Mediation Design

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The Roundup Example

- In April of 2019, U.S. District Court Judge Vince Chhabria appointed Ken Feinberg to facilitate a settlement between Bayer and over 13,000 plaintiffs who had alleged that the weed killer Roundup causes non-Hodgkin's lymphoma due to its active ingredient, glyphosate.
- Feinberg is an expert mediator who had previously mediated many disputes, including settlement of the 9/11 victims fund and BP Deepwater Horizon disaster.
- Unlike in arbitration, mediators are not allowed to impose a judgment on the parties.

The Mediator as a Facilitator and an Expert

- Mediator's role according to the legal literature:
  - facilitative – helping the parties to agree, or
  - evaluative – providing parties with a "reality check" about the merits of the case
- The mediator often engages in shuttle diplomacy
  - meets with each side in a private caucus
  - provides some information and collects information which may be transmitted to the other side
- The mediator can propose a settlement price or a settlement range
- Parties must agree to the resolution proposed by the mediator
  - unlike an arbitration panel or a judge, the mediator is not empowered to render a judgment

This Paper

- We study a mediation design model in which agents do not have full information about their values for a transaction
- A mediator - aiming to maximize the gains from trade - controls the information flow to parties (subject to Privacy constraint: each agent only receives information about her private value) and proposes a trading price
- Reality Checks: Static Mediation (i.e., Information Disclosure and Trading) Mechanisms
- Shuttle Diplomacy: Dynamic Mediation Mechanisms
- Add information design to standard mechanism design

Results

- Characterize mechanism that maximizes ex ante gains from trade:
  - optimal to provide incomplete information
  - with shuttle diplomacy, conditioning info releases and prices posted on past feedbacks from parties allows to attain ex post efficient outcome

Mediation Models in Law and Economics

- Models in law and economics (e.g. Brown and Ayres, 1994; Doornik, 2014):
  - rely on asymmetric information to explain the role of mediation
  - assume parties have full information about their values
  - cannot explain the "reality check" function of the mediator
  - cannot explain the role of "shuttle diplomacy"
- If the parties know their own private information, why do they need a "reality check" from the mediator?
- Like shuttle diplomacy, reality checks are pretty common; we ask someone else's opinion
- We show how these features allow to minimize efficiency losses associated with dispute resolution

Information Design Literature

- Bayesian persuasion - Kamenica and Gentzkov (2011), ...approach as summarized by Bergemann and Morris (2017): the “information designer ... can commit to providing information about the state..., but has no ability to change the mechanism”
- Mechanism design with exogenous information: Myerson Satterthwaite (1983), ...
- Auctions - single item seller chooses disclosure policy and trading mechanism
    - Bergemann and Pesendorfer (2007), Esö and Szentes (2007), Li and Shi (2017), Krahmer (2018)
- Roesler and Szentes (2017), Condorelli and Szentes (2018)

Environment

- The buyer's value is $v^B \in [0,1]$
- The seller's value is $v^S \in [0,1]$
- $F_0(v) = \Pr_0(v^B \leq v)$ and $G_0(v) = \Pr_0(v^S \leq v)$: - atomless - distributions from which values are (independently) drawn.

Initial information of buyer and seller:

$$v_0^B = \int_0^1 v dF_0(v)$$

and

$$v_0^S = \int_0^1 v dG_0(v)$$

- Agents use a mediator to determine whether buyer's and seller's value are such that trade should occur and at what price.

Reality Checks: Static Mediation Mechanisms

- The mediator simultaneously chooses price p and distribution of signals to buyer and seller F and G, so as to maximize the gains from trade.

- Each party receives a private signal - only - about her value.
- No restrictions on signals: the feasible (induced) distributions of posterior values, $\mathcal{F}$ and $\mathcal{G}$, are all the distributions consistent with prior distribution.
- Mediator does not observe signal realizations.
- The mediator's problem is:

$$\max_{p\in[0,1],\, F\in\mathcal{F},\, G\in\mathcal{G}} \int_p^1 \int_0^p (v^B - v^S)\, dG(v^S)\, dF(v^B)$$

Feasible Distributions

- For the buyer:
  - Acquiring no information corresponds to the signal (posterior) distributions that puts an atom of mass one on v_0^B
  - Full information acquisition (i.e., discovering the item's value) corresponds to the signal distribution $F_0(v)$

- For the seller:
  - Acquiring no information corresponds to the signal distributions that puts an atom of mass one on v_0^S
  - Full information acquisition (i.e., discovering the item's value) corresponds to the signal distribution $G_0(v)$

- Feasible distributions: F, G that are mean preserving spreads of the distributions with unit mass on v_0^B, v_0^S and such that F_0, G_0 are mean preserving spreads of them.

The Optimal Static Mechanism

Proposition 1

Under the static mediation mechanism that maximizes the gains from trade, the buyer observes whether her value is strictly below or at least as high as x and the seller observes whether her cost is strictly above or at least as low as y, with x, y such that:

$$\mathbb{E}_{G_0}\left[v^S \mid v^S \leq y\right] = x \quad \textit{and}$$
$$\mathbb{E}_{F_0}\left[v^B \mid v^B \geq x\right] = y$$

The trading price is any price $p \in [x, y]$.

- A solution always exists and $x < y$.

Static Mediation Mechanisms: Insights

- Full information is not optimal, as it does not generate enough trade:
  - trade if $v^B \geq p \geq v^S$ (all trades are efficient)
  - efficient trades lost: (i) $p > v^B > v^S$, (ii) $v^B > v^S > p$
  - most valuable trades that are lost:

    (a) $v^B = p - \varepsilon_B$ and $v^S = \varepsilon_S$;

    (b) $v^B = 1 - \varepsilon_B$ and $v^S = p + \varepsilon_S$, for $\varepsilon_B, \varepsilon_S$ small.

- At the optimal static mediation mechanism:
  - since $x < y$ trades in (a) and (b) can be completed
  - but some inefficient trades are made: (c) $v^S = y - \varepsilon_S > v^B = x + \varepsilon_B$

The Uniform Case

- Prior distributions of values F_0 and G_0 are uniform
- The solution is: $x = 1/3$ and $y = 2/3$.
  - buyer observes whether her value is above or below $1/3$;
  - seller observes whether her value is above or below $2/3$
  - any price $p \in [1/3, 2/3]$ is a solution
- Welfare (expected realized gains from trade): $\left(\frac{2}{3} - \frac{1}{3}\right) \frac{2}{3} \frac{2}{3} = \frac{4}{27}$ or 89% of the first best level $\frac{1}{6}$
  - higher than welfare in the optimal Bayesian mechanism when traders are fully informed ($\frac{9}{64}$ or 84% of the first best level,), in which case trade occurs iff $v^B \geq v^S + 1/4$.

Shuttle Diplomacy: Dynamic Mediation Mechanisms

- The mediator allows private information discovery to take place slowly over time, alternating between rounds of discoveries for the buyer and for the seller, with associated posted prices.
- The buyer starts by discovering whether her value is the lowest possible and chooses then whether to attempt trade at a correspondingly low posted price. His choice determines information released to seller.
- As time goes by, the buyer discovers whether her value is higher and higher and faces correspondingly higher and higher posted prices.
- Similarly, the seller starts by discovering whether her value is the highest possible and, as time passes, she discovers whether her value is lower and lower and decides whether to attempt trade at progressively lower and lower posted prices.

  – Will show a dynamic mechanism of this kind allows mediator to implement ex post efficient outcome.

The Shuttle Diplomacy Mechanism: Step 0

The mediator selects:

- Final buyer and seller value v^* and posted price p_F, with:

$$\mathbb{E}_{G_0}\left[v^S | v^S \leq v^*\right] \leq p_F \leq \mathbb{E}_{F_0}\left[v^B | v^B \geq v^*\right]. \tag{1}$$

- Two collections of value discovery intervals, $\left\{I_t^S = \left[\alpha_t^S, \alpha_{t-\Delta}^S\right]\right\}_{t=\Delta}^1$ for the seller, with $\alpha_0^S = 1, \alpha_1^S = v^*$, and $\left\{I_t^B = \left[\alpha_{t-\Delta}^B, \alpha_t^B\right]\right\}_{t=\Delta}^1$ for the buyer, with $\alpha_0^B = 0, \alpha_1^B = v^*$, with $t = \Delta, 2\Delta, .., 1$
- Two continuously differentiable price functions $p^S : [v^*, 1] \to \mathbb{R}_+$, and $p^B : [0, v^*] \to \mathbb{R}_+$

Shuttle Stage: Discovery Period t

Step 1

The seller:

- discovers whether her value is in I_t^S; i.e., whether it is

$$v_t^S = \mathbb{E}_{G_0}\left[v^S | v^S \in I_t^S\right];$$

- selects whether to *Stop* or *Continue*;
  - If the choice is *Stop*, then go to Final Stage;
  - If the choice is *Continue*, then go to Step 2.

Shuttle Stage: Discovery Period t

Step 2

The buyer:

- discovers whether her value is in I_t^B; i.e., whether it is

$$v_t^B = \mathbb{E}_{F_0}\left[v^B | v^B \in I_t^B\right];$$

- selects whether to *Stop* or *Continue*;
  - If the choice is *Stop*, then go to Final Stage;
  - If the choice is *Continue*, then go to:
    - period $t + \Delta$ if $t < 1$;
    - the Final Stage if $t = 1$.

Final Stage

1. If $t \leq 1$ and the seller has decided to *Stop* at t, then:
   - buyer observes if her value is or is not above v_t^S;
   - price $p^S(v_t^S)$ is posted s.t.

$$v_t^S \leq p^S\left(v_t^S\right) \leq \mathbb{E}_{F_0}\left[v^B | v^B \geq v_t^S\right]$$

   - buyer and seller decide whether they want to trade at $p^S(v_t^S)$.

2. If $t \leq 1$ and the buyer has decided to *Stop* at t, then:
   - seller observes if her value is or is not above v_t^B;
   - price $p^B(v_t^B)$ is posted s.t.

$$\mathbb{E}_{G_0}\left[v^S | v^S \leq v_t^B\right] \leq p^B\left(v_t^B\right) \leq v_t^B$$

   - buyer and seller decide whether they want to trade at $p^B(v_t^B)$.

3. If at $t = 1$ neither the buyer nor the seller selected *Stop*, price p_F is posted and buyer and seller decide whether they want to trade at p_F.

Stopping-at-value-strategy PBE

- Will show that a value v^* and a discovery process for the buyer and the seller (given by $\left(I_t^S, I_t^B\right)_t$), together with the associated price functions $p^B(v)$ and $p^S(v)$, can be chosen so that it is a perfect Bayesian equilibrium for traders to adopt a:

  Stopping-at-Value Strategy:
  always *Stop* after having discovered own value; always *Continue* after not having discovered the value; always accept to trade at a price that yields a non-negative payoff.

- In the limit, as $\Delta \to 0$, the allocation obtained is then ex post efficient.

IC

- To guarantee that both players adopting stopping-at-value strategies is a PBE of the shuttle-diplomacy mechanism,
    - to ensure IC in the last period of the shuttle stage at $t = 1$:

$$p^B(v^*) = p_F = v^* = p^S(v^*) \tag{2}$$

    - four incentive compatibility conditions, two for each agent, must be satisfied by prices and discovery speed to ensure IC at intermediate dates.

Buyer's Incentives 1

Assume the seller adopts a stopping-at-value strategy.

Case 1: The buyer has just discovered that her value is v_t^B.

- If she decides to stop, her expected payoff is:

$$\left[v_t^B - p^B\left(v_t^B\right)\right]\frac{G_0\left(v_t^B\right)}{G_0\left(v_t^S\right)}$$

- If buyer continues, may obtain a positive payoff only in the event that she is the trader stopping the shuttle stage at a later stage.
- The buyer's payoff from continuing at t and stopping in the next period, when the disclosed value is $v_{t+\Delta}^B$, is:

$$\left[v_t^B - p^B\left(v_{t+\Delta}^B\right)\right]\frac{G_0\left(v_{t+\Delta}^B\right)}{G_0\left(v_t^S\right)},$$

Buyer's Incentives 1, continued

- Thus, the following inequality must hold for all $t < 1$:

$$\left[v_t^B - p^B\left(v_t^B\right)\right] G_0\left(v_t^B\right) \geq \left[v_t^B - p^B\left(v_{t+\Delta}^B\right)\right] G_0\left(v_{t+\Delta}^B\right).$$

- Taking limits as $\Delta \to 0$, we obtain the following constraint for all $v_t^B \in [0, v^*]$:

$$\frac{dv_t^B}{dt}\left[\frac{d\left(p^B\left(v_t^B\right) G_0\left(v_t^B\right)\right)}{dv_t^B} - v_t^B g_0\left(v_t^B\right)\right] \geq 0. \qquad (3)$$

  - This says that after a buyer discovers her true value, her loss from continuing one period due to a price increase outweighs the gain due to an increase in the probability of trading.
  - (3) also implies that the buyer's price $p^B\left(v_t^B\right)$ weakly increases over time.

Buyer's Incentives 2

Case 2: At the end of period t the buyer has not yet discovered her value.

- Buyer's payoff from stopping the shuttle stage at t:

$$\left(\mathbb{E}_{F_0}\left[v^B | v^B \geq v_t^B\right] - p^B\left(v_t^B\right)\right) G_0\left(v_t^B\right)\left(1 - F_0\left(v_t^B\right)\right)$$

- Buyer's payoff from the stopping-at-value strategy:
  - in the event she is the one to stop before $t = 1$,

$$\int_{v_t^B}^{v^*}\left(v^B - p^B\left(v^B\right)\right) G_0(\left(v^B\right) f_0(\left(v^B\right) dv^B$$

  - if trading at $p_F = v^*$ with her value above and the seller's below v^*,

$$\left(\mathbb{E}_{F_0}\left[v^B \mid v^B \geq v^*\right] - v^*\right)\left(1 - F_0\left(v^*\right)\right) G_0\left(v^*\right)$$

  - in the event the seller is the one to stop before $t = 1$,

$$\int_{v^*}^{v_t^S}\left(\mathbb{E}_{F_0}\left[v^B \mid v^B \geq v^S\right] - p^S\left(v^S\right)\right)\left(1 - F_0\left(v^S\right)\right) g_0\left(v^S\right) dv^S$$

Buyer's Incentives 2, continued

- Hence, the buyer prefers to continue, following the stopping-at-value strategy, rather than stopping the shuttle stage, if and only if

$$\begin{aligned}
&\left(\mathbb{E}_{F_0}\left[v^B | v^B \geq v_t^B\right] - p^B\left(v_t^B\right)\right) G_0\left(v_t^B\right)\left(1 - F_0\left(v_t^B\right)\right) \\
&\leq \quad \int_{v_t^B}^{v^*}\left(v^B - p^B\left(v^B\right)\right) G_0(\left(v^B\right) f_0(\left(v^B\right) dv^B \\
&\quad + \left(\mathbb{E}_{F_0}\left[v^B \mid v^B \geq v^*\right] - v^*\right)\left(1 - F_0\left(v^*\right)\right) G_0\left(v^*\right) \qquad (6) \\
&\quad + \int_{v^*}^{v_t^S}\left(\mathbb{E}_{F_0}\left[v^B \mid v^B \geq v^S\right] - p^S\left(v^S\right)\right)\left(1 - F_0\left(v^S\right)\right) g_0\left(v^S\right)
\end{aligned}$$

- Similar constraints hold for the seller

Efficiency of the Shuttle Diplomacy Procedure

Proposition 2

There are continuously differentiable price functions $p^B(v)$ *and* $p^S(v)$, *speeds of learning and a buyer and seller value* v^*, *with* $p^B(v^*)$, $p^S(v^*) = p_F = v^*$, *for which the shuttle diplomacy mechanism has a stopping-at-value-strategy PBE.*
The resulting trading outcome is ex post efficient.

Shuttle Diplomacy Insight

- The shuttle-diplomacy mechanism, by letting agents discover their values and report the discovered information over time, allows mediator to:

  (i) find out whether or not trade is optimal,

  (ii) providing minimal information to parties. After one trader learns her value and decides to stop, the other trader can be given the minimum information needed to implement ex post efficient trading;

  (iii) set a price at which trade occurs if and only if trade is optimal;

- The report sent by an agent (decision to stop or not) affects both terms of trade and information provided to other party. This, and correlation of agents' information, relaxes incentives.

The Uniform Case

- Consider again case where buyer and seller's value distributions F_0 and G_0 are uniform.
- Take $v^* = \frac{1}{2}$ as the stopping value and price, with equal sized discovery intervals, so that for all t, $v_t^S = 1 - v_t^B$
- Consider price functions linked as follows:

$$p^S\left(v_t^S\right) = 1 - p^B\left(v_t^B\right)$$

- Then the incentive constraints of buyer and seller are identical.

The Uniform Case, continued

- Constraints on buyer's price function reduce to:

$$\frac{v}{2} \leq p^B(v) \leq v,\ p_B(1/2) = 1/2 \tag{5}$$

- The first incentive constraint of the buyer, (3), reduces to:

$$\frac{d\left(p^B(v)\,v\right)}{dv} \geq v. \tag{6}$$

- The second incentive constraint of the buyer, (4), reduces to:

$$p^B(v)v(1-v) \geq \frac{v}{2} - \frac{v^3}{3} - \frac{1}{12} \tag{7}$$

- For stopping-at-value to be a symmetric PBE strategy, the price function $p^B(v)$ must satisfy constraints (5), (6) and (7).

Solutions for the price functions

1. The price function
$$p_H^B(v) = v$$
is a solution (all surplus goes to agent not making the discovery).

2. Another solution is
$$p_L^B(v) = \begin{cases} \frac{v}{2} & \text{for} \quad v \in [0, \widehat{v}] \\ \frac{6v-4v^3-1}{12v(1-v)} & \text{for} \quad v \in [\widehat{v}, 0.5] \end{cases}$$
giving now maximal surplus to agent making the discovery. (price function $p^B(v) = \frac{v}{2}$ giving all surplus to this agent violates IC (7) for $v \geq \frac{1}{2}$).

- Any convex combination defined by:
$$p(v) = \lambda p_H^B(v) + (1-\lambda) p_L^B(v), \tag{8}$$
with $\lambda \in [0, 1]$ is also a solution.

A Continuum of Symmetric PBE

Proposition 3

Under the shuttle-diplomacy mechanism with uniform prior distributions $F_0(v) = G_0(v) = v$, *with buyer and seller discovering their values at the same speed and* $p_F = v^* = \frac{1}{2}$, *there exist a continuum of functions* $p\left(v^B\right) : \left[0, \frac{1}{2}\right] \rightarrow \left[0, \frac{1}{2}\right]$ *such that, if the price functions are* $p^B\left(v^B\right) = p(v^B)$ *and* $p^S\left(v^S\right) = 1 - p\left(1 - v^S\right)$, *then it is a perfect Bayesian equilibrium for agents to adopt stopping-at-value strategies.*

The Uniform Case, continued

- The shuttle-diplomacy mechanisms we constructed are ex-ante symmetric.
- They also guarantee equal split ex-post of the expected gains from trade when the buyer's value is above and the seller's cost is below $v^* = \frac{1}{2}$.
- In the other situations a completely equal ex post split of the gains from trade is not possible, as it would require $p^B(v) = \frac{3}{4}v$, which violates IC for v close to $\frac{1}{2}$.

Single-Ride Shuttle Diplomacy

- One sure way to obtain ex post efficiency is to provide information only to one party, say the seller:
- after the seller stops the discovery stage, thus revealing her value, the buyer observes whether her value is above or below the value reported by the seller.
- The seller then obtains all gains from trade.

Conclusions

- Classical Mechanism Design: Agents have full private information, the allocation (or social choice) rule must be decided
- Information Design (e.g., Bayesian Persuasion): The allocation mechanism is fixed, information given to agent must be chosen
- Mediation Design: Both the allocation and the information given to agents are chosen by the mediator.

Conclusions, continued

- General insights:
  - Some obfuscation (imperfect information) is optimal as it induces more trade.
  - With static procedures, optimal obfuscation generates additional trades (some efficient and other inefficient), with the former being more valuable than the latter.
  - There are efficiency gains in using sequential or dynamic information disclosure procedures, as information disclosure and trading price can be conditioned on past disclosures
- Information disclosure and mechanism design approach applicable to other problems.