A DSGE model of banks and financial intermediation with default

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- the credit spread can be attributed largely to the risk of default
- due to different attitudes to risk by borrowers and lenders excess loan creation may emerge
- (systemic) risk due to macroeconomic shocks may be reduced by holding collateral.

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- Curdia and Woodford (2010) allow for bad loans but these are generated exogenously and the risk of bad loans is not priced.

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- Bernanke and Gertler (1989) using an OLG model found that the higher the net worth of the borrower, the lower the agency costs.

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- This paper proposes a simplified version of that of Curdia and Woodford (2011) that abstracts from certain features, including the New Keynesian aspects of price setting and the labor market.

4. Financial intermediation

Gertler, Kiyotaki and Queralto (2010)

- Focus on liquidity risk and how perceptions of asset return risk, as well as government policy interventions, influence the degree of risk exposure that financial intermediaries choose.
- Banks face credit risk arising from accepting firm equity in exchange for loans to firms
- Crucially, they assume that firms are able to transfer their risks to the banks as there is no default risk
- Banks do not charge a risk premium on these loans despite the risks arising from fluctuations in the value of firm equity

Gertler and Kiyotaki (2010)
- Show how disruptions to financial intermediation can induce a crisis that affects real activity.
- Financial frictions, the source of disruption, causes banks to divert the funds they obtained in the inter-bank market and results in constraints on bank balance sheets, and hence in the provision of credit.
- This limits expenditures on investment, and so affects real activity.
- The central bank can relieve these financial constraints by injecting liquidity into the banks, and by providing funds directly to the private sector.
- Although Gertler and Kiyotaki address problems that may arise in financial intermediation, they do not consider the important issue of default.

5. Credit Spreads

One measure of the severity of the financial crisis is the emergence of large spreads between overnight inter-bank lending rates and the London inter-bank offer rates (LIBOR)

These spreads could be due either to liquidity shortgages - as stressed in many of the theories above - or to default risk.

Support for the latter is provided by Taylor and Williams (2008) who find that the main factor explaining the rise in such spreads is increased counterparty risk as captured by credit default swaps

Model

The aim of the model is to show how the possibility of default affects credit spreads

Model has three sectors
- a combined household-firm sector (or non-bank private sector)
- a banking sector
- and a consolidated government-central bank

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- Households and banks may different attitudes to risk
- The central bank can also hold government debt and receive the risk-free rate.
- The government issues bonds, lends to banks and holds bank reserves.
- The model does not assume either asymmetric or, due to shocks, complete information.

Non-bank Private Sector

Aims to maximize $\mathcal{U}_t$ subject to their budget constraint

$$\mathcal{U}_t = E_t \Sigma_{s=0}^{\infty} \beta^s U(c_{t+s})$$

$$\begin{aligned} L_{t+1} - \Delta D_{t+1} + R_t^{\mathrm{f}} A_t + P_t y_t + \Pi_t &= P_t(c_t + i_t) + P_t T_t \\ &\quad + \Delta A_{t+1} + \phi_t (1 + R_t) L_t \\ A_t &= B_t^{\mathrm{b}} + B_t^{\mathrm{g}}, \end{aligned}$$

$L_t =$ one-period nominal bank loans carrying a nominal interest rate of R_t
$D_t = P_t c_t =$ nominal bank deposits required for CIA
$B_t^{\mathrm{b}} =$ bank nominal bonds held by households
$B_t^{\mathrm{g}} =$ government nominal bonds held by households- both at a risk-free nominal rate of R_t^{f}
$0 \leq \phi_t \leq 1$ is the (random) proportion of repayments on loans (principal and interest) each period
Unexpected changes in ϕ_t are negatively correlated with shocks to income and the loan rate.
$\Pi_t =$ bank profits which are exogenous to the non-bank private sector

The national income identity is

$$y_t = F(k_t) = c_t + i_t + g_t,$$

k_t is the (physical) capital stock and g_t is real government expenditures. Capital accumulation is determined by

$$\Delta k_{t+1} = i_t - \delta k_t.$$

The non-bank private-sector's resource constraint is

$$\begin{aligned} L_{t+1} - P_{t+1}c_{t+1} + (1 + R_t^{\mathrm{f}})A_t + P_t F(k_t) &= P_t[k_{t+1} - (1-\delta)k_t] + P_t T_t \\ &\quad + A_{t+1} + \phi_t (1 + R_t) L_t. \end{aligned}$$

The Lagrangian is

$$\begin{aligned}\mathcal{L}_t &= E_t\{\Sigma_{s=0}^{\infty}\beta^s U(c_{t+s}) + \lambda_{t+s}[L_{t+s+1} - P_{t+s+1}c_{t+s+1} \\ &\quad +(1+R^{\mathrm{f}}_{t+s})A_{t+s} + P_{t+s}F(k_{t+s}) - P_{t+s}(k_{t+s+1} - (1-\delta)k_{t+s}) \\ &\quad -P_{t+s}T_{t+s} - A_{t+s+1} - \phi_{t+s}(1+R_{t+s})L_{t+s}]\}.\end{aligned}$$

The first-order conditions are

$$\begin{aligned}\frac{\partial \mathcal{L}_t}{\partial c_{t+s}} &= E_t\{\beta^s U'(c_{t+s}) - \lambda_{t+s-1}P_{t+s}\} = 0 \\ \frac{\partial \mathcal{L}_t}{\partial k_{t+s}} &= E_t\{\lambda_{t+s}P_{t+s}[F'(k_{t+s}) + 1 - \delta] - \lambda_{t+s-1}P_{t+s-1}\} = 0 \\ \frac{\partial \mathcal{L}_t}{\partial A_{t+s}} &= E_t\{\lambda_{t+s}(1+R^{\mathrm{f}}_{t+s}) - \lambda_{t+s-1}\} = 0 \\ \frac{\partial \mathcal{L}_t}{\partial L_{t+s}} &= E_t\{\lambda_{t+s-1} - \lambda_{t+s}\phi_{t+s}(1+R_{t+s})\} = 0.\end{aligned}$$

Solution: the loan rate must satisfy the no-arbitrage equation

$$E_t R_{t+1} - R^{\mathrm{f}}_{t+1} = \frac{1}{E_t \phi_{t+1}} \{(1 + R^{\mathrm{f}}_{t+1})(1 - E_t \phi_{t+1}) - Cov_t(\phi_{t+1}, R_{t+1}) - \frac{Cov_t[\lambda_{t+1}, \phi_{t+1}(1 + R_{t+1})]}{E_t \lambda_{t+1}}\}$$

This determines the credit spread - the difference between the loan rate and the deposit rate - that the non-bank public is willing to pay. The three terms are, in effect, the risk premium on loans.

First term

- households are willing to pay a higher loan rate the lower is the proportion of the loan that is expected to be repaid (i.e. the greater the risk of default).
- The higher is ϕ_{t+1}, the proportion of the loan repaid in period $t+1$, the smaller is the risk premium and, *cet. par.*, the less will be the demand for loans.
- An under-estimate of ϕ_{t+1}, arguably as happened in the financial crisis, would lead to loans being under-priced, and to an excess of loans.

Second term

- implies that the risk premium is larger, the greater is the correlation between default and the loan rate.

Third term

- is the usual component of the risk premium relating consumption to the cost of borrowing - in this case, the effective cost of borrowing after taking account of possible default.

The no-arbitrage equation for the required real return on capital, $r^k_{t+1} = F'(k_{t+1}) - \delta$, is

$$E_t(r^k_{t+1} - r_{t+1}) \simeq -\frac{Cov_t[\pi_{t+1}, r^k_{t+1}]}{1 + E_t\pi_{t+1}} - \frac{Cov_t\{\lambda_{t+1}, (1+\pi_{t+1})(1+r^k_{t+1})\}}{E_t\lambda_{t+1}}$$

$r_{t+1} = R^{\mathrm{f}}_{t+1} - E_t\pi_{t+1}$ is the real rate of return
$\pi_{t+1} = \frac{P_{t+1}}{P_t} - 1$ is the rate of inflation

Hence the risk premium on the return to capital does not depend on default risk.

Banks

Bank make profits solely from lending to the private non-bank sector - this can be leveraged

$$
\begin{aligned}
\Pi_t &= \phi_t(1+R_t)L_t - L_{t+1} + B_{t+1} - (1+R_t^{\mathrm{f}})B_t + \Delta D_{t+1} - \Delta H_{t+1} \\
B_t &= B_t^{\mathrm{b}} + B_t^{\mathrm{bg}} \\
H_t + L_t &= D_t + B_t
\end{aligned}
$$

$B_t^{\mathrm{bg}} =$ net borrowing from the central bank at the risk-free rate
$H_t =$ reserves held at the central bank at no interest
$D_t =$ total money supply
$L_t - B_t =$ is net credit extended by banks.

The simultaneous lending and borrowing by the private non-bank sector from banks can be justified by assuming that the household-firm holds a diversified portfolio of risky and risk-free assets, or by noting that the principal borrowers will be firms who seek a real, even if risky, return on their physical capital.

Banks choose L_{t+s} and B_{t+s} $(s > 0)$ to maximize

$$\mathcal{P}_t = E_t \Sigma_{s=0}^{\infty} (1 + i_{t,t+s})^{-s} V(\Pi_{t+s}),$$

$V(\Pi_t) =$ the utility that banks derive from profits
- implies banks could be risk averse or have an appetite for risk.
$i_{t,t+s} = E_t R^{\mathrm{f}}_{t+s}$ $(s > 0)$ the forward rate at time t for R^{f}_{t+s}.

The first-order conditions for nominal loans and nominal borrowing for $s > 0$ are

$$\begin{aligned} 0 &= \frac{\partial \mathcal{P}_t}{\partial L_{t+s}} = E_t[(1 + i_{t,t+s})^{-s} V'(\Pi_{t+s}) \phi_{t+s} (1 + R_{t+s}) \\ &\quad -(1 + i_{t,t+s-1})^{-(s-1)} V'(\Pi_{t+s-1})] \\ 0 &= \frac{\partial \mathcal{P}_t}{\partial B_{t+s}} = E_t[(1 + i_{t,t+s-1})^{-(s-1)} V'(\Pi_{t+s-1}) \\ &\quad -(1 + i_{t,t+s})^{-s} (1 + R^{\mathrm{f}}_{t+s}) V'(\Pi_{t+s})] \end{aligned}$$

Solution: implies that banks require an expected excess return on loans of

$$
\begin{aligned}
E_t R_{t+1} - R^f_{t+1} &= \frac{1}{E_t \phi_{t+1}} \{ (1 + E_t R^f_{t+1})(1 - E_t \phi_{t+1}) - Cov_t(\phi_{t+1}, R_{t+1}) \\
&\quad - \frac{Cov_t[V'(\Pi_{t+1}), \phi_{t+1}(1 + R_{t+1})]}{V'(\Pi_t)} \}.
\end{aligned}
$$

- If there is no default risk then

$$
E_t R_{t+1} - R^f_{t+1} = -\frac{Cov_t[V'(\Pi_{t+1}), R_{t+1}]}{V'(\Pi_t)}.
$$

- If banks are risk-neutral and there is no default risk, the risk premium on loans is zero.

Government

The consolidated government-central bank budget constraint is

$$P_t g_t + (1 + R_t^{\mathrm{f}})(B_t^{\mathrm{g}} + B_t^{\mathrm{bg}}) = P_t T_t + B_{t+1}^{\mathrm{g}} + B_{t+1}^{\mathrm{bg}} + \Delta H_{t+1}.$$

The government finances any deficit by borrowing B_t^{g} from the non-bank private sector at the official interest rate R_t^{f}
It may also sell debt to the banks or lend to them the net amount B_t^{bg} at this rate.

The key result is the difference between the no-arbitrage conditions for loans of households and banks

Households

$$E_t R_{t+1} - R^{\mathrm{f}}_{t+1} = \frac{1}{E_t\phi_{t+1}}\{(1+R^{\mathrm{f}}_{t+1})(1-E_t\phi_{t+1}) - Cov_t(\phi_{t+1}, R_{t+1}) - \frac{Cov_t[\lambda_{t+1}, \phi_{t+1}(1+R_{t+1})]}{E_t\lambda_{t+1}}\}$$

Banks

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They differ only in the last component of the risk premium

Loan market equilibrium requires that the two expressions are the same when

$$\frac{Cov_t[\lambda_{t+1}, \phi_{t+1}(1+R_{t+1})]}{E_t\lambda_{t+1}} = \frac{Cov_t[V'(\Pi_{t+1}), \phi_{t+1}(1+R_{t+1})]}{V'(\Pi_t)},$$

This holds if

$$\lambda_{t+1} + \varepsilon^{\lambda}_{t+1} = V'(\Pi_{t+1}) + \varepsilon^{\Pi}_{t+1},$$

$\varepsilon^{\lambda}_{t+1}$ and ε^{Π}_{t+1} are serially independent with a zero conditional covariance with $\phi_{t+1}(1+R_{t+1})$.
This implies

$$E_t\lambda_{t+1} = E_t V'(\Pi_{t+1})$$

and hence

$$\lambda_t/(1+i_{t,t+1}) = V'(\Pi_t)$$

i.e. The household's expected marginal utility from an additional unit of bank profit equals its expected marginal utility for banks
This is a necessary condition for complete markets and a consequence of introducing a utility function for banks.

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- \- but not necessarily adverse selection or moral hazard as both the lender and the borrower are aware of the risk of default.
- If banks were more risk-averse than the non-bank public, then there would be an excess supply of loans.

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- Differences in their appetites for risk could lead to credit rationing if banks have a lower appetite, or to an excess supply supply of loans if banks are more risk averse.
- A reduction in the expected proportion of loans that are repaid in full would cause an increase in the loan rate, a reduction in the volume of loans next period and of bank profits in the current period.

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- If the non-bank private sector correctly assessed their probability of default, the value of loans would be greater than it would be if the banks correctly estimated the default rate.
- It would also encourage banks to have an excess level of leverage of these loans; banks borrow at a low rate in order to lend at a higher rate, but they may over-borrow.

Discussion of the assumptions

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- Because banks tend to borrow short and lend long, their profits are the result of being able to borrow at lower rates than the non-bank private sector.
- The model has assumed that all loans are for one period. It would be straightforward to assume instead that loans are long term. The term structure of interest rates could then be used to link the loan rate facing the non-bank private sector to the one-period loans assumed. This would introduce another source of risk, the term premium.
- The model implies that the loan rate will exceed the deposit rate if there is a possibility of default - even partial default. This credit spread is likely to be greater, the less competitive is the banking sector. Given the concentration of banking in many countries, it seems more likely that banks also earn monopoly profits on credit spreads.

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- Can disaggregate the banking system and introduce interbank loans together with the risk of default on these loans; see, for example, Goodhart, Osorio and Tsomocos (2009). The greater the risk of default by a bank, the higher the cost of borrowing on the inter-bank market.

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- Default may or may not result in bankruptcy due to negative net wealth. Partial default and a restructuring of the terms of the loan is often a better alternative for both parties than complete default.

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- The reasons that credit-card debt costs so much more than other forms of borrowing are that it is not collateralized and that banks, through their own choice, have little knowledge of the financial circumstances of the card-holder. Not surprisingly, banks assume a high rate of default for credit-card debt.

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- It is straightforward to extend the model to incorporate housing and mortgage finance.
- This would entail including durables in the household sector, and including longer maturity debt both in the non-bank public's and the banks' budget constraints. The cost of this debt can then be related to one-period debt via the term structure. The risk premium on mortgage debt will reflect the risk of default as in the model. Failure to price mortgage risk correctly was a key factor in bringing about the financial crisis.

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- If they differ in this assessment then this would affect the solution. A crucial feature of the financial crisis is that the banks under-estimated the risk of default.
- In terms of the model this could happen if the wrong information were used to form expectations. In particular, the wrong distribution of shocks may have been used.

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- Even if default risk is taken into account, there is therefore no guarantee that this would eliminate future crises.

Conclusions

1. The evidence, while not plentiful, indicates that default risk is the main contributory factor in explaining the financial crisis as measured by spreads between inter-bank lending and LIBOR. Much of the theory emphasises instead the role of liquidity. In this paper we take the view that liquidity shortages were a consequence of the inability of lenders to correctly assess and price the risk of default. The main contribution of this paper is the construction of a simple general equilibrium model of banks and financial intermediation in which default-risk can be priced.

2. We show that a credit spread - the difference between the loan rate and deposit rate (or the risk-free rate) - largely reflects the risk of default. The spread may also be affected if the non-bank private sector, the principle borrower, has a different attitude to risk from the banks, the main provider of loans. This may also result in excess loan creation. We show that the model can easily be adapted to analyse the systemic risk as well as idiosyncratic risk. We argue that systemic default risk is largely due to macroeconomic shocks. The model can also be re-interpreted to show why higher collateral is likely to reduce the risk of the idiosyncratic risk of default.