Spellmeyer, Grant

From: Robert J. Weber <rjweber@kellogg.northwestern.edu>
Sent: Monday, March 23, 2015 3:27 PM
To: milgrom@stanford.edu; ausubel@econ.umd.edu; pcramton@gmail.com
Subject: Generating revenues from the assignment phase
Attachments: VCG-style assignment auction simulation.xlsx; Why __NOT__ an auction.docx

Dear Larry, Peter, and Paul,

I'd like your thoughts on the attached short note and simulation-based spreadsheet example(s). I believe that you all certainly wish for the incentive auction to succeed in reallocating spectrum, and I'm concerned that the post-clock-auction-phase frequency allocation method currently proposed by the FCC could reduce clock-auction-phase revenues (and hence keep the clock-auction phase of the forward auction from reaching its closing target).

The attached example involves two assumptions. One is that negative bids will not be allowed in the VCG-style auction that has been proposed, and the other is that the planned linear reduction in final license prices on the basis of impairment percentages doesn't precisely cover the impairment costs faced by every bidder.

In this case, the bidders' costs associated with being assigned any particular license might be positively associated with the level of impairment. The attached simulation example then shows that the proposed auction could be close to full-value-extracting. Specifically, after taking the final frequency assignment and the payments supporting that assignment into account, each bidder finds itself barely better off than if it had been freely awarded its least-desired feasible (after the FCC's contiguity optimizations) assignment (a joint assignment which is, of course, typically infeasible). The auction might generate some value from finding a "good" assignment, but it would cost the bidders so much in the process that they would systematically lower their valuations (and therefore their bids) in the clock-auction phase.

This problem is less extreme if the bidders valuations are highly complementary, but in that case, why pull any revenues from the clock-auction phase when they could just be asked what they wanted, and all be satisfied?

If the FCC ultimately chooses to avoid the problem noted here by choosing a non-revenue-generating approach to deal with the frequency-allocation issue, there remain interesting questions concerning the best alternative. I suggest a few possibilities at the end of the attached note.

I welcome your insight. Do you believe the FCC should be using a revenue-generating process to help the bidders with the post-clock-auction-phase frequency allocation issue?

Best regards, Bob

The Danger of Using a VCG-Style Auction (or any other revenue-generating procedure) for the Assignment Phase of the Forward Auction

Robert J. Weber

What is an "auction"?

Auctions typically involve a seller, and a set of bidders. The seller holds a set of property rights (as examples, to tracts of land, or financial instruments, or patents, or regulatory powers).The bidders seek to acquire those rights, and each would be willing to pay various amounts for various combinations of those rights.

The seller seeks to obtain payment (typically, as high as is feasible) for its holdings, but doesn't know the demand function which summarizes the bidders' willingness to pay.

The seller therefore solicits bids, and uses them to determine the allocation of rights across the bidders, and the payments made by the bidders to the seller. (Of course, the allocation and payment rules are announced before bids are submitted.) The auction generates revenues for the seller.

One well-known, generally-accepted principle is that, if the bidders have comparable valuations, and if there are enough bidders to generate demand for all the rights being sold, there are auction procedures which will generate for the seller revenues that extract almost all of the value the bidders receive from obtaining the rights. (In the simplest case, if two bidders assign the same value to a single item, then the seller will be able to extract that full value from them at auction.)

Is an auction an appropriate way to allocate frequency assignments after the clock phase of the forward auction ends?

The clock phase of the forward auction fully allocates property rights covering the licenses in each PEA (while generating revenues). Each bidder receives the right to a subset of that PEA's licenses, in return for a payment to the FCC. The winning bidders' acquisitions together cover all available licenses. Together, those bidders still face a frequency-assignment

problem, but the FCC has fully sold its rights.

The FCC proposes to aid the bidders, as a facilitator, to resolve the frequency-assignment issue.

The assignment phase is NOT a rights-assignment problem that calls for an auction. Indeed, the primary goal of the clock phase of the forward auction is to generate sufficient revenues in order to conclude the UHF spectrum-reallocation "incentive auction" successfully. If the FCC were to seek to gain revenues from the frequency-assignment issue, it could find itself reducing clock-phase revenues and thus working to reduce the incentive auction's chance for success!

How would the proposed Vickrey-Clarke-Groves-style auction be likely to perform?

Assume that, after contiguity issues are dealt with (using the FCC's proposed three-stage optimization procedure) and after impairment-related license prices are adjusted as proposed, the bidder's relative valuations for licenses still depend most heavily on the extent of impairment of the licenses.

Then each license would be valued comparably by all of the bidders (since each bidder would face the same impairment on that license), and one might suspect that a reasonable auction would extract most of the assignment value from the bidders. Indeed, we offer a robust set of examples to illustrate that this is the case (see the attached Excel workbook). The result of the VCG auction, when all bidders follow their value-revealing strategies, is shown to leave each bidder roughly as poorly off as if it had received its least-valuable of all feasible assignments. Some bidders, of course, get desirable assignments. But they pay roughly their full value for these assignments. Others get undesirable assignments, and pay less (but still, pay roughly their full value for those less-desirable assignments). Overall, every bidder ends up with essentially no retained value. All would be much better off, in expectation, from a simple random selection from the feasible assignments.

The explanation for what happens is straightforward: The special feature of the VCG-based assignment-phase auction is that all of the bidders ultimately receive their already-purchased

share of the licenses (there is no “loser”). If all bidders’ impairment-related costs for the individual licenses are comparable, and costs for sets of licenses are roughly additive (once contiguity has been dealt with via the FCC’s optimization procedures), then ***ALL*** feasible assignments have roughly the same aggregate value across the bidders. Assume the bidders all follow the strategy of bidding for every allocation of licenses their valuation for that allocation. Then, no matter what assignment maximizes the sum of the bids for particular allocations, had any single bidder bid zero for all allocations the resulting new maximal assignment would still have received roughly the same bid total (equal to the sum of the roughly-equal individual valuations across all of the licenses and bidders). Therefore, by the VCG pricing rule, every bidder would pay an amount close to its bid (which is its valuation, or equivalently, its gain over its worst feasible allocation) for what they receive. This transfers just about all of the aggregate bidder value generated by the chosen assignment to the seller.

What does this VCG result mean for the forward auction?

Anticipating that the value of winning generic licenses in the forward auction is actually the value of receiving the worst feasible (post the FCC’s contiguity optimization) combination of licenses in the frequency-assignment auction (after taking the assignment of frequencies plus the payments to the FCC from the VCG-based assignment phase into account), all bidders will rationally reduce their bids in the clock phase, decreasing the chance of success for the incentive auction as a whole.

Indeed, since there would typically be no single assignment pattern which is simultaneously worst for all of the bidders, the bidders would be given cause in the clock auction to bid more conservatively than would be justified in even the worst possible post-assignment world.

Are there alternatives?

Certainly: Let the FCC play just a facilitation role. For example, add a fourth objective to the preliminary optimization problem, which works to find an assignment that treats all winners comparably. And then simply randomly select one of the optimal

(and equitable) assignments. This procedure makes the calculation of individual bidder valuations in the clock phase of the forward auction much less difficult, doesn't downwardly-bias those valuations (as a VCG-based assignment-phase auction would), and can be entirely automated.

There are other approaches that could be used, although the one suggested above benefits from simplicity. The frequency-assignment problem, rather than being an "auction" problem, fits the economic rubric of so-called "dissolving a partnership" problems. One could, for example, conduct the VCG auction as proposed, collect the winning bids, and then return all of the collected funds, divided equally, to the bidders. The problem is that "bidding your valuations" would no longer be a dominant strategy for each bidder. Indeed, working out the details of a sensible strategy would be quite difficult.

To allow bidders to express preferences without generating payments, the FCC could allocate a supply of, say, 1000 bidding "points" to each bidder. Let the bidders allocate these points across assignments, in order to indicate their preferences. Then either choose an assignment which maximizes some objective function which incorporates the point allocations, or resolve the assignment as if the points were bid amounts, but collect no payments (many colleges handle the allocation of seats in popular courses in this manner).

The key point, though, is NOT to auction off the frequency assignments for monetary payments: Don't use the assignment phase of the forward auction as a revenue-generating opportunity for the FCC. To do so will risk lowering clock-phase revenues and reducing the chance of a successful incentive auction.

March 23, 2015

Example: There are six licenses, A-F; all are Category 1. Bidder 1 has won 3, Bidder 2 has won 2, and Bidder 1 has won 1. There are six feasible three-bidder assignments satisfying (1)-(3):

	A	B	C	D	E	F
Plan 1		1		2		3
Plan 2		1		3	2	
Plan 3	3		1		2	
Plan 4		2		1		3
Plan 5		2	3		1	
Plan 6	3		2		1	

After price adjustments, each license imposes on any licensee a cost of $1M / 1% impairment. (These costs are additive, and scale linearly.)

Spectrum Block (6 Category 1 licenses)	A	B	C	D	E	F
Percentage Impairment	2%	0%	6%	8%	4%	0%
Bidder 1 impairment costs	$1,900,000	$0	$5,900,000	$7,500,000	$3,800,000	$0
Cost to Bidder 1 of feasible assignments	$7,800,000					
		$13,400,000				
			$17,200,000			
				$11,300,000		
Bidder 1 impairment costs	$2,300,000	$0	$6,300,000	$8,200,000	$4,400,000	$0
Cost to Bidder 2 of feasible assignments	$2,300,000					
		$6,300,000				
				$12,600,000		
					$4,400,000	
Bidder 1 impairment costs	$1,500,000	$0	$6,100,000	$7,900,000	$4,200,000	$0
Cost to Bidder 3 of feasible assignments	$1,500,000					
			$6,100,000			
				$7,900,000		
						$0

Benefits to bidders, relative to worst feasible assignment

	Bidder 1			Bidder 2		Bidder 3
Spectrum Block	A	B	C	D	E	F
Bidder 1	$9,400,000					
(benefit over worst, -18)		$3,800,000				
			$0			
				$5,900,000		
Bidder 2	$10,300,000					
(benefit over worst, -12)		$6,300,000				
				$0		
					$8,200,000	
Bidder 3	$6,400,000					
(benefit over worst, -8)			$1,800,000			
				$0		
						$7,900,000

Bids, initially set to benefit of obtaining an assignment (but changeable for experimentation)

Bidder 1	$9,400,000					
		$3,800,000				
			$0			
				$5,900,000		
Bidder 2	$10,300,000					
		$6,300,000				
				$0		
					$8,200,000	
Bidder 3	$6,400,000					
			$1,800,000			
				$0		
						$7,900,000

Costs to each bidder from each feasible assignment

						Total	Bidder 1	Bidder 2	Bidder 3
Plan 1 imposes costs of …	$7,800,000			$12,600,000	$0	$20,400,000	$7,800,000	$12,600,000	$0
Plan 2 receives bids of …	$7,800,000			$7,900,000	$4,400,000	$20,100,000	$7,800,000	$4,400,000	$7,900,000
Plan 3 receives bids of …	$1,500,000	$13,400,000			$4,400,000	$19,300,000	$13,400,000	$4,400,000	$1,500,000
Plan 4 receives bids of …	$2,300,000		$17,200,000		$0	$19,500,000	$17,200,000	$2,300,000	$0
Plan 5 receives bids of …	$2,300,000	$6,100,000		$11,300,000		$19,700,000	$11,300,000	$2,300,000	$6,100,000
Plan 6 receives bids of …	$1,500,000	$6,300,000		$11,300,000		$19,100,000	$11,300,000	$6,300,000	$1,500,000

Copied from previous bid table

						Total			bids	Bidder 1	Bidder 2
Plan 1 receives bids of …	$9,400,000			$0	$7,900,000	$17,300,000	$18,600,000	wins	Plan 1	$9,400,000	$0
Plan 2 receives bids of …	$9,400,000			$0	$8,200,000	$17,600,000			Plan 2	$9,400,000	$8,200,000
Plan 3 receives bids of …	$6,400,000	$3,800,000			$8,200,000	$18,400,000	6		Plan 3	$3,800,000	$8,200,000
Plan 4 receives bids of …	$10,300,000			$0	$7,900,000	$18,200,000	index of first		Plan 4	$0	$10,300,000
Plan 5 receives bids of …	$10,300,000	$1,800,000		$5,900,000		$18,000,000	winning		Plan 5	$5,900,000	$10,300,000
Plan 6 receives bids of …	$6,400,000	$6,300,000		$5,900,000		$18,600,000	assignment		Plan 6	$5,900,000	$6,300,000
Bidder 1 bids 0s											
Plan 1 receives bids of …	$0			$0	$7,900,000	$7,900,000	$18,200,000	Bidder 1 bids 0s			
Plan 2 receives bids of …	$0			$0	$8,200,000	$8,200,000					
Plan 3 receives bids of …	$6,400,000	$0			$8,200,000	$14,600,000					
Plan 4 receives bids of …	$10,300,000			$0	$7,900,000	$18,200,000					
Plan 5 receives bids of …	$10,300,000	$1,800,000		$0		$12,100,000					
Plan 6 receives bids of …	$6,400,000	$6,300,000		$0		$12,700,000					
Bidder 2 bids 0s											
Plan 1 receives bids of …	$9,400,000			$0	$7,900,000	$17,300,000	$17,300,000	Bidder 2 bids 0s			
Plan 2 receives bids of …	$9,400,000			$0	$0	$9,400,000					
Plan 3 receives bids of …	$6,400,000	$3,800,000			$0	$10,200,000					
Plan 4 receives bids of …	$0			$0	$7,900,000	$7,900,000					
Plan 5 receives bids of …	$0	$1,800,000		$5,900,000		$7,700,000					
Plan 6 receives bids of …	$6,400,000	$0		$5,900,000		$12,300,000					
Bidder 3 bids 0s											
Plan 1 receives bids of …	$9,400,000			$0	$0	$9,400,000	$17,600,000	Bidder 3 bids 0s			
Plan 2 receives bids of …	$9,400,000			$0	$8,200,000	$17,600,000					
Plan 3 receives bids of …	$0	$3,800,000			$8,200,000	$12,000,000					
Plan 4 receives bids of …	$10,300,000			$0	$0	$10,300,000					
Plan 5 receives bids of …	$10,300,000	$0		$5,900,000		$16,200,000					

Press 'F9' to rerun the simulation.

Assumption: A bidder would be expected to bid 0 for its worst feasible assignment. Therefore, if "bidding your valuation" is to have meaning, it must mean that a bidder will value each feasible assignment in terms of its reduced cost relative to the worst feasible assignment.

Simulation Parameters

unimpaired are costly		(TRUE or FALSE)
basecost	$1,000,000	(per 1% impairment)
minmultiple	-5	
maxmultiple	5	
increment	$100,000	

For licenses with positive cost,
simulated cost = (100*percent unimpaired)*basecost+RANDBETWEEN(minmultiple,maxmultiple)*

Below, "horrible assignment" means typically-infeasible assignment giving every bidder its most costly frequency allocation:

	Bidder 1	Bidder 2
Cost of horrible assignment	**$17,200,000**	**$12,600,000**
Costs after auction	$16,800,000	$11,300,000

Cost of best assignment (no payments)

Vickrey pricing has the well-known consequence that bidding your own valuations is optimal, no matter how the others bid. Play around in the bid table to see this.

But the actual outcome when everyone bids this way can be horrible!

Results

	1	2	3
winning bids	**$5,900,000**	**$6,300,000**	**$6,400,000**
maximum total	$18,600,000	$18,600,000	$18,600,000
maximum with one bidder at 0s	$18,200,000	$17,300,000	$17,600,000
rebates	$400,000	$1,300,000	$1,000,000
payments	**$5,500,000**	**$5,000,000**	**$5,400,000**
impairment cost	$11,300,000	$6,300,000	$1,500,000
total payoff (cost)	**$16,800,000**	**$11,300,000**	**$6,900,000**

Plan 6 receives bids of …	$0	$6,300,000	$5,900,000	$12,200,000					