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On procurement auctions with fixed budgets☆

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Abstract

We consider an organisation which has been allotted a fixed budget 'A' by higher authorities, for procuring certain specified items. It seeks price quotations from firms. The firm quoting the lowest price secures the contract to sell the item to the organisation. In this context we compare first price and second price auctions and derive the following results. (i) The expected price in the first price auction is lower than the expected price in the second price auction. (ii) The expected quantity sold is the same across the two auctions. (iii) With a rise in the number of firms the expected price goes down and the expected quantity sold goes up in both FPA and SPA. (iv) The expected profit to any firm in equilibrium is also the same across the two auctions. (v) We analyse the effect of reserve prices and discuss optimal reserve price. (vi) We also discuss quantity auctions and show that they are equivalent to standard benchmark auctions.

Keywords: Procurement auctions; Fixed budgets

1. Introduction

Consider an organisation which has been allotted a fixed budget 'A' by higher authorities, for procuring certain specified items. It seeks price quotations from firms. The firm quoting the lowest price secures the contract to sell the item to the organisation. Here the sellers compete for the right to sell to a market characterised by a negatively sloped demand curve $q = A/p$. The amount sold clearly depends on the winning bid. This is an example of a procurement auction with variable quantity. Public sector undertakings in a country like India often procure goods in such a manner. In this framework, under standard assumptions, we compare first price and second price auctions[1] and derive some results which stand in contrast to received conventional wisdom. It may be noted that throughout the paper we will use FPA and SPA as abbreviations for first price auctions and second price auctions respectively.

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[1] Note that the first price auction is the outcome equivalent to the Dutch auction and the second price auction is the outcome equivalent to the English auction.

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Traditionally auction theory has analysed situations where a fixed number of units is up for sale. The symmetric, independent, private value (SIPV) auction has been the benchmark model. In variable quantity auction, the amount sold is not fixed but depends on the level of the winning bid. To date, only a handful of papers have dealt with such auctions. Hansen (1988) is a pioneering contribution in this regard. Kaplan et al. (2002) has some interesting results on all pay auctions with variable rewards. Other papers include Back and Zender (2001) and Lengwiler (1999) etc. However, these papers mostly deal with multi-unit auctions. Recently, in an interesting paper, Deck and Wilson (2007) study auctions in which revenue is fixed but quantity is determined by the auction mechanism.

Our exercise is based on a framework provided by Hansen (1988), who develops a two seller procurement auction model with a downward sloping demand curve $q\ (p)$. In such an auction, Hansen (1988) derives the following main results. (i) The second price auction (SPA) yields a higher expected price than the first price auction (FPA). (ii) The expected quantity sold is higher with FPA. (iii) The expected consumer surplus is higher with FPA. Conventional wisdom suggests that this is why most procurements take the form of FPA.[2]

We argue that in most procurements with fixed budgets, what really matters to the organisation is the expected quantity purchased. For example, in India, in most cases universities are given a fixed amount of money each year to buy certain specified objects.[3] The university is legally bound to ask for quotations and buy it from the firm quoting the lowest price. The money allotted for buying certain specified objects *cannot* be used for buying anything else and has to be spent within the financial year. Often, grants come under very specific "heads". For example, grants for computer tables of certain size and quality can be used to buy computer tables of that size and quality only. This money cannot be used to buy even a related product (like tables of a different size). It is in the university's interest to spend the entire sum allotted to it; because if it does not, then the unspent money goes back. Additionally, the following year's grants are going to be curtailed if the present year's funds are not utilised fully. This is an extremely common scenario in India. In such cases, the university should not worry about the price or total surplus but should be only concerned about the total quantity bought. Given a sum of money, which has to be spent within the stipulated time to buy certain specified objects, the university should concentrate on maximising the total amount purchased.

This scenario is true not only for universities in India, but also for many other institutions. For example, it is often the case that a firm requests bids from potential suppliers of services or commodities, but is constrained with respect to the amount of money it can spend on it. In many private entities, middle level managers may control a budget for certain expenses and are not allowed to transfer funds to other uses.[4]

In this paper we try to analyse such procurements with a fixed budget.[5] By closely following Hansen (1988) we first prove that the expected price in the FPA is lower than the expected price in the SPA. In the SIPV auction model (with risk neutral bidders) where one fixed item is up for sale, the expected price at which the goods are sold is same across FPA and SPA (the revenue equivalence theorem). In procurement auctions with fixed budget, which is an auction with variable quantity, this equivalence does not hold. It may be noted that in fixed-quantity auctions the expected revenue is the same as expected price. For auctions with variable quantity, expected revenue is *not* the same as expected price. In our model the expected revenue is always A, the fixed budget allotted to the organisation.

While procurement auctions with fixed budgets are auctions with variable quantity, there is a link with fixed quantity auctions as well. It may be noted that the profit function of the firms is *concave in price* and hence the firms *exhibit risk aversion in price*. That is, the firms would strictly prefer profit evaluated at the expected price to profit multiplied by the probability of winning the contract (see Spulber (1995)). Therefore, it may be argued that, like fixed quantity auctions with risk averse bidders, when firms bid in prices in a low bid procurement auction, the expected price is lower with FPA as compared with SPA (also see Krishna (2002, pp. 38–40)).

Next we prove a strong result that in such procurements with fixed budgets the expected quantity bought is exactly the same under FPA and SPA. It does not matter which type of auction is being used. We call this the "quantity equivalence theorem".

[2] In this connection see Milgrom, (1989; 2004, pp. 135–137), who provides an elegant discussion of the Hansen results. Klemperer (2004, pp. 31) and Burguet (2000, pp. 39–40) also provide a nice exposition.

[3] The funds are mainly allotted annually either by the ministry of Human Resource Development or the University Grants Commission, the apex body of all universities in India. The grants could be for computers, office stationery, maintenance work etc. The allotted funds are not fungible.

[4] A different example of a fixed budget auction is the 2002 UK auction for emissions reduction. The UK government had committed about 215 million pounds and wanted to get as many tonnes of CO2 emission as possible out of it.

[5] Che and Gale (1998) analyse bidders' behaviour with budget constraints in standard SIPV auctions.