Monetary Economics

Lecture 21: financial market frictions, part three

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This lecture

- Macroeconomics with financial market frictions, part three

- Credit rationing, lemons problems, volatility and collateral etc

  ◇ Brunnermeier, Eisenbach and Sannikov "Macroeconomics with financial frictions: a survey," NBER working paper, 2012

    sections 3.1–3.2

  ◇ Stiglitz and Weiss "Credit rationing in markets with imperfect information," *American Economic Review*, 1981

  ◇ Brunnermeier and Pedersen "Market liquidity and funding liquidity," *Review of Financial Studies*, 2009

Readings available from the LMS

Context

- Agency cost models:

  Constraints on (debt, equity) *mix* of experts and premia for external funds

  But no constraints on access to debt *per se*, no quantity rationing

- Now consider models with explicit credit rationing

  What are the interactions between asset volatility and credit rationing?

This lecture

1- Stiglitz and Weiss (1981, AER) model of credit rationing due to adverse selection

- asymmetric information about asset volatility
- equilibria with excess demand for loans
- higher interest rates make pool of loan applicants worse

2- Brunnermeier and Pedersen (2009, RFS) model of credit rationing and asset price volatility

- asset price volatility tightens credit constraints
- and tighter credit constraints amplify asset price volatility

Stiglitz/Weiss

- Entrepreneurs borrow from lenders in competitive market with interest rate r

- Entrepreneurs are *heterogeneous in riskiness* σ of their project. Project return R has conditional distribution

  $$R \sim G(R \,|\, \sigma) \equiv \text{Prob}[R' \leq R \,|\, \sigma], \text{ with } \mathbb{E}[R] = \mu \text{ for all } \sigma$$

  and

  $$\text{if } \sigma' > \sigma \text{ then } G(R \,|\sigma') \text{ is a } \textit{mean-preserving spread} \text{ of } G(R \,|\, \sigma)$$

- Distribution of entrepreneur types $F(\sigma) \equiv \text{Prob}[\sigma' \leq \sigma]$ is known. But individual entrepreneur's type is *private information*

Payoffs

- Entrepreneur with project R and loan B at interest r has payoff

$$\pi_e(R, r) = \max \left[R - (1 + r)B \, , \, 0 \right]$$

- Lender then has payoff

$$\pi_l(R, r) = \min \left[R \, , \, (1 + r)B \right]$$

- Crucially, $\pi_e(R, r)$ is *convex in R* while $\pi_l(R, r)$ is *concave in R*

- Implies different attitudes to gambles over R

Expected payoffs

- Expected payoff to entrepreneur of type σ

$$\int \pi_e(R, r)\, dG(R \,|\, \sigma)$$

Since $\pi_e(R, r)$ is convex in R, this is *increasing in σ*

- Expected payoff to lender from lending to this entrepreneur

$$\int \pi_l(R, r)\, dG(R \,|\, \sigma)$$

Since $\pi_l(R, r)$ is concave in R, this is *decreasing in σ*

Screening and adverse selection

- For given interest rate r, only entrepreneurs with σ such that

$$\int \pi_e(R, r)\, dG(R \,|\, \sigma) > 0$$

will apply for loans

- Since expected payoff is increasing in σ there is $\sigma^*(r)$ such that

$$\int \pi_e(R, r)\, dG(R \,|\, \sigma^*) = 0$$

and all $\sigma < \sigma^*(r)$ do not apply for loans at r. The interest rate r acts as a *screening device*

- Since $\pi_e(R, r)$ is decreasing in r, $\sigma^*(r)$ is *increasing in r*

Screening and adverse selection

- Pool of applicants changes as r increases (*selection*)

- In fact, pool of applicants becomes worse, $\sigma^*(r)$ increases in r (*adverse selection*)

- Increasing r has two effects on lender's expected payoff (i) direct profitability effect, and (ii) indirect adverse selection effect

Lender's problem

- Choose interest rate r to max

$$\rho(r) \equiv \int_{\sigma^*(r)}^{\infty} \left[\int \pi_l(R, r)\, dG(R \,|\, \sigma) \right] dF(\sigma)$$

subject to $\sigma^*(r)$ such that

$$\int \pi_e(R, r)\, dG(R \,|\, \sigma^*) = 0$$

- Direct effect of higher r is to increase expected payoff

- Indirect effect of higher r is to make pool of applicants worse (higher $\sigma^*(r)$), this increases riskiness of loan portfolio and decreases expected payoff

- Net effect is in general ambiguous

Credit rationing

- If $\rho(r)$ is *non-monotone in r*, then straightforward to construct examples of *equilibrium credit-rationing*

- Let r^* maximize $\rho(r)$. In such equilibria:

  - there is excess demand for loans, i.e., borrowers willing to pay more than r^* for loans

  - but lenders will not increase supply of loans since to do makes pool of applicants worse and reduces their expected payoff

  - that is, r^* does not equate demand and supply for loans

- In benchmark Stiglitz/Weiss model, lending is *not collateralized*

- With collateralized lending, extent of credit rationing depends on volatility of the *market value* of assets used as collateral

Brunnermeier/Pedersen

Key concepts:

- *Funding liquidity*: ease of raising funds by issuing claims to cash flows generated by collateral asset

  Margin lending is short term, margins adapted to conditions at high-frequencies

- *Market liquidity*: ease of raising funds by selling asset (as opposed to borrowing against it)

  Market liquidity low when selling asset depresses its price significantly. If so, costly to shrink balance sheet

Brunnermeier/Pedersen

- *Loss spiral*: due to leverage, loss net worth > loss gross worth

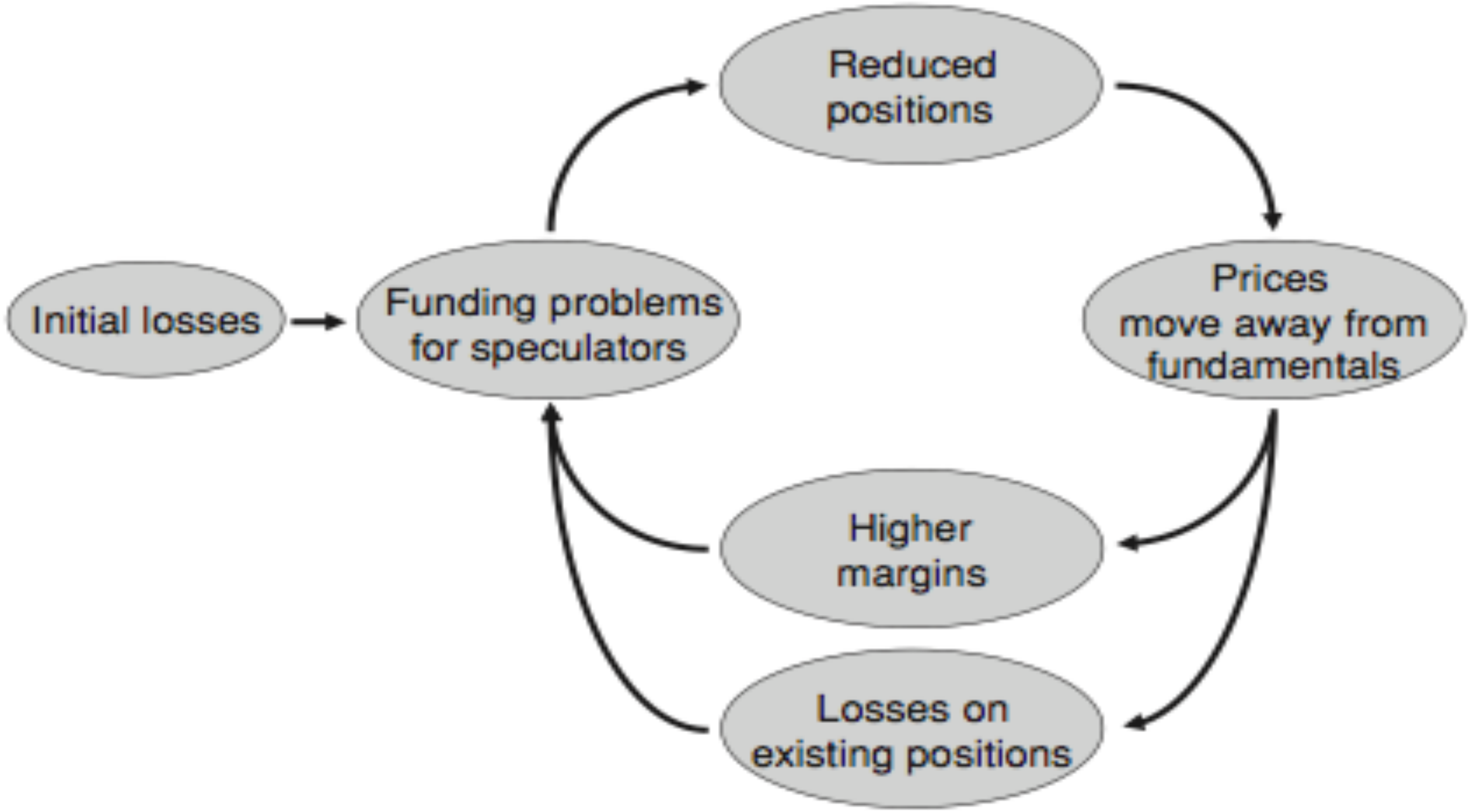
  (holding leverage ratio fixed)

- *Margin spiral*: as margins rise, need to sell even more

  (in other words, procyclical leverage ratio)

- Margin spiral reinforces the loss spiral

Margin spiral reinforces the loss spiral



Loss of net worth requires asset sales just to hold leverage constant. If in addition margins rise (leverage ratios fall), even more assets must be sold. This is particularly difficult at times of market illiquidity when selling assets quickly may involve large price reductions ('fire sales').

Stabilising vs. destabilising margins

- Why don't patient investors view low prices as opportunities to pick up good deals?

- If so, margins would be stabilising, i.e., would reward '*buy low, sell high*' strategies

- Can happen in principle, but destabilising effects if, for example,

  - unexpected price shocks predict higher future volatility, or

  - asymmetric information between outside investors and speculators

Model

- Single risky asset, traded at dates $t = 0, 1, 2, 3$

- Asset pays random v at terminal date. Let

$$v_t \equiv \mathbb{E}_t[v]$$

denote expected value conditional on date t information (fundamental value)

- Evolves according to *ARCH process*

$$v_t = v_{t-1} + \sigma_t \varepsilon_t, \qquad \sigma_{t+1} = \underline{\sigma} + \theta \left| \Delta v_t \right|$$

where $\varepsilon_t \sim$ IID and $N(0,1)$ and with parameters $\underline{\sigma}, \theta \geq 0$

Market participants

- Three kinds of market participants

(i)-(ii) customers and speculators (experts), who trade the asset
(iii) outside investors, who lend to the speculators

- Customers risk averse, types $k = 0, 1, 2$, vary in the timing of their need to trade (idiosyncratic endowment shocks)

- Speculators risk neutral, margin loans from investors backed by own wealth

Timing

- With probability $1 - a$ markets *function well*: all customers arrive together at initial date and there is efficient risk sharing

- With probability a, markets *function not-so-well*: customers arrive in sequential fashion

  - customer $k = 0$ arrives at $t = 0$, can only trade with speculators
  - customer $k = 1$ arrives at $t = 1$, can also trade with customer $k = 0$
  - customer $k = 2$ arrives at $t = 2$, now all customers in the market

- Early customer $k = 0$ trading accommodated by speculators

- At $t = 2$ all customers present, again have efficient risk sharing [solve model working backwards from this]

Margin constraints

- Speculators face *margin constraints*, for each period

$$(x_t^+ m_t^+ + x_t^- m_t^-) \leq W_t$$

- Backed by own wealth W_t

- Speculators have *long* positions x_t^+ and *short* positions x_t^-, with net position $x_t \equiv x_t^+ - x_t^-$

- Face margins m_t^+ and m_t^- on long and short positions

Margins and value-at-risk

- Margins set to cover outside investor π-value-at-risk

- Set m_t^+ to cover *price falls on long positions* up to probability π

$$\pi = \text{Prob}[\,-\Delta q_{t+1} \geq m_t^+ \,|\, \mathcal{F}_t\,]$$

(where $\mathcal{F}_t$ denotes the investors' information set)

- Set m_t^- to cover *price rises on short positions* up to probability π

$$\pi = \text{Prob}[\,+\Delta q_{t+1} \geq m_t^- \,|\, \mathcal{F}_t\,]$$

- Margins will tend to be greater when asset is more volatile

Informed vs. uninformed investors

- Two scenarios to be compared

(1) Investors are *informed*: know fundamentals, prices, shocks etc

$$\mathcal{F}_t = [v_0, \ldots, v_t, q_0, \ldots, q_t, \ldots]$$

(2) Investors are *uninformed*: only know prices

$$\mathcal{F}_t = [q_0, \ldots, q_t]$$

- Let $\Lambda_t \equiv q_t - v_t$ denote deviation of price from fundamental value

Margin setting and liquidity

- Since all customers in market at $t = 2$, $\Lambda_2 = 0$
- First consider *informed investors*. They know q_1, v_1 hence Λ_1
- Working backwards, they set margin on long positions by

$$\begin{aligned}\pi &= \text{Prob}[\,-\Delta q_2 \geq m_1^+ \,|\, \mathcal{F}_1\,] \\ &= \text{Prob}[\,-\Delta v_2 + \Lambda_1 \geq m_1^+ \,|\, \mathcal{F}_1\,]\end{aligned}$$

- Now recall that

$$\Delta v_t = \sigma_t \varepsilon_t, \qquad \sigma_{t+1} = \underline{\sigma} + \theta|\Delta v_t|$$

with $\varepsilon_t \sim N(0, 1)$

Margin setting and liquidity

- So invert this to get margin on long positions

$$m_1^+ = \overline{\sigma} + \overline{\theta}|\Delta v_1| + \Lambda_1$$

and similarly margin on short positions

$$m_1^- = \overline{\sigma} + \overline{\theta}|\Delta v_1| - \Lambda_1$$

- With parameters

$$\overline{\sigma} \equiv \underline{\sigma}\Phi^{-1}(1-\pi)$$

and

$$\overline{\theta} \equiv \theta\Phi^{-1}(1-\pi)$$

where $\Phi^{-1}(\cdot)$ denotes the inverse of the standard normal CDF

Stabilising margins

- Margins rising with volatility

  But with informed investors, the margins are *stabilising*

- Prices below fundamentals $q_1 < v_1$ (i.e., $\Lambda_1 < 0$), reduce margin on long position and increase margin on short position

  In short, reduced margins for speculators who buy low and sell high

- This is because speculators are expected to profit from reversion of prices to fundamentals $q_2 = v_2$ (i.e., $\Lambda_2 = 0$) at $t = 2$

- This expected profit from reversion to fundamentals *cushions* the speculators from losses due to volatility

- But this is not generally what we see happen in actual crises

Destabilising margins

- By contrast, consider *uninformed investors*

- In general, a difficult problem since need to filter out sequencing of customer arrivals and endowment shocks

- Obtain simple expression in limit as $a \to 0$ (that is, low likelihood of sequential trading 'shock')

$$m_1^+ = m_1^- = \overline{\sigma} + \overline{\theta}|\Delta q_1| = \overline{\sigma} + \overline{\theta}|\Delta v_1 + \Delta\Lambda_1|$$

- Margins are increasing in price volatility and market illiquidity $|\Delta\Lambda_1| > 0$ can increase margins

- Market illiquidity increases margins when $\Delta\Lambda_1$ has same sign as Δv_1, e.g., when bad news and selling pressure at the same time

- When this happens, margins are *destabilising*

Feedback to asset volatility

- Consider shock $\eta_1 < 0$ to speculator wealth at interim date $t = 1$. Effect on asset price is

$$\frac{\partial q_1}{\partial \eta_1} = \frac{1}{\frac{2}{\gamma \sigma_2^2} m_1^+ - x_0 + \frac{\partial m_1^+}{\partial q_1} x_1}$$

with key ingredients:

  - *slope of asset demand curve*, reflecting customer risk aversion (γ) and asset volatility (σ_2^2)

  - *loss spiral*, that is price falls are larger when speculators are initially long, $x_0 > 0$ (i.e., are levered)

  - *margin spiral*, if price declines leads to higher margins

$$\frac{\partial m_1^+}{\partial q_1} < 0$$

then further deleveraging amplifies initial loss spiral

Next lecture

- Macroeconomics with financial market frictions, part four
- Leverage cycles and heterogeneous beliefs
    - Brunnermeier, Eisenbach and Sannikov "Macroeconomics with financial frictions: a survey," NBER working paper, 2012

      section 3.3
    - Geanakoplos "Leverage cycles," *NBER Macro Annual*, 2009
    - Adrian and Shin "Liquidity and leverage," *Journal of Financial Intermediation*, 2010

Readings available from the LMS