

Optimal Queueing Auctions

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This paper studies theoretically the optimal design of a queue system for providing goods or services to buyers that arrive stochastically over time. In a standard auction problem, a fixed number of goods are allocated to a fixed number of potential buyers. However, many services, such as online or phone customer service, repair, food delivery, and restaurant service, take a stochastic amount of time to complete, and many goods, such as public housing, become available at stochastic times. Buyers for these services and goods also arrive stochastically over time. Specifically, we consider an $M/M/1$ model in which a potential buyer arrives at a Poisson rate, and the arrival of a good takes exponential-distributed time. Each buyer is privately informed of his valuation of the good, which is distributed according to some atomless distribution, and incurs a waiting cost per unit of time.

The seller commits to a Markovian mechanism that charges a monetary fee as a function of the type a buyer reports. Each feasible mechanism induces a Markov chain on the number and types of buyers in the queue. We look for a mechanism that maximizes the expected revenue at the steady state—the stationary distribution of the Markov chain. The extant literature from Operations Research considers screening buyers with a static policy not contingent on the state. We solve for a dynamically optimal screening mechanism that involves general dynamic allocations, and, in the process, we pin down the associated stationary distribution of the (infinite-dimensional) state. The optimal mechanism uses a reserve price (or minimum bid) that increases with the number of buyers in a queue and an auction to select the buyer with the highest valuations among those in the queue. The former feature means that the arrival of a new buyer either triggers the queue length to increase if all buyers have sufficiently high valuations or triggers an exit of a buyer with the lowest valuation. As the cost of waiting goes to zero, the optimal mechanism converges to the efficient auction rule with a reserve price set at the standard monopoly price.

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