Two-Period Version of Gertler-Karadi, Gertler-Kiyotaki Financial Friction Model

Lawrence J. Christiano


Motivation

• Beginning in 2007 and then accelerating in 2008:
  – Asset values (particularly for banks) collapsed.
  – Intermediation slowed and investment/output fell.
  – Interest rates spreads over what the US Treasury and highly safe private firms had to pay, jumped.
  – US central bank initiated unconventional measures (loans to financial and non-financial firms, very low interest rates for banks, etc.)

• In 2009 – the worst parts of 2007-2008 began to turn around.
Collapse in Asset Values and Investment

Log, real Stock Market Index, real Housing Prices and real Investment

March, 2006
October, 2007
June, 2009
September, 2008
March, 2009

S&P/Case-Shiller 10-city Home Price Index
S&P 500 Index
Gross Private Domestic Investment
Spreads for ‘Risky’ Firms Shot Up in Late 2008

Interest Rate Spread on Corporate Bonds of Various Ratings Over Rate on AAA Corporate Bonds

- BB: mean = 5.75
- B: mean = 2.71
- CCC and worse: mean = 1.75

2008Q3

Mean, junk rated bonds = 5.75
Mean, B rated bonds = 2.71
Mean, BB rated bonds = 1.75
Must Go Back to Great Depression to See Spreads as Large as the Recent Ones

Spread, BAA versus AAA bonds

October, 2007
August, 2008
March, 2009
Economic Activity Shows (anemic!)
Signs of Recovery June, 2009

Unemployment rate

Log, Industrial Production Index

September, 2008
Banks’ Cost of Funds Low

Federal Funds Rate

Annual, Percent Rate

Month

September, 2008

Characterization of Crisis to be Explored Here

• Bank Asset Values Fell.
• Banking System Became ‘Dysfunctional’
  – Interest rate spreads rose.
  – Intermediation and economy slowed.
• Monetary authority:
  – Transferred funds on various terms to private companies and to banks.
  – Sharply reduced cost of funds to banks.
• Economy in (tentative) recovery.
• Seek to construct models that links these observations together.
Objective

• Keep analysis simple and on point by:
  – Two periods
  – Minimize complications from agent heterogeneity.
  – Leave out endogeneity of employment.
  – Leave out nominal variables: just look ‘behind the veil of monetary economics’

• Models:
  – Gertler-Kiyotaki/Gertler-Karadi
  – In two-period setting easy to study an interesting nonlinearity that is possible:
    • Participation constraint may be binding in a crisis and not binding in normal times.
Two-period Version of GK Model

• Many identical households, each with a unit measure of members:
  – Some members are ‘bankers’
  – Some members are ‘workers’
  – Perfect insurance inside households...everyone consumes same amount.

• Period 1
  – Workers endowed with $y$ goods, household makes deposits, $d$, in a bank
  – Bankers endowed with $N$ goods, take deposits and purchase securities, $d$, from a firm.
  – Firm issues securities, $s$, to produce $sR^k$ in period 2.

• Period 2
  – Household consumes earnings from deposits plus profits, $\pi$, from banker.
  – Goods consumed are produced by the firm.
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### Solution to Household Problem

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\frac{u'(c)}{\beta u'(C)} = R^d \quad c + \frac{C}{R^d} = y + \frac{\pi}{R^d}
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| \[
u(c) = \frac{c^{1-\gamma}}{1-\gamma}
\]  | \[
c = \frac{y+\frac{\pi}{R^d}}{1+\frac{(\beta R^d)^{1-\gamma}}{R^d}}
\]  |

Household budget constraint when gov’t buys private assets using tax receipts, \(T\), and gov’t gets the same rate of return, \(R^d\), as households:

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c + \frac{C}{R^d} = y - T + \frac{\pi + TR^d}{R^d}
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Household Supply of Deposits

- For given $\pi$, $d$ rises or falls with $R^d$, depending on parameter values.
- But, in equilibrium $\pi = R^k(N+d) - R^d d$.
- Substituting into the expression for $c$ and solving for $d$:

$$d = \frac{(\beta R^d)^{\frac{1}{\gamma}} - \frac{N}{y} R^k}{(\beta R^d)^{\frac{1}{\gamma}} + R^k} y$$
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Upward-sloping deposit supply
Household Supply of Deposits

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## Efficient Benchmark

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**Problem:** $\max_d [sR^k - R^d d]$
Bank demand for $d$

Demand for $d$ by banks
Bank demand for $d$

$R^d$

$R^k$

Demand for $d$ by banks

Supply of $d$ by households

Equilibrium $d$
Equilibrium in Absence of Frictions

Interior Equilibrium: \( R^d, \pi, d, c, C \)

(i) \( c, d, C > 0 \)

(ii) household problem is solved

(iii) bank problem is solved

(iv) goods and financial markets clear
Equilibrium in Absence of Frictions

Interior Equilibrium: $R^d, \pi, d, c, C$

(i) $c, d, C > 0$
(ii) household problem is solved
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• Properties:
  – Household faces true social rate of return on saving:

$$R^k = R^d$$
Equilibrium in Absence of Frictions

Interior Equilibrium: $R^d, \pi, d, c, C$

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• Properties:

  – Household faces true social rate of return on saving:

    $R^k = R^d$

  – Equilibrium is ‘first best’, i.e., solves

    $\max_{c,k} u(c) + \beta u(C)$
    
    $c + k \leq y + N, \ C \leq kR^k$
Friction

• bank combines deposits, $d$, with net worth, $N$, to purchase $N+d$ securities from firms.

• bank has two options:
  – (‘no-default’) wait until next period when $(N + d)R^k$ arrives and pay off depositors, $R^d d$, for profit:
    
    $$(N + d)R^k - R^d d$$

  – (‘default’) take $\theta(N + d)$ securities, refuse to pay depositors and wait until next period when securities pay off:
    
    $$\theta(N + d)R^k$$

  – Bank must announce what value of $d$ it will choose at the beginning of a period.
Incentive Constraint

• Recall, banks maximize profits

• Choose ‘no default’ iff

\[
\begin{align*}
\text{no default: } (N + d)R^k - R^d d & \geq \theta(N + d)R^k \\
\text{default: }
\end{align*}
\]

• Next: derive banking system’s demand for deposits in presence of financial frictions.
Result for a no-default equilibrium:

- Consider an individual bank that contemplates defaulting.
- It sets a \( d \) that implies default,

\[
R^k (N + d) - R^d d < \theta R^k (d + N),
\]

or

\[
\underbrace{R^d}_{\text{what the household gets in the other banks}} > \underbrace{(1 - \theta)R^k (d + N)}_{\text{what the household gets in the defaulting bank}} / d
\]

- A deviating bank will in fact receive no deposits.
- An optimizing bank would never default
Problem of the bank in no-default, interior equilibrium

• Maximize, by choice of \( d \),

\[
R^k (N + d) - R^d d
\]

subject to:

\[
R^k (N + d) - R^d d - R^k \theta (N + d) \geq 0,
\]

or,

\[
(1 - \theta)R^k N - [R^d - (1 - \theta)R^k]d \geq 0.
\]

• Note that \( 0 < d < \infty \) requires

\[
(1 - \theta)R^k \quad < \quad R^d \quad \leq \quad R^k.
\]

If interest rate is REALLY low, then bank has no incentive to default because it makes lots of profits not defaulting.
Problem of the bank in no-default, interior equilibrium, cnt’d’d

• For $R^d = R^k$
  – a bank makes no profits on $d$ so – absent default considerations - it is indifferent over all values of $0 \leq d$
  – Taking into account default, a bank is indifferent over $0 \leq d \leq N(1-\theta)/\theta$

• For $(1-\theta)R^k < R^d < R^k$
  – Bank wants $d$ as large as possible, subject to incentive constraint.
  – So, $d = R^kN(1-\theta)/(R^d-(1-\theta)R^k)$
Bank demand for $d$

$$R^d$$

$$R^k$$

$$(1-\theta)R^k$$

$$\frac{(1-\theta)R^k}{R^d - (1-\theta)R^k} N$$

$$\frac{1-\theta}{\theta} N$$

$$d$$
Interior, no default equilibrium

In this equilibrium, $R^d = R^k$ and first-best allocations occur. Banking system is highly effective in allocating resources efficiently.
Collapse in Bank Net Worth

• Suppose that the economy is represented by a sequence of repeated versions of the above model.

• In the periods before the 2007-2008 crisis, net worth was high and the equilibrium was like it is on the previous slide: efficient, with zero interest rate spreads.
  – In practice, spreads are always positive, but that reflects various banking costs that are left out of this model.

• With the crisis, $N$ dropped a lot, shifting demand to the right and supply to the left.
Equilibrium after $N$ drops is inefficient because $R^d < R^k$. 
Government Intervention

• Equity injection.
  – Government raises $T$ in period 1, provides proceeds to banks and demands $R^kT$ in return at start of period 2.
  – Rebates earnings to households in 2.

• Has no impact on demand for deposits by banks (no impact on default incentive or profits).

• Reduces supply of deposits by households.
  – $d+T$ rises when $T$ rises (even though $d$ falls) because $R^d$ rises.

• Direct, tax-financed government loans to firms work in the same way.

• An interest rate subsidy to banks will shift their demand for deposits to the right….it will also shift supply to the left.
Equity Injection and Drop in $N$

Tax-financed injection of equity into banks or direct loans to non-financial firms shift household supply left.

$R^d$  

$R^k$  

$N$

Bank demand

Household supply
Recap

• Basic idea:
  – Bankers can run away with a fraction of bank assets.
  – If banker net worth is high relative to deposits, friction not a factor and banking system efficient.
  – If banker net worth falls below a certain cutoff, then banker must restrict the deposits.
    • Bankers fear (correctly) that otherwise depositors would lose confidence and take their business to another bank.
  – Reduction in banker demand for deposits:
    • makes deposit interest rates fall and so spreads rise.
    • Reduced intermediation means investment drops, output drops.
  – Equity injections by the government can revive the banking system.
Is the Model Narrative Consistent with the Evidence?

- Model says that reduced intermediation of funds through the financial system reflected reduced demand for credit by financial institutions.

- Prediction: interest rate to financial institutions fall.
Source: Board of Governors of the Federal Reserve System (US)
Shaded areas indicate US recessions - 2014 research.stlouisfed.org
• Model prediction for decline in cost of funds to financial institutions seems verified.

• But, other ‘risk free’ interest rates fell even more.
  – Interest rates on US government debt fell more than interest rate on financial firm commercial paper.
Assessment

• Fact that interest rates on US government debt went down more than cost of funds to financial institutions suggests that a complete picture of financial crisis may require two additional features:
  – Risky Banks:
    • Banks in the model are risk free. Default only occurs out of equilibrium.
    • Increased actual riskiness of banks is perhaps also an important part of the picture.
  – Liquidity:
    • Low interest rates on US government debt consistent with idea that high demand for liquidity played an important role in the crisis.