Endogenous Joint Venture Formation in Procurement Auction

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Joint Venture in Procurement Auction

Difficult construction and cost synergy

- Infrastructure construction requires:
    - Money : e.g. Highway construction needs 5 billion/km
    - Technology : earthquake resistance building (in particular in Japan)
    - Local expertise : local geographical survey, history, etc
- Few companies have all of them

  → Bidding and working together: This group is called Joint Venture (JV)
- Like merger, we expect cost synergies by forming a JV

Motivation

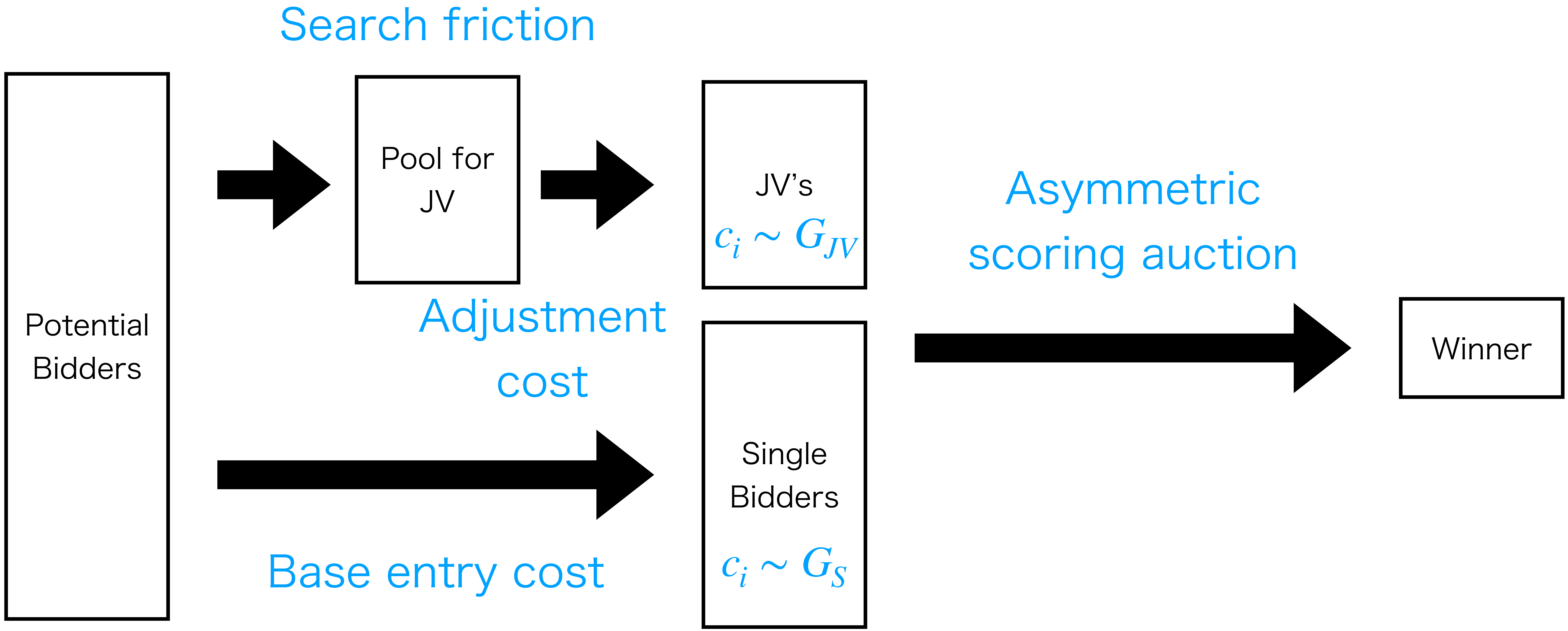
- Few JV's appear in procurement while JV's are strong in average.
    - 24% of auctions have at least one JV in our data
    - 5% of bids are joint bids in Austria (Gugler et al. 2021)
- Should we promote joint venture in procurement auction?
    - We also expect anti-competitrive effects of JV:
        - Decreasing the number of bidders and lowering the incentive to entry
- How can we promote?
    - What hinders JV formations?

Our Work

Modeling and Policy Implication

- Build a structural model of endogenous JV formation + Auction
    - Free of a specific group formation protocol such as bargaining process
- Estimate the model using data on the Japanese procurement auctions
    - Decompose the obstacles in JV formation:
        - Search friction and adjustment cost
- Simulate the alternative policy: Mild promotion is the key to success
    - More JV → Less incentive to entry of single bidder → Less efficiency

Model Structure



Model

Asymmetric Scoring Auction

Scoring Auction

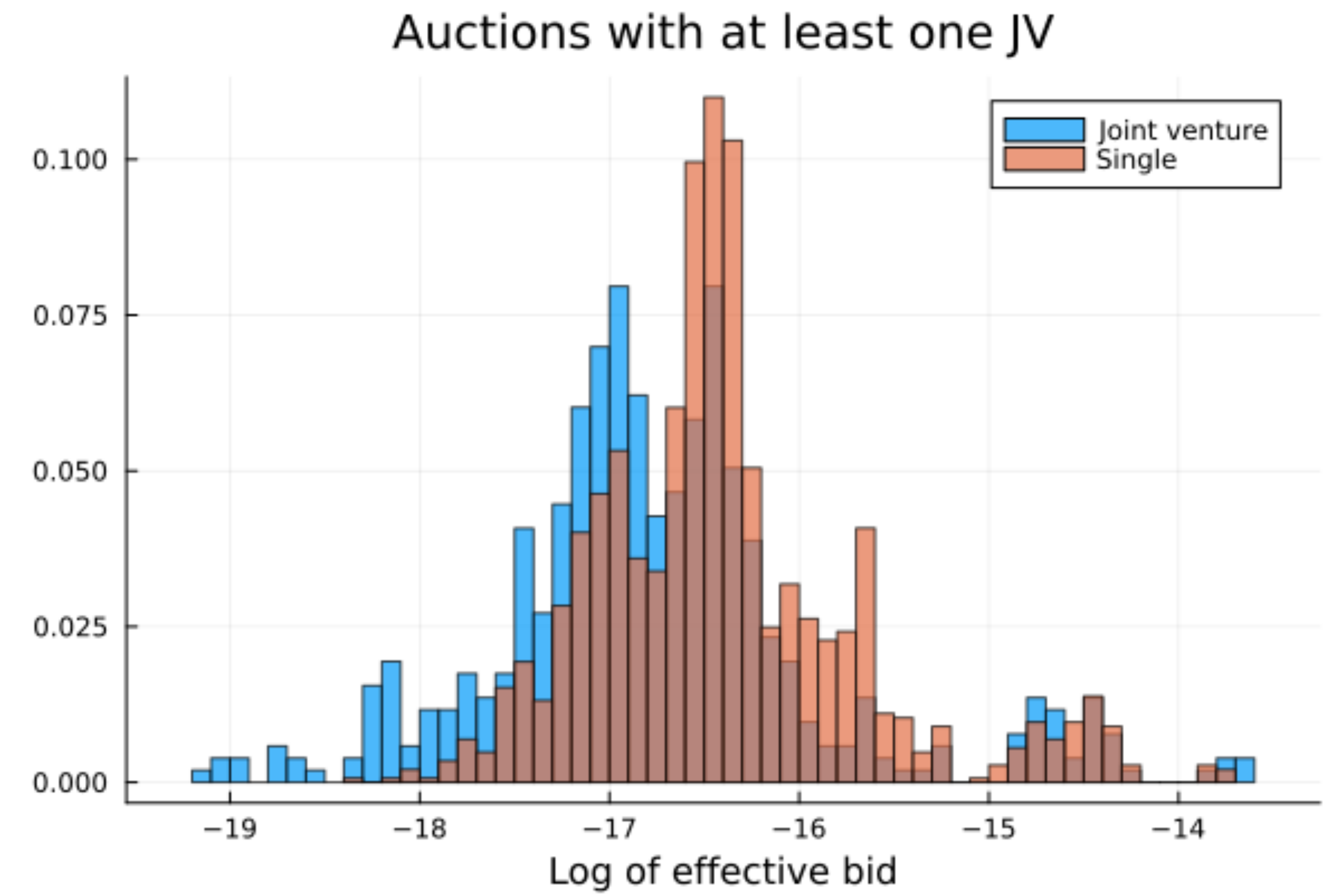
- A winner of an auction is determined by submitted bids and scores
    - The score of the firm is based on the firm’s attributes and project's characteristics:
        - e.g. past experience/performance, size, number of engineers, etc
- The firm with the highest effective bid wins where the effective bid of firm i is

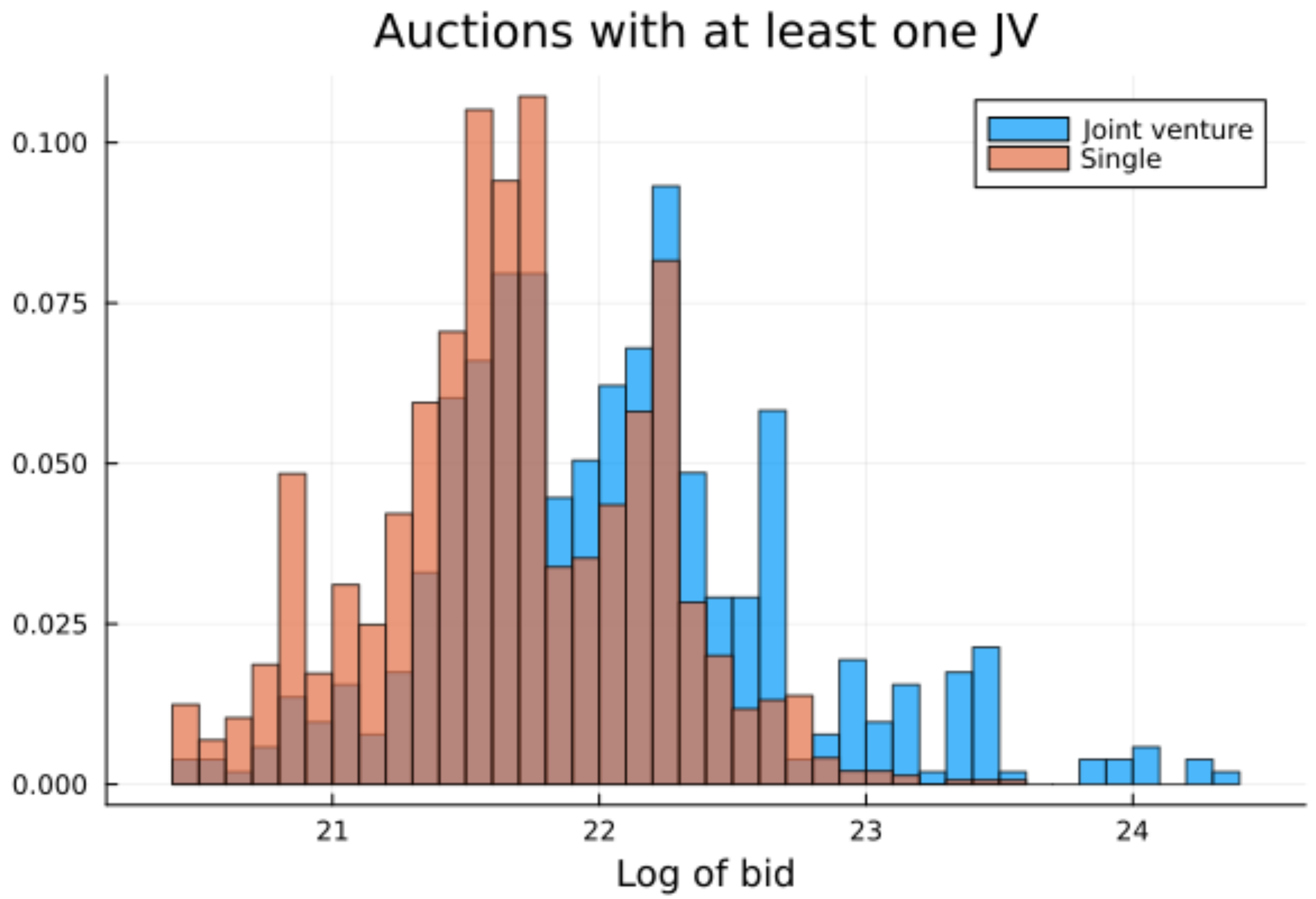
$$B_i = \frac{s_i}{b_i}$$

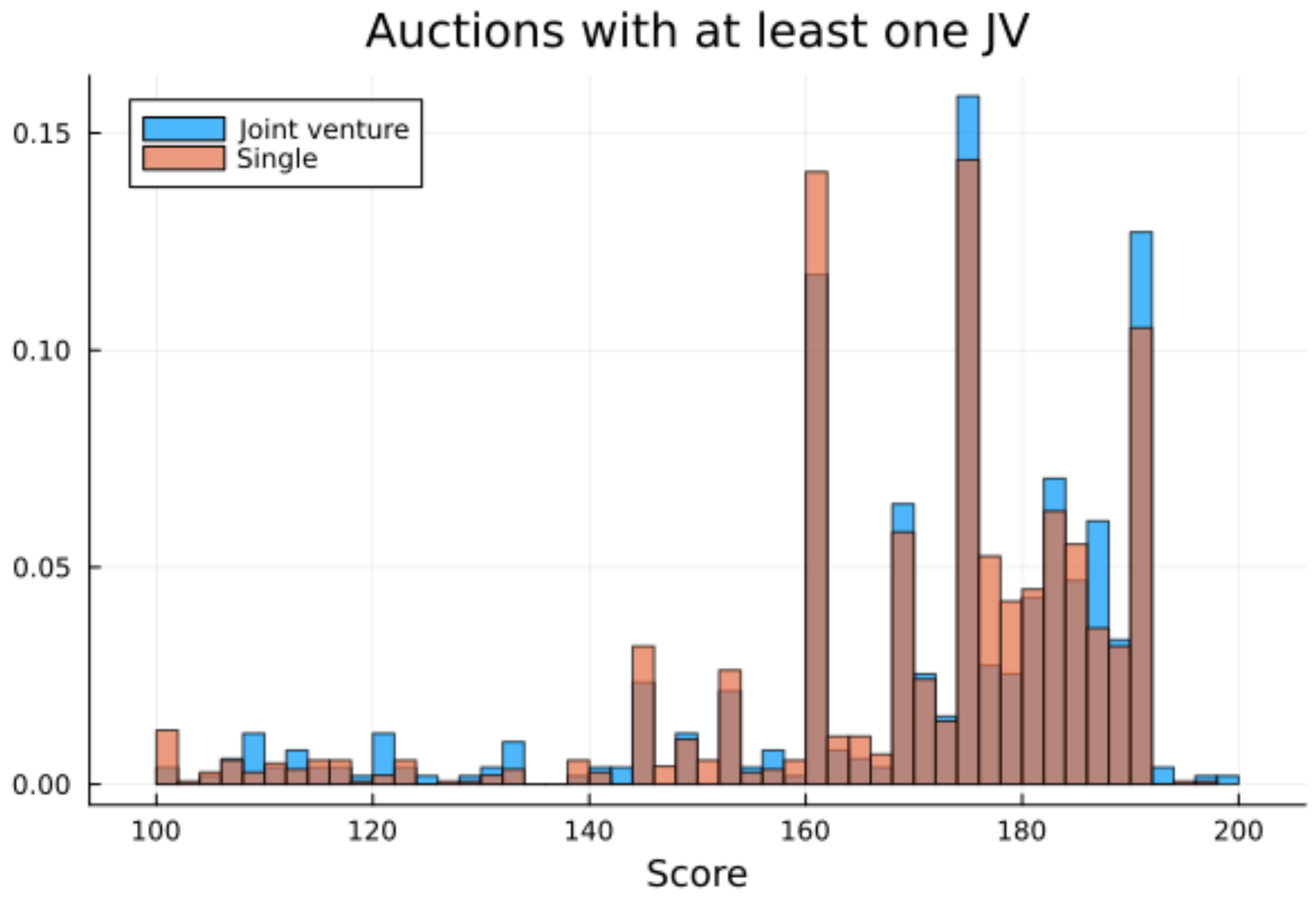
s_i : the score of firm, and b_i : the submitted bid

- We observe the scores and the bids separately

Distributions





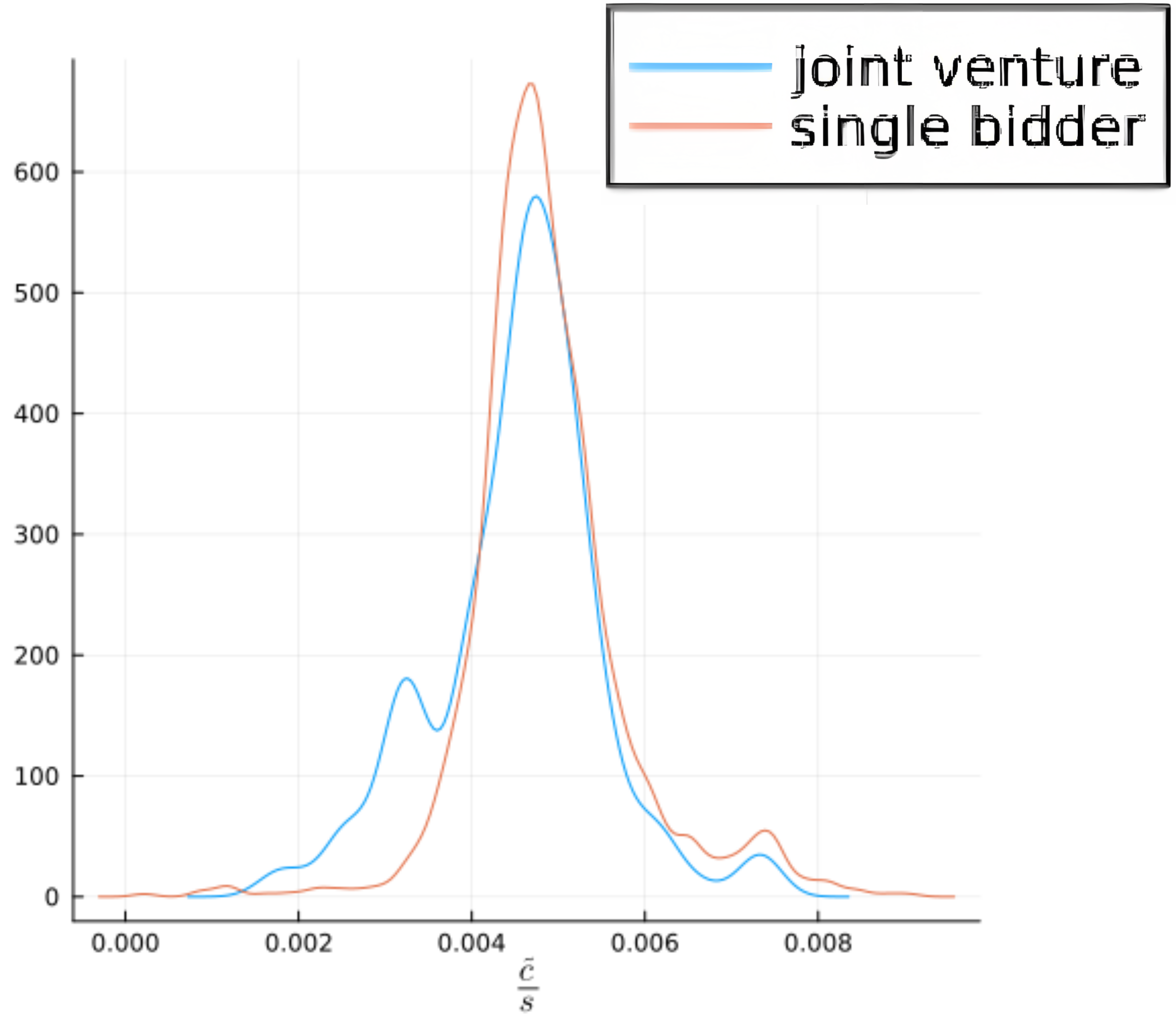


Bidding Problem

- The payoff of bidder i when it wins the auction is $b_i - \tilde{c}_i p = \frac{s_i}{B_i} - \tilde{c}_i p$
    - $\tilde{c}_i$: individual cost factor
    - p : auction specific engineer's estimate of the total cost
- Each bidder has two dimensional incomplete information, $(\tilde{c}_i, s_i)$,
    - For each entry form, $(\tilde{c}_i, s_i) \sim G_{JV}, (\tilde{c}_i, s_i) \sim G_S$
- The essential cost $\frac{\tilde{c}_i}{s_i}$ determines the optimal bid in the equilibrium
- We can recover the distribution of the essential cost by inverting F.O.C.

Estimated Dist. of $\tilde{c}_i$ / s_i

- JV's cost can be lower than single's.
- At the same time, the mode is almost the same as single.
- Uncertainty over the cost synergy.



Entry and JV Formation

Entry Pattern and Intention Pattern

Entry pattern is not determined by just discrete choice

- The potential entrants choose one from the following three intentions:
    - JV: try to form a JV, S: enter as a single bidder, N: not to enter
- Denote # companies choosing each intention by L_1, L_2, L_3
    - The triplet (L_1, L_2, L_3) is called intention pattern.
    - Choice over intentions does not determine the entry pattern, (M, N), because we do not explicitly model the JV formation process
    - We treat the process as a nuisance parameter in a semi-parametric model

An Outcome Mixing Matrix

- An outcome mixing matrix parametrizes the distribution over the entry pattern (M, N) given (L_1, L_2, L_3)

- Consider the following large column stochastic matrix R of size $C_E \times C_L$:

$$R = \begin{pmatrix} r_{1,1} & \cdots & r_{1,C_L} \\ \vdots & \ddots & \vdots \\ r_{C_E,1} & \cdots & r_{C_E,C_L} \end{pmatrix}$$

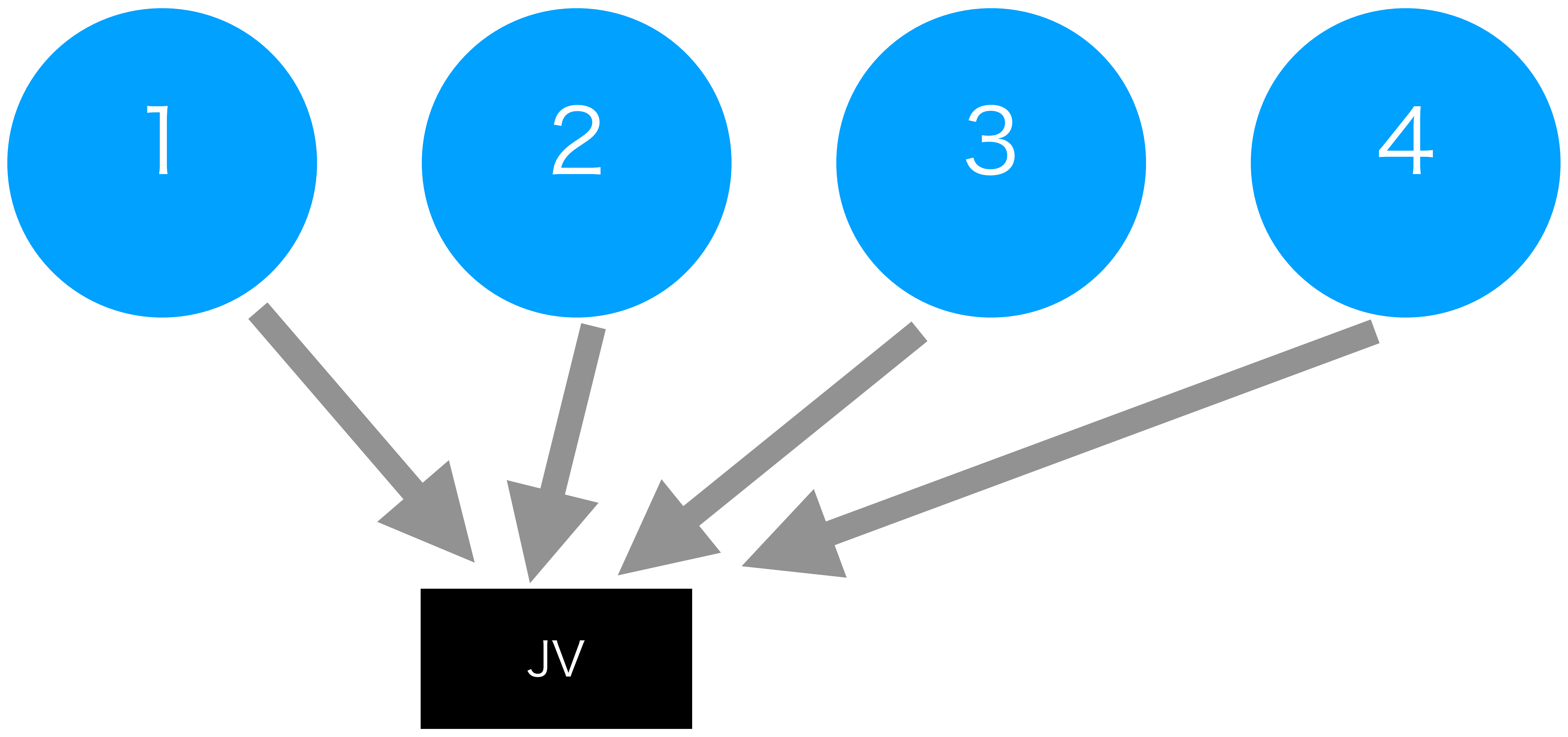
  - C_E and C_L denote #s of possible entry and intention patterns, respectively

  - $r_{i,j}$ denotes the probability that the entry pattern indexed by j realizes when the intention pattern indexed by i realizes

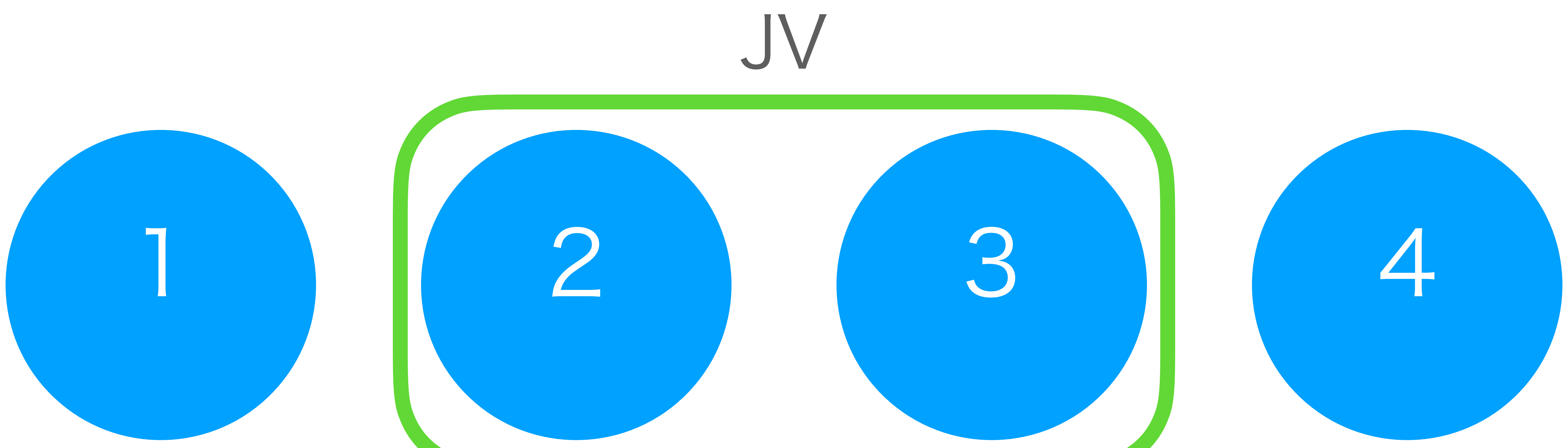
Structured Outcome Mixing Matrix

- In general, R is not under any constraint
- Choosing the place of the the non-zero entries helps the estimation
- We put the following structure on R to estimate it

    1. Intention S gives the minimum number of singles
    2. The number of JV is determined by a function $\Phi(L_1)$
    3. The probability of becoming a single bidder after failing to form a JV, which is a function of L_1, $p(L_1)$

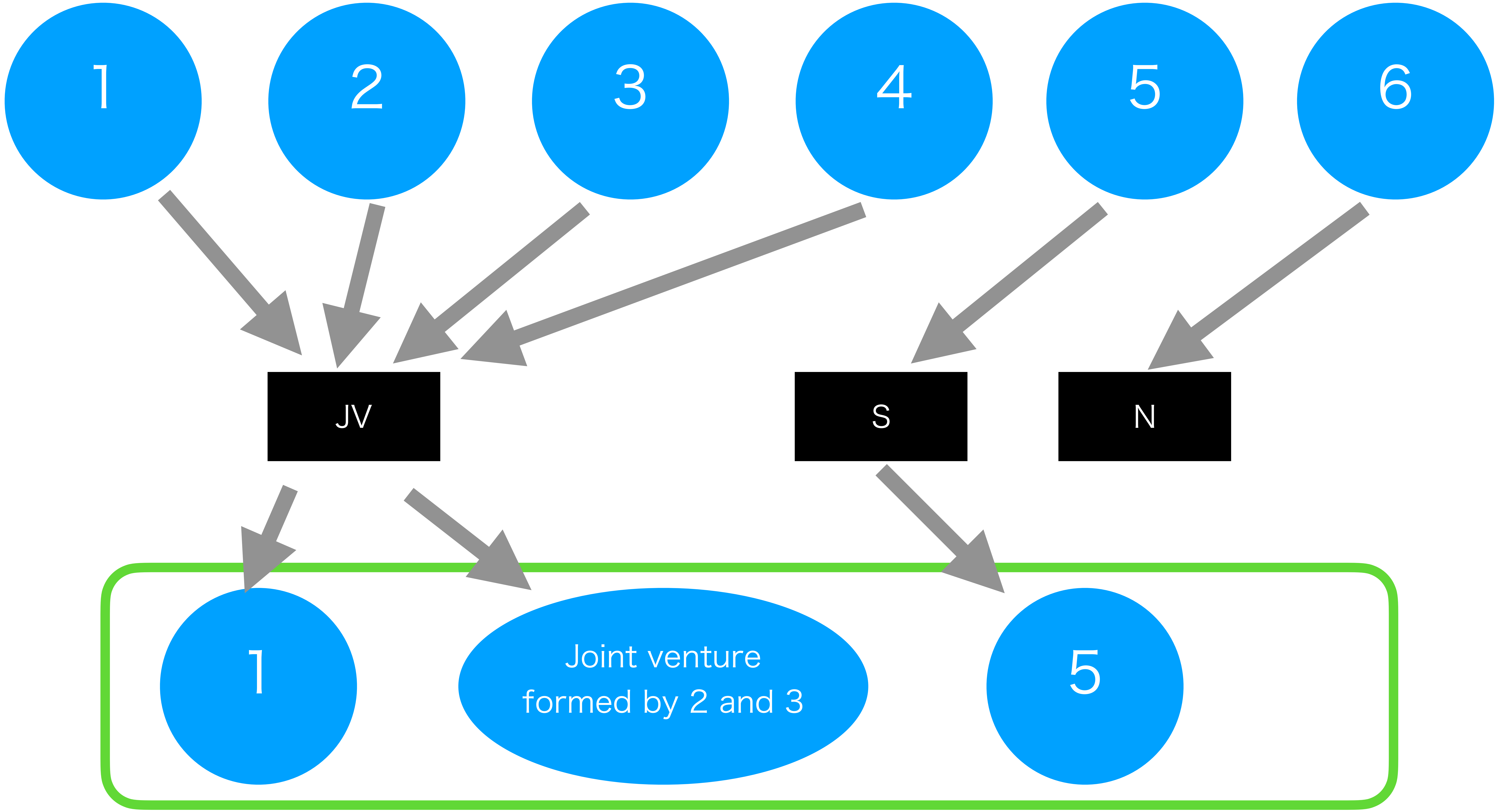


There are four firms intending to foam a JV



For example, $\Phi(L_1) = \lfloor \frac{L_1}{3} \rfloor$ and $p(L_1) = \frac{1}{2}$

Then, $\lfloor \frac{4}{3} \rfloor = 1$ JV realizes and the remaining two entry as a single bidder with probability of $\frac{1}{2}$.

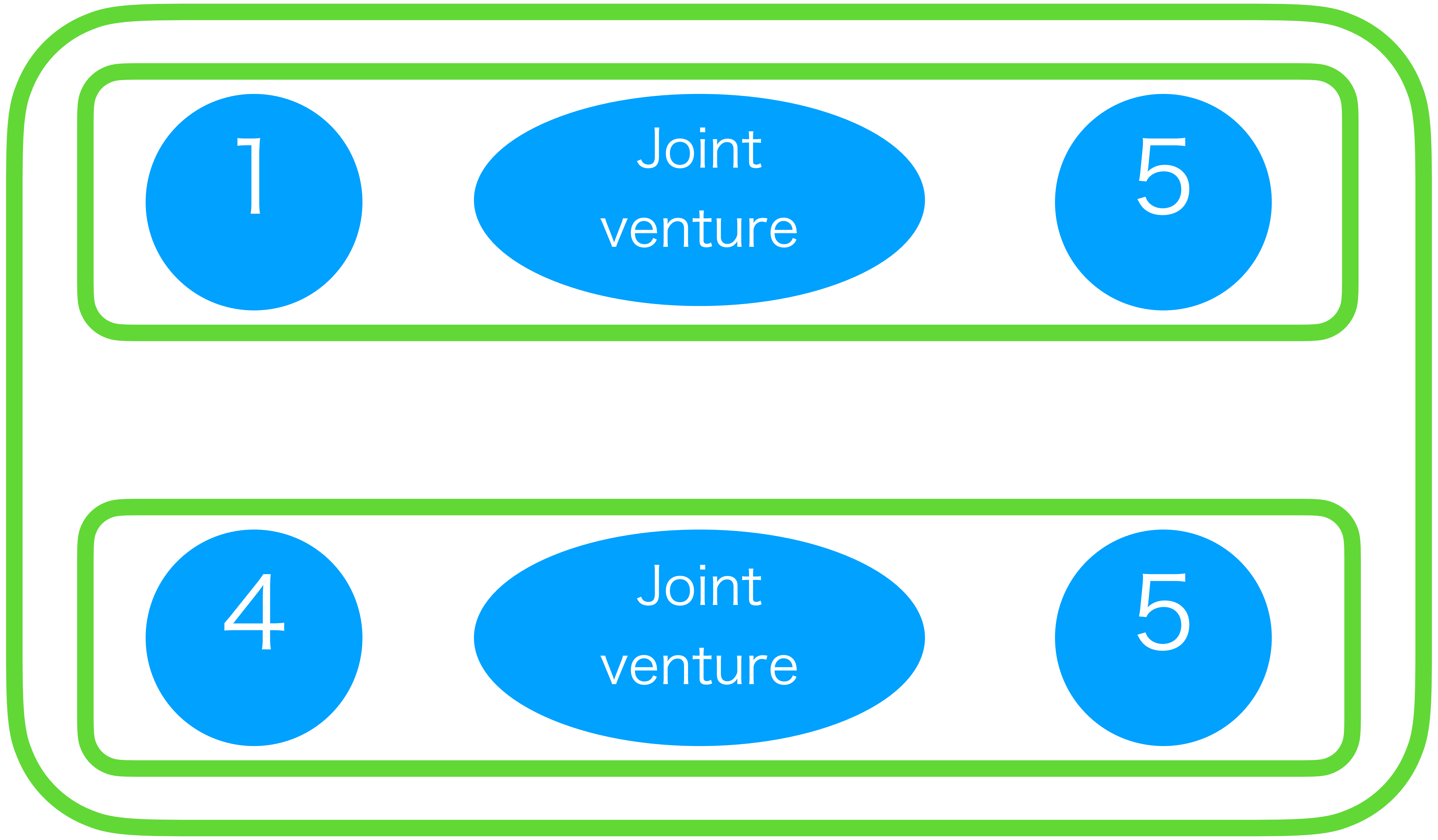


Auction Stage: 1 joint venture and 2 single bidders.

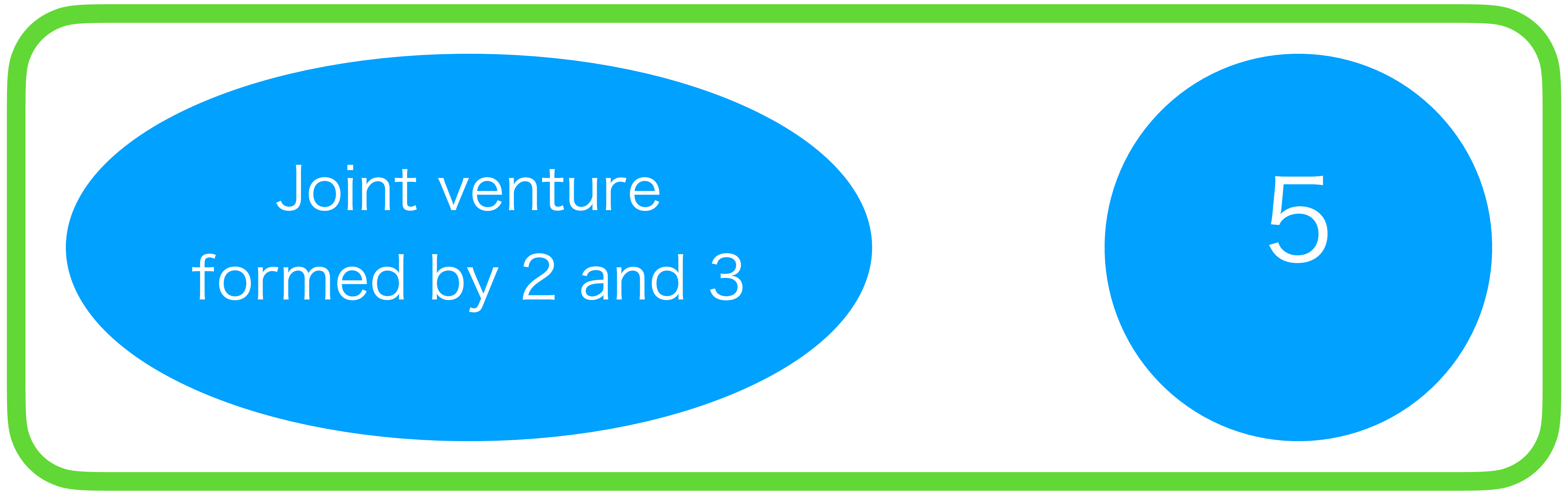
Remember M : # of JV's, N : # of singles

This probability vector is contained in one column of R

$(M, N) = (1,2)$ with prob. $\frac{1}{2}$



$(M, N) = (1,1)$ with prob. $\frac{1}{4}$



$(M, N) = (1,3)$ with prob. $\frac{1}{4}$

How to construct the likelihood

- $Q \in \Delta(\mathbb{R}^{C_L})$ denotes the distribution over the intention patterns
- $P \in \Delta(\mathbb{R}^{C_E})$ denotes the distribution over the entry patterns
- By construction, an outcome mixing matrix, R, maps $Q \to P$

$$P = RQ$$

- $Q + R \to P \to$ Likelihood
  - We estimate the parameter to close P to the observed distribution over the entry patterns

Intention Choice Problem

How to model Q

- Entry cost parameter for JV, c_{JV}, and for Single bidder, c_S
- Each potential entrant i compares the following three:

$$\text{(S)}\ P_S \cdot u_S - c_S + \epsilon_{i,S}, \qquad \text{(JV)}\ P_{JV} \cdot \begin{pmatrix} u_S - c_S \\ u_{JV} - c_{JV} \end{pmatrix} + \epsilon_{i,JV}, \qquad \text{(N)}\ \epsilon_{i,N}$$

- u_S, u_{JV} are computed by the auction stage estimation. ϵ follows i.i.d. EV1
- Intention choice determines the dist. over the intention patterns given P:
  - For S, $Q_S(P_S)$, and for JV, $Q_{JV}(P_{JV})$

Equilibrium

- We consider outcome mixing matrices for each intention:
  - For S, $R^S \in \mathbb{R}^{C_E} \times \mathbb{R}^{C_L}$
  - For JV, $R^{JV} \in \mathbb{R}^{2C_E} \times \mathbb{R}^{C_L}$
- In a Bayesian Nash equilibrium, as in Seim (2006), we expect:

$$P_S = R^S Q_S(P_S),\ P_{JV} = R^{JV} Q_{JV}(P_{JV})$$

- We can show that the this system has a unique equilibrium for each R

Estimation

Ingredients Review

- We have four parameters:

    1. c_S : cost of entry as a single bidder

    2. c_{JV} : cost of entry as a joint venture (expect $c_{JV} > c_S$)

    3. $\Phi(\cdot)$: function determines # of JVs

    4. $p(\cdot)$: probability of entry as a single after failing to form a JV

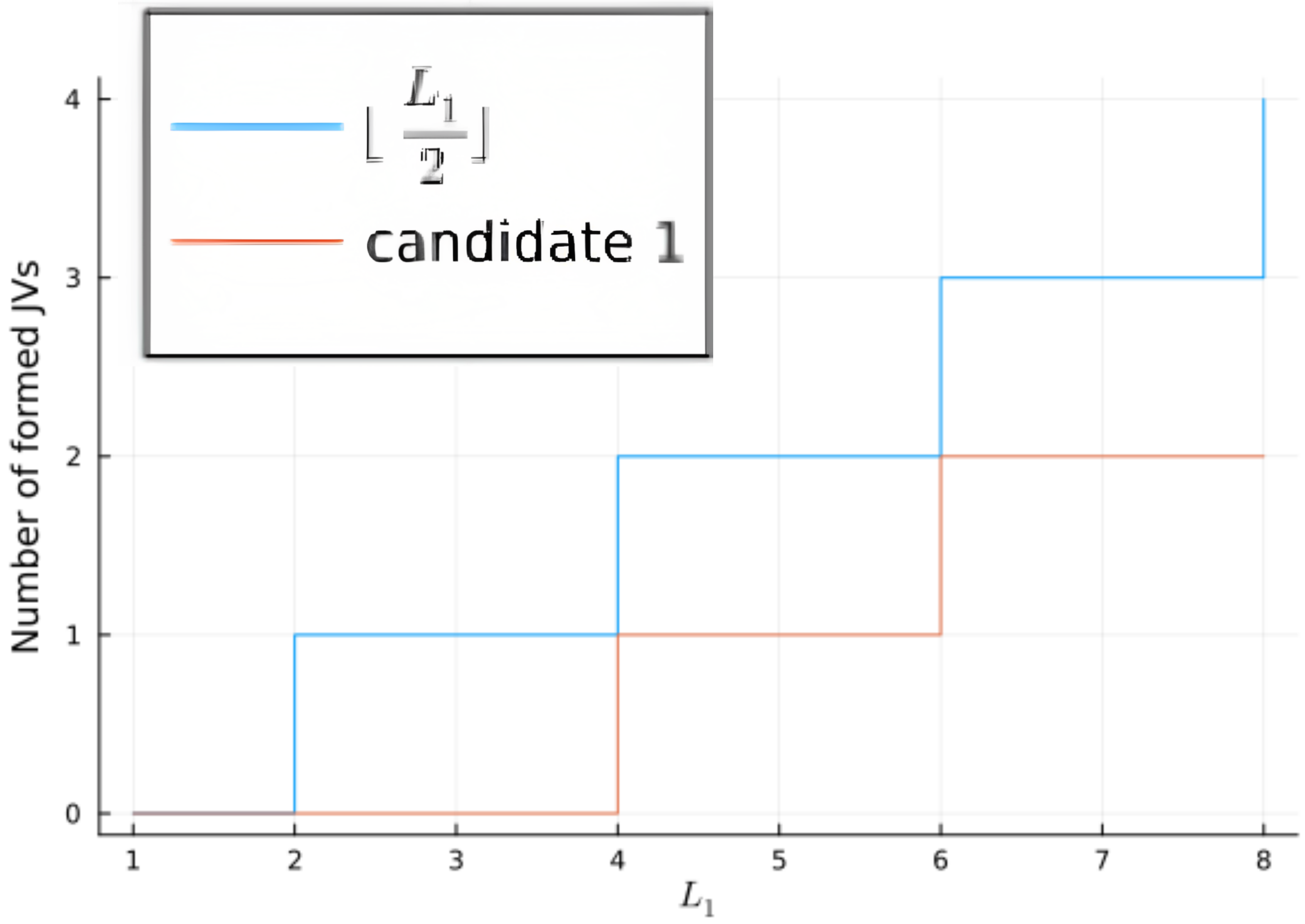
- We have P_S, P_{JV} as endogenous variables determined by the equilibrium conditions:

$$P_S = R^S Q_S(P_S),\ P_{JV} = R^{JV} Q_{JV}(P_{JV})$$

Estimation

MPEC for each possible Φ

- A JV needs at least 2 firms
    - $\lfloor \frac{L_1}{2} \rfloor$ is the upper bound of the number of JV's
- For each candidate of Φ, we estimate the model by MPEC
- Compare the log-likelihood to determine the best choice of Φ



Result

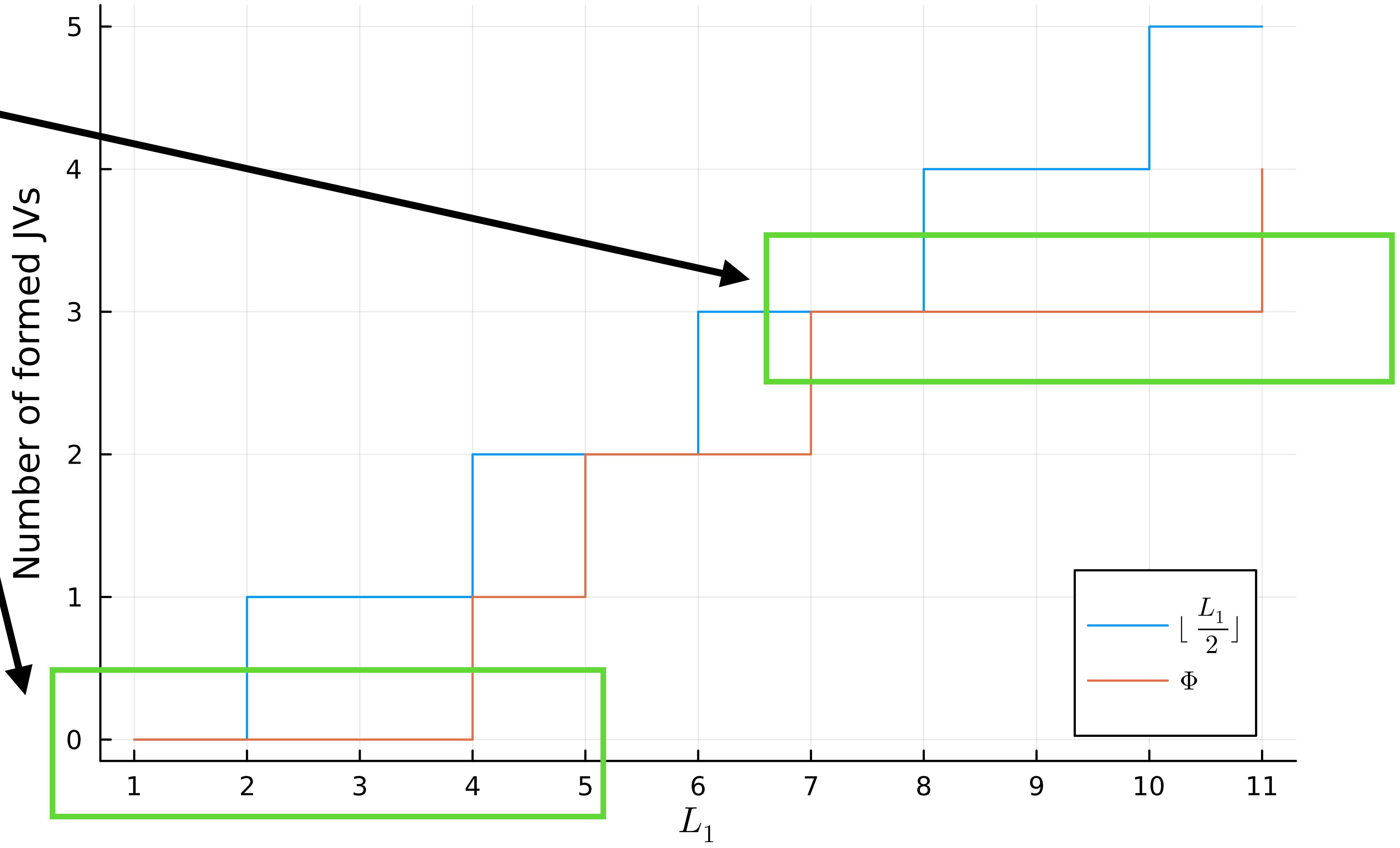
Estimation Results

Form of Φ implies there are search friction

Flat regions in the first and the last

1. When few JVs exist, just a sufficient pool of potential JV formers is enough for finding a partner

2. When several JVs exist, the quality of partners gets much more important: searching partner is again difficult



Estimation Results

Adjustment costs

- Each row corresponds to the different Φ
  - The second row is the best
- $c_{JV} > c_S$: statistically significant gap
- 8.366 Million yen = $6,200
  - 23.72% of the expected payoff in the small sized suction

Table 3. Estimation Results in Entry Stage

α	LL	c_{JV}	c_S
2.373	-1963	18.651	11.013
2.413	-1955	19.368	11.002
		(0.511)	(0.032)
2.453	-2065	14.266	10.662
2.563	-2062	14.104	10.665
2.683	-2054	14.053	10.667
2.794	-2039	16.408	10.608
2.904	-2722	2.570	0.474

The unit of the cost is $1,000,000$ yen. Standard errors are computed only for α that gives the highest log-likelihood, which are contained in the brackets below the estimated values.

Counterfactual Simulation

Measure of efficiency

- We divide all auctions into two groups by their size: large and small
- A measure of the efficiency of the procurement is defined as:

$$\text{Procurement efficiency} = \frac{\text{total engineer's estimate} - \text{total winning bid}}{\text{total expected cost}} \times 100$$

- Observed level of procurement efficiency is:
    - 11.31% for small-scale procurement auctions
    - 12.25% for large-scale procurement auctions

Counterfactual Simulation
Encouragement of JV entry

- The Japanese government promotes JV formation in response to
    - declining local economy, and
    - many infrastructures come to the repair time at the same time
        - Most of infrastructure in Japan was developed in70s and 80s
- One possible way is to reduce the adjustment cost.

Counterfactual Simulation

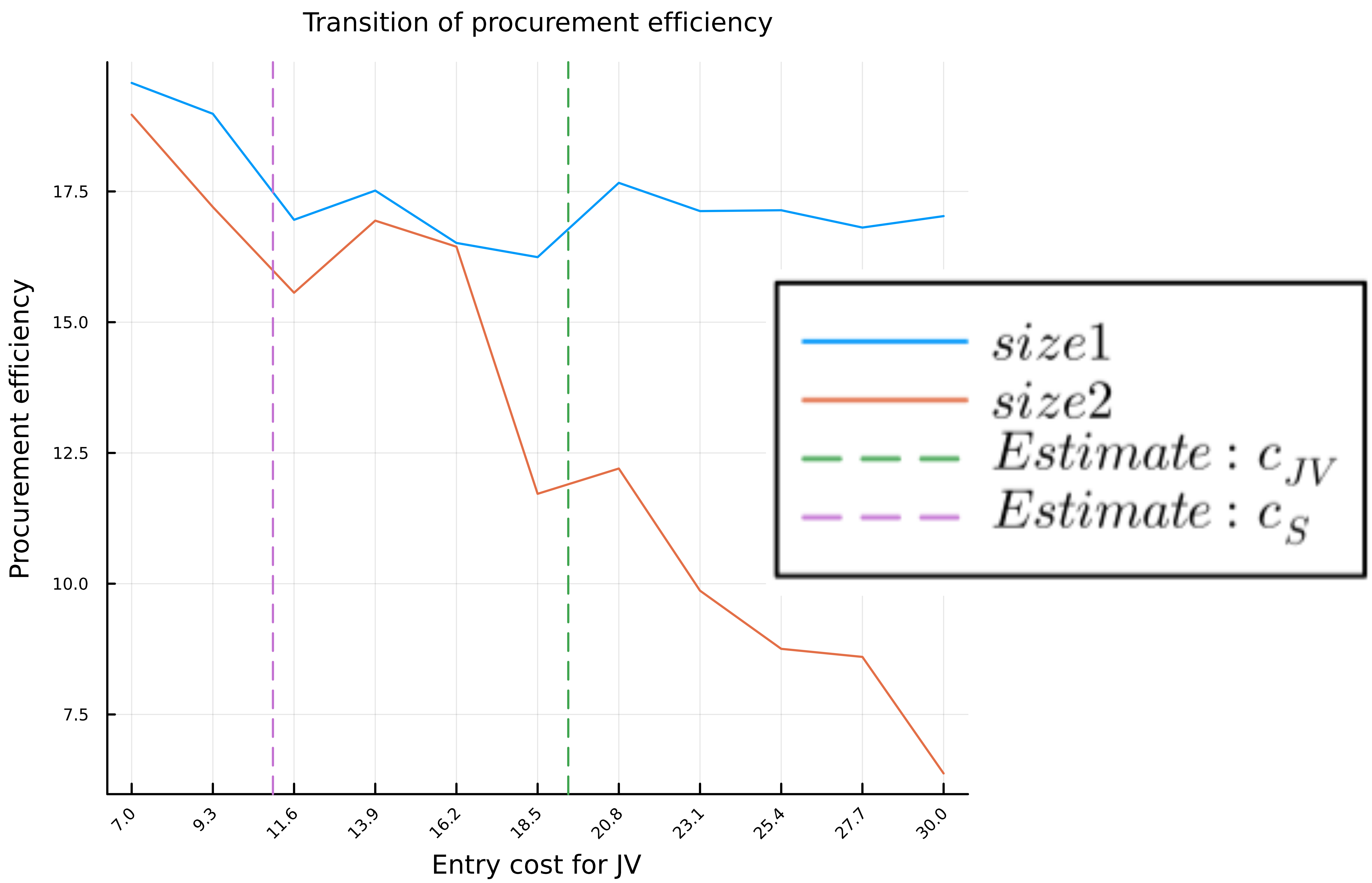
Mild reduction is key

Large reduction

→ More JVs entry

→ Less incentive to entry as a Single

→ Less competition



Conclusion

- We model joint venture formation in procurement auction.
- There exists
    - the cost synergy
    - adjustment cost for managing the JV
    - search friction in forming a JV
- We find non-linear effect of reducing adjustment cost
    - Small reduction in adjustment costs might improve efficiency, keeping entry incentive for single bidders