Theory of delay July 21 2020

Notebook:	vladbabich's notebook
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Theories explaing delays in project completion as a function of payment delay.

Theory 1.

Supplier chooses T.
Customer chooses τ.

Supplier's problem:

$$\max_{T} \underbrace{p}_{\text{payment}} e^{-r(T+\tau)} - \underbrace{c(T)}_{\text{cost}}$$

$$\max_{T} p e^{-r(\tau)} e^{-rT} - c(T)$$

Prediction As $\boxed{\tau\uparrow \quad T^*\uparrow}$

Proof $\Pi = p e^{-r(T+\tau)} - c(T)$ is supermodular in (T, τ)

If $T^* > 0 \Rightarrow T^*(\tau)\uparrow$

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Theory 2 Rework time.

Supplier chooses T
There is rework time $\rho(T)\downarrow$

Supplier's problem

$$\max_T \; p\, e^{-r(T+\rho(T)+\tau)} - c(T)$$

$$\Pi = p\, e^{-r(T+\rho(T)+\tau)} - c(T)$$

$$\frac{\partial \Pi}{\partial \tau} = p(-r)\, e^{-r(T+\rho(T)+\tau)}$$

$$\frac{\partial^2 \Pi}{\partial \tau \partial T} = p r^2 e^{-r(T+\rho(T)+\tau)} \left(1+\underbrace{\rho'(T)}_{\hat{0}}\right)$$

If $\rho'(T) < 1 \Rightarrow$ submodular section.

Generally, cannot guarantee (as before) that $T(\tau)\uparrow$

If $\rho'(T) < 1 \; \forall T \Rightarrow T(\tau)\downarrow$

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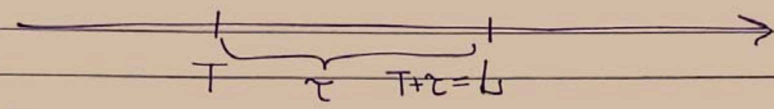
Theory 3: Constraints on project completion due to upcoming liabilities.



Project quality $\uparrow$ T $\Rightarrow$

$p(T)$ payment as a function of how long supplier worked. E.g., $p(T)$ capture $\Pr$[customer accepts]

Without date L

$$\max_{T} \underbrace{p(T)\, e^{-r(T+\tau)} - c(T)}_{\text{Assume concave in } T}$$

$\exists\, T^* > 0$ that is optimal.

But $T^* > L$.

So, the best solution is $T + \tau = L$

As $\boxed{\tau \downarrow \;\Rightarrow\; T = L - \tau \uparrow}$ Prediction

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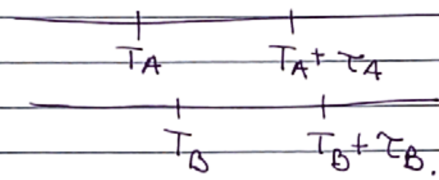
The existence of L and how pressing this constraint is depends on how financially constrained the supplier is.

Theory 4. Critical Path to loan repayment. with Single Loan.

Suppose there are two projects A, B.



Supplier can put effort in reducing T_A or T_B but not both at the same time.

Supplier finances operations with interest rate $r\,dt$!

Assume CoC/discount is normalized to 0.

Supplier takes single loan, regardless of how many projects it has. Pre-payment is not allowed.

So interest cost is =

$$r \max(T_A + \tau_A,\ T_B + \tau_B)$$

Suppose customer reduces τ_A.

If $T_B + \tau_B > T_A + \tau_A \Rightarrow$

supplier should reduce T_B at the expense of increasing T_A to reduce financing cost.

Prediction:

$$\boxed{\tau_A \downarrow \Rightarrow T_A \uparrow.}$$

This is more pronounced when both A, B are present.

If all projects are A projects $\Rightarrow T_A \downarrow$

If all projects are B projects $\Rightarrow$ no effect

But when there is a mix $\Rightarrow T_A \uparrow$

Here A is a government project.

B is a private project.