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Determining the optimal length of regulatory guarantee: A Length-of-Contract Auction

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Abstract
One of the biggest challenges in the area of infrastructure investment is the provision of funding to finance activities. This paper presents an auction design which can reduce the financing cost of infrastructure investments by allowing the length of the regulatory funding period to be determined via an auction. The auction allows bidders to submit bids against a payment for periods of varying length. Thus instead of, for example, a fixed 20-year contract period, some bidders might want to bid for financing over a longer period, say 25 or 30 years. This can be desirable in terms of securing more favourable terms in the financial markets. Our auction design can secure efficiency and lower financing costs. Our auction is motivated by the auctions currently being undertaken by the UK energy regulator (Ofgem) for financing offshore transmission assets. Although the auction was designed with electricity transmission in mind, the auction could be used in other areas of infrastructure investments (JEL: D44, D86, E43).

1. Introduction

Governments have increasingly turned to the private sector to provide infrastructure services in road, railway, energy and water: sectors that were once delivered by the public sector. The private sector's involvement has become attractive to governments as a mechanism for delivering infrastructure investment since it can be a tool to stimulate

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innovation and competition and importantly, allows private finance to replace government spending.

A wide spectrum of models has emerged in how to involve the private sector in infrastructure investment. The public-private partnership (PPP) models or competitive tender processes (hereafter, tenders) are used to own and operate the assets. In the later model, the government defines and grants rights to a private company to build and/or operate a service for a fixed period of time. Typical contract periods range from 5 to 50 years. For the duration of the contract, the private company provides the service in exchange for government transfers that compensate for upfront investments and other costs. Auctions have successfully been applied in the awarding of these contracts. Highway construction and the allocation of transmission assets linking offshore wind farms to the onshore grid in the UK (Engel et al., 1997; Ofgem, 2009a) are two examples of how tenders work. For example, in 2009, the first round of tenders for offshore transmission licences was launched by the energy regulator, Ofgem. The participants competed through a tender process in order to secure licensees to own and operate transmission assets. The participants submitted bids in terms of the costs to own and operate the assets. The contracts were for 20 years of inflation-indexed annual payments. The winners were those bidding the lowest cost, i.e. the lowest net present value, valued at the regulator’s discount rate. Bidders competed for cheaper and more accessible financing options in order to purchase their initial assets and to operate the assets efficiently (Ofgem, 2011a). As of September 2013, the second and third round of tenders are in process and launch dates are set. Here too, bidders will be competing for contracts of 20-year periods.

1.1 Price and quantity bidding

A large infrastructure investment involves uncertainty for the auctioneer in how to value/price the assets. This issue can be resolved by letting the market itself value/price the assets simultaneously during the bidding. The auction literature refers to this as a double auction. In a double auction, the buyers and sellers submit prices simultaneously, and the items are bought/sold whenever a buyer and a seller call out the same price. Chatterjee and Samuelson (1983) consider an example of a double auction in which a single buyer and a single seller trade 0 or 1 unit of a good. The buyer submits a price b and the seller a price s. If $s \leq b$, the buyer and the seller trade the good. Since both players have an incentive to misreport their true value, there is a risk that efficiency will not be achieved. Wilson (1985) analyses the double auction in a multi-buyer/multi-seller setting in which each player can trade at most one good, as in Chatterjee and Samuelson (1983). Compared to Chatterjee and Samuelson (1983) and with sufficiently many buyers, the Wilson (1985) auction is efficient.

Infrastructure investments call for financial institutions that are willing to provide funding to finance the activities. An important challenge is to provide funding to finance large infrastructures. A financially similar problem appeared in the banking system in 2007 where the Bank of England urgently needed to supply liquidity to banks (bidders). The Product-Mix Auction was designed for the Bank of England (auctioneer) in response to this crisis (Klemperer, 2010). Interestingly, the Product-Mix Auction is designed in a way where the auctioneer asks the bidders to submit bids on both prices and quantities.

1.2 The Product-Mix Auction

The Product-Mix Auction is a multiunit simultaneous sealed-bid, one round auction design, where each bid contains a set of mutually exclusive offers. Besides bids on price and quantity, the auction allows bidders to bid on multiple differentiated products, that is, product varieties such as a loan secured against strong or/and against weak collateral, that are subject to an overall supply constraint (the amount of money the auctioneer wants to lend out). The bidders can make multiple bids, both across and within product varieties. Each bid specifies the price (interest rate) and quantity (amount of money that a bidder wants to borrow from the auctioneer) for a specific product variety. In allocating the objects for sale, the auctioneer considers all the bids and chooses a cut-off price per unit of each product variety below (and equal) which bids are rejected. Hence, all bids that exceed the cut-off price for each variety are accepted, but, at most one offer from each bid, i.e. the price with strong collateral or the price with weak collateral, is accepted. If more than one of the price-offers in any bid exceed the cut-off price for the corresponding variety, the auctioneer accepts the offer that maximizes the bidder's surplus. The pricing method used is uniform pricing, that is, all accepted offers for a variety pay the same (uniform) price for that variety. The Product-Mix Auction has been deemed to be a success in the Bank of England's repo auctions (Fisher et al., 2011).

Following Klemperer (2010), the Product-Mix Auction has key strengths. It provides a greater efficiency, revenue, information, and trade than running multiple separate auctions. It is simpler and less prone to collusion than alternative auction designs, such as the Simultaneous Multiple Round Auction (SMRA; Ausubel and Cramton, 2011).

1.3 Our Length-of-Contract Auction idea

The present paper introduces an auction design which invites bids for financing costs with different regulatory guarantee periods, for example, a period of 20, 25 and/or 30 years[2]. Our design makes it possible for the market itself to reveal the desired guarantee periods for different loan opportunities. Hence, the idea is to allow the market itself so as to offer lower financing costs in return for a longer regulatory guarantee period. Importantly, we have used the idea from the Product-Mix Auction in which the bidders submit bids on price, quantity and "varieties", but where varieties in our case represent different regulatory guarantee periods. Further, we use the idea about the surplus (though in our case, it is the difference between the lowest bid and the second lowest bid) where

[2] Periods different from 20, 25 or 30 years can also be considered. The auctioneer decides the length of contracts to be offered in the auction. The choice depends on the infrastructure investment. In this paper we will focus on a specific investment profile of 20, 25 and 30 years which are the contract periods that a bidder can submit bids on and where the annual financing costs are decreasing with a longer contract period. However, the auction can be applied for different investment profiles,, including non-linear profiles. NPV minimisation is clearly limited by financing constraints on the part of consumers thus there may be a minimum financing period which sufficiently moderates the impact on consumer bills while being acceptably long for an auctioneer and an investor. Therefore, the 20 years can be seen as the minimum contract length defined by consumer willingness to pay and the 30 years as the limit year of contracts defined by regulatory unwillingness to make long dated commitments to private parties.

the chosen length of contract is the offer that gives the bidder the greatest surplus. We contribute to the literature by extending the Product-Mix Auction to infrastructure investments, by the use of the second-price rule instead of uniform pricing, and through our method of determining the cut-off prices. It is to be noted that since our auction and the Product-Mix Auction share the same basic form, they share the same advantages.

We contribute to the literature through our introduction of a method where the auctioneer does not choose the cut-off prices. This is in contrast to the Product-Mix Auction where it is the auctioneer who decides which bidders get the loan of funds by the chosen cut-off prices. The same problem appears if the auction design is used in areas with strong complementarities among the objects for sale and the bidders bid to gain from synergies. The auctioneer then is the one that decides who should benefit from these synergies. In our auction, it is the market itself that decides the cut-off prices (the cut-off financing costs in our case) through the lowest and second lowest financing cost. Therefore, when compared to the Product-Mix Auction, the leading price in our auction to determine the cut-off prices and the payments is the second lowest price (i.e. financing cost).

We show that a sealed-bid auction design for differentiated products, which we call the Length-of-Contract Auction, could provide greater financial support in the area of infrastructure investments. The idea is to allow the market itself to offer lower financing costs in return for a longer regulatory guarantee period.

This paper is organized as follows. In section 2, we introduce the area for public infrastructure investments. We highlight the financial challenges in the area and motivate why an auction design could be useful to make financial support more interesting in the market for infrastructure investments. Our Length-of-Contract Auction is presented in section 3. Section 4 contains the conclusion.

2. **Infrastructure investments and transfer value**

Infrastructure investments are calling for financial institutions that are willing to provide funding to finance the activities. This is a challenge for many infrastructure investments, even though the investments are of interest for an investor. One example is the area for offshore electricity transmission, where the UK might be investing as much as up to £30bn in the period to 2030 (DECC, 2011). According to Lloyds Bank, the key issue for lenders is the risk profile (Ofgem, 2012, page 43). Despite the fact that offshore transmission is a relatively low risk asset, securing long-term debt on favourable terms is still an issue (Ofgem, 2012).

The key feature of an infrastructure tendering process is the long term nature of contracts, 20 years for example, between the auctioneer and a private company. In offshore transmission, a successful bidder will receive a transmission licence and entitlement to an associated 20-year transfer value in return for purchasing the transmission assets from an offshore wind developer and operating them in accordance with the obligations of the licence.

In order to make infrastructure investments more interesting in terms of providing capital to finance activities, a solution is to let the length of the regulatory funding period be determined via an auction. A longer period, say 25 or 30 years, may be desirable in terms of lending since a longer tender period gives the financial institutions the security of a long term secured revenue arrangement. A longer tender period means lower repayment per-unit debt in states and therefore, lowers probability of default. Hence, a longer tender period should result in a lower interest rate.

The possibility for the bidders to submit bids against a financing cost beyond, for example, a 20-year period can be secured through an auction design where bidders are bidding for a financing cost with different contract periods. Our auction design is presented in the next section.

3. The Length-of-Contract Auction

In this section, we present an auction design, called the Length-of-Contract Auction, which could provide greater financial support in the area of infrastructure investments. We present an auction design which invites bids for financing costs with different regulatory guarantee periods, of say 20, 25 and/or 30 years. The rules of the auction are as follows:

Table 1. Rules of the auction

1	Each bidder can make multiple bids where each bid specifies an object and a Net Present transfer value (hereafter, NPV) for a specific length of contract.
2	The auctioneer chooses the lowest financing cost and the second lowest financing cost.
3	The lowest financing cost is the winning bid and the second lowest financing cost is the cut-off financing cost.
4	The length of contract to offer a winning bidder will be the offer that maximizes the winning bidder's surplus.

The auction is illustrated by the following example. Imagine that a bidder can submit bids on a number of objects for sale which in sum is equal to the total infrastructure investment being auctioned. One example could be a number of offshore transmission links in an area of sea. For simplicity, assume that the objects are sold in the context of a single-object auction[3].

Table 2 shows hypothetical bids from four bidders. Bidder 1 submits bids on objects (lots) A, B and C, for each object offers a contract period of 20, 25 and 30 years and a bid amount for each contract period. Bidder 2 submits bids on object B, bidder 3 on objects A and C and bidder 4 on object C. Hence, one bidder might make three separate bids to win: a contract to build an object secured with a financing cost over 20 years, with a financing cost over 25 years, and with a financing cost over 30 years. The quantity in our design is the object financing requirement. The price in our design is the financing cost calculated over the period in terms of the NPV evaluated at the auctioneer's discount rate.

[3] The example can be extended to more complex situations, including package bidding.

Table 2. Submitted bids

Bidder	Bid number	Object	Length of contract (years)	Bid amount (NPV)
1	1	A	20	$338m
		A	25	$326m
		A	30	$313m
	2	B	20	$249m
		B	25	$236m
		B	30	$235m
	3	C	20	$78m
		C	25	$77m
		C	30	$76m
2	1	B	20	$215m
		B	25	$207m
		B	30	$200m
3	1	A	20	$387m
		A	25	$383m
		A	30	$357m
	2	C	20	$67m
		C	25	$66m
		C	30	$64m
4	1	C	20	$94m
		C	25	$93m
		C	30	$91m

An interesting feature of our auction is the use of NPV. From Table 2, one can see that a longer contract period means lower NPV. This is an assumption in our auction. We assume that a longer contract period means lower annual repayment per-unit debt, and therefore a lower probability of default, and the ability to get lower interest rates when borrowing money from a bank which, when evaluated at the auctioneer's (higher) discount rate, lowers NPV.

In the Klemperer (2010) Product-Mix Auction, the auctioneer counts up the numbers of bids with the offered highest borrowing interest rate until the sum reaches the amount of money the auctioneer wants to lend out. The winning bids are those bids which offer the highest interest rate. The product in the Product-Mix Auction is money, whereas in our auction it is the separate objects marked A, B and C in the present example. This means that the auctioneer cannot sell an object twice. This is different from the Product-Mix Auction where money is just money. We also use the second-price rule, and so evaluate the bids by taking in two bids for each object. In our auction, the lowest financing cost is the winning bid and the second lowest financing cost represents the cut-off financing cost and therefore, the financing cost that the winning bidder will receive to finance the desired object.

Following our example, after receiving all the bids, the auctioneer chooses the lowest financing cost and the second lowest financing cost. Assume that the auctioneer has a maximum total financing cost of $750m. From Table 2, we can see that the lowest and the second lowest financing cost for object A is $338m and $387m respectively, for object B it is $215m and $249m, and for object C it is $67m and $78m. These are summarized in Table 3.

Table 3. Lowest financing cost and second lowest financing cost

Object	**Winning bidder**	**Bid amount (NPV, lowest financing cost)**	**Bid amount (NPV, second lowest financing cost)**
A	1	$338m	$387m
B	2	$215m	$249m
C	3	$67m	$78m
Total		**$620m**	**$714m**

Table 3 shows that bidder 1 is the winner of object A. The winners of object B and C are bidders 2 and 3 respectively.

It is clear that the winning bids and the cut-off financing costs are determined by the market itself. Given our example, the auctioneer allows for a total financing cost of $750m which is above the second lowest financing cost of $714m for financing the objects. First, this means in our example that all three objects will be sold. Second, the auctioneer can determine the cut-off financing cost for each object for each length of contract. Table 4 shows the cut-off financing costs for our example.

Table 4. Cut-off financing cost for every length of contracts

Object	**Length of contract (years)**	**Cut-off financing cost**
A	20	$387m
	25	$383m
	30	$357m
B	20	$249m
	25	$236m
	30	$235m
C	20	$78m
	25	$77m
	30	$76m

In order to determine which length of contract to offer the winning bidders, the auctioneer accepts the offer that maximizes the winning bidders' surplus. For example, the cut-off financing costs for object A for each length of contract are $387m, $383m and $357m respectively. Bidder 1 submitted a bid of $338m, $326m and $313m respectively. This corresponds to a surplus of $49m, $57m and $44m respectively. Following the rule of our auction, the auctioneer accepts the offer that gives the bidder the greatest surplus meaning, for example, that bidder 1 is the winning bidder of object A and will be offered a contract of 25 years and is allowed to build the object for $383m. Table 5 shows the surplus calculations.

Table 5. Surplus

Object	**Winning bidder**	**Length of contract (years)**	**Cut-off financing cost**	**Winning bidder's submitted bid**	**Surplus** (column 5-4)
A	1	20	$387m	$338m	$49m
		25	$383m	$326m	$**57m**
		30	$357m	$313m	$44m
B	2	20	$249m	$215m	$34m
		25	$236m	$207m	$29m
		30	$235m	$200m	$**35m**
C	3	20	$78m	$67m	$11m
		25	$77m	$66m	$11m
		30	$76m	$64m	$**12m**

Besides bidder 1, bidder 2 wins object B on a 30-year contract and is allowed to build the object for $235m. Bidder 3 wins object C on a 30-year contract and is allowed to build the object for $76m. Table 6 summarizes the result of the auction.

Table 6. Winning bidders and allowed financing cost

Winning bidder	**Object won**	**Length of contract (years)**	**Financing cost**
1	A	25	$383m
2	B	30	$235m
3	C	30	$76m
Total			**$694m**

The auction has the same advantages as the Product-Mix Auction, since it has the same basic form. However, our cut-off prices are directly connected to the second-price rule where the second lowest financing cost is the cut-off financing cost. In the Product-Mix Auction, the auctioneer is the one who decides which bidders get the loan of funds by the chosen cut-off prices. Additionally, if the auction design is used in areas where the objects for sale have complementarities and the bidders bid to gain from synergies the auctioneer is then the one who decides which bidders should benefit from these synergies. The starting point when choosing the cut-off prices in the Product-Mix Auction is the amount of money the auctioneer wants to lend out. The starting point of our auction is when the auctioneer wants to secure a lowest and a second lowest financing cost. Interestingly, in our auction it is the market itself that decides the cut-off prices, and therefore, who wins and gains from synergies, whereas it is the auctioneer who decides in the Product-Mix Auction. This statement appeals to the assumption that the auctioneer in the Product-Mix Auction does not reveal any information before the auction starts. Hence, the auctioneer can change supply curve and therefore, cut-off prices. In our auction, the total financing cost (the $750m in our example) will be publicly known before the start of the auction. This implies that (1) the likelihood of unsold lots is reduced, and (2) since the total financing cost is known the market itself determines the cut-off prices. Our use of the second-price rule ensures that bidders submit bids which reflect their true preferences. In spite of a publicly known total financing cost, the market itself through competition and truthful bidding determines the cut-off financing costs. Overall, our auction design secures efficiency and may even secure the optimal contract.

Our auction allows different length-of-contracts to be offered, up to whatever number the auctioneer thinks is appropriate for auctioning the objects. In our example, contract periods of 35 or 40 years could also be available. Our model can handle this too, but all the possible lengths of contracts must be specified in advance and more options may reduce direct competition and hence, raise transfer values.

One might ask whether our auction is feasible, not to mention how the auctioneer's supply curve is constructed? Also, do we have a discount rate, so the auctioneer can evaluate the bids/compare bids or compare different packages of lots? It is common for public sector auctioneers to evaluate and publish a discount rate, usually named social discount rate (SDR), in order to measure the costs and benefits of different projects. For example, in the first round of tenders for offshore transmission, Ofgem uses a number around 4.25% (2009b). Thus, the auctioneer can evaluate the bids using the NPV with an appropriate social discount rate[4].

4. Conclusion

This paper presents an auction design, the Length-of-Contract Auction, which could make infrastructure investments more interesting in terms of providing capital to finance activities. The idea is to allow the market itself to offer lower financing costs in return for a longer regulatory guarantee period. Our auction addresses an important drawback in the literature because it lets the market itself choose the prices (in our case the financing costs). This means that the auctioneer in principle does not need to have information about the length of financing costs, but can let the market itself decide the quantity they want and the corresponding financing cost.

On the company side, a longer tender period may be attractive to the financial market due to the missing market for long term financial assets (Ofgem, 2009a) and less exposure to market and regulatory risk at end of the financing period. From the point of view of the auctioneer, a longer guarantee is less attractive since it decreases the flow of new participants in the market. However, the auction design, including potential competition, secures efficiency and lower financing costs.

[4] As an example, the UK uses the so called ***Green Book: Appraisal and Evaluation in Central Government*** produced by HM Treasury to measure the costs and benefits of a project.

In the above example, bidders submitted separate bids on infrastructure investments available in the auction. The example could be extended in various ways, including package bidding on the underlying objects for sale, we shall do this in future work.

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