How sellers decide on dynamic mechanisms: Information matters

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Optimal Dynamic Mechanism Design

- To maximize the revenues (payoff), the seller (principle) sets rules of allocations and prices over multi-period as the buyer (agent) receives private information over time.
  - **Repeated selling of perishable goods**
  - Long-term principal-agent relationship
- Dynamic mechanism improves revenues and the efficiency (Baron & Besanko, 1984).
  - Clairvoyant: use all future information in design
    $\Rightarrow$ Complicated; Non-intuitive; Lack of general form
- How do human sellers choose a dynamic mechanism?

Two Easily-conducted Dynamic Mechanisms

- Non-Clairvoyant: not using future information $\Rightarrow$ general form.

(RS) The optimal Repeated Static Mechanism (Myerson, 1981)

- 100% optimal static revenue (intra-period)
- 0% optimal dynamic revenue (inter-period)

(NC) The optimal Non-Clairvoyant Dynamic Mechanism (Mirrokni et al., 2020)

- 50% optimal static revenue (intra-period)
- 50% optimal dynamic revenue (inter-period)

NC Cannot Always Outperform RS

- Relative size of inter-period revenue matters (Gui and Houser, 2023).

The optimal Repeated Static (RS)

Period 1

- Seller sets a reserve price r_1 based on the distributional knowledge F_1.
- Buyer learns his value (v_1), makes a bid : b_1
- Buyer can get the item only when $b_1 \geq r_1$ and pay $p_1 = r_1$.

Period 2

- $F_2 \Rightarrow r_2$, $v_2 \Rightarrow b_2$, pays $p_2 = r_2$ if $b_2 \geq r_2$

Myerson's Auction

monopoly price: $r_1 = arg\max_r \ r \cdot P(v_1 > r), \quad r_2 = arg\max_r \ r \cdot P(v_2 > r)$

The optimal Non-Clairvoyant Dynamic Mechanism (NC)

How the dynamic mechanism work?

Half chance of free item in period 1

Half chance of upfront fee in period 2

Research Question

How do Sellers Decide on Dynamic Mechanisms?

- How do Sellers choose between NC and RS?
- Can Sellers make good decision and improve revenues?

What Information Sellers Use in Deciding on Mechanism?

- **Relative Simplicity**: NC is harder: set more prices.
- **Distributional Knowledge**: NC is optimal for some conditions.
- **Feedback**: NC gets less revenue as Buyers might quit the second period.

Experimental Procedure

Settings

- **Clairvoyant environment**: F_1, F_2 known for Sellers at the beginning.
- 10 Rounds + 2 Practice Rounds, feedback on each round, each period.
- Fixed role, re-match for each round.
- Risk task and ambiguity task (random ordered) at the end.

Choosing from Two Mechanisms in each Round

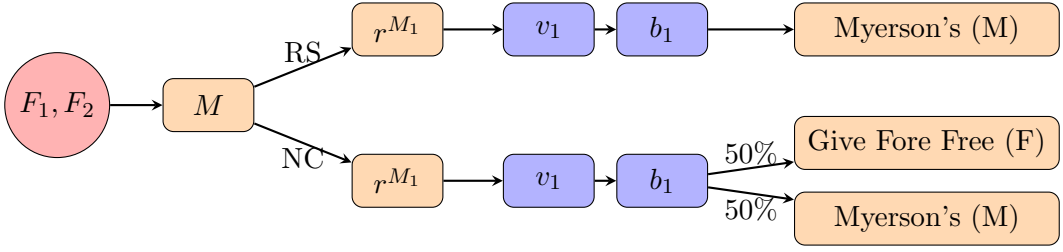
- Non-Clairvoyant Dynamic Mechanism (NC)
- Repeated Static Mechanism (RS)

Experimental Task in each Round

Period 1

1. Seller chooses mechanism, $\mathbf{M}$ (=NC or RS), buyer is informed
2. Seller sets reserve price $\mathbf{r^{M_1}}$ for Period 1, Buyer makes a bid $\mathbf{b_1(v_1)}$.
   - in RS: buyer pays r^{M_1} if $b_1 \geq r^{M_1}$
   - in NC: buyer has 50% chance to get free item

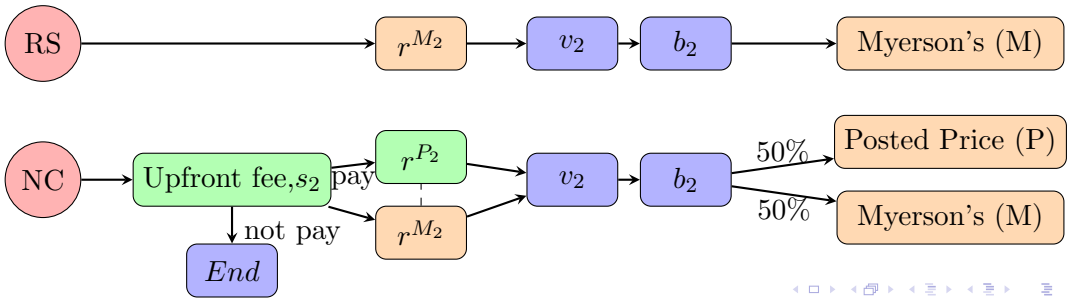
Choose Mechanism for two Periods



Experimental Task in each Round

Period 2

1. Seller sets reserve price r^{M_2} for Period 2
   Treatment Setting 2: s_2, r^{P_2} will be set by the Computer optimally
   Treatment Setting 4: s_2, r^{P_2} will be set by the Seller
2. Buyer chooses to pay the upfront fee s_2 or not
   Buyer makes a bid $b_2(v_2)$ in RS or in NC if entering in the market



Experimental Design: Different Information

Relative Simplicity - Two Treatments (Between-subject)

- Treatment Setting 2: Automated Posted Price Auction (green area)
- Treatment Setting 4: Sellers set 4 prices in NC and 2 prices in RS.

Scenario-specific Demand - Twelve Scenarios (3 Categories) (Within-subject)

- 4 NC Better: $Rev^{NC} > Rev^{RS}$
- 4 RS Better: $Rev^{NC} < Rev^{RS}$
- 4 Same: $Rev^{NC} = Rev^{RS}$
- For each Session: 2 Same in Practice Stage + 2 in Tail Stage
  Early Stage (4 rounds): 2 NC Better + 2 RS Better
  Later Stage (4 rounds): 2 NC Better + 2 RS Better

Feedback - Revenue of each Round

NC Better ($Rev^{NC} > Rev^{RS}$)

Period 2 is Profitable

- Inter-period dynamic revenue is more important in NC
- $\exists$ "target buyers" (high valuation but low probability) in Period 2

$REV^{RS} = 4,\ REV^{NC} = 4.5\ \uparrow 12.5\%$

$$F_A = \{v, p(v)\} = \{(2, \tfrac{1}{2}), (4, \tfrac{1}{4}), (8, \tfrac{1}{8}), (16, \tfrac{1}{16}), (32, \tfrac{1}{16})\}, \quad \mathbb{E}_A = 6.$$

1. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2})\}, \quad F_2 = F_A$
2. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{4})\}, \quad F_2 = F_A$
3. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{8})\}, \quad F_2 = F_A$
4. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{16}), (32, \frac{1}{16})\}, \quad F_2 = F_A$

RS Better ($Rev^{NC} < Rev^{RS}$)

Period 2 is not Profitable

- Intra-period revenue is more important in NC
- *e.g.*, Constant valuation, $v_2 = 0$ in Period 2.

$REV^{RS} = 4,\ REV^{NC} = 3.5 \downarrow 12.5\%$

$F_B = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2}), \}, \quad \mathbb{E}_B = 3.$

1. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2})\}, \quad F_2 = F_B$
2. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{4})\}, \quad F_2 = F_B$
3. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{8})\}, \quad F_2 = F_B$
4. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{16}), (32, \frac{1}{16})\}, \quad F_2 = F_B$

Same ($Rev^{NC} = Rev^{RS}$)

Inter- is as important as Intra- revenue

- $\iff Rev^{P} = Rev^{M_1} + Rev^{M_2}$
- *e.g.*, Constant valuation, $v_1 = c_1 = 0$ in Period 1, $v_2 = c_2 \geq 0$ in Period 2.

$REV^{RS} = REV^{NC} = 4$

$F_C = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{4})\}, \quad \mathbb{E}_C = 4.$

1. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2})\}, \quad F_2 = F_C$
2. $F_1 = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{4})\}, \quad F_2 = F_C$
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Summary of Theoretical Revenue (Total)

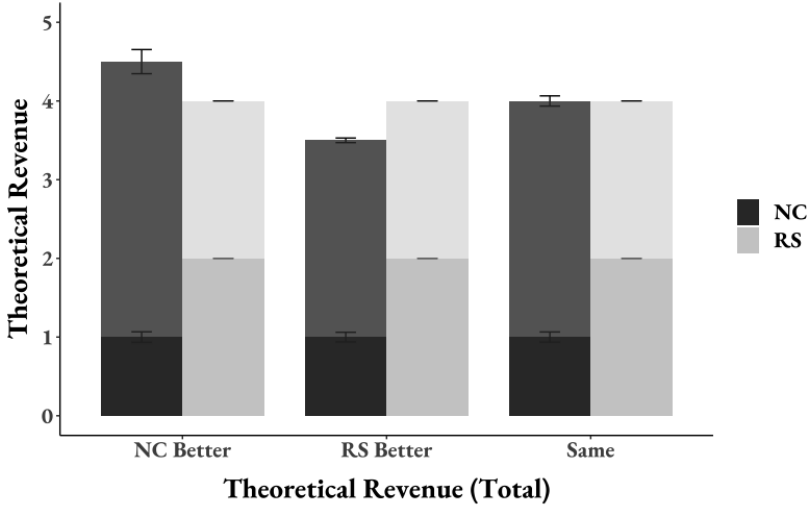

Figure 2: Theoretical Revenue (Total)

Hypotheses

Relative Simplicity

- H1: Sellers choose more NC in the treatment Setting 2.

Demand Knowledge

- H2: Sellers Choose NC more (less) in NC Better (B) in the Later Stage.
- $\Rightarrow$ Sellers choose correct mechanism more in Later stage.

Feedback on Revenues

- H3: Sellers choose NC more (less) when past revenue from NC is high (low).

* Buyers' Behaviors

- H4: Buyers participate Period 2 more in the treatment Setting 2.

Experiments

- 256 George Mason Students. October to November 2022.

Treatment	**Setting 2**		**Setting 4**	
Role	**Sellers**	**Buyers**	**Sellers**	**Buyers**
Age	22.6	22.2	21.2	22.5
Gender (Male=1)	0.59	0.62	0.52	0.50
Risk aversion	3.14	3.95	3.90	3.70
Ambiguity	3.30	3.02	3.67	3.32
Observation	64	64	64	64

Table 1: Summary Statistic

Result 1. Relative Simplicity does not Matter

R1. Sellers do not choose NC more in the treatment Setting 2. H1 is not supported.

- Early Stage: no difference from 50% in neither Treatment.
- Later Stage: Significant less than 50% in the treatment Setting 2 ($p < 0.01$).
- No treatment difference in either stage.

Sellers do not Choose NC More in General

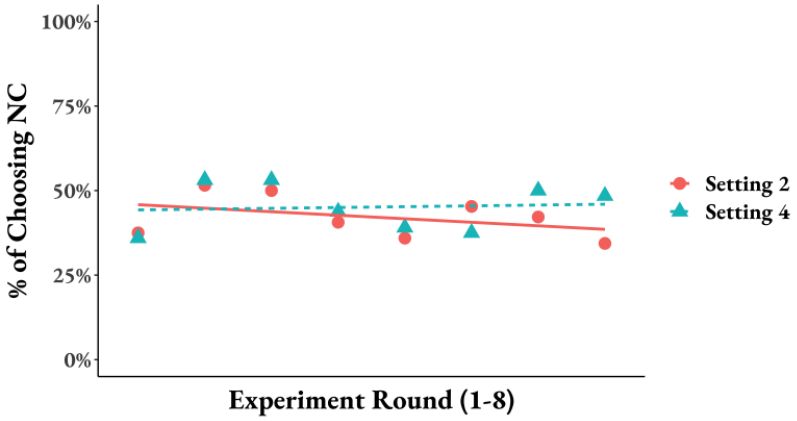

Figure 3: % of Choosing NC

Result 2. Demand Knowledge Matters

R2. Sellers choose NC less in RS Better in Later Stage. H2 is supported.

- NC Better: No difference from 50%
- RS Better: Significant less than 50% ($p < 0.01$ in Setting 2, $p < 0.01$ in Setting 4).
- More correct mechanisms in the Later stage ($p = 0.01$,in Setting 2, $p < 0.01$ in Setting 4)

R2. Sellers Choose NC Less in RS Better

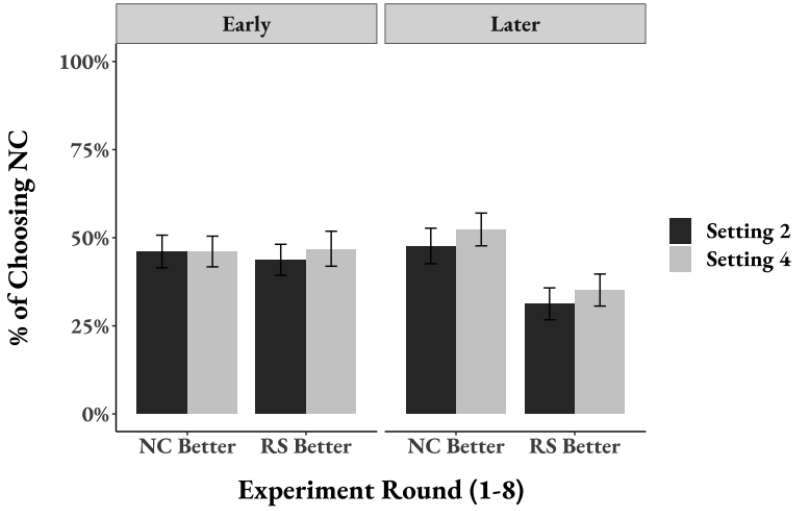

Figure 4: % of Choosing NC by Group of Scenario

% of Choosing Correct Mechanism ↑

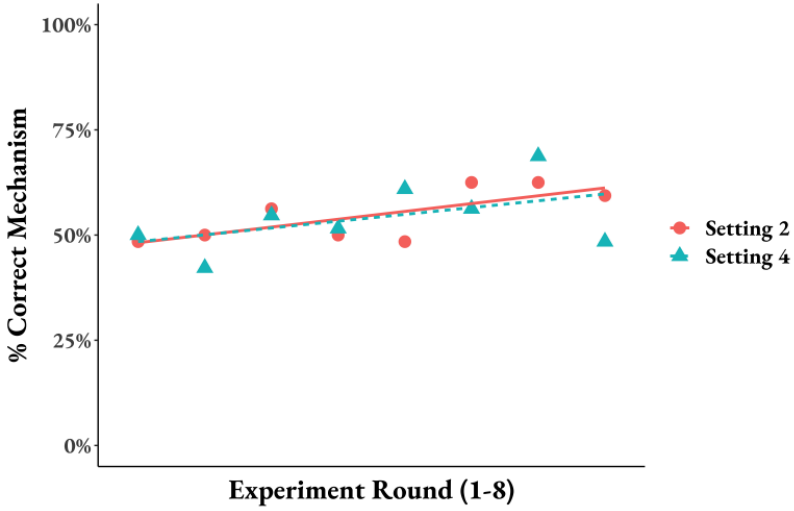

Figure 5: % of Choosing correct Mechanism

Result 3. Feedback on Revenue Matters

R3. Sellers choose NC less if past revenue from NC is low. H3 is supported.

- Persist NC more in Later rounds.
- Less likely to choose NC if last round NC got less than 3 points.

Reaction to Negative Feedback

	DV: Choosing NC	
	(1)	(2)
β_1: Last (payoff<3, NC)	-0.21^{***}	-0.21^{***}
	(0.07)	(0.07)
β_2: Later * Setting 4	0.01	-0.00
	(0.04)	(0.04)
β_3: Later * RS Better	-0.18^{***}	-0.18^{***}
	(0.06)	(0.06)
β_4: Later * Last (NC)	0.16^{*}	0.17^{*}
	(0.09)	(0.09)
β_5: Later * Last (Correct = NC)	0.02	0.01
	(0.10)	(0.10)
Constant	0.46^{***}	0.31^{**}
	(0.04)	(0.13)
Controls	No	Yes
R^2	0.05	0.05
Num. obs.	1024	1024

Table 2: Regression of Choosing NC

Revenue Improvement by choosing Correct Mechanism

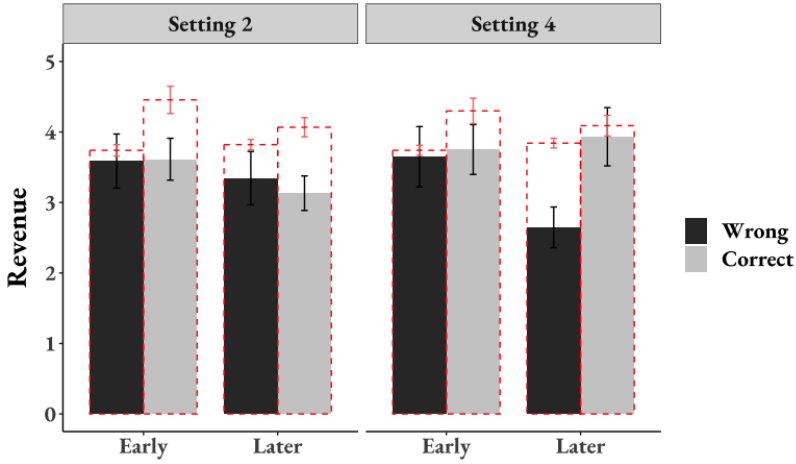

Figure 6: Experimental Revenue

Result 4. Buyers Reacting to high entry fee.

R4. Buyers participate less in the treatment Setting 4. H4 is supported.

- Explained by higher entry fee set by Sellers in the treatment Setting 4.

Sellers set higher than suggested entry fee

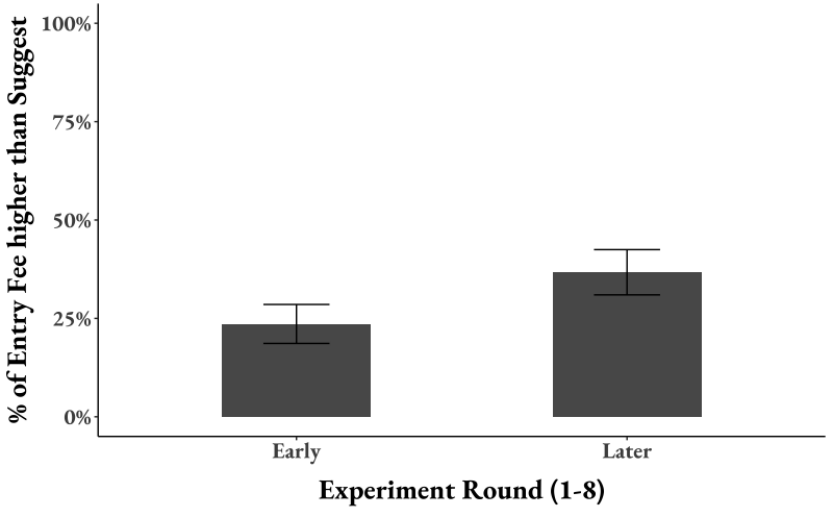

Figure 7: % of Setting Entry Fee Higher than Suggested

Sellers Set higher Prices

In Period 1

- "Go big or go home".
- Aimed high, looking for a heavy bid
- You'd be surprised when I say - I based it off the charts.
- Random.

In Period 2

- Again, attempted high roll, but failed greedily.
- Higher price didn't work so I went lower.
- buyer bid for 1?? which makes no sense so I wanted to get some out of him and set the price to 6 as possible values could have been pretty high. Then set price to 4 as I would get it 50% of the time
- Set a low price, however, buyer decided not to purchase.

Buyers participated less in the treatment Setting 4

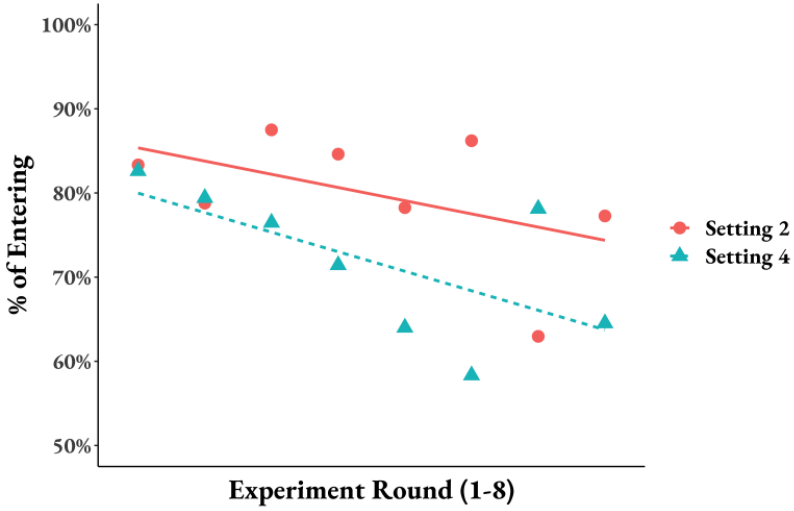

Figure 8: % of Entering Period 2

High Entry Fee Deters Entering

	DV: Enter in Period 2	
	(1)	(2)
β_1: Entry Fee	-0.24^{***}	-0.22^{***}
	(0.04)	(0.04)
β_2: Setting 4	-0.12	-0.19
	(0.20)	(0.21)
β_3: Setting 4 * Later	-0.07	-0.18
	(0.23)	(0.24)
β_4: Later	-0.36^{**}	-0.35^{**}
	(0.16)	(0.17)
Constant	2.04^{***}	2.34^{***}
	(0.23)	(0.69)
Controls	No	Yes
Num. obs.	447	447

Table 3: Probit Regression of Enter in Period 2

Conclusion

Distributional knowledge and Feedback matter in Choosing Mechanism

- Sellers can find the optimal mechanism after gaining trading experience.
- Sellers abandon the mechanism with low revenue.
- Selling strategy evolves as selling condition or expectation changes.

Discussion

- Decision Support Pool: appropriate expectation on buyers' behaviors.
- Experts: advice setting (lower) prices.

Thank you!