Credit Frictions and Optimal Monetary Policy

Vasco Cúrdia  Michael Woodford

FRB New York  Columbia University

Conference on Monetary Policy and Financial Frictions
“New Keynesian” monetary models often abstract entirely from financial intermediation and hence from financial frictions.
“New Keynesian” monetary models often abstract entirely from financial intermediation and hence from financial frictions

- Representative household
- Complete (frictionless) financial markets
- Single interest rate (which is also the policy rate) relevant for all decisions
“New Keynesian” monetary models often abstract entirely from financial intermediation and hence from financial frictions

- Representative household
- Complete (frictionless) financial markets
- Single interest rate (which is also the policy rate) relevant for all decisions

But in actual economies (even financially sophisticated), there are different interest rates, that do not move perfectly together
Spreads
(Sources: FRB, IMF/IFS)
LIBOR 1m vs FFR target
(source: Bloomberg and Federal Reserve Board)
Motivation

Questions:

- How much is monetary policy analysis changed by recognizing existence of spreads between different interest rates?

- How should policy respond to “financial shocks” that disrupt financial intermediation, dramatically widening spreads?
Motivation

- John Taylor (Feb. 2008) has proposed that “Taylor rule” for policy might reasonably be adjusted, lowering ff rate target by amount of increase in LIBOR-OIS spread

  — Essentially, Taylor rule would specify operating target for LIBOR rate rather than ff rate

  — Would imply automatic adjustment of ff rate in response to spread variations, as under current SNB policy
Motivation

- John Taylor (Feb. 2008) has proposed that “Taylor rule” for policy might reasonably be adjusted, lowering ff rate target by amount of increase in LIBOR-OIS spread

  — Essentially, Taylor rule would specify operating target for LIBOR rate rather than ff rate

  — Would imply automatic adjustment of ff rate in response to spread variations, as under current SNB policy

- Is a systematic response of that kind desirable?
The Model

- Generalizes basic (representative household) NK model to include

\[ E_0 \infty \sum_{t=0}^{\infty} \beta^t [u_{\tau t}(i)(c_t(i); \xi_t) - \int_0^1 v_{\tau t}(i)(h_t(j); i; \xi_t) dj] \]

Each period type remains same with probability \( \delta < 1 \); when draw new type, always probability \( \pi_{\tau t} \) of becoming type \( \tau \).
The Model

Generalizes basic (representative household) NK model to include

- heterogeneity in spending opportunities
- costly financial intermediation
The Model

- Generalizes basic (representative household) NK model to include
  - heterogeneity in spending opportunities
  - costly financial intermediation

- Each household has a type $\tau_t(i) \in \{b, s\}$, determining preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ u^{\tau_t(i)}(c_t(i); \zeta_t) - \int_0^1 v^{\tau_t(i)}(h_t(j; i); \zeta_t) \, dj \right],$$
The Model

- Generalizes basic (representative household) NK model to include
  - heterogeneity in spending opportunities
  - costly financial intermediation

- Each household has a type $\tau_t(i) \in \{b, s\}$, determining preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ u^{\tau_t(i)}(c_t(i); \xi_t) - \int_0^1 v^{\tau_t(i)}(h_t(j; i); \xi_t) \, dj \right],$$

- Each period type remains same with probability $\delta < 1$; when draw new type, always probability $\pi_\tau$ of becoming type $\tau$. 

Cúrdia and Woodford (2008)
Marginal utilities of the two types
The Model

- **Aggregation** simplified by assuming *intermittent* access to an “insurance agency”

Consequence: long-run marginal utility of income same for all households, regardless of history of spending opportunities. MUI and expenditure same each period for all households of a given type: hence only increase state variables from 1 to 2.
The Model

- **Aggregation** simplified by assuming *intermittent* access to an “insurance agency”
  - State-contingent contracts enforceable only on those occasions
  - Other times, can borrow or lend only through *intermediaries*, at a one-period, riskless nominal rate, *different* for savers and borrowers
The Model

- **Aggregation** simplified by assuming **intermittent** access to an “insurance agency”
  - State-contingent contracts enforceable **only** on those occasions
  - Other times, can borrow or lend only through intermediaries, at a one-period, riskless nominal rate, different for savers and borrowers

- Consequence: **long-run** marginal utility of income **same** for all households, regardless of history of spending opportunities
The Model

- **Aggregation** simplified by assuming *intermittent* access to an “insurance agency”
  - State-contingent contracts enforceable only on those occasions
  - Other times, can borrow or lend only through *intermediaries*, at a one-period, riskless nominal rate, *different* for savers and borrowers

- Consequence: long-run marginal utility of income *same* for all households, regardless of history of spending opportunities

- MUI and expenditure *same* each period for all households of a given type: hence only increase state variables from 1 to 2
The Model

- **Euler equation** for each type \( \tau \in \{b, s\} \):

\[
\lambda_t^\tau = \beta E_t \left\{ \frac{1 + i_t^\tau}{\Pi_{t+1}} \left[ \delta \lambda_{t+1}^\tau + (1 - \delta) \lambda_{t+1} \right] \right\}
\]

where

\[
\lambda_t \equiv \pi_b \lambda_t^b + \pi_s \lambda_t^s
\]
The Model

- **Euler equation** for each type $\tau \in \{b, s\}$:

  \[
  \lambda_t^\tau = \beta E_t \left\{ \frac{1 + i_t^\tau}{\Pi_{t+1}} \left[ \delta \lambda_{t+1}^\tau + (1 - \delta) \lambda_{t+1} \right] \right\}
  \]

  where

  \[
  \lambda_t \equiv \pi_b \lambda_t^b + \pi_s \lambda_t^s
  \]

- **Aggregate demand** relation:

  \[
  Y_t = \sum_\tau \pi_\tau c^\tau(\lambda_t^\tau; \xi_t) + G_t + \Xi_t
  \]

  where $\Xi_t$ denotes resources used in intermediation.
Log-Linear Equations

- Intertemporal IS relation:
  \[ \hat{Y}_t = E_t \hat{Y}_{t+1} - \bar{\sigma} [\hat{i}_t^{avg} - \pi_{t+1}] - E_t [\Delta g_{t+1} + \Delta \hat{\Xi}_{t+1}] \]
  \[ -\bar{\sigma} s_\Omega \hat{\Omega}_t + \bar{\sigma} (s_\Omega + \psi_\Omega) E_t \hat{\Omega}_{t+1}, \]
  where
  \[ \hat{i}_t^{avg} \equiv \pi_b \hat{i}_t^b + \pi_s \hat{i}_t^d, \]
  \[ \hat{\Omega}_t \equiv \hat{\lambda}_t^b - \hat{\lambda}_t^s, \]
  \[ g_t \] is a composite exogenous disturbance to expenditure of type \( b \), type \( s \), and government,
  \[ \bar{\sigma} \equiv \pi_b s_b \sigma_b + \pi_s s_s \sigma_s > 0, \]
  and \( s_\Omega, \psi_\Omega \) depend on asymmetry.
Determination of the marginal-utility gap:

$$\hat{\Omega}_t = \hat{\omega}_t + \hat{\delta} E_t \hat{\Omega}_{t+1},$$

where $\hat{\delta} < 1$ and

$$\hat{\omega}_t \equiv \hat{i}_t^b - \hat{i}_t^d$$

measures deviation of the credit spread from its steady-state value.
Financial intermediation technology: in order to supply loans in (real) quantity $b_t$, must obtain (real) deposits

$$d_t = b_t + \Xi_t(b_t),$$

where $\Xi_t(0) = 0$, $\Xi_t(b) \geq 0$, $\Xi'_t(b) \geq 0$, $\Xi''_t(b) \geq 0$ for all $b \geq 0$, each date $t$. 
The Model

- **Financial intermediation** technology: in order to supply loans in (real) quantity $b_t$, must obtain (real) deposits
  \[ d_t = b_t + \Xi_t(b_t), \]
  where $\Xi_t(0) = 0$, $\Xi_t(b) \geq 0$, $\Xi'_t(b) \geq 0$, $\Xi''_t(b) \geq 0$ for all $b \geq 0$, each date $t$.

- **Competitive** banking sector would then imply equilibrium credit spread
  \[ \omega_t(b_t) = \Xi_{bt}(b_t) \]
Financial intermediation technology: in order to supply loans in (real) quantity $b_t$, must obtain (real) deposits

$$d_t = b_t + \Xi_t(b_t),$$

where $\Xi_t(0) = 0$, $\Xi_t(b) \geq 0$, $\Xi'_t(b) \geq 0$, $\Xi''_t(b) \geq 0$ for all $b \geq 0$, each date $t$.

Competitive banking sector would then imply equilibrium credit spread

$$\omega_t(b_t) = \Xi_{bt}(b_t)$$

More generally, we allow

$$1 + \omega_t(b_t) = \mu_t^b(b_t)(1 + \Xi_{bt}(b_t)),$$

where $\{\mu_t^b\}$ is a markup in the banking sector (perhaps a risk premium)
Monetary policy: central bank can effectively control deposit rate $i^d_t$, which in the present model is equivalent to the policy rate (interbank funding rate)
Log-Linear Equations

- **Monetary policy**: central bank can effectively control deposit rate $i^d_t$, which in the present model is equivalent to the policy rate (interbank funding rate).

- Lending rate then determined by the $\omega_t(b_t)$: in log-linear approximation,

$$\hat{i}^b_t = \hat{i}^d_t + \hat{\omega}_t$$
Monetary policy: central bank can effectively control deposit rate $i_t^d$, which in the present model is equivalent to the policy rate (interbank funding rate).

Lending rate then determined by the $\omega_t(b_t)$: in log-linear approximation,

$$\hat{i}_t^b = \hat{i}_t^d + \hat{\omega}_t$$

Hence the rate $\hat{i}_t^{avg}$ that appears in IS relation is determined by

$$\hat{i}_t^{avg} = \hat{i}_t^d + \pi_b \hat{\omega}_t$$
The Model

Supply side of model: same as in basic NK model, except must aggregate labor supply of two types
The Model

- **Supply side** of model: same as in basic NK model, except must aggregate labor supply of two types

- Labor only variable factor of production for each differentiated good

\[ \text{Cúrdia and Woodford}() \]

Credit Frictions

Halloween 2008
Supply side of model: same as in basic NK model, except must aggregate labor supply of two types

- Labor only variable factor of production for each differentiated good
- Firms wage-takers in labor market
The Model

- **Supply side** of model: same as in basic NK model, except must aggregate labor supply of two types

  - Labor only variable factor of production for each differentiated good
  - Firms wage-takers in labor market
  - Competitive labor supply, except wage demand may be increased by exogenous wage markup process \( \{ \mu^w_t \} \)
The Model

Supply side of model: same as in basic NK model, except must aggregate labor supply of two types

- Labor only variable factor of production for each differentiated good
- Firms wage-takers in labor market
- Competitive labor supply, except wage demand may be increased by exogenous wage markup process \( \{\mu_t^w\} \)
- Dixit-Stiglitz monopolistic competition
The Model

- **Supply side** of model: same as in basic NK model, except must aggregate labor supply of two types

  - Labor only variable factor of production for each differentiated good
  - Firms wage-takers in labor market
  - Competitive labor supply, except wage demand may be increased by exogenous wage markup process \{\mu^w_t\}
  - Dixit-Stiglitz monopolistic competition
  - Calvo staggering of adjustment of individual prices
### The Model

- **Supply side** of model: same as in basic NK model, except must aggregate labor supply of two types
  - Labor only variable factor of production for each differentiated good
  - Firms wage-takers in labor market
  - Competitive labor supply, except wage demand may be increased by exogenous *wage markup* process \( \mu_t \)
  - Dixit-Stiglitz monopolistic competition
  - Calvo staggering of adjustment of individual prices

- Only difference: labor supply depends on both MUI: \( \lambda_t^b, \lambda_t^s \), or alternatively on \( \Omega_t \) as well as \( \lambda_t \)
Log-Linear Equations

- **Log-linear AS relation**: generalizes NKPC:

\[
\pi_t = \kappa(\hat{Y}_t - \hat{Y}_n^t) + u_t + \zeta(s_\Omega + \pi_b - \gamma_b)\hat{\Omega}_t - \zeta\bar{\sigma}^{-1}\hat{\Xi}_t + \beta E_t \pi_{t+1}
\]

where

\[
\gamma_b \equiv \pi_b \left(\frac{\bar{\lambda}^b}{\bar{\lambda}}\right)^{1/\nu}
\]

depends on $\tilde{\Omega}$
Log-Linear Equations

- Log-linear AS relation: generalizes NKPC:

\[
\pi_t = \kappa(\hat{Y}_t - \hat{Y}_t^n) + u_t + \zeta(s_\Omega + \pi_b - \gamma_b)\hat{\Omega}_t - \zeta\sigma^{-1}\hat{\Xi}_t + \beta E_t \pi_{t+1}
\]

where

\[
\gamma_b \equiv \pi_b \left(\frac{\bar{\lambda}^b}{\bar{\lambda}}\right)^{1/\nu}
\]

depends on $\hat{\Omega}$ — other coefficients, and disturbance terms $\hat{Y}_t^n, u_t$, defined as in basic NK model, using $\bar{\sigma}$ in place of the rep hh’s elasticity
A simple special case: credit spread \( \{ \omega_t \} \) evolves \textit{exogenously}, and intermediation \textit{uses no resources} (i.e., spread is a pure markup).
What Difference Do Frictions Make?

- A simple special case: credit spread \( \{ \omega_t \} \) evolves exogenously, and intermediation uses no resources (i.e., spread is a pure markup).

- Then \( \hat{\Xi}_t \) terms vanish, and \( \{ \hat{\omega}_t \} \) exogenous implies \( \{ \hat{\Omega}_t \} \) exogenous.
A simple special case: credit spread \( \{ \omega_t \} \) evolves exogenously, and intermediation uses no resources (i.e., spread is a pure markup)

Then \( \hat{\Xi}_t \) terms vanish, and \( \{ \hat{\omega}_t \} \) exogenous implies \( \{ \hat{\Omega}_t \} \) exogenous

The usual 3-equation model suffices to determine paths of \( \{ \hat{Y}_t, \pi_t, \hat{i}_{t}^{avg} \} \):
- AS relation
- IS relation
- MP relation (written in terms of implication for \( \hat{i}_{t}^{avg} \), given exogenous spread)
The difference made by the credit frictions:

- The interest rate in this system is $\hat{i}_t^{avg}$, not same as policy rate
- Additional disturbance terms in each of the 3 equations
What Difference Do Frictions Make?

- The difference made by the credit frictions:
  - The interest rate in this system is $\hat{i}_t^{\text{avg}}$, not same as policy rate
  - Additional disturbance terms in each of the 3 equations

- Responses of output, inflation, interest rates to non-financial shocks (under a given monetary policy rule, e.g. Taylor rule) are identical to those predicted by basic NK model
  - hence no change in conclusions about desirability of a given rule, from standpoint of stabilizing in response to those disturbances

Cúrdia and Woodford ( )
Credit Frictions
Halloween 2008 17 / 40
The difference made by the credit frictions:

- The interest rate in this system is \( \hat{i}_{\text{avg}} \), not same as policy rate
- Additional disturbance terms in each of the 3 equations

Responses of output, inflation, interest rates to non-financial shocks (under a given monetary policy rule, e.g. Taylor rule) are identical to those predicted by basic NK model

- hence no change in conclusions about desirability of a given rule, from standpoint of stabilizing in response to those disturbances

Responses to financial shocks: equivalent to responses (in basic NK model) to a simultaneous monetary policy shock, “cost-push” shock, and shift in natural rate of interest.
Optimal Policy

Natural objective for stabilization policy: average expected utility:

\[ E_0 \sum_{t=0}^{\infty} \beta U(Y_t, \lambda^b_t, \lambda^s_t, \Delta_t; \tilde{\xi}_t) \]

where

\[ U(Y_t, \lambda^b_t, \lambda^s_t, \Delta_t; \tilde{\xi}_t) \equiv \pi_b u^b(c^b(\lambda^b_t, \xi_t); \xi_t) + \pi_s u^s(c^s(\lambda^s_t, \xi_t); \xi_t) \]

\[ -\frac{1}{1 + \nu} \left( \frac{\lambda^b_t}{\lambda_t} \right)^{-\frac{1+\nu}{\nu}} \bar{H}_t^{-\nu} \left( \frac{Y_t}{A_t} \right)^{1+\omega} \Delta_t, \]

and \( \tilde{\lambda}_t/\tilde{\Lambda}_t \) is a decreasing function of \( \lambda^b_t/\lambda^s_t \), so that total disutility of producing given output is increasing function of the MU gap.
Optimal Policy: LQ Approximation

- Compute a **quadratic approximation** to this welfare measure, in the case of small fluctuations around the **optimal steady state**.
Optimal Policy: LQ Approximation

- Compute a \textit{quadratic approximation} to this welfare measure, in the case of small fluctuations around the \textit{optimal steady state}.

- Results especially simple in special case:
  - No steady-state distortion to level of output ($P = MC$, $W/P = MRS$) (Rotemberg-Woodford, 1997)
  - No steady-state credit frictions: $\bar{\omega} = \bar{\Xi} = \bar{\Xi}_b = 0$
Optimal Policy: LQ Approximation

- Compute a **quadratic approximation** to this welfare measure, in the case of small fluctuations around the **optimal steady state**

- Results especially simple in special case:

  - No steady-state distortion to level of output ($P = MC$, $W/P = MRS$) (Rotemberg-Woodford, 1997)

  - No steady-state credit frictions: $\bar{\omega} = \bar{\Xi} = \bar{\Xi}_b = 0$

    —Note, however, that we do allow for **shocks** to the size of credit frictions
Approximate objective: max of expected utility equivalent (to 2d order) to minimization of quadratic loss function

\[
\sum_{t=0}^{\infty} \beta^t [\pi_t^2 + \lambda_y (\hat{Y}_t - \hat{Y}_n^t)^2 + \lambda_{\Omega} \hat{\Omega}_t^2 + \lambda_{\Xi} \Xi_{bt} \hat{b}_t]
\]
Approximate objective: max of expected utility equivalent (to 2d order) to minimization of quadratic loss function

\[
\sum_{t=0}^{\infty} \beta^t \left[ \pi_t^2 + \lambda_y (\hat{Y}_t - \hat{Y}_t^n)^2 + \lambda_\Omega \hat{\Omega}_t^2 + \lambda_{\Xi} \Xi b_t \hat{b}_t \right]
\]

- Weight \( \lambda_y > 0 \), definition of “natural rate” \( \hat{Y}_t^n \) same as in basic NK model
Optimal Policy: LQ Approximation

- Approximate objective: max of expected utility equivalent (to 2d order) to minimization of quadratic loss function

\[ \sum_{t=0}^{\infty} \beta^t \left[ \pi_t^2 + \lambda_y (\hat{Y}_t - \hat{Y}_t^n)^2 + \lambda_{\Omega} \hat{\Omega}_t^2 + \lambda_{\Xi} \Xi_{bt} \hat{b}_t \right] \]

- Weight \( \lambda_y > 0 \), definition of “natural rate” \( \hat{Y}_t^n \) same as in basic NK model
- New weights \( \lambda_{\Omega}, \lambda_{\Xi} > 0 \)
Optimal Policy: LQ Approximation

- Approximate objective: max of expected utility equivalent (to 2d order) to minimization of quadratic loss function

\[
\sum_{t=0}^{\infty} \beta^t [\pi_t^2 + \lambda_y (\hat{Y}_t - \hat{Y}_t^n)^2 + \lambda_\Omega \hat{\Omega}_t^2 + \lambda_\Xi \hat{\Xi}_t \hat{b}_t]
\]

- Weight \( \lambda_y > 0 \), definition of “natural rate” \( \hat{Y}_t^n \) same as in basic NK model
- New weights \( \lambda_\Omega, \lambda_\Xi > 0 \)

- LQ problem: minimize loss function subject to log-linear constraints: AS relation, IS relation, law of motion for \( \hat{b}_t \), relation between \( \hat{\Omega}_t \) and expected credit spreads
Optimal Policy: LQ Approximation

- Consider special case:
  - No resources used in intermediation ($\Xi_t(b) = 0$)
  - Financial markup $\{\mu_t^b\}$ an exogenous process
Consider special case:

- No resources used in intermediation ($\Xi_t(b) = 0$)
- Financial markup $\{\mu_t^b\}$ an 
**exogenous** process

Result: optimal policy is characterized by the same **target criterion** as in basic NK model:
Optimal Policy: LQ Approximation

Consider special case:

- **No resources** used in intermediation ($\Xi_t(b) = 0$)
- Financial markup $\{\mu_t^b\}$ an **exogenous** process

Result: optimal policy is characterized by the same **target criterion** as in basic NK model:

$$\pi_t + \left(\frac{\lambda_y}{\kappa}\right)(x_t - x_{t-1}) = 0$$

("flexible inflation targeting")
Consider special case:

- **No resources** used in intermediation \((\Xi_t(b) = 0)\)
- Financial markup \(\{\mu_t^b\}\) an *exogenous* process

Result: optimal policy is characterized by the same **target criterion** as in basic NK model:

\[
\pi_t + \left(\frac{\lambda_y}{\kappa}\right)(x_t - x_{t-1}) = 0
\]

(“flexible inflation targeting”)

However, state-contingent path of policy rate required to implement the target criterion is **not** the same
Implementing Optimal Policy: Interest-Rate Rule

- **Instrument rule** to implement the above target criterion:

  - Given lagged variables, current exogenous shocks, and observed current expectations of future inflation and output, solve the AS and IS relations for target $i_t^d$ that would imply values of $\pi_t$ and $x_t$ projected to satisfy the target relation.
Implementing Optimal Policy: Interest-Rate Rule

- **Instrument rule** to implement the above target criterion:

  Given lagged variables, current exogenous shocks, and observed current expectations of future inflation and output, solve the AS and IS relations for target $i_t^d$ that would imply values of $\pi_t$ and $x_t$ projected to satisfy the target relation.


- Desirable properties:
  — ensures that there are no REE other than those in which the target criterion holds
  — hence ensures determinacy of REE
  — in this example, also implies “E-stability” of REE, hence convergence of least-squares learning dynamics to REE.
Implementing Optimal Policy: Interest-Rate Rule

\[
i_t^d = r_t^n + \phi_u u_t + [1 + \beta \phi_u] E_t \pi_{t+1} + \bar{\sigma}^{-1} E_t \sigma_{t+1} - \phi_x x_{t-1} - [\pi_b + \delta^{-1} s_{\Omega}] \hat{\omega}_t + [(\delta^{-1} - 1) + \phi_u \xi] s_{\Omega} \hat{\Omega}_t
\]

where \( \phi_u \equiv \frac{\kappa}{\bar{\sigma} (\kappa^2 + \lambda_y)} > 0, \quad \phi_x \equiv \frac{\lambda_y}{\bar{\sigma} (\kappa^2 + \lambda_y)} > 0 \)
Implementing Optimal Policy: Interest-Rate Rule

\[ i_t^d = r_t^n + \phi_u u_t + [1 + \beta \phi_u] E_t \pi_{t+1} + \bar{\sigma}^{-1} E_t x_{t+1} - \phi_x x_{t-1} \]

\[ - [\pi_b + \delta^{-1} s_\Omega] \hat{\omega}_t + [(\delta^{-1} - 1) + \phi_u \zeta] s_\Omega \hat{\Omega}_t \]

where \( \phi_u \equiv \frac{\kappa}{\bar{\sigma}(\kappa^2 + \lambda_y)} > 0, \quad \phi_x \equiv \frac{\lambda_y}{\bar{\sigma}(\kappa^2 + \lambda_y)} > 0 \)

- a forward-looking Taylor rule, with adjustments proportional to both the credit spread and the marginal-utility gap
Note that if $s_b \sigma_b >> s_s \sigma_s$, then $s_\Omega \approx \pi_s$, so that if in addition $\delta \approx 1$, the rule becomes approximately

$$i_t^d = \ldots - \hat{\omega}_t + \phi_\Omega \hat{\Omega}_t$$
Note that if $s_b \sigma_b >> s_s \sigma_s$, then $s_\Omega \approx \pi_s$, so that if in addition $\delta \approx 1$, the rule becomes approximately

$$i_t^d = \ldots - \hat{\omega}_t + \phi_\Omega \hat{\Omega}_t$$

Since for our calibration, $\phi_\Omega$ is also quite small ($\approx .03$), this implies that a 100 percent spread adjustment would be close to optimal, except in the case of very persistent fluctuations in the credit spread.
Essentially, in the case that $s_b\sigma_b >> s_s\sigma_s$, it is really only $i_t^b$ that matters much to the economy, and the simple intuition for the spread adjustment is reasonably accurate.
Essentially, in the case that $s_b \sigma_b >> s_s \sigma_s$, it is really only $i_t^b$ that matters much to the economy, and the simple intuition for the spread adjustment is reasonably accurate.

But for other parameterizations that would not be true. For example, if $s_b \sigma_b = s_s \sigma_s$, the optimal rule is

$$i^d_t = \ldots - \pi_t \hat{\omega}_t$$

which is effectively an instrument rule in terms of $i_t^{avg}$ rather than either $i_t^d$ or $i_t^b$. 
Above target criterion no longer an exact characterization of optimal policy, in more general case in which $\omega_t$ and/or $\Xi_t$ depend on the evolution of $b_t$
Above target criterion no longer an *exact* characterization of optimal policy, in more general case in which $\omega_t$ and/or $\Xi_t$ depend on the evolution of $b_t$

But numerical results suggest still a fairly good *approximation* to optimal policy
Calibrated Model

Calibration of preference heterogeneity: assume equal probability of two types, \( \pi_b = \pi_s = 0.5 \), and \( \delta = 0.975 \) (average time that type persists = 10 years)
Calibrated Model

- Calibration of preference heterogeneity: assume equal probability of two types, \( \pi_b = \pi_s = 0.5 \), and \( \delta = 0.975 \) (average time that type persists = 10 years)

- Assume \( C^b / C^s = 1.27 \) in steady state (given \( G/Y = 0.3 \), this implies \( C^s/Y \approx 0.62 \), \( C^b/Y \approx 0.78 \))

  — implied steady-state debt: \( \bar{b}/\bar{Y} = 0.8 \) years (avg non-fin, non-gov’t, non-mortgage debt/GDP)
Calibrated Model

- Calibration of preference heterogeneity: assume equal probability of two types, $\pi_b = \pi_s = 0.5$, and $\delta = 0.975$ (average time that type persists = 10 years)

- Assume $C^b / C^s = 1.27$ in steady state (given $G / Y = 0.3$, this implies $C^s / Y \approx 0.62$, $C^b / Y \approx 0.78$)
  
  --- implied steady-state debt: $\bar{b} / \bar{Y} = 0.8$ years (avg non-fin, non-gov’t, non-mortgage debt/GDP)

- Assume relative disutility of labor for two types so that in steady state $H^b / H^s = 1$
Assume $\sigma_b/\sigma_s = 5$

— implies credit contracts in response to monetary policy tightening (consistent with VAR evidence [esp. credit to households])
Calibrated Model

Calibration of financial frictions: Resource costs $\Xi_t(b) = \tilde{\Xi}_t b^n$, exogenous markup $\mu_t^b$
Calibrated Model

Calibration of financial frictions: Resource costs $\Xi_t(b) = \tilde{\Xi}_t b^n$, exogenous markup $\mu_t^b$

- Zero steady-state markup; resource costs imply steady-state credit spread $\bar{\omega} = 2.0$ percent per annum (follows Mehra, Piguillem, Prescott)
  - implies $\bar{\lambda}^b / \bar{\lambda}^s = 1.22$
Calibrated Model

Calibration of financial frictions: Resource costs $\Xi_t(b) = \tilde{\Xi}_t b^n$, exogenous markup $\mu_t^b$

- Zero steady-state markup; resource costs imply steady-state credit spread $\bar{\omega} = 2.0$ percent per annum (follows Mehra, Piguillem, Prescott)
  
  \[ \frac{\bar{\lambda}^b}{\bar{\lambda}^s} = 1.22 \]

- Calibrate $\eta$ in convex-technology case so that 1 percent increase in volume of bank credit raises credit spread by 1 percent (ann.)
  
  \[ \eta \approx 52 \]
Numerical Results: Alternative Policy Rules

Compute responses to shocks under optimal (i.e., Ramsey) policy, compare to responses under 3 simple rules:

- simple Taylor rule:
  \[ \hat{\delta}_t = \phi_\pi \pi_t + \phi_y \hat{Y}_t + \epsilon_m t \]

- strict inflation targeting:
  \[ \pi_t = 0 \]

- flexible inflation targeting:
  \[ \pi_t + (\lambda y / \kappa) (x_t - x_{t-1}) = 0 \]
Numerical Results: Alternative Policy Rules

Compute responses to shocks under optimal (i.e., Ramsey) policy, compare to responses under 3 simple rules:

- simple Taylor rule:
  \[ \hat{i}_t^d = \phi_{\pi} \pi_t + \phi_y \hat{Y}_t + \epsilon_t^m \]
Numerical Results: Alternative Policy Rules

Compute responses to shocks under \textit{optimal} (i.e., Ramsey) policy, compare to responses under 3 \textit{simple rules}:

- \textbf{simple Taylor rule:}
  \[ \hat{i}_t^d = \phi_\pi \pi_t + \phi_y \hat{Y}_t + \epsilon_t^m \]

- \textbf{strict inflation targeting:}
  \[ \pi_t = 0 \]

- \textbf{flexible inflation targeting:}
  \[ \pi_t + (\lambda_y / \kappa)(x_t - x_{t-1}) = 0 \]
Numerical Results: Optimal Policy

Responses to technology shock, under 4 monetary policies
Numerical Results: Optimal Policy

Responses to wage markup shock, under 4 monetary policies
Responses to shock to government purchases, under 4 monetary policies
Responses to shock to demand of savers, under 4 monetary policies
Numerical Results: Optimal Policy

Responses to shock to demand of borrowers, under 4 monetary policies
Numerical Results: Optimal Policy

Responses to financial shock, under 4 monetary policies
Provisional Conclusions

- Time-varying credit spreads do not require fundamental modification of one’s view of monetary transmission mechanism.
Provisional Conclusions

- Time-varying credit spreads do not require fundamental modification of one’s view of monetary transmission mechanism

- In a special case: the same “3-equation model” continues to apply, simply with additional disturbance terms
Provisional Conclusions

- Time-varying credit spreads do not require fundamental modification of one’s view of monetary transmission mechanism.

- In a special case: the same “3-equation model” continues to apply, simply with additional disturbance terms.

- More generally, a generalization of basic NK model that retains many qualitative features of that model of the transmission mechanism.
Provisional Conclusions

- Time-varying credit spreads do not require fundamental modification of one’s view of monetary transmission mechanism.

- In a special case: the same “3-equation model” continues to apply, simply with additional disturbance terms.

- More generally, a generalization of basic NK model that retains many qualitative features of that model of the transmission mechanism.

- Quantitatively, basic NK model remains a good approximation, esp. if little endogeneity of credit spreads.
Recognizing importance of credit frictions does not require reconsideration of the *de-emphasis of monetary aggregates* in NK models.
Recognizing importance of credit frictions does not require reconsideration of the de-emphasis of monetary aggregates in NK models.

Here, a model with credit frictions in which no reference to money whatsoever
Provisional Conclusions

- Recognizing importance of credit frictions does not require reconsideration of the de-emphasis of monetary aggregates in NK models.

- Here, a model with credit frictions in which no reference to money whatsoever.

- Credit a more important state variable than money.
Provisional Conclusions

- Recognizing importance of credit frictions does not require reconsideration of the **de-emphasis of monetary aggregates** in NK models.

  - Here, a model with credit frictions in which **no reference to money whatsoever**

  - **Credit** a more important state variable than **money**

  - However, **interest-rate spreads** really what matter more than variations in **quantity of credit**
Provisional Conclusions

- **Spread-adjusted Taylor rule** can improve upon standard Taylor rule under some circumstances.
Provisional Conclusions

- **Spread-adjusted Taylor rule** can improve upon standard Taylor rule under some circumstances

- However, **full adjustment** to spread increase not generally optimal, and optimal degree of adjustment depends on expected **persistence** of disturbance to spread
Provisional Conclusions

- **Spread-adjusted Taylor rule** can improve upon standard Taylor rule under some circumstances.

- However, **full adjustment** to spread increase not generally optimal, and optimal degree of adjustment depends on expected **persistence** of disturbance to spread.

- And desirability of spread adjustment depends on change in deposit rate being **passed through** to lending rates.
Provisional Conclusions

- **Spread-adjusted Taylor rule** can improve upon standard Taylor rule under some circumstances.

- However, **full adjustment** to spread increase not generally optimal, and optimal degree of adjustment depends on expected **persistence** of disturbance to spread.

- And desirability of spread adjustment depends on change in deposit rate being **passed through** to lending rates.

- General principle can be expressed more robustly in terms of a **target criterion**.
Provisional Conclusions

- Simple guideline for policy: base policy decisions on a target criterion relating inflation to output gap (optimal in absence of credit frictions)

- Take account of credit frictions only in model used to determine policy action required to fulfill target criterion