Asset Market Liquidity and Crisis

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1 Facts about Liquidity Crisis (2008-2009)

Asset markets became illiquid

- Stock market liquidity (similar patterns hold for corporate bond)

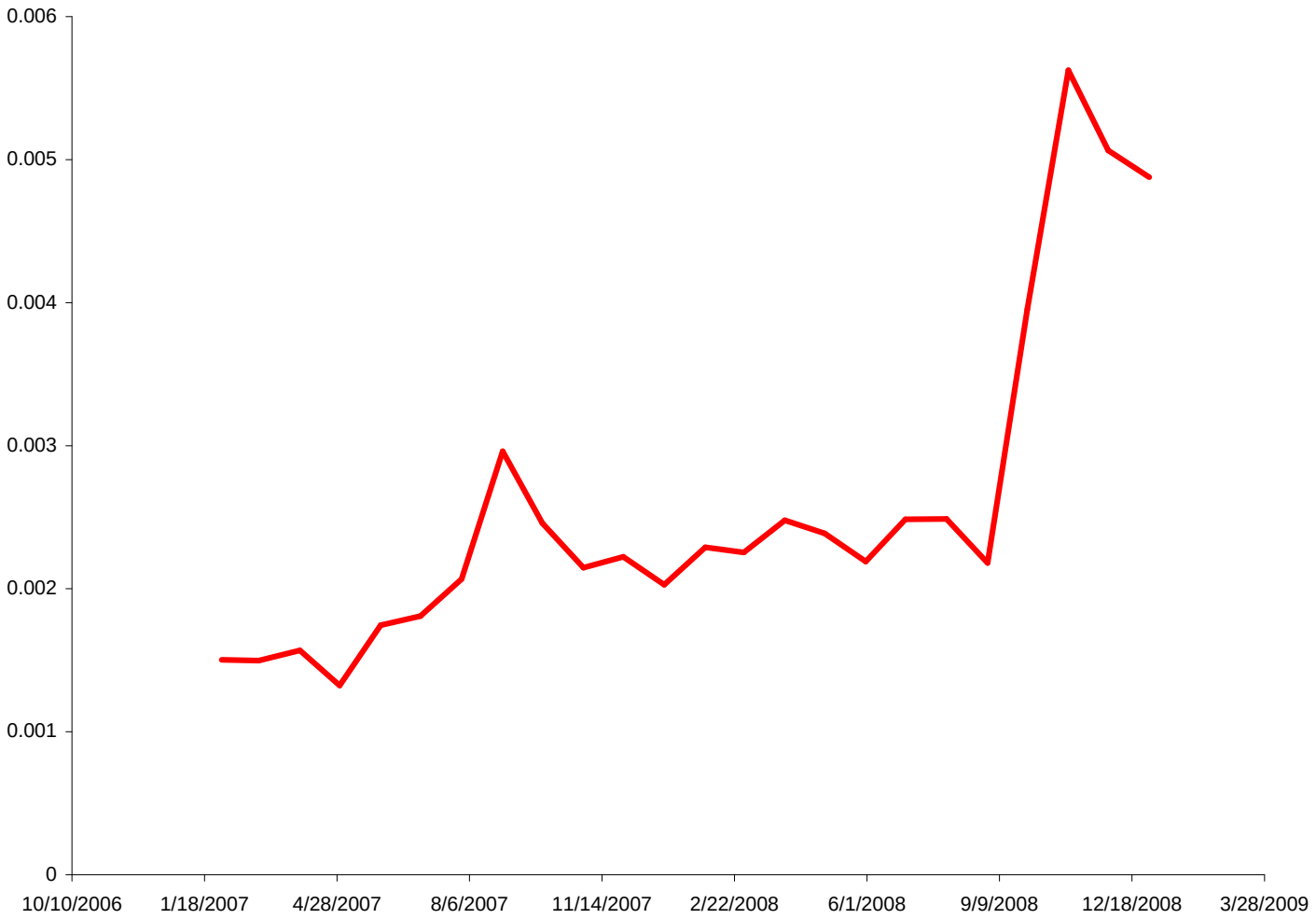


Figure 1: NYSE Bid-Ask Spread (Source[3]: Randi Næs, Johannes A. Skjeltorp and Bernt Arne Ødegaard, 2010)

- Profit of liquidity provision increases during crisis.

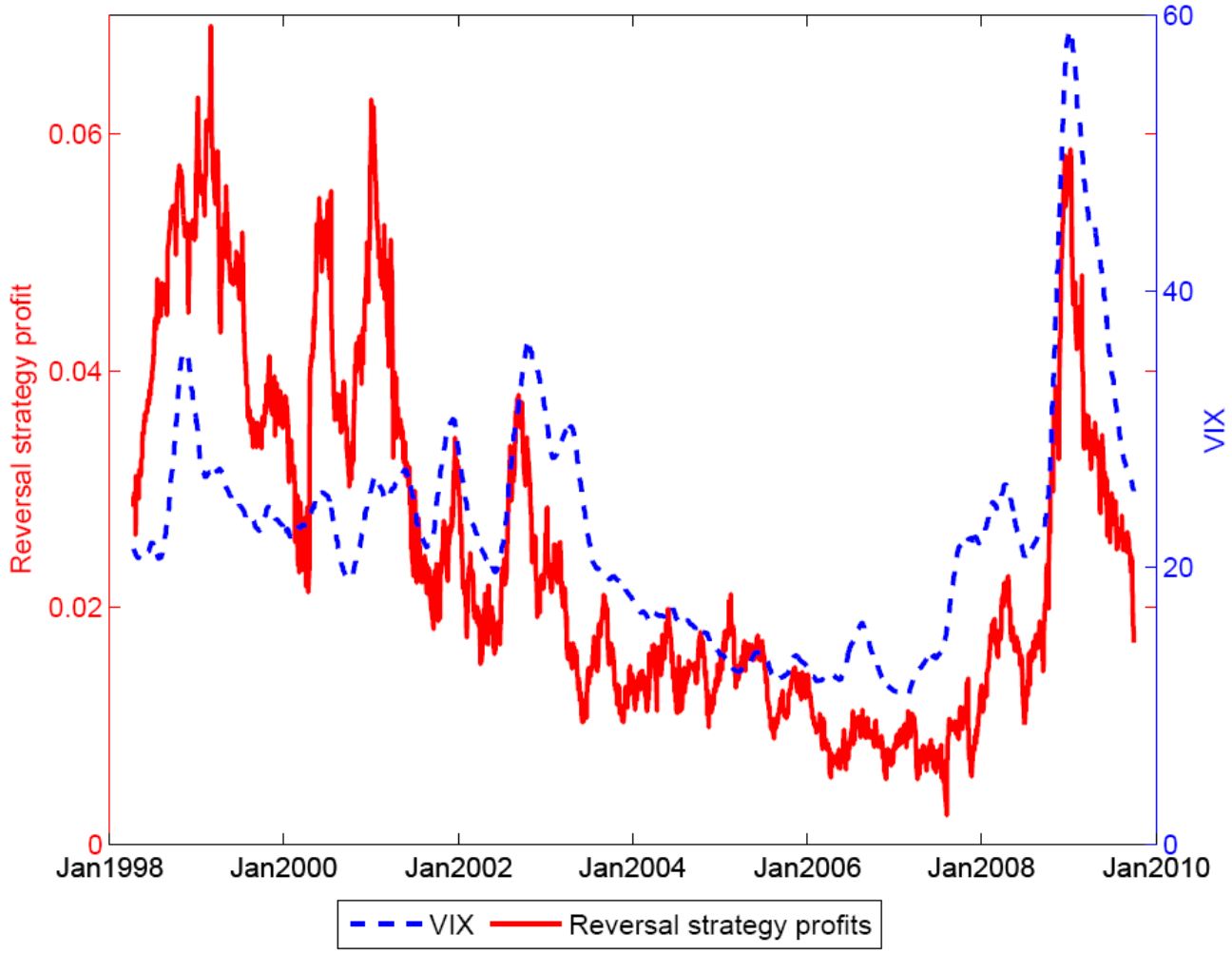


Figure 2: 3-Month Moving Average of Daily Reverse Strategies Profits (Source: Nagel, 2010)

Collateralized funding liquidity dried up since September 2008.

- Size of Repurchase Agreement Market

Figure 3: Outstanding Amount of Primary Dealer Repurchase Agreements in Millions of Dollars (Source: Federal Reserve Bank of New York).

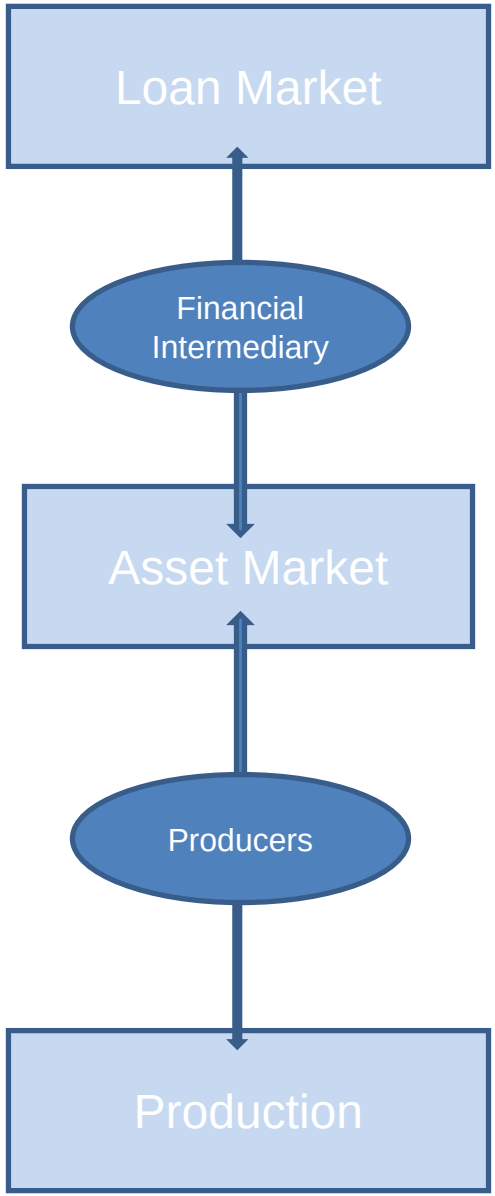
Real GDP Growth Slumped

Question: Why did asset market liquidity dry up in the crisis? how did financial and real sectors mutually affect each other through asset market liquidity?

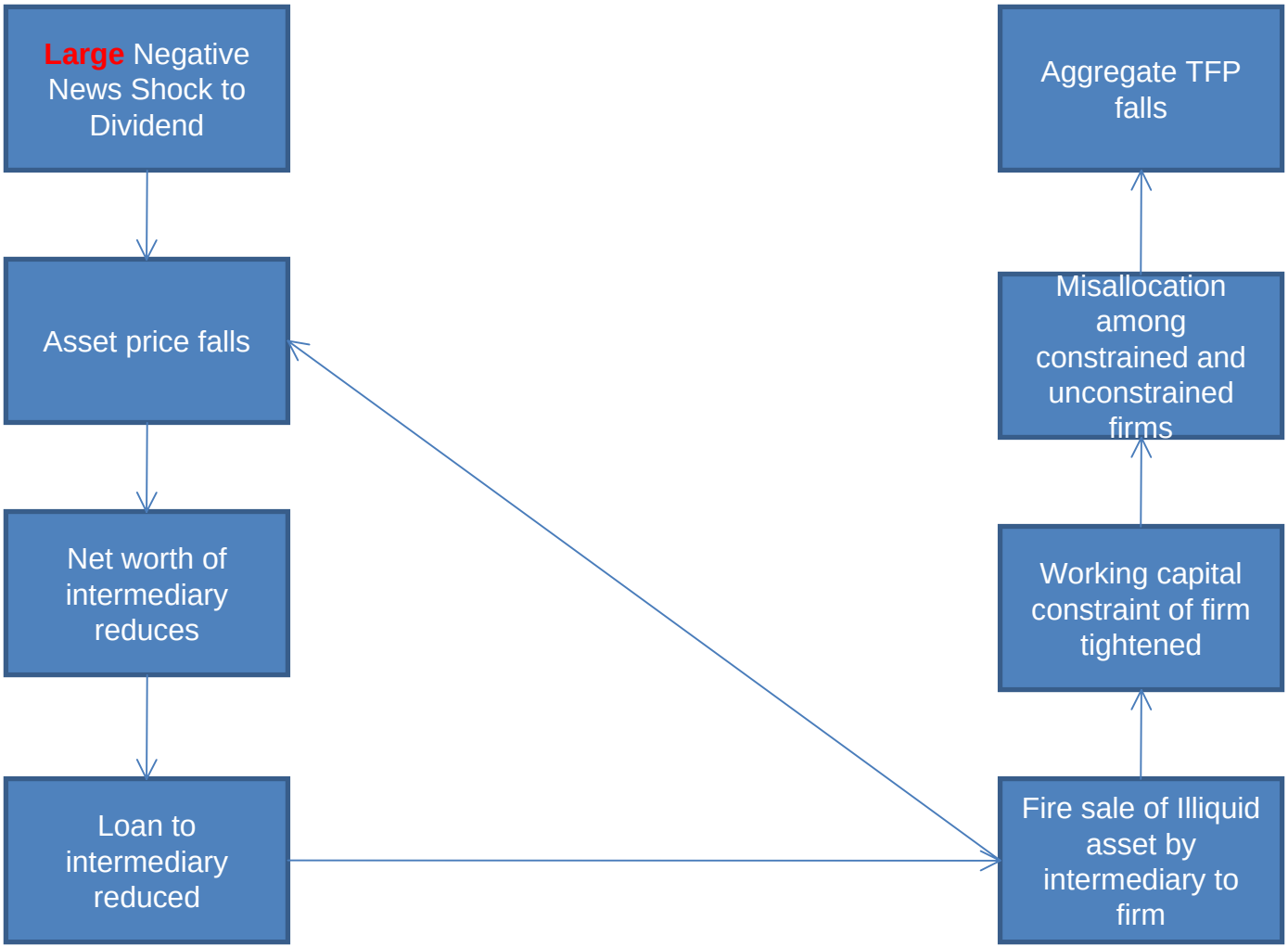
This Paper: A Theory of Asset Market Liquidity and Crisis

- Building Blocks
  - Financial intermediary: financing the purchase of security with collateralized borrowing $\Longrightarrow$ positive comovement between security price and the intermediary's demand for security.
  - Financially constrained entrepreneur: working capital financed by cash in hand, which comes from money accumulated last period and selling of security before production takes place $\Longrightarrow$ downward-sloping demand curve for security.
  - Unconstrained entrepreneur, which presence allows for misallocation of resources and the associated TFP fluctuations.

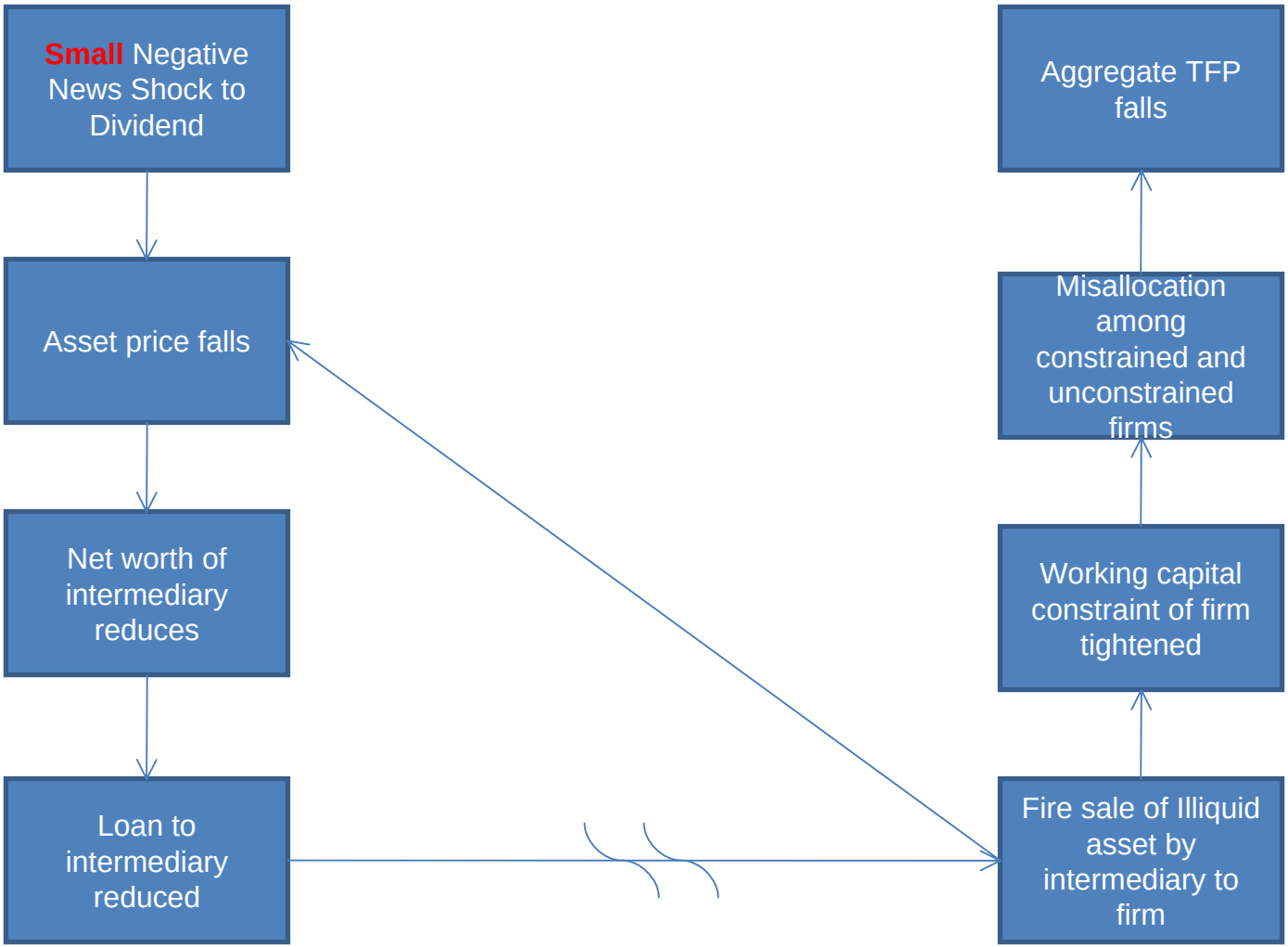
- Markets Structure


Loan Market
Financial Intermediary
Asset Market
Producers
Production

Mechanism of the Model (1)



Mechanism of the Model (2)



Main Results

Case 1: large negative shocks to dividends

- Asset market: liquidity premium jumps up and security price falls drastically.
- Financial sector: financial intermediary shifts its portfolio from security to money, i.e. "Flight to Liquidity".
- Real sector: labor is reallocated from constrained to unconstrained entrepreneur and TFP falls.

Case 2: small negative shocks to dividends

- Asset market: security price falls modestly.
- Financial sector: no portfolio shift.
- Real sector: no change in resource allocation and aggregate TFP.

Evidence Linking Funding and Market Liquidity

- Market liquidity dries up following large stock market declines, and this negative effects of market returns on liquidity is larger when financial intermediaries are more likely to face funding constraints. (Hameed, Kang and Viswanathan, 2010).

- Market liquidity declines at times of low funding liquidity, which happens after negative market returns. (Comerton-Forde, Hendershott, Jones, Moulton and Seasholes, 2008)

- Fire sale at a time when traders facing tightening capital constraint. (Mitchell, Pederson and Pulvino, 2007 show that convertible hedge funds, which provide liquidity in normal times, were forced to liquidate their convertible bond positions due to binding capital constraints)

Evidence Linking Liquidity and Business Cycles

- Roles of funding liquidity: fluctuations in the balance sheets of financial intermediaries constrain strong predictive power for future excess returns and real economic activity and various measures of inflations (Adrian, Moench, Shin, 2009)

- Roles of market liquidity: stock market liquidity is very informative of future macro fundamentals (Randi Næs, Johannes A. Skjeltorp and Bernt Arne Ødegaard, 2010)

- Theory on financial intermediation and macroeconomy
  - Gertler and Kiyotaki (2010) and Brunnermier and Sannikov (2010)
  - Both papers consider the effects of disruption in financial sector on credit supply to the real economy;
  - Our paper focus on the corresponding effect on asset market illiquidity, and the roles of asset market liquidity on both the funding shortage in financial sector and the production in real sector.

- Theory on aggregate liquidity demand and liquidity premium (Kiyotaki and Moore, 2008 and Eisfeldt and Rampini, 2009)
  - In Kiyotaki and Moore (2008), market liquidity is specified as shocks and unrelated to funding liquidity.
  - In Eisfeldt and Rampini (2009), only funding liquidity is incorporated.
  - Both papers focus on financing frictions in the real sector.
  - We explicitly model time variations in market liquidity in response to funding liquidity shortage in the financial sector.

- Theory on liquidity crisis
  - Shleifer and Vishney (1992, 1997): fire sales because others traders experience similar funding problems.
  - Brunnermier and Pederson (2005, 2008): anticipated worsening of counterparty funding problem.
  - These papers are silent on the real economy and thus the linkage between financial crisis and business cycles.

2 The Model

- Workers: A representative worker supplies one unit of labor inelastically.
  - The worker does not save.

- Entrepreneurs: Two risk-neutral entrepreneurs with linear utility, $i = 1, 2$.

$$U^i = \sum_{t=0}^{\infty} \beta^t C_t^i.$$

- Production technology:

$$Y_t^i = A^i \left(L_t^i\right)^{1-\alpha}.$$

Two Types of Assets

- Money: One unit of money at period t can be converted into $1/P_t$ units of consumption goods.

- Security: We assume that a Lucas tree that bears fruits each period. Agents trade the share of the tree.

  – The dividend of the tree here is exogenous to the economy. Holding S_t units of the security at the beginning of period t can get a return of $S_t \cdot V_t$ units of consumption goods.

  – Market for security opens each period before the production takes place.

Budget and CIA Constraints for the Entrepreneurs

- A cash-in-advance constraint, $a\ la$ Cooley-Hansen (1995), for purchasing long-run assets:

$$P_t^S S_{t+1}^i \leq M_t^i + P_t S_t^i V_t + P_t^S S_t^i. \tag{1}$$

- Budget constraint:

$$P_t C_t^i = M_t^i + P_t S_t^i V_t + P_t^S \left(S_t^i - S_{t+1}^i\right) + P_t A^i \left(L_t^i\right)^{1-\alpha} - W_t L_t^i - M_{t+1}^i, \tag{2}$$

- Note that if (1) is binding, (2) reduces to

$$P_t C_t^i = P_t A^i \left(L_t^i\right)^{1-\alpha} - W_t L_t^i - M_{t+1}^i.$$

Working Capital Constraint

- For Entrepreneur 1, working capital is required to pay the wage bill before production takes places. Working capital can be financed from two channels: (i) using money accumulated last period; (ii) selling security in hand. The working capital constraint is

$$W_t L_t^1 \leq M_t^1 + P_t S_t^1 V_t + P_t^S \left(S_t^1 - S_{t+1}^1 \right). \tag{3}$$

- For Entrepreneur 2, no working capital is needed.

- Entrepreneur 1 and 2 will be referred to as the financially constrained and unconstrained entrepreneur, respectively.

The Financially Constrained Entrepreneur's Problem

- Using the budget constraint to substitute out C_t^1, we can write the problem as

$$\max_{\left\{S_{t+1}^1, M_{t+1}^1, L_t^1\right\}_{t=0}^{\infty}} E \sum_{t=0}^{\infty} \beta^t \left(\begin{array}{c} \frac{M_t^1}{P_t} + S_t^1 V_t + \frac{P_t^S}{P_t}\left(S_t^1 - S_{t+1}^1\right) \\ +A^1 \left(L_t^1\right)^{1-\alpha} - \frac{W_t}{P_t} L_t^1 - \frac{M_{t+1}^1}{P_t} \end{array} \right)$$

  subject to the working capital constraint (3) and the budget constraint (2) .

- Here we assume that the working capital constraint (3) is always binding for any t.
  - Then, the CIA constraint (1) must not be binding.

The First-Order Conditions

- L_t^1 :

$$(1-\alpha)\, A^1 \left(L_t^1\right)^{-\alpha} = \frac{W_t}{P_t}\,(1+\lambda_t)\,, \tag{4}$$

- S_{t+1}^1 :

$$\frac{P_t^S}{P_t}\,(1+\lambda_t) = \beta \left(V_{t+1} + \frac{P_{t+1}^S}{P_{t+1}}\right)(1+\lambda_{t+1})\,, \tag{5}$$

- M_{t+1}^1 :

$$\frac{1}{P_t} = \beta \frac{1}{P_{t+1}}\,(1+\lambda_{t+1})\,. \tag{6}$$

Liquidity Premium

- By (6), we know that the (real) return of money is

$$\frac{P_t}{P_{t+1}} = \frac{1}{\beta\left(1+\lambda_{t+1}\right)}.$$

- A combination of (5) and (6) yields the nominal return for the security:

$$\frac{P_{t+1}V_{t+1} + P_{t+1}^S}{P_t^S} = 1 + \lambda_t. \tag{7}$$

- The liquidity premium is defined as the *real* return of security relative to its counterpart for money, which is $1 + \lambda_t$.

The Financially Unconstrained Entrepreneur

- Using the budget constraint to substitute out C_t^2, we can write the problem as

$$\max_{\left\{S_{t+1}^2, M_{t+1}^2, L_t^2\right\}_{t=0}^{\infty}} E \sum_{t=0}^{\infty} \beta^t \left(\begin{array}{l} \frac{M_t^2}{P_t} + S_t^2 V_t + \frac{P_t^S}{P_t}\left(S_t^2 - S_{t+1}^2\right) \\ +A^2 \left(L_t^2\right)^{1-\alpha} - \frac{W_t}{P_t} L_t^2 - \frac{M_{t+1}^2}{P_t} \end{array} \right),$$

subject to the CIA constraint (1) and the budget constraint (2).

The Financial Intermediary

- There is a representative financial intermediary, which we call "bank".
  - The bank has the access to the collateralized loan market for raising funds, B_{t+1}, at the gross interest rate of R.

- The CIA constraint for the bank is

$$P_t^S S_{t+1} \leq M_t + P_t S_t V_t + P_t^S S_t - RB_t + B_{t+1}. \tag{8}$$

- The collateralized borrowing constraint is

$$RB_{t+1} \leq \theta P_{t+1}^S S_{t+1}. \tag{9}$$

The Financial Intermediary's Problem

$$\max \sum_{t=0}^{\infty} \beta^t C_t$$

subject to (8) and (9) and

$$\begin{aligned} P_t C_t &= M_t - RB_t + B_{t+1} + P_t S_t V_t + P_t^s \left(S_t - S_{t+1}\right) - M_{t+1} && (10) \\ M_{t+1} &\geq 0 && (11) \\ S_{t+1} &\leq \bar{S} && (12) \end{aligned}$$

where (10) is the budget constraint, (11) is the non-negative constraint for money holding and (12) the upper bound constraint for security holding.

Primitive Shocks

- In our model, fluctuations in security price stem from both expected changes in future fundamentals and variations in asset market liquidity, that is, the deviation of security price from its fundamentals.

- Our focus is fluctuations in security prices due to variations in asset market liquidity.

- News shock on future dividend

$$\log V_{t+1} = (1-\rho)\log \overline{V} + \rho \log V_t + \epsilon_t$$

Timing at Each Period

- At the beginning of each period, current dividend V_t is realized.
- News about next-period dividend V_{t+1} arrives.
- Security market opens. The bank borrows in the collateralized loan market to finance the purchase of security.
- Production takes places.
- Agents consume and save in money.

Equilibrium

Definition 1 *Given interest rate R, a competitive equilibrium for this economy consists of allocation $\left\{C_t^i, L_t^i, S_{t+1}^i, M_{t+1}^i\right\}_{i=1,2;t=0}^{\infty}$ for entrepreneurs, allocation $\left\{C_t, B_{t+1}, S_{t+1}, M_{t+1}\right\}_{t=0}^{\infty}$ for the financial intermediary and prices $\left\{W_t, P_t, P_t^S\right\}_{t=0}^{\infty}$, such that*

(i) Given $\left\{W_t, P_t, P_t^S\right\}_{t=0}^{\infty}$, the allocation $\left\{C_t^i, L_t^i, S_{t+1}^i, M_{t+1}^i\right\}_{t=0}^{\infty}$ solves agent $i's$ problem as defined above.

(ii) Given R and $\left\{W_t, P_t, P_t^S\right\}_{t=0}^{\infty}$, the allocation $\left\{C_t, B_{t+1}, S_{t+1}, M_{t+1}\right\}_{t=0}^{\infty}$ solves the financial intermediary's problem.

(iii) All markets clear.

1. *Real wage* $\frac{W_t}{P_t}$ *satisfies labor market clearing condition:*

$$L_t^1 + L_t^2 = 1. \tag{13}$$

2. P_t *satisfies money market clearing condition:*

$$M_{t+1}^1 + M_{t+1}^2 + M_{t+1} = 1. \tag{14}$$

3. P_t^S *satisfies security market clearing condition:*

$$S_{t+1}^1 + S_{t+1}^2 + S_{t+1} = \bar{S}. \tag{15}$$

3 Results

Assumption 1 $\beta R < 1$.

- Assumption 1 makes sure that at steady state, the borrowing constraint for the bank is always binding.
  - This is because at steady state the nominal return for the security, $1/\beta$, is larger than the cost of borrowing, R.
- As a result, the security demand by the bank at steady state is binding at the upper bound ($S^* = \overline{S}$).
- And the bank tries to borrow as much as possible to finance the security purchase.

Proposition 1 *Given assumption 1, at steady state, the CIA constraint for the bank is not binding, whereas the bank's non-negative constraint for money is binding.*

- If R is sufficiently low, the dividend of security is more than to cover the net interest payment. As a result, the CIA constraint for the bank is not binding.

- Since money does not pay dividend, the bank will decumulate money to its lower bound, 0 for current consumption. (Since CIA is not binding, the only role of money is consumption smoothing).

- The bank has idle resources, which he would like use to purchase additional security. However, the upper bound of equity holding prevents him from spending up all the resources on security purchase.

Characterization of Asset Allocation at Steady State

- Money: $M^{1*} = 1$; $M^{2*} = M^* = 0$.
- Security: $S^* = \overline{S}$; $S^{1*} = S^{2*} = 0$.
- Hence, at steady state, the bank holds illiquid asset, which returns is higher than that of liquid asset, money.
  - The bank finances illiquid asset purchase by short-term collateralized borrowing.
- Money (liquid asset), by contrast, is held by the constrained entrepreneur to finance working capital.

- Given $S^{1*} = 0$, a news shock to dividend has no *direct* impact on the tightness of the working capital constraints and, thus, current production in the real sector.

Impulse Response to a Negative News Shock to Dividend

- figures to be added

Intuition

- In both cases, an expected fall in future dividend reduces the demand for security by both entrepreneurs and the bank due to consumption smoothing.
  - This results in an initial fall in security price.

Case 1: Small News Shocks to Dividend

- The initial fall in security price is small.
- Accordingly, the fall in net worth of the bank is so small that the remaining net worth is still more than enough to cover the downpayment of existing security holdings.
- There is no need for the bank to reduce his security demand and to increase money holdings.
- As a result, there is no change in the portfolio of the constrained entrepreneur.

- Hence no impact on the working capital constraint and labor allocation in the real sector.

Case 2: Large News Shocks to Dividend

- The initial fall in current security price is large.
- The fall in the bank's net worth is so large that the bank's CIA constraint starts to be binding.
- As a result, the bank has to cut his demand for security and starts to increase money holdings.
- The constrained entrepreneur is forced to purchase security with money, resulting in an even lower security price and higher liquidity premium.

- The working capital constraint is tightened and labor is reallocated from constrained to unconstrained entrepreneur. Aggregate TFP falls.

Implications for the Monetary Policy

- The central bank can step in the collateralized loan market (money market) to purchase the security from the bank and later on sell it back (reverse repo). This helps to relax the borrowing constraint of the bank.

- Alternatively, the central bank can advance unsecured loan to the bank.

Conclusion

- In our theory, market liquidity dried up following a large negative news shock to future dividend. This shows up as a large negative deviation of security price from its fundamentals and a sharp increase in liquidity premium.

- This fall in market liquidity amplifies the funding shortage in the financial sector, triggering even more fire sale of security by the bank.

- The constrained entrepreneur, in spite of a lower demand for security due to tightening working capital constraint, has to purchase security with money.

  - This result in a further cut of the security prices and a jump in liquidity premium.

- Asset market illiquidity, therefore, reinforces with funding shortage in the financial sector and productivity fall in the real sector during a crisis.