# Bargaining
# 談判

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# Bargaining

- Bargaining 討價還價
  - The process by which economic agents agree on the terms of a deal

- Common even in "competitive" markets
  - The "pit market" in NYSE/market experiments
  - Edgeworth Box was created to show range of possible bargaining outcomes

- Have you ever bargained with someone?

# Bargaining

- Nash (1950, 1951)
  - (Cooperative) Nash Bargaining Solution
  - (Non-cooperative) Nash Equilibrium
- Nash Program: NBS is NE/SPE of a game
  - Binmore, Rubinstein and Wolinsky (1986)
- References:
  - BGT, Ch. 4
  - HEE, Ch. 4
  - *MGS,* Ch. 23

# Bargaining

- Cooperative NBS vs. Non-cooperative NE
  - Two approaches in experiments as well…
- Unstructured Bargaining Experiments
  - Free form procedure determined by players
  - More close to naturally occurring bargaining
- Structured Bargaining Experiments
  - Procedure specified by experimenter
  - Game theory makes specific predictions

# Bargaining

- Negotiation Research: Bazerman et al. 00'
  - Applied psychology
  - Negotiate over numerical or categorial levels of several issues (like price or quantity)
  - Free form communication with a time deadline
  - Private point schedule (dep. on each issue)
- Results: Deals are not Pareto-efficient, affected by systematic heuristics and other cognitive variables (unrelated to the game)

# Bargaining

- Why not much overlap?
  - Game theory assumes too much rationality
  - Solvable games are too simplified
  - Hard to apply game theory to Negotiation games
- But the research questions are the same!
- Like 2 traditions of experimental economics
  - Game experiments are too simplified
  - Hard to apply game theory to market experiments

# Unstructured Bargaining

- Test: Nash Bargaining Solution
  - The point maximizing the product of utility gains (beyond the disagreement point)

- Only point satisfying
  - Symmetry
  - Independence of Irrelevant Alternatives
  - Independence from affine utility transformation

# Unstructured Bargaining

- Roth and Malouf (1979)
- Player bargain over 100 lottery tickets
  - Binary Lottery: Induce risk neutrality
  - "Works" if compound lotteries can be reduced
- 1 ticket = 1% chance of winning fixed prize
- Equal ($1) vs. Unequal Prize ($1.25/$3.75)
- Full vs. Partial (know own prize) Information
- NBS: 50-50 split

# Unstructured Bargaining

| Inform-ation | Money Prizes | # of Tickets for Player 2 | | | | | | | Frac. of Disagree. |
|---|---|---|---|---|---|---|---|---|---|
| | | 20 | 25 | 30 | 35 | 40 | 45 | 50 | |
| Full Info. | 1/1 | 0 | 0 | 1 | 0 | 1 | 0 | 20 | 0.00 |
| | 1.25/3.75 | 1 | 6 | 3 | 2 | 2 | 1 | 4 | 0.14 |
| Part. Info. | 1/1 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 0.06 |
| | 1.25/3.75 | 0 | 0 | 0 | 0 | 0 | 3 | 13 | 0.00 |

# Unstructured Bargaining

- Results: Agreements cluster at 50-50
  - Rare Disagreement
  - 14% Disagreement when both know inequality
  - Divide tickets equally vs. $$$ payoffs equally
  - Sensitive to $$$ payoffs (violate independence of affine transformation)
- Pairs settle in the final minutes (Stubbornness?)
- Follow-up: "strong reputation" trained by computers carry on to new human opponents

# Unstructured Bargaining

- Mehta, Starmer and Sugden (1992)
- Nash Demand Game: 2 Players
  - Each state demand
  - Get their demand If sum < 10, zero otherwise.
- Focal point: Players divide 8 cards (w/ 4 aces)
  - Aces split 2-2: Agree on 50-50 Split
  - Aces 1-3: Half 50-50, Half 25-75; 25% disagree

# Unstructured Bargaining

- Roth (1985): Coordination game – propose 50-50 or $h$ -(100-$h$) simultaneously

- MSE:
$$p_1 = \frac{h - 50}{150 - h} \quad p_2 = \frac{h - 50}{h + 50}$$

- Disagreement rates:
    - Prediction: 0→7→10 (Actual: 7→18→25)

- Murnighan et al. (1988):
    - Prediction: 1→19 (Actual: constant across $h$)

# Unstructured Bargaining

- Cause of Disagreement: Self-Serving Bias
  - "What is better for me" is "Fair"
- Loewenstein et al. 93, Babcock et al. 95, 97
  - Bargain on how to settle a legal case
  - Guess what the judge would award (if disagree)
- Diff. in E(judgement) predicts disagreement
  - Vanishes if don't know roles before reading case
  - Vanishes if "first list weakness of my own case"

# Structured Bargaining

- Finite Alternating-Offer Game
- Binmore, Shaked & Sutton (1985): 2 period
- 1 offers a division of 100p to 2
- If 2 rejects, makes counteroffer dividing 25p
- SPE: Offer 25-75
- Experimental Results: mode at 50-50, some 25-75 and others in between

# Structured Bargaining

- Neelin, Sonnenschein and Spiegel (1988)
  - Economics undergrads yield different results
- Are they taught backward induction? Also,
- Binmore – "YOU WOULD BE DOING US A FAVOR IF YOU SIMPLY SET OUT TO MAXIMIZE YOUR WINNINGS."
- Neelin – "You would be discussing the theory this experiment is designed to test in class."

# Structured Bargaining

- Social Preference or Limited Strategic Thinking?

- Johnson, Camerer, Sen & Rymon (2002), "Detecting Failures of Backward Induction: Monitoring Information Search in Sequential Bargaining," *Journal of Economic Theory,*104 (1), 16-47.

- Some do not even look at the last stage payoffs in 3-stage bargaining games…

# Structured Bargaining

- Random Termination vs. Discounting
- Zwick, Rapoport and Howard (1992)
- Divide $30 with random termination
- Continuation probabilities 0.90, 0.67, 0.17
- SPE: 14.21, 12, 4.29
  - Accepted final offers: 14.97, 14.76, 13.92
- Close to discounting results (50-50 & SPE)
  - 14.90, 14.64, 13.57

# Structured Bargaining

- Fixed Delay Cost in Bargaining
  - Lost wages, profits, etc.
- The side with the lower delay cost should get almost everything
- Rapoport, Weg and Felsenthal (1990)
- Divide 30 shekels
- Fixed Cost: 0.1 vs. 2.5 or 0.2 vs. 3.0
- Strong support for SPE (BGT, Table 4.7)

# Outside Option and Threat Points

- Binmore, Shaked and Sutton (1989)
- Bargain over £7; player 2 has outside options of £0, £2, or £4
  - Split-the-difference: NBS predicts dividing surplus gained <u>beyond the threat points</u>
  - Deal-me-out: SPE predicts change in results <u>only when threat is credible</u>
- BGT, Fig. 4.4: Deal-me-out wins

# Incomplete Information

- Add asymmetric information to bargaining
- More realistic, but
  - Hard to bargain for a bigger share AND convey information at the same time
- Might need to turn down an offer to signal patience or a better outside option

# Seller Make Offer to Informed Buyer

- Rapoport, Erve, and Zwick (MS 1995)

- Seller: Own item (worthless to herself)

- Buyer: Private reservation price is unif.[0,1]

- Seller makes an offer each period

- Common discount factor $\delta$

- Unique Sequential Equilibrium:
- Seller Offer:

$$p_0 = \gamma \cdot \frac{1 - \delta}{1 - \gamma \cdot \delta}, \quad \gamma = \frac{1 - \sqrt{1 - \delta}}{\delta}$$

- Subsequently: $p_t = p_0 \cdot \gamma^t$

- Buyer Accepts if $p_t \leq v \cdot \dfrac{1 - \delta}{1 - \gamma \cdot \delta}$

# Seller Make Offer to Informed Buyer

- Complicate Strategy: Depend on $\delta$
  - Price discriminate high/low-value buyers
  - Price declines slow enough so high-value buyers will not want to wait
- Can subjects get these in experiments?
  - Different $\delta$ : H (0.90), M (0.67), L (0.33)
  - Opening $p_0$ : H (0.24), M (0.36), L (0.45)
  - Discount $\gamma$ : H (0.76), M (0.68), L (0.55)

# Seller Make Offer to Informed Buyer
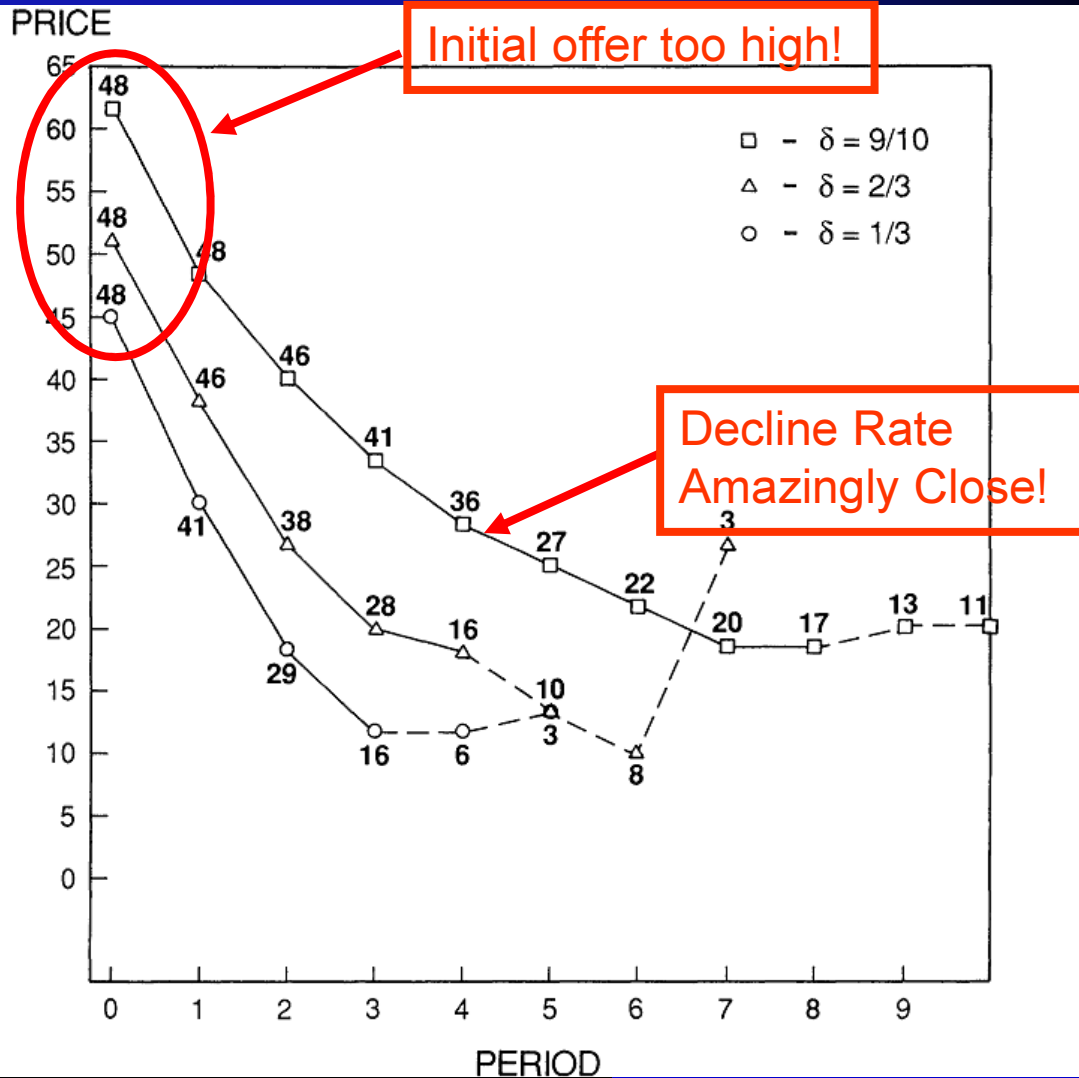
# Seller Make Offer to Informed Buyer

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  - Opening $p_0$ : H (0.24), M (0.36), L (0.45)
  - Discount $\gamma$ : H (0.76), M (0.68), L (0.55)
- Buyers accept the 1st or 2nd offer below $v$
  - Accept offers too soon
- Sellers ask for higher prices (than equil.)
  - But discount $\gamma$ : H (0.81), M (0.68), L (0.55)

- Forsythe, Kennan and Sopher (AER 1991)
- Only Informed bargainer I sees pie size
  – Either large ($\pi_g$) or small ($\pi_b$)
- Free-form bargaining
- Uninformed U can strike to shrink pie by $\gamma$
- Can we predict what happens?

# Strikes and 1-Sided Information

- Myerson (1979): Revelation Principle
  - I announces true state
  - U strikes to shrink pie by $\gamma_g$ or $\gamma_b$
  - I gives U (based on true state) $x_g$ or $x_b$
- IC requires:

$$(\gamma_g - \gamma_b)\pi_b \leq x_g - x_b \leq (\gamma_g - \gamma_b)\pi_g$$

- Interim Incentive Efficiency requires:

$$\gamma_g = 1, x_g - x_b = (1 - \gamma_b)\pi_g$$

- Strike ($\gamma_b < 1$) if and only if $\quad p\pi_g > \pi_b$

- Deriving this is complicated...
- Could ANY subject get close to this?

# Strikes and 1-Sided Information

- Random Dictator (RD) Axiom:
  - Agree fair mix between each being dictator to propose mechanism
- Then:

$$\gamma_g = 1, x_g = \frac{\pi_g}{2}, \gamma_b = \frac{1}{2}, x_b = 0 \text{ if } p\pi_g > \pi_b$$

$$\gamma_g = 1, x_g = \frac{\pi_b}{2}, \gamma_b = 1, x_b = \frac{\pi_b}{2} \text{ if } p\pi_g < \pi_b$$

# Strikes and 1-Sided Information

- This is a win-win experiment:
  - Success if theory predictions are close
  - If not, will point to which assumption fails
- Forsythe et al. (AER 1995):
  - 10 minute sessions; written messages
- Is Myerson (1979) confirmed?
  - Surprisingly yes, though not perfect…

# Strike Condition Off

| Game | $p$ | State | $\pi$ | $\pi_U$ | $\pi_I$ | total | %Strike |
|------|-----|-------|-------|---------|---------|-------|---------|
| III | 0.5 | b | 2.80 | | | | |
| | | g | 4.20 | | | | |
| | | aver. | 3.50 | 1.50 | 1.80 | 3.29 | 6.0 |
| | | pred. | | 1.40 | 2.10 | 3.50 | 0.0 |
| IV | 0.25 | b | 2.40 | | | | |
| | | g | 6.80 | | | | |
| | | aver. | 3.50 | 1.21 | 2.04 | 3.24 | 7.4 |
| | | pred. | | 1.20 | 2.30 | 3.50 | 0.0 |

# Strike Condition On

| Game | $p$ | State | $\pi$ | $\pi_U$ | $\pi_I$ | total | %Strike |
|------|-----|-------|-------|---------|---------|-------|---------|
| I | 0.5 | b | 1.00 | | | | |
| | | g | 6.00 | | | | |
| | | aver. | 3.50 | 1.05 | 2.00 | 3.05 | 13.0 |
| | | pred. | | 1.50 | 1.75 | 3.25 | 7.1 |
| II | 0.75 | b | 2.30 | | | | |
| | | g | 3.90 | | | | |
| | | aver. | 3.50 | 1.41 | 1.76 | 3.18 | 9.3 |
| | | pred. | | 1.46 | 1.75 | 3.21 | 8.3 |

# Sealed-Bid in Bilateral Bargaining

- Both buyers and sellers have private information

- Sealed-Bid Mechanism
  - Both write down a price
  - Trade at the average if $p_b > p_s$
  - Call Market: Many buyers vs. many sellers

- Two-Person Sealed-Bid Mechanism
  - One form of bilateral bargaining

# Sealed-Bid in Bilateral Bargaining

- Two-Person Sealed-Bid Mechanism
- Buyer $V \sim$ unif.$[0,100]$; Seller $C \sim$ unif.$[0,100]$
- Piecewise-linear equilibrium: (not unique)
  - Chatterjee and Samuelson (1983)
  - Max. ex ante gains (Myerson & Satterthwaite 83')

$$p_b = \begin{cases} V & \text{if } V < 25 \\ \frac{25}{3} + \frac{3}{2}V & \text{if } V \geq 25 \end{cases}$$

$$p_s = \begin{cases} 25 + \frac{2}{3}C & \text{if } C < 75 \\ C & \text{if } C \geq 75 \end{cases}$$

# Sealed-Bid in Bilateral Bargaining

- Radner and Schotter (JET 1989): 8 sessions
- 1, 2, 8: Baseline as above
- 3: Trade at price $(v + c + 50)$ / 3 if $v > c+25$
  - Should bid their values $v = V$, $c = C$
- 4:  Price $= v$, (Buyers should bid $v = V/2$)
- 5,6: Alternative distribution for more learning
  - Distribution w/ more trade (for learning): $m=0.438$
- 7: Face-to-face bargaining

# Estimated Buyer Bid Function Slope

| Session | Below cutoff | | | Above cutoff | | |
|---------|------|-------|---------|------|-------|---------|
|         | β    | β_hat | T-stat  | β    | β_hat | T-stat  |
| 1       | 1    | 1.00  | (0.01)  | 0.67 | 0.85* | (4.14)  |
| 2       | 1    | 0.91  | (-0.52) | 0.67 | 1.06  | (1.28)  |
| 8       | 1    | 0.91  | (-0.14) | 0.67 | 0.80* | (2.32)  |
| 3       | 1    | 0.92  | (-0.08) | 1    | 0.73* | (-2.64) |
| 4       | 0.5  | 0.55  | (0.66)  | 0.5  | 0.58* | (2.32)  |
| 5       | 1    | 0.80* | (-4.17) | 0.438| 0.50  | (1.12)  |
| 6(-20)  | 1    | 0.85  | (-1.40) | 0.438| 0.40  | (-0.56) |
| 6(21-)  | 1    | 1.11  | (0.70)  | 0.438| 0.32  | (-1.55) |

# Estimated Seller Bid Function Slope

| Session | β | β_hat | T-stat | β | β_hat | T-stat |
|---|---|---|---|---|---|---|
| | Below cutoff | | | Above cutoff | | |
| 1 | 0.67 | 0.58 | (-1.38) | 1 | 0.97 | (-0.32) |
| 2 | 0.67 | 0.74 | (1.28) | 1 | 1.07 | (0.14) |
| 8 | 0.67 | 0.75 | (1.65) | 1 | 1.07 | (0.17) |
| 3 | 1 | 1.06 | (1.04) | 1 | 0.67 | (-0.58) |
| 5 | 0.438 | 0.48 | (0.87) | 1 | 1.00 | (0.60) |
| 6(-20) | 0.438 | 0.57* | (2.16) | 1 | 0.97 | (-0.79) |
| 6(21-) | 0.438 | 0.52 | (1.20) | 1 | 0.95 | (-0.69) |

# Sealed-Bid in Bilateral Bargaining

- Face-to-face yields efficiency 110%
  - Some <span style="color:red">truthfully reveal</span>; others don't
- Radner and Schotter (1989, p.210),
- "The success of the face-to-face mechanism, if replicated, might lead to a halt in the search for better ways to structure bargaining in situations of incomplete information.
- It would create, however, <span style="color:red">a need for a theory</span> of such structured bargaining in order to enable us to understand why the mechanism is so successful."

- Follow-up Studies:
- Schotter, Snyder and Zheng (GEB 2000)
  - Add agents
- Rapoport and Fuller (1995)
  - Strategy method; asymmetric value dist.
- Daniel, Seale and Rapoport (1998)
  - Asymmetric value distribution (20 vs. 200)
- Rapoport, Daniel and Seale (1998)
  - Flip buyer-seller asymmetry; fixed pairing

# Communication vs. Sealed-Bid

- Valley et al. (GEB 2002): Communication
- Buyer/Seller Values/Costs ~ uniform[0, $50]
  - Bargain by stating bids; 7 periods; no rematch
  - Half had no feedback
- No communication: Sealed-bid in 2 minutes
- Written communication: Exchange messages for 13 minutes before final bid
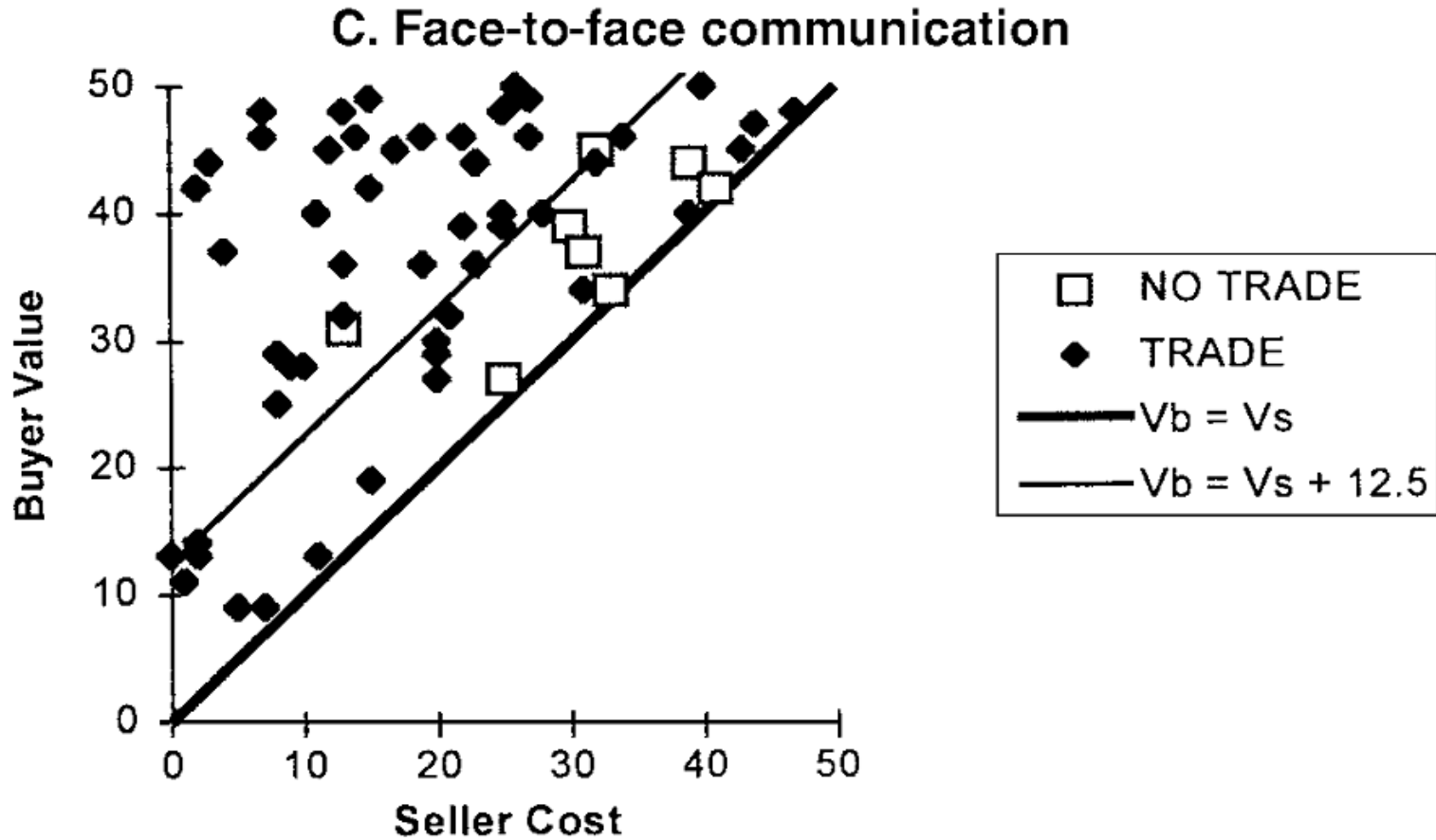- Face-to-face: Pre-game communication

A. No communication

# Communication vs. Sealed-Bid



B. Written communication

# Communication vs. Sealed-Bid



C. Face-to-face communication
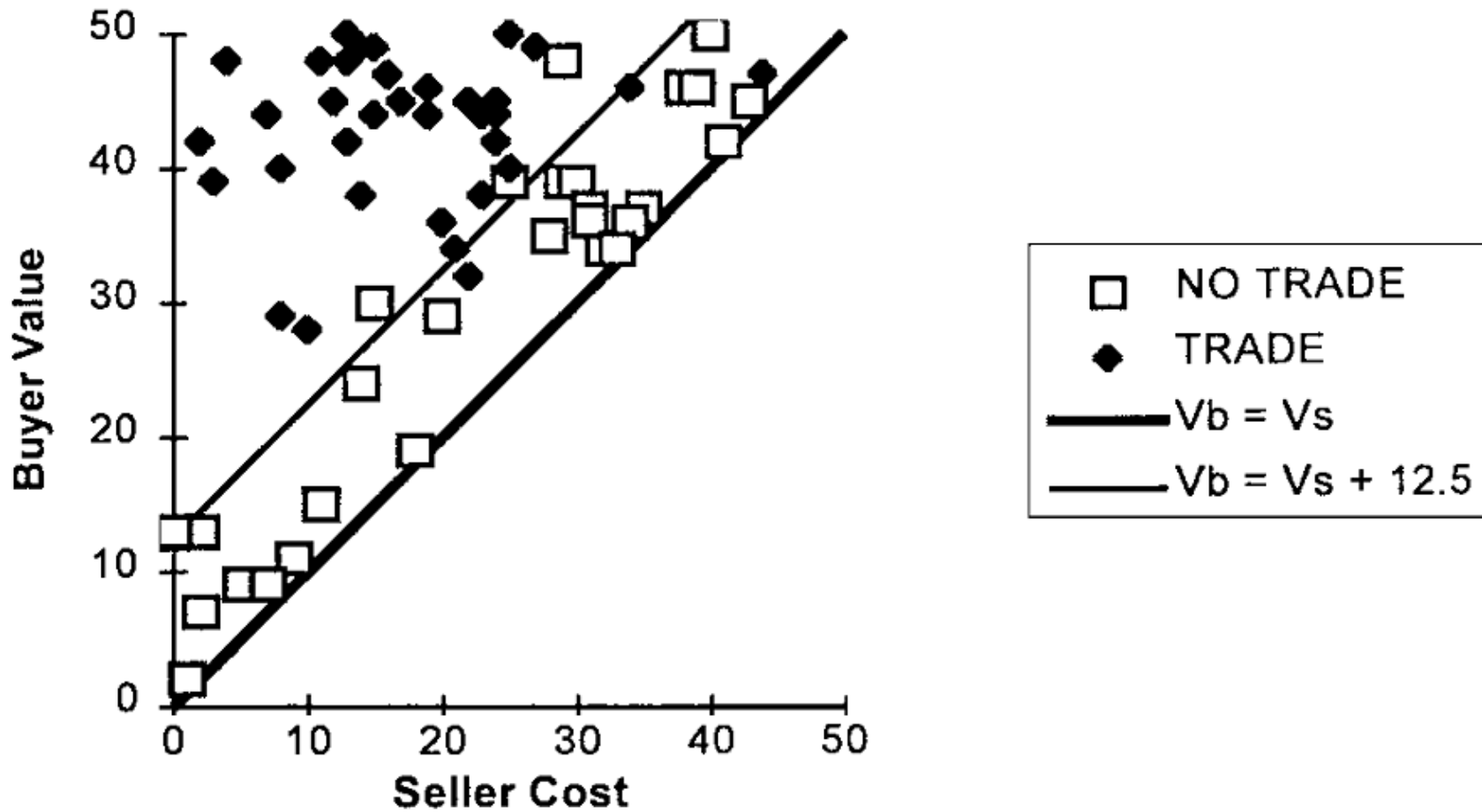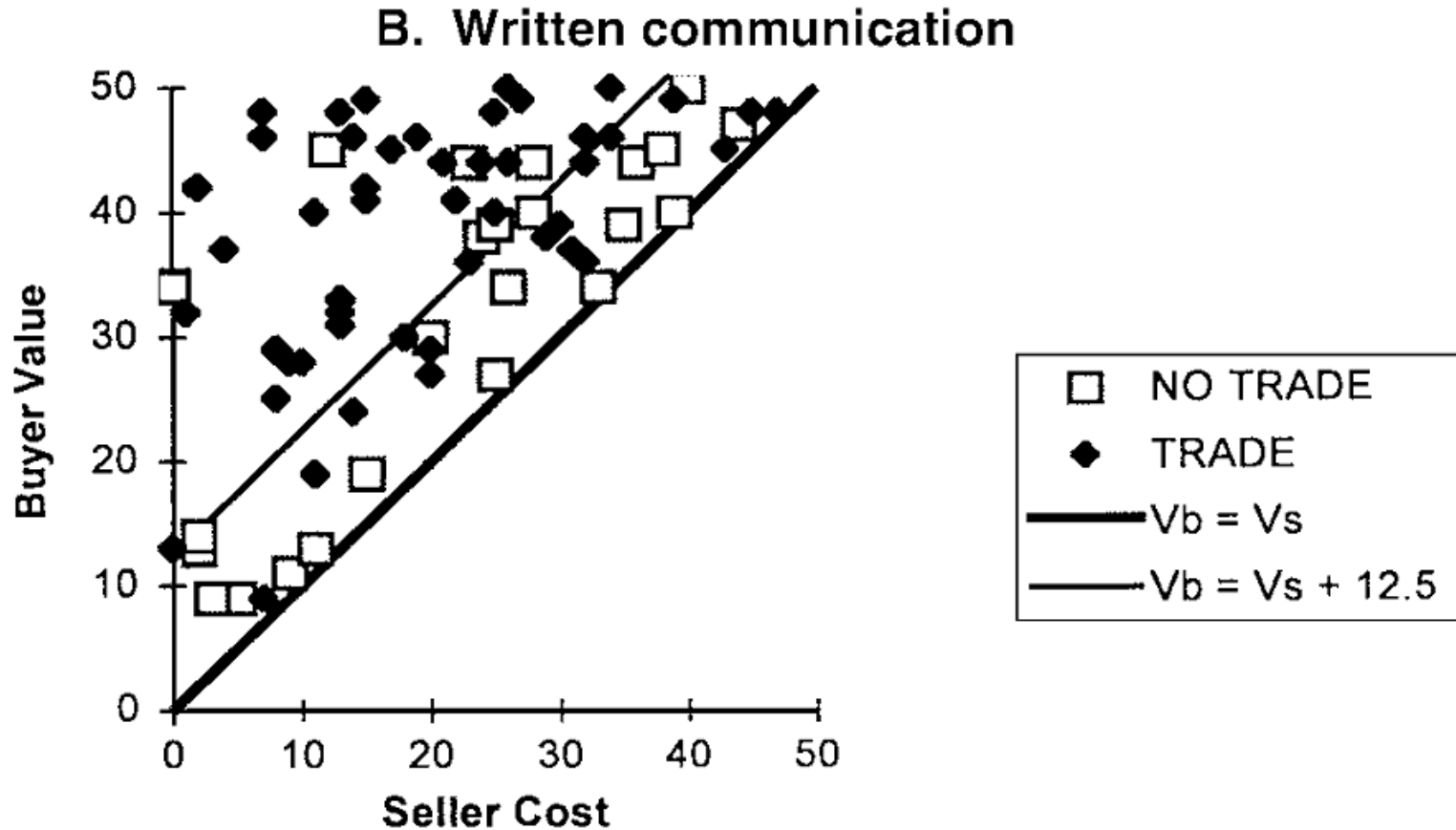
# Communication vs. Sealed-Bid

- Empirical bid function slope = 0.7 (~0.67)
- Why are there "gains of communication"?
- Slope of buyer bids against seller bids=0.6
- Buyers bid higher when seller bids higher
  - Mutual bidding of values (common in students)
  - Mutual revelation of values (com. in students)
  - Coordinating on a price (40% written; 70% face)

# Communication vs. Sealed-Bid

- Coordinating on a price
  - Happens 40% in written, 70% in face-to-face
- Not truth-telling (only 1/3)
  - TT not coordinated (4% written, 8% face)
- Feel each other out; give enough surplus
  - Modal – equal split of surplus
- Variance of surplus doubles (by mismatches)

# Conclusion

- Unstructured Bargaining
  - Focal divisions; competing focal points
  - Self-serving bias (erased by veil of ignorance or stating weakness of own case)

- Structured Bargaining
  - Deviate toward equal splits
  - Social preference models could explain this
  - But Johnson et al. (JET 2002) suggest limited look-ahead as reason for such deviations

# Conclusion

- Outside options affect bargaining divisions only if threats are credible
  - Lower fixed cost player gets everything
- Information Asymmetry: One-Sided
  - Revelation Principle + Random Dictator: Good
  - Bazaar mechanism:
  - Offers decline as theory predicts, but start too high and respond to $\delta$ wrongly
  - Buyers accept too early

# Conclusion

- Bilateral Bargaining: Two-Sided
  - Sealed-bid mechanism: between truthful revelation and piecewise-linear equilibrium
- Players over-reveal values in face-to-face
  - Too honest, but "more efficient"
- Communication → agree on a single price
- Why theory does better in sealed-bid than alternative-offer bargaining?
  - Is sealed-bid cognitively more transparent?