Auctions with Endogenous Rationing

An Experimental Study

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Mannheim, 29.11.2019

Agenda

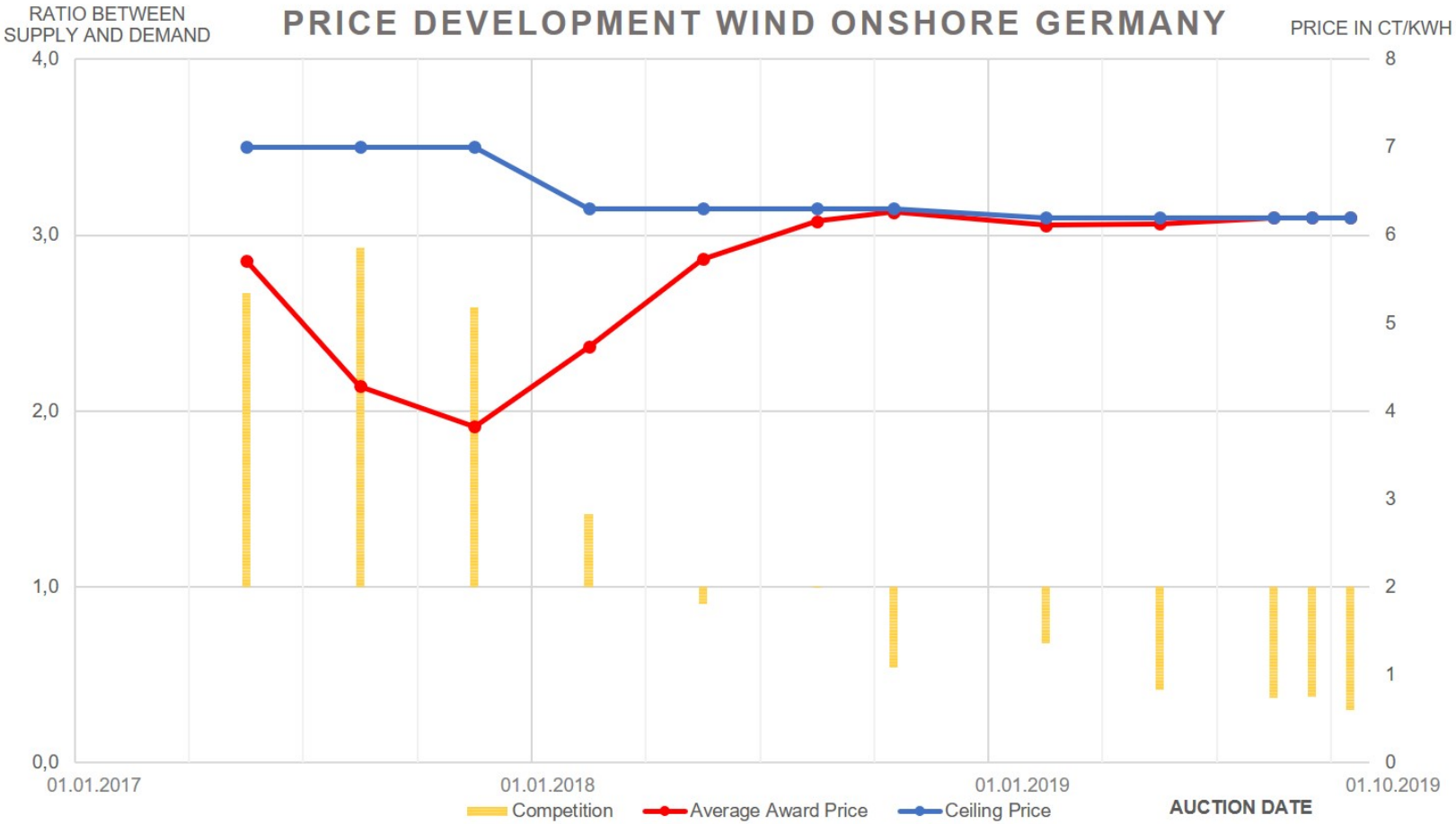
1. Motivation
2. Theoretical Findings
3. Framework & Setting
4. Hypotheses
5. Experimental Results
6. Conclusion & Questions

Background

- EU State Aid Guidelines: Support of Renewable Energies has to be determined by auctions
- Procurement Auctions
- Germany has auctions for Solar PV, Wind Onshore, Biomass (and Wind Offshore)
  - Demand: Volume in capacity (MW)
  - Supply: Price-quantity-bids for renewable energy projects
    - Price per energy unit (ct/kWh)
    - Quantity in capacity (kW)
  - Financial and physical prequalifications
- Research within the Horizon 2020 project AURES II (`aures2project.eu`).

Problem

- The last auctions for Wind Onshore are highly undersubscribed due to a lack of supply
- Coordination of bidders on the ceiling price



Solution Proposal

Endogenous Rationing

Supply-dependent reduction of the awarded volume: the awarded volume is endogenously (ex-post) adjusted to the bid volume or the bid prices

Endogenous Reduction of the Awarded Volume

In case of undersubscription (supply ¡ demand) only a certain percentage (e.g. 80%) of the offered volume is awarded ("80%-Rule").

Endogenous Reduction of the Ceiling Price

The ceiling price is determined by the bids in the previous auction round(s) or the bids in the current auction round.

$\Rightarrow$ Basic idea: Guaranteed competition in the auctions

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Auction-Theoretic Model

- Working paper:
  Ehrhart, K.-M., Hanke, A.-K. & Ott, M. (2019): *A Small Volume Reduction that Melts Down the Market: Auctions with Endogenous Rationing*,
  Karlsruhe Institute of Technology (KIT), Takon GmbH,
  ZEW - Leibniz Centre for European Economic Research, Mannheim, Germany
- Game-theoretic model of an auction for renewable energy support (RES)
  - Announced auction volume (demand volume)
  - Set of single-project bidders (potential supply volume) with heterogenous project realisation costs
  - Homogenous participation costs (due to physical prequalification)
  - Endogenous volume reduction in case of a low supply volume

Bidder's Incentives and Considerations

- A company's choice to participate in the auction i.a. depends on the relationship between the demand volume and the supply volume of its potential competitors.
- In the "standard" auction without endogenous rationing, the weakest bidders (i.e., the bidders with the highest costs and thus the highest bids) will only win if supply does note exceed demand.
- Because of the participation costs (sunk costs), the weakest bidders will only participate in the auction if the event that supply does not exceed demand has a positive probability.

Auction-Theoretic Results

- In the case of endogenous volume reduction, the weakest bidders will never be awarded because the awarded volume will be reduced if supply does not exceed demand.
- As a consequence, the weakest bidders' winning probability is zero. Thus, participating in the auction will always lead to a loss. Therefore, the weakest bidders will not participate.
- Then, the "second weakest" bidders become the weakest bidders and the same argumentation holds for them.
- This results in a downwards spiral of supply.
- In the game-theoretic equilibrium, only a few (or even no) bidders will participate.

General Framework

- Two treatments
  - Control treatment: "standard" procurement auction without endogenous rationing
  - Endogenous rationing treatment: procurement auction with endogenous volume reduction
- Subjects: 144 students at KD2Lab Karlsruhe
- 8 sessions overall with each 18 participants (4 sessions for each treatment)
- Programming via oTree[1]

[1] Chen, Daniel L., Martin Schonger, and Chris Wickens. "oTree—An open-source platform for laboratory, online, and field experiments." Journal of Behavioral and Experimental Finance 9 (2016): 88-97.

Experiment Setting

- Repeated auction (15 rounds)
- "Half-stranger setting": Out of the set of 18 participants 2 groups of 9 are formed each round. Thus, the group composition changes in each round.
- In each auction, 9 single-project bidders participate who
  - have the same participation costs but different project realisation costs,
  - decide on their participation in the current auction round and, if they participate, on their bid.
- Number of awards differs between treatments:
  - Control: Maximal 6 bids are awarded. If less than 6 bidders submit a bid, all bids are awarded.
  - Endogenous rationing: If 8 or 9 bidders submit a bid, 6 bids are awarded. If 7 or less bidders submit a bid, 2 bids less than submitted are awarded.

Parameters

- Participation costs 5 ExCU
- Independent private signals (realisation costs) uniformly distributed (i.i.d.) between 50 and 75 ExCU
- Bid allowed between 0 and 77 ExCU
- Pay-as-Bid auction
- Bidder's Profit
  - Award: Profit = Bid - Realisation Costs - Participation Costs
  - Non-Award: Profit = - Participation Costs
- Payment consists of three parts
  - Fixed amount of 8 €
  - Average profit of 5 randomly selected rounds (1 ExCU = 0,50 €)
  - Payment resulting from risk-aversion test at end of experiment

Hypotheses

Four Hypotheses

1. Lower number of bids in endogenous rationing treatment
2. Lower price level in endogenous rationing treatment
3. Lower auctioneer's surplus in endogenous rationing treatment
4. Higher social costs/ lower social welfare in endogenous rationing treatment

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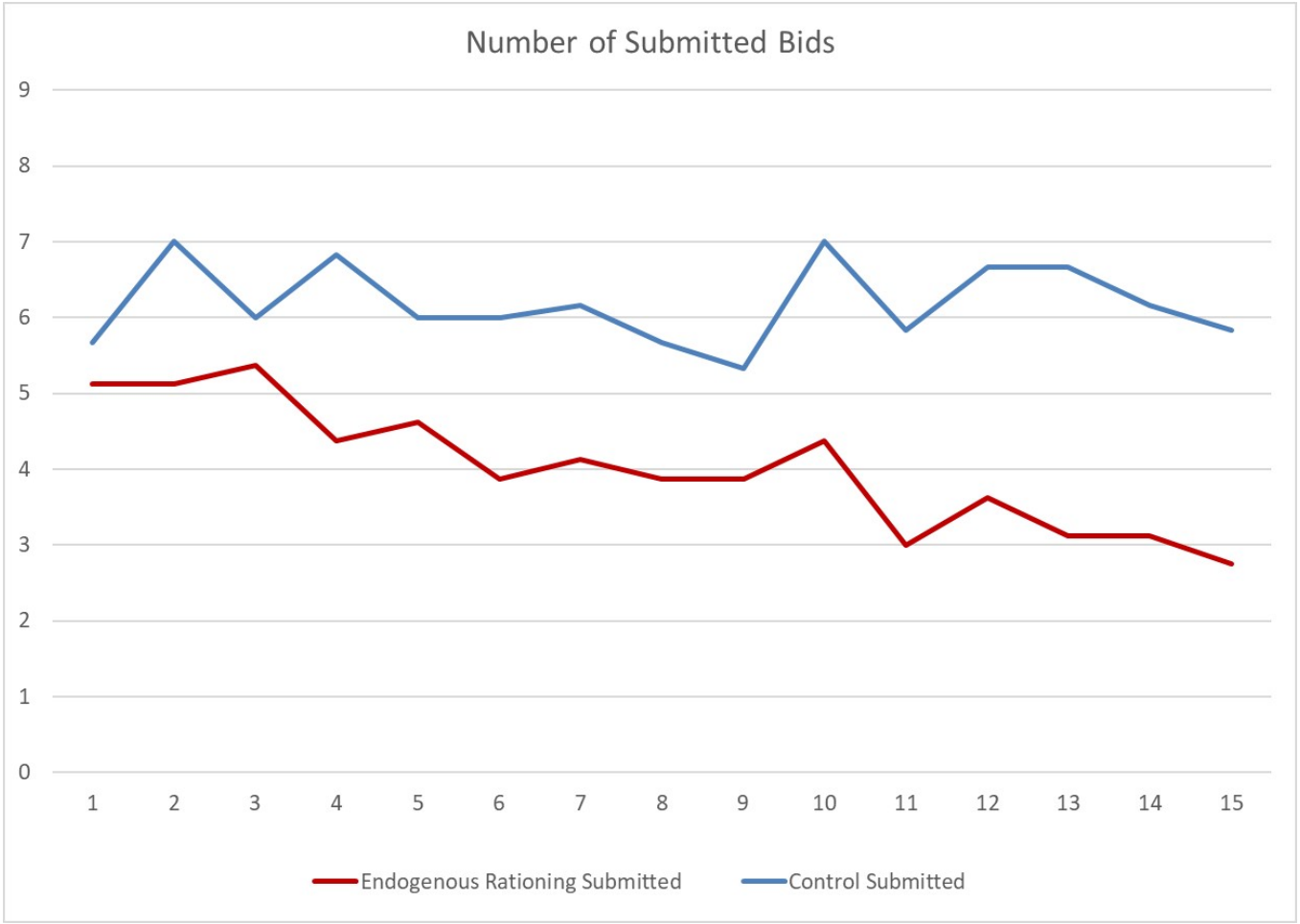
Number of Bids



- Significant difference between treatments.
- Significant decrease in endogenous rationing treatment.

▸ Test Submitted Bids ▸ Test Awarded Bids

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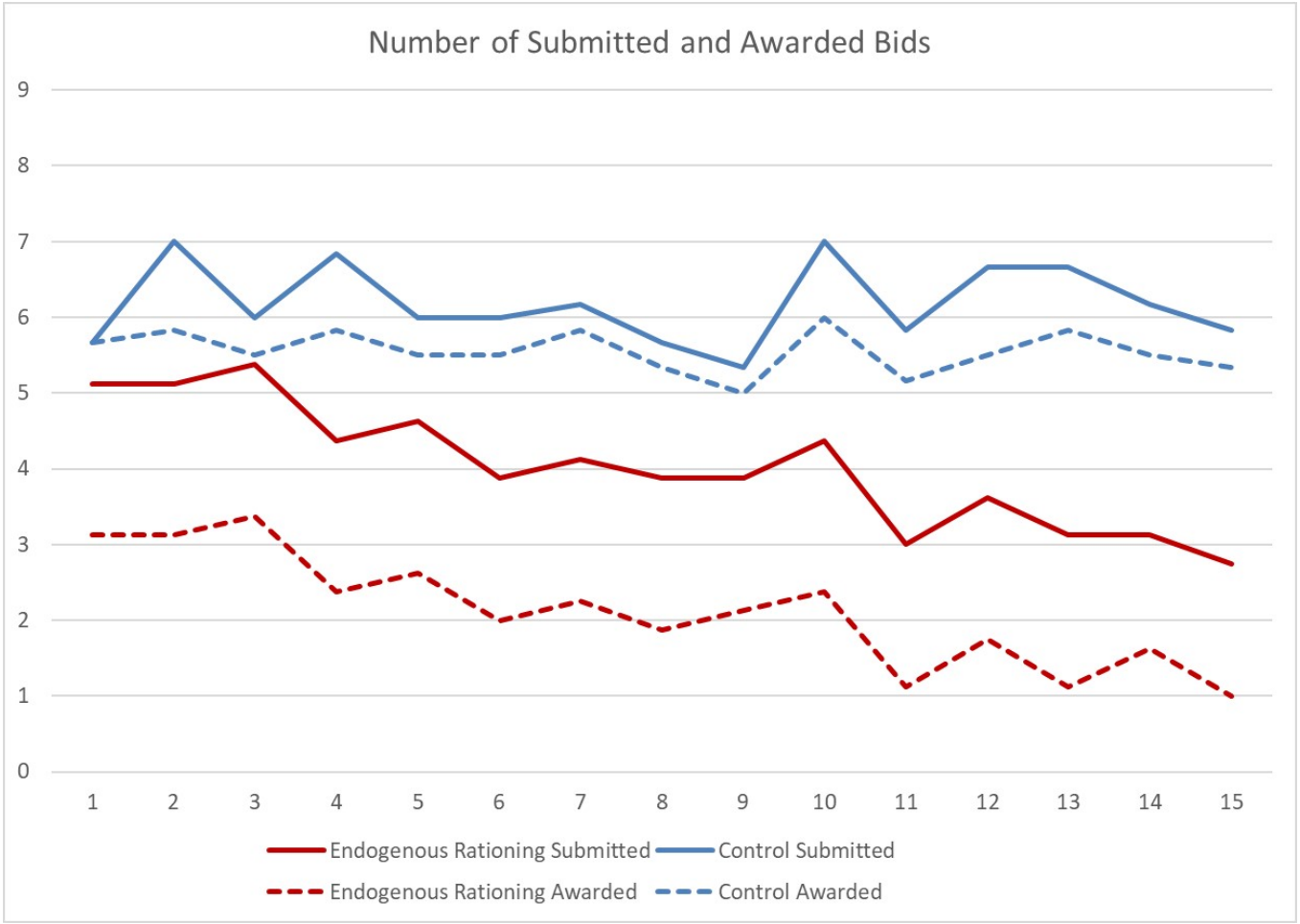

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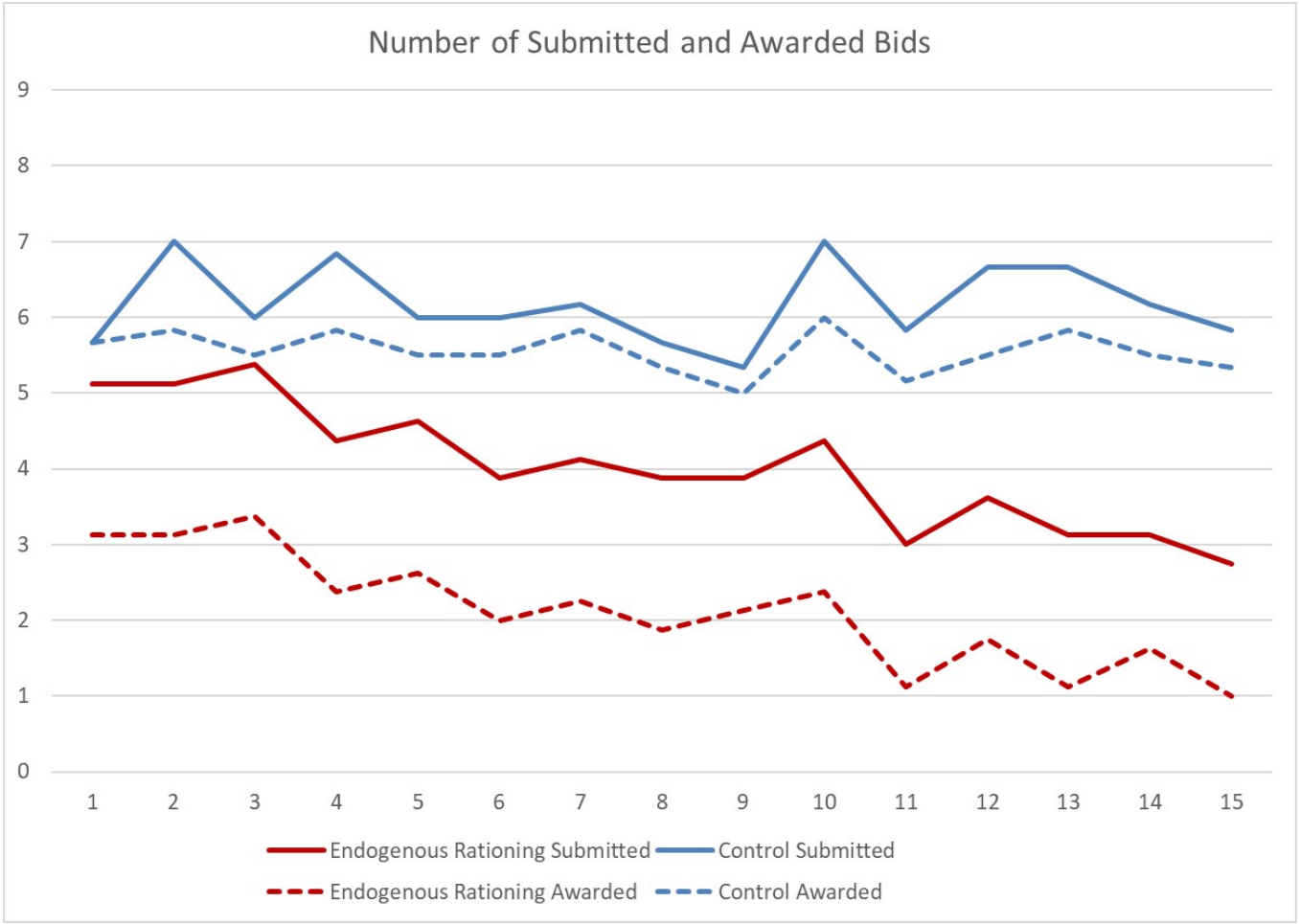

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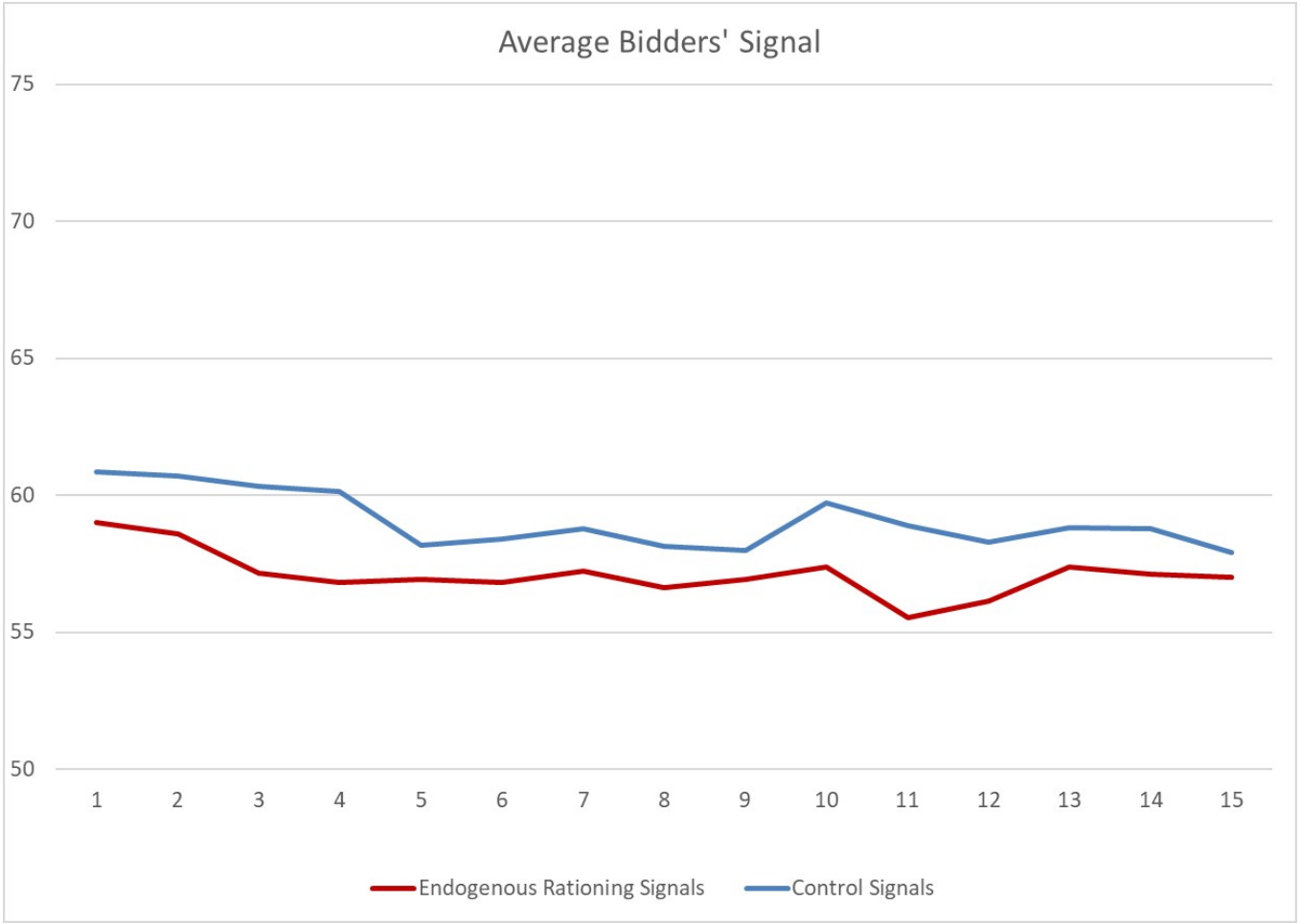
Signals (Realisation Costs) and Bids



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Test Participation Signals | Test Average Bids | Figure Bid-Shading

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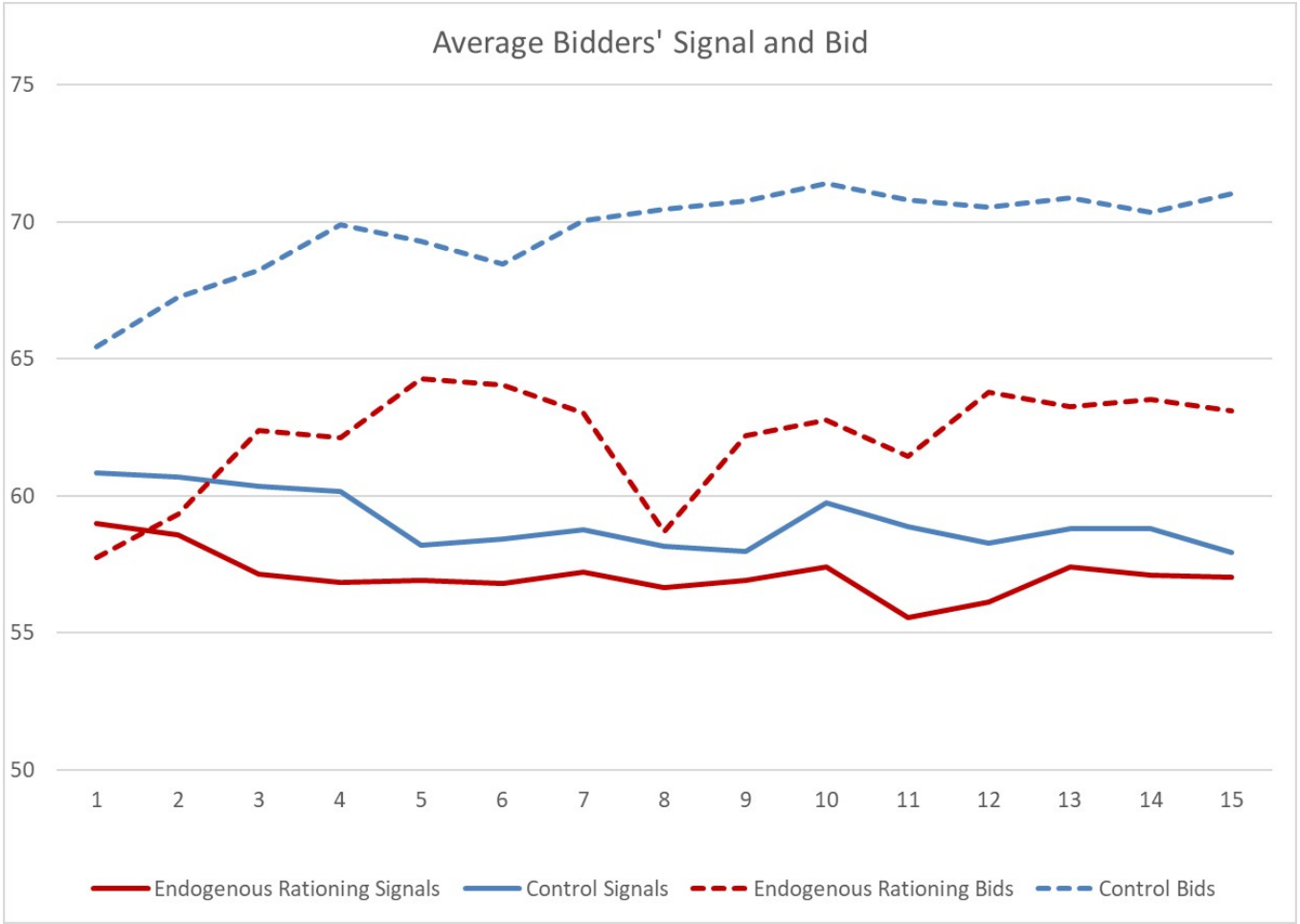

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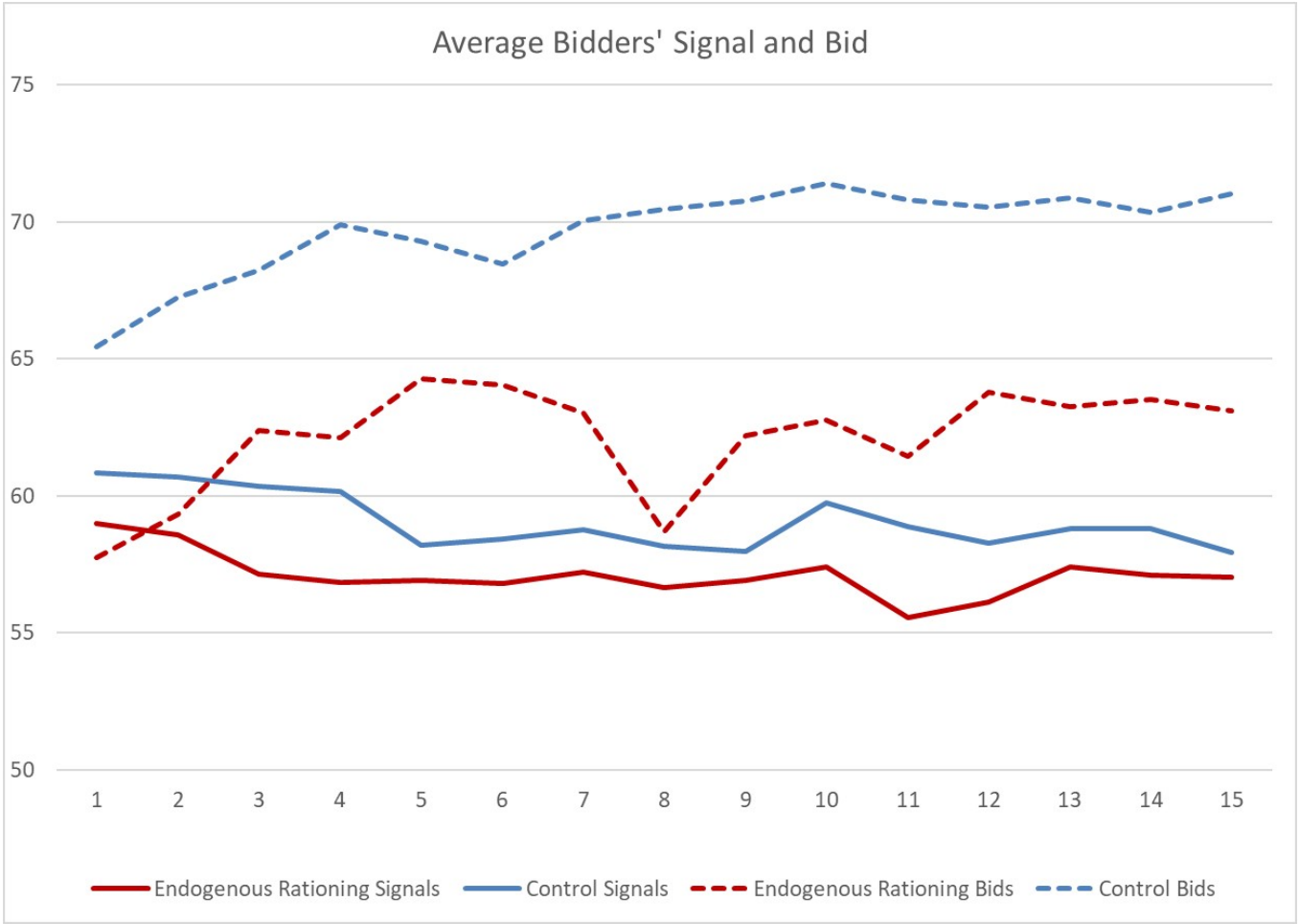

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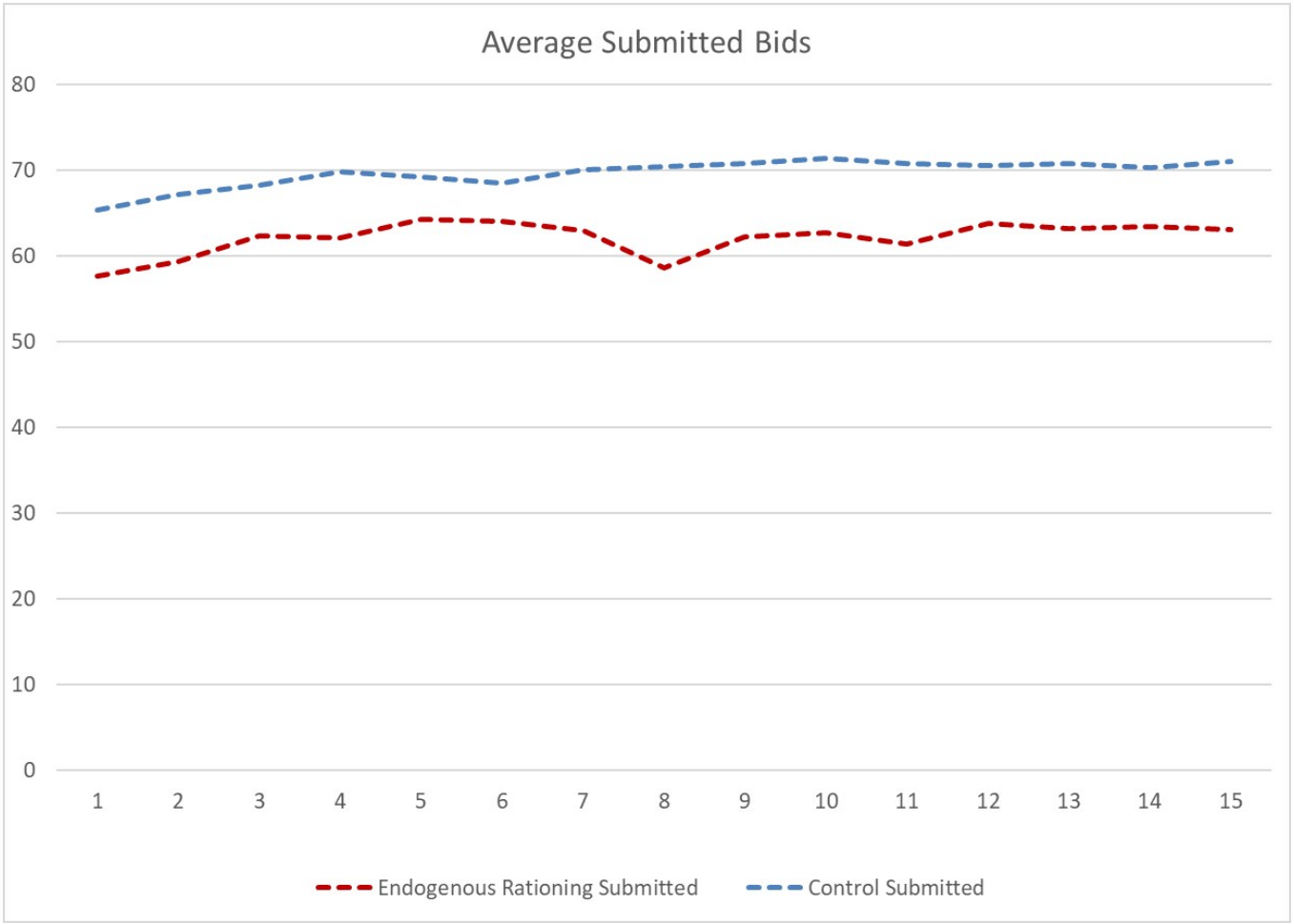
Average Awarded Bids



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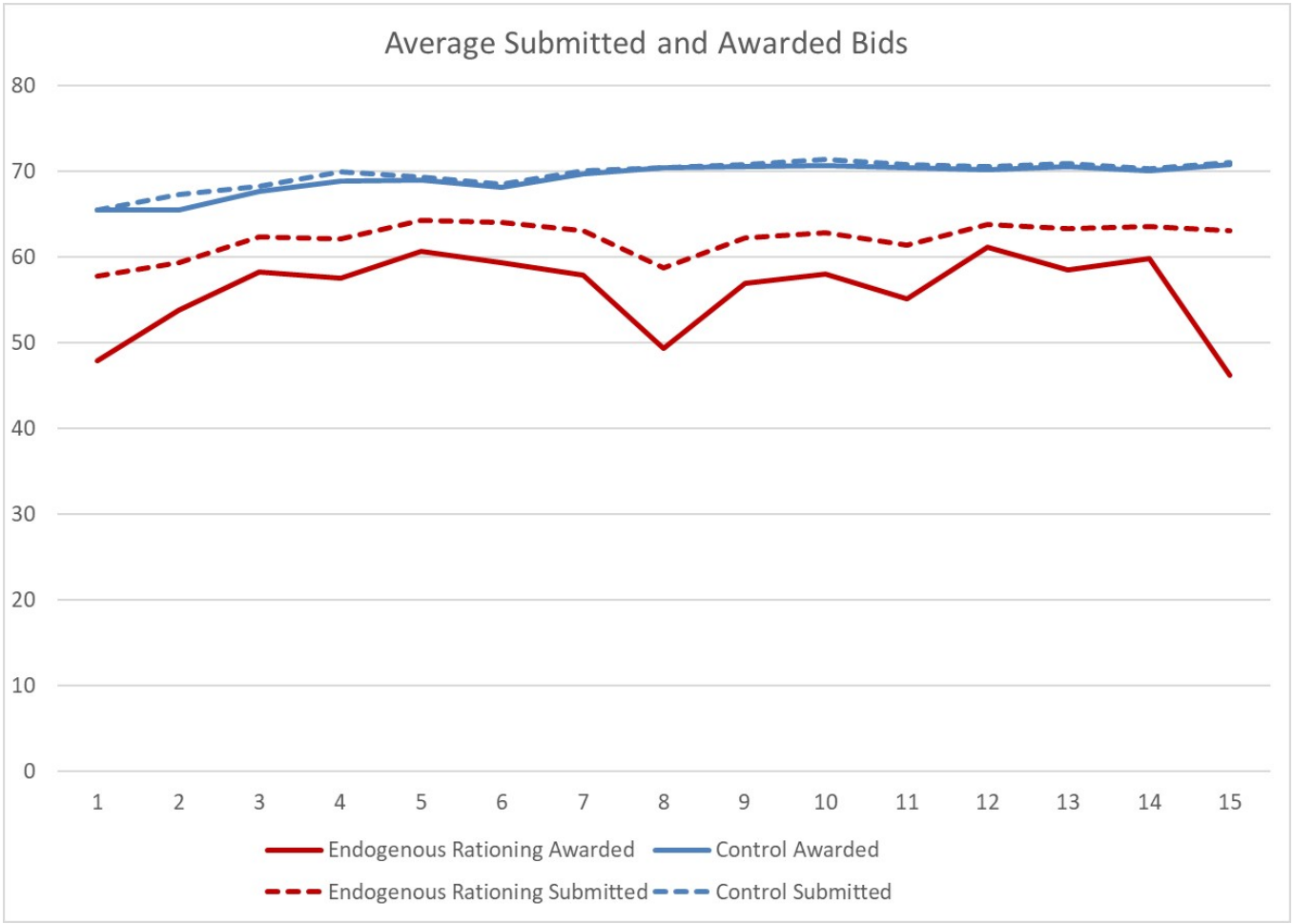

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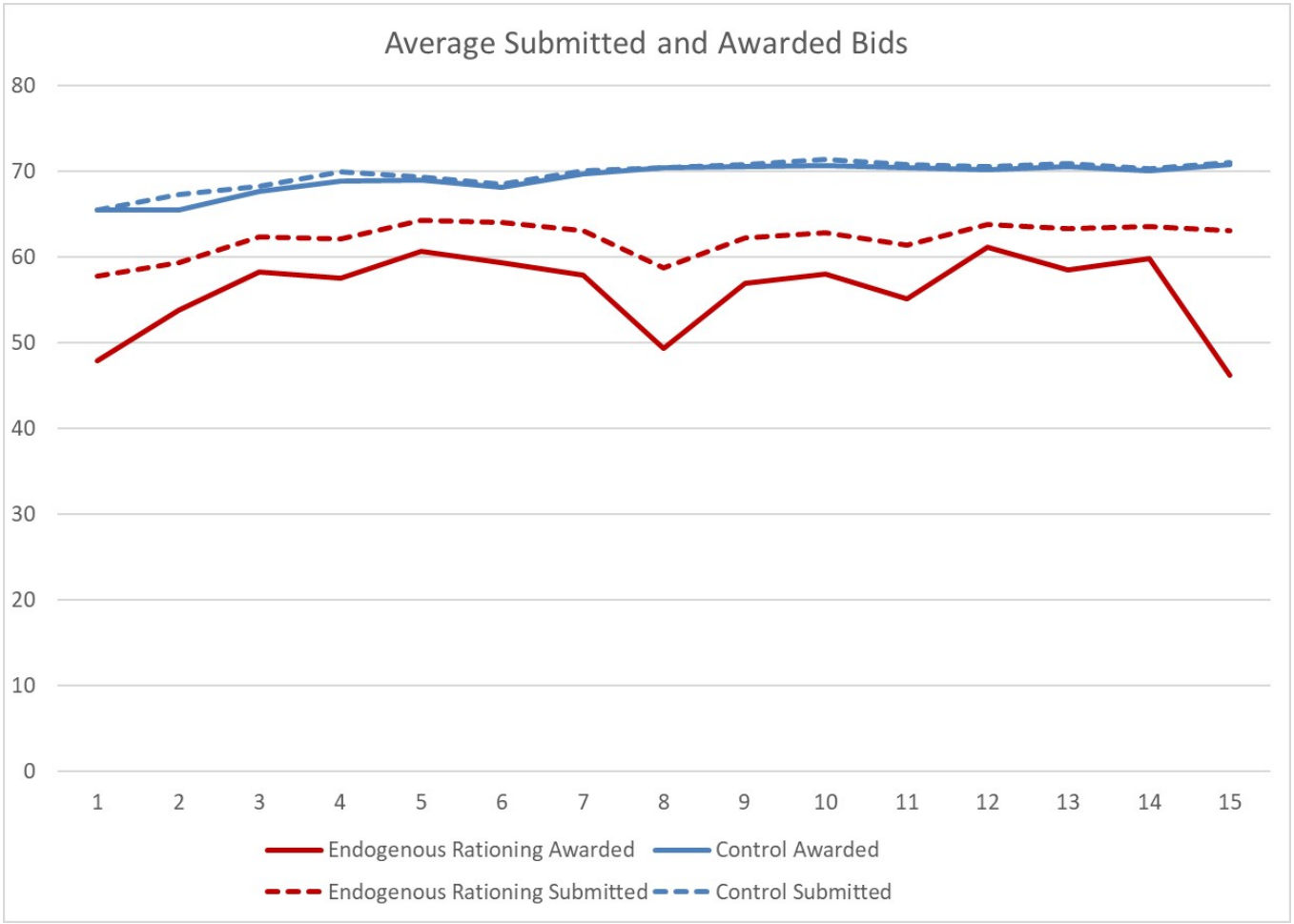

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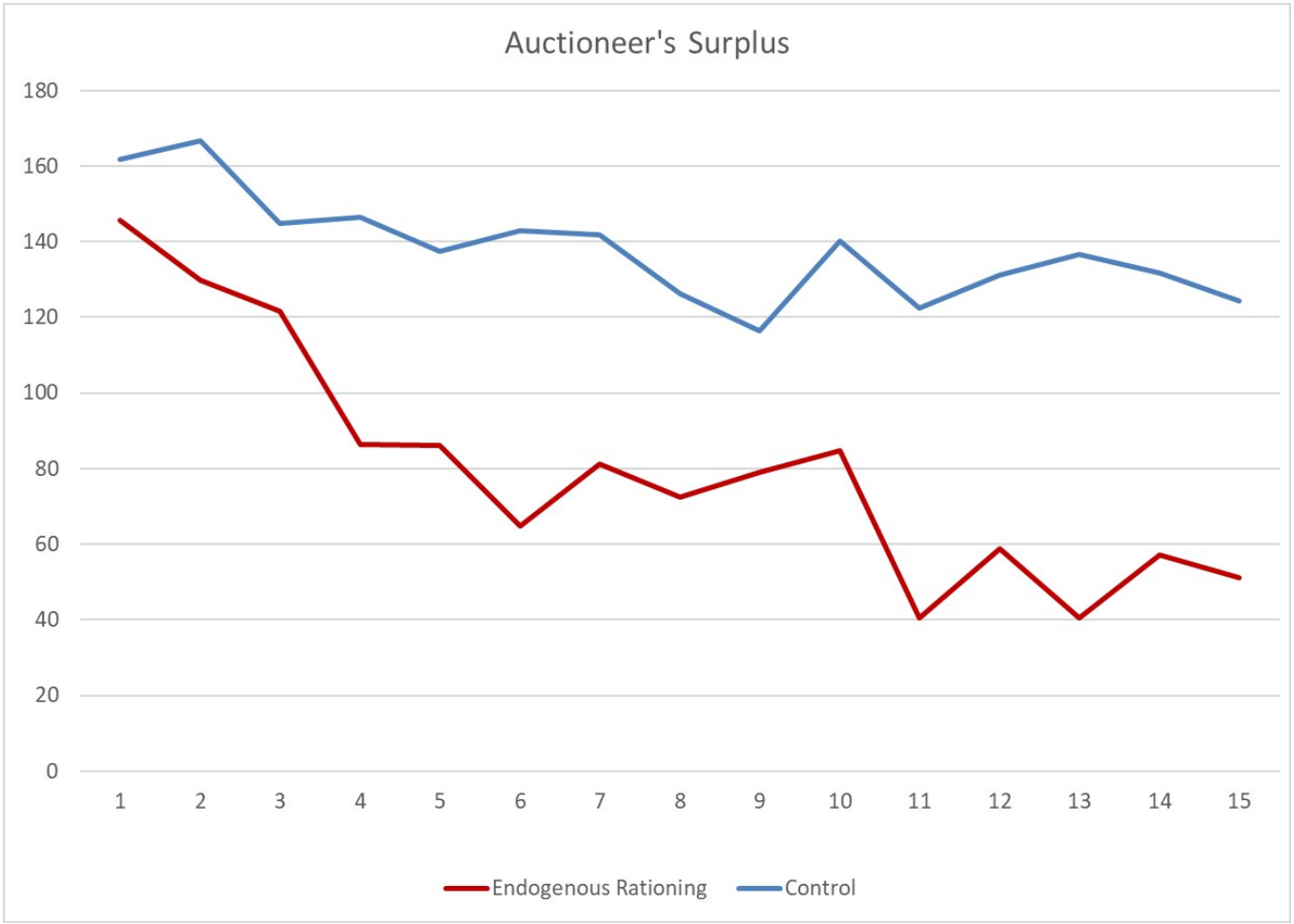
Auctioneer's Surplus



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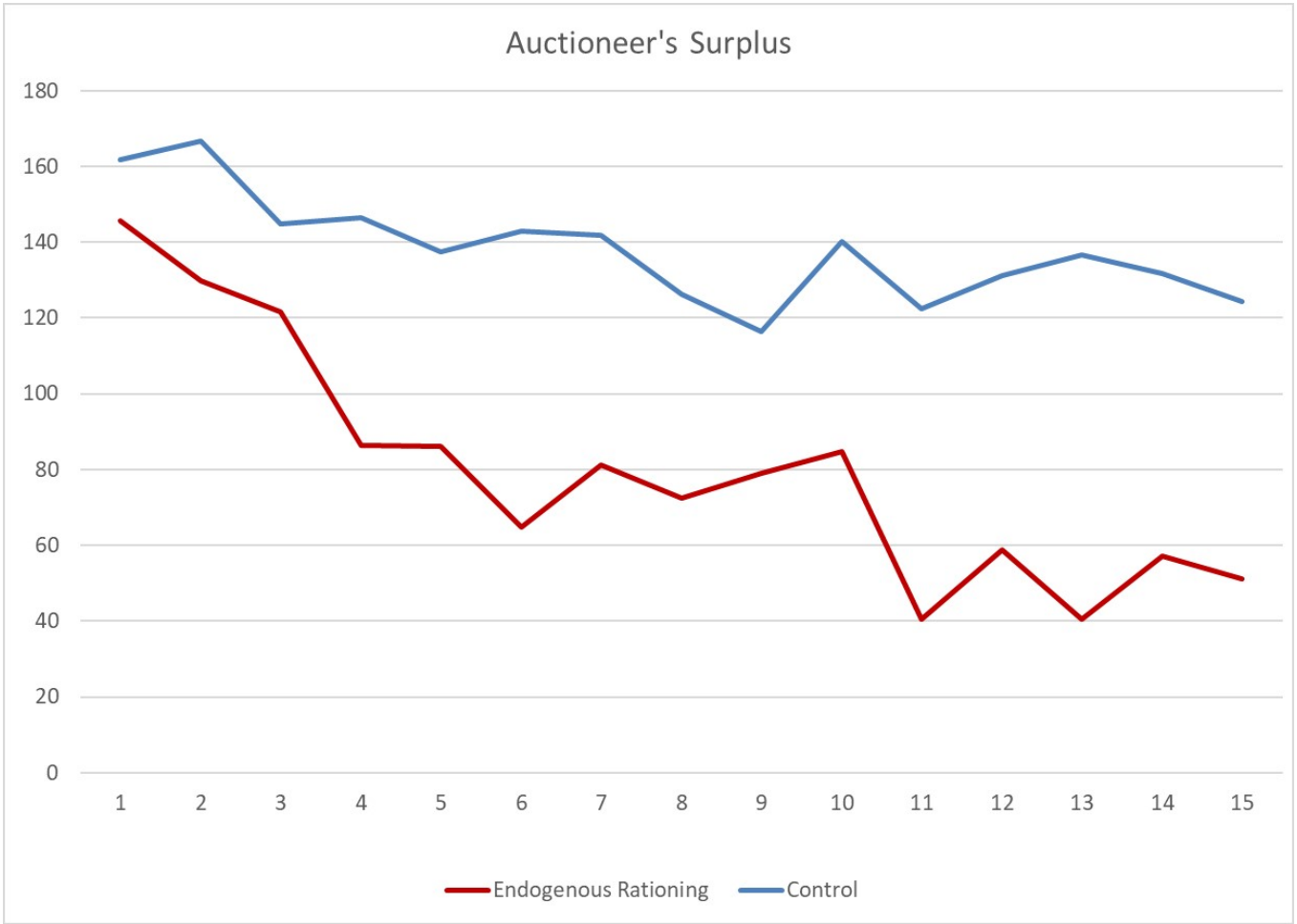

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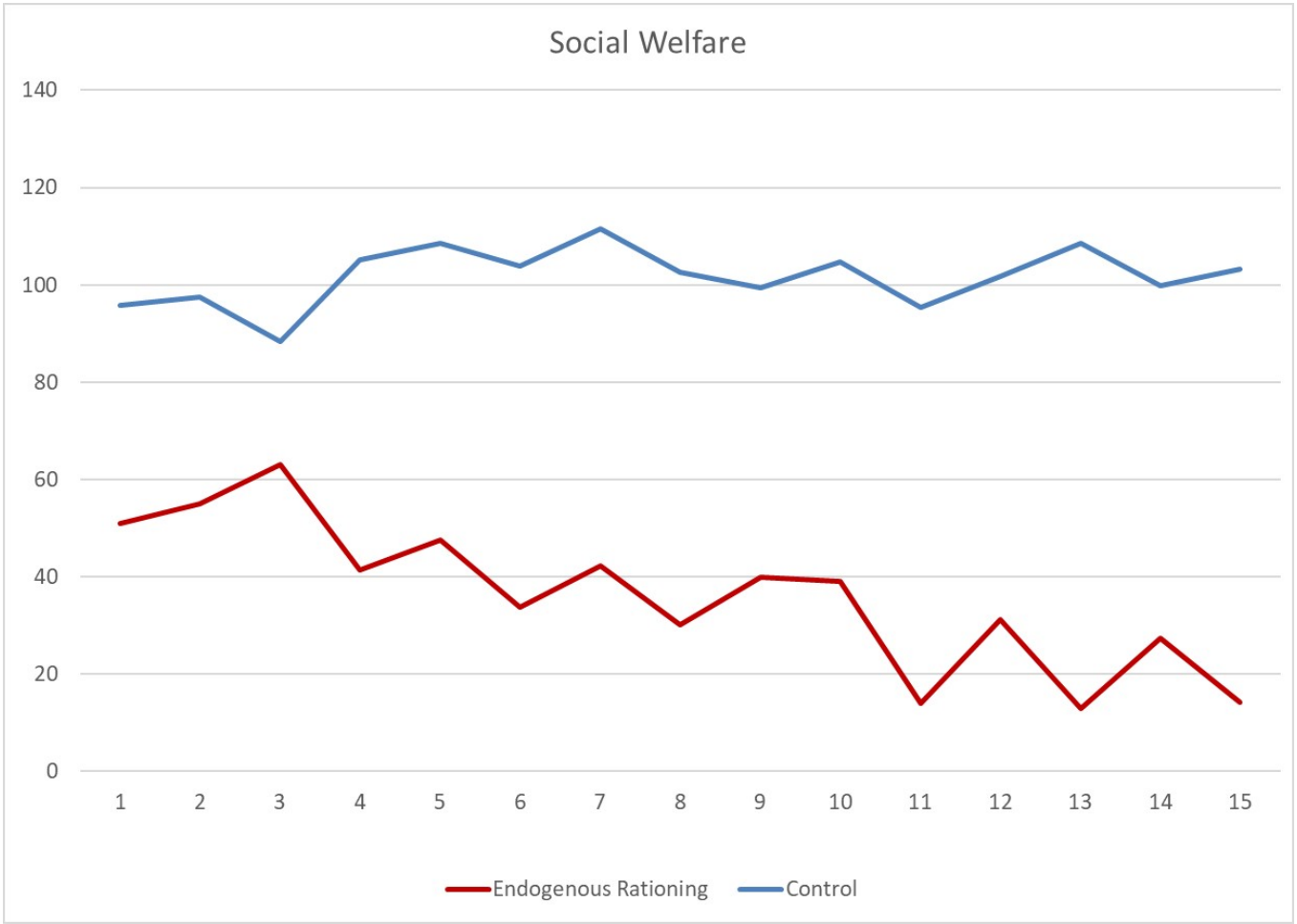
Social Welfare



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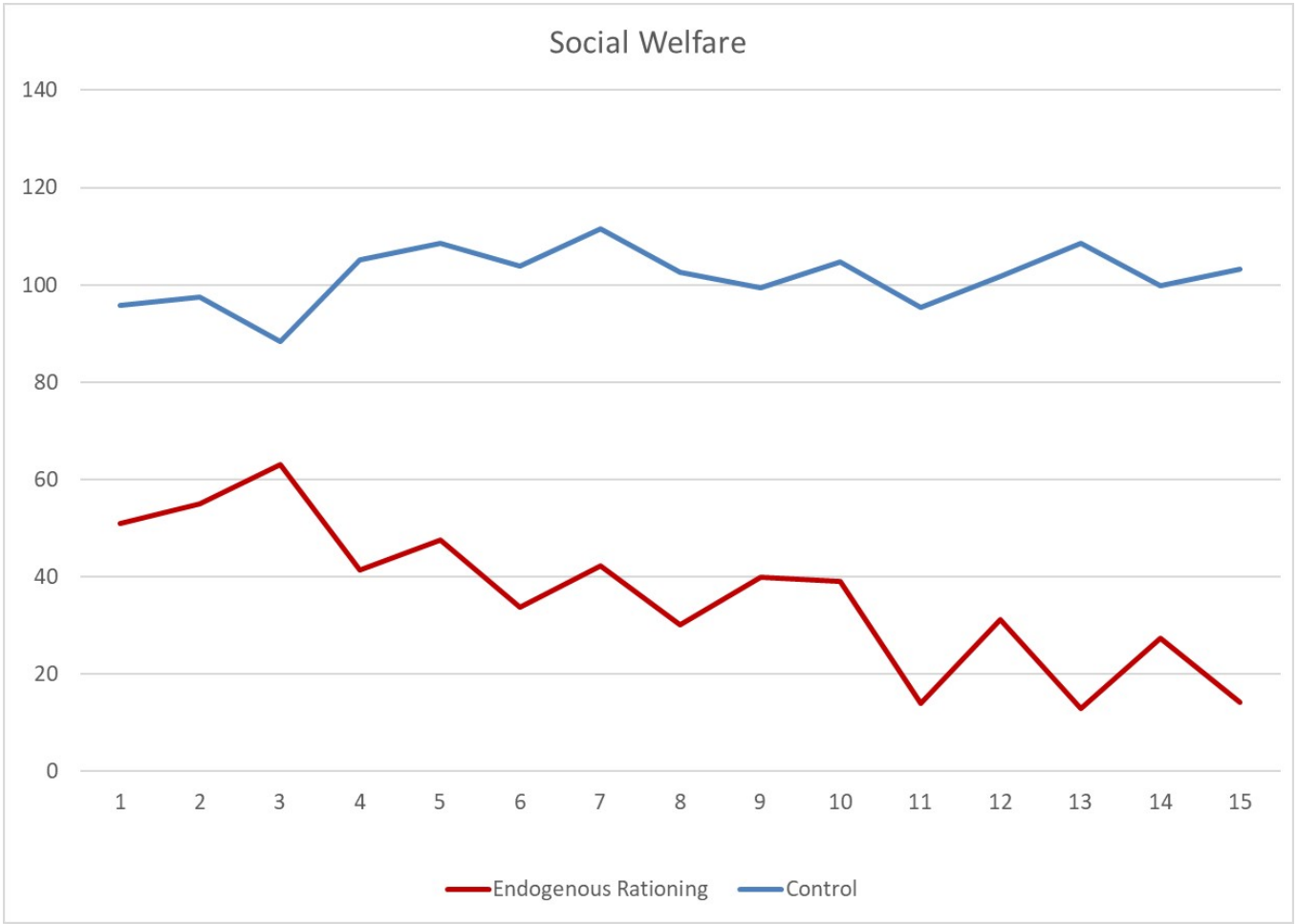

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- Significant decrease in endogenous rationing treatment.

▸ Test Social Welfare

Conclusion

Overview Results

- All hypotheses are supported by the experimental results.
- Subjects in control treatment play very close to theoretic equilibrium.
- Subjects in endogenous rationing treatment approach the theoretic equilibrium during the 15 rounds.

Further Research

- Comments on the experiment?
- Comments on possible extensions?

Thank you for your attention!

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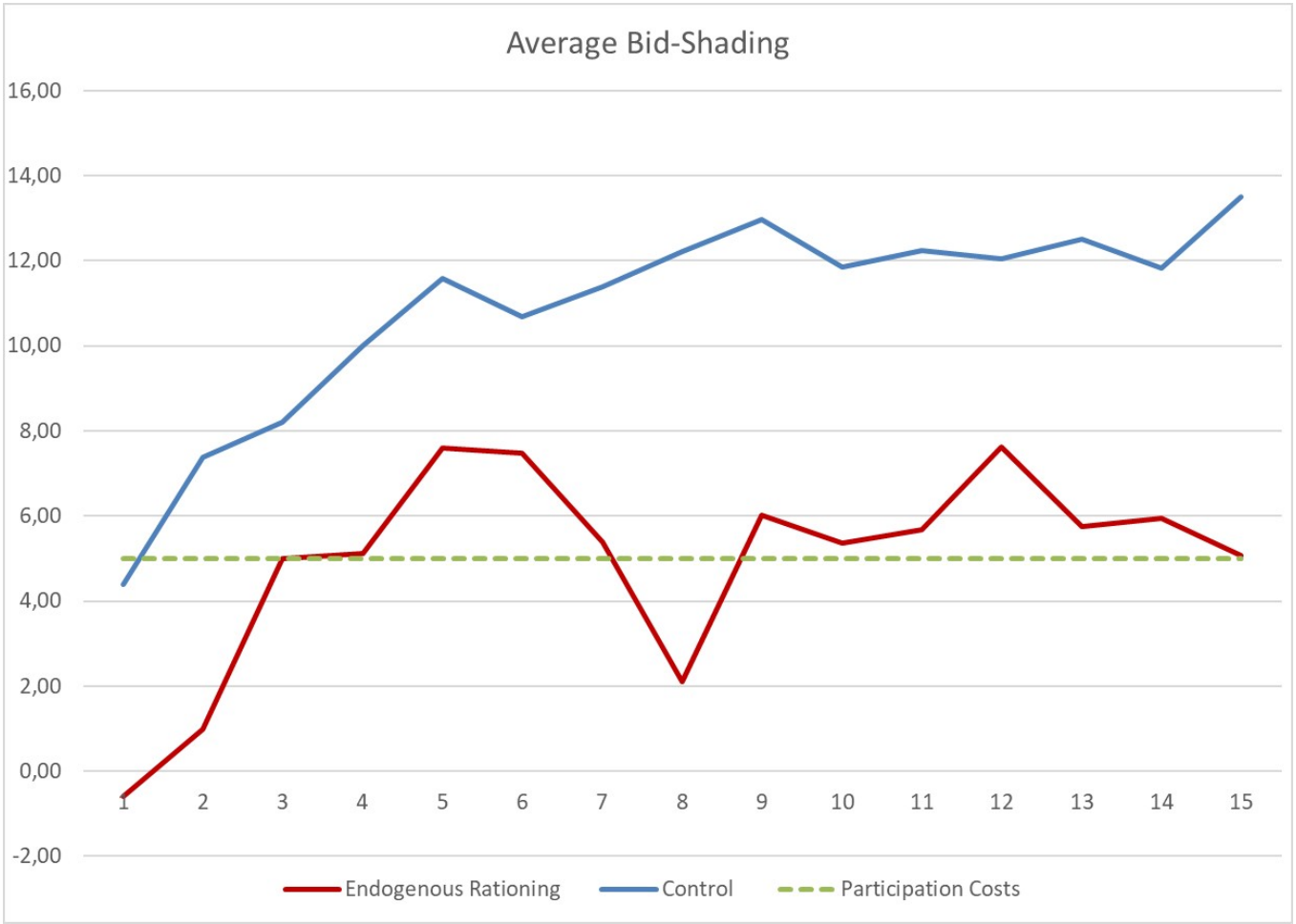
Karlsruhe Institute of Technology

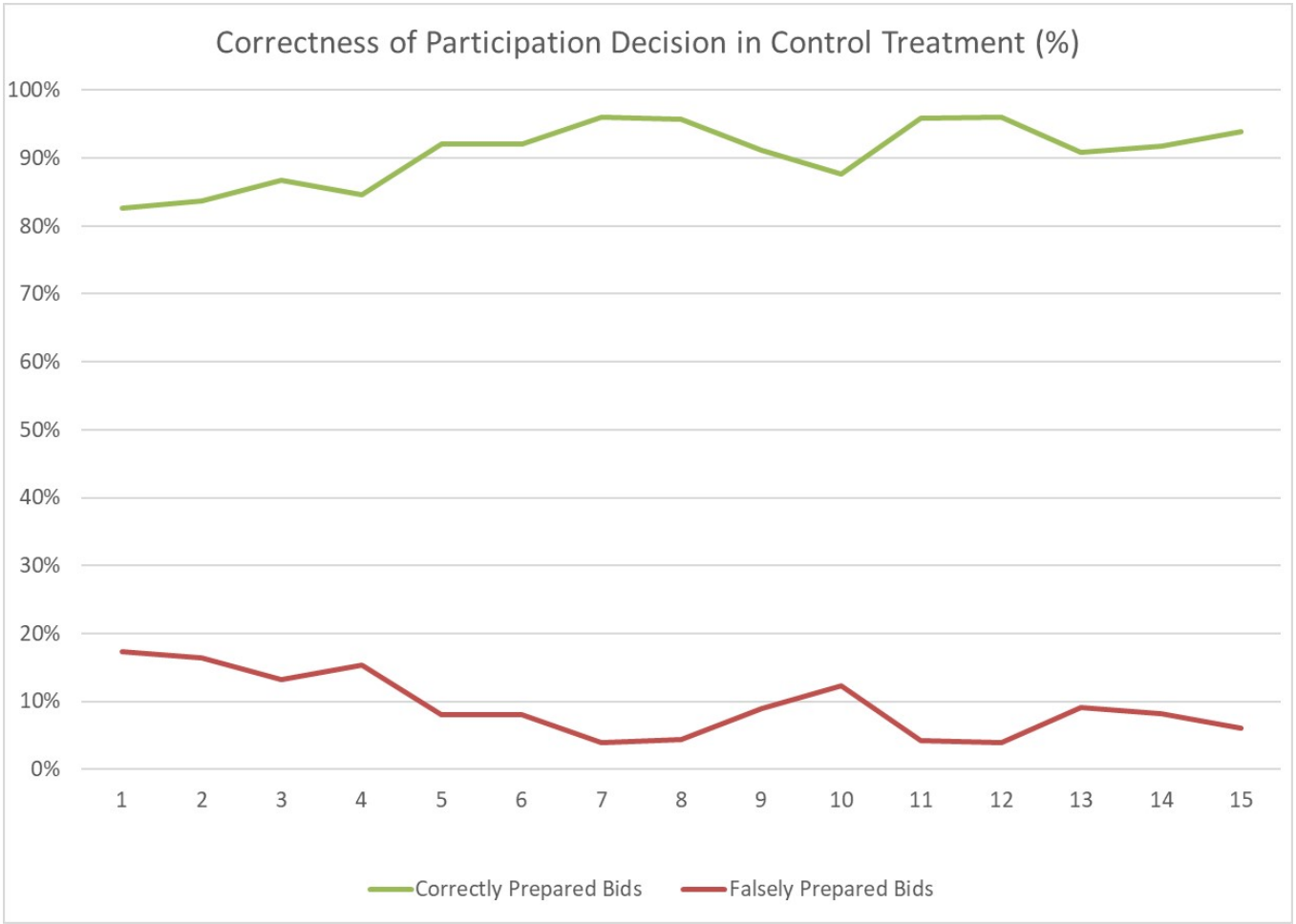
Institute of Economics (ECON)
Research Group Strategic Decisions

Backup - Bid-Shading

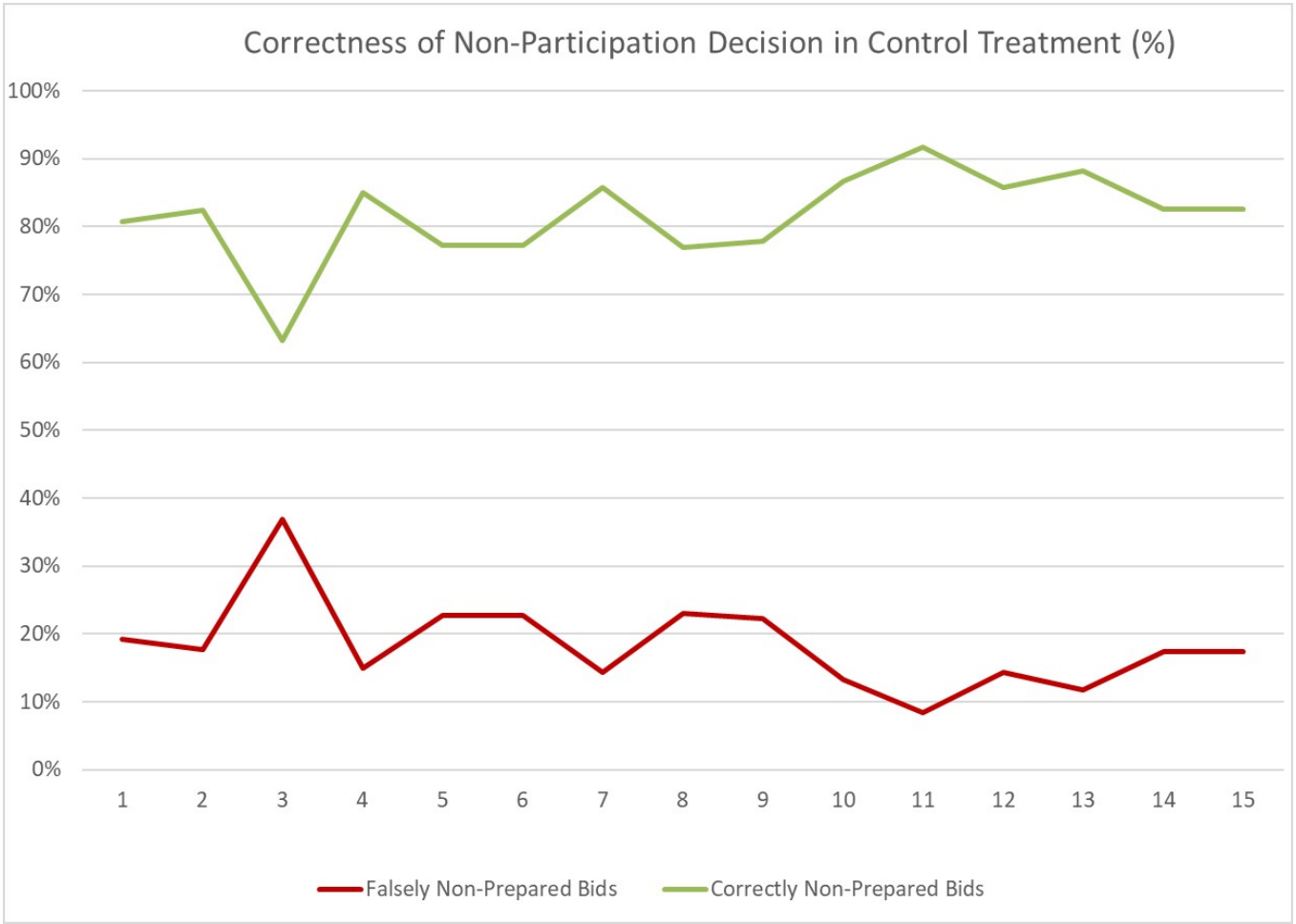


▸ Figure Signals and Bids ▸ Test Bid-Shading

Backup - Participation I



Backup - Participation II



Backup - Test Number Submitted Bids

```
Formula: V1 ~ treatment + subsession.round_number + (1 | group.id)
Fixed effects:
##                            Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)                 6.99226    0.31543   25.57487  22.167  < 2e-16
## treatmentDynamic           -2.28333    0.38294   14.00000  -5.963 3.47e-05
## subsession.round_number    -0.08549    0.02022  223.00000  -4.227 3.45e-05
##
## (Intercept)                ***
## treatmentDynamic           ***
## subsession.round_number    ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Number Bids

Backup - Test Number Awarded Bids

```
Formula: V1 ~ treatment + subsession.round_number + (1 | group.id)
##    Data: data.avg
Fixed effects:
##                            Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)                 6.26548    0.25919  22.54944  24.173  < 2e-16
## treatmentDynamic           -3.50833    0.32500  14.00000 -10.795 3.59e-08
## subsession.round_number    -0.07902    0.01498 223.00000  -5.274 3.16e-07
##
## (Intercept)                ***
## treatmentDynamic           ***
## subsession.round_number    ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Number Bids

Backup - Test Signals

```
Formula:
## player.is_prepared ~ treatment * subsession.round_number +
player.realization_cost +
##     (1 | group.id) + (1 | participant.code)
Fixed effects:
##                                            Estimate Std. Error z value
## (Intercept)                                29.95056    1.50235  19.936
## treatmentDynamic                           -1.48483    0.48193  -3.081
## subsession.round_number                    -0.01934    0.02452  -0.789
## player.realization_cost                    -0.44223    0.02185 -20.239
## treatmentDynamic:subsession.round_number -0.13532    0.03523  -3.841
##                                            Pr(>|z|)
## (Intercept)                                 < 2e-16 ***
## treatmentDynamic                           0.002063 **
## subsession.round_number                    0.430180
## player.realization_cost                     < 2e-16 ***
## treatmentDynamic:subsession.round_number 0.000122 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Signals and Bids

Backup - Test Bids

```
Formula: V1 ~ treatment + subsession.round_number + (1 | group.id)

Fixed effects:
##                           Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)                52.5736     2.3692  26.5202  22.191  < 2e-16 ***
## treatmentDynamic          -21.2871     2.8494  14.0000  -7.471 3.01e-06 ***
## subsession.round_number    -0.4399     0.1558 223.0000  -2.824  0.00518 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Signals and Bids

Backup - Test Awarded Bids

```
Formula:
## player.bid ~ treatment + subsession.round_number + (1 | group.id) +
##     (1 | participant.code)
Fixed effects:
##                            Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)                66.36772    0.90820  74.58237  73.076  < 2e-16
## treatmentDynamic          -10.15386    1.22648  58.31585  -8.279 2.01e-11
## subsession.round_number     0.38145    0.05369 799.41883   7.104 2.68e-12
##
## (Intercept)                ***
## treatmentDynamic           ***
## subsession.round_number    ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Awarded Bids

Backup - Test Auctioneer's Surplus

```
Formula: Auct.rent ~ Treatment + Round + (1 | Group)

Fixed effects:
##                   Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)       173.5633    14.2203   7.9573  12.205 1.97e-06 ***
## TreatmentDynamic -59.4706    18.7528   6.0285  -3.171   0.0192 *
## Round             -4.2621     0.6093 108.2148  -6.995 2.30e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Auctioneer's Surplus

Backup - Test Social Welfare

```
Formula: Social.welfare ~ Treatment + Round + (1 | Group)
##    Data: Welfare
Fixed effects:
##                   Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)       113.5648     7.2959   9.0068  15.566 8.11e-08 ***
## TreatmentDynamic -66.2654     9.3268   6.0402  -7.105 0.000379 ***
## Round             -1.3863     0.3702 108.3142  -3.744 0.000292 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Social Welfare

Backup - Test Bid-Shading

```
Formula: value ~ treatment + round + (1 | group)
Fixed effects:
##                    Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)         6.15225    0.77081    9.01924   7.981 2.23e-05 ***
## treatmentDynamic   -5.46782    0.98445    6.00000  -5.554  0.00144 **
## round               0.17721    0.04138 2151.00000   4.283 1.93e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

▸ Figure Bid-Shading