Reference Pricing and Consumption Inequality

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Motivation

- In the status quo, firms sustain large cross-country price gaps
  - Household heterogeneity shapes markups across products of varying qualities
  - I argue that across space, household heterogeneity can generate heterogeneous markups for identical products
  - Price gaps reveal differences in demand composition across markets

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  - Price gaps reveal differences in demand composition across markets
- In 2015, the EU proposed the Digital Single Market Strategy
  - Removes virtual borders across Europe
  - Requires retailers to charge identical prices to all EU customers
- Raises a natural question of welfare effects of such policies across space
  - I identify the winners and losers of the policy if it were implemented globally

This Paper

- I document a middle ground between law of one price and full pricing-to-market in digital goods
  - Show imperfect geo-blocking enables price discrimination in wealthy markets
- Develop a model that embeds the endogenous location choices of heterogeneous customers with imperfect enforcement by the firm
  - Some customers engage in “risky arbitrage”
  - Prices increase in poorer countries
  - The policy would reallocate surplus from low income countries to high income countries
- Estimate the model on the video game market
  - Allows me to abstract away from differences in costs or quality
  - Under reasonable parameters, the imperfect enforcement is optimal for the firm
  - Eventually: compare prices, profits, and consumer surplus under different pricing regimes

Additional Examples

Literature Review

- Violations of Law of One Price
  - Simonovska (2015), Crucini and Yilmazkuday (2014), Fajgelbaum et al (2011)
  - **Contribution**: in digital settings, cheaper markets enable price discrimination
- Uniform pricing and household sorting
  - DellaVigna Gentzkow (2019), Bils Klenow (2001), Jaimovich, Rebelo, Wong, and Zhang (2019)
  - **Contribution**: firms use low prices in smaller markets to segment households within the same country
- Reference Pricing
  - Dubois, Gandhi, and Vasserman (2022), Danzon and Chao (2000), Jensen (2007)
  - **Contribution**: cheaper online markets can act as reference prices
- Allocative Effects of Exchange Rate Shocks
  - Engel (2006), Drenik and Perez (2021), Cravino (2018), Gopinath et al (2011)
  - **Contribution**: exchange rate shocks change *where* goods are purchased

Empirical Application

Why Video Games?

- Focusing on video games allows me to rule out several traditional explanations of price variation across space:
  - No transport costs
    - Shuts down transport costs as a source of marginal cost heterogeneity
  - Products are identical across markets
    - Rules out quality differences across space
  - Goods cannot be resold across markets
    - Rules out arbitrage across customers in different locations

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- The video game market is an *ideal setting* Market Size

The Video Game Market

- Video games are the largest global digital media market
- Steam is the largest PC video game retailer in the world, holding a 75% market share
  - “Amazon” of video games
- Steam operates in many countries, including pricing in over 40 currencies

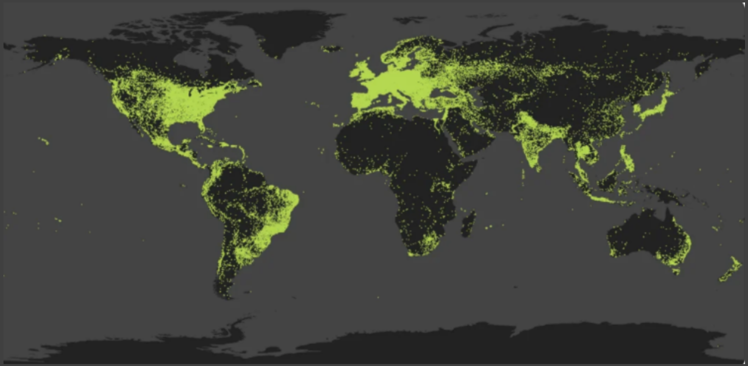


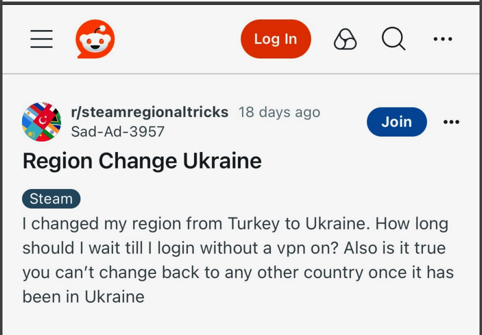
Figure: Map of Steam Users (2016)

Cross-Country Price Variation

CURRENCY	CURRENT PRICE	CONVERTED PRICE	
U.S. Dollar	$59.99	$59.99	
British Pound	£49.99	$62.94	+4.92%
Euro	59,99€	$64.22	+7.06%
Russian Ruble	1999 ₽	$32.37	-46.04%
Brazilian Real	R$ 199,99	$41.05	-31.56%
Japanese Yen	¥ 6990	$52.70	-12.15%
Indonesian Rupiah	Rp 699999	$48.39	-19.33%
Malaysian Ringgit	RM219.00	$49.82	-16.95%
Philippine Peso	₱2599.00	$49.20	-17.99%
Singapore Dollar	S$69.00	$50.22	-16.28%
Thai Baht	฿1799.00	$52.31	-12.80%
Vietnamese Dong	990000₫	$42.68	-28.84%
South Korean Won	₩ 66000	$52.59	-12.33%
Turkish Lira	₺249,00	$14.78	-75.35%
Ukrainian Hryvnia	899₴	$30.42	-49.29%
Mexican Peso	Mex$ 1299.00	$66.33	+10.58%
Canadian Dollar	CDN$ 79.99	$63.82	+6.40%
Australian Dollar	A$ 89.95	$65.04	+8.43%
New Zealand Dollar	NZ$ 99.99	$64.89	+8.18%
Norwegian Krone	549,00 kr	$58.00	-3.31%
Polish Zloty	199,00zł	$46.54	-22.42%
Swiss Franc	CHF 69.99	$71.97	+19.98%
Chinese Yuan	¥ 298	$44.67	-25.53%
Indian Rupee	₹ 2999	$38.61	-35.64%
Chilean Peso	CLP$ 39999	$48.42	-19.28%
Peruvian Sol	S/.199.00	$53.20	-11.32%
Colombian Peso	COL$ 199000	$52.62	-12.28%
South African Rand	R 799.00	$51.91	-13.46%
Hong Kong Dollar	HK$ 399.00	$50.85	-15.23%
Taiwan Dollar	NT$ 1599	$54.31	-9.46%
Saudi Riyal	229.00 SR	$61.04	+1.75%
U.A.E. Dirham	229.00 AED	$62.34	+3.93%
Argentine Peso	ARS$ 2199,00	$18.13	-69.77%
Israeli New Shekel	₪269.00	$80.43	+34.08%
Kazakhstani Tenge	11499₸	$26.64	-55.58%

Text Data

- Steam regional tricks subreddit
- Users discuss the best ways to exploit cross-country price variation on Steam
- Share payment methods, VPNs, etc
- Discuss consequences if detected by the firm



Data Sources

- Daily Game price histories scraped from SteamDB in various currencies
  - Currencies: USD, Euro, Turkish Lira, Argentinian Peso, Brazilian Real, Colombian Peso, Japanese Yen, Uruguayan Peso, Chilean Peso, British Pound, Israeli New Shekel, and the Chinese Yuan
  - Characteristics: International release dates, developer, genre, AAA status

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- Household Consumption Survey from Argentina
  - includes demographic information and expenditures
  - explicitly asks about video game purchases
- Currency data from FRED

Model

Home Customer Location Choice

- Customers choose a purchase location
- Focus on two countries: home and foreign
  - Foreign market customers *always* choose to purchase in foreign
  - Exposition of the household block focuses on home customers
- Each period, customers observe a global menu of prices, firm's strategy π, and exchange rates (E_t)

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- Each period, customers observe a global menu of prices, firm's strategy π, and exchange rates (E_t)
- Customers of type (θ, L) vary along 4 exogenous attributes, θ, and 1 state, L:
  - c_i: physical location (home or foreign)
  - y_i: income
  - α_i: preferences over video games
  - τ_i: lump-sum hassle cost to access foreign market prices
  - $L_{i,t}$: library size that tracks the number of previously purchased goods

"Risky" Arbitrage

- Customers earn per-period utility based on their purchase choice:

$$
\begin{aligned}
r(L, a; \theta) &= u(c_a) + \alpha_i L \\
c_0 &= y_i \\
c_H &= y_i - p_H \\
c_F &= y_i - (E_t p_F + \tau_i)
\end{aligned}
$$

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- Purchases at home (H) or in foreign (F) add to the customer's library size
- Firms punish customers for purchasing in foreign with probability π by revoking access to the users' library based on Steam's terms and conditions
- The library law of motion is given by:

$$L'(L, a) = \begin{cases} L, & \text{if a = 0} \\ L+1, & \text{if a = H} \\ L+1, & \text{if a = F with probability } 1-\pi \\ 0, & \text{if a = F with probability } \pi \end{cases}$$

Customer Location Choice

- A type θ customer with existing library of size L chooses a location from which to purchase a good to solve:

$$V_\theta(L) = \max_a \left\{ u(c_a) + \alpha L + \beta \mathbb{E}\left[V_\theta(L'; L, a) \right] \right\}$$

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- $\text{pol}_\theta(L)$ is the purchase location policy by a customer of type θ
- As the library size L grows, the shadow cost of purchasing in foreign rises
  - Life cycle pattern of initially buying in foreign and eventually switching to home
  - Customers exit the market with hazard rate s and new entrants are drawn from distribution ν Hazard Rate Estimation
  - Changes to exchange rates break this monotonicity in library size by changing relative prices

Demand

- Demand in the home location is given by integrating over all of the consumer types θ and library sizes L for those purchasing at home

$$D_H(p_H, p_F, \pi, G) = \int_L \int_\theta \mathbb{1}\{\text{pol}_\theta(L) = H\} dG(\theta, L)$$

- Demand in the foreign location is given by:

$$D_F(p_H, p_F, \pi, G) = \int_L \int_\theta \mathbb{1}\{\text{pol}_\theta(L) = F\} dG(\theta, L)$$

  - Includes foreign customers and arbitrageurs

Firm Problem

- Firm selects (p_H, p_F, π) to maximize profits subject to a convex punishment strategy cost for implementing π
- The firm solves:

$$\max \quad p_H D_H + p_F D_F - C(\pi; k_1, k_2)$$

- where $C(\pi; k_1, k_2)$ is a convex punishment strategy cost:

$$C(\pi; k_1, k_2) = k_1 \pi + k_2 \pi^2$$

- taking as given induced customer demand Timing

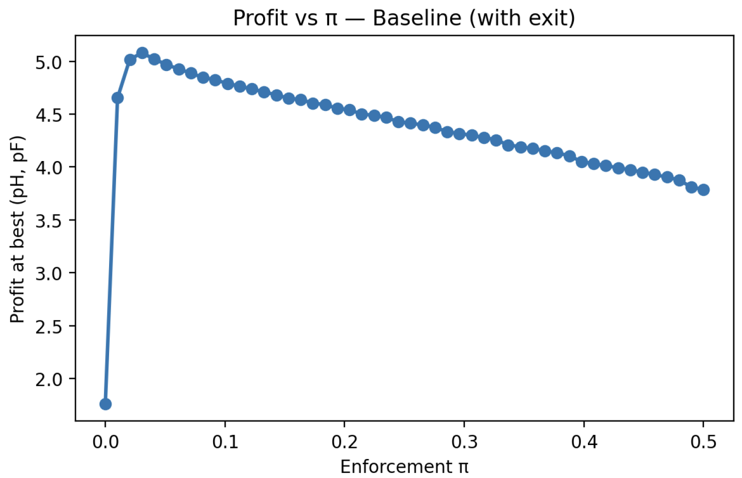
Global Prices and Consumer Surplus

- The firm solves for a global price vector and punishment strategy via a fixed point that trades off: Equilibrium Concept
  - Market expansion effect from the price sensitive group: home customers attracted by the lower prices
  - Decreased revenue from the savvy group: home customers that instead purchase in foreign
  - Decreased revenue from customers located in the foreign market
- Both savvy and price sensitive customers gain from imperfect enforcement
- Consumer surplus of foreign customers *decreases* relative to fully segmented markets

Estimation

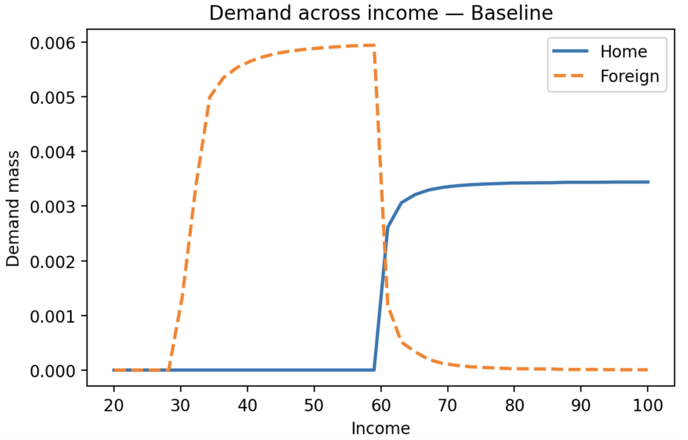
Model Simulations

- At each level of punishment probability π, find the highest profit by varying p_F and p_H Calibrated Parameters
- At the optimal π, the recovered prices are 59.58 for home and 15.00 for foreign



Demand Across Income Levels

- For prices of 59.58 and 15.00, π^* of .03 efficiently sorts home households
- Lower income households largely purchase in the foreign market:
  - Higher marginal utility of non-video game consumption
  - Smaller accumulated library sizes



Estimation Strategy: Simulated Method of Moments

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- Outer loop: choose candidate parameter vector θ, firm cost vector k_1, k_2
- Inner loop: solve the firm–consumer environment given θ, k_1, k_2:
  - Consumer side: solve value functions and policies; aggregate to demand $D_H(\theta), D_F(\theta)$
  - Firm side: given induced demand, solve for optimal $(p_H(\theta), p_F(\theta), \pi(\theta))$

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- Simulate model moments $m^{\text{model}}(\theta)$ to match data moments m^{data}
- Minimize $Q(\theta) = \left[m^{\text{data}} - m^{\text{model}}(\theta)\right]^{\top} W \left[m^{\text{data}} - m^{\text{model}}(\theta)\right]$ Moments

From Model to Data Moments

- Market shares: pin down income and switching cost distributions by capturing substitution patterns
  - Baseline home vs. foreign shares
  - Response to exchange rate shocks
  - Lags in switching
- Text data moments (Reddit)
  - Reflect the product of enforcement intensity π and switching volume
  - Frequency of punishment discussions
  - Correlation with large shocks
  - Baseline frequency / false positives
- Market shares identify the volume of switches, while Reddit data identifies how often switches trigger punishment

Counterfactuals

- Compare the prices and profits under imperfectly enforced digital boundaries to two benchmarks
  - Digital Single Market regime where law of one price must hold
  - Segmented Market regime where firms can price to each market individually
- Preliminary simulation results yield regime-dependent prices:
  - Imperfect enforcement: $p_H = 59.58$, $p_F = 15.00$
  - Uniform prices: $p = 47.917$
  - Segmented markets: $p_H = 53.75$, $p_F = 11.25$
  - Unified markets raise prices by $> 300\%$ in poor countries and lower prices by 20% in rich countries
- Zero hassle cost for customers [Zero hassle cost]
- Zero enforcement cost for the firm [Zero Enforcement Cost]

Conclusion

- I document a new empirical pattern that firms allow price-sensitive consumers to access lower foreign market prices
- I develop and estimate a model to rationalize these new empirical findings
- To estimate the welfare effects of uniform price mandates, I consider prices under counterfactual pricing regimes (in progress)
  - Fully segmented market benchmark
  - Digital single market benchmark

Appendix

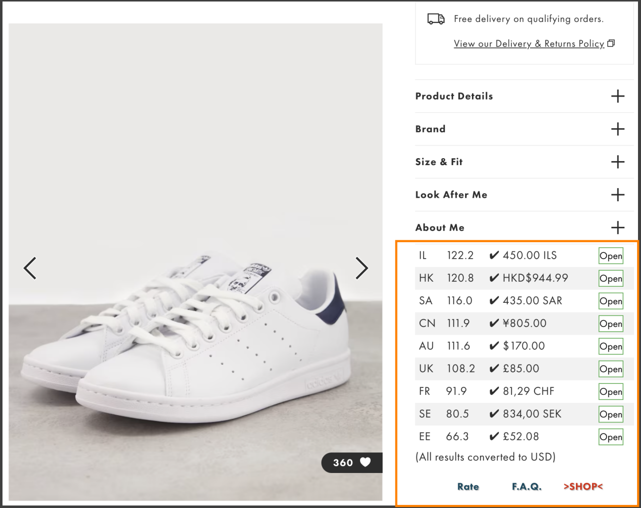
EU's Digital Single Market

- The EU's Single Digital Market prohibits geoblocking to ensure equal access to digital goods.
- Cross-country price differences for video games remain substantial, despite regulatory efforts.
- Increased competition and access to consumer goods are key goals of the Single Digital Market.

Back

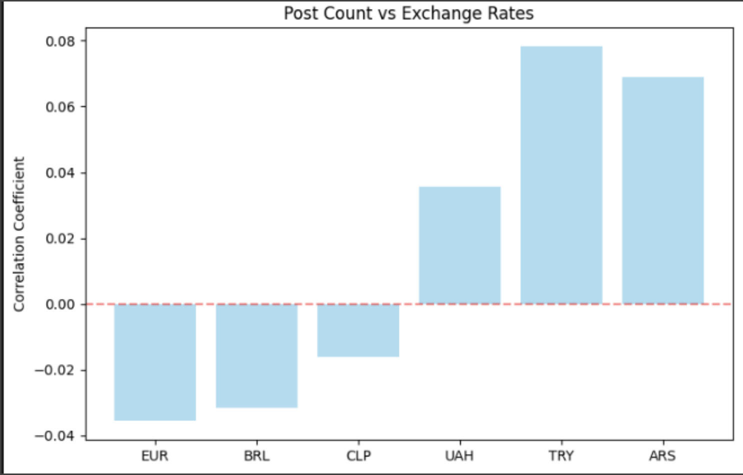
Key Mechanism: Endogenous Purchase Location Choice

- Price sensitive customers can change their digital market and access cheaper prices
- Cross-country price gaps reveal information about the underlying demand curves of customers that take each action
- Similar features show up in Netflix, Spotify, other digital goods Back

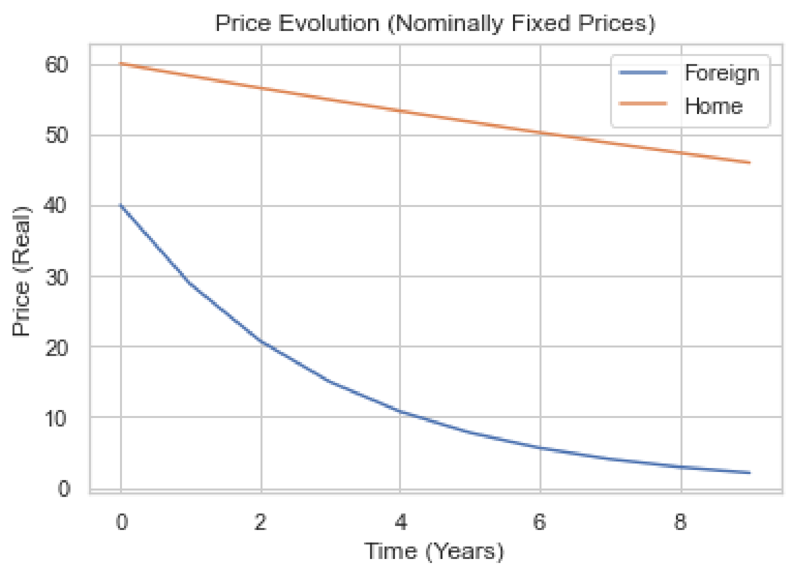


Reddit Posts vs Exchange Rates

- Counts of Steam regional tricks Reddit posts increase when the USD appreciates relative to the Ukrainian hryvnia, Turkish lira, and Argentinian peso Back



Movements of Relative Prices Example



Back

Timing

- In each time period t:

Exchange rate E_t realized

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↓

Customer library evolves via law of motion

↓

Exit with probability s, new entrants drawn from ν

Back

Recursive Stationary Equilibrium

A recursive stationary equilibrium is a collection of prices, punishment strategy, purchase policies such that

1. $\forall\theta$, $V_\theta(L)$ and $\text{pol}_\theta(L)$ solve the consumer Bellman equation
2. Firm maximizes profits given induced demand curves by selecting p_H, p_F, π
3. $\forall\theta$ μ^*_θ satisfies $\mu^*_\theta = (1-s)\mu^*_\theta P_\theta + s\nu$
4. $G(\theta, L) = w(\theta)\mu^*_\theta(L)$

Back

Total Revenue

- The firm chooses prices p_H and p_F to maximize total revenue:

$$\sum_t \beta^t p_H \int_L \int_\theta \underbrace{\mathbb{1}\{\text{pol}_\theta(L) = H\} dG(\theta, L)}_{\text{Purchase at home}}$$

Home customers that purchase in the home market

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Home customers that buy at foreign prices

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Home customers that buy at foreign prices

$$+ \sum_t \beta^\dagger E_t p_F \int_L \int_{\theta:\theta_c = F} \underbrace{\mathbb{1}\{\text{pol}_\theta(L) = F\} dG(\theta, L)}_{\text{Foreign customer purchasing at F price}}$$

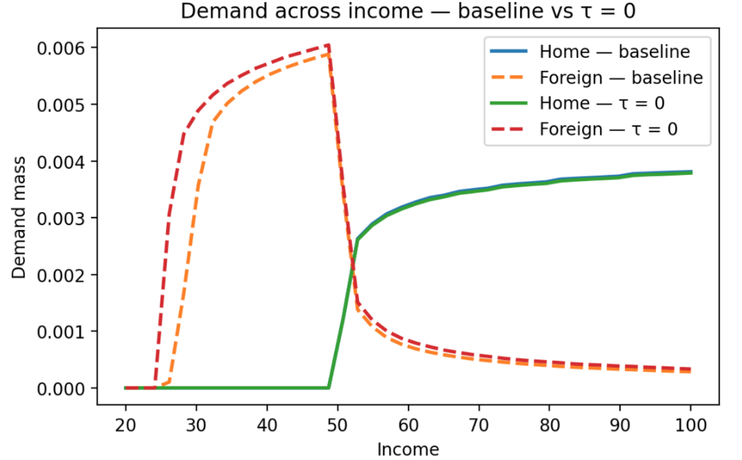
Foreign customers purchasing in foreign Back

Externally Calibrated Parameters

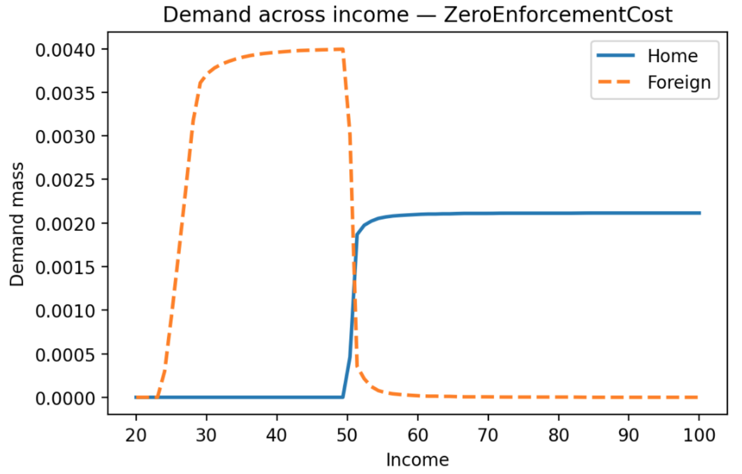
- Discount factor $\beta = .98$
- Exchange rate process
  - Matched to monthly exchange rate data for Argentina
- Hazard rate $s = .0037$
  - Fit to match the hazard rate of playing video games over the lifecycle
    Hazard Estimation Back

Counterfactual: Information Shock

- Suppose information about accessing foreign markets becomes easier to access
- The benefits of this accrue to lower income home customers
- Increased democratization of video games Back



Zero Enforcement Cost



Back

From Model to Data Moments

Model Object / Parameter	**Informative Data Moments**
Switching costs $(\underline{\tau}, \bar{\tau})$	Lag between exchange rate shocks and changes in foreign share
Income distribution (μ_y, σ_y)	Baseline foreign vs. domestic shares by income group
Taste for library size $(\mu_\alpha, \sigma_\alpha)$	Correlation between library size and foreign purchasing; baseline foreign share levels
Firm enforcement strategy π	Correlation between large exchange rate shocks and frequency of punishment discussions; baseline punishment rate
Punishment cost curvature (k_1, k_2)	Magnitude and frequency of observed punishment actions; false positive rate

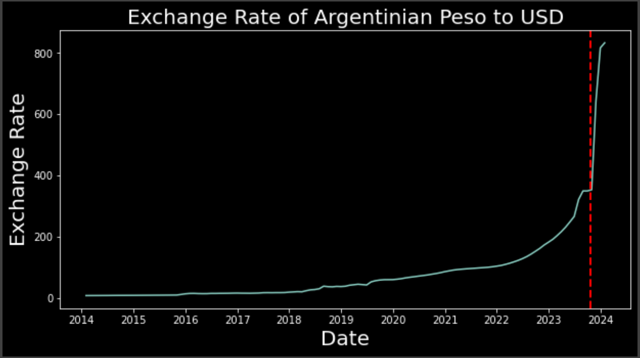
Back to Estimation Strategy

Parameter Estimation via SMM (in progress)

- I am currently estimating customer heterogeneity and firm punishment strategy via SMM:
  - Normal distribution of risk aversion: μ_γ, σ_γ
  - Uniform distribution of fixed switching costs: $\underline{\tau}, \bar{\tau}$
  - Normal distribution of income (can be Pareto as long as shape > 1): μ_y, σ_y
  - Normal distribution of taste for library size: μ_α, σ_α
  - Firm strategy: π
  - Convex punishment cost: k_1, k_2
- Data moments that inform identification
  - Response of foreign purchase share (level) to exchange rate shocks
  - Correlation of size of exchange rate shocks and discussions of punishment actions
  - Baseline foreign and domestic shares
  - Baseline frequency of punishment discussion
  - Lag between exchange rate shocks and changes in foreign share (τs)
  - False positive rate on punishment Back

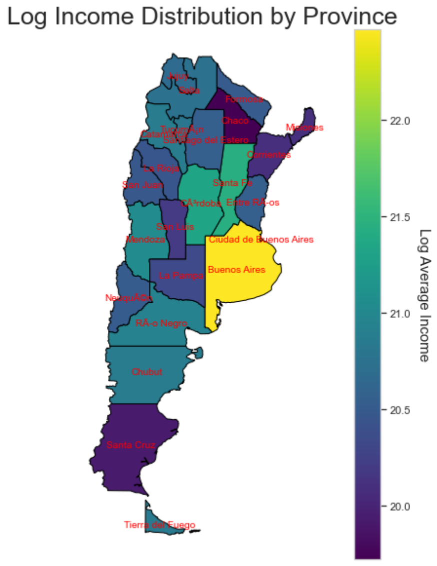
Demand-Side Assumption: Volatility

- Currency volatility exacerbates the tradeoff between arbitrage and price discrimination
- Consider Argentina Back



Demand-Side Assumption: Heterogeneity

- Customer heterogeneity creates price discrimination motives
- US customers are heterogeneous
- Argentinian customers also exhibit high heterogeneity Back



Dollarization and Steam's Policy Change

- The model predicts that the incentive constraints become more difficult to satisfy when there are exchange rate shocks
- When exchange rate shocks are more frequent than price changes, the firm anticipates possible exchange rate trends
- To reduce arbitrage, the firm can either:
  1. Reduce price gap η Model
  2. Price in the home currency (e.g. dollars)
- Under a stable exchange rate, (2) is rarely optimal Proof
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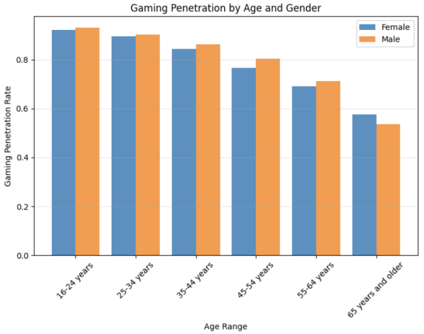
- October 25, 2023: Steam announces that all sales in Argentina and Turkey will be in US Dollars starting November 20, 2023
- The policy change reset cross-country price gaps *and* currency simultaneously

Back

Estimating the Hazard Parameter

- Customers in the model have a constant hazard s of exiting the market
- Since the model has a lifecycle component in terms of the size of the video game library, natural to think of s as the rate of exiting the video game market writ large
- Fit a constant hazard rate to the cross-sectional fractions of American adults that play video games in different age buckets
- End up with a hazard rate of .0044 for women and .0037 for men Back



Demand Estimation Results: Argentina

Table: Estimation Results

	Coefficient	Confidence Interval
constant	-3.597***	
	(0.258)	[-4.102, -3.092]
AAA	1.316***	
	(0.261)	[0.804, 1.828]
price	-0.600***	
	(0.092)	[-0.781, -0.420]

Table: *

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses. Developer-level fixed effects are included.

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Demand Estimation Results: US

Table: Estimation Results

	Coefficient	Confidence Interval
constant	-3.191***	
	(0.188)	[-3.561, -2.821]
AAA	.636***	
	(0.114)	[0.412, 0.860]
price	-0.051***	
	(0.009)	[-0.070, -0.033]

Table: *

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses. Developer-level fixed effects are included.

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Argentina's Video Game Market

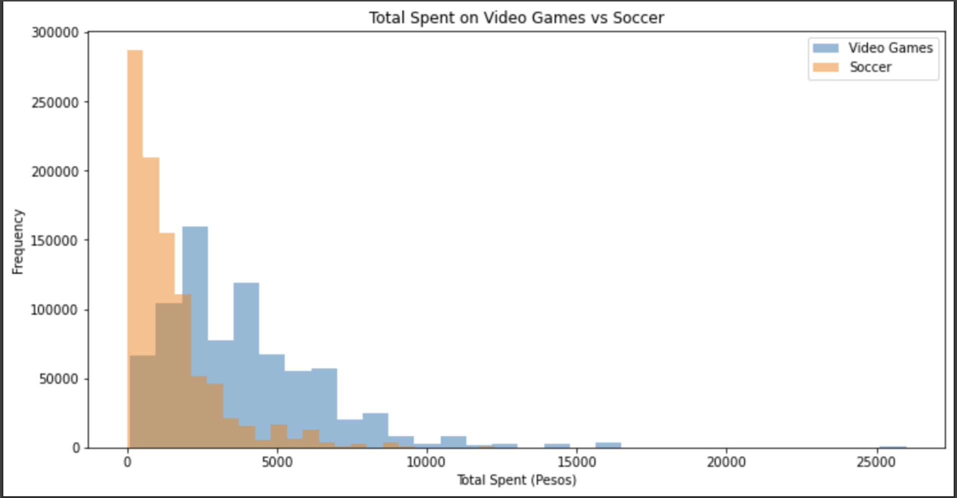
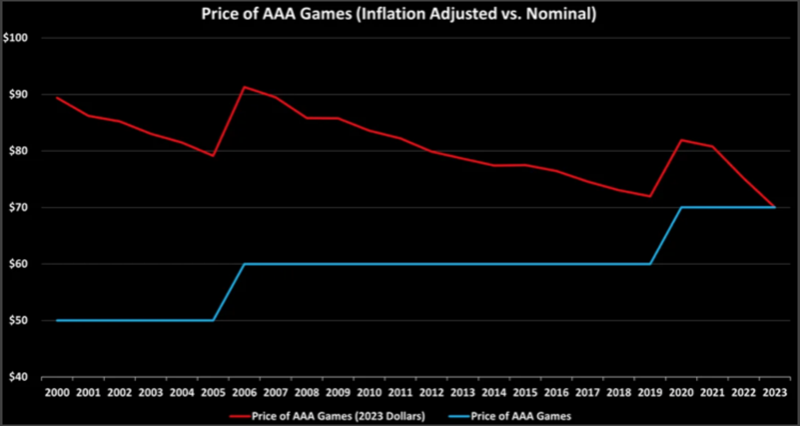


Figure: Argentinians spend more on video games than on soccer Back

Nominal Price Rigidity

- Nominal prices for AAA games do not move much over time Back



Demand Estimation: Argentina

- Discrete choice in each period between buying a game or selecting the outside option
- Think of each choice as a game-market pair
- Estimate a logit demand model with indirect utility:

$$u_{idjt} = \alpha ln p_{jt} + \beta \text{AAA}_j + \phi_d + \mu_t + \xi_{jt}$$

- I estimate separately for Argentina and for the US
- Coefficient on price is -.600 (se: 0.092)
- Coefficient on AAA is 1.316 (se: 0.261)
- Full demand estimation results AR Demand Estimation Back

Static Model in GE

Model Overview

- An alternative formulation of the model embeds the Mongey-Waugh pricing inequality framework in space with multiple locations
- Infinite-horizon economy with households, heterogeneous firms, and a government.
- Two goods:
  - Composite good: produced competitively.
  - Differentiated product: produced by heterogeneous firms (quality ψ_{jt}, productivity z_{jt}).
- Finite set of markets $m = 1, \ldots, M$ with market-specific prices and exchange rates e_{mt}.
- Households can buy from any market by paying hassle cost τ_{imt}.

Households

Preferences:

$$E\left[\sum_{t=0}^{\infty}\beta^t\sum_{m\in M}\sum_{j\in J}\tilde{u}_{ijmt}\right]$$

where

$$\tilde{u}_{ijmt}=\begin{cases}u(c_{it})+\psi_j+\xi_{jmt}, & \text{if } j \text{ purchased from } m,\\ 0, & \text{otherwise.}\end{cases}$$

- Taste shocks ξ_{ijmt}: i.i.d. Type I Extreme Value with parameter θ.
- Effective price: $\tilde{p}_{ijmt}=\frac{p_{jm}}{e_{mt}}+\tau_{imt}$.
- Labor: supplied inelastically, evolves via Markov process $P(l,l')$.
- Budget constraint:

$$c_{ijmt}+\tilde{p}_{ijmt}+a_{i,t+1}\leq R_{t+1}a_{it}+w_t l_{it}+\Pi_t.$$

Firms

- Produce differentiated product with:

$$y_{jt} = z_{jt} n_{jt}^{\alpha}$$

- Profits:

$$\Pi_{jt} = \sum_{m} p_{jm} y_{jmt} - W_t n_{jt}$$

- Bertrand competition: choose p_j across all markets to maximize profits.
- First-order condition in matrix form:

$$x_j = -J^{\top}(p_j - mc_j)$$

with elasticity matrix E_j and revenue vector R_j.

Markup Equation

From FOCs:

$$\mu_j = -\left(E_j^\top \operatorname{diag}(R_j)\right)^{-1} R_j$$

Element k:

$$\mu_k = \frac{1 + \sum_{m \neq k} \epsilon_{mk} \frac{R_m}{R_k} \mu_m}{-\epsilon_{kk}}$$

- Positive cross-elasticities $\epsilon_{mk} > 0 \Rightarrow$ diversion raises markups.
- Firms internalize that higher prices in one market may shift demand to other markets they control.

Government

- Provides elastic supply of assets.
- Budget constraint:

$$R_t B_t = B_{t+1}.$$

Household Problem in Bellman Form

Let $M_t = a_t + w_t l_t + \pi_t - \frac{a_{t+1}}{R}$ be effective expenditure.

$$v_{jm}(a, l, \tau) = \max \{u(M_t - \tilde{p}_{jm}) + \psi_j + \beta E[v(\cdot)]\}$$

Choice probability:

$$\rho_{jm}(M_t) = \frac{\exp\left[\theta(u(M_t - \tilde{p}_{jm}) + \psi_j)\right]}{\sum_{k \in J} \sum_{n \in M} \exp\left[\theta(u(M_t - \tilde{p}_{kn}) + \psi_k)\right]}$$

Aggregation and Equilibrium

- Household law of motion:

$$\Lambda(a', l', \tau') = \int \rho_{jm}(a, l, \tau)\Lambda(a, l, \tau)P(l, l')\, da\, dl\, d\tau$$

- Aggregate demand for firm j in market m:

$$x_{jm} = \int \rho_{jm}(a, l, \tau)\Lambda(a, l, \tau)\, da\, dl\, d\tau$$

- Stationary recursive equilibrium: household optimization, firm optimization, market clearing, stationary Λ, government budget constraint.