The Maturity Rat Race

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Is There Too Much Maturity Mismatch?

Is maturity mismatch good/bad?

- Households have long-term saving needs
- Banks have long-term borrowing needs

⇒ Why is intermediary borrowing so short-term?

Rationale for 'beneficial' maturity mismatch:

- Diamond Dybvig (1983)
- Calomiris Kahn (1991), Diamond and Rajan (2001)

There may be **excessive maturity mismatch** in the financial system
Implications for monetary policy, government debt issuance

This Paper

A financial institution can borrow

- from multiple creditors
- at different maturities

Negative externality causes excessively short-term financing:

- shorter maturity claims dilute value of longer maturity claims

Externality arises for any maturity structure

- successively unravels all long-term financing

$\Rightarrow$ **A Maturity Rat Race**

Outline of Talk

Model Setup: Long-term Project

Long-term project:

- investment at $t = 0$: \$1
- payoff at $t = T$: $\theta \sim F(\cdot)$ on $[0, \bar{\theta}]$

Over time, more information is learned:

- s_t observed at $t = 1, \ldots, T - 1$
- S_t is sufficient statistic for all signals up to t: $\theta \sim F(\cdot|S_t)$
- S_t orders $F(\cdot)$ according to strict MLRP

Premature liquidation is costly:

- early liquidation only generates $\lambda E[\theta|S_t]$, $\lambda < 1$

Model Setup: Credit Markets

Risk-neutral, competitive lenders

All promised interest rates

- are endogenous
- depend aggregate maturity structure

Debt contracts specifies maturity and face value:

- can match project maturity: ${}_0D_T$
- or shorter maturity ${}_0D_t$, then rollover ${}_tD_{t+\tau}$ etc.
- lenders make uncoordinated rollover decisions

Maturing debt has equal priority in default:

- proportional to face value

Model Setup: Credit Markets (2)

Financial institution deals bilaterally with multiple creditors:

- simultaneously offer debt contracts to creditors
- cannot commit to aggregate maturity structure
- can commit to aggregate amount raised

An equilibrium maturity structure must satisfy **two conditions**:

1. **Break even:** all creditors must break even
2. **No deviation:** no incentive to change one creditor's maturity

Outline of Talk

Model Setup

One-step Deviation

- **Simple Example**
- General Setup

Multi-period Maturity Rat Race

Seniority, Covenants

Related Literature

Analysis with One Rollover Date

For now: focus on only one possible rollover date, $t < T$

Notation:

- α is fraction of ‘short-term’ debt with maturity t
- $\bar{D}_T(S_t)$: total face value due at T

Note: if some debt rolled over at t, $\bar{D}_T(S_t)$ depends on S_t

Outline of thought experiment:

- Conjecture an equilibrium in which all debt has maturity T
- Calculate break-even face values
- At break-even interest rate, is there an incentive do deviate?

A Simple Example

θ only takes two values:

- θ^H with probability p
- θ^L with probability $1 - p$

$p \sim$uniform on $[0, 1]$, realized at t.

If all financing has maturity T:

$$\frac{1}{2}\theta^L + \frac{1}{2}{}_0D_T = 1, \qquad {}_0D_T = 2 - \theta^L$$

Break-even condition for first t-rollover creditor:

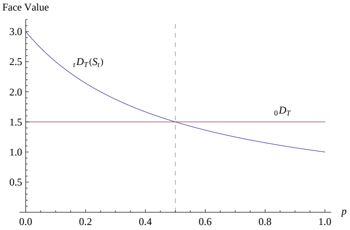
$$(1 - p)\,\frac{{}_tD_T}{2 - \theta^L}\theta^L + p\,{}_tD_T = \underbrace{{}_0D_t}_{=1}, \qquad {}_tD_T = \frac{2 - \theta^L}{2p\,(1 - \theta^L) + \theta^L}$$

Illustration

$$\frac{\partial \Pi}{\partial \alpha} = \int_0^1 p\left[{}_0D_T - {}_tD_T(p)\right]dp$$
$$= \frac{1}{2}{}_0D_T - \int_0^1 p_t D_T(p)\,dp > 0?$$

Product of two quantities matters:

- Promised face value under ST and LT debt (left)
- Probability that face value is repaid (right)



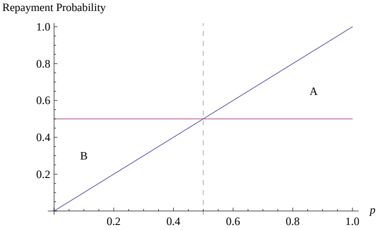


Illustration (2)

Multiplying promised face value and repayment probability:

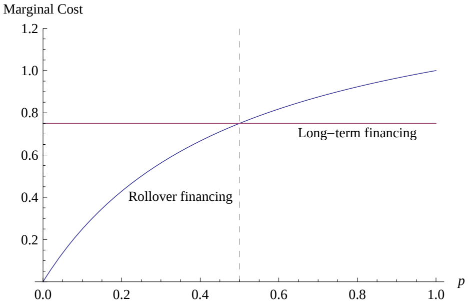
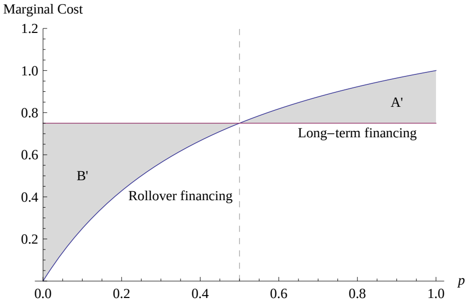


Illustration (2)

Multiplying promised face value and repayment probability:



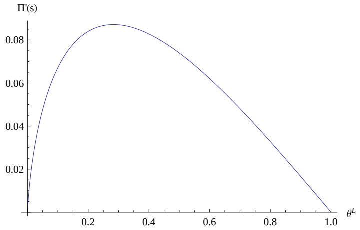
Note:

$A' < B'$ implies rolling over cheaper in expectation

Simple Example cont'd: Deviation Payoff

$$\frac{\partial \Pi}{\partial \alpha} = \int_0^1 p \left[{}_0D_T - {}_tD_T(p) \right] dp > 0?$$

Deviation payoff from all long-term financing:



Positive except:

- $\theta^L = 1$ (project risk-free)
- $\theta^L = 0$ (nothing to divide up in default)

Intuition behind the Deviation

Marginal ST creditor causes contractual externality:

Benefits from ST financing accrue mostly to institution

- Rolling over ST financing cheap after good news
- Those are the states in which institution is likely to be residual claimant

Costs of ST financing disproportionately paid by LT creditors

- Rolling over costly after bad news
- Remaining LT creditors more likely to bear costs

$\Rightarrow$ Shorter maturities reduce value of existing longer term debt

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Creditor Break-Even: Rolling over at time $t < T$

- Rolling over from time t to T:

$$\underbrace{\int_0^{\bar{D}_T(S_t)} \frac{{}_tD_T\left(S_t\right)}{\bar{D}_T\left(S_t\right)} \theta dF\left(\theta|S_t\right)}_{\text{Payoff in default}} + \underbrace{{}_tD_T\left(S_t\right) \int_{\bar{D}(S_t)}^{\bar{\theta}} dF\left(\theta|S_t\right)}_{\text{Payoff if no default}} = {}_0D_t$$

- Rollover is possible when there is enough cash flow to pledge:

$$\alpha_0 D_t \leq \underbrace{\int_0^{\bar{\theta}} \theta dF\left(\theta|S_t\right)}_{\text{Maximum pledgeable CF}}$$

- Rollover not possible when $S_t < \tilde{S}_t(\alpha)$, project is liquidated (inefficient)

Creditor Break-Even: Face Values from Time 0

- Creditor with maturity t: ${}_0D_t$ must satisfy:

$$\underbrace{\frac{1}{\alpha}\int_{S_t^L}^{\tilde{S}(\alpha)} \lambda E[\theta|S_t] dG\left(S_t\right)}_{\text{No rollover at } t} + \underbrace{\left[1 - G\left(\tilde{S}_t\left(\alpha\right)\right)\right] {}_0D_t}_{\text{Rollover at } t} = 1$$

- Creditor with maturity T: ${}_0D_T$ must satisfy:

$$\int_{\tilde{S}_t(\alpha)}^{\infty} \left[\underbrace{\int_0^{\bar{D}(S_t)} \frac{{}_0D_T}{\bar{D}_T\left(S_t\right)} \theta dF\left(\theta|S_t\right)}_{\text{Default at } T} + \underbrace{{}_0D_T \int_{\bar{D}(S_t)}^{\bar{\theta}} dF\left(\theta|S_t\right)}_{\text{No default at } T} \right] dG\left(S_t\right) = 1$$

The 'No Deviation' Condition

- Profit to institution:

$$\Pi = \int_{\tilde{S}_t(\alpha)} \int_{\bar{D}_T(S_t)}^{\bar{\theta}} \left[\theta - \bar{D}_T\left(S_t\right)\right] dF\left(\theta|S\right) dG\left(S\right)$$

- Payoff from Moving one additional creditor to short-term:

$$\frac{\partial \Pi}{\partial \alpha} = \int_{\tilde{S}_t(\alpha)} \int_{\bar{D}_T(S_t)}^{\bar{\theta}} \left[{}_0D_T - {}_tD_T\left(S_t\right) - \alpha \frac{d}{d\alpha} {}_tD_T\left(S_t\right)\right] dF\left(\theta|S_t\right) dG\left(S_t\right)$$

- There is an incentive deviate by shortening maturities when:

$$\frac{\partial \Pi}{\partial \alpha} > 0$$

General One-Step Deviation

The logic from the example works much more generally:

Proposition

One-step Deviation. *Under a regularity condition on* $F(\cdot)$*, in any conjectured equilibrium maturity structure with some amount of long-term financing (*$\alpha \in [0, 1)$*), the financial institution has an incentive to increase the amount of short-term financing by switching one additional creditor from maturity* T *to the shorter maturity* $t < T$*, since* $\frac{\partial \Pi}{\partial \alpha} > 0$*. As a result, the maturity structure of the financial institution shortens to time-*t *financing.*

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Many Rollover Dates: The Maturity Rat Race

Up to now: focus on one potential rollover date

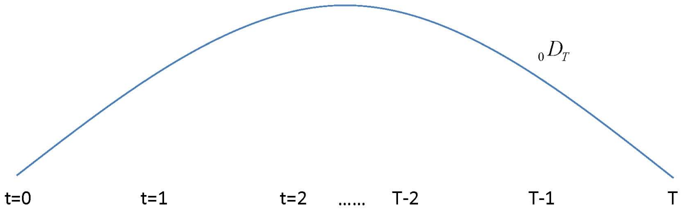
- Assume everyone has maturity of length T
- Show that there is a deviation to shorten maturity to t

This extends to **multiple** rollover dates

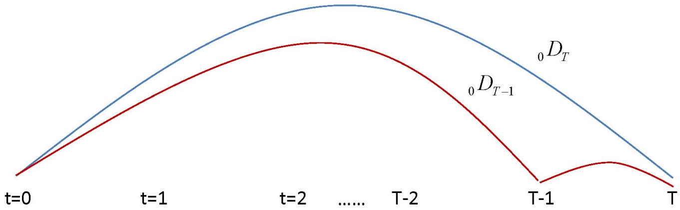
- Assume all creditors roll over for the first time at some time $\tau < T$
- By same argument as before, there is an incentive to deviate
- In proof: For $\tau < T$ replace final payoff by **continuation value**

$\Rightarrow$ **Successive unraveling** of maturity structure

The Maturity Rat Race: Successive Unraveling



The Maturity Rat Race: Successive Unraveling



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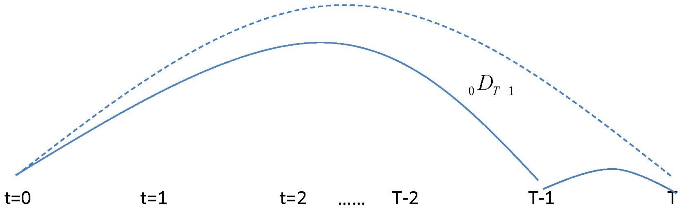

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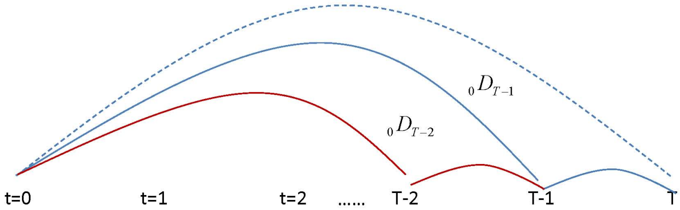

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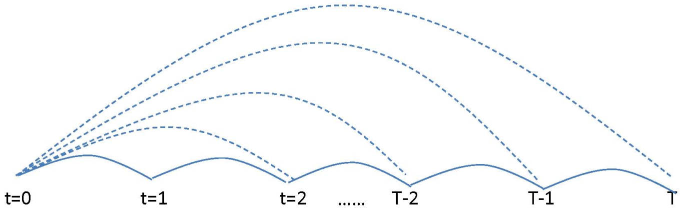

Inefficiency 1: Excessive Rollover Risk

- Project could be financed without *any* rollover risk
- Rat race leads to *positive rollover risk* in equilibrium

$\Rightarrow$ Clearly inefficient

Corollary

Excessive Rollover Risk. *The equilibrium maturity structure ($\alpha = 1$) exhibits excessive rollover risk when conditional on the worst interim signal the expected cash flow of the project is less than the initial investment 1, i.e.* $\int_0^{\bar{\theta}} \theta dF\left(\theta | S_t^L\right) < 1$.

Inefficiency 2: Underinvestment

Creditors rationally anticipate rat race:

- NPV of project must outweigh eqm liquidation costs
- $\Rightarrow$ some positive NPV projects don't get financed

Corollary

Some positive NPV projects will not get financed. *As a result of the maturity rat race, some positive NPV projects will not get financed. Only projects whose NPV exceeds* $(1-\lambda)\int_{S_t^L}^{\tilde{S}_t(1)} E\left[\theta|S_t\right] dG\left(S_t\right)$ *will be financed in equilibrium.*

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Extensions: Seniority, Covenants

Priority for LT debt and covenants may limit rat race

Can reduce externality of ST debt on LT debt

- Seniority for LT debt
- Restrictions on raising face value of ST debt at $t < T$

But:

- by pulling out early, ST creditors may still have *de facto* seniority
- even if equilibrium with long-term debt restored, second inefficient equilibrium may remain (next slide . . .)

The Short-term Financing Trap

Even if seniority/covenants restore LT equilibrium, an inefficient ST equilibrium may also exist

Intuition for multiplicity:

- if everyone else finances long-term, priority restrictions can prevent rat race
- if everyone else finances short-term, individual creditor does not want to move to long-term

Why?

- if other creditors finance with short maturities, individual creditor moving to longer maturity will charge high face value
- but then not individually rational for financial institution to lengthen maturity

Extensions: Debt Acceleration

For simplicity we have assumed no debt acceleration if default occurs at $t < T$

This assumption can be relaxed

For example:

- non-matured debt is accelerated when project is liquidated at $t < T$
- priority is relative to principal (non-matured interest not considered)

Acceleration Changes Creditor Break-Even at $t = 0$

Acceleration changes how time-t liquidation proceeds are split

Generally: Rollover creditors receive fraction β, LT creditors fraction $1 - \beta$ of liquidation proceeds

- Rollover creditor: ${}_0D_t$ must satisfy:

$$\underbrace{\beta \int_{S_t^L}^{\tilde{S}(\alpha)} \lambda E[\theta|S_t] dG\left(S_t\right)}_{\text{Liquidation payoff to rollover creditors}} + \underbrace{\left[1 - G\left(\tilde{S}_t\left(\alpha\right)\right)\right] {}_0D_t}_{\text{Rollover at } t} = 1$$

- Long-term creditor: ${}_0D_T$ must satisfy:

$$\underbrace{(1-\beta) \int_{S_t^L}^{\tilde{S}(\alpha)} \lambda E[\theta|S_t] dG\left(S_t\right)}_{\text{Liquidation payoff to LT creditors}} + \underbrace{\int_{\tilde{S}_t(\alpha)}^{\infty} \left[\ldots\right] dG\left(S_t\right)}_{\text{Payoff if no liquidation at } t} = 1$$

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'Beneficial' Maturity Mismatch

- Diamond and Dybvig (1983)
- Calomiris and Kahn (1991), Diamond and Rajan (2001)

Papers on 'Rollover Risk'

- Acharya, Gale and Yorulmazer (2009)
- He and Xiong (2009)
- Brunnermeier and Yogo (2009)

Signaling Models of Short-term Debt

- Flannery (1986)
- Diamond (1991)
- Stein (2005)

Conclusion

- Equilibrium maturity structure may be efficiently short-term
- Reason: Contractual externality between ST and LT creditors
- Maturity Rat Race successively unravels long-term financing
- Leads to excessive rollover risk, underinvestment ...