From such curves, we can calculate competitive equilibrium prices for each *category* of digital goods and compare these prices with the average market prices in the posted-price market. This test statistic will provide us with information on whether this posted-price market with the dynamic price update feature is an efficient mechanism.

Another important form of market organization is an auction institution, first experimentally studied by Smith (1962), who observed rapid convergence to competitive equilibrium when the market was repeated several times with stationary parameters. In EDE, sellers post the location of a product, a product description, a minimum price, a minimum bid increment, the number of copies to be sold, the expiration date and time, and choose an auction format (Yankee or Dutch). To bid a price, buyers first enter their user IDs and passwords. While the auction is open, buyers can bid many times and the reservation price feature allows a buyer to bid automatically if the highest bid is under the

buyer's reservation value. An experimenter can choose or require sellers to use a certain type of auction format, termination rules, and other mechanisms. The efficiency of the one-side-sequential Dutch auction, which is the most popular auction market mechanism on the Internet, will be calculated as in the case of posted-price market. To compare the posted price with dynamic update feature and a sequential Dutch auction with automatic reservation price execution, the same goods will be sold to different buyer groups.

In addition to the choice of a suitable trading institution, digital goods have an inherent problem of uncertainty regarding quality and fit with buyers' requirements. The sellers have better information on product quality (leading to the possibility of a lemons market), while buyers know their requirements better than the sellers. This asymmetry of information can lead to a market failure. We focus on the role of quality certification by third parties (the electronic mall provider in our experimental setting) and other quality signaling measures in mitigating inefficiencies in our digital products market.

Conclusion

Evolving theories of electronic markets and digital products as well as their underlying assumptions need to be tested with data from real digital economies. However, given the difficulties associated with data collection from the real world, we have chosen to concentrate on the creation of simpler but real electronic markets for digital products within a virtual experimental setting. Such a setting involves many issues including the development of software applications, methodological choices including agent incentives, transaction rules, and experimental controls. Being based on real products created by sellers, our experimental setting is rich in complexity and realism, and enables us to test the impact of various choices made by sellers on their profitability as well as market efficiency. Through the testing of propositions related to market mechanisms, this research will provide an in-depth analysis of the behavior of sellers, buyers and market prices for digital products traded in a competitive environment.

References

[1] Barua, A., R. Chellappa, and A. B. Whinston, (1998a), "Designing and Testing Electronic Commerce Applications for Digital Products Companies," under revision, *International Journal of Electronic Commerce*.

[2] Barua, A., R. Chellappa, and A. B. Whinston, (1998b), "Quasi-naturally Occurring Experiments With Electronic Markets and Digital Products," under revision, *Communications of the ACM*.

[3] Chamberlin, Edward H., (1948), "An Experimental Imperfect Market," *Journal of Political Economy*, (56), pp. 95-108.

[4] Davis, Douglas D. and Charles A. Holt, (1992), *Experimental Economics*, Princeton, New Jersey.

[5] Kydland, Finn E. and Edward C. Prescott, (1996), "The Computational Experiment: An Economic Tool," *Journal of Economic Perspective*, 10, 1, Winter, 69-85.

[6] Plott, C. R. and V. L. Smith, (1978), "An Experimental Examination of Two Exchange Institutions," *Review of Economic Studies*, 45, pp. 133-53.

[7] Smith, V. L, (1962), "An Experimental Study of Competitive Market Behavior," *Journal of Political Economy*, 70, pp. 111-137.

[8] Smith, V. L, (1964), "The Effect of Market Organization on Competitive Equilibrium," Quarterly Journal of Economics, 78, pp. 387-393.