

# 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  $\theta$ .
- 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  $\theta$  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  $\Theta$  that include  $\theta$ . I.e.,  $\theta$  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  $\theta$  (except for maybe the lowest one) present evidence, so there is full learning.*

- Argument for finite  $\Theta$ :
- Suppose statement is not true: there is a set of types  $\Theta_S$  that stay silent (do not disclose).
- Then the firm's payoff when hiding evidence is  $\mathbb{E}[\theta|\phi_0, \Theta_S]$ , where  $\phi_0$  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  $\theta$  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  $\theta$  – so all types  $\theta$  have the exact same reporting incentives!
- The result works for interval  $\Theta$  too, though the argument is slightly more subtle.
- We will now look at a couple of variations where unraveling **breaks**.

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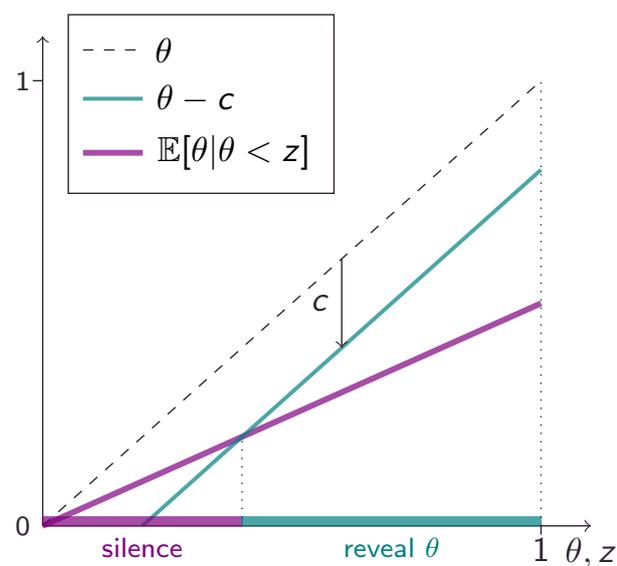
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## Costs of disclosure [Verrecchia, 1983]

- 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  $\Theta_S$  silent. Payoff from silence is  $\mathbb{E}[\theta \mid \theta \in \Theta_S]$ , indep of  $\theta$ ; from disclosure is  $\theta - c$ , incr in  $\theta \Rightarrow$  high  $\theta$  disclose, low  $\theta$  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  $\Theta_S$  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  $\theta$  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  $\theta$  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  $\theta$  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  $\theta$ :
- 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  $\theta$ .  
 $\Rightarrow \mathbb{E}u_R = 0.2$ .
  - **With commitment**, receiver can commit to  $x(\emptyset) = 1 \Rightarrow$  sender reveals  $\theta$  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  $\theta$  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  $\theta$  iff  $\theta > \pi\mathbb{E}[\theta] + (1 - \pi)\mathbb{E}[\theta | \text{silence}]$ .
- Similarly, the competitor wants to reveal  $\theta$  iff  $\theta < \pi\mathbb{E}[\theta] + (1 - \pi)\mathbb{E}[\theta | \text{silence}]$ .
- Regardless of  $\theta$ , one of them wants to reveal  $\Rightarrow$  someone always reveals  $\theta$   
 $\Rightarrow$  **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  $\theta_i$ ; 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  $\theta_i$ ).

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## Item allocation with evidence

- **Without evidence**, we'd have to require payments as a proof of high  $\theta_i$ .
- **With evidence**, can simply ask a player to show proof of their high  $\theta_i$   
⇒ 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  $\theta_i$ , only the principal does
  - no single-crossing in this case ⇒ 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.