The Maturity Rat Race

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Is There Too Much Maturity Mismatch?

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

$\Rightarrow$ Why is intermediary borrowing so short-term?

Rationale for 'beneficial' maturity mismatch:

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

There may be **excessive maturity mismatch** in the financial system

This Paper

A financial institution can borrow

- from multiple creditors
- at different maturities

Negative externality can cause excessively short-term financing:

- shorter maturity claims dilute value of longer maturity claims
- depending on type of interim information received at rollover dates

Externality arises

- for any maturity structure
- particularly during times of high volatility (crises)

Successively unravels all long-term financing: $\Rightarrow$ **A Maturity Rat Race**

Outline

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 FOSD

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 on aggregate maturity structure

Debt contracts specifies maturity and face value:

- can match project maturity: $D_{0,T}$
- or shorter maturity $D_{0,t}$, then rollover $D_{t,t+\tau}$ etc.
- lenders make uncoordinated rollover decisions

All debt has equal priority in default:

- proportional to face value

Model Setup: Credit Markets (2)

Main Friction: Financial institution has opaque maturity structure

- simultaneously offers 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

Analysis with One Rollover Date

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

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?

Denote fraction of short-term debt by α

A Simple Example: News about Default Probability

θ only takes two values:

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

p random, revealed at date t

If all financing has maturity T:

$$(1 - p_0)\,\theta^L + p_0 D_{0,T} = 1, \qquad D_{0,T} = \frac{1 - (1 - p_0)\,\theta^L}{p_0}$$

Break-even condition for first t-rollover creditor:

$$(1 - p_t)\,\frac{D_{t,T}}{D_{0,T}}\theta^L + p_t D_{t,T} = 1, \qquad D_{t,T} = \frac{1 - (1 - p_0)\,\theta^L}{\theta^L p_0 + (1 - \theta^L)\,p_t}$$

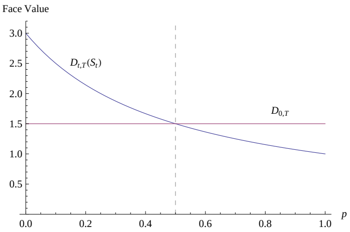
Illustration: News about Default Probability

Deviation payoff:

$$\left.\frac{\partial \Pi}{\partial \alpha}\right|_{\alpha=0} = E\left[p_t D_{0,T}\right] - E\left[p_t D_{t,T}\right] > 0?$$

Product of two quantities matters:

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



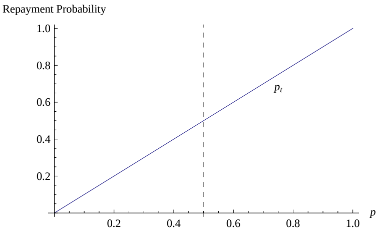
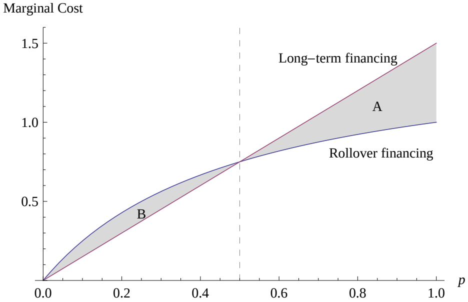


Illustration: News about Default Probability

Multiplying promised face value and repayment probability:



Note:

$A > B$ implies **rolling over cheaper** in expectation

A Simple Example: News about Recovery Value

θ only takes two values:

- θ^H with probability $p = 1/2$
- θ^L with probability $1 - p$

Low cash flow θ^L random, revealed at date t

If all financing has maturity T:

$$\frac{1}{2} D_{0,T} + \frac{1}{2} E\left[\theta^L\right] = 1, \qquad D_{0,T} = 2 - E\left[\theta^L\right]$$

Break-even condition for first t-rollover creditor:

$$\frac{1}{2} D_{t,T} + \frac{1}{2} \frac{D_{t,T}}{D_{0,T}} \theta^L = 1, \qquad D_{t,T}\left(\theta^L\right) = 2 \frac{2 - E\left[\theta^L\right]}{2 - E\left[\theta^L\right] + \theta^L}$$

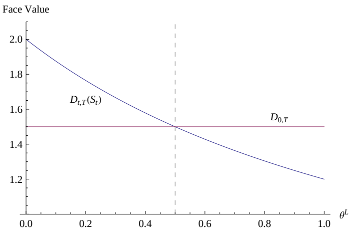
Illustration: News about Recovery Value

Deviation payoff:

$$\left.\frac{\partial \Pi}{\partial \alpha}\right|_{\alpha=0} \quad = \quad \frac{1}{2} D_{0,T} - \frac{1}{2} E[D_{t,T}(\theta^L)] > 0?$$

Product of two quantities matters:

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



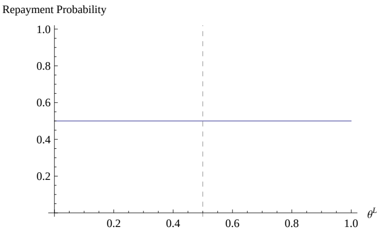
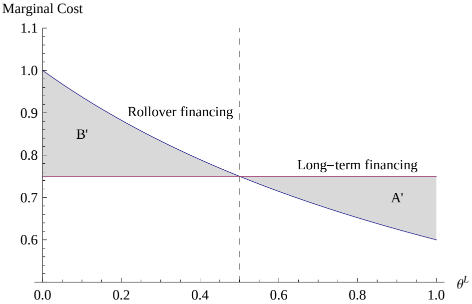


Illustration: News about Recovery Value

Multiplying promised face value and repayment probability:



Note:

$A' < B'$ implies **rolling over more expensive** in expectation

What is going on? Interim Information Matters!

Rollover face value $D_{t,T}$ (promised interest rate)

- is endogenous
- adjusts to interim information

Interim Signal	$D_{t,T}$	default	no default
Negative	high	LT creditors lose	no effect
Positive	low	LT creditors gain	no effect

If default sufficiently more likely after negative signals
$\Rightarrow$ **LT creditors lose on average**

General One-Step Deviation

Extend to:

- general payoff distribution
- start from any conjectured equilibrium that involves some amount of LT debt

Assumption 1: $D_{t,T}\left(S_t\right) \underbrace{\int_{\bar{D}_T(S_t)}^{\infty} dF\left(\theta|S_t\right)}_{\text{repayment probability}}$ is weakly increasing in S_t

- Guarantees signal has sufficient effect on default probability

Proposition: One-step Deviation. Under Assumption 1, the unique equilibrium is all short-term financing ($\alpha = 1$).

Outline

Many Rollover Dates: The Maturity Rat Race

Up to now: focus on one potential rollover date

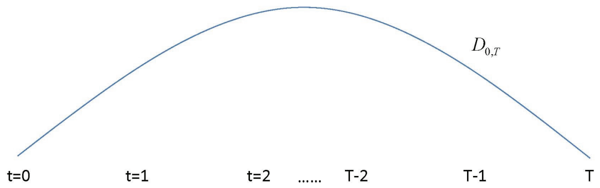
- Assumed everyone has maturity of length T
- Showed that there is a deviation to shorten maturity to t

This extends to **multiple** rollover dates

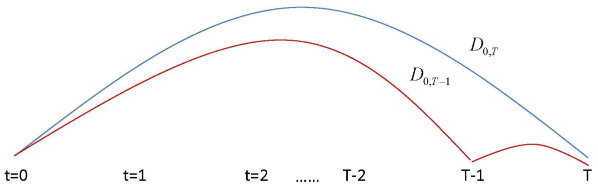
- Assume all creditors roll over for the first time at some time $\tau < T$
- By same argument as before, there is an incentive to deviate
- In proof: For $\tau < T$ replace final payoff by **continuation value**

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

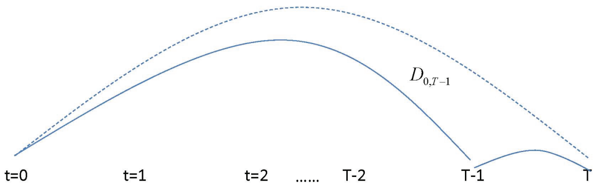
The Maturity Rat Race: Successive Unraveling



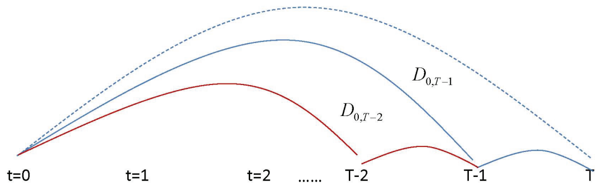
The Maturity Rat Race: Successive Unraveling



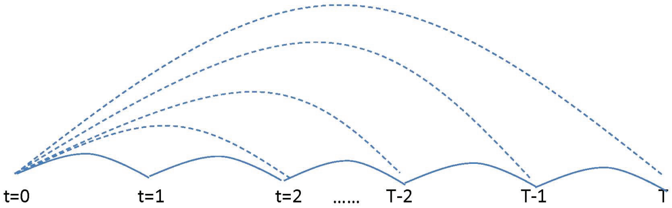
The Maturity Rat Race: Successive Unraveling



The Maturity Rat Race: Successive Unraveling



The Maturity Rat Race: Successive Unraveling



The Maturity Rat Race: Successive Unraveling

Assumption 2: $D_{t-1,t}\left(S_{t-1}\right)\underbrace{\int_{\tilde{S}_t}^{\infty} dG\left(S_t|S_{t-1}\right)}_{\text{prob of rollover at t}}$ is increasing in $S_{t-1}\ \forall t$

- Guarantees signal has sufficient effect on rollover probability at next rollover date

Proposition: Sequential Unraveling. Under Assumption 2, successive application of the one-step deviation principle results in unraveling of the maturity structure to the minimum rollover interval.

Outline

Rat Race Causes Inefficiencies

Excessive Rollover Risk

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

Underinvestment

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

Rat Race Strongest During Crises

Rat race stronger when more information about default probability is released at interim dates

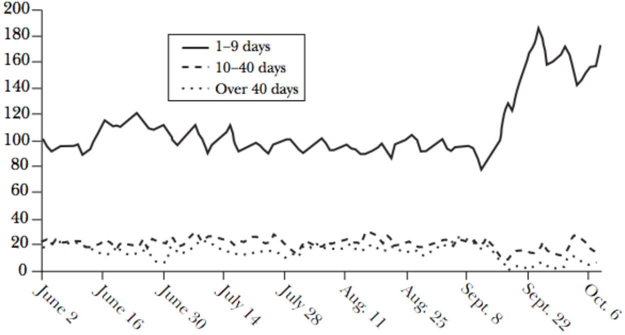
- ability to adjust financing terms becomes more valuable

$\Rightarrow$ **Volatile environments, such as crises, facilitate rat race**

Explains drastic shortening of unsecured credit markets in crisis

- e.g. commercial paper during fall of 2008

Commercial Paper Issuance 2008



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
- Particularly for financial institutions, covenants are hard to write/enforce

Outline

Related Literature

'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

- Contractual externality between ST and LT creditors
- Maturity Rat Race successively unravels long-term financing

This leads to

- too much maturity mismatch
- excessive rollover risk
- underinvestment

Not easily fixed through covenants or seniority for LT debt

Extra Slides

A Simple Example: News about Default Probability

θ only takes two values:

- $\theta^H = 1.5$ with probability $p = 0.8$
- $\theta^L = 0.6$ with probability $1 - p = 0.2$

p updated at date t to $p_t = 0.8 \pm 0.1$

If all financing has maturity T:

$$(1 - p_0)\,\theta^L + p_0 D_{0,T} = 1, \qquad D_{0,T} = 1.1$$

Break-even condition for first t-rollover creditor:

$$(1 - p_t)\,\frac{D_{t,T}}{D_{0,T}}\theta^L + p_t D_{t,T} = 1, \qquad D_{t,T} = \begin{cases} 1.047 & \text{if } p_t = 0.9 \\ 1.158 & \text{if } p_t = 0.7 \end{cases}$$

Illustration: News about Default Probability

Deviation payoff:

$$\frac{\partial \Pi}{\partial \alpha} = p_0 D_{0,T} - E[p_t D_{t,T}(p_t)] > 0?$$

Product of two quantities matters:

- Promised face value under ST and LT debt
- Probability that face value is repaid

$$\frac{\partial \Pi}{\partial \alpha} = 0.8 * 1.1 - 0.5 * (0.9 * 1.047) - 0.5 * (0.7 * 1.158) = 0.0033 > 0$$

$\Rightarrow$ **Deviation profitable**

A Simple Example: News about Recovery Value

θ only takes two values:

- $\theta^H = 1.5$ with probability $p = 0.8$
- $\theta^L = 0.6$ with probability $1 - p = 0.2$

Low cash flow θ^L random, updated at date t: 0.6 ± 0.1

If all financing has maturity T:

$$(1-p)E\left[\theta^L\right] + pD_{0,T} = 1, \qquad D_{0,T} = 1.1$$

Break-even condition for first t-rollover creditor:

$$(1-p)\frac{D_{t,T}}{D_{0,T}}\theta^L + pD_{t,T} = 1, \qquad D_{t,T} = \begin{cases} 1.078 & \text{if } \theta^L = 0.7 \\ 1.112 & \text{if } \theta^L = 0.5 \end{cases}$$

Illustration: News about Recovery Value

Deviation payoff:

$$\frac{\partial \Pi}{\partial \alpha} \quad = \quad pD_{0,T} - pE[D_{t,T}(\theta^L)] > 0?$$

Product of two quantities matters:

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

$$\frac{\partial \Pi}{\partial \alpha} \quad = \quad 0.8 * 1.1 - 0.5 * (0.8 * 1.078) - 0.5 * (0.8 * 1.122) = -0.0003 < 0$$

$\Rightarrow$ **Deviation not profitable**

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. To be financed in equilibrium, a project's NPV must exceed

$$(1-\lambda)\int_{S_t^L}^{\tilde{S}_t(1)} E\left[\theta|S_t\right] dG_t\left(S_t\right).$$