Rollover Risk and Market Freezes

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Introduction

- Reliance on short-term rollover debt features in financing of many financial institutions and vehicles.
- During the sub-prime crisis, one such market – the market for asset-backed commercial paper (ABCP) – experienced a sudden freeze (August 2007).
- While we are yet to understand its exact cause, many institutions reliant on it have since collapsed.
- Overnight secured (repo) markets froze as well, e.g., for Bear Stearns in mid-March 2008.
- Our paper is an attempt to provide a model of such market freezes.

Money market's "canary in the coal mine"

- On July 31, 2007, two hedge funds of Bear Stearns, based in Cayman Islands, invested in sub-prime assets, filed for bankruptcy. Bear Stearns blocked investors in a third fund from withdrawing money.
- On August 7, 2007, BNP Paribas halted withdrawals from three investment funds and suspended calculation of the net asset values because it could not "fairly" value their holdings:

" *[T]he complete evaporation of liquidity in certain market segments of the US securitization market has made it impossible to value certain assets fairly regardless of their quality or credit rating... Asset-backed securities, mortgage loans, especially sub-prime loans don't have any buyers... Traders are reluctant to bid on securities backed by risky mortgages because they are difficult to sell on... The situation is such that it is no longer possible to value fairly the underlying US ABS assets in the three above-mentioned funds.*" (Bloomberg, 9 August 2008)

Effect of BNP Paribas' announcement

- The announcement appeared to cause a "freeze" in asset-backed commercial paper (ABCP) market as its investors – money market funds – could no longer hear the "canary in the coal mine."
- Since many ABCP vehicles had recourse back to banks, this raised counter-party risk concerns, causing LIBOR to shoot upwards.
- On August 9, sub-prime crisis truly took hold as ECB pumped 95 billion Euros in overnight lending market due to sudden demand for cash from banks.
- In mid-March 2008, Bear Stearns faced a similar "freeze", this time in the overnight secured repo market.

The failure of Bear Stearns

- In his analysis of the failure of Bear Stearns, the Federal Reserve Chairman Ben Bernanke observed:

" *[U]ntil recently, short-term repos had always been regarded as virtually risk-free instruments and thus largely immune to the type of rollover or withdrawal risks associated with short-term unsecured obligations. In March, rapidly unfolding events demonstrated that even repo markets could be severely disrupted when investors believe they might need to sell the underlying collateral in illiquid markets. Such forced asset sales can set up a particularly adverse dynamic, in which further substantial price declines fan investor concerns about counterparty credit risk, which then feed back in the form of intensifying funding pressures. . . In particular, future liquidity planning will have to take into account the possibility of a sudden loss of substantial amounts of secured financing.* "

Summary

- We model this "adverse dynamic" in a model that features
  - Rollover risk.
  - Liquidation cost.
  - Switch in expectations from "optimistic" to "pessimistic".
- Natural to assume with rollover debt that information is not fully revealed by the time debt is due.
- For assets specific to financial sector – "complex" stuff, "toxic waste", "crowded" trades – lenders suffer a cost in selling assets to another buyer (proportional to its rollover debt capacity).
- How is information revealed relative to the rollover rate?
  - "Optimistic" case: No news is good news (Figure 2).
  - "Pessimistic" case: No news is bad news (Figure 3).

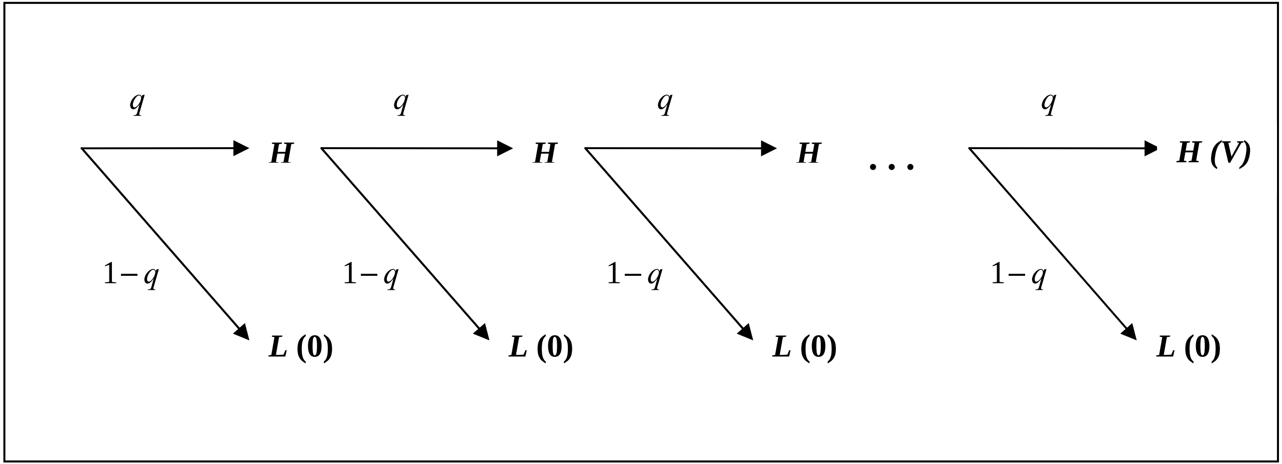
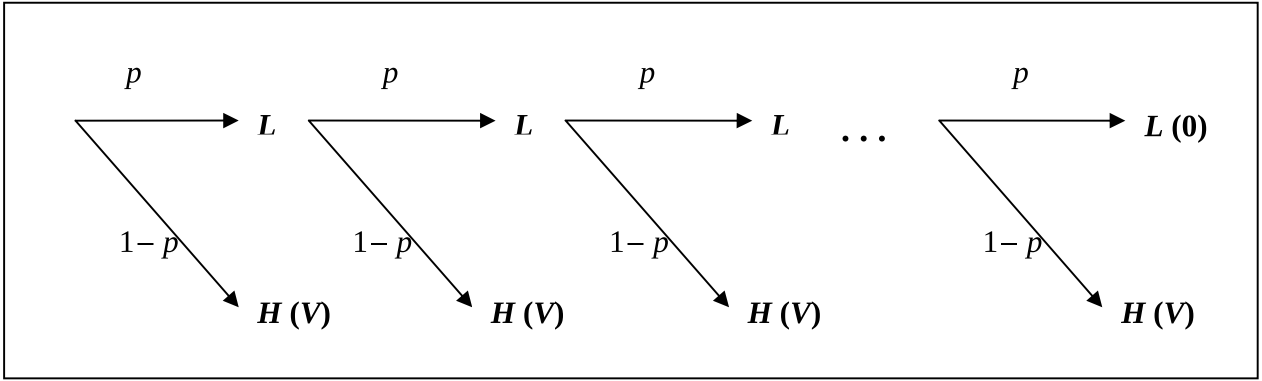


Figure 2: Optimistic information structure

Figure 3: Pessimistic information structure



Results

- Optimistic information/expectations case:
  - The debt capacity of an asset
    - Equals the expected value of asset's cash flows.
    - Expands if information has not arrived.
    - Is unaffected by rollover risk.
- Pessimistic information/expectations case:
  - Debt capacity is declining in rollover frequency and liquidation cost.
  - As the number of rollovers grow without bound, debt capacity goes to zero, *even for an arbitrarily small amount of credit risk*.
- "Market freeze" in ABCP and repo markets can arise when the rate of arrival of information becomes slower than the rollover rate:
  - Events such as the news of sub-prime losses cause investors' expectations to rationally switch to *waiting for good news*.

Results

- The result holds more generally in a Markov switching model of states between optimistic and pessimistic ones (Figure 4).
- Indeed, when rollover frequency is unbounded, debt capacity in the pessimistic state goes to zero, *even where there is a likelihood of switching to the optimistic state*.
- Since debt capacity of the asset differs from its expected cash flows, we obtain a "haircut" in secured borrowing that depends upon:
  1. Investors' expectations or information structure.
  2. Rollover risk.
  3. Liquidation cost.
  4. Credit risk.

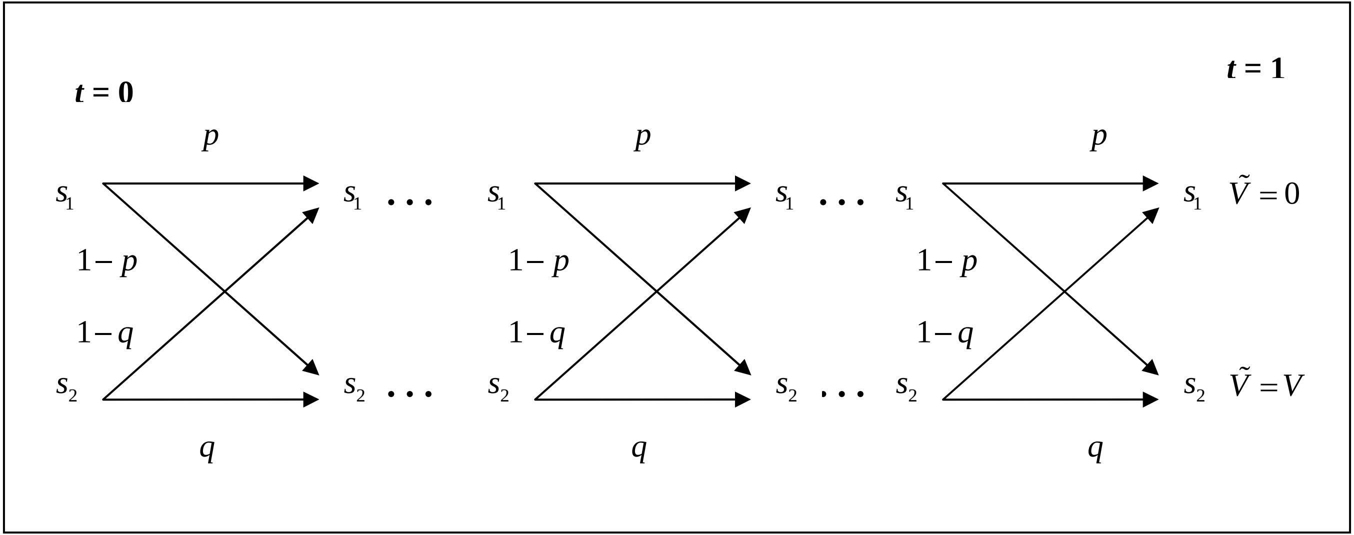


Figure 4: State transitions in the model with nested information structures.

Box 1.5 *(concluded)*

Typical "Haircut" or Initial Margin

(In percent)

	April 2007	August 2008
U.S. treasuries	0.25	3
Investment-grade bonds	0–3	8–12
High-yield bonds	10–15	25–40
Equities	15	20
Investment grade corporate CDS	1	5
Senior leveraged loans	10–12	15–20
Mezzanine leveraged loans	18–25	35+
ABS CDOs: AAA	2–4	95[1]
AA	4–7	95[1]
A	8–15	95[1]
BBB	10–20	95[1]
Equity	50	100[1]
AAA CLO	4	10–20
Prime MBS	2–4	10–20
ABS	3–5	50–60

Sources: Citigroup; Morgan Stanley Prime Brokerage; and IMF staff estimates.

Note: ABS = asset-backed security; CDO = collateralized debt obligation; CDS = credit default swap; CLO = collateralized loan obligation; MBS = mortgage-backed security; RMBS = residential mortgage-backed security.

[1]Theoretical haircuts as CDOs are no longer accepted as collateral.

Setup: A binomial example

- Consider a SIV attempting to raise asset-backed finance at date $t = 0$ with a collection of assets as collateral (Figure 5).
- The assets mature at date $t = 1$; the SIV rollover its debt exactly N times, at dates $t = \tau, 2\tau ..., N\tau$, where $(N + 1)\tau = 1$.
- At each date $t_0, \ldots, t_N$, information about the quality of the assets becomes available as in Figure 4 (or Figure 2 or Figure 3).
- The information is released before the debt is rolled over and is independent over time.
  - Rollover and information can be allowed to arrive independently (see our continuous-time model of both as Poisson processes).

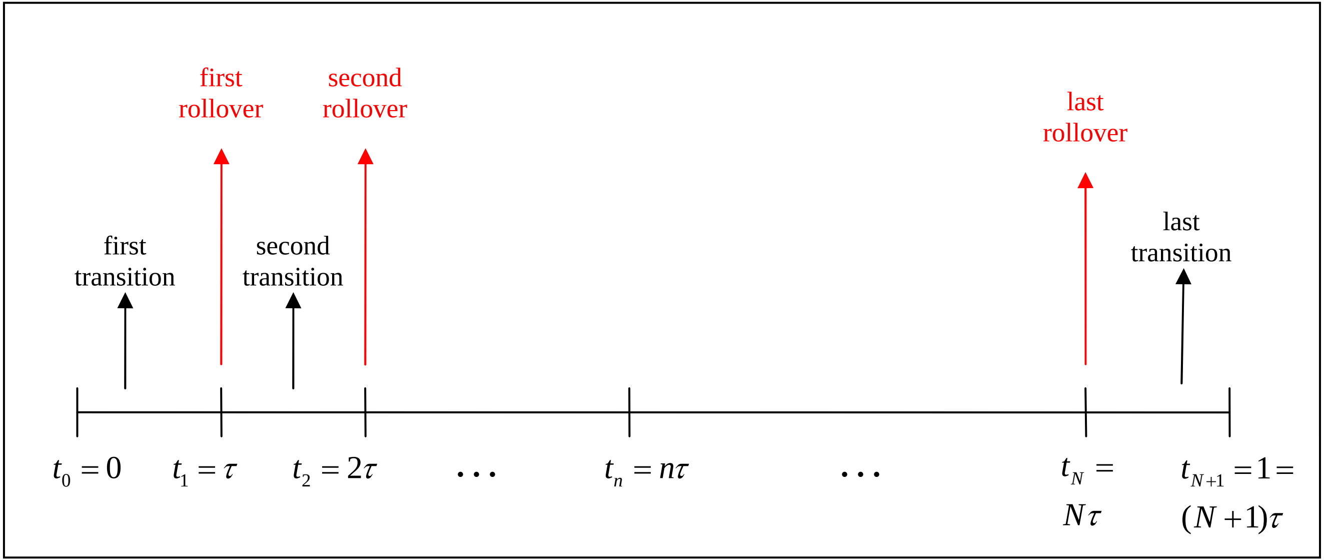


Figure 5: Timeline (illustrating N+1 state transitions and N rollovers).

Setup – continued

- Assumption: If the SIV is forced to default and liquidate, then the assets fetch a fraction $\lambda \in [0, 1]$ of the *maximum amount of finance that could be raised by the SIV as a going concern*.
  - The buyer of the assets is another financial institution that must also issue short term debt.
  - Hence, the buyer is constrained by the same forces that determined the debt capacity in the first place.
- What is the maximum debt capacity (B_0^i) as a function of the number of rollovers (N), $i = 1$ (pessimistic) or $i = 2$ (optimistic)?
- Answer: Can be provided based on an induction argument.
- Denote the face value of debt as D.

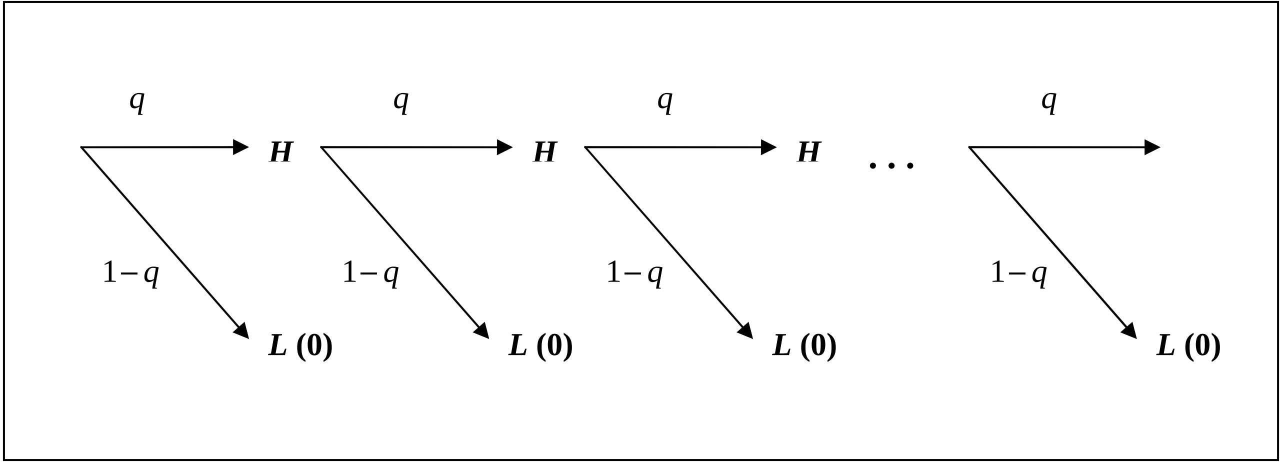


Figure 2: Optimistic information structure

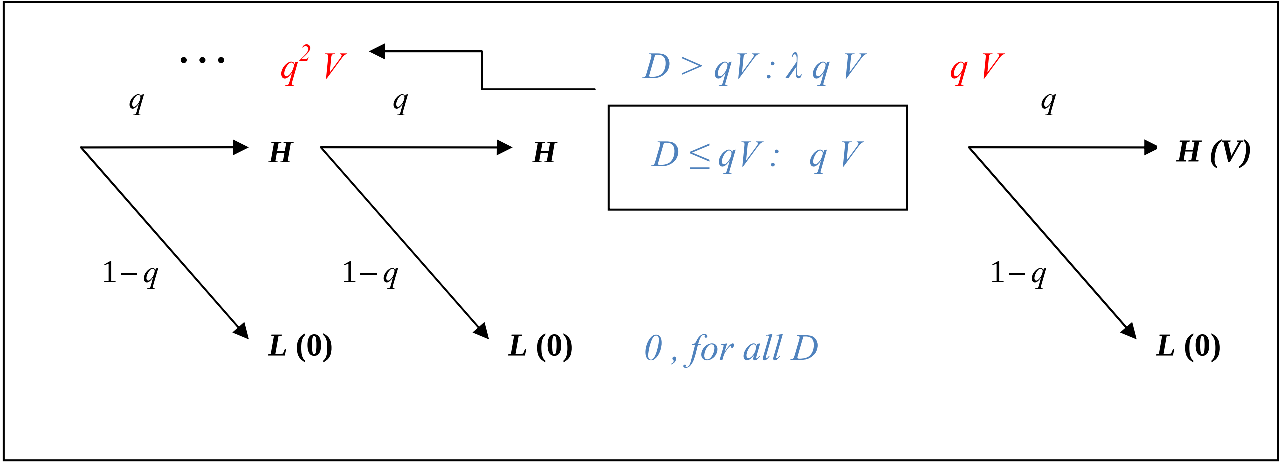


Figure 2c: Optimistic information structure

Debt capacity B_n^2 in the optimistic case

- At last rollover, debt capacity depends on whether $D > V$ or $D \leq V$:

$$\max\{q\lambda V, qD\}.$$

- Setting $D = V$ maximizes the debt capacity to $B_N^2 = qV$.

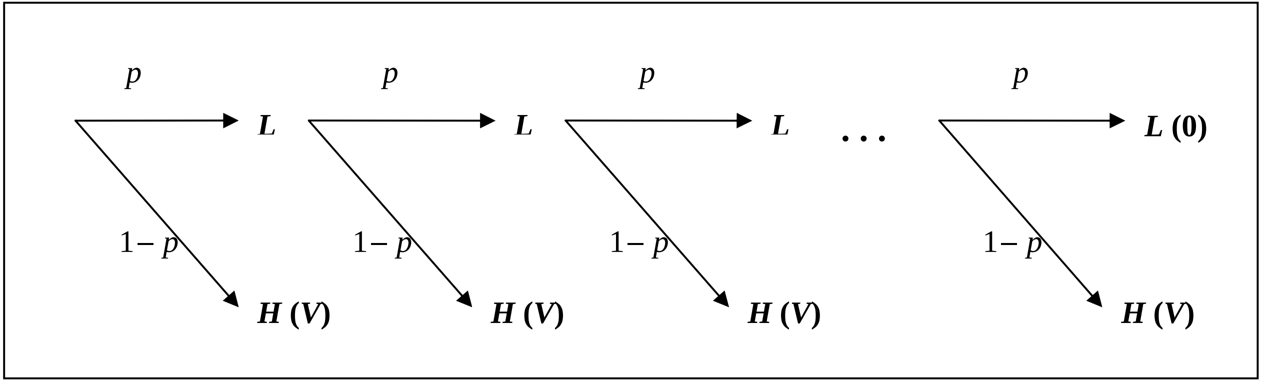
- Working backwards, debt capacity in the ante-penultimate period is

$$\begin{cases} q\lambda B_N^2 & \text{if } D > B_N^2 \\ qD & \text{if } D \leq B_N^2. \end{cases}$$

- Thus, debt capacity is maximized by setting $D = B_N^2$.
- In turn, the maximum value of the debt is $B_{N-1}^2 = qB_N^2 = q^2 V$.

- By induction, $B_n^2 = q^{N-n+1} V$, the fundamental value of the asset's cash flows, *regardless of the number of rollovers*.

Figure 3: Pessimistic information structure



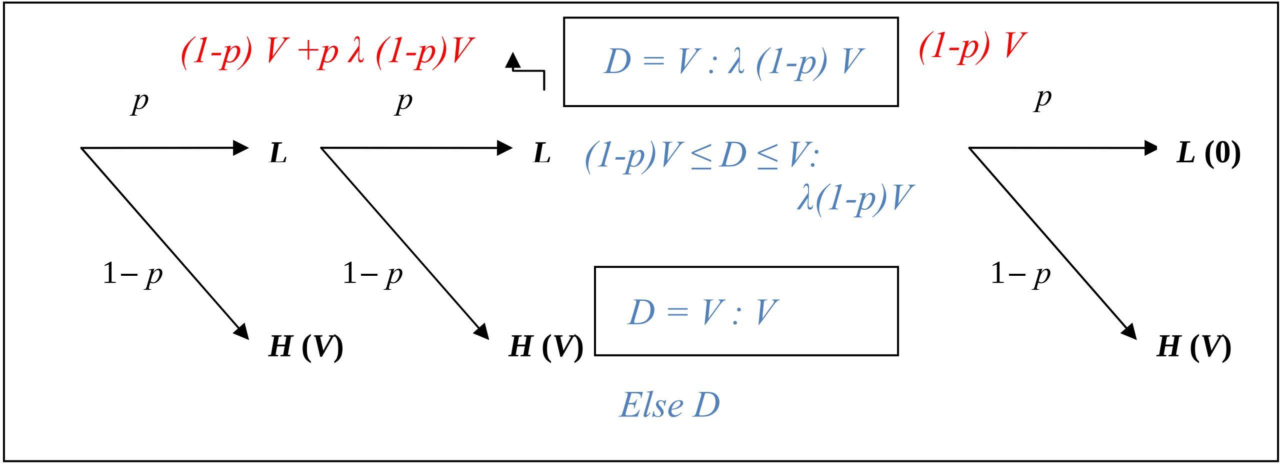


Figure 3c: Pessimistic information structure

Debt capacity B_n^1 in the pessimistic case

- Again, debt capacity at last rollover depends on whether $D > V$ or $D < V$:

$$\max\{(1-p)\lambda V, (1-p)D\}.$$

- Setting $D = V$ maximizes the debt capacity to $B_N^1 = (1-p)V$.

- Working backwards, debt capacity in the ante-penultimate period is

$$\begin{cases} (1-p)\lambda V + p\lambda B_N^1 & \text{if } D > V \\ (1-p)D + p\lambda B_N^1 & \text{if } B_N^1 < D \leq V \\ D & \text{if } D \leq B_N^1. \end{cases}$$

- Since $V > B_N^1$, debt capacity is maximized by setting $D = V$.
- In turn, the maximum value of the debt is

$$B_{N-1}^1 = (1-p)V + p\lambda(1-p)V$$

Debt capacity B_n^1 in the pessimistic case (Cont'd)

- Note the contrast with the optimistic case:

$$B_{N-1}^1 = (1-p)V + p\lambda(1-p)V$$

$$B_{N-1}^2 = (1-p)V + p(1-p)V$$

- The difference arises because in the pessimistic case, debt capacity is maximized by setting $D = V > B_N^1 = (1-p)V$.

- Setting D equal to B_N^1 produces no additional benefit from the state with good news ($V > B_N^1$).

- This tradeoff results in default and liquidation due to rollover risk in the pessimistic case, but not in the optimistic case.

Main result

- By induction, debt capacity in the pessimistic case with n rollovers:

$$B_n^1 = \left(\sum_{i=0}^{N-n} p^i \lambda^i \right) (1-p)V.$$

- Next, hold constant the total credit risk p^{N+1} as we vary n, to say p' (equal to $1 - q^{N+1}$).

- Question: What is B_0^1 as $N \to \infty$ (or $\tau \to 0$)?

- "Market freeze": As $N \to \infty$, $(1-p) \to 0$ so that $B_0^1 \to 0$ too.

$$B_0^1 \le (1-p)V \sum_{i=0}^{\infty} p^i \lambda^i = (1-p)V \frac{1}{1-p\lambda} \le \frac{1}{1-\lambda}(1-p)V.$$

Intuitive sketch of the market freeze

- In the pessimistic case, things are going to get worse unless "good news" arrives.
- When the rate at which good news is rationally expected to arrive is much slower than the rollover rate,
  - Borrower anticipates that he will still be in the pessimistic scenario with probability close to one at the next rollover.
  - Then, debt capacity today $\approx$ debt capacity tomorrow.
  - As the final rollover date approaches, the fundamental value of the assets is zero.
  - By backwards induction, the debt capacity at any preceding date is close to zero as well.
- Similar argument in the optimistic case leads to opposite result:
  - Fundamental value – and hence the debt capacity – increases over time as the maturity date is approached in the optimistic case.

Critical drivers of the freeze

- Pessimistic expectations or information structure.
  - Optimistic case (Figure 2) leads to debt capacity equal to expected cash flows regardless of rollovers.
  - Adverse dynamic arises *only* in the pessimistic case (Figure 3).
- Rollover risk.
  - Buy-to-hold financing has same debt capacity, regardless of the information structure.
- Liquidation cost.
  - If $\lambda = 1$, there is no rollover risk.
- Credit risk.
  - Is of course the central assumption, but its magnitude is not the critical factor affecting the freeze.

Formula for haircuts

- "Haircut" defined as debt capacity of the asset relative to its fundamental value or buy-and-hold debt capacity.

- Haircut is zero under the optimistic case: "normal" times.

- In the pessimistic case, as long as $p' > 0$ and $\lambda < 1$, the haircut of an asset is strictly positive:

$$H_0 = 1 - \frac{1-p}{1-p'}\left(\sum_{i=0}^{N} p^i \lambda^i\right),$$

- The haircut approaches 100% as its rollover risk N becomes unbounded as long as $\lambda < 1$.

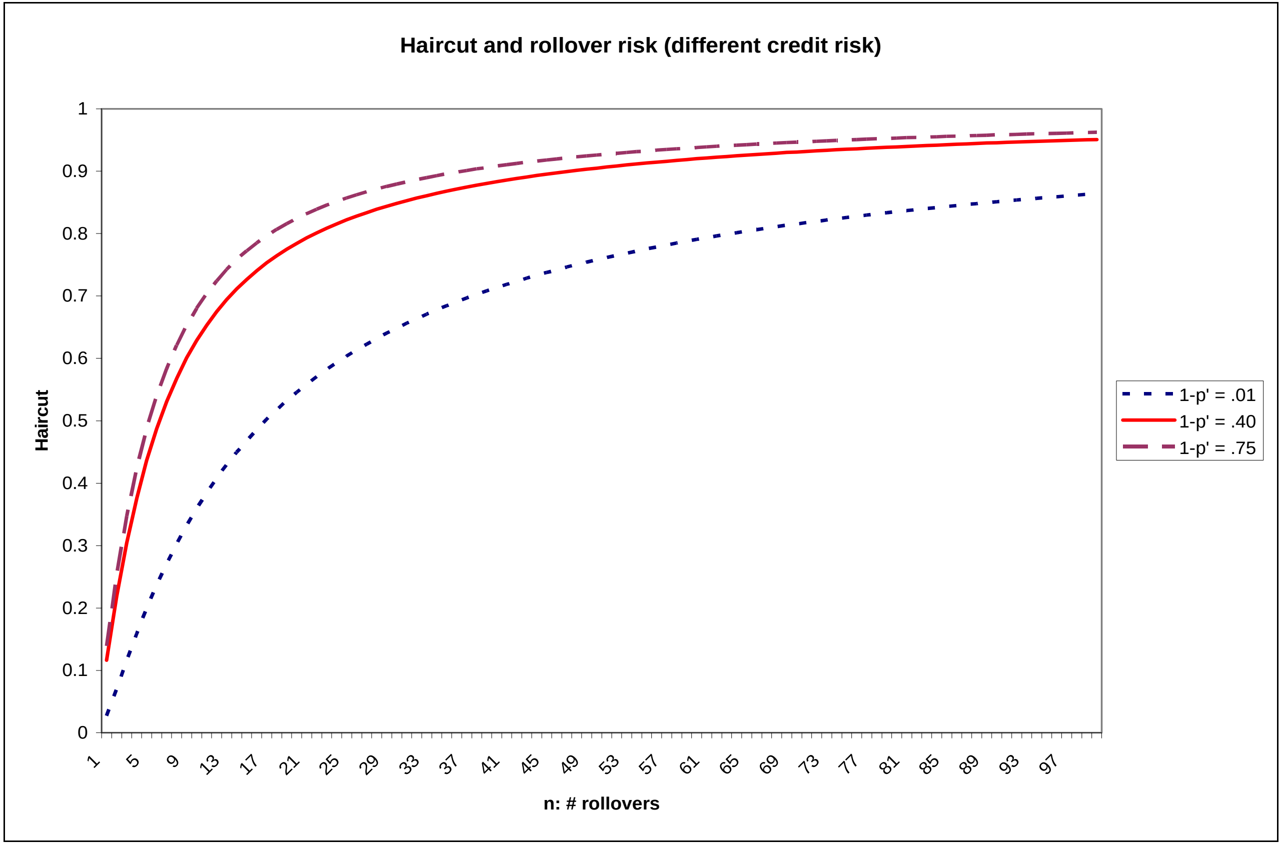


Figure 6a: Haircut as a function of *n* for different levels of credit risk (1-*p'*) for $\lambda = 0.7$.

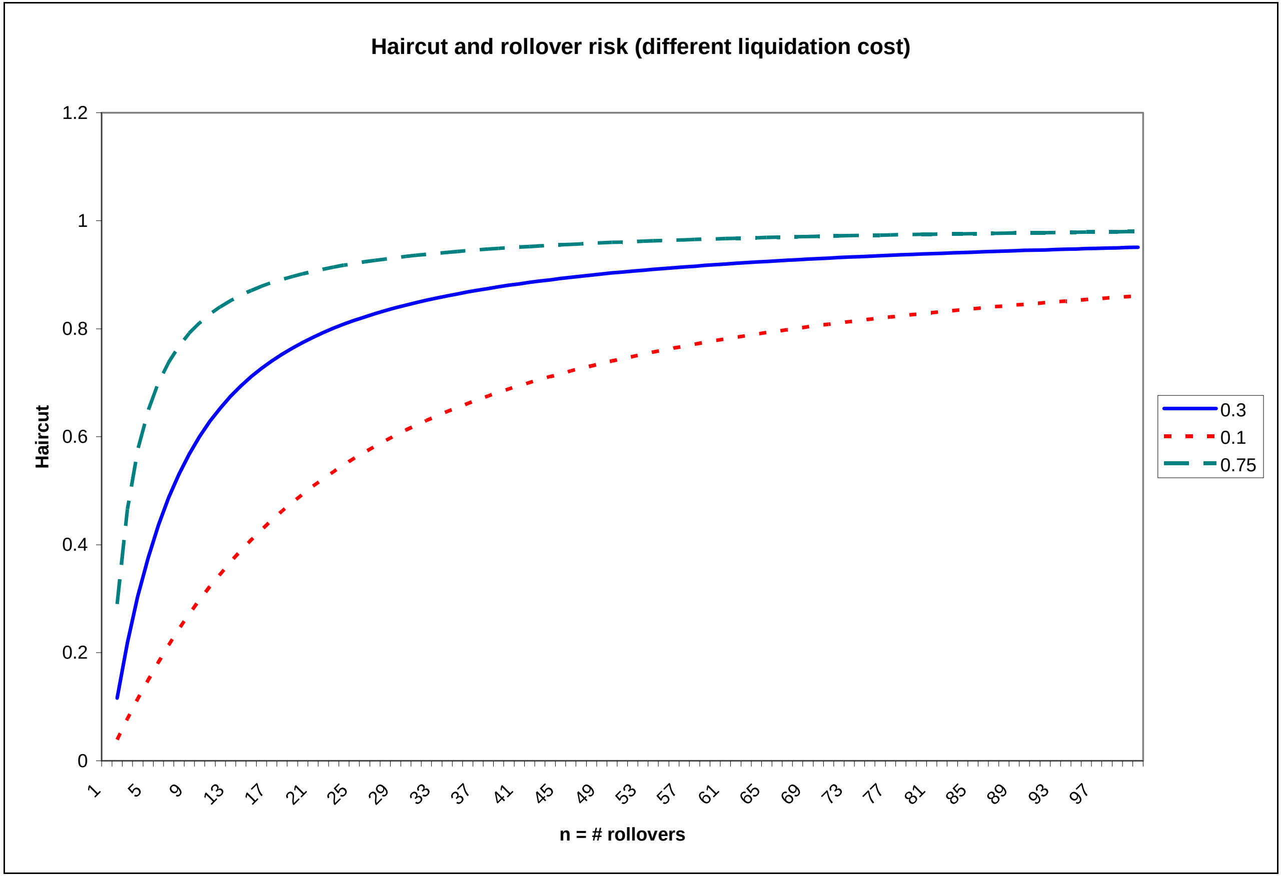


Figure 6b: Haircut as a function of *n* for different levels of liquidation risk (1-λ) for *p'*= .60.

Related literature

- Rosenthal and Wang (1993):
  - Backward induction works through adverse selection at each point.
  - Our model better captures the observed pattern of haircuts.
- Huang and Ratnovski (2008):
  - Wholesale financiers rely on imprecise public signals.
  - Focus is on inefficient runs rather than rollover and liquidation risks.
- He and Xiong (2009):
  - Dynamic bank runs with multiple maturities of debt.
  - Each rollover faces the risk of higher future uncertainty.
  - Both level and uncertainty are constant in our model but the nature of temporal resolution of uncertainty changes.
- Knightian uncertainty: Knight (1921), Gilboa-Schmeidler (1989), Dow-Werlang (1992), Routledge-Zin (2004), Easley-O'Hara (2005), Caballero-Krishnamurthy (2007), . . .
  - Short-term debt, rollover risk, liquidation risk, . . . ?

Conclusions

- A model of market freezes and haircuts in secured borrowing:
  - Rollover risk.
  - Liquidation risk.
  - (Switch in) Information structure or investors' expectations.
- Delay in arrival of information which keeps financiers of short-term debt *"waiting for good news"* may explain why in response to events that people have not witnessed before, for example, the LTCM collapse, sub-prime losses, etc., short-term debt markets freeze.
- Policy implications: lending against illiquid collateral, long-term capital versus rollover debt.
- Future work:
  - Embed agency-theoretic micro-foundation for short-term debt.
  - Strategic disclosure of information.