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Thomas Greve and Michael G. Pollitt

CWPE 1245 & EPRG 1221

EPRG WORKING PAPER

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JEL Classification D44, L94

Contact tg336@cam.ac.uk
Publication October, 2012
Financial Support EPSRC, Autonomic Power Grand Challenge

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October 2012

Abstract

The UK has ambitious plans for exploiting offshore wind for electricity production in order to meet its challenging target under the EU Renewable Energy Directive. This could involve investing up to £20bn in transmission assets to bring electricity ashore. An investment of this magnitude calls for an efficient mechanism to determine which projects get financed and ensuring that only those projects that are selected can be delivered at least costs to consumers. The electricity regulator's ongoing tender auctions are likely to work well for point-to-point transmission and for networks already built. However, it is still unclear what kinds of models could be considered for complex meshed offshore networks where licences are granted not only to own and operate, but also to build a transmission network. This paper provides an extensive survey on the current theory and experience of auctions. The main objective is to discuss the design of auctions for transmission assets in which bidding for packages of transmission assets is a possibility.

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[1] The authors wish to thank Ofgem for sharing their valuable insights into the subject. They acknowledge the financial support of the EPSRC Autonomic Power Project. They also thank Marta Rocha and Mallika Chawla as well as an anonymous reviewer for their thoughtful comments. The opinions in this paper reflect those of the authors alone and do not necessarily reflect those of any other individual or organisation.

1. Introduction

Offshore generation has a critical role to play in delivering renewable energy targets and securing UK's future supply needs (and potentially other countries which have suitable offshore resources). Such generation requires offshore transmission assets to be put in place in order to connect offshore wind parks to the onshore electricity grid.

In March 2007, the government decided to license offshore electricity transmission and licenses were granted to build, own and operate offshore transmission assets. The aim was to secure cheap and timely grid connections, encourage innovation, and enable new entrants to compete in the market while remaining focused on generator's requirements (Ofgem, 2008). All this while maintaining the vertical separation between transmission and generation as envisaged by the 2009 EU Electricity Directive (DECC, 2010).

In July 2009, Ofgem launched the first round of competitive tenders for offshore electricity transmission owners (OFTO) to own and operate links that have been, or are currently being, constructed by the developers of the relevant offshore wind generation projects. Nine transmission projects of the following nature were auctioned. Ofgem defines the transfer value of the transmission asset being auctioned. This has to be paid to the generator who built the transmission asset by the winner of the OFTO license. OFTO bidders then bid for a guaranteed inflation indexed 20-year revenue stream which they would require to own and operate the transmission link at a target level of availability. The winning bidder is the one who bids the lowest net present value revenue stream or tender revenue stream (TRS). Bidders compete on their ability to obtain cheaper financing (to make the initial asset purchase) and to operate these assets efficiently (Ofgem, 2011b). As of August, 2012 these first nine projects were at the preferred bidder stage and were moving towards financial closure.

According to the government statement in 2007, the competitive tender rounds do not involve licences to build as well as own and operate the transmission links. Nor do the tender rounds allow for the possibility to bid on a group of projects (i.e. to submit a 'package' bid). Such package bidding is a common feature of auctions, however is this feasible for auctioning transmission assets?

Package auctions are in use. Governments and institutions use package auctions to sell spectrum licenses for mobile-phone (Ofcom, 2008), long-term repo operations in the financial sector (Fisher et al., 2011) or to award contracts to service bus routes (Cantillion and Pesendorfer, 2004). However, the use of package auctions in the market for energy transmission is under-explored. Countries like Argentina and Brazil use auctions for energy transmission, but these auctions are all connected to a single object auctions (Littlechild and Skerk, 2004; Power Advisory, 2010). It is interesting to see how these examples suggest that it is possible to finance a large transmission grid through the use of auctions.

Argentina began a major energy reform in 1992. A part of the reform was the so-called Public Contest method which can be used when the country enacts the major expansions of the electricity transmission system. Under this mechanism a maximum value to the electrical system was put on a major transmission link. This formed the cap price level in an auction. The object for sale was a contract for building, operating and maintaining a given transmission system link. One link was up for auction at a time and so, there was no allowance for package bidding. If the winning (the least cost) bid was less than the reservation price then the bidder would be awarded a contract to build the transmission link.

The reform is regarded as a success (Littlechild and Skerk, 2004), and the bidding process worked well, especially in bringing down the construction costs (Littlechild, 2007). Examining the bidding process, it was found that the auction lowered costs and led to better use of the existing lines (Littlechild, 2007).

Brazil is another country which has used auctions for long-term contracts to construct, own and operate transmission facilities. This practice began in 1999 and was similar in set-up to the process used in Argentina. There is a consensus that these auctions were also a success (Woolf et al., 2010; Power Advisory LLC, 2010). Again, one link was up for auction at a time and hence, there was no scope for package bidding.

This paper seeks to build on the success of former auctions for transmission links, but it allows for package bidding and therefore, adds the possibility to gain from synergies between individual transmission links. Building on the experience in Argentina and Brazil, this paper investigates the possibility of using combinatorial and multidimensional auctions to design, build, own and operate different offshore transmission links, where building can involve a more meshed network. Our analysis contributes to the literature on auctions by highlighting the motivations and consequences of package bidding in the market for offshore transmission that formerly have not been pointed out in the auction context. This paper is the first in a series of two, where this one gives an overview of the literature in auction design and discusses its application to auctioning offshore transmission networks. The second paper of the series (Greve and Pollitt, 2012) examines the potential design of auctions and provides design suggestions to solve common auction problems that might arise in Ofgem's auction process. Specifically, the second paper examines a potential design of an auction where bidders might propose different offshore network configurations.

The literature is based on four basic types of auctions: the English auction, the Dutch auction, the first-price sealed-bid auction and the second-price sealed-bid auction. In this paper, the focus will be on a number of variations where there is a possibility of bidding on packages of auction lots (i.e. groups of items for individual sale in the auction). In particular, two auction formats will be discussed – the package clock auction (Ausubel and Cramton, 2011a) and Klemperer's "Product-Mix Auction" (Klemperer, 2010). Our focus is on the use of procurement auctions to procure services most cheaply, rather than the use of conventional use of auctions to sell objects at the highest price.

Our findings suggest that the package clock auction is well-suited for auctioning offshore transmission. Experience from the UK 3G spectrum auction shows that the package clock auction (Cramton, 2008) is strong in allocating the objects/packages to those who value them the most. The clock rounds induce price discovery, therefore, reduce winner's curse and induce efficiency. The "best-and-final" round can attract entry and prevent collusion. Further, this paper shows that the "Product-Mix Auction" could be used to secure cheaper financing by allowing the length of the regulatory funding period to be determined via a competitive auction. Multiple factors can be allowed in a package clock auction. If nonmonetary factors (such as the size of a given transmission link, the timeliness of the building process and the quality of service delivery to consumers) are to be part of the bids, a two-phase multiple factor auction can be used. The first phase can evaluate the nonmonetary factors while the second phase can be the chosen price-only auction format.

This paper is organized as follows. Section 2 introduces the auction used in the first-round tender process. Section 3 discusses the basic procurement auction theory. Section 4 discusses multi-unit auctions, including combinatorial auctions. Section 5 compares the different types of multiple factor auctions. Guidelines for a good auction design are discussed in section 6. Section 7 applies the guidelines to offshore transmission auctions. Section 8 makes suggestions for further development.

Throughout this paper, we use the term “object” to define the product that is going to be sold. In our case, the object being auctioned is an offshore transmission link. We use the term “lot” as an auction term used for an object for sale or “lots” for more than one object for sale. In this paper an object / lot is one transmission link.

2. The first-round tender process

The auction model used in the tender process is based on multiple stages of the following form (Ofgem, 2009a):

1. Pre-qualification
2. Qualification to tender
3. Invitation to tender
4. Best-and-final offer
5. Preferred bidders
6. Successful bidder to whom a license would be granted

The pre-qualification stage is open to all and is the stage where the applicants are required to demonstrate through a pre-qualification questionnaire that they meet the criteria of a qualifying applicant.

The qualification to tender is the stage where qualified bidders are shortlisted in connection to specified projects. As in the pre-qualification stage, the applicants must complete a questionnaire, but here the questionnaire is specific to the projects for which they wish to be invited to bid for. Hereafter, Ofgem evaluates and scores the qualifying applicant's submissions on a per qualifying project basis. The criteria for the evaluation and the weighting are specified in the tender document, and the submissions are scored against the criteria. Given the submissions, each bidder will after the qualification to tender stage be shortlisted for one or more projects.

Invitation to tender is the first bidding stage. A qualified bidder can submit bids for more than one project, subject to being shortlisted for more than one project. In these instances, separate bids are submitted on a project-by-project basis. The auction format is a sealed-bid.

The best-and-final offer stage is used if it is not possible to clearly identify a preferred bidder. If this is the case, Ofgem has a reserved right to ask a small number of bidders to submit their best-and-final offer before making its final selection. This stage is not mandatory and will only be applied if considered necessary by Ofgem. The best-and-final offer stage uses, like the invitation to tender stage, a sealed-bid auction format.

In the last two stages, Ofgem will announce the preferred bidders and winners for each qualifying project.

In May 2011, Ofgem (2011a) announced that all nine projects have a preferred bidder. Six consortia (Ofgem, 2009b) were shortlisted to bid for the right to own and operate the nine offshore transmission links in return for a 20-year regulated revenue stream, and four were appointed preferred bidders. None of the preferred bidders were existing transmission system operators in the UK (Ofgem, 2011a).

The result of the auction was that there was around £4 billion of investment appetite for the nine links worth around £1.1 billion. Ofgem considered the auction a success, and further stating that this auction delivered “forecast savings of £350 million compared to equivalent onshore transmission costs” (Ofgem, 2010, p.1).

Power Advisory LLC (2010) examined the first-round tender process. It pointed out that one critical point for a tender process was to ensure sufficient coordination between the offshore generation project developers, the prospective bidders, and the National Electric Transmission System Operator (NETSO, owned by National Grid) in order to connect and operate the links most efficiently in accordance with the existing transmission grid. Power Advisory LLC stated that the tender process complied with this through the transfer from Ofgem to the generation developers, at a price that reflects the economic and efficient costs of developing the assets, and through the 20-year revenue stream in return for purchasing the transmission assets.

Power Advisory LLC outlined the selection of the shortlisted bidders as another critical issue. It stated that the purchase price offered should have been the primary consideration in selecting the asset buyer, and that Ofgem may put more weight on the tender revenue stream in future tenders. This implies that some of the shortlisted bidders were not among the lowest cost bids.

Ofgem commenced a second-round tender process for six additional offshore transmission links in November 2010 (Ofgem, 2011b).

3. Basic procurement auction theory

This section provides a brief overview of the main concepts and results of auction theory. Although the application we have in mind involves applying the basic theory to the procurement of services/assets at least cost, most auction theories are defined in terms of maximising the value of the objects being auctioned. The basic mechanisms for allocating lots within both procurement or sales auctions are the same (even though the price dynamics are different – lowest price bid wins in a procurement auction versus highest price bid wins in a conventional auction). Although the auctions considered in this paper are complex, there are several similarities to the basic auction models. This section follows the work of Vickrey (1961), McAfee and McMillan (1987) and Klemperer (1999). We will apply auction theory specifically to offshore transmission in subsequent sections.

There are four basic types of procurement auction (reversing the conventional price dynamics) models:

1. The English auction or the descending price auction is an open auction format where the auctioneer announces a high opening price and bidders compete against one another with each subsequent bid lower than the previous bid. The bidder with the lowest bid supplies the object at that price.

2. The Dutch auction or the ascending price auction is also an open auction format, but compared to the English auction, here the auctioneer announces a low opening price which is increased until a bidder offers to supply the object. The winning bidder receives the last announced price.

3. The first-price sealed-bid auction is a close auction format where all bidders submit a sealed bid. The bidder with the lowest bid supplies the object and receives the price it submitted.

4. The second-price sealed-bid auction, also known as the Vickrey auction, is identical to the first-price sealed-bid auction except that the winning bidder receives the second lowest bid rather than its own bid.

When literature discusses the right auction design, typically, the goal is to secure an optimal auction or an efficient auction, i.e., minimize cost or ensure that the auction allocates the object to the bidder that values the object the most (or can supply it most cheaply). These goals can be complementary, but are often not. The right auction can be optimal and/or efficient in one environment and fail to be so in another environment. Hence, the choice of auction format is crucial. In a single fixed price procurement auction setting, a descending price auction is for example more likely to achieve efficiency than a sealed-bid auction. This is because a lower cost bidder can price the bid after seeing its rival's bids. This is generally not the case in a sealed-bid auction where bidders cannot revise their enclosed bids, and where a higher cost bidder can win the auction.

When designing an auction, it is critical to have a good understanding of the underlying environment and of the preferences as well as the possible reactions of the auctioneer and the bidders. Klemperer (2002a, pp. 170-175) proposes some guidelines for designing a good auction. According to Klemperer, the most important considerations in auction design are to:

- Attract entry
- Prevent collusion
- Prevent predatory behaviour

Attracting entry is essential in an auction. An open auction is particularly vulnerable to insufficient entry because a stronger bidder can always bid below any bid a weaker bidder makes. A weaker bidder knows this and may not enter at all which allows the stronger bidder to win the auction at a high price. Gilbert and Klemperer (2000) show that it is profitable for an auctioneer to accept some inefficiency for the sake of entry. This model was demonstrated for asymmetric bidders where bidders submit bids according to different distributions, i.e., bidders bid differently. Bulow and Klemperer (1996) conclude the same when bidders are symmetric. This result was demonstrated for conventional ascending price auctions. Using the same setting, they extend the conclusion to show that in a private-value auction, and in a wider class of common-value auction settings (the value of the item /package of items is similar for all bidders, but the bidders have different estimates about the underlying value), a conventional ascending price auction with no reserve price and N+1 symmetric bidders are worth more to the auctioneer than any auction with N bidders.

Klemperer (2002a) states a similar entry problem for other auction formats if the entry costs and the asymmetry between bidders are too high. Compared to the conventional ascending price auction, a sealed-bid auction can be more attractive to an auctioneer since the uncertainty around bids can attract bidders. Weaker bidders have a chance to win the auction and hence, more bidders may enter a sealed-bid auction.

Preventing collusion is also essential in an auction. Bidders can tacitly collude by dividing up the objects between them and avoid bidding down prices. Collusion can arise in different ways. It can be seen as a voluntary agreement between one or more bidders or as a threat to punish a bidder if it does not enter the agreement (Cramton and Schwartz, 2002).

Collusion is much easier in an open auction than in a sealed-bid auction where bidders cannot observe rivals' bids until the auction is over. Robinson (1985) shows that an agreement in a conventional second-price sealed-bid auction is easier to arrange than an agreement in a first-price sealed-bid auction. In a second-price sealed-bid auction, a bidder can submit a very low bid while the rest of the bidders bid very high. In a first-price sealed-bid auction the arrangement must be that the agreed winner submits a high bid while other bidders stay above this bid. However, if another bidder has the opportunity to win the auction, they have an incentive to cheat on the agreement with the agreed winner. Klemperer (2002a) states something similar by using a uniform-price auction.

A third issue to secure a good auction design is to *prevent predatory behaviour*. Predatory behaviour in a procurement auction is associated with preventing entry where a strong bidder publicly announces that any bid on a certain object from any rival will be underbid, or in other words - *stay out of the auction, because you do not have a chance winning the auction*. This behaviour can also be used to prevent future competition in future auctions or a rival's presence in a market (Bikhchandani, 1988; Klemperer, 2002b). Predatory behaviour is particularly easy in a open auction where bidders can follow their rivals' bids and strategies. The sealed-bid auction provides no opportunities to signalling during the auction, but the predatory behaviour can, as in the open auction, be exercised before the auction starts.

Ausubel and Cramton (2011a, 2011b and 2011c) analysed auction design closer to the energy market. In the context of auctions for tracts of sea-shelf with the right to install offshore wind turbines, they suggest the following three main principles for securing an effective auction:

- Enhance substitution
- Encourage price discovery
- Induce truthful bidding

This first concern is more connected to product design rather than auction design. *Enhancing substitution* involves the risk that the bidders cannot distinguish the lots from each other and therefore, cannot substitute across the lots being sold. Poor substitution arises when a bidder is unsure about the product being auctioned. A similar problem arises when an auctioneer fails to vary the lots or to make the bundling of the lots clear enough, so a bidder loses the benefit from complementarities. By enhancing substitution, the bidders can bid on their wanted configurations and maximize their value. Ausubel and Cramton (2011a) suggest that the auctioneer vary the size of lots and bundle the lots in order to promote identification by bidders of complementarities.

Encouraging price discovery is important when the auction is designed to help the bidders to discover what their wanted tracts are worth. If the auction is not designed to secure this, the bidders are unsure about the price of their bids and the configurations they wish to buy. Ausubel and Cramton (2011a) suggest that the auctioneer uses a dynamic auction process, so that the bidders can reduce the uncertainty in the value of the products being auctioned or what packages that are most relevant to bid on. This involves some revelation about other bidders' valuations as the process goes on.

Inducing truthful bidding is a classic objective in auction theory and the way to secure an equilibrium. By designing an auction which secures truthful bidding, the auction will allocate the lots to those who value them the most and therefore, secure efficiency. From the four basic types of auction models, the second-price sealed-bid auction is, by itself, the only auction format which secures truthful bidding. According to Ausubel and Cramton (2011a), truthful bidding is induced through an effective pricing rule and an activity rule. The activity rule limits what bids a bidder can make in subsequent rounds of a multiple round auction depending on the bidder's bids in earlier rounds, and so it can avoid bid sniping, i.e., last minute bidding.

In the next section, we will discuss the theory more in the context of the energy market and the literature connected to energy transmission.

4. Multi-unit procurement auctions

The previous section introduced the basic auction formats which work well for sale of single objects. In this section we introduce the literature on multi-unit auctions. This literature focuses on maximising the sale value of objects (in a *conventional* auction), however we discuss how it can be applied to the procurement of services/assets at least cost. These are appropriate when bidding on packages. The section will, hereafter, discuss more concrete combinatorial auction formats and the literature on how to secure a good auction design.

A multi-unit auction is an auction in which several objects are sold. The timing, sequencing of different objects, rules and requirements become important elements for success when a seller chooses to sell several objects. Theory typically discusses sequential and simultaneous auctions as two important mechanisms for buying and selling multiple objects because both are closely connected to the efficiency and the optimality of an auction and hence, good auction design.

We know that bidders in a sequential auction can react to former information which influences the auctioneer's revenue and therefore, optimality. The literature on auctions usually concludes that sequential auctions more commonly entail a downward drift in prices (Klemperer, 2004).

The general message from the theory of multi-unit auctions is that it is very hard to achieve efficiency (Klemperer, 2004). We know that the conventional Vickrey auction in general is decision efficient, and this is also the case in a multi-unit setting, since the winner for sure is the bidder with the highest valuation, but other standard auctions are inefficient, even for sale of homogeneous goods (Ausubel, 2004; Ausubel and Cramton, 2002).

When multiple objects go for sale, the auctioneer has to decide whether to sell the objects separately in multiple auctions or jointly in a single auction. Bundling versus unbundling becomes an issue, where bundling involves the combination of multiple objects into one lot.

Klemperer (2005) emphasizes the advantages and disadvantages of bundling. Looking at the advantages, bundling can be desirable since it makes the contract larger, making it into a "must-win" object. This attracts more competitive bidding. Likewise, bundling can prevent collusion since it makes it impossible for bidders to divide the pie and hence, benefit from co-ordination. Also, bundling can reduce inefficiency if the objects for sale are complementary goods. It does so by removing the possibility that complementary goods are won by different bidders. Examining the disadvantages, one should have in mind that dividing a contract into pieces among multiple winners can attract weaker bidders and therefore induce inefficiency, but at the same time induce competition. Even without weaker bidders, bundling can still be inefficient if the "quantity discounts" mean that the object ends up in the hands of others than those who value them the most, but acquire them cheaply. Likewise, dividing a contract into pieces can create different markets which require the auctioneer to know the industry structure in advance and the possible consequences. This is because the market will be left to recombine the pieces/or indeed be prevented from recombining the pieces following the auction.

Combinatorial auctions

A commonly used multi-unit auction which allows for bundling is the combinatorial auction where bidders can place bids on combinations of objects (packages). In such an auction, the auctioneer can choose among the wider class of auction formats (e.g. first-price sealed-bid auction, descending price auction etc.).

A combinatorial auction can be an extremely efficient mechanism under the right conditions. If the bidders are well informed and can freely choose the most wanted combination of goods, allowing the bidders to fully express their preferences, this auction can lead to efficiency and lowest cost for the auctioneer. This would be the case where a regulator in charge of an auction knew the market much less than the firms.

An efficient package mechanism is the *Vickrey-Clarke-Groves (VCG) mechanism* - an extension of the Vickrey auction. In a VCG auction, bidders report their valuations for all packages. The winners of the auction are those for whom the maximum value of the auction is achieved. Each winner pays the opportunity cost of its winnings, i.e., the value if the objects were assigned to the next best use among the other bidders. Like the Vickrey auction, the VCG auction gives bidders an incentive to bid their true value. Neither the Vickrey auction nor the VCG auction is commonly used in practice.

Ausubel and Milgrom (2002) consider a more interesting auction format, the conventional *ascending proxy auction*, which is a close alternative to the Vickrey auction. The idea is that each bidder submits its valuation information of the lots in the auction to a proxy agent which iteratively bids on the most profitable package. The auction ends when no proxy agent has a profitable bid. The ascending proxy auction yields the same outcome as the Vickrey auction. In a procurement context this would involve a descending proxy auction.

Closely related to the above is the *clock-proxy auction* proposed by Ausubel, Cramton and Milgrom (Cramton et al., 2006). The model consists of two phases, a simultaneous multiple round clock phase and a last-and-final proxy round. In the clock phase, the auctioneer sets the price for each object. Bidders respond with quantities desired at the specified prices. If there is an excess demand after a round, prices are increased (or decreased in the context of procurement). This process continues until there is no excess demand for any objects. In the last-and-final proxy round, each agent sends their values to a proxy agent which bids straightforwardly to maximize profits. Besides the use of a proxy agent, the proxy phase differs from the clock phase in terms of announced prices. In the last-and-final proxy round only packages are priced and the prices may be bidder-specific. The clock rounds are used to promote price discovery. The proxy round secures efficiency. Cramton et al. (2006) state that the clock-proxy auction has some advantages over the simultaneous ascending auction in which it has no exposure problem (the risk of winning only some lots, but not all wanted lots), no incentives to decrease demand and it reduces collusion.

A variant of the clock-proxy auction is the *Anglo-Dutch auction* where the first stage is run as a conventional ascending auction until two bidders remain (this can be run as a descending price procurement auction). The second stage is run as a one round best-and-final sealed-bid auction. The winner pays its bids for the lot (Klemperer, 2002a).

The Anglo-Dutch auction, like the clock-proxy auction, captures the advantages of attracting entry and reducing collusion by having the sealed-bid stage. Likewise, it has the benefits from the ascending auction in which the objects for sale end up in the hands of those who value them the most, and raise revenue (or lower cost in the context of procurement). This goes for a single sale and package sale.

Ausubel and Cramton (2011a) and Ausubel and Cramton (2011c) discuss combinatorial auctions for auctioning offshore sea shelf for wind generation. They discuss the following three categories of auctions:

1. Sealed-bid auction
2. Simultaneous multiple round auction (SMRA)
3. Clock auction

Sealed-bid auction

This auction format can be used for package bids. Ausubel and Cramton (2011c) do make the sealed-bid auction an option for auctioning sea shelf. However, they point out that when bidders have difficulty in valuing the objects for sale, and the lots have strong complementarities, the sealed-bid auction is less attractive. Ausubel and Cramton (2011c) do not even suggest the sealed-bid auction for a single lot sale because of the bidders' difficulty in valuing the objects and the fact that they cannot rely on any information revealed during the auction.

Simultaneous multiple round auction (SMRA)

The SMRA is typically referred to as a generalization of the conventional ascending auction with multiple objects. However compared to the conventional ascending auction, the objects for sale are auctioned simultaneously in a sequence of rounds. In each round, each bidder can submit bids on any of the objects. At the end of each round, the "winners" of the round (provisional winners) and prices are announced for the next round. The auction ends when no new bids are received on any objects, i.e., the auction does not close on any object until it closes on all of the objects. As Ausubel and Cramton (2011a, p.18) point out; "it allows bidders the flexibility to switch their bidding to other more attractively priced objects during the auction".

The SMRA is designed around eligibility points (points associated with the size and the number of bids entered in each bidding round) based on a deposit, which means that a bidder has an upper limit of lots that the bidder can bid for. The upfront deposit assures a bidding commitment.

Before the start of the auction, the auctioneer announces the reserve prices which are the prices in round 1. During the rounds, if an object receives a valid bid, the prices are increased (or decreased in the context of procurement) by a certain amount (absolute or percentage). Ausubel and Cramton (2011a) suggest that the SMRA is supported by an activity rule to ensure that bidders are active throughout the auction. The activity rule could be related to the eligibility points. They propose an activity rule in which a bidder have to be active up to at least 80% of its eligibility in order to maintain the eligibility in the next round, i.e., if a bidder failed to be active on at least 80% of its eligibility points, its eligibility will be permanently reduced commensurately. The proposed activity rule rules out bid sniping (placing a winning bid at the last possible moment) since bidders can lose eligibility.

The major problem with using the SMRA is the possibility that a bidder can end up winning some of the desired lots, but not all. As the prices increase (or decrease in the context of procurement), a bidder can find itself in a position where it can no longer afford to continue to bid on all wanted lots. Other winning lots can suddenly be useless and unwanted because the bidder can be stuck with some lots by being a provisional winner of the lots. Ausubel and Cramton (2011a) propose the SMRA to be followed by a rule that allows bidders to withdraw their provisionally winning bid subject to a penalty. Typically, a default object remains unsold and is included in a subsequent auction. Ausubel and Cramton (2011a) state that this possibility is an imperfect solution in the auction format.

Ausubel and Cramton (2011a) discuss an extension of the SMRA - the conventional simultaneous ascending auction with package bidding (SAAPB) which allows for package bids. The SAAPB follows the same rules as the SMRA, but compared to the SMRA, each bidder in each round can place a bid for a package of lots. A provisional winner in the SAAPB is a bidder whose combination of bids gives the highest value. A bidder can only be a provisional winner for all of the lots in its package or none of the lots in its package, that is, a bidder cannot be a provisional winner for some lots in the package bid. The auction ends when no new bids are submitted by any bidder.

One problem in using the SAAPB is the decisions the bidders can make on specified packages for prices announced by the auctioneer. The auctioneer-announced-prices can interfere with the bids submitted. The bidders can end up winning the lots that are not needed or can choose to be reluctant because of the announced prices. Again, the format creates an efficiency problem. Ausubel and Cramton (2011a) state that they do not recommend the SMRA/SAAPB for auctioning offshore sea shelf because the following package clock auction solves this problem.

Package clock auction

The package clock auction addresses the failure of the SMRA/SAAPB. As with the SAAPB, the package clock auction gives the bidder the opportunity to bid on packages and therefore, benefit from complementarities. The package clock auction is designed to have two steps. The first step is a clock auction which consists of multiple rounds where the auctioneer announces prices in each round. In each of these rounds, the bidders specify the packages that they wish to buy at the price announced by the auctioneer. The prices on the objects for sale increase with excess demand (or decrease in the context of procurement). The second step, the supplementary round (a final sealed-bid round), starts when there is no more excess demand in the clock auction. In the supplementary round, the bidders can bid on new packages and improve their bids on these packages from the clock auction subject to an activity rule. Bids and prices are evaluated and the winners are those whose bids on lots that maximize total value. Payments could follow the second-price rule.

Like the SMRA/SAAPB, the objects in the package clock auction are auctioned simultaneously in a sequence of sealed-bid rounds, and bidders can submit bids on any of the items for sale. An important difference between the SMRA/SAAPB and the package clock auction is that a provisional winner in the package clock auction is not determined and announced at the end of each round, only the aggregate demand. Another important difference is the sealed-bid supplementary round. By not determining a provisional winner and the use of a supplementary round, the bidders can, subject to the activity rule, place any additional bids or improve any prior clock bids on any of the packages. All the packages are available since a provisional winner is not used, and the bidders can freely change their clock bids in the supplementary round. Therefore, the bidder can focus on the packages that they most prefer and former bad decisions can be altered. Efficiency is increased.

Another important advantage of having a supplementary round, if objects have complementarities, is that it reduces the possibility of ending the auction with unsold lots. This is because a bidder can freely choose objects and prices in this extra round.

Besides the above advantages of having a supplementary round, Ausubel and Cramton (2011a) point out the following strengths of their preferred auction:

- Encourages price discovery from the use of clock rounds which can reduce winner's curse, since a start price gives some information of the value of the lots
- Enhances substitution by allowing package bids
- The use of the second-price rule secures truthful bidding and therefore, induces efficiency by placing the objects in the hands of the bidders who value them the most
- Eliminates exposure since allowing package bids reduces the risk of winning only some of the lots
- Minimizes gaming as bidders cannot exploit the exposure of rival bidders
- Fits an environment of strong and varied complementarities

Ausubel and Cramton (2011c) state that its main weakness is the complexity of the auction design. However, they state that in spite of this, the package clock auction is the most appropriate auction design for auctioning offshore sea shelf.

Experience from the package clock auction – Cramton (2008) review of UK mobile spectrum band auctions

Cramton (2008) examines the package clock auction used in selling the 10-40 GHz spectrum band in the UK. Before this review, Ofcom had used the combinatorial auction only once before.

Table 1: Experience from the package clock auction for 10-40 GHz spectrum in the UK, 2008

Auction design	The auction design used was similar to the package clock auction described above. It consisted of a clock auction in the first stage and a supplementary sealed-bid auction in the second stage. As described above, the auction was capped under an eligibility point rule. The payment followed the second-price rule for a multi-unit auction, i.e., the price was the value from the value-maximizing assignment without the winner.
Results	There were 17 lots up for sale. Eight bidders entered the auction. One company won the auction. (In the first auction, 10 lots were up for sale and 10 companies won the spectrum).
Critical points	Cramton points out that the auction design was fully efficient. However, why only one winner? Did the auction design reveal some information during the auction in which seven bidders hesitated from bidding full values? Is this a sign of inefficiency? Following Cramton, the auction design did not reveal any information during the auction. Instead, the design, clock rounds and a supplementary round, gave the bidders an opportunity and an incentive to express their true preferences and bid the full value to increase the possibility of winning. Another concern was the non-monotonic bids from several bidders in which a bidder submitted a higher bid for a package that was a strict subset of a larger package. This was not consistent with the incentive of using eligibility points. Under the eligibility point rule, the best strategy is to bid on the largest package that is still profitable. This ensures that a bidder is able to bid the full value for desirable packages in the supplementary round. Bidding for the most profitable package in the clock rounds can limit the supplementary bidding for packages larger than the package bid in the final clock round. According to Cramton, the eligibility point rule could be the reason why most of the bidders failed to submit a complete set of supplementary bids. At the worst, the rule may have reduced the auction revenue.
Conclusion	Cramton concludes that the winner would still have won all the lots simply because it valued the lots more than the other bidders. The auction outcome was not because of the auction design. This auction reveals an extreme example of what might happen in a package auction when all the lots are optimally won by a single bidder.

Demand/Supply auction

In the Ausubel and Cramton discussion of offshore sea shelf, the objects for sale are pre-defined before start of the auction, and bidders can, hereafter, submit bids on different combinations of these objects. One can say that the auctioneer controls the auction. However, one could create an auction where buyers submit bids and sellers submit asks. This kind of auction is referred to as a double auction. A double auction market can also be carried out in a way where sellers and buyers call out prices that they are willing to buy and sell at, and a match is made if a seller and a buyer calls out the same price.

Chatterjee and Samuelson (1983) analyse the double auction in an environment of a single buyer and a single seller. The buyer submits a bid *b* and the seller submits an ask *s*. If the bid exceeds the ask then a trade is completed. Because both players have an incentive to misreport their true value, efficiency is not necessarily given.

Wilson (1985) analysed the double auction in a multi-buyer/multi-seller setting. As in Chatterjee and Samuelson (1983), each agent can at the most trade one unit of the good given the bids and asks. Compared to Chatterjee and Samuelson and with sufficiently many buyers, this double auction is efficient.

Rustichini et al. (1994) analysed a different setting where buyers' and sellers' equilibrium bids and asks are different from their actual values. As with Wilson (1985) and when the market is large enough, the misreporting (and hence, inefficiency) is small.

Klemperer (2010) proposes a combinatorial auction ("The Product-Mix Auction") where bidders can submit bids on packages. The model was designed for the Bank of England after 2007 with the objective of allocating liquidity to banks under the liquidity crisis. Compared to the combinatorial models as described above, the Klemperer model follows the idea from a double auction where the auctioneer asks for a quantity and a price of liquidity and bidders submit bids in terms of both. More concretely, the model is a simultaneous sealed-bid, one round format auction where each bid contains a set of mutually exclusive offers.

The idea behind the model is that the auctioneer asks the banks for bids without revealing any information in terms of preferences or conditions. Each bidder can submit any combination of bids consisting of a quantity (an amount a bank wants to borrow) and a price (an interest rate) for each variety (the loan is secured against strong collateral or/and against weak collateral). From these bids the auctioneer gets a market demand curve. The auctioneer then decides its supply curve by looking at the bids submitted and chooses a price for each variety of collateral offered. This chosen price for each variety does not follow a specified auction rule, but is "freely" chosen by the auctioneer. The price chosen could, for example, fit the amount of money the Bank of England wants to lend to the banks. The auctioneer can then accept all the bids that exceed this chosen price for each variety, but accepts at most one offer from each bid (the price with strong collateral or the price with weak collateral). If the prices for the varieties all exceed the auctioneer's chosen prices for the varieties, the auctioneer accepts the offer that maximizes the bidder's surplus. The payment follows the uniform pricing rule (where all accepted offers pay the same price) for each variety.

Klemperer (2010) points out the following key strengths of using the "The Product-Mix Auction":

- Greater efficiency, revenue, and trade than running a standard simultaneous multiple separate auctions
- Simpler to use and understand and less vulnerable to collusion than a SMRA

By running a standard auction for each variety, where the auctioneer announces prices and bidders submit the quantity they wish to buy, the auctioneer has to choose prices and quantities before learning bidders' preferences. Meanwhile, the bidders have to guess how much to bid for in each auction without knowing the price-differences between varieties before the end of the auction. Some of the bidders could choose to stay out of the auction and/or some of the objects could end up in hands other than those who value them the most. These problems are reduced in the "The Product-Mix Auction". Likewise, each bidder can give the precise quantity it was bidding on at the wanted prices, which increases efficiency.

In terms of the guidelines to secure a good auction design, "The Product-Mix Auction" can induce entry by the use of the sealed-bid, simultaneous format. Klemperer (2010) states that this auction model is less vulnerable to collusion than a SMRA where each lot is sold individually since all offers compete directly with each other in a single auction. The uniform-price rule can induce truthful bidding, as in a second-price auction, which secures efficiency unless the bidder thinks its own bids will affect the auction prices.

The "Product-Mix Auction" has advantages and all these advantages can lead to greater revenue (Klemperer, 2010) which primarily comes from the efficiency/truthful bidding, competition and the reduced possibility of collusion.

However, there are disadvantages. An important one is the auctioneer's choosing of prices. Combinatorial auctions can be an attractive auction format when objects have complementarities where bidders can benefit from synergies. However, especially for the "Product-Mix Auction", it is the auctioneer who decides if the bidders benefit from the synergies of the chosen prices. Further, how to value/price? If the auctioneer is unclear about these, it can be disadvantageous to use this auction model.

<u>Experience from the "Product-Mix Auction" – Bank of England review of long-term repo operations</u>

Bank of England used the "Product-Mix Auction" during 2010/2011 (Fisher et al., 2011). The first twelve operations were held in a period of 12 months (spanning from June 2010 to May 2011) where the bank offered indexed long-term repo operations on a monthly basis. In each calendar quarter, two £5 billion auction with a three-month maturity and one £2.5 billion auction with a six-month maturity have been offered.

Table 2: Experience from the "Product-Mix Auction" for Repo operations in the UK

Auction design	The auction followed the "Product-Mix Auction" design in which bidders were able to submit multiple bids against either or both collateral sets including paired bids. There were no restrictions on the number of bids submitted, but the Bank of England restricted on the value of bids received from each bidder to 30% of the auction size to prevent a single bidder dominating the auction.
Results	Bank of England received bids for £6,045 billion with three-month maturity and £3,743 billion with six-month maturity (over the whole period). The participation level was lower compared to the peak of the crisis as the results from the two types of auctions did result in an amount of bids lower than amount offered. In terms of prices, the results of the auctions showed that the clearing rates have been broadly similar across operations of the same maturity.
Conclusion	Bank of England concludes that the auction mechanism works well and that the operational framework met the objectives for the sales.

5. Multi-dimensional auctions

Up to now we have looked at the single dimensional auctions where the bid dimension is price (and quantity). Another category of auctions are the multi-dimensional auctions where bidders can bid on monetary factors as well as nonmonetary factors. This auction format is important if factors such as quality and service are important elements of a winning bid.

Ausubel and Cramton (2011b) present four main designs where multiple factors can be used:

1. Comparative hearings
2. Single-phase multiple factor auctions
3. Scoring auctions
4. Two-phase multiple factor auctions

Comparative hearings

Bidders submit their bid, and the winners are determined based on the attractiveness of the bid. The problem with this method is the one of a highly subjective decision rule. Likewise, if the preferences of the auctioneer are known, the bidders can focus the offer and increase the chance of winning. Also, the process can be time consuming, expensive and vulnerable to litigation.

Single-phase multiple factor auctions

Bidders submit a sealed-bid in response to a procurement request, and the bid contains technical and commercial parts. The technical parts are evaluated in proportion to minimum standards. Then, all bids, which meet the minimum standards, are evaluated and scored. The bidder with the highest score wins the auction. The problems with this method are again the highly subjective nature of the evaluation (the blind sealed-bid format) which induces winner's curse, and inefficiency.

Scoring auctions

Bidders submit bids, but are allowed to revise them during the auction. The bid is evaluated by a scoring rule, and the bidder with the highest score wins the auction. If the scoring rule is a sealed-bid first-score auction, it could be identical to the single-phase multiple factor auctions where the highest bid wins and the winner must perform in a manner that yields the winning score. Payment is its own bid. Compared to the single-phase multiple factor auctions, a scoring auction can use other formats - a conventional ascending format, first-score or second-score pricing rule. Further, the auction design not only allows the bidder to compete on price, but also on non-price factors.

Again, the problems are the subjective scoring criteria, and the regulators' ability to value the bids against each other.

Two-phase multiple factor auctions

In the two-phase multiple factor auctions, bids are evaluated in two phases. In the first phase, the technical bids are evaluated. This phase determines if the bidders are eligible for getting the contract. The second phase is a price-based auction. All eligible bidders participate in the auction. The auction stage can take all possible formats, like those discussed earlier. As with other multiple factor formats, subjectivity in phase one can be a problem. The advantages and disadvantages from different price-only auction formats are also advantages and disadvantages in this auction format.

Following Ausubel and Cramton (2011c), the two-phase multiple factor auction is best-suited for auctioneering offshore sea shelf if a multi-dimensional auction is needed. The preferable auction format in the second phase would be the clock auction or the package clock auction.

6. Guidelines for securing a good auction design

To comply with the guidelines from Klemperer (2002a), and Ausubel and Cramton (2011a) for securing a good auction design, the auctioneer has to consider the following questions. What is a saleable object? What is a lot? Can bidders benefit from bundling? Can the auctioneer and the bidders calculate an object's/a package's value and price? What are the preferences of the auctioneer? How can competition be encouraged?

These questions lead to other decisions about the design of the auction. Should it be possible to submit bids on packages? Should all possible objects be sold simultaneously? Should there be a reserve price? Should the auctioneer reveal its reserve price or any other information before or during the auction? Should we promote entry? Who is the "winner"? How much does the winner have to pay?

Ideally, a perfect auction design will be the one which secures efficiency and optimality. However, no auction guarantees that both conditions are satisfied.

We know from the literature that different auction formats have their advantages and disadvantages. From above, we realise that only some auction formats could work well for auctioning offshore transmission. But which auction formats are feasible, and which format should we choose? Some answers can be drawn from practice (Klemperer, 2002b).

One of the leading examples of a good auction design is the UK auction of 3G mobile-phone spectrum licences from April 2000. One major problem in designing the auction was the number of potential bidders. The original plan was to auction four licences, but with four strong incumbent 2G mobile-phone operators in the market, the key concern for the government was how to attract competition. The original auction format under consideration was an "Anglo-Dutch" auction where first step, the conventional ascending auction, should continue until five bidders remained.

The auction was conducted on five licences and the government decided to use only the ascending auction format with the rule that a bidder could only win one licence and the licences could not be divided. Therefore, at least one licence would be given to a new operator. The information revealed during the auction was fully transparent, where each bidder was fully informed about the identities of the bidders, prices submitted and the price in the next round.

The auction managed to attract, besides the incumbents, nine new bidders and finished after 150 rounds and seven weeks of bidding. The auction achieved a record-breaking £22.5 billion in revenues (Cramton, 2001).

The Netherlands (July 2000), Italy (October 2000) and Switzerland (November/December 2000) adopted or copied the UK design, but the auction design failed in each one of them (Klemperer, 2002b). The firms' choice of competitive and bidding behaviour shows us that the failure of these later auctions could have been a result from learning from the UK auction. Deals between entrants and incumbents were made without action from the government and/or entrants simply choose not to enter the auction, because they had learned from earlier auctions who were the stronger bidders and the possible winners of the auction. Klemperer (2002b) concludes that the organisers after the UK auction failed to give enough attention to attracting entry, magnified their problems by permitting joint-bidding agreements prior to the auctions. The Swiss auction set the reserve price too low. Weak competition resulted in prices equal to the reserve prices and the revenue was just one-fiftieth of expected revenue.

Klemperer (2002b) states that an Anglo-Dutch auction could have been a better solution for all three auctions because of the uncertainty using the sealed-bid process. However, theory and experience have showed us that the conventional ascending auction is vulnerable to a lack of competition and gives incentives to collude and promotes predatory behaviour and punishment. It is similar for a repeated auction. This does not mean that a sealed-bid auction is always the solution (Klemperer, 2002a).

Klemperer (2002a) proposes lessons for what a designer should have in mind when designing an auction. The paper proposes the following lessons when using the conventional auction formats:

- Ascending-price auction
- Sealed-bid auctions
- The Anglo-Dutch auction

The ascending-price auction has its problems, but it has the advantage wherein it can place the objects in the hands of those who value them the most. Therefore, the outcome of the auction can come, under the right conditions, very close to efficiency. This is possible because bidders can learn from other bidders’ valuations during the auction. This reduces the winner’s curse.

Klemperer (2002a) suggests how the *ascending-price auction* can be made more robust and therefore, usable. One way could be to force the bidders to submit bids in a number of rounds where the exact price rise is pre-specified and bids are anonymous. The benefit from signalling can be reduced which reduces collusion and predatory behaviour.

Another way could be to aggregate the objects for sale into larger packages and keep the number of the remaining bidders anonymous during the auction. The benefit from collusion is reduced since larger package reduces the opportunity to split the spoils and bidders cannot observe the number of bidders in the auction.

A third way could be to induce competition by paying bidders to enter and stay in the auction.

Attracting entry and preventing predatory behaviour as well as collusion are major concerns of the practical auction design. A *sealed-bid auction* can however be more profitable for an auctioneer, even absent these problems (Klemperer, 2005). Klemperer (2002a) points out that the sealed-bid auction is more robust in terms of preventing collusion than the ascending-price auction since bidders cannot use signalling during the auction. The sealed-bid format can attract entry, since it gives the weaker bidders a chance of winning.

However, entry could also come from bidders whose objectives are to resell the winning objects. Using a conventional ascending auction could prevent entry from weaker bidders following the openness, but also because of the difficulty of making a profit from resale of an object to a losing bidder. The possibility of a resale in combination with the sealed-bid auction becomes interesting. From the perspective of efficiency, the sealed-bid auction is less attractive but the possibility for a resale is likely to be broadly efficient (Klemperer, 2005). Reselling can however discourage entry in a package auction, if a weaker bidder can buy from stronger bidders after the auction.

An alternative way to attract entry could be to have “non-competitive” lots for sale where bidders are given the possibility to make “non-competitive bids”. These are bids where, in terms of short term value only, it might be better to leave the lot unsold. This could be mixed with making anonymous bids and a sealed-bid auction.

Likewise, one has to be careful when using a “Pay-your-bid” sealed-bid auction, because it may discourage weaker bidders from entering the market. A uniform-price auction could be better, since winner’s payment is the non-winners’ bids. However, a uniform-price auction can induce collusion in the context of multiple lots.

The sealed-bid format seems to be an obvious choice when auctioning an object. However, Klemperer (2002a) points out that the auctioneer should have in mind that the bidders need to have good information about the other bidders’ valuations (Persico, 2000) or at least some idea about the value of the objects for sale. If this is not the case, efficiency can be reduced.

Even with information, the sealed-bid format is not perfect. Klemperer (2002a) points out that one could take out the advantages of using an ascending-price auction and use a simultaneously “best-and-final” offer in a sealed-bid format.

The *Anglo-Dutch auction* becomes interesting as it is closely related to the package clock auction and shares some of its advantages. Klemperer (2002a) states that the ascending auction stage induces efficiency and increases revenue, and the sealed-bid stage attracts entry and reduces collusion.

Besides the above guidelines on auction format, Klemperer (2005) gives the following main lessons:

Bundling: Using larger contracts can make bids into “must-win” bids, and make the auction more competitive. Bundling and packages can have the same effect. Likewise, a commitment to divide a price among multiple winners can attract entry of weaker bidders and therefore, induce competition by reducing winner’s curse. If the objects for sale have complementarities, bundling can reduce inefficiency since each bidder can design its own package and bid for the objects they really want. Without the bundling possibility, bidders can fail to win complementary objects and/or win objects which have little or no worth to them. Bundling can increase inefficiency by offering “quantity discounts” if the winner at the same time can (1) charge a price above the marginal cost, (2) charge the same price per unit to all consumers irrespective of quantity purchased. As a result a winner can raise profits at the same time as lowering social surplus (i.e. too little output is supplied) if it is costly to reorganise the ownership of assets once the auction is over.

Learning: Learning opponents’ valuations can be a positive thing in an auction if the object for sale is new or difficult to value. However, in repeated auctions it can induce mutual understanding and therefore, collusion. The European telecom auctions are the typical examples. A repeated auction is still interesting because allowing bidders to submit multiple sealed bids over a period of time can frustrate bidders and make collusion harder.

Anonymity: Keeping the number and the identity of the bidders a secret can increase competition and encourage entry.

Reserve prices: Setting different reserve prices and therefore, discriminating between bidders by giving bidding credits to particular bidders could force stronger bidders to bid more aggressively, and could encourage entry (Bulow and Roberts, 1989). A problem is to set a proper reserve price. Experience from the Swiss spectrum auction highlights this issue.

Structure the auction: Determine the industry structure before the start of the auction, for example fix the number and the size of the licences for sale, allow companies to win at the most one object, and avoid that the auction creates new sub-markets in the market.

Like Klemperer (2002a) and Klemperer (2005), Maurer and Barroso (2011) propose lessons for what to have in mind when designing an auction. The latter analysis is more a general guideline for auctions and follows Klemperer. However, the following lessons from Maurer and Barroso (2011) are interesting:

- Attracting one more bidder is more effective than tuning reserve prices to increase competition
- Specify who should be allowed to participate in the auction
- Allow bidders to benefit from economies of scale in the way objects are combined
- Include a few standard products. It could induce entry
- Provide clear auction rules

Methods for attracting entry – experiences from spectrum band, airport slots and NFL drafting

A major concern of auction design is to attract bidders. Some areas can attract entry by the product itself, while others need a mechanism to secure entry because of high entry costs and high asymmetries between the bidders. Here, we present some auctions which have built in a mechanism to attract entry.

<u>4G spectrum band</u>

Ofcom's coming auction on the 4G spectrum band is an example. Ofcom (2011) considers different mechanisms to attract entry. They concluded that at least four competitors were needed, and a mechanism should help to secure this. The following five options were considered

1. Spectrum caps: restrictions on the total amount of spectrum any competitor can hold
2. Spectrum floors: guaranteeing that at least four competitors have the minimum necessary amount of spectrum. The minimum portfolio of spectrum will be pre-specified. If this is not ensured, the auction is not accepted
3. Safeguard caps: would only be used in combination with a spectrum floor to secure that the auction results do not provide wide asymmetry between bidders. The safeguard caps provide a limit on the spectrum that can be held
4. Regulated access conditions: can help to ensure at least four competitors. For example, by allowing some flexibility to build service features on top of the basic access service. Prices would be regulated
5. Reserving some spectrum to be used on a shared use basis

Based on the expected entry from having spectrum caps or spectrum floors and safeguard caps, Ofcom concluded that the spectrum floor and safeguard cap would be a better option than a spectrum cap. Likewise, Ofcom also concluded that the regulated access conditions are not needed based on the expectation of having at least four competitors in the market. In terms of reserving some spectrum, Ofcom concluded that the consequences could be that some bidders could rely on shared access and therefore, it did not deliver maximum competition in the auction. Furthermore, the costs are likely to be significant and the benefits are uncertain if the auctioneer chooses to reserve exclusively.

Airport slots

The allocation of airport slots uses a simple mechanism to induce entry. The allocation in the EU and other EU Member States are governed by the 1993 Slot Allocation Regulation. A main provision of the Regulation secures that 50% of slots placed in the pools, which contains all the slots not allocated on the basis of Article 8(2) and 8(4) (Regulation No 793/2004), shall be allocated to new entrants unless the requests by the entrants are less than 50% (Council Regulation No 95/93).

NFL drafting

The NFL drafting (Draftsite, 2011) use rules for favouring new and smaller teams. The aim of the rules is not directly specified to attract entry, but more in the direction of giving new and smaller teams a chance to compete with the bigger and stronger teams. The NFL drafting uses the following rules:

Draft order:

1. First pick goes to the team that has the worst win-loss record in the previous season
2. A new team (expansion team) is automatically granted the first selection

Compensatory picks:

3. 32 picks at the ends of rounds 3 through 7 are awarded to the teams that in the previous year's free agency period have lost more or better free agents (a player whose contract with a team has expired and is thus eligible to sign with another club) than they gained
4. The maximum amount of picks is four and they cannot be traded

Cap on salary:

This restricts the total salary paid to the signed players by any team, thus, preventing one team bidding for and keeping all the best players.

7. Main lessons for securing a good auction design in offshore transmission

Here, the paper presents a discussion on the right solution for auctioning offshore transmission. Firstly, there is no one size "fits-all" auction. The right solution differs from situation to situation. Secondly, we can get closer to a right solution by using the right design and knowing all the details when preparing the auction rules. This section highlights what we should take with us from the previous discussions when designing an auction for offshore transmission.

To begin with, experience from Argentina and Brazil shows us that a design, build, own and operate transmission auction is both possible and desirable. Experience from UK shows that offshore transmission auctions for owning and operating are being used in practice.

We also observe from the sale of spectrum licenses for mobile-phones and from the sale of long-term repo operations that the package clock auction and the "Product-Mix Auction" can induce optimality and efficiency. Therefore, based on such experiences, the applicability of these two auction formats should be considered when auctioning offshore transmission.

The main lessons outlined in this paper suggest that the following should be considered when designing an auction for offshore transmission.

The lot and packages to be auctioned:

- Define the lots for sale, so that there is no uncertainty for the bidders to see the opportunities.
- Be sure that the bidders have an idea of the prices for lots/packages for sale. If this is not the situation, help them and encourage price discovery.
- Allow bidders to benefit from economies of scale.
- Use a package auction if the objects for sale have complementarities. The benefits can induce efficiency and a higher surplus for the auctioneer (i.e. lower prices of transmission services).
- Winning a package or winning large packages/contracts should be a possibility. It can make the lots for sale to a "must-win" sale which can prevent collusion.

Smaller lots and smaller packages can be considered, since it can attract smaller bidders. But it can also attract weaker bidders and therefore, increase inefficiency. Smaller packages can be considered if the auctioneer knows the consequences of dividing market structure and if this is a desirable outcome.

The current auction design defines the lots as existing point-to-point links to existing wind parks. A key issue going forward is whether these are the optimal packages to be auctioned and whether larger groups of links should form a package to be auctioned.

The auction format

- If using a descending price auction, collusion and predatory behaviour can be reduced by forcing bidders to submit bids in a number of rounds, making the procurement price fall be pre-specified and the bids anonymous. This would encourage price discovery, therefore, reduce winner's curse, and induce efficiency.
- A sealed-bid auction alone is not a good auction format for offshore transmission because of complementarity of bids. However, it can attract entry and prevent collusion.
- Anonymity can induce entry and therefore reduce the failure from using a pure descending price auction.
- The package clock procurement auction is a model in two stages: an anonymous descending price auction in a multiple round sealed-bid design (the clock auction) and an anonymous best-and-final sealed-bid round (the supplementary round). Thus, this model takes in all the advantages of the above auction formats.
- If the auction design entails that the bidders submit both the quantity and the price, for example in the "Product-Mix Auction", the auctioneer shall be sure that the bidders are able to do so. Likewise, the auctioneer shall be able to calculate all the valuable combinations and allocate the objects to the right companies.

It is important to recognise that sequential/repeated auctions can lead to learning on the part of bidders on how to increase their winning procurement bids over time, increasing transmission service prices. At the same time, learning can discourage future entry and increase collusion between incumbents. However, repeated auctions can also reduce collusion by using a sealed-bid format because multiple rounds can frustrate attempts by the bidders to collude.

The current auction design for offshore transmission is based on a sealed-bid for a single lot. A key issue is whether there should be a clock stage with revealed bids followed by a sealed-bid stage, as well as possibility of bidding for combinations of lots.

There may be a role for the "Product-Mix Auction" if a parallel with the Bank of England repo auction exists with respect to transmission funding streams. The regulator may invite bids for the regulated revenue streams with different regulatory guarantee periods (akin to the Bank of England accepting different qualities of the collateral). This would allow the market to make offers of lower financing costs in return for longer regulatory guarantee periods. The risk with this type of auction is that with offshore transmission, unlike for the Bank of England repo auction, all lots must be sold.

Pricing rule

- A second-price format in its purest form ensures truthful bidding, but is vulnerable to collusion. In terms of attracting entry, the second-price auction can do well.
- Like the second-price auction, a uniform price format (where all the winning bidders get paid the same price) can induce truthful bidding and induce entry, but may also induce collusion.
- "Pay-your-bid" can discourage entry, but reduces regret on the part of the auctioneer.

The current offshore auction design is based on a "pay-your-bid" rule. This has optimality issues associated with it as mentioned above. However, there may be substantial scope for regret on the part of the regulator if a second-price auction were adopted. Some consideration might be given to some, partial recognition, of the value of the difference between the winning bid and the second-price bid.

Entry

- Competition and therefore, entry is vital in the auction design.
- Entry can be secured by paying bidders to enter and stay in the auction or by creating "non-competitive bids" on specified transmission assets (e.g. some small uncomplicated links) combined by making the bids anonymous in a sealed-bid format.
- A few standard products can also be interesting for some bidders, especially, new bidders who have problems finding out the right combination bids to make.
- Making reselling a possibility can attract entry, but also discourages entry if a weaker interested bidder can buy the wanted lot after the auction.
- Making different reserve prices can attract entry and force stronger bidders to bid more aggressively.
- Can use caps and floors. This would restrict the amount of transmission assets that can be held by one consortium at a time and encourage entry.
- Can use an airport slot allocation rule for entrants where a certain percentage of new transmission assets must be assigned to new entrants.
- Give advantages to new bidding firms (who have not previously won a package/lot in the auction) as in the NFL drafting process.

Ensuring competition in transmission auctions which may be repeated every year for 20+ years is going to be a big challenge. It is highly likely that some mechanism will be needed to maintain competition between bidders in such a setting and to prevent incumbents from becoming entrenched in this market. There are good ideas worth investigating from other auctions which specifically address this issue.

8. Suggestions

In this paper, we discuss different auction formats, experiences and guidelines for a good auction design. The aim is to find a design which attracts entry, prevents collusion, prevents predatory behaviour, enhances substitution, encourages price discovery and induces truthful bidding.

In making our overall recommendations, we think that the auction for *offshore transmission could follow the idea from the package clock auction* where a package is defined as a group of individual lots. As used to sell spectrum licenses for mobile-phones, the price rule could follow the second-price rule, and the auctioneer should define the lots for sale before the start of auction. A package clock auction is an attractive model if bidders have different preferences for the lots being auctioned. Likewise, the package clock auction provides bidders with flexibility in specifying alternative bids in an environment with strong complementarities.

The "Product-Mix Auction" is worthy of further investigation because it does offer a way to bid different qualities of bids. The quality dimension could be in terms of the length of regulatory financing guarantee sought. This might be something of interest to a regulator to see how much value the market assigns to longer regulatory guarantees.

The number of bidders is always difficult to predict. Based on the ongoing tender processes, competition is to be expected, especially, from the three preferred consortia in the Round 1 tenders. If competition is a potential problem, we think that the auction can benefit from having a mechanism which secures competition. In order to secure the highest possible efficiency, comply with economies of scale, and ensure that all bidders can get the package in which they benefit the most, we think that *a floor and a safeguard cap* should be considered. These tools were the cheapest ones in the context of a requirement to have at least four winners in the 3G mobile-phone auction. However, calculations have to be done before the final decision. If there are transmission links for which no bids are received, because of minor interest or the bidders have reached the safeguard cap, these lots can be reserved for weaker bidders at their lowest cost.

In order to secure entry and in accordance with the theory and the experience, *reselling could be an option*.

If nonmonetary factors should be part of the auction (such as the size of a given transmission link), we think that the two-phase multiple-factor auction is best-suited for auctioning offshore transmission. The first phase can evaluate the nonmonetary factors, and the second phase can be the chosen price only auction format.

The UK has taken welcoming steps in introducing auctions into the development of the offshore transmission system. However, the design of the auctions for the current Round 1 and Round 2 transmission links are very simple. This paper has provided ideas from key elements of the advanced auction design that might be considered in auctioning offshore transmission assets. A subsequent paper will examine feasible auction designs for offshore transmission (and onshore networks) which build on the lessons learnt from the auction literature discussed in this paper.

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