Cognitive cost and the preference for prominent numbers

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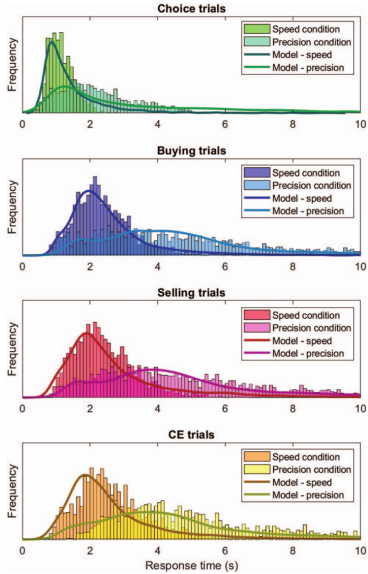
Today

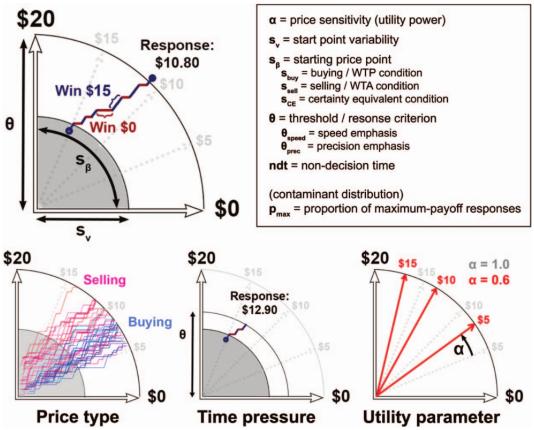
- Albers (1997, 2001) claimed that "powers of ten, their halves and their doubles" are prominent: 1, 2, 5, 10, 20, 500, 100, 200, 500, ...
- Prominent numbers dominate people's free number choice
- An elementary model that separates the economics from the psychology of prominence
- Evidence of a switchable mental resolution for prominent number
- We see prominence as complementing other representations: the logarithmic number line (Dehaene, 2003; Feigenson, Dehaene, & Spelke, 2004) and subitizing to 4 (Trick & Pylyshyn, 1994)

Valuation takes much longer than choice

In Kvam and Busemeyer (2020) valuation of one gamble typically takes twice as long as choice (see also Johnson & Busemeyer, 2005)



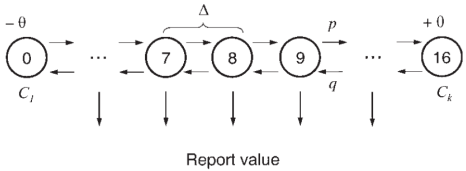
Kvam and Busemeyer (2020) model of valuation



Valuation is slower because "participants are more careful when they have more options to consider and select" (cf. Hick's law)

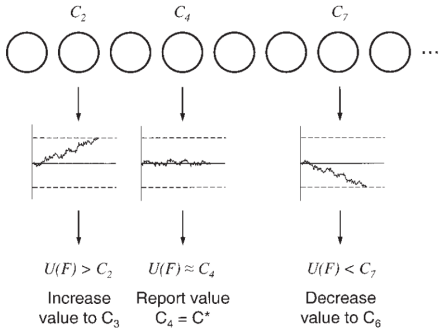
Johnson and Busemeyer (2005) model of valuation

a



Valuation is slower because participants titrate a value, making a series of DFT choices between the gamble and a candidate sure thing

b

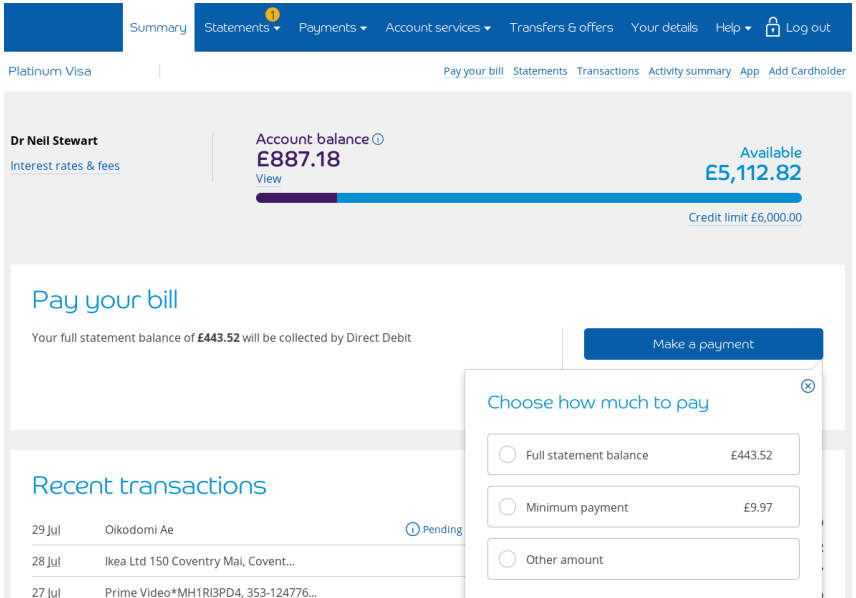


Credit Card Data

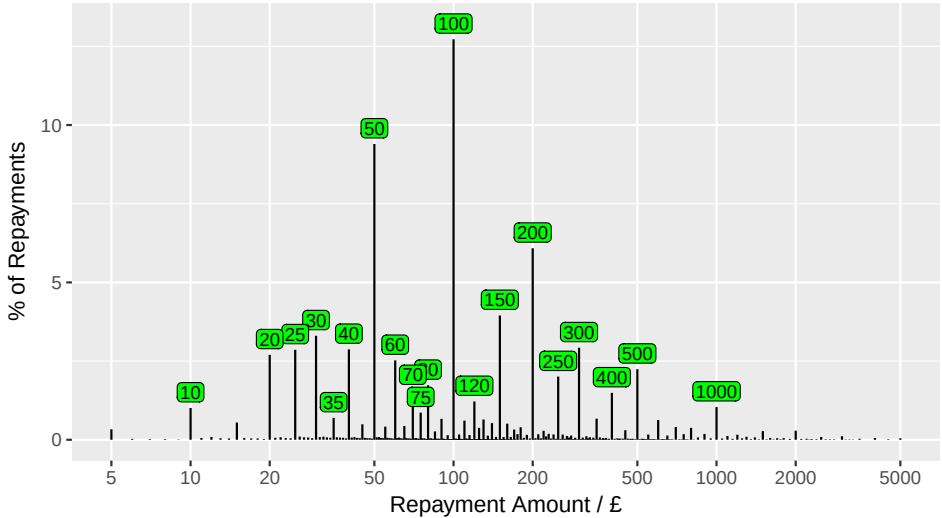
Credit card repayment data from five major UK credit card issuers (Sakaguchi, Gathergood, & Stewart, 2026)

- Jan 2013 to Dec 2014
- 1.2 million credit cards
- 23.5 million card-months
- Mean balance £1,700 (median £850)
- Mean minimum payment due £37

Credit Card Repayments



Histogram of Credit Card Part Repayments



Bins are 1 penny wide. 5,634,840 partial repayments from 526,365 accounts

Part Repayment Frequencies

Repayment	Frequency	Percentage	Cumulative Percentage
100.00	717040	12.73	12.73
50.00	529516	9.40	22.12
200.00	342902	6.09	28.21
150.00	222501	3.95	32.16
30.00	186182	3.30	35.46
300.00	164719	2.92	38.38
40.00	161820	2.87	41.26
25.00	161077	2.86	44.11
20.00	152144	2.70	46.81
60.00	142072	2.52	49.34

The top ten most frequent amounts cover half of all repayments

Modelling Plan

Objective: Separate out the economics effects which demand a level of repayment from the psychological attractiveness of prominent numbers

1. Build an economic model to predict the desire to repay
2. Explore which prominent numbers people use at each level of predicted repayment

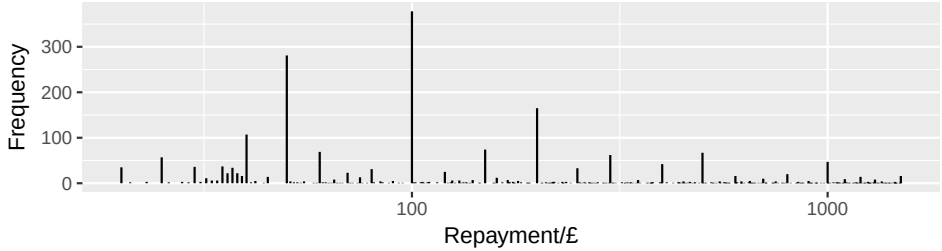
Balance	Credit Limit	Predicted Repayment	Actual Repayment
222.50	13500	97.78	100.00
6063.25	7200	202.97	209.00
899.92	1000	58.90	35.00
1929.35	5050	130.64	1309.00
1591.30	6300	136.32	800.00
...	...	...	...

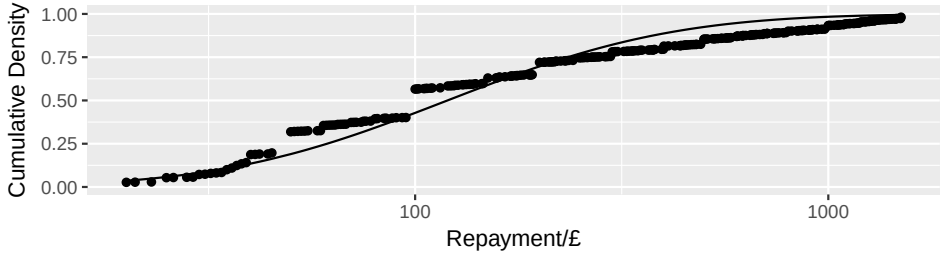
Economic Model to Predict Repayments

$$\log(\textit{repayment}) \sim \log(\textit{balance}) + \log(\textit{balance})^2 + \log(\textit{credit limit}) + \log(\textit{credit limit})^2$$

	Dependent variable:
	$\log_{10}(\textit{repayment})$
$\log_{10}(\textit{balance})$	0.786^{***}
	(0.779–0.793)
$\log_{10}(\textit{balance})^2$	-0.077^{***}
	(−0.078–−0.075)
$\log_{10}(\textit{credit limit})$	-0.473^{***}
	(−0.488–−0.458)
$\log_{10}(\textit{credit limit})^2$	0.122^{***}
	(0.120–0.124)
Constant	0.434^{***}
	(0.409–0.459)
Observations	5,634,840
R^2	0.260
Residual Std. Error	0.432 (df = 5634835)
F Statistic	$495{,}350.100^{***}$ (df = 4; 5634835)
Note:	*p<0.1; **p<0.05; ***p<0.01

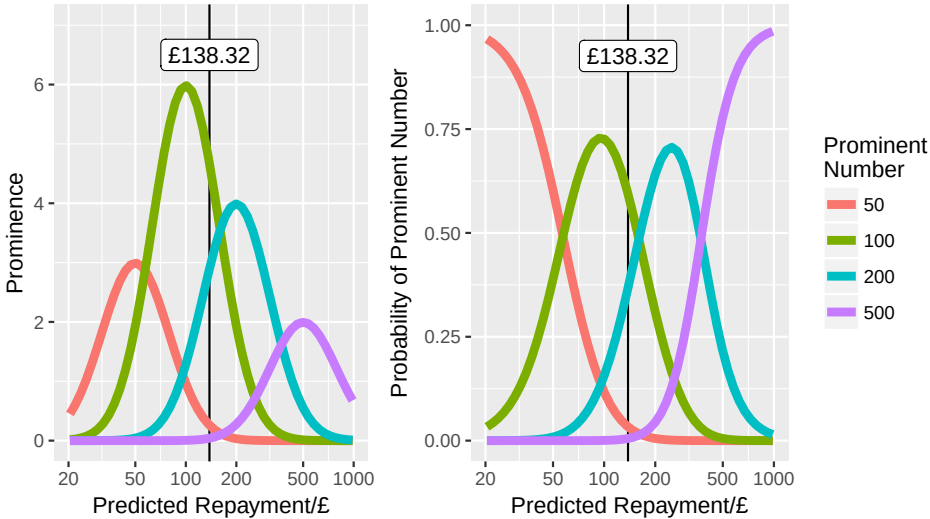
Repayment Distribution at Median Balance and Credit Limit





Median balance = £1,637, median credit limit = £4,600, median repayment = £100

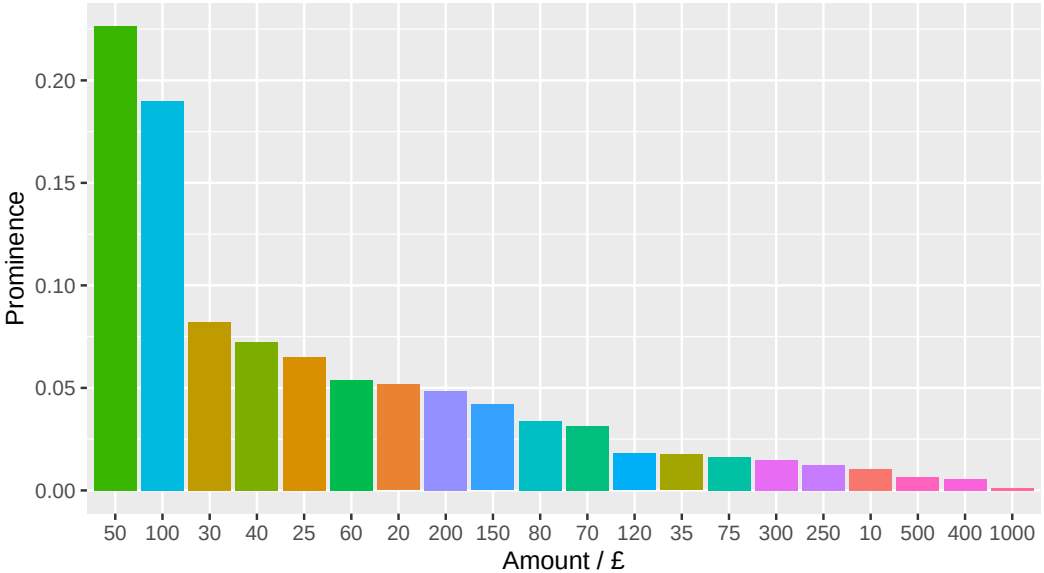
Generalisation to Prominent Numbers



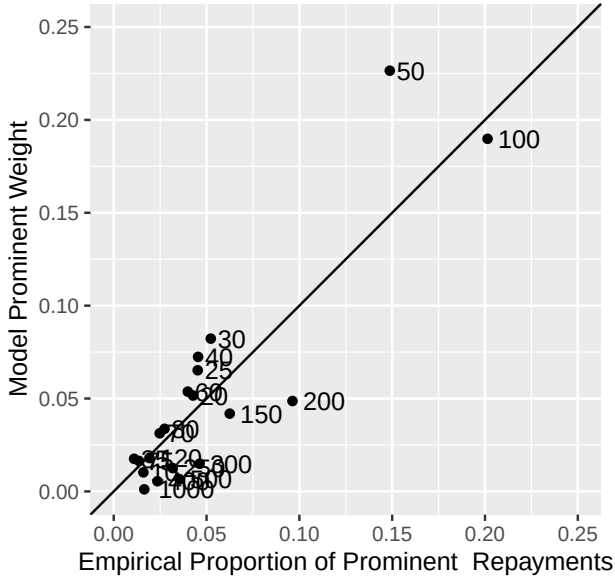
Model Fitting

Adjust the prominences and the generalisation for the top prominent numbers to maximize the likelihood of the observed prominent number repayments given the predicted repayment from the economic model

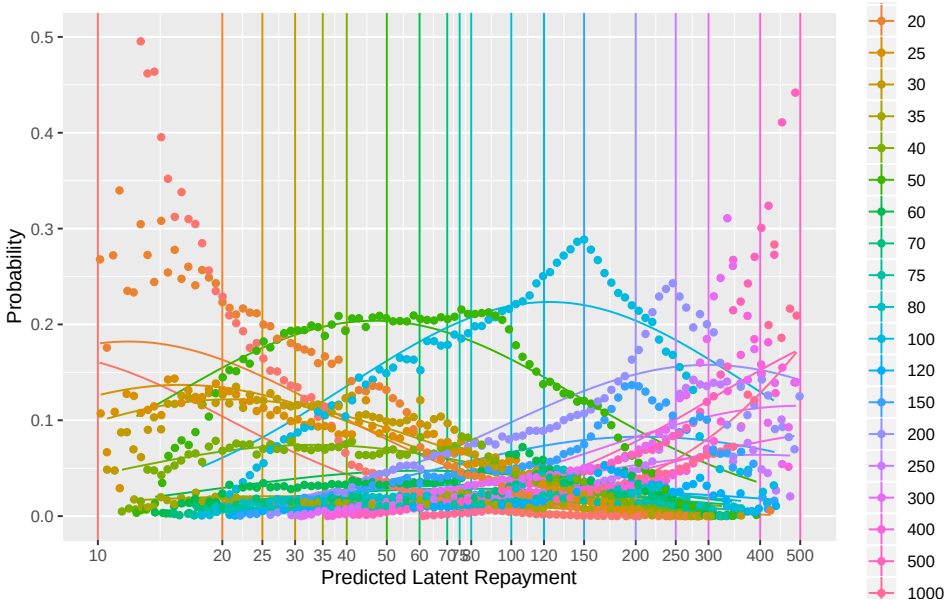
Prominence, Ranked



Prominence Against Frequency



Model Fit

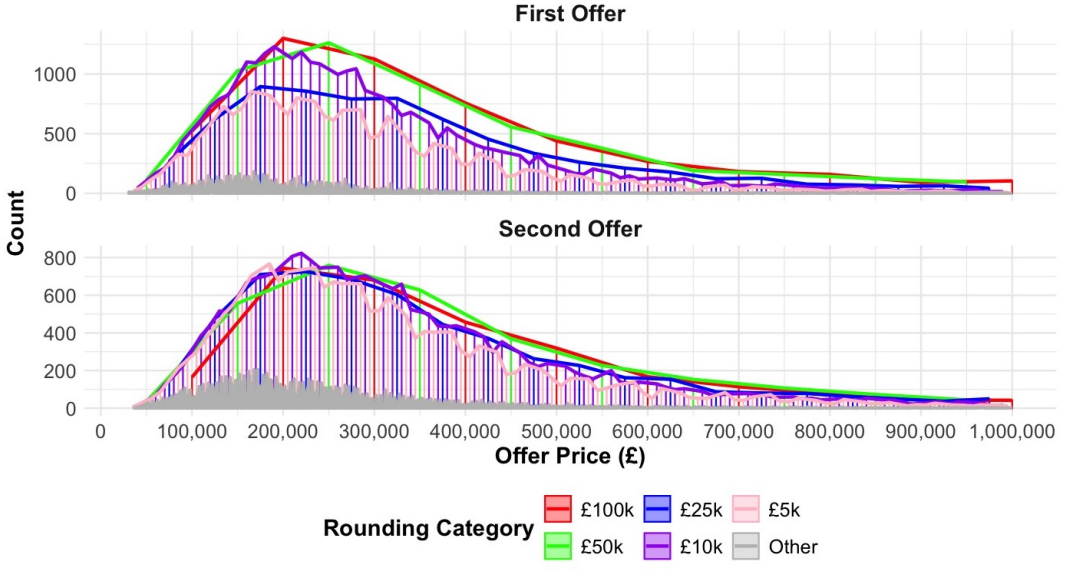

Probability
0.0
0.1
0.2
0.3
0.4
0.5
10
20
25
30
35
40
50
60
70
75
80
100
120
150
200
250
300
400
500
Predicted Latent Repayment
20
25
30
35
40
50
60
70
75
80
100
120
150
200
250
300
400
500
1000

Offer-Accept Data

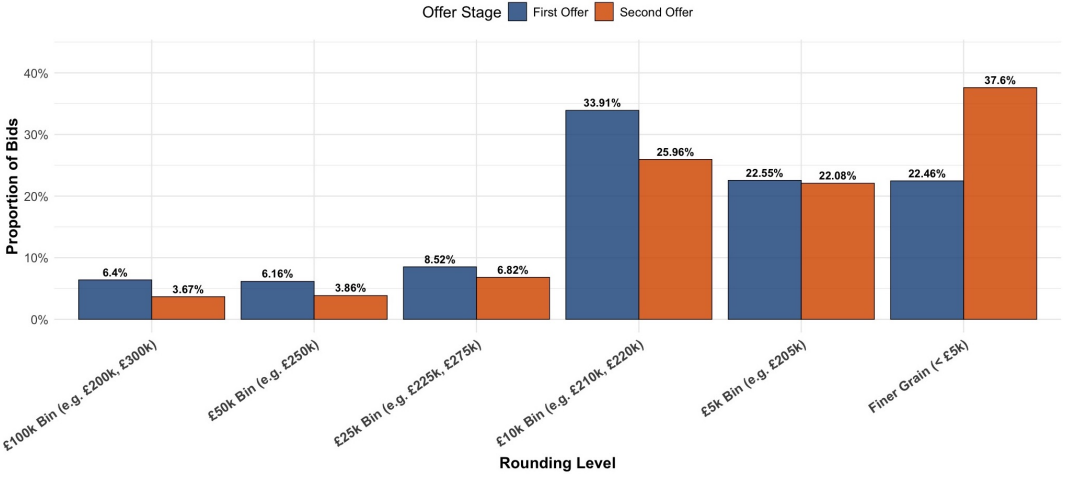
Offer-accept data from a UK real estate agent

- 2nd Jan 2019 to 20th March 2025
- 209,924 properties
- 430,131 bidders
- 653,329 offers
- Mean 2.05 bidders per property
- Mean 3.11 offers per property

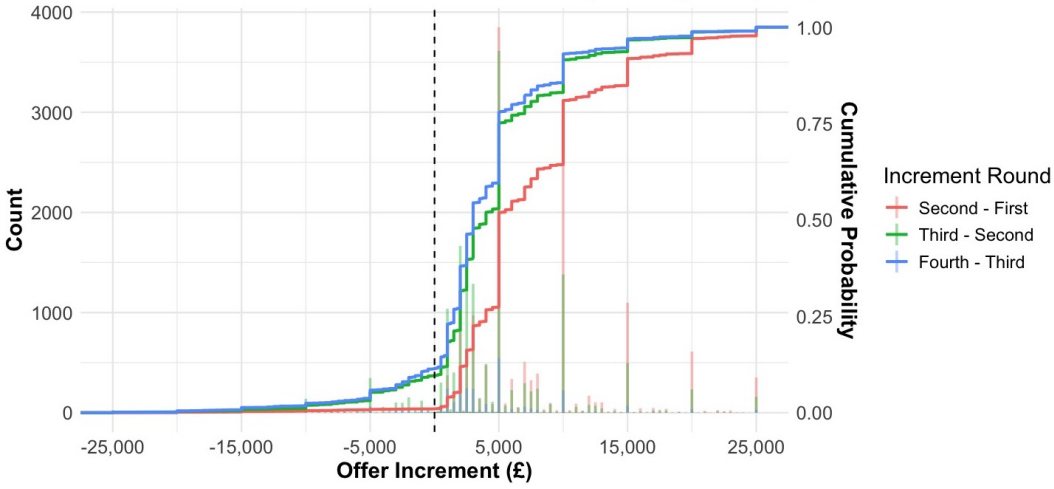
Histogram of offers



Rounding granularity shifts between rounds



The distribution of offer increases



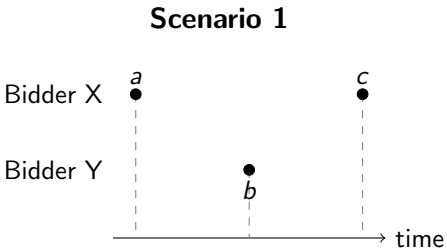
Estimation of offer increases

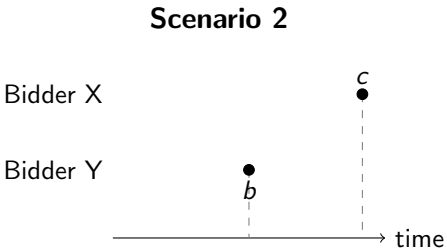
Dependent variable: log(Current Offer/Previous Offer)

	(1)
Second Offer	0.0419***
	(0.0010)
Third Offer	0.0156***
	(0.0003)
Fourth Offer	0.0135***
	(0.0012)
Observations	36,494
R^2	0.01939
Adj. R^2	0.01933

S.E. clustered by Bidder & Property. Sample: all offers with offer number ≤ 4. Signif.: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

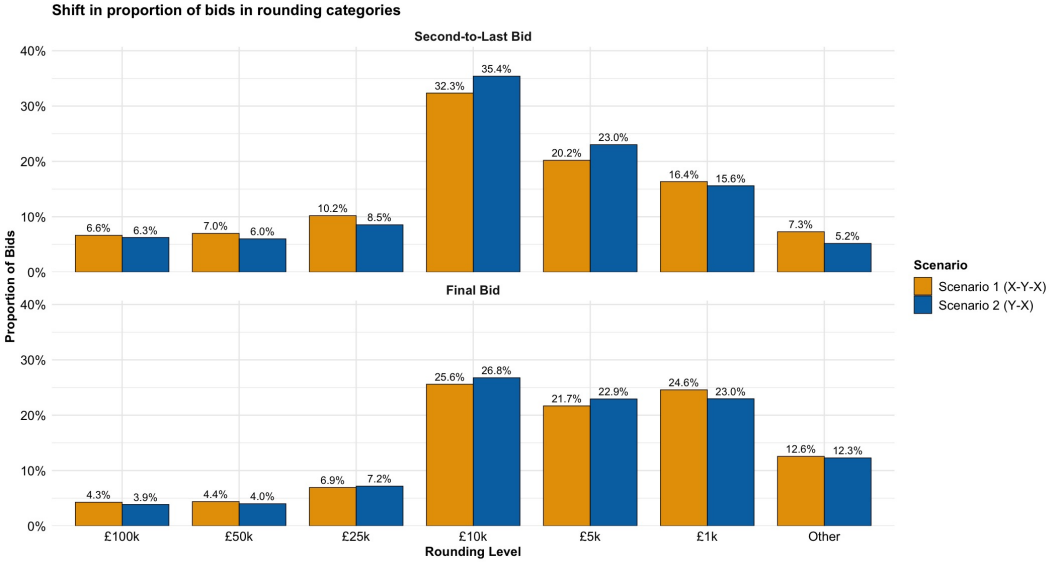
Two Bidding Scenarios





Scenario 2 is as Scenario 1, but missing Bidder X's initial offer *a*

Bid granularity changes



Conclusion

- Valuation is slow compared to choice: pricing a single gamble takes about twice as long as choosing between two, because valuation requires resolving a continuum of possible responses rather than just two
- We have an opening model for estimating the prominence of different numbers, separating the economic pull toward a repayment level from the psychological pull toward round numbers
- We see some evidence for a change in resolution as people make a series of bids: bidders shift toward finer, less rounded numbers as an offer sequence progresses toward a final bid

References I

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