

Mechanism Design

8: Communication with verifiable information

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Introduction

- Throughout the course we dealt with situations where players had some private information that the designer was interested in.
- The players could act based on this private info, but had no way of proving their type (except through the choice of actions).
- Would anything change if the players could **disclose hard evidence** of their type?
- This lecture is based on (and expands on) the address by Dekel [2016].
- For a broader survey of the literature, see the survey by Dranove and Jin [2010].

Hard evidence

Examples of hard (verifiable) evidence:

- statements about **verifiable characteristics of the product**:
 - performance,
 - energy efficiency for appliances / fuel efficiency for vehicles,
 - university departments disclose graduates' employability data.
- **external ratings and certificates**
 - cafes & restaurants have sanitary ratings
 - exchange-traded firms get credit ratings
 - videogames and movies get age ratings, and also critics' reviews

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Disclosure game: basic version [Grossman, 1981]

Let's start with a **disclosure game**: no design, simply an exploration of how the sender would behave.

- 1 A firm has a product of privately known quality $\theta \in \Theta$, chooses whether to show a certificate that verifies θ .
- 2 A consumer observes evidence (if any) and updates their belief $\phi_c \in \Delta(\Theta)$.
- 3 The firm's payoff is $\mathbb{E}[\theta|\phi_c]$.
 - I.e., the firm wants to induce the highest possible belief (so it can charge higher price, get more consumers, etc – not modelled)

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If you want an actual, properly defined game, here it is:

Players: a sender (firm) with private type $\theta \in \Theta \subset \mathbb{R}$; a receiver (consumer) with belief $\phi_0 \in \Delta(\Theta)$.

Actions: sender of type θ chooses a message $m \in \{\emptyset, \theta\}$; the receiver observes m and selects $x \in \mathbb{R}$.

- Some models allow for a richer evidence structure: $m \in M(\Theta)$, where $M(\Theta)$ is some collection of subsets of Θ that include θ . I.e., θ can disclose some but not all information about their type. [Milgrom, 1981]

Payoffs: sender's utility is $u_S(x, \theta) = x$; receiver's utility is $u_R(x, \theta) = -(x - \theta)^2$

- So in eqm, the receiver selects $x = \mathbb{E}[\theta|m]$, and the sender chooses m to maximize $\mathbb{E}[\theta|m]$.

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Unraveling

Theorem (Unraveling)

In equilibrium, all firm types θ (except for maybe the lowest one) present evidence, so there is full learning.

- Argument for finite Θ :
- Suppose statement is not true: there is a set of types Θ_S that stay silent (do not disclose).
- Then the firm's payoff when hiding evidence is $\mathbb{E}[\theta|\phi_0, \Theta_S]$, where ϕ_0 is the consumer's prior belief.
- Consider type $z \equiv \max \Theta_S$. Revealing the type (with evidence) yields payoff z , which is higher than the payoff from silence (which is a weighted average of z and lower types).
- So regardless of which types stay silent, the highest of such types would like to separate. Then the highest of the remaining types would like to do the same, etc – this process is called **unraveling**.

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Unraveling: reasons and robustness

- The opportunity to present evidence leads to **all information being revealed**.
- Note the buyer-designer would **not be able** to get this result **without evidence**:
 - As we discussed, our elicitation methods relied on different agent types θ having different preferences (e.g., single-crossing preferences over multidimensional outcomes, non-monotone preferences over one-dimensional outcome).
 - In this example, only the buyer's preferences depend on the type (or so the story suggests) – note that the firm gets $\mathbb{E}[\theta|\phi_c]$ regardless of true θ – so all types θ have the exact same reporting incentives!
- The result works for interval Θ too, though the argument is slightly more subtle.
- We will now look at a couple of variations where unraveling **breaks**.

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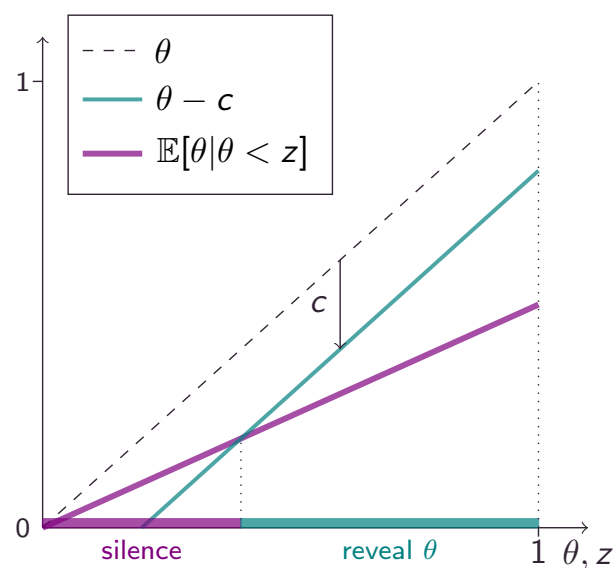
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Costs of disclosure [Verrecchia, 1983]

- Continue the previous example, but suppose now that showing evidence costs $c > 0$ for the firm.
- Then for the low enough types, the profit from showing evidence is not worth the cost.
- **Example:** $\theta \sim U[0, 1]$. Suppose types Θ_S silent. Payoff from silence is $\mathbb{E}[\theta \mid \theta \in \Theta_S]$, indep of θ ; from disclosure is $\theta - c$, incr in $\theta \Rightarrow$ high θ disclose, low θ silent. Cutoff type z must be indifferent: $z - c = \mathbb{E}[\theta \mid \theta < z] = \frac{z}{2} \Rightarrow z = 2c$.
Eqm: $\theta \in [0, 2c)$ silent, $\theta \in [2c, 1]$ disclose.



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Uncertain evidence [Dye, 1985, Jung and Kwon, 1988]

- Now return to the case $c = 0$, but the firm only has evidence with probability $\lambda < 1$.
- With probability $1 - \lambda$ the firm has no evidence and is forced to stay silent.
- Then, if types Θ_S stay silent (even with evidence):

$$\mathbb{E}[\theta \mid \text{silence}] = \frac{\lambda \mathbb{P}(\Theta_S) \mathbb{E}[\theta \mid \Theta_S] + (1 - \lambda) \mathbb{E}[\theta]}{\lambda \mathbb{P}(\Theta_S) + (1 - \lambda)}.$$

This is higher than in the baseline ($\lambda = 1$), because the consumer understands the firm may not have any evidence. So profit from disclosure is smaller.

- This may again lead to some low types staying silent (pretending to have no evidence).

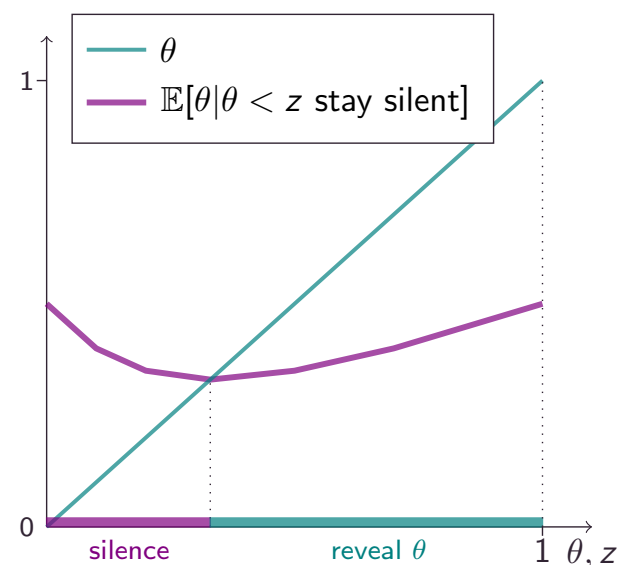
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Uncertain evidence: example

- Suppose again $\theta \sim U[0, 1]$ and let $\lambda = 3/4$.
- In eqm, types $\theta \in [z, 1]$ disclose their type if they can; types $\theta \in [0, z)$ always silent (same argument as in costly disclosure). Then using LIE and Bayes' rule,

$$\mathbb{E}[\theta \mid \text{silence}] = \frac{3z^2 + 1}{2(3z + 1)}$$

- Type θ discloses if $\theta \geq \mathbb{E}[\theta \mid \text{silence}]$ and silent otherwise. Hence $z = \mathbb{E}[\theta \mid \text{silence}] \iff z = 1/3$.
- Eqm: types $\theta \in [1/3, 1]$ disclose if they can; types $\theta \in [0, 1/3)$ always stay silent.



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Naive receiver [Milgrom and Roberts, 1986]

- Go back to the base setup, but assume that with probability $\pi \in [0, 1]$ the receiver/consumer is **naïve** (or, as Eyster and Rabin [2005] call them, **cursed**).
- A cursed receiver makes no inference from silence: $\mathbb{E}[\theta \mid \text{silence}] = \mathbb{E}[\theta]$; is otherwise same as a rational receiver.
- Then if $\theta \sim U[0, 1]$ and the firm reveals θ iff $\theta \geq z$, eqm cutoff z must be such that:

$$z = \pi \mathbb{E}[\theta] + (1 - \pi) \mathbb{E}[\theta \mid \Theta_S] = \frac{\pi}{2} + (1 - \pi) \frac{z}{2} \quad \Rightarrow \quad z = \frac{\pi}{1 + \pi}.$$

So in equilibrium, the firm reveals θ only if $\theta > \frac{\pi}{1+\pi}$ (i.e., always reveals when $\pi = 0$; reveals only if $\theta > \mathbb{E}[\theta]$ when $\pi = 1$).

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Disclosure: Interim conclusion

- In the basic game with evidence, unraveling leads to **full information revelation**.
- Unraveling can be tamed in many ways, including disclosure costs, naïveté, or receivers allowing for a chance of sender having no evidence. (There are, of course, not the only reasons; see Dranove and Jin [2010] for more.)
- Even in those later cases, the idea is simple: **reveal good news**, **hide bad news**.
- Think of evidence and incentives to reveal it as an additional tool in your information extraction toolbox.

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Good news and bad news

The asymmetry between **good & bad news** is fun to explore:

- it means that **silence is bad news** (but humans are bad at inferring it, see Jin, Luca, and Martin [2021]),
- that **silence leaves more uncertainty** than good announcements [Shin, 2003],
- that bad news are revealed in **bunches** [Acharya, DeMarzo, and Kremer, 2011]
- that the desire to have good news to disclose leads to **excessive risk-taking** [Ben-Porath, Dekel, and Lipman, 2018]
- There are also a few reasons why sender might want to voluntarily reveal bad news, see an overview in Smirnov and Starkov [2022]

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Evidence and Mechanism design

- We have looked at disclosure games so far, where receiver/designer had to be sequentially rational (maximize $\mathbb{E}u_R$ given $m \Rightarrow$ choose $x = \mathbb{E}[\theta|m]$).
- What if we take a mechanism design perspective? I.e., suppose the receiver can **commit** to a decision rule $x(m)$. Can this help produce a **better outcome**?
 - E.g., in the **Dye setting** (uncertain evidence).
 - Note: choosing a strategy $x(m)$ in the no-commitment game can be seen as “a mechanism design problem with a sequential rationality constraint”. Extra constraint = worse outcome. Or is it?
- Hart, Kremer, and Perry [2017] show this is not the case.
- Their result: under some conditions on the sender's evidence and the receiver's preferences (that our setting satisfies):
 - disclosure game has a unique equilibrium,
 - the optimal disclosure mechanism exists and is unique,
 - the two **coincide** \Rightarrow **no value from commitment**.

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Evidence and Mechanism design 2

- Their result (no value from commitment) relies on concavity of the receiver's preferences + assumptions on evidence structure.
- **Counterexample** with preferences not concave in x given θ :
- Let $\theta \in \{1, 2, \dots, 9\}$ with $\phi_0(9) = 0.2$ and $\phi_0(\theta) = 0.1$ for $\theta < 9$.
- Suppose types $\theta < 9$ are verifiable: $m \in \{\emptyset, \theta\}$; type $\theta = 9$ has no evidence: $m = \emptyset$.
- Receiver's payoff is $u_R(x, \theta) = \mathbb{I}\{x = \theta\}$; sender's payoff is still $u_S(x, \theta) = x$.
- Then commitment outcome is better than no commitment:
 - In eqm **w/o commitment**, after silence the receiver chooses $x(\emptyset) = 9$, so sender never reveals θ . $\Rightarrow \mathbb{E}u_R = 0.2$.
 - **With commitment**, receiver can commit to $x(\emptyset) = 1 \Rightarrow$ sender reveals θ if possible $\Rightarrow \mathbb{E}u_R = 0.8$.

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Many senders, same evidence [Milgrom and Roberts, 1986]

- Go back to the game with **naïve receiver**, but suppose that in addition to **the firm**, there is now also **a competitor**.
- Both observe firm quality θ and can disclose it in a verifiable way.
- The competitor's payoff is $-\mathbb{E}[\theta|\phi_c]$, the opposite of the firm's.
- Then the firm wants to reveal θ iff $\theta > \pi\mathbb{E}[\theta] + (1 - \pi)\mathbb{E}[\theta \mid \text{silence}]$.
- Similarly, the competitor wants to reveal θ iff $\theta < \pi\mathbb{E}[\theta] + (1 - \pi)\mathbb{E}[\theta \mid \text{silence}]$.
- Regardless of θ , one of them wants to reveal \Rightarrow someone always reveals θ
 \Rightarrow **full info** in equilibrium.

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Many senders, same evidence

- Conclusion: if players have a **conflict of interest** and access to the same info, **more information** is revealed.
- This complements the results without evidence: the receiver can exploit the conflict of interest between players to extract more info (we saw this in the Battaglini [2002] model).

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Item allocation with evidence [Ben-Porath, Dekel, and Lipman, 2019]

- Evidence+competition help elicit info even with no common info.
- E.g., consider an **item allocation problem**:
 - N bidders with private, **verifiable** types θ_i ; designer chooses allocation $x \in \Delta(N)$;
 - bidder i 's utility: $u_i(x, \theta) = x_i \theta_i$;
 - designer's utility: $u_0(x, \theta) = \sum_{i=1}^N x_i \theta_i$ (designer wants to allocate to highest θ_i).

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Item allocation with evidence

- **Without evidence**, we'd have to require payments as a proof of high θ_i .
- **With evidence**, can simply ask a player to show proof of their high θ_i
 \Rightarrow efficient allocation is implementable even without transfers!
- The same is true even if $u_i(x, \theta) = \mathbb{I}\{x_i = 1\}$
 - i.e., if players don't care about their θ_i , only the principal does
 - no single-crossing in this case \Rightarrow transfers wouldn't implement the principal's desired allocation
 - Example: investor only wants to fund projects that are genuinely good, but all entrepreneurs think their projects are genuinely good
- Bottom line:
 - Evidence helps info elicitation
 - Evidence makes commitment power unnecessary

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Evidence: Conclusion

- Evidence helps info elicitation, and may even lead to unraveling of all of players' private info
- Some factors (like direct cost of disclosure or a milder penalty for silence) may hinder disclosure; competition stimulates it.
- The intrinsic incentives to disclose evidence may be strong enough to render commitment useless for the principal/receiver
 - Good news for receiver – can achieve commitment outcome even without any commitment power!

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References I

- V. V. Acharya, P. DeMarzo, and I. Kremer. Endogenous Information Flows and the Clustering of Announcements. *American Economic Review*, 101(7):2955–2979, December 2011. ISSN 0002-8282. doi: 10.1257/aer.101.7.2955.
- M. Battaglini. Multiple Referrals and Multidimensional Cheap Talk. *Econometrica*, 70(4): 1379–1401, July 2002. ISSN 1468-0262. doi: 10.1111/1468-0262.00336.
- E. Ben-Porath, E. Dekel, and B. L. Lipman. Disclosure and Choice. *The Review of Economic Studies*, 85(3):1471–1501, July 2018. ISSN 0034-6527, 1467-937X. doi: 10.1093/restud/rdx064.
- E. Ben-Porath, E. Dekel, and B. L. Lipman. Mechanisms With Evidence: Commitment and Robustness. *Econometrica*, 87(2):529–566, 2019. ISSN 0012-9682. doi: 10.3982/ECTA14991.

References II

- E. Dekel. On Evidence in Games and Mechanism Design, 2016. Econometric Society Presidential Address.
- D. Dranove and G. Z. Jin. Quality Disclosure and Certification: Theory and Practice. *Journal of Economic Literature*, 48(4):935–963, 2010. ISSN 0022-0515. doi: 10.2307/29779704.
- R. A. Dye. Disclosure of nonproprietary information. *Journal of accounting research*, pages 123–145, 1985.
- E. Eyster and M. Rabin. Cursed Equilibrium. *Econometrica*, 73(5):1623–1672, September 2005. ISSN 0012-9682, 1468-0262. doi: 10.1111/j.1468-0262.2005.00631.x.
- S. J. Grossman. The informational role of warranties and private disclosure about product quality. *The Journal of Law and Economics*, 24(3):461–483, 1981.

References III

- S. Hart, I. Kremer, and M. Perry. Evidence Games: Truth and Commitment. *American Economic Review*, 107(3):690–713, March 2017. ISSN 0002-8282. doi: 10.1257/aer.20150913.
- G. Z. Jin, M. Luca, and D. Martin. Is No News (Perceived As) Bad News? An Experimental Investigation of Information Disclosure. *American Economic Journal: Microeconomics*, 13(2):141–173, May 2021. ISSN 1945-7669. doi: 10.1257/mic.20180217.
- W.-O. Jung and Y. K. Kwon. Disclosure When the Market Is Unsure of Information Endowment of Managers. *Journal of Accounting Research*, 26(1):146, 1988. ISSN 00218456. doi: 10.2307/2491118.
- P. Milgrom and J. Roberts. Relying on the Information of Interested Parties. *The RAND Journal of Economics*, 17(1):18–32, 1986. ISSN 0741-6261. doi: 10.2307/2555625.

References IV

- P. R. Milgrom. Good news and bad news: Representation theorems and applications. *The Bell Journal of Economics*, pages 380–391, 1981.
- H. S. Shin. Disclosures and asset returns. *Econometrica*, 71(1):105–133, 2003.
- A. Smirnov and E. Starkov. Bad News Turned Good: Reversal under Censorship. *American Economic Journal: Microeconomics*, 14(2):506–560, May 2022. ISSN 1945-7669. doi: 10.1257/mic.20190379.
- R. E. Verrecchia. Discretionary disclosure. *Journal of Accounting and Economics*, 5:179–194, January 1983. ISSN 0165-4101. doi: 10.1016/0165-4101(83)90011-3.