Are consumers really strategic?

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Motivation

- 35% of inventory is being sold at discount (Ghemawat and Nueno 2006)
- Consumers are hunting for bargains
- Purchase timing recommender systems
- Innovative pricing schemes: clearance seasons, progressive markdowns, reservations, auctions

Motivation (cont'd) and Research questions

RM literature with strategic consumer behavior

i. Contingent vs. pre-announced pricing

ii. Myopic vs. strategic behavior

iii. Role of information in evaluating intertemporal and risky options

iv. Imbalance between theoretical work and empirical evidence

Choosing between buy-now vs. buy-later people have to evaluate riskiness of the latter option:

1. Are consumers strategic (forward looking)?
   - How do they evaluate risk (overly optimistic, pessimistic)?
   - How heterogeneous are they?
   - Do they incorporate available information fully?
2. What is an equilibrium, empirically?
   - Bayesian Nash
   - Heuristics

Literature review

- Economics/Behavioral studies
  - Frederick et al (2002), Chevalier and Goolsbee (2009), Hendel and Nevo (2010)
  - Context really matters!
- Revenue management
  - Theory: Aviv and Pazgal (2007), Caldentey and Vulcano (2007), Elmaghraby et al. (2009), O and Vulcano (2010), Mersereau and Zhang (2012), Lobel et al (2013), Bernstein and de Albeniz (2014), many others.
  - Empirics and Experiments: Li et al. (2014), Mak et al. (2014), Mantin et al (2014)
- Role of information (salience, cognitive limits, bounded rationality)
  - Steckel et al. (2004), Klingberg (2009), Su (2008), Kremer, Moritz, Siemsen (2011)

Example

Choose "Buy Later" to purchase items automatically when they drop to that price, providing they do not sell out first.

Example provided by Elmaghraby et al. (2009)

Normative model

- v – valuation
- p_h – buy now price
- p_l – buy later price
- π – probability of getting an item (successful reservation). Computed in equilibrium.
- w – risk attitude (notice no time discounting)

- Buy now if: $$(v - p_h) \geq (v - p_l)\pi_{subj}, \qquad (1)$$

$$\pi_{subj} = \pi^{w}$$

- Challenge: w is unobservable
  - Two step estimation/classification procedure

Design of experiment

- Treatments: p_h, p_l, v, t, π shown
  - 270 possible combinations, randomized counterbalancing
  - Can identify the strategic wait if the rational response is to reserve:
    - Risk neutral response: 70/30 towards Reserve
- Treatment: π is shown in 50% cases
- Subjects play against 'environment' consumers.
  - Forward looking, play equilibrium strategy
    - Equilibrium is proven to exist (O and Vulcano, 2010)

Experiment: implementation

You've just arrived at a retailer's site. You've found an item that you'd like to purchase
However, this is an item that the retailer will not be ordering more of in the future.
To help make room for new offerings, the retailer has set up a Special Sale period of 10 days to liquidate its stock on this item.

You happened to have arrived on Day 3 of this 10 day window.

You estimate that the item's value to you in dollars is $6.18

At this point, the item you are interested in can be bought one of two ways:

Buy Now at a price **$6.00** (Agree to pay this price now, and you are *guaranteed* to receive it. Payment and delivery will take place at the end of the Special Sales period)

Reserve Now at a price **$5.40** (*If* there are any left *at the end* of the Special Sales period, you'll pay this price and it will be sent to you at that point)

Note that there is no guarantee that any of these items will be available for purchase at this price, but Reserving Now will put you 'in line' for this opportunity. Remaining items will be sold at this price at the end of the period to those at the front of this 'line'.

Given this uncertainty, you have a 82.9% chance of successfully getting this item this way

Please indicate your choice of the two above options by clicking on the green button for the option you prefer

24 of 30 completed

Experiment: demographics and payoff

- 155 participants
  - 53% undergraduate seniors
  - 47% MBAs
  - 54% female
- Each subject was presented with 30 randomly selected scenarios
- Actual responses split 50/50
- Individual effort, no communication, no time limit
- Payoff based on the cumulative performance
  - Randomized payoff scheme for “Reserve” decisions
  - Guaranteed minimum $5, average $17, maximum ≈$35

Identification of strategic behavior

		Decision Modeled *(rationally anticipated)*	
		Buy Now	*Reserve*
Individual's Decision	*Buy Now*	d_{11}	d_{12}
	Reserve	d_{21}	d_{22}

1. Forward-looking
   a) Correctly estimate risk
   b) Overly pessimistic (ln w>1)
   c) Overly optimistic (ln w<-1)
2. Counter rational
3. Statistically random
4. Unclassified

Classification is performed by binomial tests

Challenge: Need to estimate unobservable risk attitude

Estimating risk attitude from observed choice

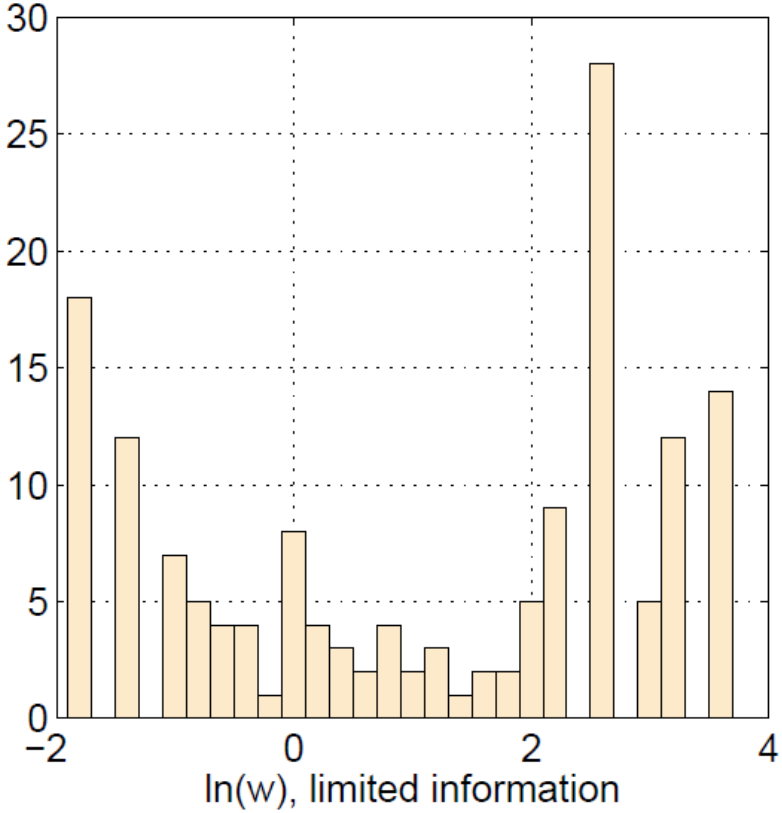
1. Choice decisions – interval censored "current status" data
2. NPMLE
   - Each decision provides a bound on w
   - E.g., a reserve decision corresponds to:

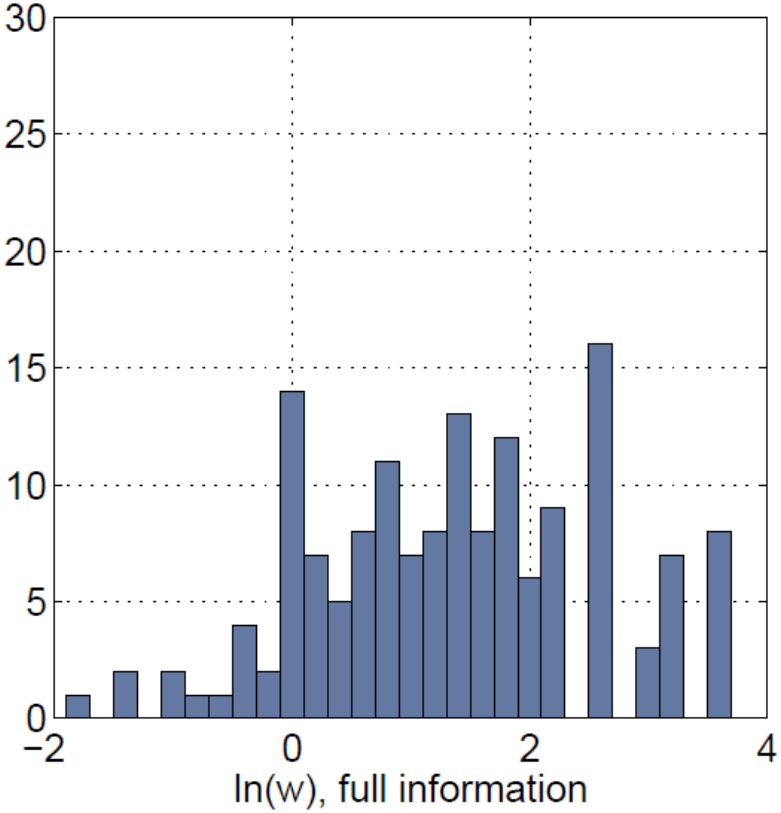
$$w_{(i)} \le \frac{\ln(v_{(i)} - p_{h(i)}) - \ln(v_{(i)} - p_{l(i)})}{\ln(\pi_{(i)})} = U_{(i)}$$

   - Algorithm (Huang and Wellner, 1997) :

     1. Define $\delta_{(i)} = 1(w \le U_{(i)})$
     2. Sort $U_{(i)}$ in non decreasing order and re-label $\delta_{(i)}$ accordingly.
     3. Form the function $(i, \sum_{j=1}^{i} \delta_{(i)}), i = 1..n$
     4. Build a maximum convex minorant G* of the function in step 2.
     5. The NPMLE estimate is a left derivative of G* at i= 1. .n

Heterogeneity in risk attitudes





1. Information availability affects heterogeneity of risk attitudes

2. Absence of risk information encourages bargain-seeking behavior (delayed purchases)

Are consumers strategic?

	Pooled	Limited information	Full information
(1) Forward-looking	115	62	115
(1a) Correctly estimate risk	38 (33%)	12 (19%)	42 (37%)
(1b) Pessimistic	66 (57%)	37 (60%)	72 (63%)
(1c) Optimistic	11 (10%)	13 (21%)	1 (1%)
(4) Opposite of (1)	0	0	0
(5) Random	3	7	3
(6) Unclassified	37	86	37
% forward-looking	74%	40%	74%
% forward-looking among classified	97%	90%	97%

1. 74% are forward-looking
2. Among classified subjects 97% are forward-looking
3. Distribution of tendencies in the 'Unclassified' category mimics the classified population

Consumers <u>are strategic</u> but heterogeneous in their risk attitudes

Informational impact

		Limited information setting				
		(1) Forward-looking	(2) Opposite of (1)	(3) Random	(4) Unclassified	Total
Full inf.	(1) Forward-looking	47	0	5	63	115
	(2) Opposite of (1)	0	0	0	0	0
	(3) Random	1	0	0	2	3
	(4) Unclassified	14	0	2	21	37
	Total	62	0	7	86	155

1. Notice transitions out of 'Unclassified'
2. 76% of forward looking consumers retain the classification even when π is shown.
3. Random behavior is more prevalent if π is not given

Experiment: Summary

- Fraction of forward looking consumers increases from 40% to 74% when π is given
  - 76% remain forward looking when π is given
- Random behavior decreases when π is given
- Subclasses of forward looking
  - Correctly estimate risk: almost doubles (19% to 37%)
  - Pessimistic: remains approximately the same (60% to 63%)
  - Optimistic (bargain seeking): decreases dramatically (21% to 1%)
- Providing information facilitates risk-neutral forward looking behavior
- Limiting information facilitates risk-taking and random behavior

Individual decisions and parameters of experiment

$$Y_{ij} = \text{Probit}(\beta_1 \ \ln(v_{(i)}\text{-}p_{h(i)}) - \beta_2 \ \ln(v_{(i)}\text{-}p_{l(i)}) - \beta_3 \ \ln(\pi_{(i)}) + u_{(j)} + \varepsilon_{(ij)})$$

$$Y_{ij} = 1, if \ \ 'BuyNow'$$

- Probit model:
  - random effects (individual discount factors)
  - interaction terms (π shown or not)
    - Ai and Norton (2003)
  - Differential time effects
  - Price scale effects
  - Asymptotic and bootstrapped S.E.

	Base Model				*Differential Time effect model*				*Differential time and scale effect model*			
	b	Boot-strap S.E.	Marg. Effect	Inter. Effect	b	Boot-strap S.E.	Marg. Effect	Inter. Effect	b	Boot-strap S.E.	Marg. Effect	Inter. Effect
$\ln(v\text{-}p_h)$	0.098 **	0.025	0.039		0.106 **	0.027	0.042		0.087 **	0.026	0.035	
$\ln(v\text{-}p_h)$ x π_shown	0.130 **	0.027	0.052	0.051 **	0.115 **	0.027	0.046	0.045 **	0.106 **	0.027	0.042	0.042 **
$\ln(v\text{-}p_l)$	-0.230 **	0.031	-0.091		-0.235 **	0.032	-0.093		-0.031	0.071	-0.012	
$\ln(v\text{-}p_l)$ x π_shown	-0.190 **	0.030	-0.075	-0.079 **	-0.170 **	0.035	-0.068	-0.071 **	-0.171	0.096	-0.068	-0.069 **
ln(p)	0.008	0.024	0.003		0.059 **	0.022	0.023		0.131 **	0.033	0.052	
ln(π) x π_shown	-0.470 **	0.050	-0.187	-0.171 **	-0.491 **	0.048	-0.195	-0.179 **	-0.485 **	0.063	-0.193	-0.178 **
T	-	-	-	-	0.044 **	0.017	0.018		0.070 **	0.017	0.028	
t x π_shown	-	-	-	-	-0.019	0.017	-0.007	-0.007	-0.015	0.022	-0.006	-0.006
Scalefactor1	-	-	-	-	-	-	-	-	-0.456 **	0.158	-0.180	
Scalefactor1 x π_shown	-	--		-	-	-	-	-	-0.103	0.235	-0.041	-0.040
Scalefactor2	-	--		-	-	-	-	-	-0.926 **	0.304	-0.356	
Scalefactor2 x π_shown	-	--		-	-	-	-	-	0.091	0.443	0.036	0.032
Constant	0.579	0.078	-		0.447 **	0.094	-		0.305 **	0.118	-	
Ln L	-2681.738				-2673.985				-2663.218			
Prob > c^2	0.000				0.000				0.000			
ρ	0.232				0.233				0.235			
Prob(ρ=0)	0.000				0.000				0.000			
% Correctly Classified	65.3				65.6				65.4			

Alternative heuristics for strategic consumers

- Explain observed decisions
- If π is given it is clearly important
  - Including π increases the % of correctly classified (predicted) decisions from 72% to 85%

- If π is not given, can strategic behavior be explained by a simple heuristic?
  - Yes
  - Including the arrival time increases % of correctly classified from 74% to 86%
  - Including π increases % of correctly classified only to 81%

Conclusions

- Consumers are <u>strategic but heterogeneous</u>
  - Important to control for individual risk aversion
    - Approach similar to ours can be applied in the purchase context in general
  - Implications for RM models
    - Strategic/myopic mixed case is not enough
    - Incorporate the heterogeneity explicitly?
- Information enables strategic behavior
- Subjects respond to the information differently:
  - Those pessimistic about the risk are less sensitive to π
- Providing availability information (π) facilitates strategic behavior and limits bargain-seeking behavior
  - Positive revenue lift
- If π is not available, simple heuristics explain the behavior even better than the complete model