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Foreword

Vernon L. Smith

More than a quarter of a century ago, the federal government moved to deregulate airline routes, over the vigorous objections of all but two airlines. The political impetus was fueled by public realization that airline regulation had not benefited the airline passengers.

At the time, Stephen Rassenti was working on his Ph.D. in systems engineering, but he had minored in economics—theory, econometrics, and experimental economics. He was looking for a thesis topic, and I suggested that with airline route deregulation and the decision to sunset the Civil Aeronautics Board we were moving far and fast with no one thinking about the airports. Planes have to use runways to serve routes, and the airports were still regulated with a cumbersome political process for allocating runway rights. I proposed that Stephen, with his expertise in algorithms, work on the question of how you might design a smart computer-assisted market to solve this complex 0-1 combinatorial rights allocation problem. Bidders can naturally value packages of runway slots and can bid on them, but they need algorithm support so that the complex combinatorial problem of allocating elemental rights to the most efficient packages is simple for them. Their management problem is impossibly complex if they have to bid on package elements, obtain some, but not others, and then enter a secondary market to buy (or sell) the fragments that are not properly packaged. The basic idea was to engineer the market design to fit the management problem that businesses faced, and economize on transactions and strategizing costs. Stephen's solutions to this class of problems resulted in his dissertation (Rassenti 1981), and I think it is accurate to say this event launched the field of combinatorial auctions. More generically, Stephen had created the concept of the smart computer assisted exchange. Thus, as we noted at the time:

> To our knowledge, this study constitutes the first attempt to design a "smart" computer-assisted exchange institution. In all the computer-assisted markets known to us in the field, as well as those studied in laboratory experiments, the computer passively records bids and contracts and routinely enforces the trading rules of the institution. The RSB mechanism has potential application to any market in which commodities are composed of combinations of elemental items (or

> characteristics). The distinguishing feature of our combinatorial auction is that it allows consumers to define the commodity by means of the bids tendered for alternative packages of elemental items. It eliminates the necessity for producers to anticipate, perhaps at substantial risk and cost, the commodity packages valued most highly in the market. . . . The experimental results suggest that: (a) the procedures of the mechanism are operational, i.e., motivated individuals can execute the required task with a minimum of instruction and training; (b) the extent of demand under revelation by participants is not large, i.e., allocative efficiencies of 98–99% of the possible surplus seem to be achievable over time with experienced bidders. This occurred despite repeated early attempts by inexperienced subjects to manipulate the mechanism and to engage in speculative purchases. (Rassenti, Smith, and Bulfin 1982, p. 672)

In 1976, we had ''gone electronic'' in the conduct of laboratory experiments at Arizona. What we learned over the next three years was the unanticipated ecological consequence of laboratory experience: human interactive experiments governed by a computer network enabled the accommodation of far larger message spaces, opened the way to the application of coordination and optimization algorithms to the messages of subjects, and facilitated their capacity to reach sophisticated equilibrium outcomes that they did not need to understand. Their expert system help was part of the overall design of the market mechanism.

From this very limited, modest, and hopeful beginning an exciting intellectual history followed, and this book is a truly important landmark in that development.

Stephen's 1981 results pale in comparison with what we have all learned since, and that learning continues unabated. What have we learned in and beyond the laboratory?

- The ideal incentive mechanism design should lead managers to a two-step procedure: (1) an estimation of the value of the auctioned item(s), followed by (2) a readiness to reveal this value in the form of a bid, if necessary, such action being a fair approximation to that which serves the interest of the bidder.
- Market design should focus on how to facilitate this procedure. Very complex market allocation problems for runway rights, gas in pipeline networks, energy on a high voltage grid, and so on, can be made simple for the participants. Humans make the value judgments, and smart markets handle the complexity.
- Participants are not required to be experts in anything except their own business uses of the auctioned items, and must apply what they know to determine the private values of those items. That must be their specialty and their focus, and strategizing should not be plainly required of them.
- Privacy is essential: public information on who is bidding for what, how much, and when, fosters manipulation, gaming, collusion, and inefficiency. It is a fantasy to think that such activities can be controlled by piecemeal auction rules adjusted after each auction based on complete information examples, good for teaching, but not for designing. The Federal Communication Commission's Simultaneous Multiple Round

auction evolved over a sequence of field applications in which weaknesses and defects revealed in each application led to "fine tuning," followed by the observation of further problems leading to new "fixes," and so on. Each "fix," designed to limit a particular strategic exploitation, tended also to generate complexity and its attendant higher transactions' cost.

▪ This was precisely what had been learned in the laboratory in a series of elementary experiments that led to a sequence of increasingly complicated modifications of English procedures (McCabe, Rassenti, and Smith 1988; hereafter MRS). These experiments illustrated the potential for initiating the following dangerous design cycle. You begin with a precise theoretically "optimal" auction procedure—both of Vickrey's proposals for multiple unit English auctions seemed transparent. In implementation, you encounter behavioral incentives or "strategic" problems not considered as part of the original theory and likely intractable from a theoretical point of view. You come up with an intuitively plausible rule "fix" to provide a countervailing incentive. This creates a new problem requiring a new rule adjustment, and so on.

▪ In this study we found that all problems arose from a common feature: bidder control over price bids from the floor. These are issues not readily anticipated by formal analysis that can surface naturally in experiments, but make sense, ex post. The bottom line, transparently evident in the MRS results, is that if you want to do English multiple unit (incentive compatible) auctions, the way to do them is to use the English Clock. In forty-four English Clock auctions, only one failed to award the item to a highest value buyer. This method dominates all others in terms of efficiency. There can be no jump bidding because no one can bid a price.

▪ Thus, the MRS (p. 70) conclusion: "The English Clock is our best implementation and is likely to find acceptance in the field. This auction gives participants feedback during the auction ... produces consistent pricing and very high efficiency, (and) can accommodate programmed (or electronic) ... bidding." Essentially, the procedure works well because it removes from bidders the right to announce bids from the floor—they can only indicate willingness to be in, or out, at the standing price, and once out they cannot reenter (in the MRS implementation). Bidding from the floor invites jump bidding, collusion, and longer auctions. Avoid it by denying all opportunity and information that supports it. All the theoretical examples of incentive failure, manipulation, gaming, and bad outcomes that I know are based on complete information.

▪ Others have discovered through the hard knocks of experience the efficacy of English Clock Auctions, as in the nice chapter in this volume by Ausubel, Cramton, and Milgrom (chapter 5). They offer many elaborations eminently worthy of study.

▪ Elsewhere we report a Combo Clock (CC) auction that is easy for the participants, and places minimal computational requirements on the auctioneer (Porter et al. 2003). The optimization, if needed, is run only after all clocks have stopped and all information is submitted for processing. It trivially accommodates the sale of multiple units of multiple items. Bidders have complete freedom to move in and out of the auction bidding on any packages at will. It allows the bidder to impose logical constraints without increasing the computational burden during the auction. For example, a bidder may implement mutually exclusive bids and "if and only if" bids: the auction simply computes his demand for an item as the maximum number of units he could possibly win. The bidder is also free to blend current and previous clock prices in a current compound bid as long as part of the bid is at current clock prices. The CC auction may be the most flexible known combinatorial auction, but more testing is obviously in order. Moreover, *strategic behavior is controlled by feeding back only that information bidders need to know (item prices) in order to avoid bidding more than their maximum willingness to pay. For this purpose bidders do not need to know who is bidding, how many are bidding, and on which items or packages*. Hence, in auction environments where certain items have only one bidder—for example, timber and offshore petroleum tracts—this fact may still elicit full value bidding if every tract is potentially contestable, and bidders face much uncertainty about how active the bidding will be on any one item.

- The needs of the future are twofold: first, more laboratory tests by independent scholars, including explorations of alternative economic environments, with the objective of uncovering the Combo Clock's boundaries of validity—I believe that all mechanisms have limits to their robustness that can only be determined empirically, whether guided by theory or not; second, tests in the field where users must be persuaded to see the merits of strict security that enables bidding to be driven primarily by private information. This latter need will be particularly difficult because the problem was not addressed up front—early designers were all inexperienced—and users have become accustomed to the hope that ever more complex rules can control strategizing, without significantly increasing implementation costs for everyone.
- It is our understanding that the Freedom of Information Act and other legislation does not prevent complete bidder privacy in an auction until some time after the auction is completed.
- As economists our task is to emphasize that efficiency, not revenue, is the key criteria in economic systems design. For government sales of rights and assets, efficiency is the route to maximizing the creation of income and wealth in the economy, and that gives you more tax revenue tomorrow. To the extent that the FCC auctions have maximized revenue and contributed to the winner's curse, they have contributed to bankruptcies, spoiled the market for subsequent auctions, and reduced the generation of new wealth. For private auctions, public policy should lend support to programs for achieving efficient allocations.

It is a pleasure to commend the editors, who should be proud of having produced a volume likely to generate long lasting benefits to the growing market design community.

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