# Three Essays on Non-clairvoyant Dynamic Mechanism Design

Proposer: Shan Gui

Advisor: Daniel Houser

Committee: Cesar Martinelli, Johanna Mollerstrom, Thomas Stratmann

George Mason University

Sept 16, 2022

# Outline

## Chapter 1 - Testing Non-clairvoyant dynamic mechanism

- Compare two mechanisms feasible under non-clairvoyant environment.
- Focus on buyers behaviors.

## Chapter 2 - Can sellers set up the optimal mechanism?

- Let human sellers choose the mechanism for each scenario.
- Investigate how sellers make decisions.

## Chapter 3 - When is the non-clairvoyant dynamic mechanism the optimal?

- Formalize sufficient or necessary conditions of mechanism comparisons.

Chapter 1

# Non-Clairvoyant Dynamic Mechanism Design: Experimental Evidence

# Main Takeaways

## What do we do?

- Bring Non-Clairvoyant Environment (Mirrokni et al., 2020) into Lab.
- Test optimal Non-Clairvoyant dynamic mechanism (NC).
- Compare the performance with Repeated Static optimal mechanism (RS).

## What do we find?

- Dynamic NC works well as theory predicts - more revenue.
- Participants overbid less in NC.
- Risk aversion $\rightarrow$ No full participation $\rightarrow$ Revenue loss in NC.

# Optimal Dynamic Mechanism Design

- How the principal (seller) establish the rules of allocation and price over **multi-period** as the agent (buyer) receives private information over time.
  - Long-term principal-agent relationship
  - **Repeated selling of perishable goods**
- Dynamic mechanism improves revenues and efficiency (Baron & Besanko, 1984).

# Non-Clairvoyance

## Clairvoyance: Future demand distribution is known at the beginning.

- Form of the optimal dynamic mechanism depends on environment.
- Buyers tend to have biased forecast on future demand (DellaVigna & Malmendier, 2006).

## Non-Clairvoyance: Future demand is not accessible at the beginning.

- No needs to share unbiased belief.
- General Form.

$F_2$ is unknown in Day 1

$v_1 \sim F_1$

$v_2 \sim F_2$ ?

# Requirements of Mechanisms under Non-clairvoyant Environment

Seller sets up:

- Allocation rule $x \in \{0, 1\}$ : whether buyer can get the item or not
- Price rule $p \in \mathcal{R}$ : how much to pay if buyer gets the item

Buyer: $\max_{\{b_1, b_2\}} u_1 + u_2 = (x_1 v_1 - p_1) + (x_2 v_2 - p_2)$

- Dynamic Incentive Compatibility (DIC)

  For a buyer, it is optimal to bid true value in each period

- Ex-post Individual Rationality (EPIR)

  $u_1 + u_2 \geq 0$, for all realization of $v_1, v_2$

## Intra-period Revenue & Inter-period Revenue

- Intra-period revenue: independent revenue, using information within that period $\Rightarrow$bounded my Myerson's revenue.
- Inter-period revenue: dependent revenue, linking past periods with current period $\Rightarrow$ bounded by current-period expected value.

# Mechanisms under Non-Clairvoyant Environment

$\Rightarrow$ Optimal clairvoyant revenue $Rev^*$ is unachieveble.

## Repeated Static optimal mechanism (Myerson, 1981)

- Rules in two days are independent of each other

  Maximize **intra-period revenue** for each period separately.

  $\Rightarrow \frac{Rev^{RS*}}{Rev^*}$ could be arbitrarily small (Papadimitriou et al., 2016)

## Non-Clairvoyant optimal dynamic mechanism (Mirrokni et al., 2020)

- Rules in Day 2 depends on bid in day 1

  Best Revenue Guarantee: $\Rightarrow \frac{Rev^{NC*}}{Rev^*} \geq \frac{1}{a}$

  Achieve at least $\frac{1}{2}$ revenue produced by optimal clairvoyant mechanism under all scenarios in **two-period single-buyer** case.

# When can Non-Clairvoyant dynamic mechanism do better?

Theoretically, Non-Clairvoyant mechanism can not always outperform.

| | **Optimal Intra-period Revenue** | **Optimal Inter-period Revenue** |
|---|---|---|
| RS | 100% | zero |
| NC | $\geq 50\%$ | $\geq 50\%$ |

Relative size of optimal intra- and inter-period revenues is the key.

- Scenario A: Optimal inter - period revenue is larger $\Rightarrow$ NC outperforms.
- Scenario B: Optimal intra - period revenue is larger $\Rightarrow$ RS outperforms.

# Experimental Design $2 * 2$

## Two Mechanisms

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

## Two Scenarios

$F_A = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2})\}, \mathbb{E}_A = 3.$
$F_B = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{16}), (32, \frac{1}{16})\}, \mathbb{E}_B = 6.$

- Scenario A ($S_A$): Non-Clairvoyant Dynamic has more revenue than Repeated Static.

$$F_1 = F_A,\ F_2 = F_B \quad \Rightarrow REV^{RS} = 4,\ REV^{NC} = 4.5\ \uparrow 12.5\%$$

- Scenario B ($S_B$): NC has less revenue than RS.

$$F_1 = F_B,\ F_2 = F_A \quad \Rightarrow REV^{RS} = 4,\ REV^{NC} = 3.5\ \downarrow 12.5\%$$

# Non-Clairvoyant Environment

- **Buyer**: Participant
- **Robot Seller**: Experimenter, $c = 0$
- **Two periods** : Buyer can buy one item in each period from seller, $t = 1, 2$.
- **Non-clairvoyance** : The distribution of buyer's value $(F_t)$ is common knowledge **only in that period**
- **Incomplete Information** :
  1. **Only buyer** knows his value for the item in each period, $v_t$.
  2. Buyer's value is drawn **independently**.

## Variables for Environment

- **Endowment**: $E = 50$

# Mechanism - Repeated Static (RS)

## Period 1

- Seller sets a secret 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: $r_1 = r_2 = 2$

$r_A = 2 \in \{arg\max_r \ r \cdot P(v_A > r)\}, \quad r_B = 2 \in \{arg\max_r \ r \cdot P(v_B > r)\}$

# Mechanism - Non-Clairvoyant Dynamic (NC)

## How the dynamic mechanism work?

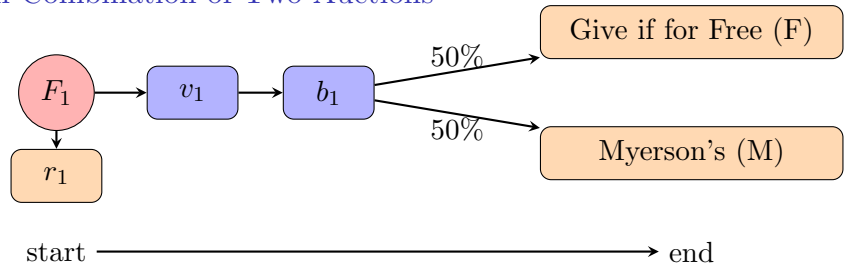

Half chance of free item in Period 1


Half chance of upfront fee in Period 2

# Non-Clairvoyant Mechanism in Period 1

- Seller sets a fixed secret reserve price $r_1$ based on the distribution $F_1$.
- Buyer learns his value ($v_1$), makes a bid : $b_1$
- Buyer has 50% chance to get the item for free: $p_1 = 0$;
  Otherwise, buyer can get the item only when $b_1 \geq r_1$ and pay $p_1 = r_1$.

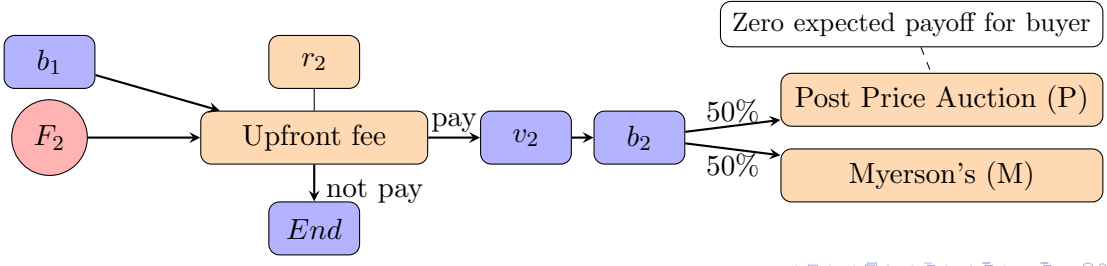
## Uniform Combination of Two Auctions



# Non-Clairvoyant Mechanism in Period 2

- Seller sets an upfront fee $e_2 = \min(b_1, E(v_2))$.
- Buyer decides pay or leave. If buyer leave ($enter = 0$), game over.
- If buyer pays, ($enter = 1$),
  - Buyer learns his value, $v_2$, and makes a bid: $b_2$
  - Buyer has 50% chance to get the refund on the upfront fee ($luck = 1$).
  - Seller sets two secret reserve prices ($r_2$) based on the $F_2, luck$ for each given $m_2$, Buyer can get the item only when $b_2 \geq r_2$ and pay $p_2 = r_2$

## Uniform Combination of Two Auctions



# Hypotheses

## Hypothesis 1 - Revenue Comparison

- In Scenario A ($S_A$), Non-Clairvoyant mechanism has more revenue than Repeated Static mechanism;
- In $S_B$, NC has less revenue than RS.

# Revenue Comparison in Scenario A

$F_1 = F_A = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2})\}$ $\mathbb{E}_1 = 3.$
$F_2 = F_B = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{16}), (32, \frac{1}{16})\},$ $\mathbb{E} = 6.$

- Non-Clairvoyant Mechanism increases revenue, $\uparrow 12.5\%$

| Revenue in $S_A$ | Non-clairvoyant Dynamic | | Repeated Static | |
|---|---|---|---|---|
| Period 1 | **Give for Free (F)**<br>Myerson's Auction (M) | 0<br>2 | Myerson's Auction (M) | 2 |
| Period 2 | **Post Price Auction (P)**<br>Myerson's Auction (M) | 5<br>2 | Myerson's Auction (M) | 2 |
| Total | | **4.5** | | **4** |
| Intra-period Revenue | | 2 | | 4 |
| **Inter-period Revenue** | | 2.5 | | 0 |

Table 1: Theoretical Revenues in Scenario A.

# Revenue Comparison in Scenario B

$$F_1 = F_B = \{v, p(v)\} = \{(2, \tfrac{1}{2}), (4, \tfrac{1}{4}), (8, \tfrac{1}{8}), (16, \tfrac{1}{16}), (32, \tfrac{1}{16})\},\ \mathbb{E}_1 = 6.$$
$$F_2 = F_A = \{v, p(v)\} = \{(2, \tfrac{1}{2}), (4, \tfrac{1}{2})\},\ \mathbb{E}_2 = 3.$$

- Non-Clairvoyant Mechanism decreases revenue, $\downarrow 12.5\%$

| Revenue in $S_B$ | Non-clairvoyant Dynamic | | Repeated Static | |
|---|---|---|---|---|
| Period 1 | **Give for Free (F)** | 0 | Myerson's Auction (M) | 2 |
| | Myerson's Auction (M) | 2 | | |
| Period 2 | **Post Price Auction (P)** | 3 | Myerson's Auction (M) | 2 |
| | Myerson's Auction (M) | 2 | | |
| Total | | **3.5** | | **4** |
| Intra-period Revenue | | 2 | | 4 |
| **Inter-period Revenue** | | 1.5 | | 0 |

Table 2: Theoretical Revenues in Scenario B.

# Hypotheses

## Hypothesis 2 - Individual Rationality

- Risk attitude matters in the second-period participation decision.
- Risk-averse buyers not paying upfront fee hurts the revenue of Non-Clairvoyant mechanism.

# Hypotheses

## Hypothesis 3 - Incentive Compatibility

- Randomization in NC leads participants overbid less.
  - In the first period, 50% chance of free item encourages buyers not to bid aggressively.
  - In the second period, 50% chance of not getting refund on the upfront fee deters aggressive bids.

# Experiments

- 256 George Mason Students. September to November 2021.

| Treatment | Scenario A | | Scenario B | |
|---|---|---|---|---|
| | Non-Clairvoyant | Repeated Static | NC | RS |
| Age | 21.6 | 22.3 | 21.9 | 22.7 |
| Gender (Male=1) | 0.48 | 0.44 | 0.52 | 0.47 |
| Risk aversion | 4.46 | 4.90 | 4.55 | 4.63 |
| Observation | 64 | 64 | 64 | 64 |

Table 3: Summary Statistic

# Results

## Result 1.

Experimental observations match with theoretical prediction.

- In $S_A$, Non-Clairvoyant mechanism has more revenue than Repeated Static mechanism.
- In $S_B$, Non-Clairvoyant mechanism has less revenue than Repeated Static mechanism.

# Experimental Revenue Comparison - Period 1

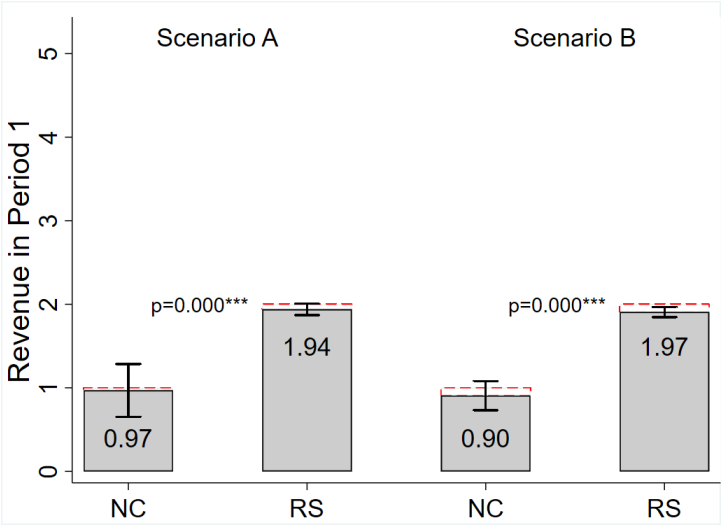



Figure 3: Revenues of Period 1 in each Treatment

# Experimental Revenue Comparison - Period 1 & Period 2

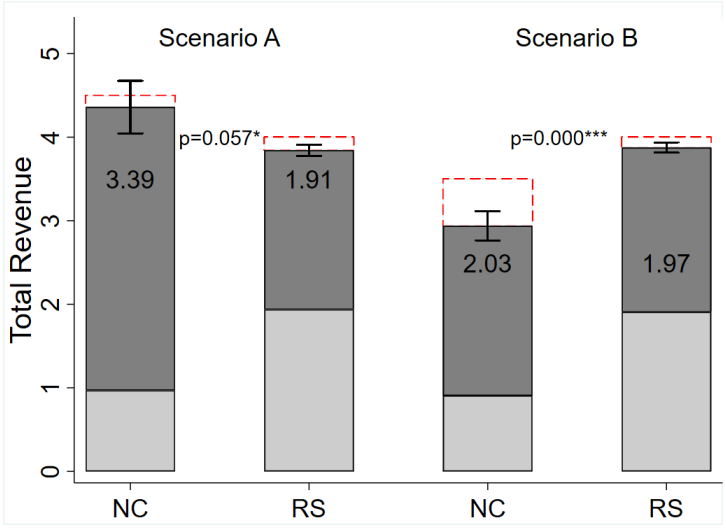



Figure 4: Revenues in each Treatment

# Results

## Result 2.

Risk aversion hurts the revenue of Non-Clairvoyant mechanism.

- In $S_A$, 4 buyers quit the second period, and the number goes to 8 in $S_B$.
- The more risk-averse the buyer is, the more likely they will refuse to pay the upfront fee and quit the second period.

# Revenue Loss Decomposition

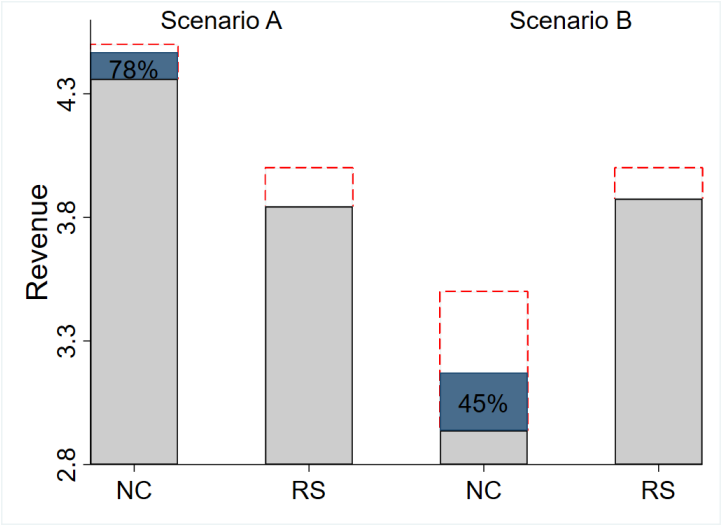



Figure 5: Revenues Increase if all Buyers enter in Period 2.

# Why not pay the upfront fee

- “Since I got a profit the first time I didn’t want to go again with my luck”
- “Risk vs Reward..... I got lucky and did not have to pay.”
- “Based on the membership fee. ”
- “didn’t want to take any big risks so I just lowballed my offers and refused to take the membership”
- “i read the instructions carefully. i think the second period isn’t worth losing the points - i had to pay membership fee and could only get the item by bidding higher than the price set by the seller..... honestly, i haven’t been feeling lucky so i’d rather not take my chances. so i tried not to lose money in the first period and just left it as is.”

# Risk Aversion Affects Second-period Participation

| | **Enter in period 2 (=1)** | | | | | |
|---|---|---|---|---|---|---|
| | **Scenario A** | | | **Scenario B** | | |
| | (1) | (2) | (3) | (1) | (2) | (3) |
| **risk aversion** | **-0.0279*** | **-0.0281*** | **-0.0465**** | **-0.0909**** | **-0.0825*** | **-0.0938*** |
| | (0.0161) | (0.0164) | (0.0199) | (0.0437) | (0.0462) | (0.0503) |
| $Free_1(=0)$ | 0.044 | 0.044 | 0.140* | -0.026 | -0.013 | 0.004 |
| | (0.0620) | (0.0629) | (0.0707) | (0.124) | (0.134) | (0.146) |
| Upfront fee | -0.028 | -0.003 | -0.020 | -0.243** | -0.203* | -0.232** |
| | (0.0215) | (0.0304) | (0.0227) | (0.107) | (0.109) | (0.111) |
| $Value_1$ | 0.046 | | 0.029 | 0.0142* | | 0.008 |
| | (0.0313) | | (0.0342) | (0.00799) | | (0.00955) |
| $Bid/Value_1$ | | -0.025 | | | -0.007 | |
| | | (0.0300) | | | (0.0185) | |
| Constant | 1.068*** | 1.139*** | 0.968*** | 2.971*** | 2.756*** | 2.907*** |
| | (0.272) | (0.271) | (0.304) | (0.651) | (0.678) | (0.728) |
| Controls | | | ✓ | | | ✓ |

Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 4: Regression of Participation Choice on Risk attitude.

# Results

## Result 3.

- Generally overbid.
- Buyers overbid less under Non-Clairvoyant mechanism when the distribution of their valuation has low variance.

# Bid-Value Ratio Comparison

| **Bid/value** | **Non-Clairvoyant Dynamic** | **Repeated Static** | (p-value) [1] |
|---|---|---|---|
| $F_A$ (Low variance) | 1.264 (0.04) | 1.379 (0.04) | **0.060*** |
| $F_B$ (High variance) | 1.194 (0.05) | 1.251 (0.04) | 0.392 |
| (p-value) | 0.116 | **0.008*****  | |

Table 5: Bid-Value Ratio Comparison

[1] We report two-sided p-value under t-test.

# Conclusions

- We find the experimental observations are consistent with theoretical predictions: the optimal Non-Clairvoyant dynamic mechanism outperforms the optimal Repeated Static mechanism when it is predicted to do so.
- Buyers' risk attitudes matter in the success of Non-Clairvoyant mechanism.
- Randomization in non-clairvoyant mechanism leads buyers to overbid less.

# Discussion

## How should sellers choose between mechanisms?

- In “good” scenario where second period distribution has higher expected value, Non-Clairvoyant dynamic mechanism produces more revenue.
- NC encourages more accurate valuation information.
- NC works better when buyers are not risk-averse.

## Future work

- Experiments on multi-buyer with more than 2 periods.
- Can participants (human sellers) set up correct rules ?

# Chapter 2

## Can Sellers Discover the Optimal Dynamic Mechanism?

# Motivation

## Background

- Theoretically, NC cannot always outperform RS
- Under the **non-clairvoyant environment**, sellers **cannot** identify which is better without future distributional information

## Research Question

- Under the **clairvoyant environment**, can sellers discover which is the optimal mechanism through learning by doing?

# Hypotheses

## Learning by doing

1. Sellers retake mechanism chosen in last round if they get more-than-average revenue.
2. Over time, sellers can correctly select the optimal mechanism more.

## How do sellers choose mechanism?

1. More risk averse sellers would choose RS more.
2. More ambiguity averse sellers would choose NC more?
3. Sellers experiencing unpleasant real-life subscription fee will choose RS more.
4. Sellers feel NC more enjoyable will choose NC more.

# Experimental Procedure

## Settings

- 10 Rounds + 2 Practice Rounds, feedback on each round, each period
- Fixed role, re-match for each round
- Risk task and ambiguity task at last (random ordered)

## Plan of Experiments

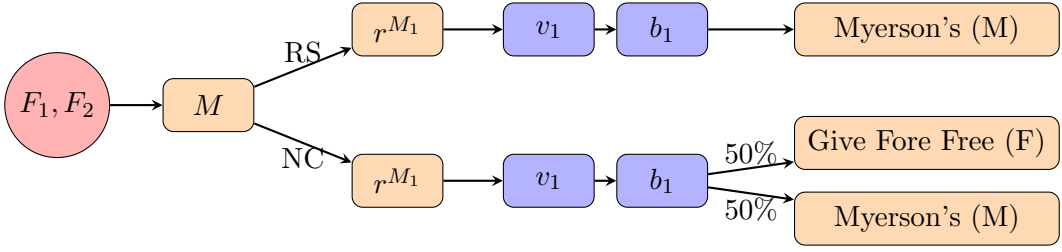
1. Power Analysis based on some behavioral assumptions
2. Test Fest, IRB by the end of October
3. Experiments by the end of November

# 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 $b_1 > r^{M_1}$
   - in NC: buyer has 50% chance to get free item

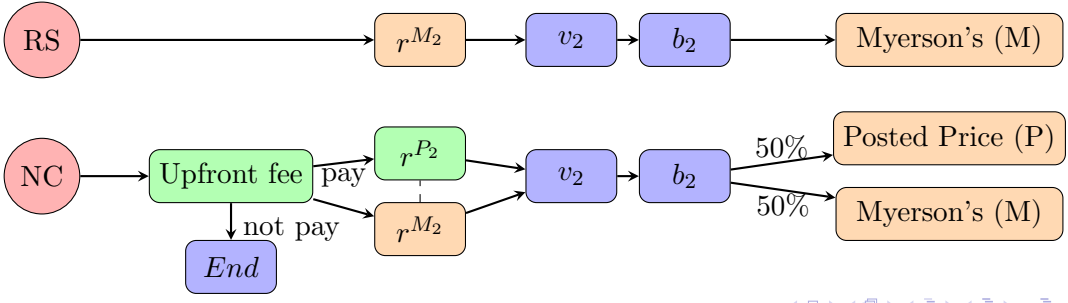
## Choose Mechanism for two Periods



# Experimental Task in each Round

## Period 2

1. Seller sets reserve price $r^{M_2}$ for Period 2
   (for NC, $u_2, r^{P_2}$ will be set by computer optimally)
2. Buyer chooses to pay the upfront fee $u_2$ or not
   Buyer makes a bid $b_2(v_2)$ in RS or in NC if entering in the market



# Experimental Design (within-subject)

## Two Mechanism

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

## Ten Scenarios (3 Groups)

- 4 Scenarios A: $NC > RS$
- 4 Scenarios B: $NC < RS$
- 4 Scenarios C: $NC = RS$ (2 scenarios in practice session)
- Fixed shuffled order for all subjects

# Scenarios A ($NC > RS$)

## Inter-period revenue is more important

- $\mathbb{E}_2$ is greater than $Rev^M$ in the second period
- $\exists$ "target buyers" (high valuation but low probability) in Period 2

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

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

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

# Scenarios B ($NC < RS$)

## Intra-period revenue is more important

- $\mathbb{E}_2$ is not great enough while $Rev^M$ can achieve at least half of $\mathbb{E}_2$
- *e.g.*, Constant valuation, $v_2 = 0$ in Period 2.

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

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

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

# Scenarios C ($NC = RS$)

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.

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

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

$REV^{RS} = REV^{NC} = 6$

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

# Chapter 3

When can the Non-Clairvoyant dynamic mechanism generate more revenue than the Repeated Static mechanism?

# Motivation

## Background

- Theoretically, NC cannot always outperform RS.
- Characterizing scenarios where NC generates more revenue than RS can help sellers set up mechanism.

## Research Question

- Under what (generate) condition can NC generate more revenue than RS?

# Relative size of Intre- and Intra- Period Revenue

## Scenarios A ($NC > RS$)

- $E_2$ is greater than $Rev^M$ in the second period
- $\exists$ "target buyers" (high valuation but low probability) in Period 2

## Scenarios B ($NC < RS$)

- $\mathbb{E}_2$ is not great enough while $Rev^M$ can achieve at least half of $\mathbb{E}_2$
- *e.g.*, Constant valuation, $v_2 = 0$ in Period 2

## Scenarios C ($NC = RS$)

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

# Specific Structure of Scenarios

## Revenue Equivalent Distribution in both period

- Restricted on $Rev^{M_1} = Rev^{M_2}$
- Comparision results depends on distribution in Period 2

## Bernoulli Distribution in Period 2

- $NC \leq RS$, as $Rev^{M_2} \geq \frac{1}{2} * \mathbb{E}_2$

## Uniform Distribution

- $NC < RS$

.

# Behavioral Assumptions

## Behavioral models

- Buyers bid 80% on true value, bid 20% randomly among other options
- Buyers have a 15% chance of quit
- Sellers learn from past outcome, and have more chance of figuring out the intuition in later periods.

## Risk attitude

- If $NC > RS$, then NC must violate single-period individual rationality in Period 2.

*Thank you!*

# Reserve price $(r_1, r_2)$ in Scenario A

$F_1 = F_A = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{2})\}, \ \mathbb{E}_1 = 3.$
$F_2 = F_B = \{v, p(v)\} = \{(2, \frac{1}{2}), (4, \frac{1}{4}), (8, \frac{1}{8}), (16, \frac{1}{16}), (32, \frac{1}{16})\}, \ \mathbb{E}_2 = 6.$

## Period 1

- Myserson's Auction: $r_1 = 2$

## Period 2

- If $luck = 1$, Myserson's Auction: $r_2 = 2$
- If $luck = 0$, Posted Price Auction: $r_2$ satisfies

$$E_{v_2}[(v_2 - r_2)^+] = min(b_1, E(v_2)) = upfront\ fee.$$

Piece-wise function: $r_2^P = 0$ if $b_1 \geq 6$, $r_2^P = 2$ if $b_1 = 4$, $r_2^P = 8$ if $b_1 = 2$, and $r_2^P = 32$ if $b_1 = 0$.

# Reserve price $(r_1, r_2)$ in Scenario B

$$F_1 = F_B = \{v, p(v)\} = \{(2, \tfrac{1}{2}), (4, \tfrac{1}{4}), (8, \tfrac{1}{8}), (16, \tfrac{1}{16}), (32, \tfrac{1}{16})\},\ \mathbb{E}_1 = 6.$$
$$F_2 = F_A = \{v, p(v)\} = \{(2, \tfrac{1}{2}), (4, \tfrac{1}{2})\},\ \mathbb{E}_2 = 3.$$

## Period 1

- Myserson's Auction: $r_1 = 2$

## Period 2

- If $luck = 1$, Myserson's Auction: $r_2 = 2$
- If $luck = 0$, Posted Price Auction: $r_2$ satisfies

$$E_{v_2}[(v_2 - r_2)^+] = min(b_1, E(v_2)) = upfront\ fee.$$

Piece-wise function: $r_2^P = 0$ if $b_1 \geq 3$, $r_2^P = 1$ if $b_1 = 2$ and $r_2^P = 4$ if $b_1 = 0$.

# Experimental Revenue Decomposition in Scenario A

| **Revenue in $S_A$** | **Non-clairvoyant Dynamic** | | | **Repeated Static** | | |
|---|---|---|---|---|---|---|
| | **Theory** | | **Experiment** | **Theory** | | **Experiment** |
| Period 1 | Give it for free | 0 | 0 | Myerson's | 2 | 1.94(0.04) |
| | Myerson's auction | 2 | 1.94(0.06) | | | |
| Period 2 | Post Price Auction | **5** | 4.84(0.47) | Myerson's | 2 | 1.91(0.05) |
| | Myerson's auction | 2 | 1.94(0.06) | | | |
| Total | | 5 | **4.35**(0.32) | | 4 | **3.84**(0.07) |

Table 6: Revenue decomposition in $S_A$

# Experimental Revenue Decomposition in Scenario B

| **Revenue in $S_B$** | **Non-clairvoyant Dynamic** | | | **Repeated Static** | | |
|---|---|---|---|---|---|---|
| | **Theory** | | **Experiment** | **Theory** | | **Experiment** |
| Period 1 | Give it for free | 0 | 0 | Myerson's | 2 | 1.91(0.05) |
| | Myerson's auction | 2 | 1.93(0.06) | | | |
| Period 2 | Post Price Auction | **3** | 2.25(0.21) | Myerson's | 2 | 1.97(0.03) |
| | Myerson's auction | 2 | 1.75(0.12) | | | |
| Total | | 3.5 | **2.91**(0.18) | | 4 | **3.88**(0.06) |

Table 7: Revenue decomposition in $S_B$