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 naivety**. 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 \( p = 0.5 \)
- Asset B returns $1 tomorrow with \( p = 0.5 \)

- Arbitrage \( \rightarrow \) 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 $\frac{60}{40} = \frac{3}{2}$ price of Shell

- $p_{RD}/p_S$ differs substantially from 1.5 (Fig. 1)
• Plenty of other example (Palm/3Com)

• What is the problem?
  – Noise trader risk, investors with correlated valuations that diverge from fundamental 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

→ 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

\[ \rho_t \sim i.i.d. \mathcal{N}(\rho^*, \sigma^2_\rho) \]

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

\[ \rightarrow \] Justification?

* fads and bubbles (Internet stocks, biotechs)

* pseudo-signals (advice broker, financial guru)

* behavioral biases / misperception riskiness
What else?

- \( \mu \) 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
    \[ \implies \text{price} = 1 \text{ (numeraire)} \]
  - unsafe asset: inelastic supply (1 unit)
    \[ \implies \text{price?} \]

- Demand for unsafe asset: \( \lambda^a \) and \( \lambda^n \), with \( \lambda^a + \lambda^n = 1 \).
- **CARA:**

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

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

\[ = -e^{-2\gamma(\bar{w} - \gamma\sigma^2_w)} \]

\[ \max E[U(w)] \quad \Rightarrow \quad \max \bar{w} - \gamma\sigma^2_w \]
Arbitrageurs:

\[
\max(w_t - \lambda^a_t p_t)(1 + r)
\]

\[
+ \lambda^a_t (E_t[p_{t+1}] + r)
\]

\[
- \gamma (\lambda^a_t)^2 \text{Var}_t(p_{t+1})
\]

Noise traders:

\[
\max(w_t - \lambda^n_t p_t)(1 + r)
\]

\[
+ \lambda^n_t (E_t[p_{t+1}] + \rho_t + r)
\]

\[
- \gamma (\lambda^n_t)^2 \text{Var}_t(p_{t+1})
\]

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

Arbitrageurs: \( \frac{\partial E[U]}{\partial \lambda^a_t} \overset{!}{=} 0 \)

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

Noise traders: \( \frac{\partial E[U]}{\partial \lambda^n_t} \overset{!}{=} 0 \)

\[
\lambda^n_t = \frac{r + E_t[p_{t+1}] - (1 + r)p_t}{2\gamma \cdot Var_t(p_{t+1})} \quad + \quad \frac{\rho_t}{2\gamma \cdot Var_t(p_{t+1})}
\]
Interpretation

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

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

• 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 $R_a$:

$$\Delta R = R^n - R^a = (\lambda^n_t - \lambda^a_t) [r + p_{t+1} - p_t (1 + r)]$$

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

- 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:
    \[
    p_{t,k} = e_{t,k} + \frac{e_{t+1,k}}{1 + r} + \frac{e_{t+2,k}}{(1 + r)^2} + \ldots
    \]
    – 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: $h \approx 3, 4$ years

  2. Long-term "growth rate" of earnings $g_e$

• Common forecasting model:

$$\hat{p}_{t,k} = e_{t,k} + \frac{\hat{e}_{t+1,k}}{1 + r} + \frac{\hat{e}_{t+2,k}}{(1 + r)^2} + \ldots$$

$$+ \sum_{t=0}^{\infty} \frac{1}{(1 + r)^{h+t}} \hat{e}_{t+h,k} \ast g_e$$
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 based 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”

\[ \tau(0) = 6.61 \]
• 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 for consumers with \((\beta, \hat{\beta}, \delta)\) 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 $t = 0$:

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

  $\iff c < \delta b - p$

- Actual consumption decision at $t = 1$:

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

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

  $\text{Consume} \iff c < \hat{\beta} \delta b - p$ (Naiveté)
FIRM BEHAVIOR. Profit-maximization

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

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

- Notice the difference between $\beta$ and $\hat{\beta}$
Solution for the per-unit price $p^*$:

\[
p^* = a \quad \text{[exponentials]}
\]

\[
- (1 - \hat{\beta}) \delta b \frac{f (\hat{\beta} \delta b - p^*)}{f (\beta \delta b - p^*)} \quad \text{[sophisticates]}
\]

\[
- \frac{F (\hat{\beta} \delta b - p^*) - F (\beta \delta b - p^*)}{f (\beta \delta b - p^*)} \quad \text{[naives]}
\]

Features of the equilibrium

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

\[ p^* = a \]  
\[ - (1 - \hat{\beta}) \delta b \frac{f(\hat{\beta} \delta b - p^*)}{f(\beta \delta b - p^*)} \]  
\[ - \frac{F(\hat{\beta} \delta b - p^*) - F(\beta \delta b - p^*)}{f(\beta \delta b - p^*)} \]

2. Hyperbolic agents. Time inconsistency

\[ \rightarrow \text{below-marginal cost pricing: } p^* < a. \]

(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

$\Rightarrow$ 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. $\Rightarrow$
   
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 naivété ⇒ Real effect of time inconsistency

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

• 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 naivety’ \( \hat{\beta}(\text{monopoly}) \)

• Welfare_{naive} \leq \text{Welfare}_{soph}.

• Large welfare effects of non-rational expectations
4.2 Self-Control 2


- 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 \( \theta \)
     – Utility is \( v(a) \) with probability \( 1 - \theta \)
     – Heterogeneity: Distribution of types \( \theta \)
  3. Transfers:
     – Consumer pays firm \( t(a) \)
     – Restrictive assumption: no cost to firm of providing \( a \)
Therefore:

- Time inconsistency ($\beta < 1$) $\rightarrow$ Difference between $u$ and $v$

- Naiveté ($\hat{\beta} > \beta$) $\rightarrow$ $\theta > 0$

- 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 \((\theta < \theta)\)
  2. Exploitative contracts for sufficiently naive agents \((\theta > \theta)\)

• 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:
    \[ u(a_\theta^v) - t(a_\theta^v) < 0 \]
  – Maximize overestimation of agents:
    \[ a_\theta^u = \arg\max (u(a) - v(a)) \]
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
  $\rightarrow$ 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
    \[ U_{ia} = Q_i - p_i + \sigma_i \varepsilon_{ia} \]

$\sigma_i$ is complexity of product $i$.
$\varepsilon_{ia}$ 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 $i$

$$D_i = P \left( U_i > \max_{j \neq i} U_j \right)$$

$$= E \left[ P \left[ \text{for all } j \neq i, U_i > U_j | \varepsilon_i \right] \right]$$

$$= E \left[ \prod_{j \neq i} P \left[ U_i > U_j | \varepsilon_i \right] \right]$$

$$= E \left[ \prod_{j \neq i} P \left[ \frac{Q_i - p_i - (Q_j - p_j) + \sigma_i \varepsilon_i}{\sigma_j} > \varepsilon_j | \varepsilon_i \right] \right]$$

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

Bertrand competition with

- \( Q_i \): quality of a good,
  \( \sigma_i \): complexity of a good,
  \( c_i \): production cost
  \( p_i \): price

- Simplification: \( Q_i, \sigma_i, c_i \) 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:

\[
D_1 = P(Q - p_1 + \sigma \varepsilon_1 > Q - p_2 + \sigma \varepsilon_2)
\]

\[
= P\left(p_2 - p_1 > \sigma \sqrt{2} \eta \right) \text{ with } \eta = (\varepsilon_2 - \varepsilon_1) / \sqrt{2} \sim N(0,1)
\]

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

Usual Bertrand case (\( \sigma = 0 \)) : infinitely elastic demand at \( p_1 = p_2 \)
\[ D_1 \in \left\{ \begin{array}{ll} 1 & \text{if } p_1 < p_2 \\ [0, 1] & \text{if } p_1 = p_2 \\ 0 & \text{if } p_1 > p_2 \end{array} \right\} \]

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 \(\sigma\).
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 $\sigma$ 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