Econ 219B
Psychology and Economics: Applications
(Lecture 11)

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Outline

1. Market Reaction to Biases: Introduction

2. Market Reaction to Biases: Behavioral Finance

3. Intro to Problem Set

4. Market Reaction to Biases: Pricing

1 Market Reaction to Biases: Introduction

- So far, we focused on consumer deviations from standard model

- Who exhibits these deviations?

  1. **Self-control and naivete'.** Consumers (health clubs, food, credit cards, smoking), workers (retirement saving, benefit take-up), students (homeworks)

  2. **Reference dependence.** Workers (labor supply, increasing wages), (inexperienced) traders (sport cards), financial investors, consumers (insurance), house owners

  3. **Social preferences.** Consumers (giving to charities)

4. **Inattention.** Individual investors, Consumers (eBay bidding)

5. **Menu Effects.** Individual investors, Consumers (loans)

6. **Social Pressure and Persuasion.** Voters, Employees (productivity), Individual investors (and analysts)

7. **Biased Beliefs.** Individual investors, CEOs, Consumers (purchases)

- What is missing from picture?

- Experienced agents
- Firms
- Broadly speaking, market interactions with ‘rational’ agents

- Market interactions
  - Everyone ‘born’ with biases
  - But: Effect of biases lower if:
    - learning with plenty of feedback
    - advice, access to consulting
    - specialization

    * Competition 'drives out of market'

- For which agents are these conditions more likely to be satisfied?

- Firms

- In particular, firms are likely to be aware of biases.

- Implications? Study biases in the market

- Five major instances:

  - Interaction between experienced and inexperienced investors (noise traders and behavioral finance — today)

  - Interaction between firms and consumers (contract design, price choice — today)

  - Interaction between managers and investors (corporate finance — briefly next week)

  - Interaction between employers and employees (labor economics — briefly next week)

  - Interaction between politicians and voters (political economy — next week)

2 Market Reaction to Biases: Behavioral Finance

- Who do ‘smart’ investors respond to investors with biases?

- First, brief overview of anomalies in Asset Pricing (from Barberis and Thaler, 2004)

  1. **Underdiversification.**
     (a) Too few companies.
        - Investors hold an average of 4-6 stocks in portfolio.
        - Improvement with mutual funds

     (b) Too few countries.
        - Investors heavily invested in own country.
        - Own country equity: 94% (US), 98% (Japan), 82% (UK)

- Own area: own local Bells (Huberman, 2001)

(c) Own company

- In companies offering own stock in 401(k) plan, substantial investment in employer stock

2. **Naive diversification.**

   - Investors tend to distribute wealth 'equally' among alternatives in 401(k) plan (Benartzi and Thaler, 2001; Huberman and Jiang, 2005)

3. **Excessive Trading.**

   - Trade too much given transaction costs (Odean, 2001)

4. **Disposition Effect in selling**
   - Investors more likely to sell winners than losers

5. **Attention Effects in buying**
   - Stocks with extreme price or volume movements attract attention (Odean, 2003)

- Should market forces and arbitrage eliminate these phenomena?

- **Arbitrage**:
  - Individuals attempt to maximize individual wealth
  - They take advantage of opportunities for free lunches
- Implications of arbitrage: ‘Strange’ preferences do not affect pricing
- Implication: For prices of assets, no need to worry about behavioral stories
- Is it true?

- Fictitious example:
  - Asset A returns \$1 tomorrow with $p = .5$
  - Asset B returns \$1 tomorrow with $p = .5$

  - Arbitrage –> Price of A has to equal price of B
  - If $p_A > p_B$,
    * sell A and buy B
    * keep selling and buying until $p_A = p_B$
  - Viceversa if $p_A < p_B$

- Problem: Arbitrage is limited (de Long et al., 1991; Shleifer, 2001)
- In Example: can buy/sell A or B and tomorrow get fundamental value
- In Real world: prices can diverge from fundamental value
- Real world example. Royal Dutch and Shell
  - Companies merged financially in 1907
  - Royal Dutch shares: claim to 60% of total cash flow
  - Shell shares: claim to 40% of total cash flow
  - Shares are nothing but claims to cash flow

– Price of Royal Dutch should be 60/40=3/2 price of Shell

- p_{RD}/p_S differs substantially from 1.5 (Fig. 1)

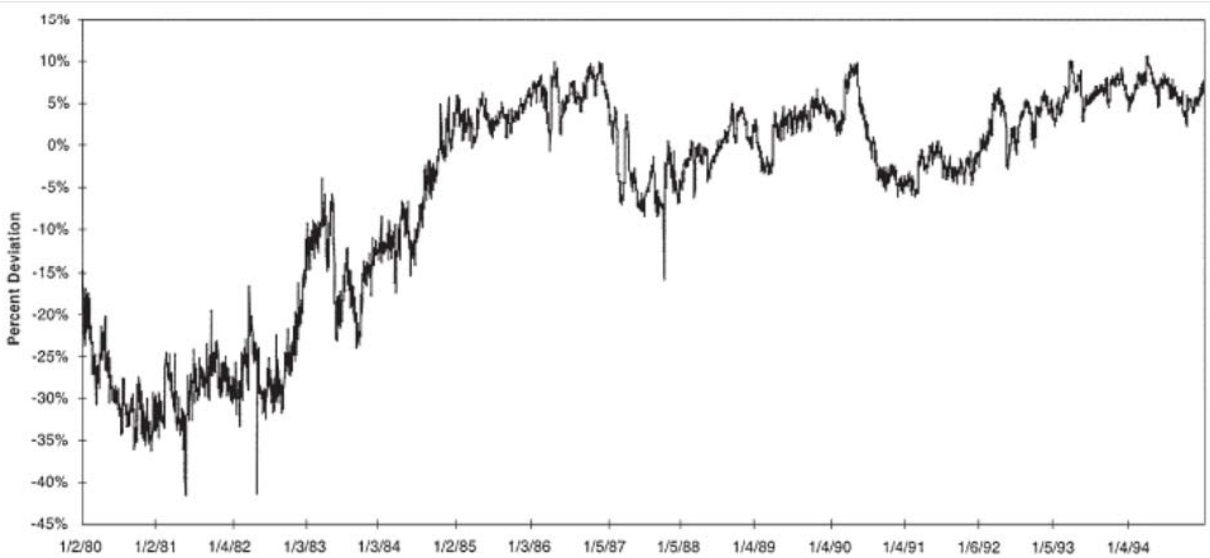


Fig. 1. Log deviations from Royal Dutch/Shell parity. Source: Froot and Dabora (1999).

- Plenty of other example (Palm/3Com)

- What is the problem?

  - Noise trader risk, investors with correlated valuations that diverge from fondamental value

  - (Example: Naive Investors keep persistently bidding down price of Shell)

  - In the long run, convergence to cash-flow value

  - In the short-run, divergence can even increase

  - (Example: Price of Shell may be bid down even more)

- **Noise Traders**

- DeLong, Shleifer, Summers, Waldman (*JPE* 1990)

- Shleifer, *Inefficient Markets*, 2000

- Fundamental question: What happens to prices if:
  - (Limited) arbitrage
  - Some irrational investors with correlated (wrong) beliefs

- First paper on Market Reaction to Biases

- *The* key paper in Behavioral Finance

The model assumptions

A1: arbitrageurs risk averse and short horizon

$\longrightarrow$ Justification?

* Short-selling constraints

(per-period fee if borrowing cash/securities)

* Evaluation of Fund managers.

* Principal-Agent problem for fund managers.

A2: noise traders (Kyle 1985; Black 1986)

misperceive future expected price at t by

$$\rho_t \overset{i.i.d.}{\sim} \mathcal{N}(\rho^*, \sigma_\rho^2)$$

misperception *correlated* across noise traders ($\rho^* \neq 0$)

$\longrightarrow$ Justification?

* fads and bubbles (Internet stocks, biotechs)

* pseudo-signals (advice broker, financial guru)

* behavioral biases / misperception riskiness

What else?

- μ arbitrageurs, $(1-\mu)$ noise traders
- OLG model
  - Period 1: initial endowment, trade
  - Period 2: consumption
- Two assets with identical dividend r
  - safe asset: perfectly elastic supply
    $\Longrightarrow$ price=1 (numeraire)
  - unsafe asset: inelastic supply (1 unit)
    $\Longrightarrow$ price?
- Demand for unsafe asset: λ^a and λ^n, with $\lambda^a + \lambda^n = 1$.

- CARA:

$U(w) = -e^{-2(\gamma w)}$ (w wealth when old)

$$E\left[U(w)\right] = \int_{\infty}^{\infty} -e^{-2\gamma w} \cdot \frac{1}{\sqrt{2\pi\sigma^2}} \cdot e^{-\frac{1}{2\sigma^2}(w-\overline{w})}$$

$$= -e^{-2\gamma(\overline{w}-\gamma\sigma_w^2)}$$

$$\Downarrow$$

$\max E\left[U(w)\right] \quad \underset{\text{pos. mon. transf.}}{\curvearrowright} \quad \max \overline{w} - \gamma\sigma_w^2$

Arbitrageurs:

$$\max(w_t - \lambda_t^a p_t)(1 + r)$$

$$+\lambda_t^a (E_t[p_{t+1}] + r)$$

$$-\gamma \left(\lambda_t^a\right)^2 Var_t(p_{t+1})$$

Noise traders:

$$\max(w_t - \lambda_t^n p_t)(1 + r)$$

$$+\lambda_t^n (E_t[p_{t+1}] + \rho_t + r)$$

$$-\gamma \left(\lambda_t^n\right)^2 Var_t(p_{t+1})$$

(Note: Noise traders know how to factor the effect of future price volatility into their calculations of values.)

f.o.c.

Arbitrageurs: $\frac{\partial E[U]}{\partial \lambda_t^a} \stackrel{!}{=} 0$

$$\lambda_t^a = \frac{r + E_t[p_{t+1}] - (1+r)p_t}{2\gamma \cdot Var_t(p_{t+1})}$$

Noise traders: $\frac{\partial E[U]}{\partial \lambda_t^n} \stackrel{!}{=} 0$

$$\lambda_t^a = \frac{r + E_t[p_{t+1}] - (1+r)p_t}{2\gamma \cdot Var_t(p_{t+1})}$$

$$+ \quad \frac{\rho_t}{2\gamma \cdot Var_t(p_{t+1})}$$

Interpretation

- Demand for unsafe asset function of:
  - $(+)$ expected return $(r + E_t[p_{t+1}] - (1+r)p_t)$
  - (-) risk aversion (γ)
  - (-) variance of return $(Var_t(p_{t+1}))$

  - $(+)$ overestimation of return ρ_t (noise traders)

- Notice: noise traders hold more risky asset than arb. if $\rho > 0$ (and viceversa)

- Notice: Variance of prices come from noise trader risk. “Price when old” depends on uncertain belief of next periods’ noise traders.

Impose general equilibrium: $\lambda^a + \lambda^n = 1$

Price

$$p_t = 1 + \frac{\mu(\rho_t - \rho^*)}{1+r} + \frac{\mu\rho^*}{r} - \frac{2\gamma\mu^2\sigma_\rho^2}{r(1+r)^2}$$

- Noise traders affect prices!

Interpretation

- Term 1: Variation in noise trader (mis-)perception
- Term 2: Average misperception of noise traders
- Term 3: Compensation for noise trader risk
- Special case: $\mu = 0$ (no noise traders)

Relative returns of noise traders

- Compare returns to noise traders R^n to returns for arbitrageurs R_a:

$$\Delta R = R^n - R^a = (\lambda_t^n - \lambda_t^a)\left[r + p_{t+1} - p_t(1+r)\right]$$

$$E(\Delta R) = \rho^* - \frac{(1+r)^2(\rho^*)^2 + (1+r)^2\sigma_\rho^2}{2\gamma\mu\sigma_\rho^2}$$

- Noise traders hold more risky asset if $\rho^* > 0$
- Return of noise traders can be higher if $\rho^* > 0$ (and not too positive)
- Noise traders therefore may outperform arbitrageurs if optimistic!
- (Reason is that they are taking more risk)

Welfare

- Sophisticated investors have higher utility

- Noise traders have lower utility than they expect

- Noise traders may have higher returns (if $\rho^* > 0$)

- Noise traders do not necessarily disappear over time

- Three fundamental assumptions

    1. OLG: no last period; short horizon

    2. Fixed supply unsafe asset (a cannot convert safe into unsafe)

    3. Noise trader risk systematic

- Noise trader models imply that biases affect asset prices:

    – Reference Dependence

    – Attention

    – Persuasion

- Here:
  - Biased investors
  - Non-biased investors
- Behavioral corporate finance:
  - Investors (biased)
  - CEOs (smart)
- Behavioral Industrial Organization:
  - Consumers (biased)
  - Firms (smart)

3 Intro to Problem Set

- Accounting — Information on company performance
  - accounting books
  - quarterly earnings announcement
- Two main focuses:
  - Optimal accounting rules
  - Stock price response to profitability information in accounting books

- What is right valuation of company?
  - Crucial to guarantee right allocation of capital
  - Denote $e_{t,k}$ earnings (profits) of company k in year t
  - Stock price = Discounted sum of future cash flows:

$$p_{t,k} = e_{t,k} + \frac{e_{t+1,k}}{1+r} + \frac{e_{t+2,k}}{(1+r)^2} + ...$$

  - Need forecasts of future profitability $e_{t,k}$

- Two main components:
  - Short-run earnings performance
  - Long-run performance
  - Analysts provide forecasts on both

- **Analysts.** Process information on companies and make it available (for a fee)
  - Sell-side. Work for brokerage firm (investment bank)
  - Buy-side. Work for mutual funds

  - Sell-side analysts:
    - more likely to have conflict of interest (Inv. Bank selling shares of target company)
    - data widely available (IBES, FirstCall)

- Analysts generate two main outputs:
  1. Earning forecasts $\hat{e}_{t,k}$
     - Dollar earning per share of company
     - Quarterly or annual
     - Forecast h years into the future: $h \simeq 3, 4$ years
  2. Long-term "growth rate" of earnings g_e

- Common forecasting model:

$$\begin{aligned}\hat{p}_{t,k} &= e_{t,k} + \frac{\hat{e}_{t+1,k}}{1+r} + \frac{\hat{e}_{t+2,k}}{(1+r)^2} + \ldots \\ &+ \sum_{t=0}^{\infty} \frac{1}{(1+r)^{h+t}} \hat{e}_{t+h,k} * g_e\end{aligned}$$

Company releases of information

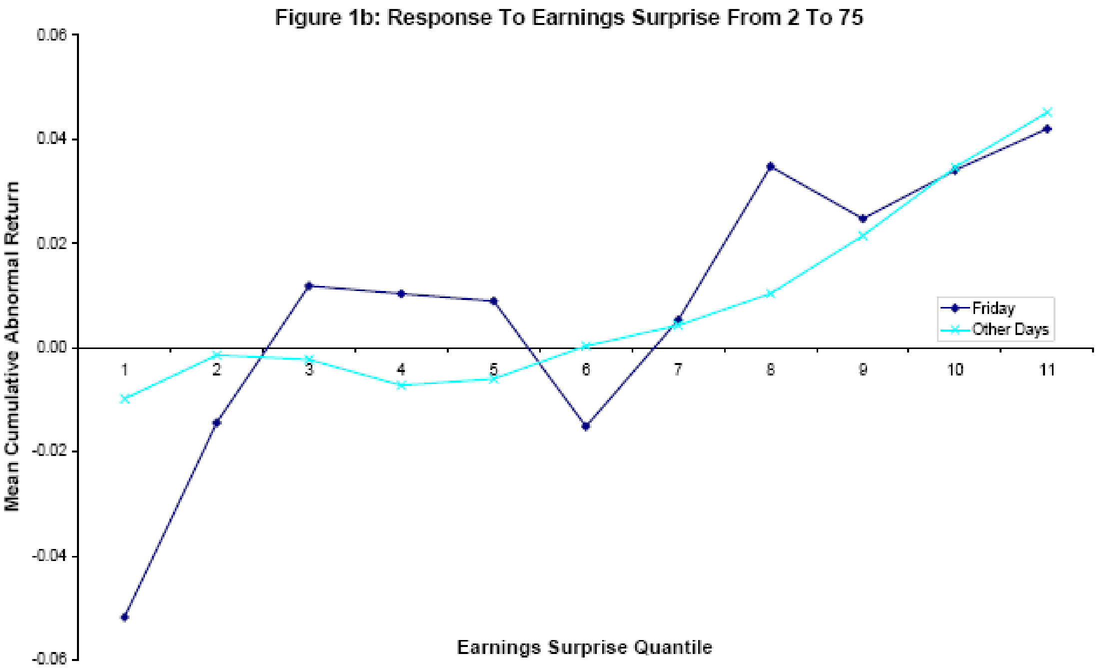
- Each quarter: Announcement of accounting performance
  - Scheduled announcement, conference call
  - Release of accounting indicators
  - Special focus on earnings per share $e_{t,k}$
- Comparison of forecasted and realized earnings
- Measure of new information: earning surprise $e_{t,k} - \hat{e}_{t,k}$.
- Renormalize by price of share: $s_{t,k} = \left(e_{t,k} - \hat{e}_{t,k}\right)/p_{t,k}$
- Investors react to new information by updating stock price $p_{t,k}$

- **Problem set**
- Focus on response of stock prices to earning surprise
- Economic significance:
  - Processing of new information
    - Clean measure of information
    - Clean measure of response
  - Timing of release of information by company

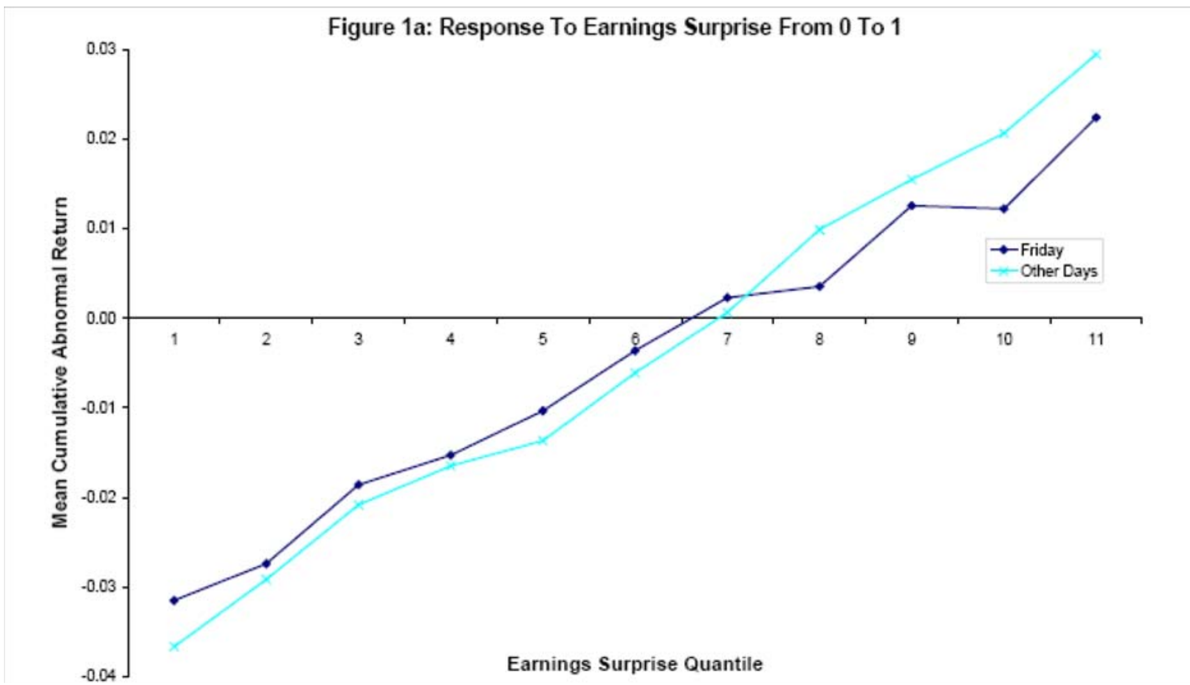
- Identify in the data three anomalies:
- **Anomaly 1. Post-Earnings Announcement Drift. (Chan, Jegadeesh, and Lakonishok, 1996; Bernard and Thomas, 1989).**
  - Announcements of good news in earnings $e_{t,k}$ are followed by higher returns over next 2-3 quarters
  - Arbitrage should eliminate this
  - Interpretation: Investors are inattentive when news emerges, news incorporated slowly over time
- How to measure this? Use as measure of new information the earnings surprise $s_{t,k}$
- Follow standard 'quantile' procedure: Divide into quantiles beased on $s_{t,k}$

- Plot returns for each quantile

- Focus on light blue line for now (Figure from DellaVigna and Pollet, 2006)

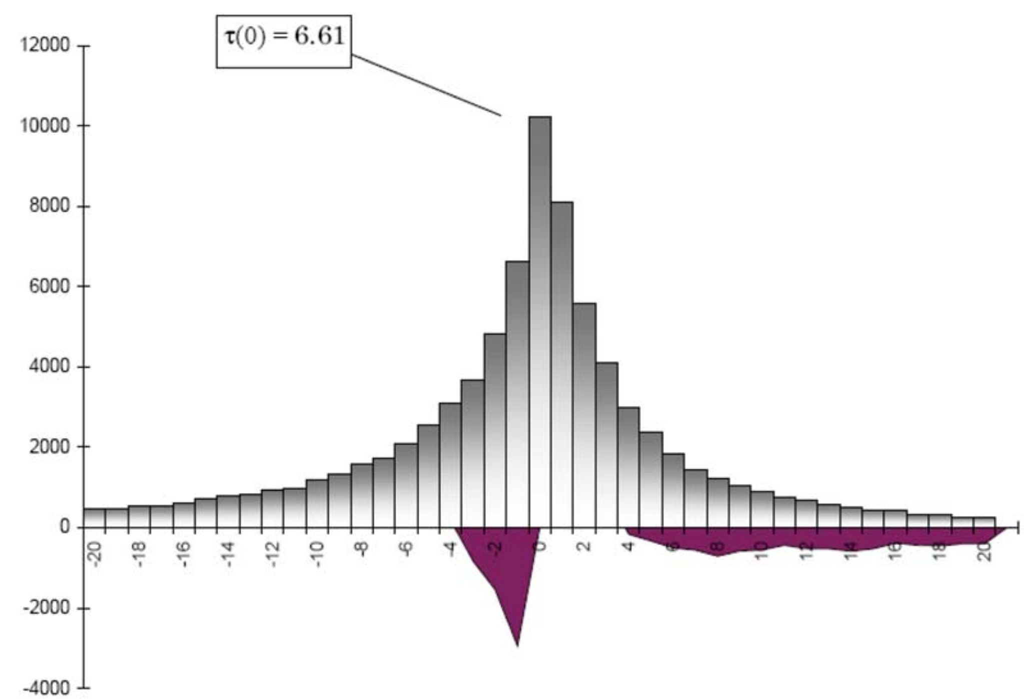


- **Anomaly 2. Less Immediate Response and more Drift for Friday announcements (DellaVigna and Pollet, 2006)**
  - Drift is stronger for announcements made on Friday
  - Immediate response is lower for announcements made on Friday
  - Inattention interpretation: More distracted investors on Friday



- **Anomaly 3.** (Degeorge, Patel, and Zeckhauser, 1999)
  - CEOs shift the earnings so as to meet analyst expectations

Figure 6. Histogram of Forecast Error for Earnings Per Share: Exploring the threshold of "meet analysts' expectations"



- Similar result if earnings compared to earnings 4 quarters ago or compared to zero profits
- Interpretation:
  - Investors have 'bias': They penalize significantly companies that fail to meet thresholds
  - Managers cater to this bias by manipulating earnings

4 Market Reaction to Biases: Pricing

- Consider now the case in which consumers purchasing products have biases
- Firm maximize profits
- Do consumer biases affect profit-maximizing contract design?
- How is consumer welfare affected by firm response?
- Analyze first the case fo consumers with $\left(\beta, \hat{\beta}, \delta\right)$ preferences

4.1 Self-Control

MARKET (I). INVESTMENT GOODS

- Monopoly
- Two-part tariff: L (lump-sum fee), p (per-unit price)
- Cost: set-up cost K, per-unit cost a

Consumption of investment good

Payoffs relative to best alternative activity:

- Cost c at $t = 1$, stochastic
  - non-monetary cost
  - experience good, distribution $F(c)$
- Benefit $b > 0$ at $t = 2$, deterministic

CONSUMER BEHAVIOR.

- Long-run plans at $t = 0$:

Consume $\iff \beta\delta(-p - c + \delta b) > 0$

$\iff c < \delta b - p$

- Actual consumption decision at $t = 1$:

Consume $\iff c < \beta\delta b - p$ (Time Inconsistency)

- Forecast at $t = 0$ of consumption at $t = 1$:

Consume $\iff c < \hat{\beta}\delta b - p$ (Naiveté)

FIRM BEHAVIOR. Profit-maximization

$$\max_{L,p} \delta \left\{ L - K + F\left(\beta\delta b - p\right)\left(p - a\right) \right\}$$

$$\text{s.t. } \beta\delta \left\{ -L + \int_{-\infty}^{\hat{\beta}\delta b - p} \left(\delta b - p - c\right) dF\left(c\right) \right\} \geq \beta\delta\overline{u}$$

- Notice the difference between β and $\hat{\beta}$

Solution for the per-unit price p^*:

$$
\begin{aligned}
p^* &= a && \text{[exponentials]} \\
&\quad - \left(1-\hat{\beta}\right)\delta b \frac{f\left(\hat{\beta}\delta b - p^*\right)}{f\left(\beta\delta b - p^*\right)} && \text{[sophisticates]} \\
&\quad - \frac{F\left(\hat{\beta}\delta b - p^*\right) - F\left(\beta\delta b - p^*\right)}{f\left(\beta\delta b - p^*\right)} && \text{[naives]}
\end{aligned}
$$

Features of the equilibrium

1. *Exponential agents* ($\beta = \hat{\beta} = 1$).
   Align incentives of consumers with cost of firm
   $\Longrightarrow$ marginal cost pricing: $p^* = a$.

$$
\begin{aligned}
p^* &= a && \text{[exponentials]} \\
&\quad -\left(1-\hat{\beta}\right)\delta b \frac{f\left(\hat{\beta}\delta b - p^*\right)}{f\left(\beta\delta b - p^*\right)} && \text{[sophisticates]} \\
&\quad -\frac{F\left(\hat{\beta}\delta b - p^*\right) - F\left(\beta\delta b - p^*\right)}{f\left(\beta\delta b - p^*\right)} && \text{[naives]}
\end{aligned}
$$

2. *Hyperbolic agents.* Time inconsistency
$\Longrightarrow$ below-marginal cost pricing: $p^* < a$.

   (a) *Sophisticates* ($\beta = \hat{\beta} < 1$): commitment.

   (b) *Naives* ($\beta < \hat{\beta} = 1$): overestimation of consumption.

MARKET (II). LEISURE GOODS

Payoffs of consumption at $t = 1$:

- Benefit at $t = 1$, stochastic
- Cost at $t = 2$, deterministic

$\Longrightarrow$ Use the previous setting: $-c$ is "current benefit", $b < 0$ is "future cost."

Results:

1. *Exponential agents.*

   Marginal cost pricing: $p^* = a$, $L^* = K$ (PC).

2. *Hyperbolic agents* tend to overconsume. $\Longrightarrow$

   Above-marginal cost pricing: $p^* > a$. Initial bonus $L^* < K$ (PC).

EMPIRICAL PREDICTIONS

Two predictions for time-inconsistent consumers:

1. Investment goods (Proposition 1):
   (a) Below-marginal cost pricing
   (b) Initial fee (Perfect Competition)
2. Leisure goods (Corollary 1)
   (a) Above-marginal cost pricing
   (b) Initial bonus or low initial fee (Perfect Competition)

FIELD EVIDENCE ON CONTRACTS

- US Health club industry ($11.6bn revenue in 2000)
  - monthly and annual contracts
  - Estimated marginal cost: $3-$6 + congestion cost
  - Below-marginal cost pricing despite small transaction costs and price discrimination
- Vacation time-sharing industry ($7.5bn sales in 2000)
  - high initial fee: $11,000 (RCI)
  - minimal fee per week of holiday: $140 (RCI)

- Credit card industry (\$500bn outstanding debt in 1998)
  - Resale value of credit card debt: 20% premium (Ausubel, 1991)
  - No initial fee, bonus (car / luggage insurance)
  - Above-marginal-cost pricing of borrowing

- Gambling industry: Las Vegas hotels and restaurants:
  - Price rooms and meals below cost, at bonus
  - High price on gambling

WELFARE EFFECTS

Result 1. Self-control problems + Sophistication $\Rightarrow$ First best

- Consumption if $c \leq \beta\delta b - p^*$
- Exponential agent:
  - $p^* = a$
  - consume if $c \leq \delta b - p^* = \delta b - a$
- Sophisticated time-inconsistent agent:
  - $p^* = a - (1 - \beta)\delta b$
  - consume if $c \leq \beta\delta b - p^* = \delta b - a$
- Perfect commitment device
- Market interaction maximizes joint surplus of consumer and firm

Result 2. Self-control + Partial naiveté $\Rightarrow$ Real effect of time inconsistency

- $p^* = a - [F(\delta b - p^*) - F(\beta\delta b - p^*)]/f(\beta\delta b - p^*)$

- Firm sets p^* so as to accentuate overconfidence

- Two welfare effects:
  - Inefficiency: $\text{Surplus}_{\text{naive}} \leq \text{Surplus}_{\text{soph.}}$
  - Transfer (under monopoly) from consumer to firm

- Profits are increasing in naivete' $\hat{\beta}$(monopoly)

- $\text{Welfare}_{\text{naive}} \leq \text{Welfare}_{\text{soph.}}$

- Large welfare effects of non-rational expectations

4.2 Self-Control 2

- Kfir and Spiegler (2004), Contracting with Diversely Naive Agents.

- Extend DellaVigna and Malmendier (2004):
  - incorporate heterogeneity in naiveté
  - allow more flexible functional form in time inconsistency
  - different formulation of naiveté

- Setup:
  1. Actions:
     - Action $a \in [0, 1]$ taken at time 2
     - At time 1 utility function is $u(a)$
     - At time 2 utility function is $v(a)$
  2. Beliefs: At time 1 believe:
     - Utility is $u(a)$ with probability θ
     - Utility is $v(a)$ with probability $1 - \theta$
     - Heterogeneity: Distribution of types θ
  3. Transfers:
     - Consumer pays firm $t(a)$
     - Restrictive assumption: no cost to firm of providing a

- Therefore:
  - Time inconsistency ($\beta < 1$) –> Difference between u and v
  - Naiveté ($\hat{\beta} > \beta$) –> $\theta > 0$
  - Partial naiveté here modelled as stochastic rather than deterministic
  - Flexibility in capturing time inconsistency (self-control, reference dependence, emotions)

- Main result:
- **Proposition 1.** There are two types of contracts:
  1. Perfect commitment device for sufficiently sophisticated agents ($\theta < \underline{\theta}$)
  2. Exploitative contracts for sufficiently naive agets ($\theta > \underline{\theta}$)

- Commitment device contract:
  - Implement $a_\theta = \max_a u(a)$
  - Transfer:
    - $t(a_\theta) = \max_a u(a)$
    - $t(a) = \infty$ for other actions
  - Result here is like in DM: Implement first best

- Exploitative contract:
  - Agent has negative utility:

$$u\left(a_\theta^v\right) - t\left(a_\theta^v\right) < 0$$

  - Maximize overestimation of agents:

$$a_\theta^u = \arg\max\left(u\left(a\right) - v\left(a\right)\right)$$

4.3 Bounded Rationality

- Gabaix and Laibson (2003), *Competition and Consumer Confusion*
- Non-standard feature of consumers:
  - Limited ability to deal with complex products
  - imperfect knowledge of utility from consuming complex goods

- Firms are aware of bounded rationality of consumers
  $\longrightarrow$ design products & prices to take advantage of bounded rationality of consumers

Three steps:

1. Given product complexity, given number of firms: What is the mark-up? Comparative statics.

2. Given product complexity: endogenous market entry. What is the mark-up? What is the number of firms?

3. Endogenous product complexity, endogenous market entry: What are mark-up, number of firms, and degree of product complexity?

We will go through 1 and talk about the intuition of 2 and 3.

Example: Checking account. Value depends on

- interest rates
- fees for dozens of financial services (overdraft, more than x checks per months, low average balance, etc.)
- bank locations
- bank hours
- ATM locations
- web-based banking services
- linked products (e.g. investment services)

Given such complexity, consumers do not know the exact value of products they buy.

Model

- Consumers receive noisy, *unbiased* signals about product value.
  - Agent a chooses from n goods.
  - True utility from good i:

$$Q_i - p_i$$

  - Utility signal

$$U_{ia} = Q_i - p_i + \sigma_i \varepsilon_{ia}$$

    σ_i is complexity of product i.

    ε_{ia} is zero mean, iid across consumers and goods, with density f and cumulative distribution F.

    (Suppress consumer-specific subscript a;
    $U_i \equiv U_{ia}$ and $\varepsilon_i \equiv \varepsilon_{ia}$.)

- Consumer decision rule: Picks the one good with highest signal U_i from $(U_i)_{i=1}^n$.
  (**Assumption!** What justifies this assumption?) Demand for good i

$$
\begin{aligned}
D_i &= P\left(U_i > \max_{j \neq i} U_j\right) \\
&= E\left[P\left[\text{for all } j \neq i, U_i > U_j | \varepsilon_i\right]\right] \\
&= E\left[\prod_{j \neq i} P\left[U_i > U_j | \varepsilon_i\right]\right] \\
&= E\left[\prod_{j \neq i} P\left[\frac{Q_i - p_i - \left(Q_j - p_j\right) + \sigma_i \varepsilon_i}{\sigma_j} > \varepsilon_j | \varepsilon_i\right]\right]
\end{aligned}
$$

$$
D_i = \int f\left(\varepsilon_i\right) \prod_{j \neq i} F\left(\frac{Q_i - p_i - \left(Q_j - p_j\right) + \sigma_i \varepsilon_i}{\sigma_j}\right) d\varepsilon_i
$$

Market equilibrium with exogenous complexity

Bertrand competition with

- Q_i : quality of a good,

  σ_i : complexity of a good,

  c_i : production cost

  p_i : price

- Simplification: Q_i, σ_i, c_i identical across firms. (*Problematic simplification. How should consumers choose if all goods are known to be identical?*)

- Firms maximize profit:

$$\pi_i = (p_i - c_i)\, D_i$$

- Symmetry reduces demand to

$$D_i = \int f(\varepsilon_i) F\left(\frac{p_j - p_i + \sigma\varepsilon_i}{\sigma}\right)^{n-1} d\varepsilon_i$$

Consider different demand curves

1. Gaussian noise $\varepsilon \sim N(0,1)$, 2 firms

Demand curve faced by firm 1:

$$\begin{aligned} D_1 &= P(Q - p_1 + \sigma\varepsilon_1 > Q - p_2 + \sigma\varepsilon_2) \\ &= P\left(p_2 - p_1 > \sigma\sqrt{2}\eta\right) \text{ with } \eta = (\varepsilon_2 - \varepsilon_1)/\sqrt{2} \text{ N(0,1)} \\ &= \Phi\left(\frac{p_2 - p_1}{\sigma\sqrt{2}}\right) \end{aligned}$$

Usual Bertrand case $(\sigma = 0)$: infinitely elastic demand at $p_1 = p_2$

$$D_1 \in \left\{ \begin{array}{ccc} 1 & \text{if} & p_1 < p_2 \\ [0,1] & \text{if} & p_1 = p_2 \\ 0 & \text{if} & p_1 > p_2 \end{array} \right\}$$

Complexity case ($\sigma > 0$) : Smooth demand curve, no infinite drop at $p_1 = p_2$. At $p_1 = p_2 = p$ demand is 1/2.

$$\max \Phi \left(\frac{p_2 - p_1}{\sigma\sqrt{2}} \right) [p_1 - c_1]$$

$$\frac{1}{\sigma\sqrt{2}} \phi \left(\frac{p_2 - p_1}{\sigma\sqrt{2}} \right) [p_1 - c_1] = \Phi \left(\frac{p_2 - p_1}{\sigma\sqrt{2}} \right)$$

Intuition for non-zero mark-ups: Lower elasticity increases firm mark-ups and profits. Mark-up proportional to complexity σ.

2. Other distributions.

   - Benefit of lower markup: probability of sale increases.
   - Benefit of higher markup: rent (if sale takes place) increases

   For "thin tailed" noise, mark-up decreases in number of firms. Larger and larger numbers of firms entering drive the equilibrium price to MC.

   For "fat tailed" noise, mark-up *increases* with number of firms. ("Cherry-Picking")

Endogenous number of firms

Intuition: As complexity increases, mark-ups & industry profit margins increase, thus entry increases.

These effects strongest for fat-tailed case. (Endogenous increases in n reinforce the effects of σ on mark-ups.)

Endogenous complexity

- Assumption: $Q_i(\sigma_i)$!

  Firms increase complexity, unless "clearly superior" products in model with heterogenous products.

In a nutshell: market does not help to overcome bounded rationality. Rather competition exacerbates the problem.

5 Next Lecture

- More Market Response to Biases
  - More Pricing: Behavioral IO
  - Employers: Contracting
  - Managers: Equity Issuance
- Methodology of Field Psychology and Economics
- Final Remarks