What Makes Players Pay?
An Empirical Investigation of In-Game Lotteries

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Lotteries in Video Games: Loot Boxes

- An in-game (virtual) item that a user can purchase to receive a *randomized* reward
- Different from other randomness in video games
  - Purchasable
  - A stand-alone choice
- A prominent source of revenue for video games. In 2020:
  - Global revenue of \$15B ($\sim$10% of the gaming industry)
  - Used in $\sim$58% of highest-grossing iPhone/Android mobile games

Loot Boxes Example: FIFA Ultimate Team Mode

Two Views on Loot Boxes

1. Enhance **gaming** experience
   - Voluntary and useful in the game, complements the gameplay
   - Another strategic dimension in the “game of skill”
   - “Reflects the real-world excitement and strategy of building and managing a squad” (EA CEO re: Ultimate Team Mode)

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2. **Gambling** embedded into video games
   - A *lottery* (for *real money*) to obtain a *prize*
   - Consumers get direct utility from resolving uncertainty and collecting items
   - Similar problem gambling as in other contexts
     - Addiction, impulsive consumption, other behavioral mechanisms → leads to over-spending
   - A substantial share of consumers are minors

Regulation of Loot Boxes: No Consensus

- Banned due to being gambling (e.g. Belgium)
- Partially banned or regulated (e.g. Japan, China)
- Determined not gambling and allowed (e.g. Poland, New Zealand)
- Inquiries into loot boxes in major jurisdictions
  - US: A 2019 Workshop at the FTC
  - UK: A 2020 Government Call for Evidence
  - EU: A 2023 European Parliament's Resolution

More

A Stand-Alone Product or Part of the Game of Skill?

- In March 2022, the Dutch Council of State overruled the district court, making EA's Ultimate Team mode legal Ruling
- *"...obtaining and opening the [randomized] packs is not an isolated game.* ***They are part of a game of skill [...] used for game participation*** *[...] Because the packs are not a stand-alone game, they are not a game of chance and do not require a license"*

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   - In-game functional value/complementarity with the game?
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   - Do 🐳 open loot boxes for other reasons than regular players?
   - Externalities for product design?

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3. What are the implications of:
   - A full loot box ban
   - A ban on paid loot boxes
   - Spending limits

This Paper

1. A simple model to separate out complementary and direct values of loot boxes
2. Data from a Japanese mobile puzzle game
   - Describe consumers' behavior
   - Model-free evidence of the source of loot box value
3. Estimate an empirical model of gameplay with loot boxes
   - Forward-looking players that accumulate inventory
   - A two-step estimator using the terminal action property
4. Characterize consumer tastes, evaluate product design and policy counterfactuals
   - Measure the relative importance of complementarity
   - Evaluate alternative game and loot box designs
   - Measure the effects of potential regulatory actions

A Toy Model

- A consumer considers playing a video game with loot boxes. She makes two decisions:
  - Do I play the game, $Y_G \in \{0, 1\}$?
  - Do I open a loot box, $Y_L \in \{0, 1\}$?

- Playing the game, $Y_G = 1$, gives

$$U_G(Y_G = 1, Y_L) = \alpha + \quad I(\text{win}|Y_L), \tag{1}$$

- Opening a loot box, $Y_L = 1$, gives

$$U_L(Y_L = 1) = \qquad \rho p, \tag{2}$$

and weakly increases the probability of winning at the game,
$Pr(\text{win}|1) \quad Pr(\text{win}|0) \quad 0$

Two Sources of Loot Box Tastes

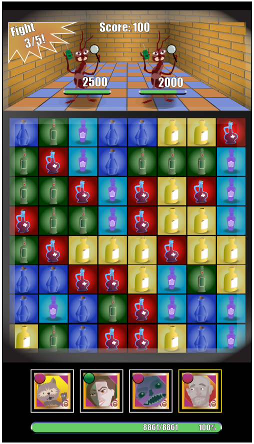
- Two reasons to open a loot box:
  1. Higher expected win utility, $[Pr(\text{win}|1) \quad Pr(\text{win}|0)]$
     - Open loot boxes more when the functional value is higher
  2. Persistent taste for opening loot boxes,
     - Want to open loot boxes regardless of functional value

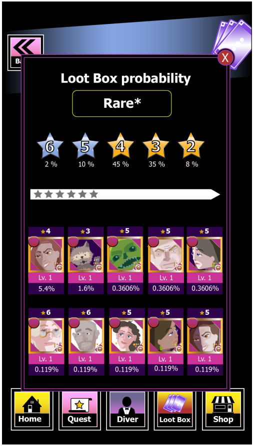
- can capture various mechanisms
  - Direct utility from uncertainty
  - Habit formation: positive state dependence as part of
  - Variable-ratio schedule of reinforcement: higher if higher variance of the draws

Empirical Context: A Japanese Mobile Video Game

- A free-to-play puzzle mobile game, run April 2015-July 2019
  - The mechanics is “match-three puzzle” (e.g. Candy Crush)
- Core features:
  - A sequence of 173+ stages of increasing difficulty
  - A player accumulates an inventory of items that help to complete stages (“divers”), vertically differentiated (“rarity”)
  - Chooses up to four divers before each stage play
  - Divers are accumulated either through play/points or through opening loot boxes
  - Loot boxes can be opened between stage plays using in-game currency, acquired through play or pay ($\sim 3.5\$$)
  - A player can open 11 loot boxes at once (for the price of 10)

Examples of Game Visuals





Game Data

- Access to complete data logs
  - ~ 2.5M players
  - User play and loot box opening decisions, play and loot box outcomes, inventories, currency stocks, etc

Summary Statistics

Table 1: Summary statistics across users.

	Min	Mean	Median	Max	SD	Total
# of actions	1	106.31	10	119,007	540.61	267,521,534
- Played main stage games	0	38.44	4	28,586	115.67	96,719,354
- Played event games	0	48.16	0	83,805	378.10	121,186,908
- Opened rare lootboxes	0	7.88	3	6,204	30.54	19,829,420
- Opened normal lootboxes	0	11.84	2	24,426	58.93	29,785,852
Max main stage achieved	0	18.54	4	173	32.27	–
Win share: main stage games	0	0.94	1	1	0.14	–
Win share: event games	0	0.74	0.84	1	0.29	–
Opened 11 rare lootboxes at once	0	1.02	0	3,256	8.45	2,559,307
In-game currency received	0	78	18	178,698	457.52	196,267,039
- through gameplay	0	72.80	18	128,831	359.30	183,187,916
- through a purchase	0	5.20	0	49,867	119.89	13,079,123
In-game currency spent	0	66.76	9	178,606	442.07	168,001,147
- got through gameplay	0	61.58	9	128,739	340.72	154,962,617
- got through a purchase	0	5.18	0	49,867	119.75	13,038,530
Sessions	1	21.21	1	9,102	103.80	53,368,821
Unique days played	1	11.42	1	1,548	45.14	28,744,507
Length of play (in calendar days)	0	38.19	0	1,553	137.29	–

Actions correspond to playing the game or opening lootboxes. A session is defined as a sequence of actions that are no more than 1 hours apart.

Inequality in the Expenditures

- Game purchases are highly concentrated:
  - 90% of money spent by 1.5% of players (🐳)
  - The highest: ∼\$33K by one user, ∼\$3K in one session

- "Organic" in-game currency expenditures are much less concentrated:
  - 90% of spending by 31.5% of players
  - Similar for gameplay

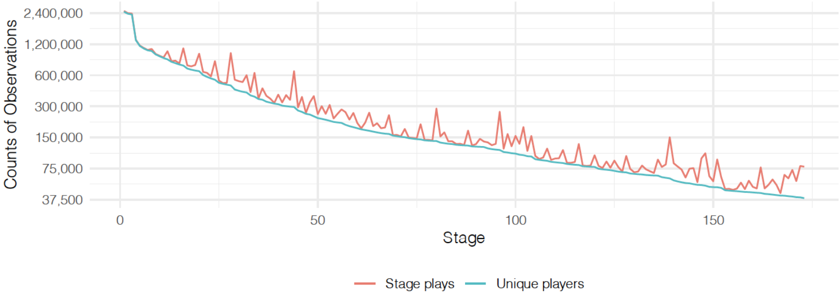
- 95.7% of money spent on loot boxes

Lorenz Curves

Descriptives: Game Progress by Stage

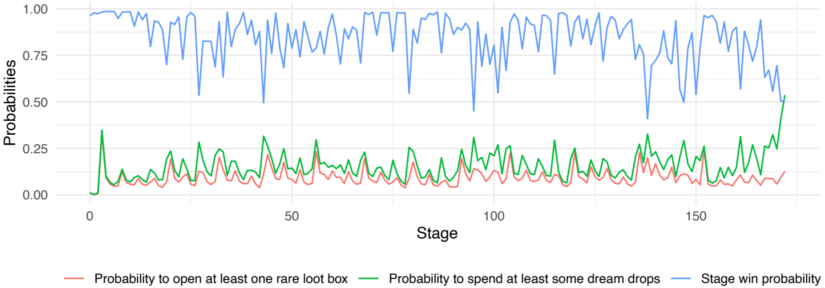
- 37K players reach stage 173
- Every four stages there is a harder "boss" stage

Figure 4: The Number of Plays and Unique Players Present at Each Stage



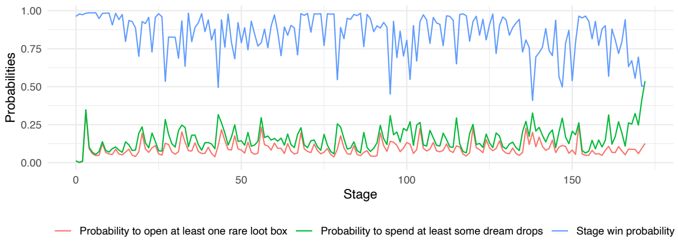
Descriptives: Win Probability vs. Loot Box Opening

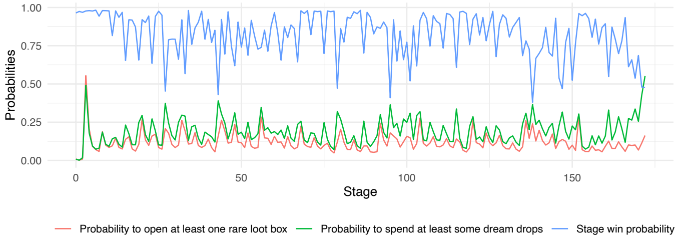
- Based on people who reached stage 173
- Lower win probability in later stages
  - The first (96%) vs. final (48%) rounds
- Players more likely to open loot boxes and spend currency when the game is harder (elasticity $\sim$1%)



Regression | Game Progress by Stage

Descriptives: Players Reaching Stage 173 vs. All Players





Model-Free Evidence: Effects of Loot Box Outcomes

- Functional value of loot boxes $\rightarrow$ "good" realizations should increase the utility from gameplay
- A stronger effect if larger impact on game performance
  - Added to the low- vs. high-quality inventories

Model-Free Evidence: Effects of Loot Box Outcomes

- Functional value of loot boxes → "good" realizations should increase the utility from gameplay

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- Use loot box outcome as an instrument for inventory quality, controlling for the inventory in $t \quad 1$

$$I(a_{it} = \text{loot box} | a_{i,t \quad 1} = \text{loot box}) = bR_{it} + \kappa_i + \kappa'_{s,R_{it \quad 1}} + \xi_{it}$$

  - where R_{it} is the total rarity of the top-4 divers in the inventory
  - Include user i and stage s by rarity in $t \quad 1$ fixed effects
  - Standard errors clustered two-way, on the user and stage levels

Effects of Inventory Quality on Loot Box Probability: Non-whales

	Dependent variable: $I(a_{it} \in \{2,3\} \| a_{i,t-1} \in \{2,3\})$
	All
	(1)
II. Non-whales:	
$\hat{R}_{it}$ (IV: $\text{rarity}_{L_{it-1}}$)	-0.1725***
	(0.0513)
First stage ($R_{it} \sim \text{rarity}_{L_{it-1}}$)	0.1562***
	(0.0383)
Average $I(a_{it} \in \{2,3\} \| a_{i,t-1} \in \{2,3\})$	0.6439
R^2	0.3236
Number of observations	14,563,179

Effects of Inventory Quality on Loot Box Probability: Non-whales

	Dependent variable: $I(a_{it} \in \{2,3\} \| a_{i,t-1} \in \{2,3\})$		
	All	$R_{it-1} < 16$	$R_{it-1} \geq 16$
	(1)	(2)	(3)
II. Non-whales:			
$\hat{R}_{it}$ (IV: $\text{rarity}_{L_{it-1}}$)	-0.1725***	-0.0880***	-0.8094***
	(0.0513)	(0.0075)	(0.2168)
First stage ($R_{it} \sim \text{rarity}_{L_{it-1}}$)	0.1562***	0.4458***	0.0320***
	(0.0383)	(0.0380)	(0.0075)
Average $I(a_{it} \in \{2,3\} \| a_{i,t-1} \in \{2,3\})$	0.6439	0.5471	0.7141
R^2	0.3236	0.4155	0.2552
Number of observations	14,563,179	6,116,584	8,446,595

Effects of Inventory Quality on Loot Box Probability: 🐳

	Dependent variable: $I(a_{it} \in \{2,3\} \mid a_{i,t-1} \in \{2,3\})$
	All
	(1)
III. Whales:	
$\hat{R}_{it}$ (IV: $\text{rarity}_{L_{it-1}}$)	-0.0080
	(0.0363)
First stage ($R_{it} \sim \text{rarity}_{L_{it-1}}$)	0.0400**
	(0.0171)
Average $I(a_{it} \in \{2,3\} \mid a_{i,t-1} \in \{2,3\})$	0.8025
R^2	0.1537
Number of observations	3,856,246

Effects of Inventory Quality on Loot Box Probability: 🐳

	Dependent variable: $I(a_{it} \in \{2,3\} \mid a_{i,t-1} \in \{2,3\})$		
	All	$R_{it-1} < 16$	$R_{it-1} \geq 16$
	(1)	(2)	(3)
III. Whales:			
$\hat{R}_{it}$ (IV: $\text{rarity}_{L_{it-1}}$)	-0.0080	-0.0313***	-0.0212
	(0.0363)	(0.0040)	(0.0952)
First stage ($R_{it} \sim \text{rarity}_{L_{it-1}}$)	0.0400**	0.4238***	0.0152**
	(0.0171)	(0.0435)	(0.0061)
Average $I(a_{it} \in \{2,3\} \mid a_{i,t-1} \in \{2,3\})$	0.8025	0.5571	0.8269
R^2	0.1537	0.2229	0.1238
Number of observations	3,856,246	349,426	3,506,820

Play Utility

- Consider consumer i who reached stage s by time t

- Four choice options a_{it}: play stage s ($a_{it} = 1$), open 1/11 loot box(es) ($a_{it} = \{2, 3\}$), or leave the game forever ($a_{it} = 0$)

- State variables: stage s_{it}, diver rarity in inventory R_{it}, currency stock c_{it}, whether the current stage was lost q_{it}, state dependence d_{it}, loot box prices $\{p^1_{it}, p^{11}_{it}\}$

- The utility of playing is

$$u(a_{it} = 1) = \alpha_{G,s_{it}} \qquad q_{it} \tag{3}$$

 where

 - $\alpha_{G,s_{it}} = \alpha_{G,s}$ is utility from playing stage s
 - captures the disutility of having lost the current stage and having to replay it

Win Probability

- The win probability is determined by

$$\Pr(\text{win}|s_{it}, q_{it}, D_{it}) = \zeta_{1,s,q} + \zeta_{2,s,q} * R_{it} + \zeta_{3,R_{it}} \tag{4}$$

  where
  - $\zeta_{1,s,q}$, $\zeta_{2,s,q}$ and $\zeta_{3,R_{it}}$ allow for stage-and-loss-specific effects of inventory rarity on the win probability
  - R_{it} is the summed up rarity of top-4 divers in the inventory D_{it} of the player (from 8 to 24, 17 combinations)

One Loot Box Opening Utility

- If i opens a single loot box L_s, $a_{it} = 2$, with $\Pr_s$ get diver $d \in D_{L_s}$
  - Updating the inventory $D_{i,t+1} = \{D_{it}, d\}$ and the implied R_{it+1}

- Pays p^1_{it}, updating $c_{it+1} = c_{it} \quad p^1_{it}$
  - If $p^1_{it} > c_{it}$, need to spend real money to acquire $p^1_{it} \quad c_{it}$ of in-game currency

- Gets utility

$$u\left(a_{it} = 2\right) = \alpha_{L,1} \qquad \mathbb{1} \;\; p^1_{it} > c_{it} \;\; \times \;\; p^1_{it} \quad c_{it} \;\; + \eta d_{it} \tag{5}$$

where

- $\alpha_{L,1}$ is the direct utility of opening one loot box
- is the (dis)utility of spending money on in-game currency
- η is state.dep. coef on $d_{it} = \mathbb{1}\left(a_{i,t \quad 1} \in \{2, 3\}\right)$

Eleven Loot Boxes Openings Utility

- Separate utility of consumer i opening eleven loot boxes, $a_{it} = 3$

$$u\left(a_{it} = 3\right) = \alpha_{L,11} \quad \mathbb{1} \;\; p_{it}^{11} > c_{it} \;\; \times \;\; p_{it}^{11} \quad c_{it} \;\; + \eta d_{it} \tag{6}$$

where

  - $\alpha_{L,11}$ is the direct utility of opening eleven loot box

- The utility of quitting the game forever, $a_{it} = 0$, is normalized to zero

Player's Objective

- A forward looking player chooses a_{it} $\forall t$ to maximize

$$max_{\{a_{it} \;\; \forall t\}} E \sum_{t=1}^{\infty} \} \, {}^{t \quad 1} u_{it}(a_{it}, O_{it}; \quad) + \varepsilon_{iat} \tag{7}$$

where

  - $O_{it} = \quad R_{it}, c_{it}, s_{it}, q_{it}, d_{it}, p_{it}^{1}, p_{it}^{11}$ are state variables Transitions
  - are preference parameters
  - ε_{iat} are player, choice, time specific idiosyncratic shocks

- Writing out as a value functional using Bellman equation:

$$V\left(O_{it}, \varepsilon_{iat}\right) = \max_{a_{it} \in \{0,1,2,3\}} u\left(a_{it}\right) + \varepsilon_{iat} + \quad E_{O', \varepsilon' | O_{it}, a_{it}} V \quad O', \varepsilon' \tag{8}$$

  - Boils down to simple multinomial logit if we know $E_{O', \varepsilon' | O_{it}, a_{it}} V\left(O', \varepsilon'\right)$

Estimation

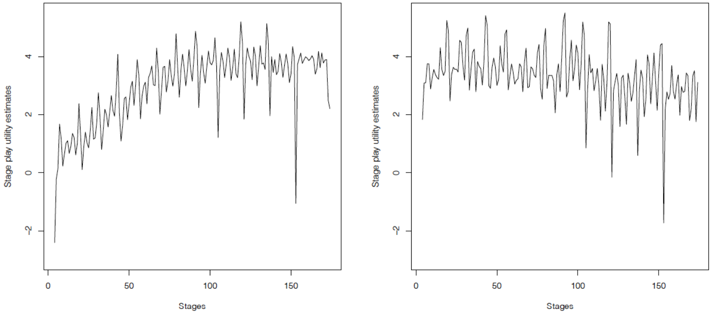
- Use a two-step estimator [Hotz and Miller, 1993] leveraging terminal action property [Arcidiacono and Miller, 2011]

  1. Estimate the conditional choice probability $(CCP_0(O_{it}) = CCP(a_{it} = 0|O_{it}))$ of the terminal action, $a_{it} = 0$, and state transition probabilities, $G(\cdot)$
  2. Express $\int_{\epsilon_{it}} V(O_{it}, \varepsilon_{it})\, dF(\epsilon_{iat})$ as the function of $CCP_0(O_{it})$
  3. Compute expected $E_{O', \varepsilon' | O_{it}, a_{it}} V(O', \varepsilon')$ using $G(\cdot)$
  4. Use Berry [1994] inversion to estimate utility parameters

Details

Estimation Results: $\alpha_{G,s}$

Figure 9: Estimates of Preference for Stage Play, $\alpha_{G,s}$



(a) Non-whales (b) Whales

- Increasing over the first 20 periods of the game
  - Aligned with the design: the first 10-15 stages are relatively simple to complete
- Even at later stages, systematically higher play utility from harder

Estimation Results: The Rest of

Table 5: Estimates of Preference for Loot Boxes and Winning in the Game

	Non-Whales		Whales	
	Estimate	S.e.	Estimate	S.e.
One loot box ($\alpha_{L,1}$)	-1.7180	(0.4514)	0.1125	(0.1844)
State dependence (η)	1.1262	(0.2751)	2.0187	(0.2671)
Eleven-pack loot box ($\alpha_{L,11} - \alpha_{L,1}$)	0.0312	(0.4311)	-0.4776	(0.1913)
Payment (γ)	-0.1954	(0.0098)	-0.1545	(0.0039)
Lose the game (-β)	-0.4293	(0.1136)	-1.4488	(0.0846)

Standard errors are computed using Bayesian bootstrap, with clustering (draws of observation weights) done at the stage level.

- For 🐳:
  - Stronger preference for loot boxes
  - Stronger state dependence
  - Lower preference for eleven-pack loot boxes
  - Less price responsive
  - Care about losing

Heterogeneity by Event Plays   Heterogeneity within whales and non-whales

Functional vs. Direct Loot Box Value

- **A:** Baseline future expected utility

$$\tilde{V}_{\text{baseline}}(O) = \ln\Bigg(\underbrace{\exp\left(u(a=1) + E_{R',\hat{O}',\varepsilon'|O,a=1} V\left(O',\epsilon'\right)\right)}_{\text{Playing stage game}} \tag{9}$$

$$+ \underbrace{\sum_{\tilde{a}\in\{2,3\}} \exp\left(u(a=\tilde{a}) + E_{R',\hat{O}',\varepsilon'|O,a=\tilde{a}} V\left(O',\epsilon'\right)\right)}_{\text{Opening 1 or 11 loot boxes}} + \underbrace{\exp\left(u(a=0)\right)}_{\text{Exit game}}\Bigg) \tag{10}$$

  - Compare to utilities that shut down the two mechanisms, holding future actions fixed

Functional vs. Direct Loot Box Value

- **B:** No option to open loot boxes

$$\tilde{V}_{\text{n.l.}}(O) = \ln\left(\underbrace{\exp\left(u(a_0 = 1) + E_{R',\hat{O}',\varepsilon'|O,a_0=1} V\left(O', \epsilon'\right)\right)}_{\text{Playing stage game}} + \underbrace{\exp\left(u(a = 0)\right)}_{\text{Exit game}}\right) \tag{11}$$

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- **C:** No rarity adjustments from opening loot boxes

$$\tilde{V}_{\text{n.f.}}(O) = \ln\left(\underbrace{\exp(\cdots)}_{\text{Playing stage game}} + \underbrace{\sum_{\tilde{a}\in\{2,3\}} \exp\left(u(a=\tilde{a}) + E_{R,\hat{O}',\varepsilon'|O,a=\tilde{a}} V\left(O',\epsilon'\right)\right)}_{\text{Opening 1 or 11 loot boxes}} + \underbrace{\exp(\cdots)}_{\text{Exit game}}\right) \tag{12}$$

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- **D:** Similarly, shut down the state dependence in opening loot boxes

Functional vs. Direct Loot Box Value: Results

Table 8: Decomposition of the Loot Box Value

	Overall		Stage 5		Stage 50		Final stage	
	Non-Whales	Whales	Non-Whales	Whales	Non-Whales	Whales	Non-Whales	Whales
Functional value	89.51	3.04	93.73	21.92	6.72	3.91	0.24	0.08
	(2.67)	(0.72)	(1.76)	(3.58)	(4.57)	(0.95)	(0.13)	(0)
Direct value	10.49	96.96	6.27	78.08	93.28	96.09	99.76	99.92
	(2.67)	(0.72)	(1.76)	(3.58)	(4.57)	(0.95)	(0.13)	(0)
State Dependence	2.50	33.38	2.04	37.17	30.89	42.26	24.56	29.71
	(0.71)	(3.08)	(0.58)	(6.23)	(7.46)	(4.22)	(7.31)	(2.86)
Option to loot	7.98	63.58	4.23	40.90	62.40	53.84	75.20	70.21
	(2.43)	(2.52)	(1.53)	(3.56)	(9.8)	(3.46)	(7.4)	(2.86)

Standard errors are computed using Bayesian bootstrap, with clustering (draws of observation weights) done at the stage level.

- Non-whales get 90% of loot box value from the functional mechanism
- 🐳 get only 3% of the loot box value from the functional mechanisms and 33.4% from state dependence
- Lower functional value in later stages

Decomposition with Heterogeneity

Counterfactuals: Product Design

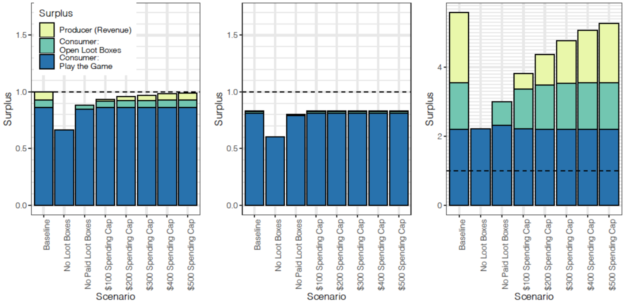
Table 9: Simulations under varying game stage win probabilities

	Revenue			# of Stage Games Played			Share of Consumers At Stage 20		
	Overall	Non-whales	Whales	Overall	Non-whales	Whales	Overall	Non-whales	Whales
Harder									
Win prob -50%	23.49	0.05	659.77	0.28	0.18	2.89	0.21	0.15	1.93
Win prob -40%	15.92	0.05	446.70	0.37	0.29	2.52	0.33	0.27	1.95
Win prob -30%	7.24	0.06	202.17	0.49	0.42	2.3	0.47	0.41	1.97
Win prob -20%	3.33	0.07	91.86	0.64	0.58	2.14	0.63	0.58	1.98
Win prob -10%	2.23	0.07	61.02	0.81	0.77	2.04	0.82	0.77	1.98
Current win prob	**1.00**	0.07	26.21	**1.00**	0.96	1.96	**1.00**	0.96	1.98
Win prob +10%	0.73	0.07	18.26	1.05	1.02	1.91	1.05	1.02	1.98
Win prob +20%	0.62	0.07	15.52	1.06	1.03	1.88	1.07	1.04	1.98
Win prob +30%	0.58	0.06	14.58	1.06	1.03	1.87	1.08	1.05	1.98
Win prob +40%	0.55	0.06	13.85	1.06	1.03	1.86	1.1	1.06	1.98
Win prob +50%	0.54	0.06	13.58	1.06	1.03	1.85	1.1	1.07	1.98
Easier									

- Evaluate outcomes under the counterfactual game difficulty
- A harder game design (lower win prob) increases revenue (from 🐳) but decreases engagement (from regular players)

Counterfactuals: Welfare Effects of Policies

Figure 10: Revenue and Consumer Surplus under Loot Box Bans and Spending Caps

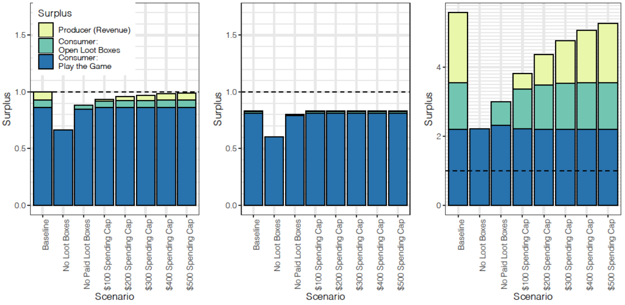


(a) Overall (b) Non-Whales (c) Whales

1. Baseline:
   - Firm gets 7.4% of the total surplus
   - Players: 6.3% of the total surplus from opening loot boxes, 86.3% from playing stages
     - For regular players: 1.8% from l.b. and 97.8% from playing
     - For 🐳: 24.3% from l.b. and 39.3% from playing

Counterfactuals: Welfare Effects of Policies

Figure 10: Revenue and Consumer Surplus under Loot Box Bans and Spending Caps

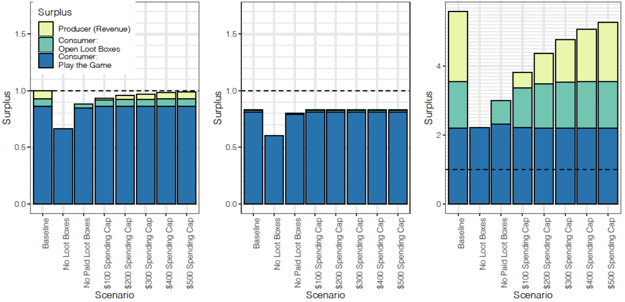


(a) Overall (b) Non-Whales (c) Whales

2. A blanket ban on loot boxes:
   - Zero revenue and CS from loot boxes (by construction)
   - Regular players get 25.4% less CS from playing stages
     - Due to the complementarity of loot boxes and the gameplay

Counterfactuals: Welfare Effects of Policies

Figure 10: Revenue and Consumer Surplus under Loot Box Bans and Spending Caps

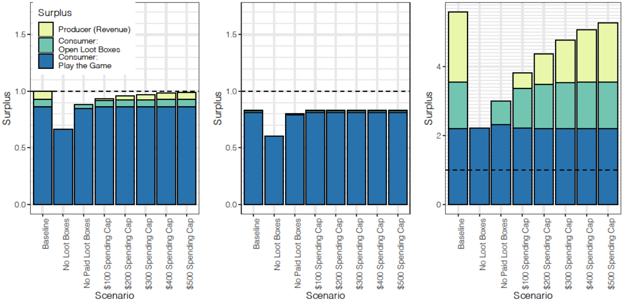


(a) Overall (b) Non-Whales (c) Whales

3. A ban on paid loot boxes:
    - Zero revenue (by construction)
    - Regular players get 2.1% less CS from playing stages
    - 🐳 get 50% less CS from opening loot boxes

Counterfactuals: Welfare Effects of Policies

Figure 10: Revenue and Consumer Surplus under Loot Box Bans and Spending Caps



(a) Overall (b) Non-Whales (c) Whales

4. $100-$500 spending limits:
   - Regular players not affected (never spend above $100)
   - 🐳 get the same CS from playing
   - $100-$500 caps:
     - 🐳 get 84%-99.9% of CS from loot boxes vs. baseline
     - the firm gets 24.3%-86.5% of PS

Conclusions

1. Loot boxes bring different types of value for regular and high-spending players
   - Mostly (90%) complementary to the game for regular players → "part of a game of skill"
   - Mostly (97%) direct values for high-spending players → "a stand-alone game"

2. Current game design (complexity) trades-off the engagement from regular players and revenues from high-spending players

3. Use the estimates to evaluate loot box bans and spending limits (per consumer) on consumer and producer surplus

Thank you!