Screening for breakthroughs

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6 December 2021

paper: arXiv.org/abs/2011.10090

Progress: finding & implementing
better ways of doing things.

Requires

(1) discovery

(2) disclosure.

$\Longrightarrow$ must incentivise prompt disclosure:

screen for private info about *when*, rather than *what.*

Model

Breakthrough occurs at uncertain time.

- privately observed by agent
- expands utility possibilities
- causes conflict of interest

Agent (verifiably) discloses breakthrough at time of her choosing.

Principal controls payoff-relevant allocation over time.

Principal has commitment.

Applications

Talent-hoarding

Manager observes whether & when subordinate acquires skill.

Conflict: HQ wants to assign talent optimally,
manager wants to keep worker.

Unemployment insurance

Unemployed worker receives job offer at uncertain time.

State observes employment status, not job offers.

Conflict: state wants employed to work hard & pay tax.

Results

Question: how best to incentivise disclosure of privately-observed breakthrough?

Answer: mechanisms with deadline structure.

– affine case: simple deadline mechanism.

– in general: graduated deadline mechanism.

Related literature

Incentives for proposing agent Armstrong–Vickers '10, Nocke–Whinston '13, Guo–Shmaya '21

– agent privately observes which allocations available

(a) agent can propose only available allocations

(b) principal can implement only proposed allocations.

Bird–Frug '19: different dynamic model with (a) & (b).

– simple payoffs $\implies$ no conflict of interest in our sense

– promised rewards subject to dynamic budget constraint.

Verifiable disclosure: (a) $\cancel{\text{(b)}}$ Grossman/Hart/ Milgrom '80–'81

Dynamic adverse selection: $\cancel{\text{(a)}}$ $\cancel{\text{(b)}}$ e.g. Green–Taylor '16, Madsen '21

Contribution

(1) identify pervasive agency problem:
the need to incentive *prompt* disclosure.

(2) isolate & study the problem:
characterise optimal mechanisms.

(3) develop techniques for this problem.

Plan

Model

The principal's problem

Keeping the agent indifferent

Deadline mechanisms

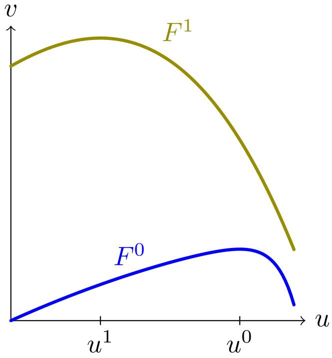
Optimal mechanisms in general

Unemployment insurance

Model

Agent & principal. Utilities $u \in [0, \infty)$ and $v \in [-\infty, \infty)$.

Time $t \in [0, \infty)$. Common discount rate $r > 0$.



Utility possibility frontiers $F^0 \leq F^1$

– unique peaks u^0, u^1.

– concave and upper semi-continuous

– finite on $\left(0, u^0\right]$.

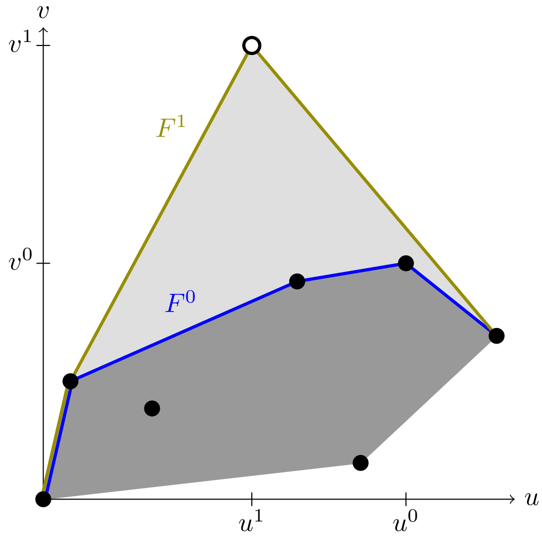
Conflict of interest:
peaks satisfy $u^1 < u^0$.

F^1 arrives at $\tau \sim G$.

Agent observes breakthrough, can disclose availability of F^1.

Principal controls flow u, has commitment. (discussion: slide 41)

Illustration



Old allocations (●), new allocation (○), utility possibility (grey).

Mechanisms

A mechanism is (x^0, X^1)

– x_t^0: flow utility at time t if agent has not disclosed,

– X_t^1: continuation utility from disclosing at time t

$$= r\int_t^\infty e^{-r(s-t)} x_s^{1,t} \mathrm{d}s \quad \text{for some flow } \left(x_s^{1,t}\right)_{s\geq t}.$$

Incentive-compatibility

Mechanism (x^0, X^1) is *incentive-compatible ('IC')*
iff agent prefers to disclose promptly:

(a) does not prefer to delay disclosure by some $d > 0$

(b) does not prefer to *never* disclose.

Revelation principle: suffices to consider IC mechanisms.

Wlog for IC to use F^1 when available. (Clearly optimal.)

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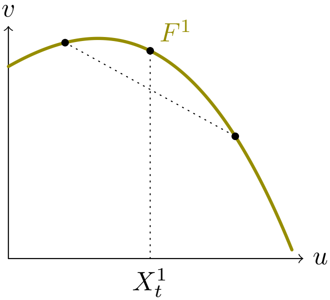
The principal's problem after disclosure

Fix a mechanism (x^0, X^1).

Recall: for each t, continuation X_t^1 provided by a flow $\left(x_s^{1,t}\right)_{s\geq t}$



$$\text{s.t.} \quad r\int_t^\infty e^{-r(s-t)} x_s^{1,t} \mathrm{d}s = X_t^1.$$

Principal's flow payoff: $F^1(x_s^{1,t})$.

Option 1: constant flow
$x_s^{1,t} = X_t^1 \quad \forall s \geq t.$

Option 2: non-constant flow.

F^1 concave $\implies$ constant better.

The principal's problem

Fix an IC mechanism (x^0, X^1).

Principal's flow payoff:

– before breakthrough: $F^0(x^0_t)$

– after breakthrough: $F^1(X^1_\tau)$ forever

Principal's problem:

$$\max_{(x^0, X^1)} \mathbf{E}_{\tau \sim G}\left(r \int_0^\tau e^{-rt} F^0\left(x^0_t\right) \mathrm{d}t + e^{-r\tau} F^1\left(X^1_\tau\right) \right) \quad \text{s.t. IC.}$$

Undominated and optimal mechanisms

Principal's problem:

$$\max_{(x^0, X^1)} \mathbf{E}_{\tau\sim G}\left(r \int_0^\tau e^{-rt} F^0\left(x_t^0\right) \mathrm{d}t + e^{-r\tau} F^1\left(X_\tau^1\right)\right) \quad \text{s.t. IC.}$$

An IC mechanism *dominates* another iff

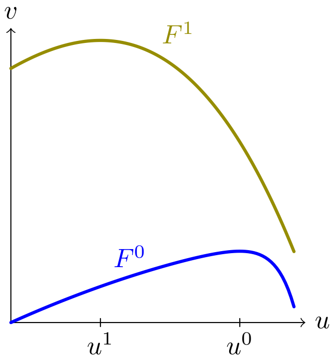
- former is better for every G,
- strictly for some G.

Undominated: not dominated by any IC mechanism.

An IC mechanism is *optimal* for G iff undominated
& maximises principal's payoff under G.

Undominated mechanisms have $\boldsymbol{x^0 \leq u^0}$

Lemma. If (x^0, X^1) is undominated, then $x^0_t \leq u^0$ for a.e. t.



If $x^0_t > u^0$, lower it:

- better for principal
- delay *less* attractive
  $\implies$ still IC.

(proof: slide 42)

Plan

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The principal's problem

Keeping the agent indifferent

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Unemployment insurance

Keeping the agent indifferent

Fix a mechanism (x^0, X^1).

Let X_t^0 denote time-t continuation utility from *never* disclosing:

$$X_t^0 := r \int_t^\infty e^{-r(s-t)} x_s^0 \mathrm{d}s.$$

Agent chooses between

– disclosing promptly: payoff X_t^1

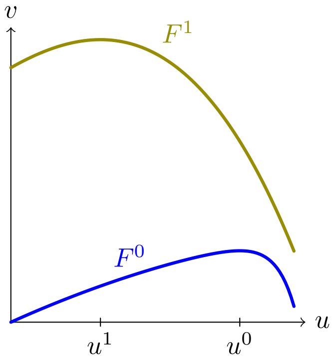
– never disclosing: payoff X_t^0

– delaying by $d > 0$: payoff $X_t^0 + e^{-rd}\left(X_{t+d}^1 - X_{t+d}^0\right)$

Theorem 1. If (x^0, X^1) is undominated,
then agent always indifferent: $X_t^1 = X_t^0$ for every t.

Keeping the agent indifferent

Theorem 1. If (x^0, X^1) is undominated,
then agent always indifferent: $X^1_t = X^0_t$ for every t.



Naïve intuition:
when incentive strict,
lower disclosure reward X^1_t.

Problem: need not benefit principal.

Hurts her if $X^1_t \in [0, u^1]$.
And will spend time here!

(sketch proof: slide 43)

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Dropping superscripts

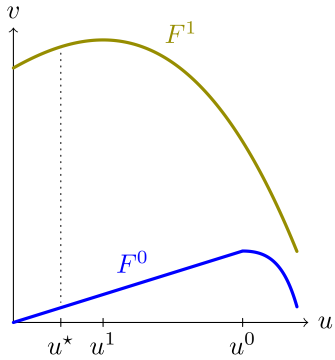
A mechanism is (x^0, X^1).

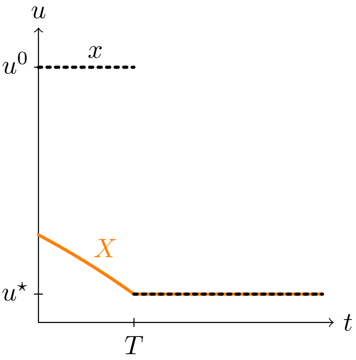
An *undominated* mechanism is pinned down by x^0 since X^1 must make agent indifferent (Theorem 1):

$$X_t^1 = X_t^0 = r \int_t^\infty e^{-r(s-t)} x_s^0 \mathrm{d}s.$$

Drop superscripts: a mechanism is (x, X). (Automatically IC.)

Deadline mechanisms



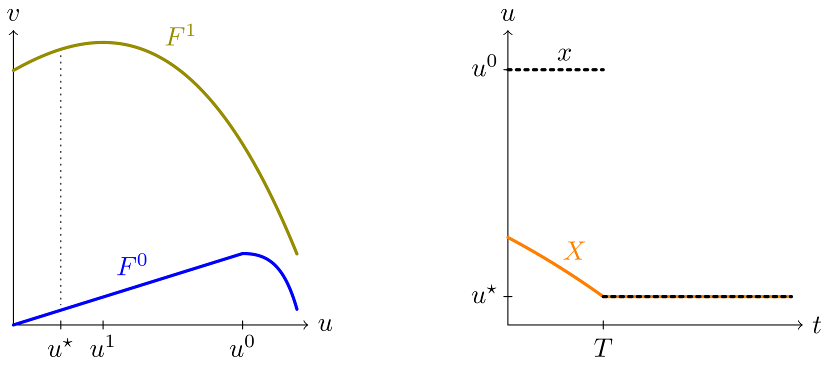


Suppose F^0 is affine on $[0, u^0]$.

Write $u^\star$ for max of $F^1 - F^0$ on $[0, u^0]$. Assume unique.

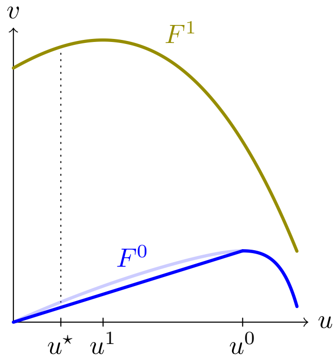
Deadline mechanism (x, X): $\quad x_t = \begin{cases} u^0 & t < T \\ u^\star & t \geq T \end{cases}$ for $T \in [0, \infty]$.

Deadline mechanisms



Theorem 2. If F^0 is affine on $[0, u^0]$,
then all undominated mechanisms are deadline mechanisms.

The role of affineness

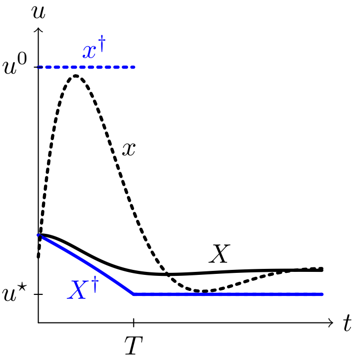


Countervailing force:

if F^0 strictly concave,
then intermediate flows x^0
better than extreme ones.

This force is absent if F^0 is affine.

Front-loading



Fix a mechanism (x, X)

with $\quad u^\star \leq x \leq u^0$.

Deadline mechanism:

$$x_t^\dagger = \begin{cases} u^0 & \text{for } t < T \\ u^\star & \text{for } t \geq T \end{cases}$$

with T s.t. $\quad X_0^\dagger = X_0$.

A *front-loading:* flow has same present value,
but is higher early and lower late.

(better: slide 48)

Optimal deadline

Optimal deadline depends on breakthrough distribution G:
given by a first-order condition. (undom. DLs: slide 54) (FOC: slide 55)

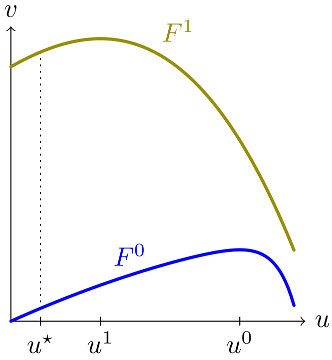
Later breakthrough ($G \nearrow$ in FOSD) $\implies$ later deadline.

Summary: if F^0 affine,

- qualitative prediction: deadline mechanism.
  distribution-free.
- quantitative prediction: deadline given by FOC.
  distribution-dependent.

Plan

Optimal mechanisms in general



Let $u^\star$ be the rightmost $u \in [0, u^0]$ at which F^0, F^1 have equal slopes.

Assume $u^\star$ is strict local max of $F^1 - F^0$ (rather than saddle).

Theorem 3. Any mechanism (x, X) optimal for a distribution G with $G(0) = 0$ & unbounded support has $x_t \searrow$ from $\lim_{t\to 0} x_t = u^0$ to $\lim_{t\to\infty} x_t = u^\star$.

Only difference from deadline mech:
transition $u^0 \longrightarrow u^\star$ possibly gradual.

Front-loading vs. concavity

Theorem 3 combines

- Theorem 2 insight: front-loading $\Longrightarrow$ deadline incentives
- mechanical force: concavity $\Longrightarrow$ graduality.

Proof: a 'local' front-loading argument. (Rather involved.)

Optimal path

Distribution-free qualitative prediction: $x_t \searrow$ from u^0 to $u^\star$.

Optimal path depends on breakthrough distribution G:
described by an Euler equation. (Euler: slide 58)

Later breakthrough ($G \nearrow$ in MLRP)

$\Longrightarrow$ more lenient: $X_t \nearrow$ in every period t.

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Unemployment insurance

Unemployment insurance

Purpose of UI: support the involuntarily unemployed.

– want those with job offers to accept.

Difficulty: job offers privately observed.

$\Longrightarrow$ cannot be too generous
lest workers turn down offers.

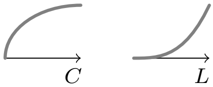
Model

Unemployed worker receives job offer at uncertain time,
chooses whether & when to accept.

Homogeneous jobs: wage $w > 0$. No saving/borrowing.

State observes employment status, not job offers.

Worker values consumption & leisure: $u = \phi(C) - \kappa(L)$



Social welfare: $$v = \underbrace{u}_{\text{worker}} + \lambda \times \underbrace{(wL - C)}_{\text{net tax revenue}}$$

State controls benefits & income tax
$\iff$ controls C, L. (equivalence: slide 59)

Optimal UI: literature

Private job offers esp. Atkeson and Lucas (1995)

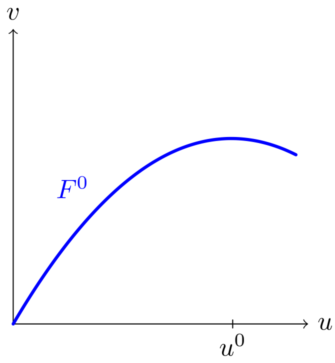
– *assumption:* offers expire instantly.

Private search effort esp. Shavell and Weiss (1979), Hopenhayn and Nicolini (1997)

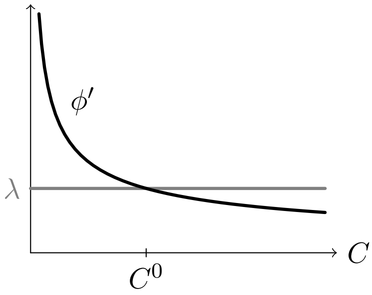
– moral hazard rather than adverse selection

Utility possibilities

$$u \;=\; \phi(C) \qquad\qquad v \;=\; u \;+\; \lambda \times (\qquad - C)$$

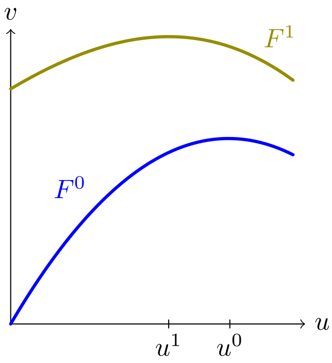


Unemployed: $L = 0$.



Utility possibilities

$$u \;=\; \phi(C) \;-\; \kappa(L) \qquad\qquad v \;=\; u \;+\; \lambda \times \big(wL - C\big)$$



Unemployed: $L = 0$.

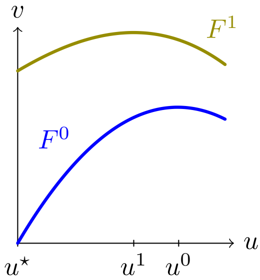
Employed: vary both C & L.

Conflict $u^1 < u^0$:
state wants $L > 0$, worker doesn't.

($u^\star$: slide 60)

Deadline benefits

Deadline mechanism:	e.g. Germany, France, Sweden, …
– before deadline:	high benefit / efficient consumption
Germany:	60% of previous net salary.
– after deadline:	low benefit.
Germany:	€446 per month.



Approx optimal iff F^0 approx affine.

either (a) ϕ close to affine

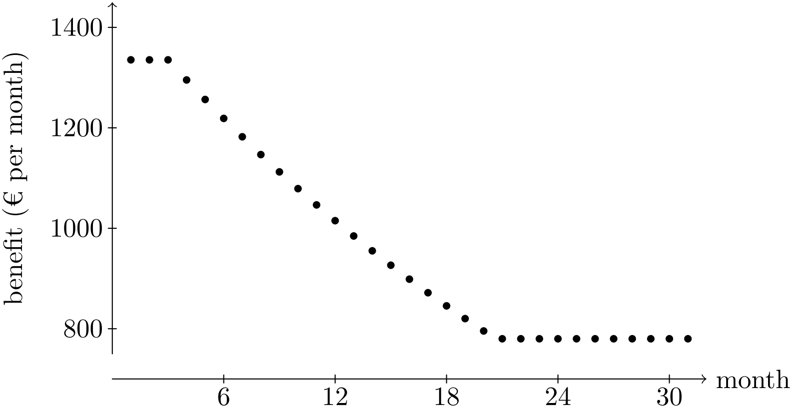
or (b) λ small.

(other countries: slide 61)

Gradual tapering

Exactly optimal benefit: $\searrow$ from generous to low.

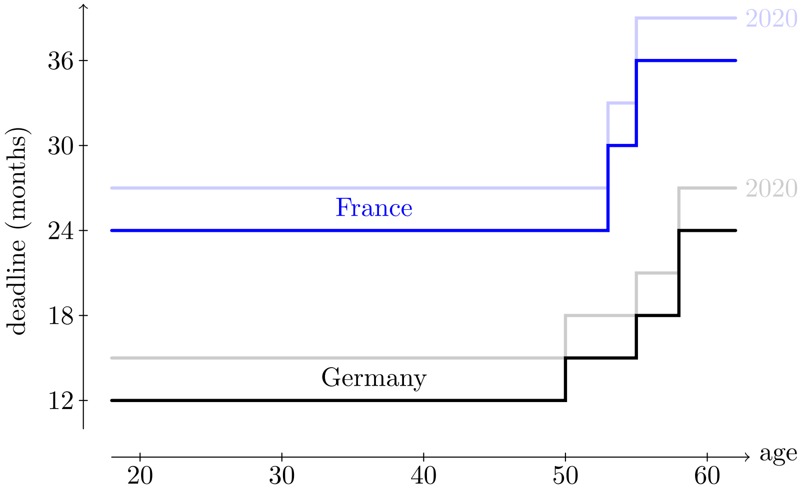
Italy:



Choice of deadline

Optimal deadline: later for workers with worse prospects.

$\Longrightarrow$ later (1) for older workers. (2) during recessions.



Conclusion

Problem: agent privately observes technological breakthrough.

Solution: a deadline structure to incentivise disclosure.

– affine case: simple deadline mechanism.

– in general: graduated deadline mechanism.

Method: new techniques, e.g. front-loading argument.

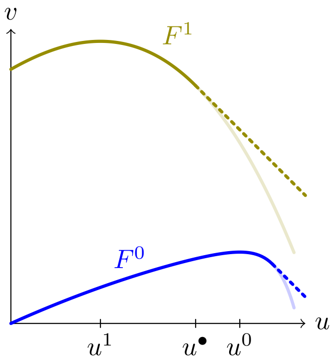
Conclusion

Problem: agent privately observes technological breakthrough.

Future work: embed our problem in richer environments, utilising our techniques. E.g.

- costly & unobservable effort to hasten breakthrough
- repeated breakthroughs over time.

The limited role of transfers



Suppose can pay agent $w \geq 0$.

$\Longrightarrow$ payoffs resp. $u + w$ & $v - w$.

Expands utility possibility frontiers when slope < -1.

Transfers used only where expanded frontier > original.

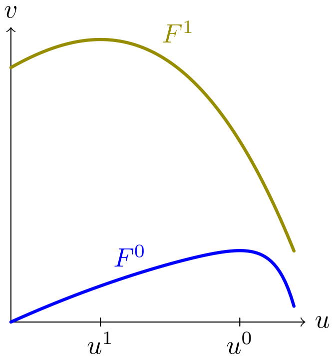
Proposition. Undominated mechanisms (x, X) use transfers

– only after disclosure

– only when $X > u^\bullet$.

Robustness

Weak assumptions on frontiers F^0, F^1, none on distribution G.



Without loss:

- F^0, F^1 concave, usc, finite on $(0, u^0]$
- disclosures verifiable (if principal observes her payoff)

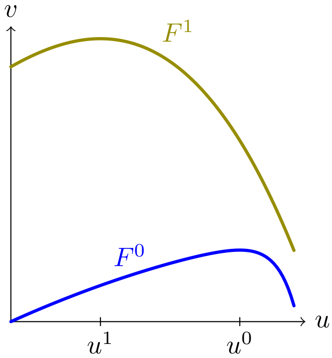
Nothing changes:

- participation instead of $u \geq 0$
- random F^1, provided agent doesn't observe realisation.

(back to slide 9)

Undominated mechanisms have $\boldsymbol{x^0 \le u^0}$: proof

Lemma. If (x^0, X^1) is undominated, then $x^0_t \le u^0$ for a.e. t.



Proof: Fix an IC (x^0, X^1).

Alternative mechanism:
$(\min\{x^0, u^0\}, X^1)$.

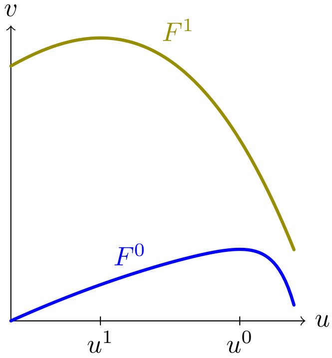
Better, strictly unless $x^0 \le u^0$ a.e.

and IC: in every period,

- disclosure equally attractive
- non-disclosure (weakly) less attractive. ∎

(back to slide 17)

Sketch proof of Theorem 1



Discrete time. Write $\beta \coloneqq e^{-r}$.

IC requires

$$X_s^1 \geq (1-\beta) x_s^0 + \beta X_{s+1}^1 \quad \forall s.$$

Suppose IC slack at time t:

$$\underbrace{X_t^1}_{> u^1} > (1-\beta) \underbrace{x_t^0}_{\geq u^1} + \beta \underbrace{X_{t+1}^1}_{\geq u^1}.$$

If both RHS terms are $\geq u^1$, then the LHS is $> u^1$

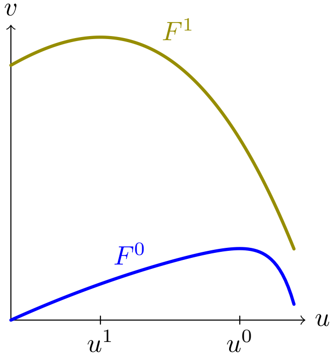
$\iff$ either (i) $X_t^1 > u^1$, (ii) $x_t^0 < u^1$, or (iii) $X_{t+1}^1 < u^1$.

Sketch proof of Theorem 1

slack IC: $X_t^1 \quad > \quad (1-\beta)x_t^0 \quad + \quad \beta X_{t+1}^1$

$\implies$ either (i) $X_t^1 > u^1$, (ii) $x_t^0 < u^1$, or (iii) $X_{t+1}^1 < u^1$

There's an IC-preserving improvement in each case:



Case (i): lower X_t^1
(Preserves time-t IC,
slackens time-$(t-1)$ IC.)

Case (ii): raise x_t^0
(Preserves time-t IC.)

Case (iii): raise X_{t+1}^1
(Preserves time-t IC,
slackens time-$(t+1)$ IC.)

(back to slide 20)

Sketch proof of Theorem 1: remaining pieces

(1) We showed: agent is indifferent about *delaying* disclosure.

Final piece: agent indifferent about *never* disclosing.

(proof: slide 46)

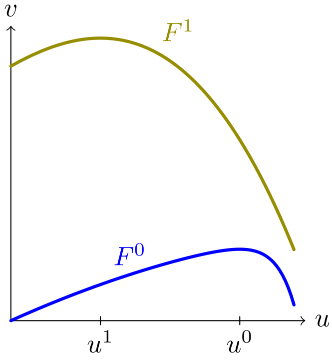
(2) Proof in continuous time: delicate, but same economics.

– case (ii): insufficient to modify x^0 in single period:
must increase it on *non-null* set of times.

– cases (i) & (iii): cannot modify X^1 in single period
while preserving IC.

(back to slide 20)

Final piece in proof of Theorem 1



We showed: agent is indifferent about *delaying* disclosure:

$$X_t^1 = (1-\beta)x_t^0 + \beta X_{t+1}^1$$
$$= \underbrace{(1-\beta)\sum_{s=t}^{T-1}\beta^{s-t}x_s^0}_{\to X_t^0 \text{ as } T\to\infty} + \beta^{T-t}X_T^1.$$

Must show:
indifferent about *never* disclosing:

$$X_t^1 = X_t^0 \iff \lim_{T\to\infty}\beta^{T-t}X_T^1 = 0.$$

If not, then X_t^1 blows up as $t\to\infty$.
Fairly clear that this is not optimal.

(back to slide 45)

Final piece in proof of Theorem 1: formal

Since $X_t^1 \to \infty$, there is a time T after which $X_t^1 > u^0 + u^1$.

Consider $(x^0, X^{1\dagger})$, where $X_t^{1\dagger} \coloneqq \begin{cases} X_t^1 & \text{for } t \leq T \\ X_t^0 + u^1 & \text{for } t > T. \end{cases}$

Better since $u^1 \leq X_t^{1\dagger} \leq X_t^1, \quad$ strictly after T.

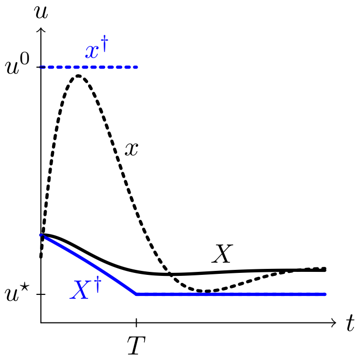
To verify IC, check deviations:

– never disclosing is unprofitable: $\quad X^{1\dagger} \geq X^0$

– before T, delay is unprofitable:
  – delaying to $t' \leq T$: same as in original mechanism
  – delaying to $t' > T$: worse than in original mechanism

– after T, delay is unprofitable:
earn u^1 upon disclosure, so sooner is better. (back to slide 45)

Sketch proof of Theorem 2



Fix a mechanism (x, X)

with $\quad u^\star \le x \le u^0.$

Deadline mechanism:

$$x_t^\dagger = \begin{cases} u^0 & \text{for } t < T \\ u^\star & \text{for } t \ge T \end{cases}$$

with T s.t. $\quad X_0^\dagger = X_0.$

Front-loading x makes X decrease faster (before T):

$$X_t^\dagger \le X_t \quad \text{with equality at } t = 0.$$

(proof: slide 51)

Sketch proof of Theorem 2

$$\text{Write} \quad Y_t := r\int_t^\infty e^{-rs}F^0(x_s)\mathrm{d}s$$
$$= F^0\left(r\int_t^\infty e^{-rs}x_s\mathrm{d}s\right) = F^0(X_t) \quad \text{since } F^0 \text{ affine.}$$

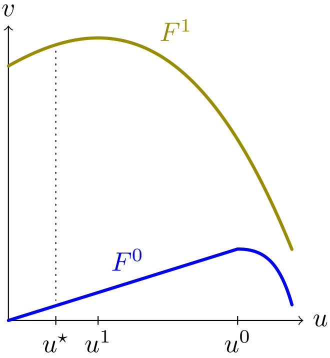
$$\text{Principal's payoff:} \qquad Y_0 \quad + e^{-r\tau}\Big[F^1(X_\tau) - \quad Y_\tau \quad \Big]$$
$$= F^0(X_0) + e^{-r\tau}\Big[F^1(X_\tau) - F^0(X_\tau)\Big].$$

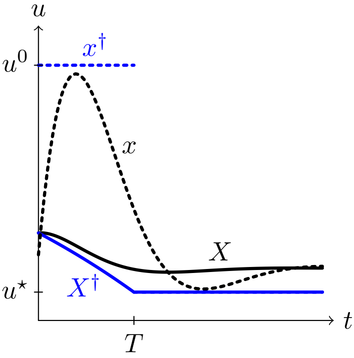
Front-loading…

– increases pre-disclosure payoff $Y_0 - e^{-r\tau}Y_\tau$.

– changes post-disclosure payoff $F^1(X_\tau)$.

Sketch proof of Theorem 2





Principal's payoff: $\quad F^0(X_0) + e^{-r\tau}\Big[F^1(X_\tau) - F^0(X_\tau)\Big].$

Since $X \geq u^\star$, $\quad F^0$ steeper than $F^1 \implies$ lower X is better.

Slight elaboration to drop assumption $x \geq u^\star$. (full proof: slide 52)

(back to slide 25)

Proof of Theorem 2: front-loading lowers $\boldsymbol{X}$

Mechanism (x, X). Deadline mechanism:

$$x^\dagger_t = \begin{cases} u^0 & \text{for } t < T \\ u^\star & \text{for } t \geq T \end{cases} \quad \text{with } T \text{ s.t. } X^\dagger_0 = X_0.$$

Claim. $X^\dagger \leq X$. (With equality at $t = 0$.)

Proof:

- For $t < T$, since $x^\dagger = u^0 \geq x$ on $[0, t] \subseteq [0, T]$,

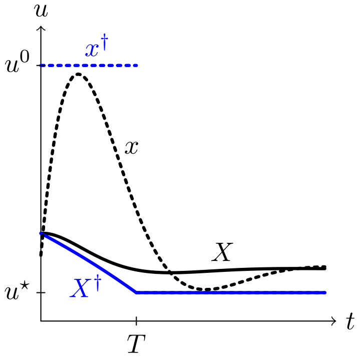
$$\begin{aligned} e^{-rt} X^\dagger_t \;&=\; X^\dagger_0 - r \int_0^t e^{-rs} x^\dagger_s \mathrm{d}s \\ &\leq\; X_0 - r \int_0^t e^{-rs} x_s \mathrm{d}s \;=\; e^{-rt} X_t. \end{aligned}$$

- for $t \geq T$, $X^\dagger_t = u^\star \leq X_t$.
  (Recall: assumed $u^\star \leq X$ for simplicity.) ■

(back to slide 48)

Proof of Theorem 2: dropping $\boldsymbol{x \geq u^\star}$

$$\text{Principal's payoff} \;=\; F^0(X_0) + e^{-r\tau}\Big[F^1 - F^0\Big](X_\tau)$$



Fix any mechanism (x, X).

Alternative deadline mechanism:

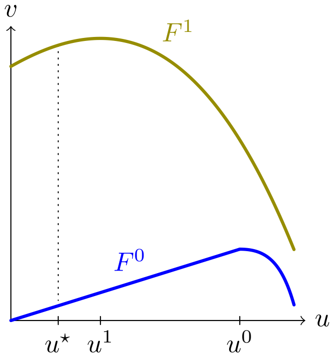
$$x_t^\dagger = \begin{cases} u^0 & \text{for } t < T \\ u^\star & \text{for } t \geq T, \end{cases}$$

with T s.t. $\quad X_0^\dagger = \underline{\underline{X_0 \vee u^\star}}$.

Idea: still a front-loading, but now possibly *increase* X_0. (Good.)

Proof of Theorem 2: dropping $x \geq u^\star$

Principal's payoff $= F^0(X_0) + e^{-r\tau}\left[F^1 - F^0\right](X_\tau)$



By the front-loading logic,
$X^\dagger \;\leq\; X \vee u^\star$.

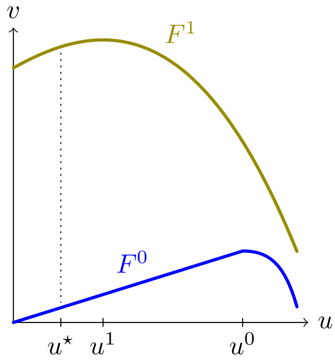
$X^\dagger$ better since
both are $\geq u^\star$,
and $F^1 - F^0 \searrow$ on $[u^\star, u^0]$.

Clearly $X \vee u^\star \;\geq\; X$.

$X \vee u^\star$ better since
they differ only when in $[0, u^\star]$,
and $F^1 - F^0 \nearrow$ on $[0, u^\star]$.

(back to slide 25)

Undominated deadlines



Are *all* DL mechs undominated?

No. If T so early that $X_0 < u^1$, better to increase until $X_0 = u^1$:

- X higher in every period $\implies$ closer to peak u^1
- x high for longer.

But that's all:

Proposition. If F^0 is affine on $[0, u^0]$, then the undominated mechanisms are exactly the DL mechanisms with deadline late enough that $X_0 \geq u^1$.

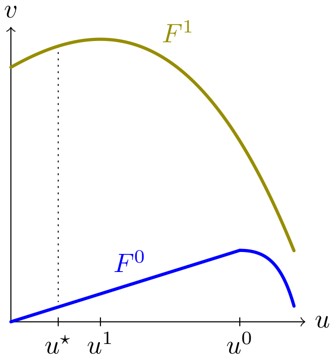
(back to slide 26)

First-order condition

Assume $u^\star > 0$ & F^1 diff'able on $(0, u^0)$. (And F^0 affine.)

Proposition. Mechanism (x, X) is optimal for G iff it is a deadline mechanism with $\mathbf{E}_{\tau \sim G}\big(F^{1\prime}(X_\tau)\big) = 0$.

(derivation: next slide)



Use new technology optimally on average.

Pins down deadline T since X depends on it.

(back to slide 26)

Derivation of first-order condition

$$\text{principal's payoff:} \quad \mathbf{E}_{\tau\sim G}\left(r\int_0^\tau e^{-rs}F^0(x_s)\mathrm{d}s + e^{-r\tau}F^1(X_\tau)\right).$$

Increasing T has two effects:

– if $\tau > T$,

$$\underbrace{\left[F^0(u^0) - F^0(u^\star)\right]}_{=F^{0\prime}(u^\star)\times(u^0-u^\star)}\mathrm{d}T \times \text{discounting}.$$

– if $\tau \leq T$,

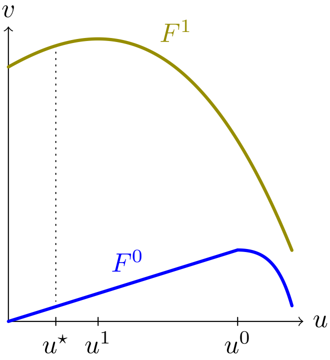
$$\begin{aligned} &F^{1\prime}(X_\tau) \times \mathrm{d}X_\tau \times \text{discounting}.\\ =\ &F^{1\prime}(X_\tau) \times \left(u^0 - u^\star\right)\mathrm{d}T \times \text{discounting}.\end{aligned}$$

First-order condition:

$$[1 - G(T^\star)]F^{0\prime}(u^\star) + G(T^\star)\mathbf{E}_{\tau\sim G}\left(F^{1\prime}(X_\tau)\middle|\tau \leq T^\star\right) = 0.$$

Derivation of first-order condition

FOC: $\quad [1 - G(T^\star)]F^{0\prime}(u^\star) + G(T^\star)\mathbf{E}_{\tau\sim G}\Big(F^{1\prime}(X_\tau)\Big|\tau \le T^\star\Big) = 0.$



$F^{0\prime}(u^\star) = F^{1\prime}(u^\star)$
since $u^\star$ is interior max of $F^1 - F^0$.

$X_\tau = u^\star$ for $\tau > T^\star$.

$\Longrightarrow$ first FOC term
$= [1 - G(T^\star)]F^{1\prime}(X_\tau)$

$\Longrightarrow$ FOC reads
$\mathbf{E}_{\tau\sim G}\big(F^{1\prime}(X_\tau)\big) = 0.$

(back to slide 26)

Optimal path: Euler equation

Proposition. Assume $u^\star > 0$ & F^0, F^1 diff'able on $(0, u^0)$. If (x, X) is optimal for G with $G(0) = 0$ & unb'd'd support, then satisfies

- initial condition $\mathbf{E}_{\tau\sim G}\big(F^{1\prime}(X_\tau)\big) = 0$
- Euler eq'n $$\begin{aligned} F^{0\prime}(x_t) &= \mathbf{E}_{\tau\sim G}\big(F^{1\prime}(X_\tau)\big|\tau > t\big) && \text{if } x_t < u^0 \\ &\geq && \text{if } x_t = u^0. \end{aligned}$$

If G has cont's density g & F^0 twice diff'able with $F^{0\prime\prime} < 0$, differentiated (& rearranged) Euler reads

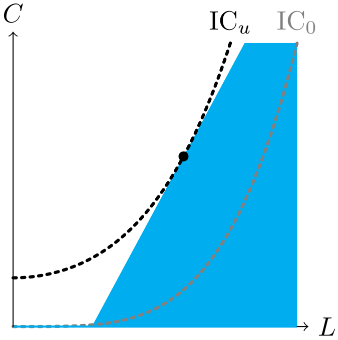
$$\dot{x}_t = -\underbrace{\left(\frac{g(t)}{1 - G(t)}\right)}_{\text{hazard rate}} \frac{F^{0\prime}(x_t) - F^{1\prime}(X_t)}{\underbrace{-F^{0\prime\prime}(x_t)}_{\text{curvature}}}.$$

(back to slide 30)

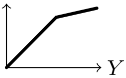
Taxation principle for UI

By choosing income tax schedule $\theta(Y) \leq Y$,

can implement any C, L s.t. $\phi(C) - \kappa(L) \geq 0$.



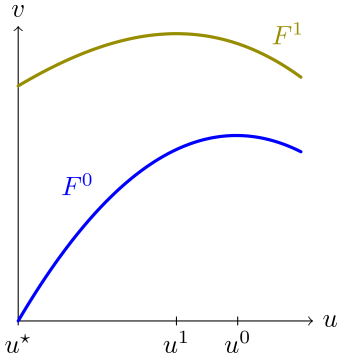
budget set $\{(C, L) \in \mathbf{R}^2_+ : C \leq wL - \theta(wL)\}$

induced by $\theta(Y) = \min\{Y, mY + b\}$ $=$ 

(back to slide 33)

Utility possibilities in UI: $\boldsymbol{u^\star}$

$$u \;=\; \phi(C) \;-\; \kappa(L) \qquad\qquad v \;=\; u \;+\; \lambda \times \big(wL - C\big)$$



$$F^{0\prime} > F^{1\prime} \implies u^\star = 0.$$

Reason: interests less aligned when worker employed.

(back to slide 35: utility poss)
(back to slide 36: DL UI mechs)

Some deadline UI schemes

	before DL	after DL (€/mo.)
Germany	60% of net salary	446
Sweden	80% of net salary	415
Netherlands	70% of net salary	1059
France	€368/mo. $+ 0.404 \times$ SJR*	515

*SJR: an industry-specific reference salary.

Note: this excludes additional funds for particular expenses, such as rent or utilities. These are large in e.g. Sweden.

(back to slide 36)

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