(In)Effectiveness of Signal Jamming in Regime-Change Games

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Motivation

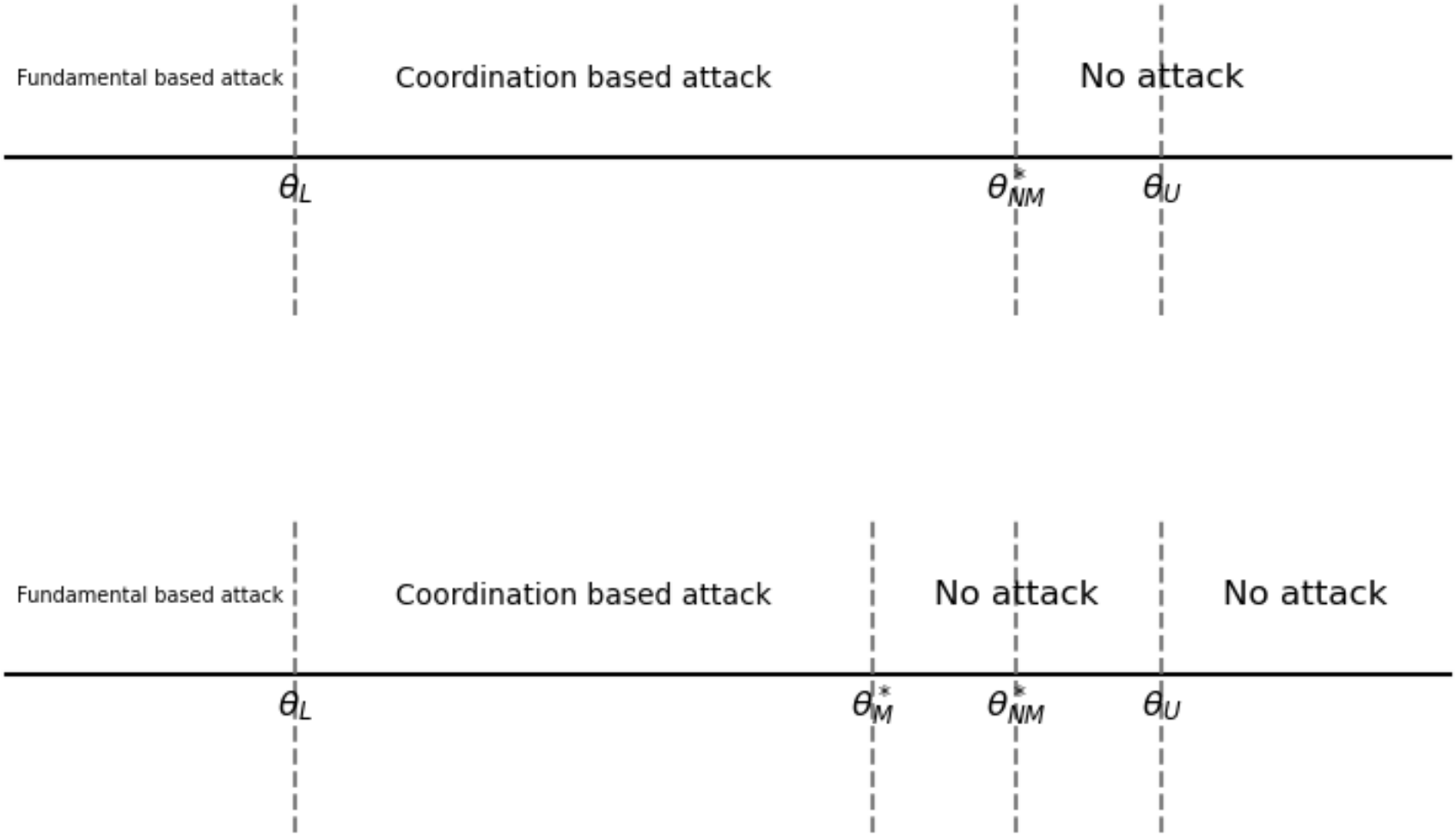
- Info manipulation is universal
- Manipulation/Accounting Reporting Choices by/of banks:
  - Wells Fargo's fake accounts scandal
  - Deutsche Bank's hiding of losses
  - "Window dressing" or "selective reporting"
- Change of valuation methods by central banks
- Autocratic Regimes' use of propaganda
- **This paper**: (In)effectiveness of signal jamming

Main Question

- Global Games separate an attack against a regime to:
  - Fundamental based attack
  - Panic or coordination based attack
- Signal-Jamming: regime can manipulate information at cost, agents do not observe regime's manipulation

Does the ability of the regime to jam signals improve the chances of survival, or, in other words, does it reduce coordination based attacks?

Main Question



Preview of Results

- Signal jamming may be ineffective despite regime being perfectly informed
- Key primitive: marginal cost of manipulation at zero (fixed cost)
- Ineffective when cost of attacking low
- Effective when cost of attacking intermediate
- Form of manipulation (pooling vs separation) does not matter

Plan

- Model
- Preliminary Analysis
- Equilibrium w/ Linear Manipulation Cost
- Equilibrium w/ Convex Manipulation Cost
- (In)Effectiveness in the Limit
- Conclusions

Model

Model

- Players
  - Continuum of agents, $i \in [0, 1]$
  - Regime
- State
  - Regime's type (fundamentals)
  - $\theta \sim$ improper prior
- Information
  - Agent i: $x_i = r + \varepsilon_i / \sqrt{\alpha}$
    - $r = \theta + m$: "report" sent by regime
    - $\varepsilon_i \sim_{IID} F$ w/ density f, which is symmetric about 0, log-concave, differentiable, strictly increasing on $(-\infty, 0)$

Model

- Choices
  - Agents:
    - Two actions:
      - Attack the status quo: $a_i = 1$
      - Refrain from attacking: $a_i = 0$
    - Aggregate action: $A = \int_{[0,1]} a_i \mathrm{d}i$
  - Regime:
    - Choose a report $r = \theta + m$
    - $m \geq 0$: signal jamming

Model

- Regime's payoff:

$$V(m;\theta,A)=\begin{cases} R(\theta,A)-C(m) & \text{if } R(\theta,A)\geq 0 \\ -C(m) & \text{if } R(\theta,A)<0 \end{cases}$$

  - $R(\theta,A)=g(\theta)-A$: regime outcome function
    - $g(\theta)$: continuous, strictly increasing; $\exists \underline{\theta}<\overline{\theta}$: $g(\underline{\theta})=0$, $g(\overline{\theta})=1$
    - Status quo abandoned (regime change occurs) iff $R(\theta,A)<0$
  - $C(m)$: cost of manipulating info
    - $C'(m)>0$, $C''(m)\geq 0$
    - $C'(0)=k>0$

Model

- Agents' payoff:

$$u(\theta, A) = \begin{cases} Z(\theta) - t & \text{if } R(\theta, A) < 0 \\ -t & \text{if } R(\theta, A) \geq 0 \end{cases}$$

  - $t > 0$: cost of attacking
  - $Z(\theta) > t$: continuous
- Solution concept:
  - Perfect Bayesian equilibrium (PBE)

Examples

- Rochet and Vives (2004) bank run model
- Morris and Shin (1999) currency attack model
- Edmond (2013) revolution model

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Preliminary Analysis

Equilibrium w/o signal jamming

Proposition

Unique equilibrium is characterized by two thresholds θ^*_{NM} and x^*_{NM}:

(i) Regime change occurs iff $\theta < \theta^*_{\text{NM}}$;

(ii) An agent attacks iff $x_i < x^*_{\text{NM}}$.

Subscript "NM": no manipulation

Equilibrium w/ signal jamming

Proposition

Unique equilibrium is characterized by two thresholds θ^*_{M} and x^*_{M}:

(i) Regime change occurs iff $\theta < \theta^*_{\mathrm{M}}$;

(ii) An agent attacks iff $x_i < x^*_{\mathrm{M}}$.

Our definition

Definition

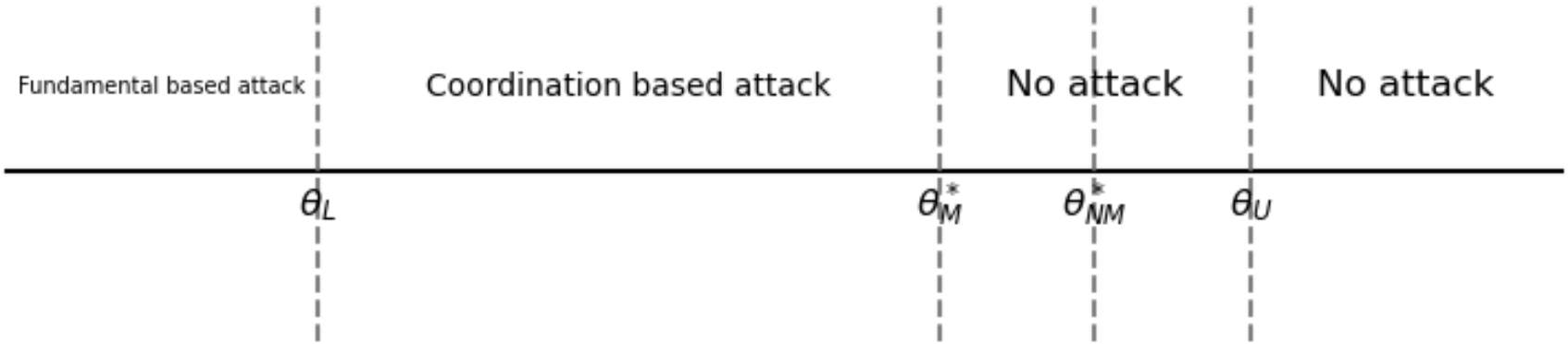
Suppose the regime jams agents' signals in equilibrium, then:

(i) Signal jamming is *effective* if $\theta^*_{\mathrm{M}} < \theta^*_{\mathrm{NM}}$;

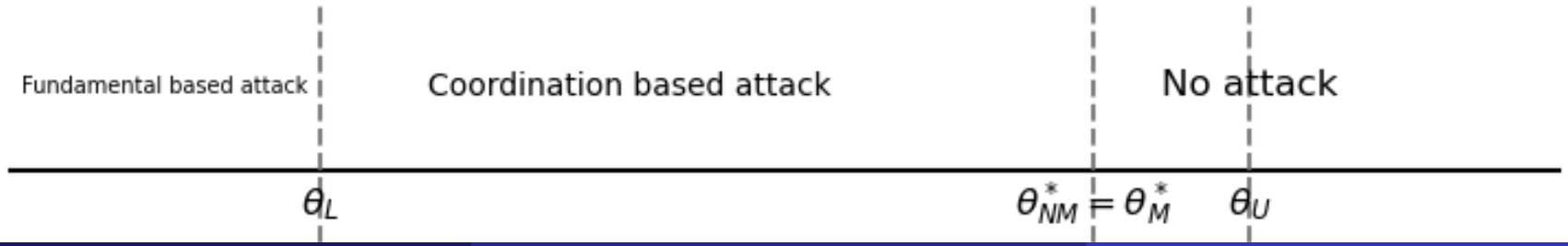
(ii) Signal jamming is *ineffective* if $\theta^*_{\mathrm{M}} = \theta^*_{\mathrm{NM}}$.

Our definition

Effective: Enabling more regime types to survive



Ineffective: Same regimes survive



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Equilibrium w/ Linear Manipulation Cost

Regime's problem

- $C(m) = k \cdot m$
- Suppose all agents follow x^*_{M}
- Aggregate attack: $A(m;\theta) = F[\sqrt{\alpha}(x^*_{\mathrm{M}} - \theta - m)]$
- Regime θ's signal jamming policy:

$$m(\theta) \in \arg\max_{m \geq 0} V(m;\theta, A(m;\theta))$$

where

$$V(m;\theta, A(m;\theta)) = \begin{cases} \underbrace{R(\theta, A(m;\theta)) - C(m)}_{=\tilde{V}(m;\theta):\ \textit{manipulation payoff}} & \text{if } R(\theta, A(m;\theta)) \geq 0 \\ -C(m) & \text{if } R(\theta, A(m;\theta)) < 0 \end{cases}$$

Regime's problem

- No incentive to jam signals iff $\tilde{V}(\tilde{m}(\theta);\theta) < 0$, where

$$\tilde{m}(\theta) \in \arg\max_{m \geq 0} \tilde{V}(m;\theta)$$

- Equivalently,

$$\tilde{r}(\theta) = \tilde{m}(\theta) + \theta \in \arg\max_{r \geq \theta} \tilde{V}(r - \theta;\theta)$$

- FOC of relaxed problem (assuming $\alpha > (k/f(0))^2$):

$$\underbrace{\sqrt{\alpha} f[\sqrt{\alpha}(r - x_{\mathrm{M}}^*)]}_{\text{marginal benefit}} = k \quad \Longrightarrow \quad r = x_{\mathrm{M}}^* + \overline{\rho}$$

Regime's problem

Lemma (partial pooling)

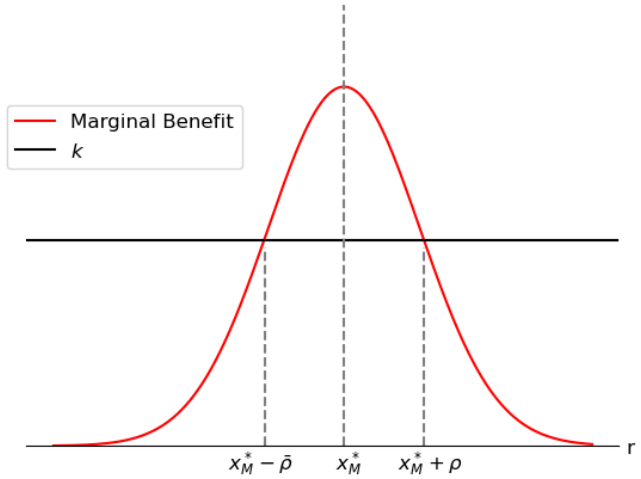
There exists $\overline{\rho} > 0$ such that

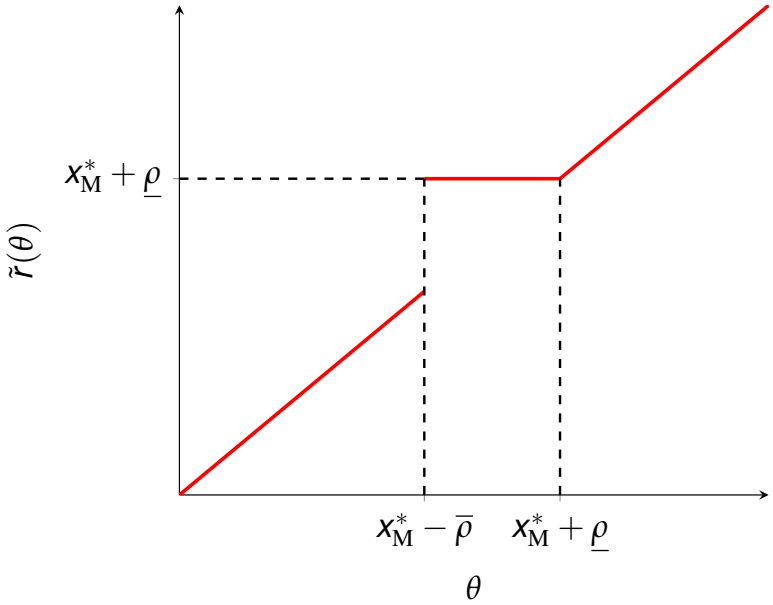
$$\tilde{r}(\theta) = \begin{cases} \theta & \text{if } \theta \notin [x_M^* - \overline{\rho}, x_M^* + \underline{\rho}] \\ x_M^* + \underline{\rho} & \text{if } \theta \in [x_M^* - \overline{\rho}, x_M^* + \underline{\rho}] \end{cases},$$

where $\overline{\rho} > \underline{\rho}$ and solving

$$F(\sqrt{\alpha}\overline{\rho}) - k\overline{\rho} = F(-\sqrt{\alpha}\underline{\rho}) + k\underline{\rho}$$

Regime's problem





Equilibirum

- Agents attack if and only if expected payoff greater than cost
- Regime abandons status quo if and only if $g(\theta) < A$

Equilibrium pinned down by

$$g(\theta_M^*) = F(\sqrt{\alpha}(x_M^* - \theta_M^*))$$

$$\mathbb{E}_{\theta \sim \Psi(\cdot; x_i, m(\cdot))}[\mathbb{1}(\theta < \theta_M^*) Z(\theta)] = t$$

where

$$\Psi(\theta; x_i, m(\cdot)) = \frac{\int_{-\infty}^{\theta} \sqrt{\alpha} f[\sqrt{\alpha}(x_i - \eta - m(\eta))] \mathrm{d}\eta}{\int_{-\infty}^{\infty} \sqrt{\alpha} f[\sqrt{\alpha}(x_i - \eta - m(\eta))] \mathrm{d}\eta}$$

is the agents' posterior CDF about θ

Effectiveness of signal jamming

Proposition

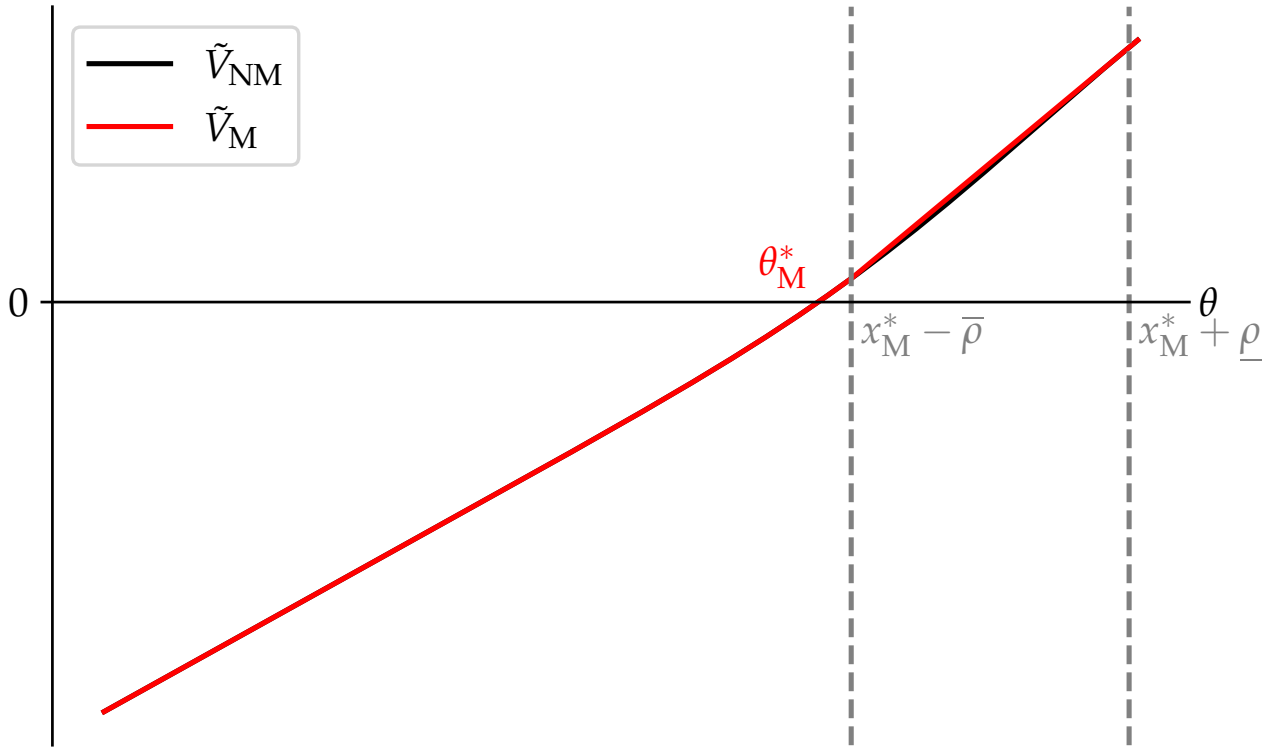
There exist $\underline{t} < \bar{t}$ such that:

(i) If $t < \underline{t}$, signal jamming is ineffective;

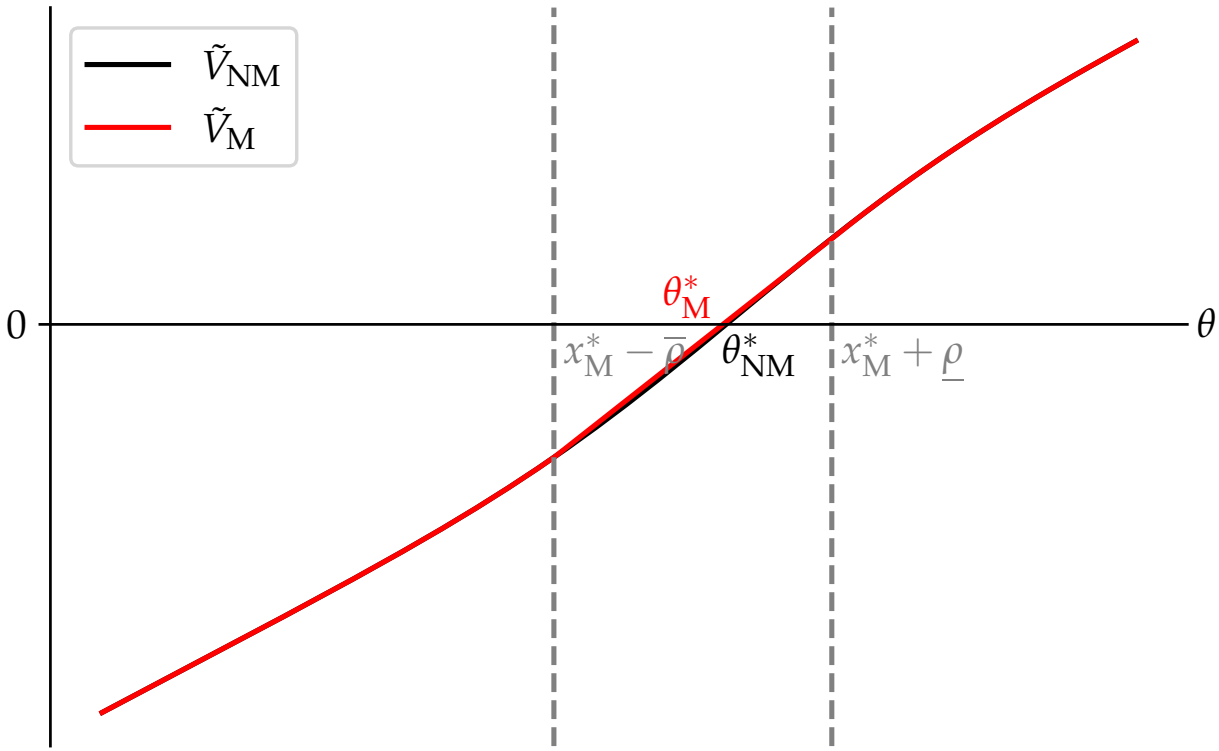
(ii) If $\underline{t} \leq t \leq \bar{t}$, signal jamming is effective;

(iii) If $t > \bar{t}$, the regime does not engage in signal jamming

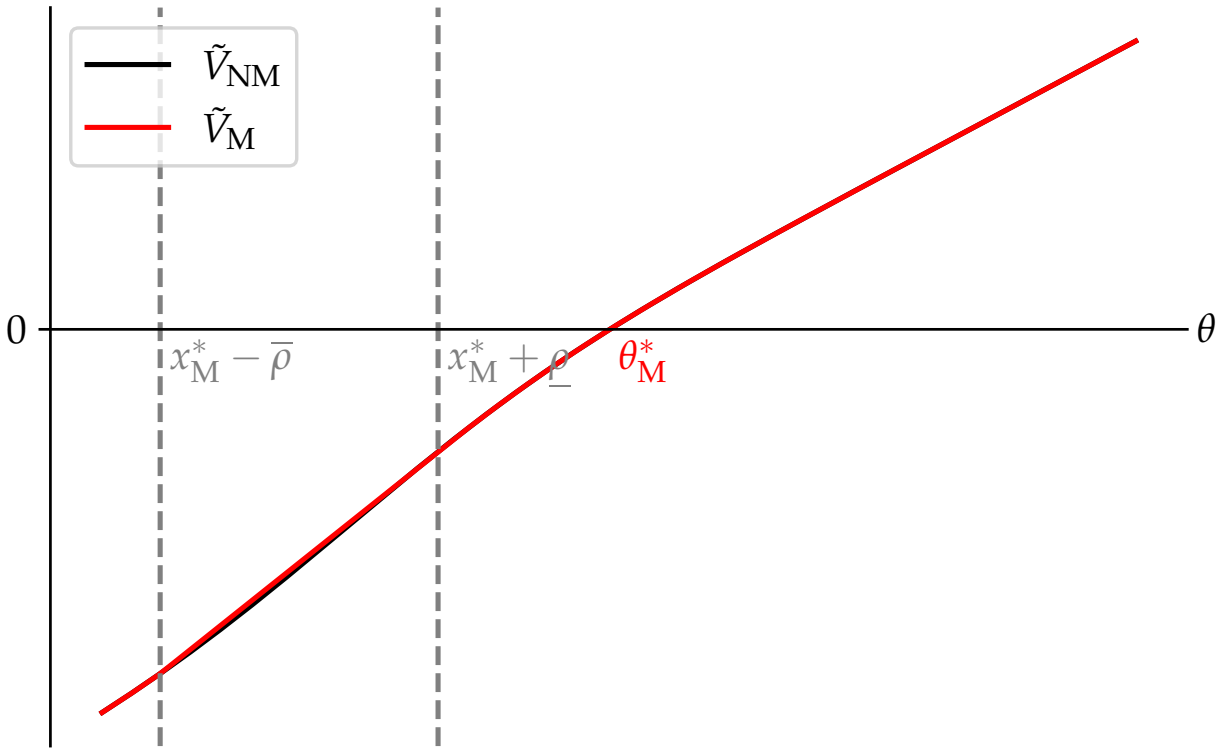
Ineffective signal jamming



Effective signal jamming



No signal jamming



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Equilibrium w/ Convex Manipulation Cost

Regime's problem

Assumption: $C''(m) > \alpha \max f'$

Lemma (fully separating)

$$\tilde{r}(\theta) = \begin{cases} \theta & \text{if } \theta \notin (x_M^* - \underline{\rho}, x_M^* + \underline{\rho}) \\ \text{sol'n to FOC} & \text{if } \theta \in (x_M^* - \underline{\rho}, x_M^* + \underline{\rho}) \end{cases}$$

Regime's problem

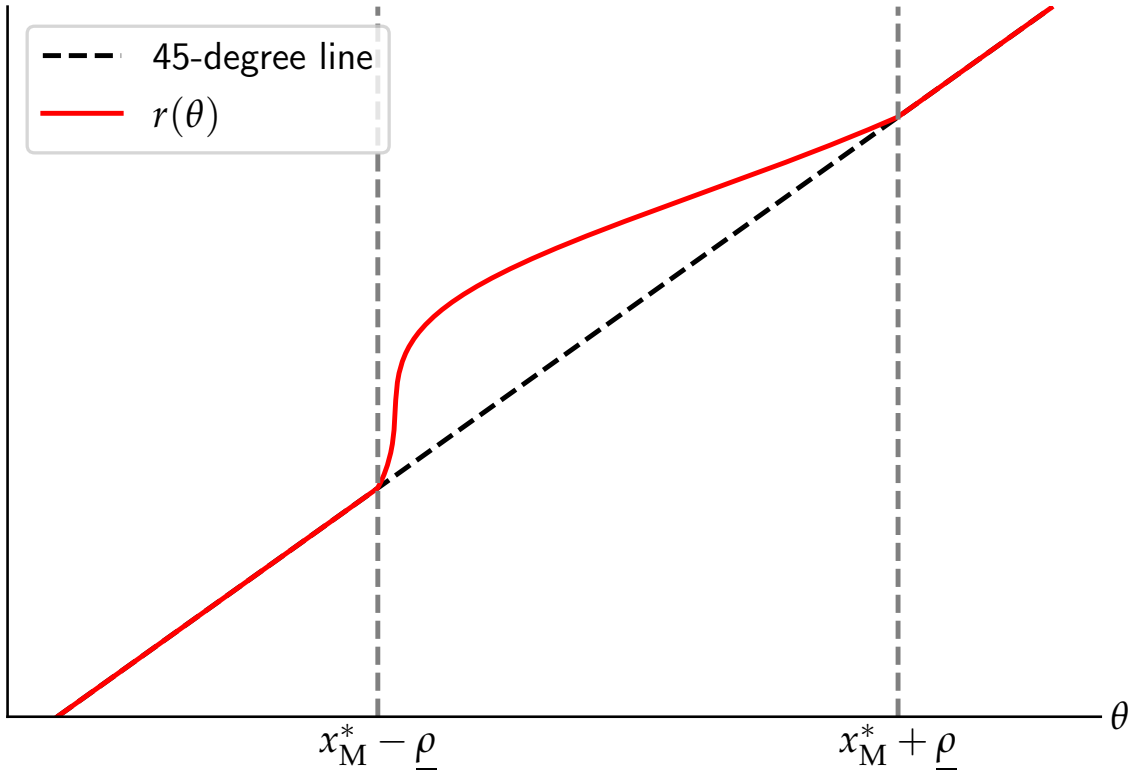

Figure: Signal jamming policy $\tilde{r}(\theta)$

Effectiveness of signal jamming

Proposition

There exists $\breve{t} < 1/2$ such that:

(i) If $t < \breve{t}$, signal jamming is ineffective;

(ii) If $\breve{t} \leq t \leq 1 - \breve{t}$, signal jamming is effective;

(iii) If $t > 1 - \breve{t}$, the regime does not engage in signal jamming

No Fixed Cost

- Suppose $c'(0) = 0$

Proposition

Signal-jamming is always effective.

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(In)Effectiveness in the Limit

Behavior in the Limit

Proposition

In the limit $\alpha \to \infty$,

(i) If $c(\cdot)$ is convex and $c'(0) = 0$ or if $c(\cdot)$ linear then $\theta_M^* \to \theta_L$ (full effectiveness);

(ii) **CONJECTURE** If $c(\cdot)$ is convex and $c'(0) > 0$ no manipulation.

Conclusions

Conclusions

- Effectiveness of signal jamming is regime-change games
- (In)Effectiveness when $c'(0) > 0$
  - Effective when agents' cost is intermediate
  - Ineffective (but occurs) when agents' cost is small
- Always effective if $c'(0) = 0$

Thanks!