The Dean and The Chair

Paolo Martellini
Wisconsin

Guido Menzio
NYU and NBER

Motivation

- Addressing hiring discrimination is challenging in the presence of
    - attribute observable by principal and agent that is the basis of contention (e.g. race, gender)
    - attribute observable only by biased agent (e.g. productivity, match quality)
- Key trade-off:
    - the presence of bias creates a motive for restricting the agent's freedom
    - the lack of information imposes a cost on the principal that exerts control over hiring

Motivation

- Addressing hiring discrimination is challenging in the presence of
  - attribute observable by principal and agent that is the basis of contention (e.g. race, gender)
  - attribute observable only by biased agent (e.g. productivity, match quality)

- Key trade-off:
  - the presence of bias creates a motive for restricting the agent's freedom
  - the lack of information imposes a cost on the principal that exerts control over hiring

- Similar trade-offs characterize other, very different, environments such
  - internal-rating systems vs mandated capital ratios under limited liability
  - approval of medical procedures by Medicare

This Paper

We study the problem of a principal (Dean) who can delegate hiring to an agent (Chair)

1. We write down a simple, generalizable environment
   a. every period a vacancy opens and a contentious candidate applies
   b. the agent is biased against the candidate but privately observes the candidate's quality

This Paper

We study the problem of a principal (Dean) who can delegate hiring to an agent (Chair)

1. We write down a simple, generalizable environment
2. We solve for the optimal mechanism without transfers
   a. Under some conditions, the optimal dynamic mechanism achieves better outcomes than static mechanisms (i.e. pure delegation or control)
   b. The optimal dynamic mechanism has two regimes, starting with delegation
      - In delegation, agent chooses whether to hire. If candidate is hired, agent's value increases. If not, agent's value falls
      - If the agent's value falls below a threshold, lottery between delegation and control regimes
      - In control, the principal hires any candidate. The regime is permanent
   c. The mechanism never reaches full delegation, but it does eventually reach control

This Paper

We study the problem of a principal (Dean) who can delegate hiring to an agent (Chair)

1. We write down a simple, generalizable environment
2. We solve for the optimal mechanism without transfers
3. Since we work with a continuum of types, the characterization of the optimal mechanism in the simple environment extends immediately to more realistic environments
    a. contentious and non-contentious candidates applying for the same vacancy
    b. multiple contentious candidates applying for the same vacancy
    c. unobservable applications, positive bias,...

Related Literature

- **Delegation.** Holmstrom (1977); Amador and Bagwell (2013); Angeletos, Werning and Amador (2006); Athey, Atkeson and Kehoe (2005); Halac and Yared (2018); Frankel (2021)
    - With iid types, optimal mechanism is often static
    - Our mechanism is dynamic: the principal and the agent disagree today *and* in the future
- **Dynamic Mechanisms without Transfers.** Jackson and Sonnenschein (2007); Frankel (2016), Malenko (2019); Lipnowski and Ramos (2020); Li, Matouschek and Powell (2017); Guo and Horner (2020)
    - Our model features partially aligned preferences + *continuum of types*
    - We incorporate natural extensions like multiple (contentious and non-contentious) candidates

Mechanism Design Problem

Environment

- Every period, there is a vacancy and a candidate $x \in X$, $x \overset{iid}{\sim} F(x)$ and $\mathbb{E}[x] = 0$
- Flow payoffs if candidate x is hired ($\beta \equiv$ discount factor)
  - Principal: $(1-\beta)x$
  - Agent: $(1-\beta)(x-\eta), \quad \eta > 0$
- Flow payoffs from not hiring are normalized to 0

Mechanism and Strategy

- Period t outcome: $h_t = \{\ell_t, s_t, a_t\}$ where
  - $\ell_t \in L = \{\text{delegation, control (hire), control (no hire)}\}$
  - $s_t \in X$ (report)
  - $a_t \in A = \{\text{hire, no hire}\}$
- A mechanism for the principal is a sequence of functions
  - $\sigma_{\ell,t} : H^{t-1} \to \Delta(L)$
  - $\sigma_{a,t} : H^{t-1} \times L \times X \to A$
- A strategy of the agent is a sequence of functions
  - $\sigma_{s,t} : H^{t-1} \times L \times X \to X$

Mechanism and Strategy

- Period t outcome: $h_t = \{\ell_t, s_t, a_t\}$ where
  - $\ell_t \in L = \{\text{delegation, control (hire)}\}$
  - $s_t \in X$ (report)
  - $a_t \in A = \{\text{hire, no hire}\}$
- A mechanism for the principal is a sequence of functions
  - $\sigma_{\ell,t} : H^{t-1} \to \Delta(L)$ & control $\in H^{t-1} \Rightarrow \sigma_{\ell,t}(H^{t-1}) =$ control
  - $\sigma_{a,t} : H^{t-1} \times L \times X \to A$
- A strategy of the agent is a sequence of functions
  - $\sigma_{s,t} : H^{t-1} \times L \times X \to X$

Restrictions on the mechanism (*wlog*): Control means hiring & Control is an absorbing state

Observations

It is immediate to establish two properties of an incentive compatible mechanism

1. Two reports that lead to same hiring decision deliver same continuation value to the agent
   - $\Rightarrow$ Only two continuation values after reporting: V_0 (no hiring), V_1 (hiring)
2. If a report s_1 leads to hiring, any report $s_2 > s_1$ must also lead to hiring
   - $\Rightarrow$ Cutoff quality R: the agent only reports whether candidate is "above the bar"

Recursive Formulation

Lottery between Delegation and Control Regimes

The beginning-of-period value to the principal is *(first stage)*

$$J(V) = \max_{p \in [0,1], \hat{V} \in \hat{\mathcal{V}}} pJ_P + (1-p)\hat{J}(\hat{V})$$

$$V = pV_P + (1-p)\hat{V}$$

where the values in control are

$$J_P \equiv \mathbb{E}[x]$$

$$V_P \equiv \mathbb{E}[x] - \eta$$

Recursive Formulation

Lottery between Delegation and Control Regimes

The beginning-of-period value to the principal is *(first stage)*

$$J(V) = \max_{p \in [0,1], \hat{V} \in \hat{\mathcal{V}}} pJ_P + (1-p)\hat{J}(\hat{V})$$

$$V = pV_P + (1-p)\hat{V}$$

where the values in control are

$$J_P \equiv \mathbb{E}[x]$$

$$V_P \equiv \mathbb{E}[x] - \eta$$

Recursive Formulation

Incentives in Delegation

The value to the principal conditional on delegation is *(second stage)*

$$\hat{J}(\hat{V}) = \max_{[V_0, V_1] \in \mathcal{V}^2, R \in X} (1-\beta) \int_R x dF(x) + \beta[F(R)J(V_0) + (1-F(R))J(V_1)]$$

$$\hat{V} = (1-\beta) \int_R (x-\eta) dF(x) + \beta[F(R)V_0 + (1-F(R))V_1] \quad \text{[PK]}$$

$$R = \eta - \frac{\beta}{1-\beta}(V_1 - V_0) \quad \text{[IC]}$$

Recursive Formulation

Implementable Values

Lemma. The sets of feasible promises in the first ($\mathcal{V}$) and the second ($\hat{\mathcal{V}}$) stage are equal to

$$\mathcal{V} = [V_p, V_F] \qquad \hat{\mathcal{V}} = [V_L, V_F]$$

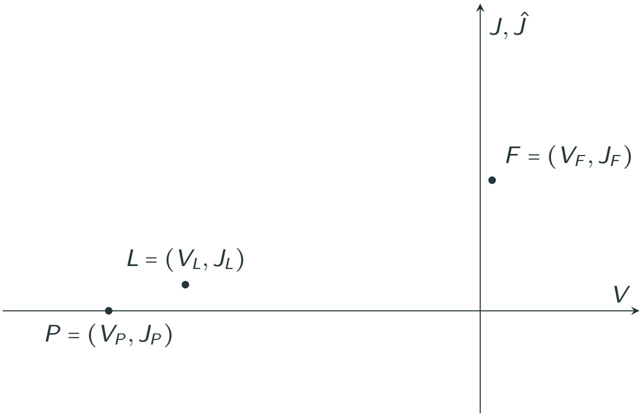
where

$$V_F \equiv \int_{\eta} (x - \eta) dF(x)$$

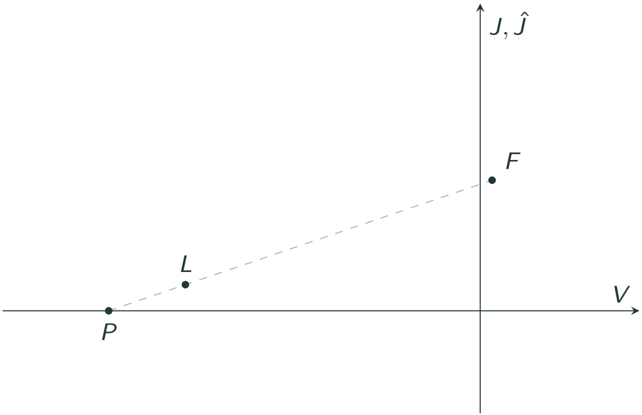
$$V_L \equiv (1 - \beta) V_F + \beta V_p$$

Dynamic vs Static Mechanism

Static Mechanisms



Static Mechanisms



Optimality of Partial Delegation

A simple dynamic mechanism

- Consider the following dynamic mechanism
  - If the agent hires the candidate, the mechanism delegates hiring to the agent forever
  - If the agent does not hire, the mechanism gives control to the principal forever w.p. ϵ and delegates to the agent forever w.p. $1 - \epsilon$
- This mechanism is better than a static mechanism if

$$\underbrace{-\frac{\partial R}{\partial \epsilon}(1-\beta)\eta F'(\eta)}_{\text{(current) gain from lower } R} > \underbrace{\beta F(\eta)(J_F - J_P)}_{\text{(future) cost of punishment}}$$

A simple dynamic mechanism

- We have established a condition under which a dynamic mechanism is worth more to the principal than any static mechanism

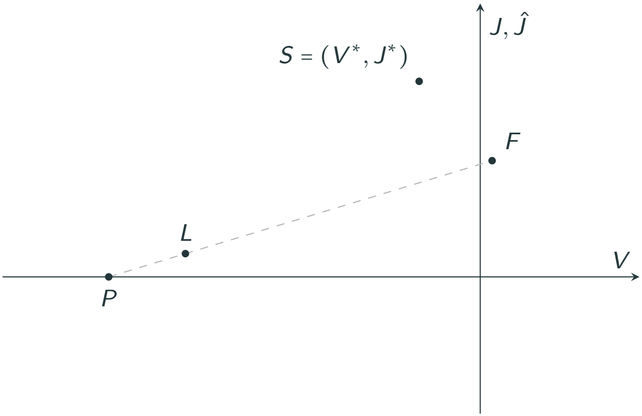
Proposition 1. The optimal mechanism $S = (V^*, J^*)$ is such that $J^* > J_F$ if

$$\frac{\eta F'(\eta)}{F(\eta)} > \frac{\int_\eta x dF(x)}{\int_\eta x dF(x) + \eta F(\eta)}$$

Example: $x \sim U[-\bar{x}, \bar{x}] \Rightarrow$ a dynamic mechanism is optimal if $\eta > \frac{\bar{x}}{2}$

Optimal Promised Value

Optimal Dynamic Mechanism and Static Mechanisms



Optimal Lottery

$$J(V) = \max_{p \in [0,1], \hat{V} \in \hat{\mathcal{V}}} pJ_P + (1-p)\hat{J}(\hat{V})$$
$$V = pV_P + (1-p)\hat{V}$$

Characterizing the Optimal Mechanism

Proposition 2. If $\hat{J}$ is strictly concave, $\exists! V_C \in (V_L, V^*)$ such that

i. For $V \in [V_P, V_C)$, the principal takes over with probability

$$p(V) = \frac{V_C - V}{V_C - V_P}$$

and if the agent retains control his continuation value is V_C. The value to the principal is

$$J(V) = pJ_P + (1-p)\hat{J}(V_C)$$

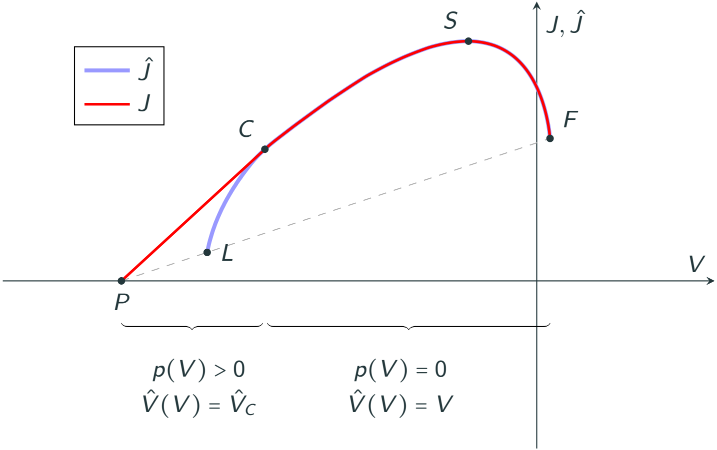
ii. For $V \in [V_C, V_F]$, the principal never takes over hiring. The agent's continuation value is V and the principal's value is $\hat{J}(V)$

iii. The point (V_C, J_C) with $J_C = \hat{J}(V_C)$ is the unique solutions to

$$\hat{J}'(V_C) = \frac{J_C - J_P}{V_C - V_P}$$

Characterizing the Optimal Mechanism

Optimal Lottery



Optimal Incentives in Delegation

- The second stage problem is

$$\hat{J}(\hat{V}) = \max_{[V_0, V_1] \in \mathcal{V}^2, R \in X} (1-\beta) \int_R x dF(x) + \beta [F(R) J(V_0) + (1 - F(R)) J(V_1)]$$

$$\hat{V} = (1-\beta) \int_R (x - \eta) dF(x) + \beta [F(R) V_0 + (1 - F(R)) V_1] \qquad \text{[PK]}$$

$$R = \eta - \frac{\beta}{1-\beta}(V_1 - V_0) \qquad \text{[IC]}$$

Characterizing the Optimal Mechanism

Proposition 3. For all $\hat{V} \in [V_C, V_F]$,

1. Rewards and punishments

$$V_0(\hat{V}) < \hat{V} < V_1(\hat{V})$$

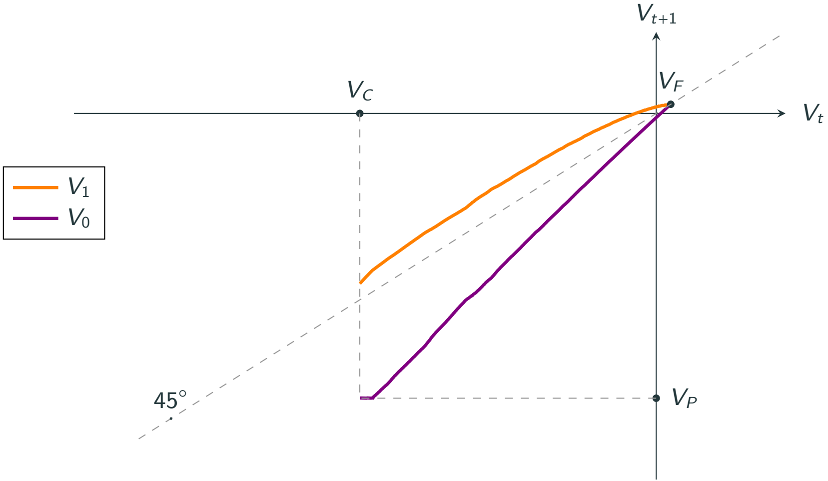
2. Agent selects candidates, but tilted towards principal

$$R < \eta$$
$$F(R) > 0, \quad 1 - F(R) > 0$$

3. Full delegation is never achieved, full control occurs in finite time

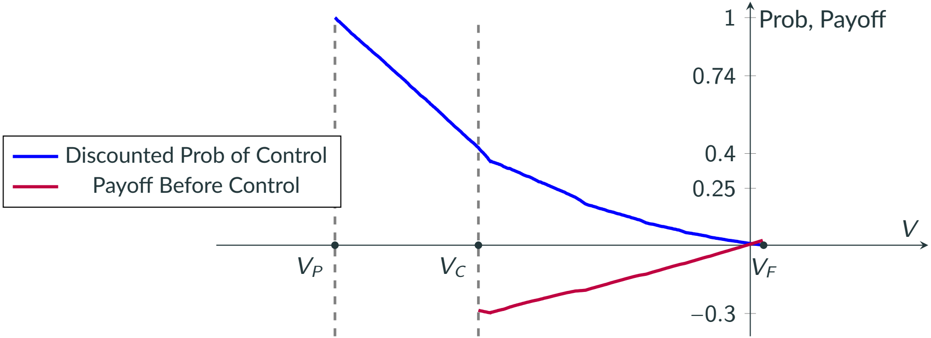
$$V_1(\hat{V}) < V_F \quad \forall \hat{V} < V_F$$
$$V_0(V_C) < V_C$$

Characterizing the Optimal Mechanism



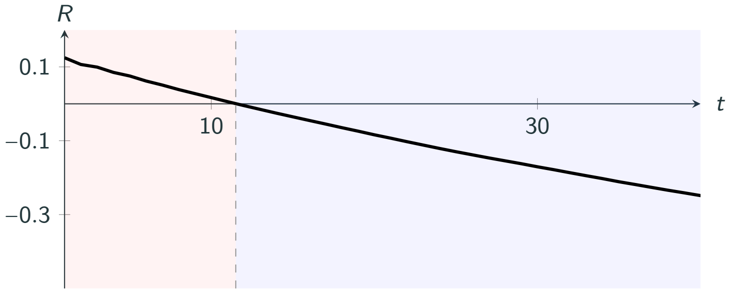
How is lower value delivered to the agent?

- Lower V delivered via
  - higher discounted expected probability of control (blue line)
  - lower candidate quality during delegation ($R \downarrow$) (purple line)



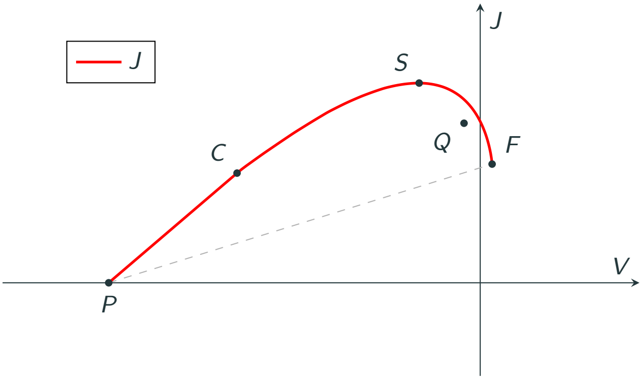
Characterizing the Optimal Mechanism

Agent's Reservation Quality



Optimal Mechanism vs Quota System

- Hiring review every N periods: must hire at least $M \leq N$ candidates (with $N = 10$, optimal $M = 4$)
- Quota equal to $1 - F(0)$ is optimal for $\beta \to 1$ by LLN (Jackson and Sonnenschein 2007)



Characterizing the Optimal Mechanism

Relaxing Restrictions

- We restricted attention to mechanisms such that
  1. Control regime is an absorbing state
  2. In control regime, principal hires every candidate
- The restrictions are without loss in generality. Intuition:
  1. Any mechanism with temporary control regime is equivalent to a mechanism in which the control regime is absorbing but entered with lower probability details
  2. Any mechanism in which the principal does not hire during control is improvable, because hiring gives lower payoff to the agent but same payoff to the principal details

Extensions

Departing from previous literature, we considered an environment where the candidate's productivity is a continuous random variable.

This allows us to extent the results in a number of important directions:

- Positive bias
- Multiple Contentious Applicants
- Contentious and Non-Contentious Applicants

Extensions

Positive bias

- The agent is biased in favor of contentious applicant.
- The optimal mechanism is the same as in baseline, with
  - V_0 and V_1 swapped
  - control involves not hiring candidates

Extensions

Multiple Contentious Applicants

- Every period N contentious candidates apply for the vacancy.
- Optimal mechanism as in baseline, with
  - F_N replacing F, where F_N is the distribution of the maximum among N
  - during control, hire the best candidate

Extensions

Contentious and Non-Contentious Applicants

- A contentious (x) and an non-contentious (y) candidate apply for the vacancy.
- Optimal mechanism as in the baseline with
  - F_z replacing F, where F_z is the distribution of $z = x - \max\{y, 0\}$
  - control is always hiring contentious (all other payoffs increased by $(1 - \beta)\mathbb{E}[\max\{y, 0\}]$

Conclusion

- We studied the problem of delegated hiring in which
  - a biased expert has private information about candidates' quality and candidates arrive sequentially
- The principal adopts dynamic incentives. Punishment provided by
  - $\uparrow$ probability of taking hiring decision away from agent & $\downarrow$ quality of hires before exerting control
- Agent initially too selective but eventually lowers the bar below principal's ideal cutoff
- Model generalizes to multiple contentious and non-contentious candidates
- Future work:
  - Simple implementation
  - Unknown bias
  - Quantification?!

Temporary vs Permanent Punishment

back

- We generalize the problem by allowing for any length of punishment. The first stage becomes

$$\tilde{J}(V) = \max_{p,\tilde{V},\hat{V}} pG(\tilde{V}) + (1-p)\hat{J}(\hat{V})$$

where

$$G(\tilde{V}) = (1-\beta)J_P + \beta\tilde{J}(\hat{V})$$

$$\tilde{V} = (1-\beta)V_P + \beta\hat{V}$$

- Let V_t be the current state at some date t. Given optimal choices, we can write

$$\tilde{J}(V) = \left[(1-\beta)\sum_{\tau=0}^{\infty}\beta^{\tau}\prod_{i=0}^{\tau}p_{t+i}\right]J_P + \sum_{\tau=0}^{\infty}\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}\hat{J}(\hat{V}_{\tau})$$

Temporary vs Permanent Punishment

back

- We generalize the problem by allowing for any length of punishment. The first stage becomes

$$\tilde{J}(V) = \max_{p,\tilde{V},\hat{V}} pG(\tilde{V}) + (1-p)\hat{J}(\hat{V})$$

where

$$G(\tilde{V}) = (1-\beta)J_P + \beta\tilde{J}(\hat{V})$$
$$\tilde{V} = (1-\beta)V_P + \beta\hat{V}$$

- Let V_t be the current state at some date t. Given optimal choices, we can write

$$\begin{aligned}\tilde{J}(V) &= \left[(1-\beta)\sum_{\tau=0}^{\infty}\beta^{\tau}\prod_{i=0}^{\tau}p_{t+i}\right]J_P + \sum_{\tau=0}^{\infty}\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}\hat{J}(\hat{V}_{\tau}) \\ &= \tilde{p}J_P + (1-\tilde{p})\left[\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}\hat{J}(\hat{V}_{\tau})\right]\end{aligned}$$

Temporary vs Permanent Punishment

back

- We generalize the problem by allowing for any length of punishment. The first stage becomes

$$\tilde{J}(V) = \max_{p,\tilde{V},\hat{V}} pG(\tilde{V}) + (1-p)\hat{J}(\hat{V})$$

where

$$G(\tilde{V}) = (1-\beta)J_P + \beta\tilde{J}(\hat{V})$$
$$\tilde{V} = (1-\beta)V_P + \beta\hat{V}$$

- Let V_t be the current state at some date t. Given optimal choices, we can write

$$\begin{aligned}
\tilde{J}(V) &= \left[(1-\beta)\sum_{\tau=0}^{\infty}\beta^{\tau}\prod_{i=0}^{\tau}p_{t+i}\right]J_P + \sum_{\tau=0}^{\infty}\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}\hat{J}(\hat{V}_{\tau}) \\
&= \tilde{p}J_P + (1-\tilde{p})\left[\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}\hat{J}(\hat{V}_{\tau})\right] \\
&\leq \tilde{p}J_P + (1-\tilde{p})\hat{J}\left(\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}(\hat{V}_{\tau})\right)
\end{aligned}$$

Temporary vs Permanent Punishment

back

- We generalize the problem by allowing for any length of punishment. The first stage becomes

$$\tilde{J}(V) = \max_{p,\tilde{V},\hat{V}} pG(\tilde{V}) + (1-p)\hat{J}(\hat{V})$$

where

$$G(\tilde{V}) = (1-\beta)J_P + \beta\tilde{J}(\hat{V})$$
$$\tilde{V} = (1-\beta)V_P + \beta\hat{V}$$

- Let V_t be the current state at some date t. Given optimal choices, we can write

$$\begin{aligned}
\tilde{J}(V) &= \left[(1-\beta)\sum_{\tau=0}^{\infty}\beta^{\tau}\prod_{i=0}^{\tau}p_{t+i}\right]J_P + \sum_{\tau=0}^{\infty}\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}\hat{J}(\hat{V}_{\tau}) \\
&= \tilde{p}J_P + (1-\tilde{p})\left[\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}\hat{J}(\hat{V}_{\tau})\right] \\
&\leq \tilde{p}J_P + (1-\tilde{p})\hat{J}\left(\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}(\hat{V}_{\tau})\right) \\
&\leq J(V_t)
\end{aligned}$$

Temporary vs Permanent Punishment

back

- We generalize the problem by allowing for any length of punishment. The first stage becomes

$$\tilde{J}(V) = \max_{p,\tilde{V},\hat{V}} pG(\tilde{V}) + (1-p)\hat{J}(\hat{V})$$

where

$$G(\tilde{V}) = (1-\beta)J_P + \beta\tilde{J}(\hat{V})$$
$$\tilde{V} = (1-\beta)V_P + \beta\hat{V}$$

- Let V_t be the current state at some date t. Given optimal choices, we can write

$$\begin{aligned}
\tilde{J}(V) &= \left[(1-\beta)\sum_{\tau=0}^{\infty}\beta^{\tau}\prod_{i=0}^{\tau}p_{t+i}\right]J_P + \sum_{\tau=0}^{\infty}\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}\hat{J}(\hat{V}_{\tau}) \\
&= \tilde{p}J_P + (1-\tilde{p})\left[\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}\hat{J}(\hat{V}_{\tau})\right] \\
&\leq \tilde{p}J_P + (1-\tilde{p})\hat{J}\left(\sum_{\tau=0}^{\infty}\frac{\beta^{\tau}(1-p_{\tau})\prod_{i=0}^{\tau-1}p_{t+i}}{1-\tilde{p}}(\hat{V}_{\tau})\right) \\
&= J(V_t)
\end{aligned}$$

Never Hiring

back good distribution

- We generalize the problem by allowing the principal's control to take the form of never hiring. The first stage becomes

$$\tilde{J}(V) = \max_{p,q,\hat{V}} pJ_P + qJ_Q + (1-p-q)\hat{J}(\hat{V})$$

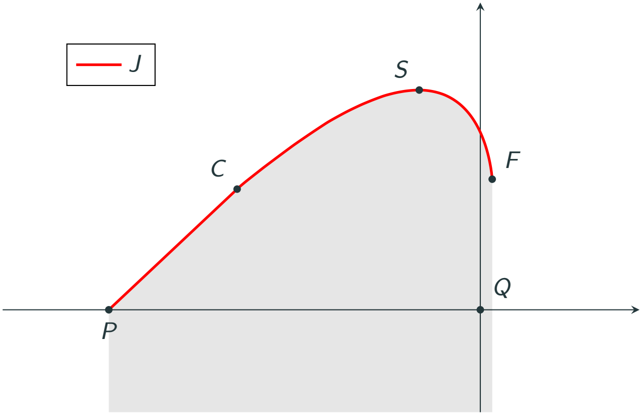
$$V = pV_P + qV_Q + (1-p-q)\hat{V}$$

where $V_Q = J_Q = 0$.

Never Hiring

back good distribution

- Why is $q(V) = 0$ for all V? $Q = (V_Q, J_Q)$ is in the interior of the graph of J



Never Hiring under Good Distribution of Candidates

back

- What if the distribution of candidates is sufficiently good that $V_Q = 0 < \mathbb{E}[x] - \eta = V_P$?
- Numerically we find that V_q is still not used. Intuition: lowering V too costly for the principal