Bid Shading and Bidder Surplus in U.S. Treasury Auctions

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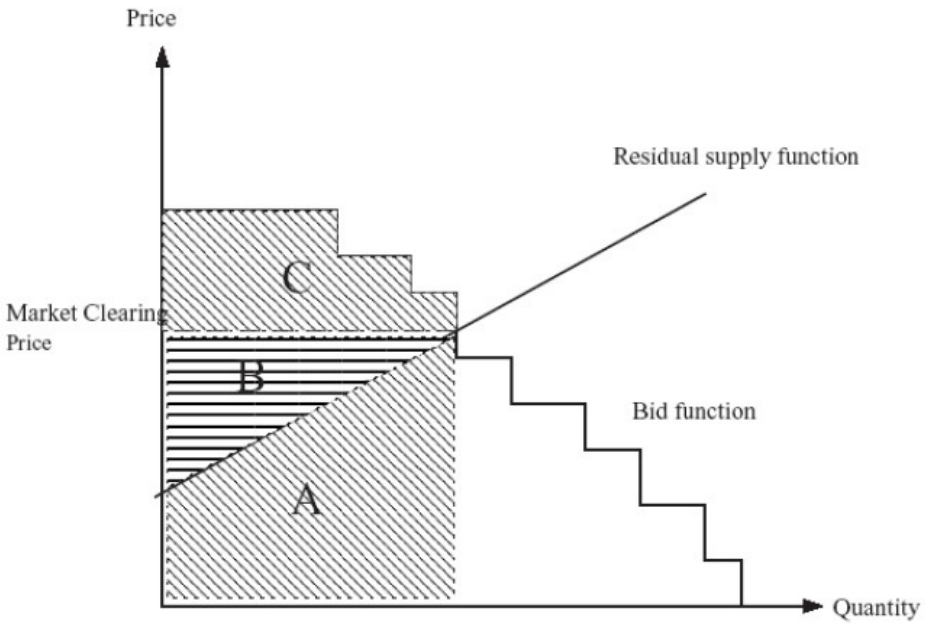
U.S. Treasury Auction System

- In 2013, U.S. Treasury auctioned 7.9 trillion dollars of debt
- ODM charter: "Lowest cost of financing over time"
- Auctions as sale mechanism
  - Discriminatory/pay-as-bid until 1998, since then: uniform price
- How do (different classes of) bidders behave?
- Do (some) bidders possess significant market power?
- Could changes in mechanism lead to significant revenue/efficiency gains?

Bidder's problem



Auction Data

- Detailed bidding data from auctions between July 2009-Oct 2013
- Data on 3 categories of bidders:
  - Primary Dealers
  - Direct Bidders
  - Indirect Bidders (they route bids through PDs)

Quantity Patterns

- 22 PDs purchase 63% of auction volume
- Concentration measures:
  - HHI: 561 (bills), 450 (bonds) , C4: 21%, C10: 44%
- Direct bidder share rising over time (especially for notes): from almost less than 10% to 19%.

Market shares over time

Bills	2009	2010	2011	2012	2013
PD	59%	65%	65%	69%	69%
Direct	7%	6%	9%	9%	8%
Indirect	34%	29%	26%	22%	23%

Notes	2009	2010	2011	2012	2013
PD	50%	49%	51%	50%	47%
Direct	9%	14%	13%	18%	19%
Indirect	41%	37%	36%	32%	34%

What about bids?

- PDs bid lower prices (higher yields) than Direct Bidders, who bid lower than Indirect Bidders
- The patterns clearer for note/bond auctions vs. bill auctions

Bid Regressions

	Bills		Notes	
	(1)	(2)	(3)	(4)
Dep. Var.	QwBid(bp)	QwBid(bp)	QwBid(bp)	QwBid(bp)
Direct	-2.457***	-0.929***	-5.974***	-0.965***
	(0.0580)	(0.0600)	(0.270)	(0.314)
Indirect	-4.204***	-2.529***	-10.89***	-4.437***
	(0.0604)	(0.0613)	(0.356)	(0.399)
%Q Total		10.04***		61.75***
		(0.219)		(5.452)
Constant	13.87***	11.99***	172.0***	165.0***
	(0.0316)	(0.0426)	(0.261)	(0.460)
Observations	41,359	41,359	13,692	13,692
R-squared (within)	0.254	0.289	0.086	0.099
No. of auctions	822	822	153	153

How to interpret bid regressions

- Quantity-weighted average bids lower for bidders who demand higher quantity: this suggests that market power may play an important role!
- In any model we can think of writing:

$$BID = WTP - SHADING$$

- How to decompose bids into strategic (shading) vs. non-strategic (WTP/demand) components?

With discrete bids - Kastl (REStud 2011)

$$\underbrace{E\left(P^c | b_k > P^c > b_{k+1}\right)}_{\text{BID BY A PRICETAKER}} = \underbrace{v(q_k)}_{\text{WTP}} - \underbrace{\frac{q_k}{\Pr\left(b_k > P^c > b_{k+1}\right)} \frac{\partial \mathbb{E}\left(P^c; b_k \geq P^c \geq b_{k+1}\right)}{\partial q_k}}_{\text{MARKET POWER (SHADING)}}$$

- This is very similar to the familiar monopoly pricing formula

$$P = MC - Q * P'(Q)$$

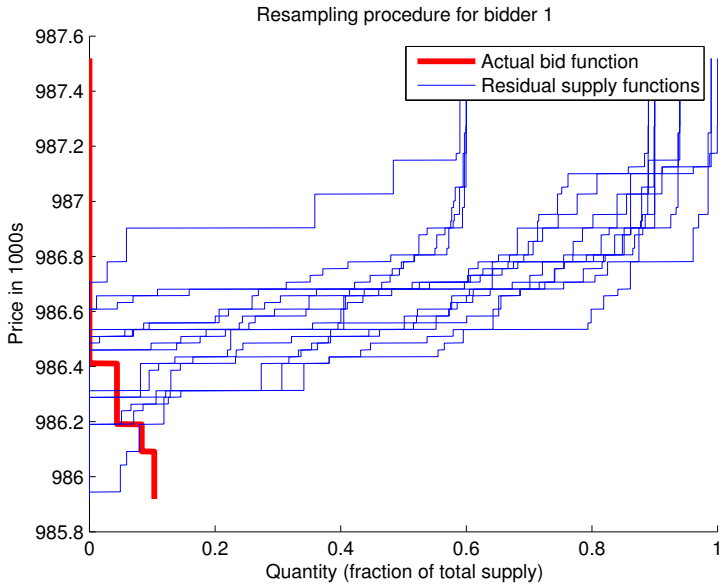
Intuition

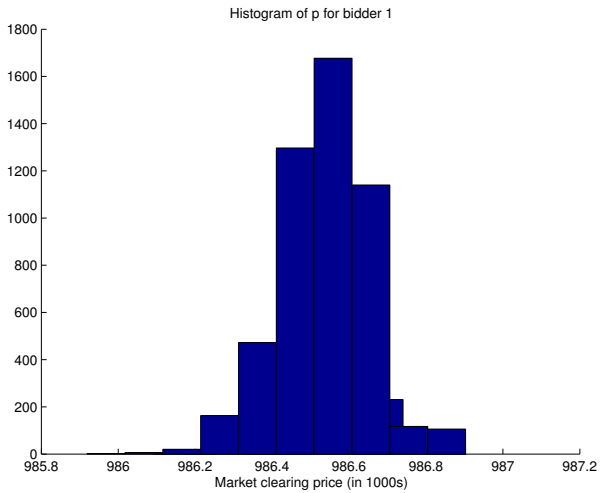
- Alternative expression: the inverse elasticity pricing formula $P = MC + \frac{1}{|\varepsilon|} * P$
- Typically, one recovers MC by estimating elasticity of demand, utilizing variation in Q due to variation in P
- In an auction, the relevant demand (supply) curve is made up of bid schedules of other bidders, i.e. the "residual supply."
- Moreover, residual supply is random from perspective of each bidder
- Hence, bidder optimizes expected profit against the *distribution* of the market clearing price (which is a function of the residual supply curves)

Estimation in the symmetric iid case (Hortaçsu and McAdams, JPE 2010)

- We need the distribution of the market clearing price
- Obtain this distribution by simulating residual supply
  - Draw with replacement $(N-1)$ bids from the observed bids, add them up
  - Subtract from the supply and intersect thus obtained residual supply with a bidder's bid to obtain one possible market clearing price.
- Many such simulation draws will result in a distribution of the market clearing price

Resampling method

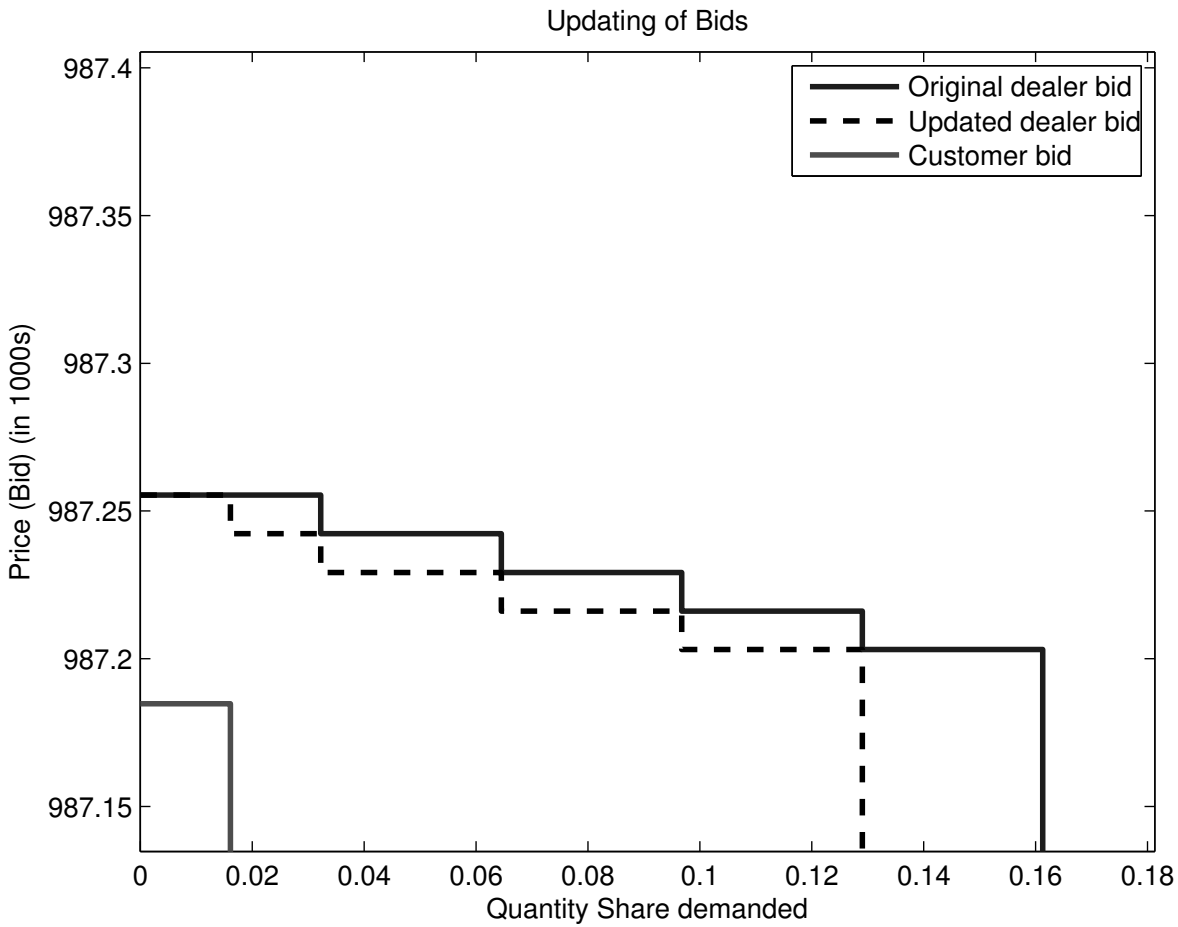




Modelling Challenges Posed by U.S. Treasury Auction Context

- Bidders are not symmetric. Clear differences in bid patterns across groups.
- Bidders have differential information
  - PDs observe the bids of their customer IBs.
  - Given customer/IB bids, PDs can make better forecasts of the market clearing price distribution
- Fortunately, we can incorporate this informational asymmetry in our estimation method (treat IB bids as "known" and not random from the perspective of PDs)

Bid Updating by PDs (from Canadian Treasury Auctions, Hortaçsu and Kastl (ECMA 2013))



Using the estimates to analyze strategic bid shading

	Strategic Shading (in bp)			
	Bills		Notes	
	(1)	(2)	(3)	(4)
Direct	-0.862***	-0.771***	-0.0954***	-0.0480***
	(0.0727)	(0.0884)	(0.0103)	(0.0105)
Indirect	-1.125***	-1.025***	-0.122***	-0.0608***
	(0.0813)	(0.0978)	(0.0116)	(0.0129)
%Q Total		0.600*		0.584***
		(0.330)		(0.108)
Constant	1.174***	1.062***	0.125***	0.0579***
	(0.0441)	(0.0756)	(0.00883)	(0.0122)
Observations	41,264	41,264	13,692	13,692
R-squared	0.015	0.015	0.062	0.069
No. of auctions	822	822	153	153

How does the uniform price auction do?

- With our estimates of bidders' values, we can answer the following questions:
  1. How much money did the mechanism fail to extract (ie bidder surplus)?
  2. Did the mechanism implement an efficient allocation? If not, how much surplus was lost?

Estimates of Bidder Surplus

Maturity	PD Surplus (bp)	DB Surplus (bp)	IB Surplus (bp)
CMBs	0.17	0.02	0.04
4-Week	0.04	0.00	0.002
13-Week	0.13	0.02	0.008
26-Week	0.33	0.03	0.026
52-Week	0.68	0.08	0.14
2-Year	7.40	1.15	0.91
5-Year	13.07	1.87	1.39
10-Year	22.22	3.58	1.73
Overall	2.3	0.35	0.23

- If the mechanism were able to extract all consumer (i.e. bidder) surplus, the auctioneer would have gained an extra 2.3 bp in terms of revenue.

Estimates of (In)efficiency of Allocation

Maturity	Efficiency Loss (in basis points)
1-month	0.67
3-months	0.68
6-months	0.76
12-months	0.65
2-year	2.08
5-year	4.50
10-year	6.41
Overall	2.05

- Had the bills/notes been allocated to the bidders with highest values, the total surplus would have been about 2 bp higher.

Preliminary Conclusions

- There is considerable heterogeneity in bidding patterns across PD, DB, IB
- PDs bid the lowest (highest yield), followed by DB and then IB
- We find similar differences in bid shading
- However, the surplus that PDs derive from the auctions, although higher than the surplus of DB and IB, is quite modest
- Modest surplus and inefficiency together suggest that the market is quite competitive, and changing the mechanism design is likely not going to have that much impact on revenues (or efficiency)
- Interesting avenue for future research: did the participation of direct bidders affect the surplus of primary dealers?