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John Doe, Editor
Journal of Economy

Dear Mr. Doe,

Enclosed please find my review of Kei Kawai's "Auction Design and Incentives to Invest: Evidence from Procurement Auctions" for the *Journal of Economy*.

In this paper, Kawai estimates a model of Japanese municipal plastic recycling auctions. Kawai's model is first-price, sealed-bid with endogenous seller investment in quality and alone it would be an original contribution to the auction literature. He proceeds to estimate the model using data from roughly 2,500 recycling auctions from 2005 to 2009, adapting previously established techniques (e.g., Guerre, Perrigne, and Vuong (2000) and Athey and Haile (2002)) to his particular setting. In my view, the paper's foremost contributions are to (1) introduce a FPSB auction with endogenous seller investment, (2) adapt existing theory to the very stylized setting of Japanese municipal recycling, and (3) adapt established estimation methods to the new model. The resulting parameter estimates and policy simulations are also valuable to practitioners and market designers, including the Japanese government.

The major points in my feedback are bolded in the review, but I briefly review them here (in order):

- *Acknowledge moral hazard of the seller*. Since bidders bid for the *next* year of plastic waste, municipalities may have incentive to shirk on effort after the auction concludes. I recommend that the author look for evidence of this moral hazard, discuss it in the text, and if necessary incorporate it into the model.

- *Data quality and measurement error.* I recommend that the author add more discussion of data quality and potential sources of measurement error, particularly in the plastic quality measure.

- *Descriptive data on the distribution of plastic quality.* I recommend more descriptive data about plastic quality, since it is noisily measured (with sampling variance) and the annual averages are not significantly different from "perfect" quality.

- *Modeling the evolution of plastic quality.* The dynamic model of investment and plastic quality can be enriched by incorporating more data (e.g., demographics) into the model.

- *Information about 'effort' variable.* Unobserved effort, or municipal investment in quality, is one of the most important pieces in the model. The paper would benefit from an extensive discussion of what this variable is, what it measures, what units it takes, and how it should be interpreted.

- *Bidders' private information.* The assumption that bidders lack private information about quality is fundamental to the IPV framework. Though the author discusses the assumption in Section 3.3, I suggest additional tests of the assumption using existing data.

- *Universe of potential bidders.* The author uses a distance criterion to identify the universe of potential bidders in an auction. The paper would benefit from a sensitivity analysis of this rule.

- *Distribution of reserve prices.* Although reserve prices are fixed, they are unknown to the bidders at the time of the auction and are effectively random to the bidders. The paper would benefit from additional discussion of reserve prices and the author's choices of how to handle them.

- *Policy experiments.* The policy experiments in Section 7 are underdeveloped and appear to be a work in progress. I suggest a few rough directions in which to take the simulation.

In light of these comments, my recommendation for this paper is Revise & Resubmit. I look forward to reading future drafts and hope to see it published when it is complete.

Sincerely,

Daniel Gross
Graduate Student

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Referee Report for "Auction Design and Incentives to Invest: Evidence from Procurement Auctions"

Overview

In this paper, Kei Kawai develops and structurally estimates a model of Japanese municipal plastic recycling auctions. Kawai opens the paper with a detailed, narrative account of the auction market, supported by descriptive statistics and reduced-form regressions. This narrative discussion describes the operation of the market, bidder and auction characteristics, and a policy that introduced incentives for municipalities to invest in improving the quality of the auctioned plastic waste. He next develops a model of a first-price, sealed-bid auction with endogenous seller investment in quality that reflects the stylized features of the market being studied. Kawai proceeds to estimate the model using data from roughly 2,500 recycling auctions from 2005 to 2009, adapting previously established semi-parametric techniques and identification results (e.g., Guerre, Perrigne, and Vuong (2000), Athey and Haile (2002)) to his particular setting. Kawai follows the estimation with a policy simulation and calculates welfare effects.

More generally, the paper explores the effectiveness of federal policies that incentivize municipal investment in the quality (purity) of recyclable waste. Its contributions are several: the model introduces endogenous seller investment, a new addition to the theoretical literature; the estimation adapts existing techniques to the application of recycling auctions; and the results inform designers of recycling auction markets, investment subsidies, and general recycling policy. Kawai does an exceptional job drawing on and extrapolating from theoretical results to study a market of practical importance. While questions about the relevance of the empirical findings to other settings (e.g., other materials, policies, countries) remain, these concerns are beyond the scope of the paper.

Critique

The critique follows the sequence of the paper, with sections bolded and underlined for quick navigation. Major points are bolded. Before launching into the critique, I want to emphasize that this paper is an impressive effort in both applied theory and semi-parametric structural estimation, and these comments are meant to be constructive (certainly not *de*structive).

To reiterate my commentary above, the exposition in **Section 2** is very effective at educating the reader about the institutional details of Japanese municipal recycling auctions. This level of detail is necessary and is too often missing from other research. Even so, I believe this section has some opportunities for improvement that deserve mention:

- In Section 2.2, the author explains that recyclers bid for the right to a municipality's *next* year of plastic waste. Since the future quality is unknown, bidders can only take previous years' quality as a signal of future quality; to this end, Table 7 gives evidence that the upcoming year's plastic quality does not factor into the winning bid. The disconnect between the time of payment and time of delivery potentially introduces **moral hazard for the municipality**, which may have the incentive to shirk once the auction concludes. This moral hazard may be deterred by reputation concerns in repeated auctions, but if not, it should be accounted for in the equilibrium bidding strategies. In any case, it would be good to address the possibility of post-auction shirking, both descriptively and in the model. A very easy descriptive implementation might be to present some data on autocorrelation in the quality measure, perhaps under different cuts of the sample (esp. if you notice any outlying years or municipalities with decreasing quality). For example, one cut might be pre- and post-introduction of the incentive scheme. This exercise would be distinct from the specifications in Table 9, which are designed to answer a different question.

- In Sections 2.3-2.4, I would like to see a little more discussion about **data quality** and **sources of measurement error**. The author gives some discussion about potential sources of measurement error in the quality measure – I'm not sure if these can be more concretely quantified, perhaps using the interim years when both the bidders and the auctioneer were evaluating a substantial fraction of the recycling facilities.

- More discussion about the **distribution of quality** is also warranted, as the quality measurements are inherently noisy (due to sampling variance) and none of the mean quality point estimates in Table 4 are significantly different from 100%. A plot of quality measures by year would give the reader more information about variation in quality across space and time.

The model presented in **Section 3** is innovative and parsimoniously characterizes the setting described in Section 2. The author does a nice job adapting the FPSB auction to this context. Detailed comments on this section are as follows:

- Notation: In Section 3.2, the author denotes the cdf of the highest rival bid for both preferred and non-preferred bidders as G_{ij}. It would be helpful if the author could distinguish the notation for the two distributions, perhaps with P and NP superscripts, or otherwise indicate that the two groups do not share the same distribution of "other bids". To this end, it would also be good to clarify how these two distributions are separately estimated (if I understand, the author exploits the fact that the winning bidder's type is observed, and he estimates G for each group using the subsample of auctions with a P winner and the subsample with an NP winner).

- The model in Section 3.2 describing the **evolution of quality** strikes me as a little obtuse and unintuitive, for several reasons:

    - Taking the estimate for alpha in Table 13, the standard normal parameterization of H(.) used in the estimation, and *any* starting value for quality: if the municipality makes zero effort for all t, then quality eventually converges to 82.6% [which is the q that solves q=Phi(alpha*q)]. While there may be some merit to this result, I would argue it warrants further discussion – why is 82.6% a steady-state?

    - Relatedly, and perhaps as a resolution to the above comment, argument to the H(.) function in Section 3.2 is overly simple but is likely easily enriched. For example, I can imagine household-level variables co-determining the evolution of quality, like income or consumption patterns (e.g., of products generating plastic waste). These data may be available from government-administered surveys.

- Section 3.2 is where the **effort variable** e_{t} first appears. This variable is very important but it isn't much discussed. A little more discussion would go a long way. What is effort? What would it look like if we could observe it? What are its units in the model?

- The notation R_{t} used for the return function in the investment model is easily confused with the R_{t} reserve price in the auction model. Similarly, the U(.) used for warm glow utility can be confused with the firms' private values. Consider a change in notation.

- The discussion of the modeling assumptions in Section 3.3 does a nice job justifying the IPV assumption. Based on that section, I find it fairly plausible – though with following caveat:

- In *Section 3.3*, page 27, the author "looks for evidence that the winner of the auction from the previous year may have private information regarding the current year quality q_{t}" and "does not find any positive effect of having the same winner in consecutive years on quality," supporting the IPV assumption. I would like to see this analysis expanded in several ways: to *any* previous winner of a given municipality's auction (not just last year's winner), to include bidder covariates like distance (proximate bidders might have better information), and anything else you think the data might support. Bidders may yet have **private information**, and in my view, the question of whether private information exists has not been settled. This question is important both to the model and for auction design, and it merits more attention.

Section 4 discusses identification, successfully drawing on results in Athey and Haile (2002) and Guerre, Perrigne, and Vuong (2000) to identify the auction model. Identification of the investment model rests on the assumption that municipalities invest up to the point where MB=MC and uses an exclusion restriction to separately identify the cost function from the utility function. This restriction – that population density is correlated with municipality costs but not utility – raises some concerns. It's not hard to imagine how population density could indirectly enter the utility function through quality (which circles back to the earlier comment about enriching the specification of the quality evolution). For example, in dense cities where households store their waste bins on a sidewalk, pedestrians might discard non-recyclable waste into a household recycling bin out of convenience, degrading the quality.

Section 5 exposits the specifications used in estimation. Comments are as follows:

- In Section 5.1, Kawai describes a distance criterion he uses to compile the set of "potential" bidders for every auction. The criterion is intuitive. However, it would be good to see how sensitive the set of **potential bidders** is to this rule. E.g., I would like to see the distribution of material recyclers' and chemical recyclers' plant distance to each auction.

- The author imposes several parametric restrictions on the evolutionary process for quality in Section 5.2. Since these restrictions are ultimately a matter of judgment, I would like to see more discussion about his choices and perhaps some sensitivity analysis. What are the epsilon shocks to quality (what do they represent)? Why are they normally distributed? Why is the H(.) function specified as a standard normal cdf, and what happens if we use a different function?

- In the second equation on page 33, the letter 't' should be replaced with 's'

- The paper would benefit from additional discussion of the distribution of reserve prices (Section 5.4 as well as Section 4). In practice, the reserve prices for P and NP bidders are nonrandom, but since the true values are unknown to the bidders, they are effectively random. The specification in Section 5 parameterizes R_{t} as normal and retrieves its mean and variance from observed bids, relying on an exclusion restriction for identification. Notably, this procedure imposes that bidders are ex-ante identical in their beliefs over reserve prices. More discussion about reserve prices, the normal parameterization, and ex-ante assumptions would be helpful.

The results in **Section 6** are interesting; however, since they follow from the model and the estimation procedure, I will not discuss them here. The policy experiment in **Section 7** is underdeveloped (it appears to be work in progress). The following comments address what Kawai has on paper thus far:

- I believe the first-best dynamic programming problem in Section 7.1 has some mistakes in the notation. First, q_{t} should be q_{t}^{e} (a.k.a., "expected quality") because the quality remains

a function of the random term epsilon. In other words, even in a first-best problem, the planner choosing investment e_{t} still faces randomness from the evolution of quality. Since the epsilon is specified to be mean zero, it should disappear in expectation anyway. Also, the constraint should have q_{t}, not q_{t-1}, in the LHS. Also, what does the SP in R_{t}^{SP} stand for?

- The first-best problem convolutes the sequence of events in recycling auctions.[1] This is fine, as a matter of course, because we want to study the full-information equilibrium (where bidders have perfect foresight of the seller's effort in the *upcoming* year), but in practice it would require some commitment mechanism on the seller. I think this warrants some discussion.

- Similarly, the first-best problem has the winning bidder paying its true value, which is ex-post known but ex-ante unknown (and as a result, the planner must optimize over expected private values). I think some discussion about what features of the original model carry over to the first-best analysis would be helpful.

If the policy simulation is in fact a first pass, I look forward to seeing later developments. Otherwise, I'd suggest experimenting with other incentive programs (i.e., other R_{t}^{SP} functions), other estimates of future values of the social benefit variable (V_{t}^{M}), etc.

Conclusion

Overall, Kawai does a nice job (1) tying together a first-price, sealed-bid auction model with endogenous seller investment that reflects the unique features of Japanese recycling auctions and (2) taking this model to the data. Among his many contributions are a new model of auctions with investment, a new dataset, a novel implementation of semi-parametric structural estimation techniques, and perhaps most importantly, evidence on the effectiveness of subsidies in auctions for recyclable waste. Although he draws from what came before, Kawai's paper is effectively entirely new. In light of its novelty, this paper is an impressive effort at modeling and estimating an auction market of practical importance.

I believe this paper is on its way to being a successful publication and is a compelling implementation of auction theory and empirical methods.

[1] In practice, bids are placed before the municipality's effort level is chosen; in the experiment, the effort level is chosen before bids are placed.