

# Credit Risk and the Macroeconomy

## Evidence From an Estimated DSGE Model

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## Macroeconomic-Financial Linkages

- The information content of credit spreads for the state of the economy suggests important linkages between the financial sector and the real economy.
- Quantify the importance of financial shocks in U.S. business cycle fluctuations.
  - Construct financial series from security-level data.
  - Use this information to estimate a DSGE model (CEE/SW) with the financial accelerator mechanism emphasized by BGG.

## Preview of the Results

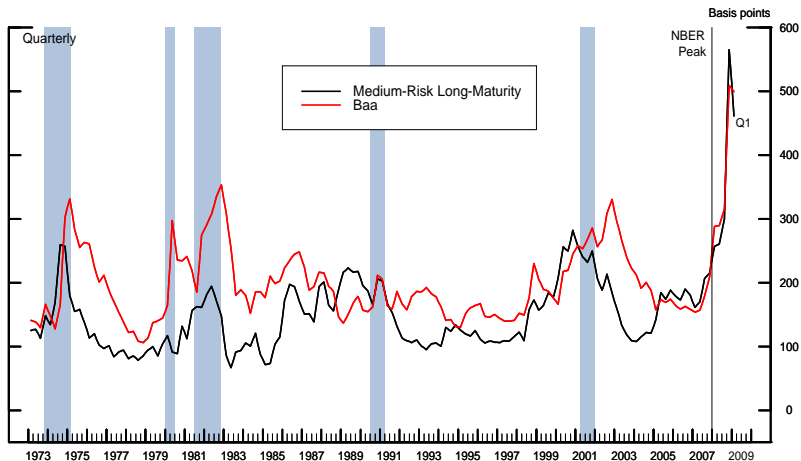
- Medium-risk long maturity (M-R/L-M) credit spreads have substantial predictive power for economic activity
- Estimation of a DSGE model that uses financial information to identify financial market distortions implies important role for credit-supply shocks for investment and output at business cycle frequencies.

## Data Sources

- **Credit Spreads:** prices of outstanding corporate bonds traded in the secondary market (Lehman/Warga & Merrill Lynch):
  - Sample period: Jan1973–Mar2009
  - 927 U.S. (nonfarm) nonfinancial issuers
  - 5,661 senior unsecured issues (364,403 bond/month observations)
  - Spreads relative to yields on comparable-maturity Treasuries
- **Credit Risk:** Merton (1974) distance-to-default (DD) model

# Selected Corporate Credit Spreads

(1973:Q1–2009:Q1)



# Comparison of Out-of-Sample Predictive Accuracy

(Sample period: 1973:Q1–2009:Q1; 4-quarter forecast horizon)

- **Specification 1:** term spread, real funds rate, Baa-Treasury spread
- **Specification 2:** medium-risk, long-maturity credit spread
- Jump-off point: 1989:Q4

<b>Economic Activity Indicator</b>	RMSFE-1	RMSFE-2	Ratio	Pr >  S
Private Payroll Employment	1.597	0.949	<b>0.594</b>	0.019
Unemployment Rate	0.840	0.562	<b>0.669</b>	0.022
Mfg. Industrial Production	4.693	3.132	<b>0.667</b>	0.007
Real Business Inventories	2.146	1.631	<b>0.760</b>	0.011
Real GDP	1.917	1.177	<b>0.614</b>	0.001
Real Business Fixed Investment	5.858	4.561	<b>0.779</b>	0.114

## DSGE Models with Financial Frictions

- Financial market imperfections imply that borrowers face an **external finance premium** (EFP) when trying to raise funds in capital/credit markets.
  - EFP depends inversely on agents' net worth.
  - EFP is larger for agents subject to greater agency problems.
- The presence of EFP gives rise to the **financial accelerator** mechanism:
  - During an economic downturn, asset prices fall and quality of borrowers' balance sheets deteriorates.
  - Worsening of borrowers' balance sheet conditions causes premiums on the various forms of external finance to increase.
  - As EFP jumps, agents cut back on their spending, causing asset prices to drop further, thereby amplifying the economic downturn.

## Related Literature

- Christensen and Dib (2008):
  - Provide quantitative evidence in favor of a financial accelerator mechanism.
- Queijo von Heideken (2008):
  - Presence of financial frictions improves the fit of the model for both the U.S. and Euro area.
- De Graeve (2008):
  - Recovers the model-implied EFP and relates it to measures of “credit availability” (i.e., credit spreads, bank lending standards).
- Christiano, Motto & Rostagno (2009):
  - Demonstrate that shocks to the financial sector have played an important role in cyclical fluctuations in both the U.S. and Euro area.



# Estimated DSGE Model

Smets & Wouters (2007); Christiano, Motto & Rostagno (2009)

- Key features of the model:
  - Habit formation in consumption.
  - Higher-order adjustment costs to investment.
  - Shocks to investment technology.
  - Variable capacity utilization.
  - Calvo-style price rigidities with partial indexation—New Keynesian Phillips curve.
  - Calvo-style wage rigidities with partial indexation.
  - Nominal interest rate rule responds to inflation, output gap, and output growth.

# Implementation

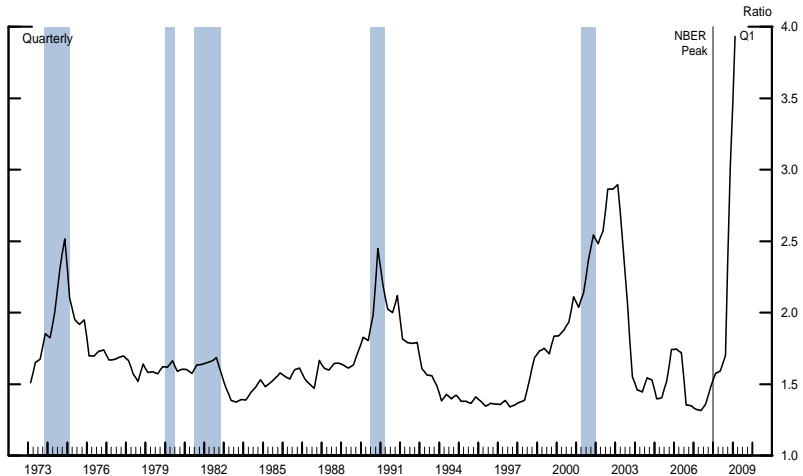
- Use medium-risk long-horizon credit spreads to measure external finance premium:

$$s_t = \chi (q_t + k_t - n_t) + \varepsilon_t^{fd}, \quad \chi > 0$$

$$n_t = \frac{K}{N} r_t^K - \left( \frac{K}{N} - 1 \right) (s_{t-1} + r_{t-1} - \pi_t) + \theta n_{t-1} + \varepsilon_t^{mw}$$

- $z_t \equiv q_t + k_t - n_t = \log$  of leverage ratio
- Allow for **credit-supply** shocks:
  - $\varepsilon_t^{fd}$ : disturbances to credit intermediation
  - $\varepsilon_t^{mw}$ : disturbances to asset values that serve as collateral

# Leverage in the U.S. Nonfinancial Corporate Sector (1973:Q1–2009:Q1)



## Shock Processes

- 9 structural shocks:

Preferences:  $\varepsilon_t^b = \rho_b \varepsilon_{t-1}^b + \eta_t^b$

Technology:  $\varepsilon_t^a = \rho_a \varepsilon_{t-1}^a + \eta_t^a$

Government Spending:  $\varepsilon_t^g = \rho_g \varepsilon_{t-1}^g + \eta_t^g + \rho_{g\alpha} \eta_t^a$

Price Mark-Up:  $\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + \eta_t^p - \mu_p \eta_{t-1}^p$

Wage Mark-Up:  $\varepsilon_t^w = \rho_w \varepsilon_{t-1}^w + \eta_t^w - \mu_w \eta_{t-1}^w$

Monetary Policy:  $\varepsilon_t^r = \rho_r \varepsilon_{t-1}^r + \eta_t^r$

Investment-Specific Technology:  $\varepsilon_t^{qs} = \rho_{qs} \varepsilon_{t-1}^{qs} + \eta_t^{qs}$

**Credit Spread:**  $\varepsilon_t^{fd} = \rho_{fd} \varepsilon_{t-1}^{fd} + \eta_t^{fd}$

**Net Worth:**  $\varepsilon_t^{nw} = \eta_t^{nw}$

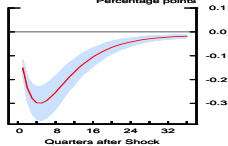
## Data

- 9 macroeconomic/financial series:
  - $GDP_t$  = real GDP per capita
  - $CONS_t$  = real PCE per capital (nondurable goods & services)
  - $INV_t$  = real investment per capita  
(private fixed investment & durable goods PCE)
  - $W_t$  = real wage per capita (nonfarm business sector)
  - $HRS_t$  = average hours worked per capita  
(nonfarm business sector)
  - $P_t$  = GDP price deflator
  - $FF_t$  = effective federal funds rate
  - $LEV_t$  = average leverage (nonfinancial corporate sector)
  - $CS_t$  = M-R/L-M credit spread
- Sample period: 1973:Q1–2009:Q1

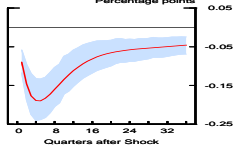
# Contractionary Monetary Policy Shock

(1-standard-deviation shock to federal funds rate)

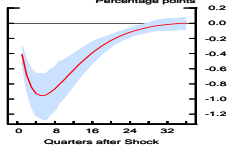
Output Percentage points



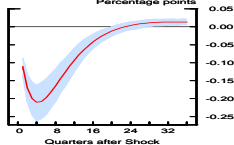
Consumption Percentage points



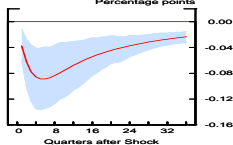
Investment Percentage points



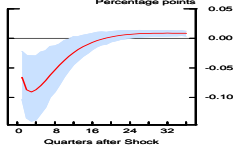
Hours worked Percentage points



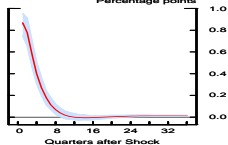
Wages Percentage points



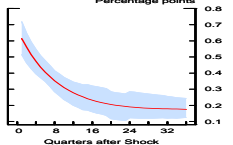
Inflation Percentage points



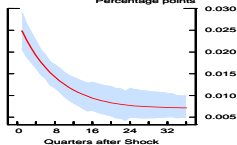
Federal funds rate Percentage points



Leverage Percentage points

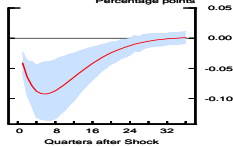


Credit spread Percentage points

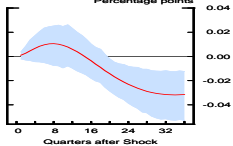


# Adverse Credit Spread Shock (1-standard-deviation shock to credit spreads)

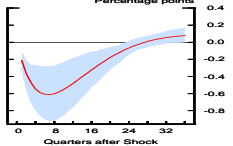
Output Percentage points



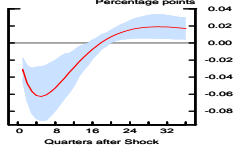
Consumption Percentage points



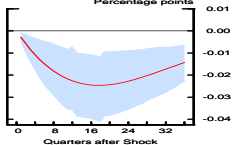
Investment Percentage points



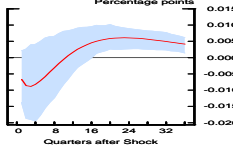
Hours worked Percentage points



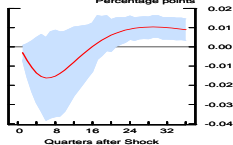
Wages Percentage points



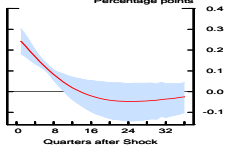
Inflation Percentage points



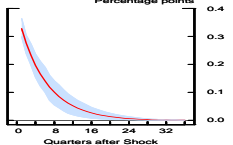
Federal funds rate Percentage points



Leverage Percentage points

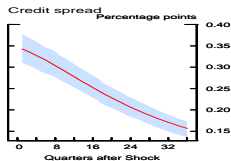
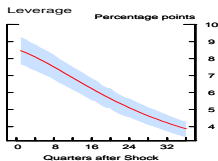
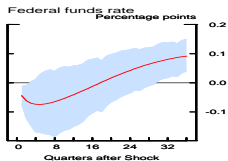
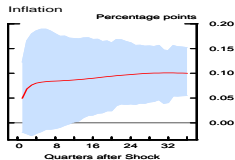
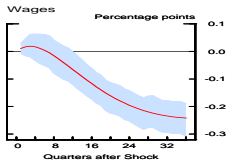
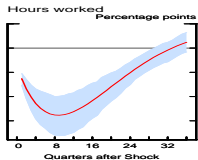
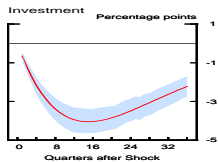
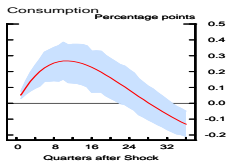
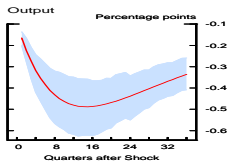


Credit spread Percentage points



# Adverse Net Worth Shock

(1-standard-deviation shock to net worth)





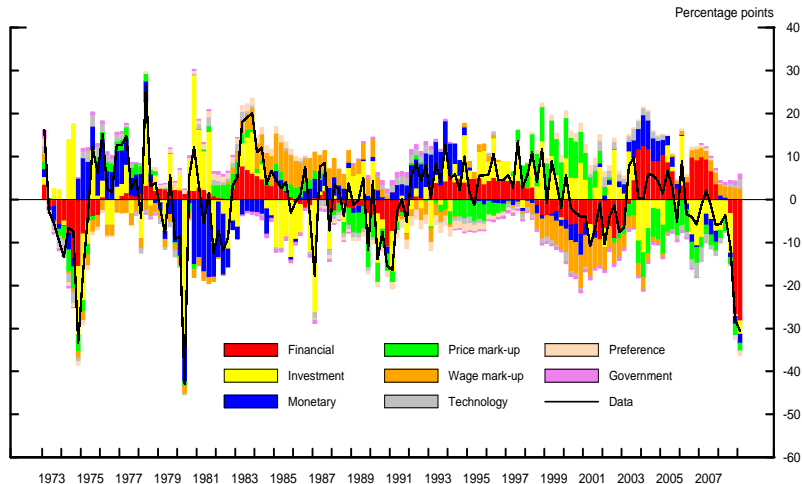
Horizon	Net Worth	Fin. Distress	Investment	Monetary	Price markup	Wage markup	Technology	Preference	Government
<b>Output Growth</b>									
1Q	10.1	0.6	29.6	6.0	0.0	0.5	8.6	8.0	36.6
4Q	13.6	0.8	35.2	7.2	1.2	0.9	6.6	6.6	27.8
8Q	16.4	0.8	33.0	6.7	1.9	3.0	6.1	6.1	25.8
16Q	17.5	0.8	33.8	6.3	2.3	4.0	5.8	5.7	23.8
24Q	16.9	0.8	35.0	6.3	2.6	4.2	5.8	5.5	22.8
Asymptotic	17.9	0.8	34.6	6.3	2.6	5.3	5.6	5.3	21.6
<b>Consumption Growth</b>									
1Q	0.2	0.0	0.0	11.5	0.2	0.6	0.0	87.4	0.1
4Q	0.8	0.0	0.2	16.5	0.8	2.9	0.1	78.7	0.1
8Q	2.3	0.0	1.1	15.0	2.4	6.6	0.1	72.4	0.1
16Q	7.9	0.1	2.9	13.3	2.4	8.3	0.2	64.7	0.1
24Q	12.3	0.1	3.0	12.6	2.6	7.9	0.3	61.0	0.2
Asymptotic	13.0	0.2	6.0	12.1	2.6	9.0	0.3	56.6	0.2
<b>Investment Growth</b>									
1Q	10.0	1.3	83.9	4.3	0.2	0.0	0.2	0.0	0.0
4Q	16.5	1.5	75.9	4.3	1.0	0.4	0.3	0.1	0.0
8Q	21.9	1.4	69.2	4.0	1.4	1.6	0.3	0.2	0.0
16Q	23.0	1.3	67.9	3.6	1.6	2.1	0.3	0.2	0.0
24Q	21.8	1.4	68.6	3.5	1.9	2.2	0.4	0.2	0.0
Asymptotic	23.0	1.4	66.2	3.6	1.9	3.3	0.4	0.2	0.0

Horizon	Net Worth	Fin. Distress	Investment	Monetary	Price markup	Wage markup	Technology	Preference	Government
<b>Hours</b>									
1Q	9.0	0.6	27.1	5.4	0.1	0.5	16.6	7.3	33.5
4Q	17.1	1.1	42.7	9.3	0.5	1.7	5.5	6.4	15.8
8Q	27.9	1.2	37.4	9.7	1.5	4.7	2.5	4.9	10.2
16Q	46.0	1.0	21.2	7.9	1.6	10.6	1.2	3.5	7.0
24Q	55.4	0.7	15.4	6.1	1.1	11.5	1.0	2.7	5.9
Asymptotic	54.8	0.7	21.0	4.6	1.4	9.2	1.1	2.1	5.1
<b>Wage Growth</b>									
1Q	0.1	0.0	0.0	0.0	8.9	90.9	0.1	0.0	0.0
4Q	0.1	0.0	0.0	0.0	17.0	82.4	0.4	0.0	0.0
8Q	0.2	0.0	0.2	0.0	18.2	80.8	0.7	0.0	0.0
16Q	0.3	0.0	0.5	0.0	17.7	80.8	0.7	0.0	0.0
24Q	0.7	0.0	0.5	0.0	17.7	80.2	0.7	0.0	0.0
Asymptotic	1.2	0.0	0.7	0.0	17.6	79.6	0.8	0.0	0.0
<b>Inflation</b>									
1Q	0.2	0.0	0.2	0.0	86.3	11.6	1.5	0.0	0.1
4Q	0.7	0.0	1.0	0.1	53.8	40.1	3.8	0.1	0.4
8Q	1.0	0.0	2.4	0.1	37.5	54.5	3.9	0.1	0.5
16Q	1.0	0.1	6.2	0.1	28.8	59.7	3.3	0.1	0.7
24Q	1.7	0.2	8.8	0.2	27.4	57.7	3.1	0.1	0.8
Asymptotic	7.7	0.3	9.3	0.4	25.0	53.5	2.9	0.1	0.7

Horizon	Net Worth	Fin. Distress	Investment	Monetary	Price markup	Wage markup	Technology	Preference	Government
<b>Interest rate</b>									
1Q	1.8	0.0	0.1	82.3	3.9	1.3	2.2	8.1	0.3
4Q	8.2	0.0	0.6	66.4	3.0	8.9	5.0	6.8	1.0
8Q	14.5	0.1	0.5	44.2	6.7	22.3	5.9	4.5	1.4
16Q	16.6	0.1	4.9	31.1	5.3	32.4	4.9	3.2	1.5
24Q	14.6	0.3	12.6	27.1	4.6	32.4	4.2	2.8	1.4
Asymptotic	20.7	0.5	16.0	22.7	3.7	29.4	3.4	2.4	1.1
<b>Leverage</b>									
1Q	99.0	0.1	0.4	0.4	0.0	0.1	0.0	0.0	0.0
4Q	98.8	0.1	0.7	0.3	0.0	0.1	0.0	0.0	0.0
8Q	98.1	0.0	1.4	0.2	0.1	0.1	0.0	0.0	0.0
16Q	95.9	0.0	3.3	0.1	0.2	0.4	0.0	0.0	0.0
24Q	93.6	0.0	5.1	0.1	0.3	0.8	0.0	0.0	0.0
Asymptotic	90.6	0.1	6.7	0.2	0.3	2.0	0.0	0.1	0.0
<b>External Finance Premium</b>									
1Q	52.8	46.7	0.2	0.2	0.0	0.1	0.0	0.0	0.0
4Q	61.3	38.0	0.4	0.2	0.0	0.1	0.0	0.0	0.0
8Q	69.0	29.7	1.0	0.2	0.1	0.1	0.0	0.0	0.0
16Q	75.9	20.9	2.7	0.1	0.1	0.3	0.0	0.0	0.0
24Q	77.5	17.2	4.2	0.1	0.2	0.7	0.0	0.0	0.0
Asymptotic	77.1	15.0	5.7	0.1	0.3	1.7	0.0	0.1	0.0

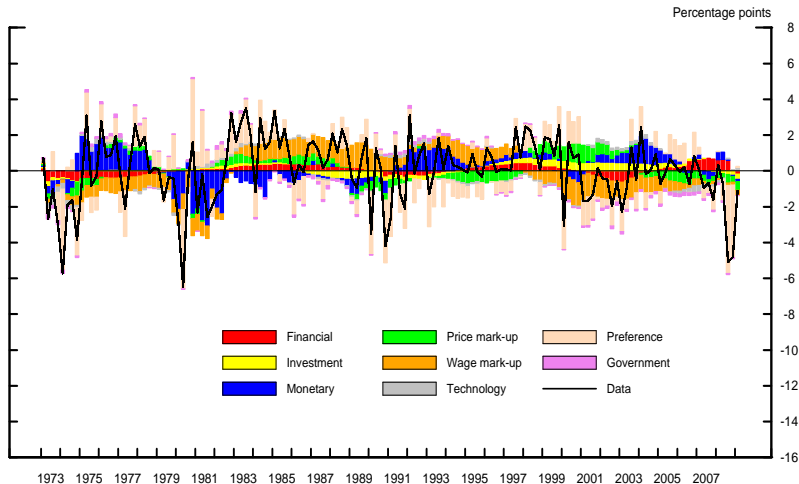
# Decomposition of Investment Growth

(Percentage point deviation (annual rate) from steady state)



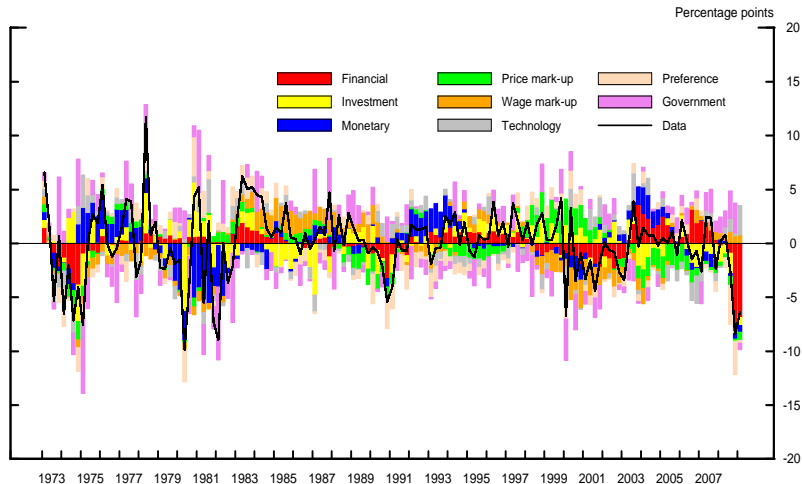
# Decomposition of Consumption Growth

(Percentage point deviation (annual rate) from steady state)



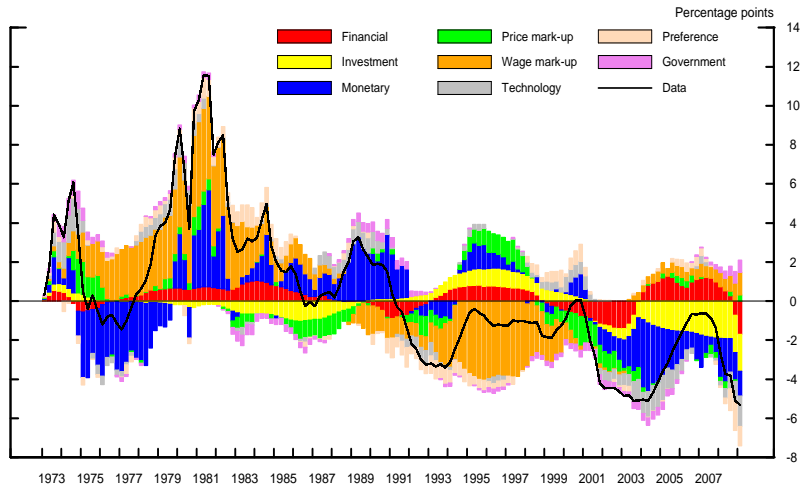
# Decomposition of Output Growth

(Percentage point deviation (annual rate) from steady state)



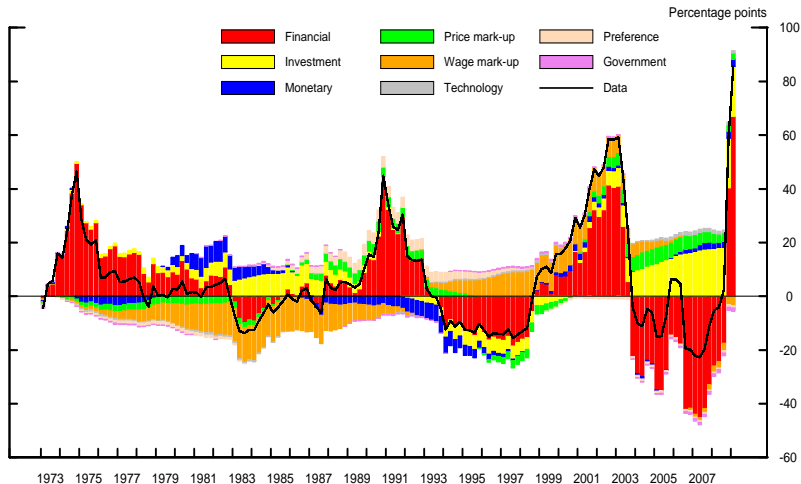
# Decomposition of Federal Funds Rate

(Annualized percentage point deviation from steady state)



# Decomposition of Leverage

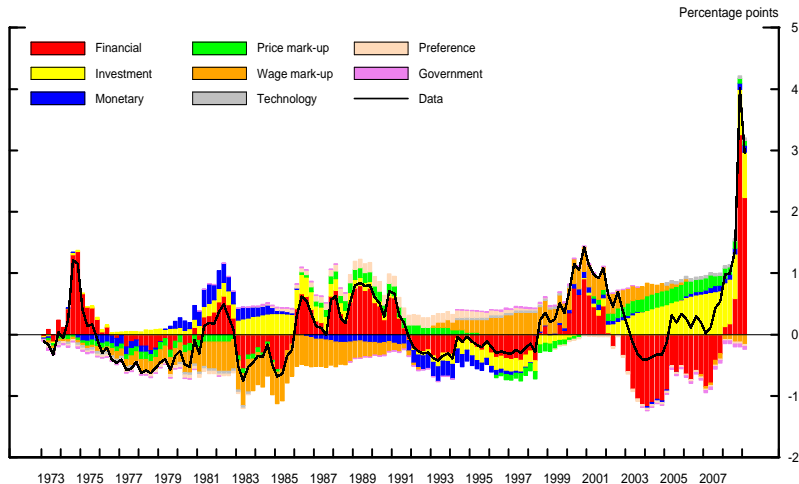
(Percentage point deviation from steady state)





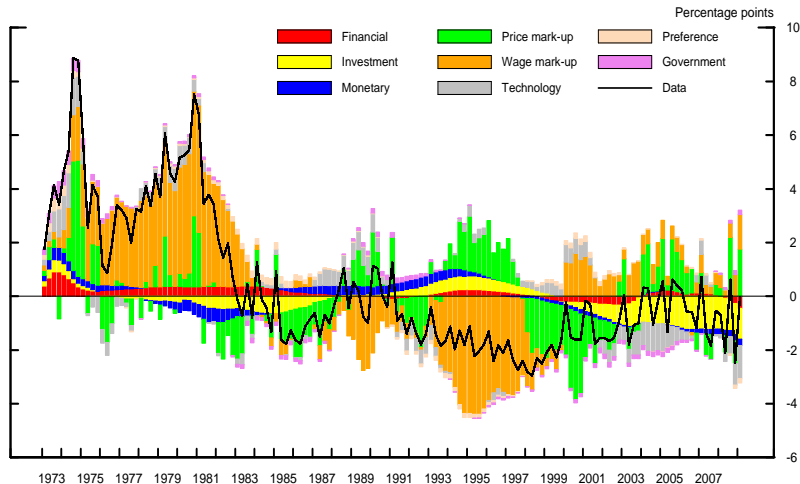
# Decomposition of M-R/L-M Credit Spread

(Annualized percentage point deviation from steady state)



# Decomposition of Price Inflation

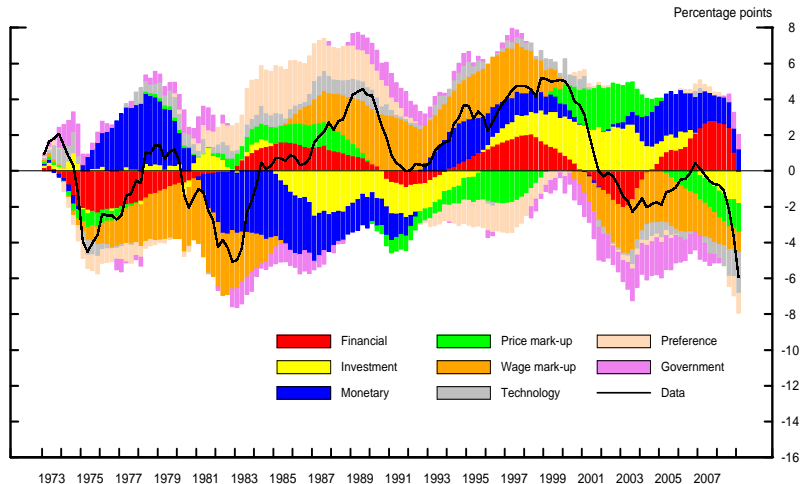
(Percentage point deviation (annual rate) from steady state)





# Decomposition of Hours Worked

(Percentage point deviation from steady state)



## Concluding Remarks

- Medium-risk long-maturity (M-R/L-M) credit spreads have substantial predictive power for economic activity.
- Estimation of a DSGE model that uses M-R/L-M credit spreads to identify financial market distortions implies important role for credit-supply shocks for investment and output at business cycle frequencies.
- Directions for future research:
  - Addition of frictions in the intermediation process linking household borrowing to asset prices.
  - Explicit modeling of the financial sector.

## Priors & Posteriors: Structural Parameters

Parameter	Prior			Posterior			
	Distr.	Mean	SD	Mode	Mean	P5	P95
$\chi$	Beta	0.05	0.02	0.01	0.01	0.01	0.01
$\varphi$	Normal	4.00	1.50	4.62	6.98	5.43	8.56
$\sigma_c$	Normal	1.50	0.37	0.98	0.95	0.88	1.02
$h$	Beta	0.70	0.10	0.90	0.92	0.89	0.95
$\xi_w$	Beta	0.50	0.10	0.94	0.77	0.68	0.87
$\sigma_l$	Normal	2.00	0.75	2.36	1.43	0.25	2.73
$\xi_p$	Beta	0.50	0.10	0.72	0.74	0.68	0.80
$\iota_w$	Beta	0.50	0.15	0.38	0.46	0.25	0.67
$\iota_p$	Beta	0.50	0.15	0.65	0.38	0.19	0.61
$\psi$	Beta	0.50	0.15	0.36	0.57	0.44	0.71
$\phi_p$	Normal	1.25	0.12	1.70	1.49	1.36	1.64

## Priors & Posteriors: Structural Parameters (cont.)

Parameter	Prior			Posterior			
	Distr.	Mean	SD	Mode	Mean	P5	P95
$r_\pi$	Normal	1.50	0.25	1.10	1.72	1.45	1.97
$\rho$	Beta	0.75	0.10	0.74	0.79	0.75	0.84
$r_y$	Normal	0.12	0.05	0.001	0.08	0.04	0.12
$r_{\Delta y}$	Normal	0.12	0.05	0.14	0.17	0.12	0.23
$\bar{\pi}$	Gamma	0.62	0.10	0.88	0.77	0.61	0.94
$100(\beta^{-1} - 1)$	Gamma	0.25	0.10	0.34	0.27	0.14	0.43
$\bar{l}$	Normal	0.00	2.00	-5.61	-4.61	-5.56	-3.70
$\bar{\gamma}$	Normal	0.40	0.10	0.33	0.36	0.33	0.39
$\alpha$	Normal	0.30	0.05	0.26	0.20	0.17	0.23
$\bar{z}$	Normal	52.0	10.0	45.7	45.3	40.6	50.3
$\bar{s}$	Normal	0.39	0.10	0.35	0.34	0.26	0.41

# Priors & Posteriors: Shock Processes

## Volatility Parameters

Parameter	Prior			Posterior			
	Distr.	Mean	SD	Mode	Mean	P5	P95
$\sigma_n$	Invgamma	0.10	2.00	7.88	8.15	7.38	8.91
$\sigma_{fd}$	Invgamma	0.10	2.00	0.08	0.08	0.07	0.09
$\sigma_{qs}$	Invgamma	0.10	2.00	0.56	0.47	0.33	0.59
$\sigma_a$	Invgamma	0.10	2.00	0.41	0.41	0.37	0.46
$\sigma_b$	Invgamma	0.10	2.00	0.14	0.12	0.09	0.15
$\sigma_g$	Invgamma	0.10	2.00	0.50	0.50	0.45	0.55
$\sigma_r$	Invgamma	0.10	2.00	0.25	0.25	0.22	0.28
$\sigma_p$	Invgamma	0.10	2.00	0.20	0.18	0.12	0.23
$\sigma_w$	Invgamma	0.10	2.00	0.21	0.23	0.18	0.27



# Priors & Posteriors: Shock Processes (cont.)

## Persistence Parameters

Parameter	Prior			Posterior			
	Distr.	Mean	SD	Mode	Mean	P5	P95
$\rho_{fd}$	Beta	0.50	0.20	0.84	0.84	0.79	0.89
$\rho_{qs}$	Beta	0.50	0.20	0.61	0.74	0.61	0.87
$\rho_a$	Beta	0.50	0.20	0.92	0.84	0.75	0.93
$\rho_b$	Beta	0.50	0.20	0.29	0.52	0.37	0.68
$\rho_g$	Beta	0.50	0.20	0.89	0.89	0.82	0.96
$\rho_r$	Beta	0.50	0.20	0.22	0.19	0.07	0.30
$\rho_p$	Beta	0.50	0.20	0.64	0.82	0.71	0.94
$\rho_w$	Beta	0.50	0.20	0.80	0.88	0.80	0.96
$\mu_p$	Beta	0.50	0.20	0.89	0.82	0.64	0.99
$\mu_w$	Beta	0.50	0.20	0.72	0.75	0.61	0.89
$\rho_{ga}$	Beta	0.50	0.20	0.62	0.47	0.30	0.65