Market Design: Auctions and Matching

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Economists are increasingly being asked to design markets. Alvin Roth provides a beautiful summary of this activity in matching markets. Here I extend the discussion to auction markets and emphasize connections between auctions and matching.

Auctions determine who gets the goods and at what prices. The assignment of goods is simply a match. The key difference is that prices—formed from the bids—mediate the match. Auctions are matching with prices.

Interestingly, the major matching results have close analogs in auctions. In matching, stability is important. We do not want people to object to the match. Fortunately, stability is easily achieved with the deferred-acceptance algorithm. Incentives are important. We do not want people to game. Although there is no strategy-proof stable mechanism, if markets are thick enough, then the deferred-acceptance algorithm performs extremely well and provides optimal incentives. In auctions, stability is still important. We do not want an outcome where a group of bidders could offer the seller a better deal. Incentives are still important. Again, there is no strategy-proof mechanism that always satisfies the stability property. However, if markets are thick enough, a variant of the deferred-acceptance algorithm will minimize gaming opportunities and achieve highly efficient outcomes.

Auction applications are rapidly expanding. Communication and computational advances have certainly played an important role, but the development of simple and powerful auction methods has been important too. Market designers now have a much richer set of tools to address more complex problems.

One example is a package auction (or combinatorial auction) in which bidders can bid on packages of items. In a package auction bidders can express preferences for complementary items without running the risk that they will win just some of what they need. This is important, for example, in spectrum auctions in which different technologies require that the spectrum be organized in different ways. In the past, the regulator has been forced to decide how the spectrum is organized with a specific band plan—effectively deciding how much spectrum is available for each technology. A package auction enables the regulator to conduct a technology-neutral auction, which lets the bidders determine the band plan through their competitive bids. A good example is the United Kingdom's 2.6 GHz auction in 2009: the quantity of paired versus unpaired spectrum is determined in the auction, not by the regulator.

One of the challenges of package auctions is finding an effective way for bidders to convey preferences. There are simply too many packages to ask for preferences for all possible packages. A common approach is to begin with a clock auction. The auctioneer names a price for each product, and bidders respond with their most preferred packages. The price is then raised on all products with excess demand, and the bidding continues. This price-discovery process focuses the bidders' attention on packages that are most relevant. Once this price discovery is over, the bidders are in a much better position to submit any additional bids, as well as improve the bids already submitted. An optimization is then done to determine the value-maximizing assignment, as well as competitive prices that satisfy the

stability constraints. Typically, there are many such prices, so a further optimization is done to find the prices that provide the best incentives for truthful bidding.

Package auctions are also proposed for auctioning takeoff and landing rights at congested airports, such as the three New York City airports. The goal of the auction is to make the best use of scarce runway capacity. Left to their own devices, airlines will overschedule flights during peak hours, creating congestion and costly delay. The package auction enables each airline to bid for its preferred package of slots. The resulting competitive prices motivate airlines to substitute away from expensive slots, either by shifting flights to less expensive times or by using larger aircraft to carry the same number of passengers with less runway use.

Another example of market design is electricity markets. Modern electricity markets are organized as a number of auction markets. The markets, taken together, are designed to provide reliable electricity at the least cost to consumers. Spot markets determine how much each supplier is generating on a minute-by-minute basis; forward energy markets enable customers and suppliers to lock in medium-term prices for electricity; and long-run investment markets coordinate new entry to cover any expansion in electricity demand. These auction markets must be carefully designed to work together to achieve the goal of least costly, reliable supply. Design failures can be quite costly, as the California electricity crisis of 2000–2001 demonstrated. When the stakes are high, an important step in market design is building prototypes and then testing those prototypes in the experimental lab or in the field before full-scale implementation.

One exciting aspect of market design is working on the forefront of theory and bringing that theory to practice. In both auctions and matching, solving real problems has proved to be an excellent way to develop new theory. The applications benefit from the improved markets, and the theory is enriched in the process.