The Cyclicality of the Term Structure of Interest Rates

Mirko Abbritti, Carlos Fellmann and Antonio Moreno

National Bank of Belgium

February 16th, 2023

Outline

- Motivation
- Model
- Results
- Robustness
- Conclusions

Outline

- Motivation
- Model
- Results
- Robustness
- Conclusions

The Key Objects in this Paper

$SP_t = R_t^{(10)} - R_t^{(1)}$ => Term Spread (Yield Slope)

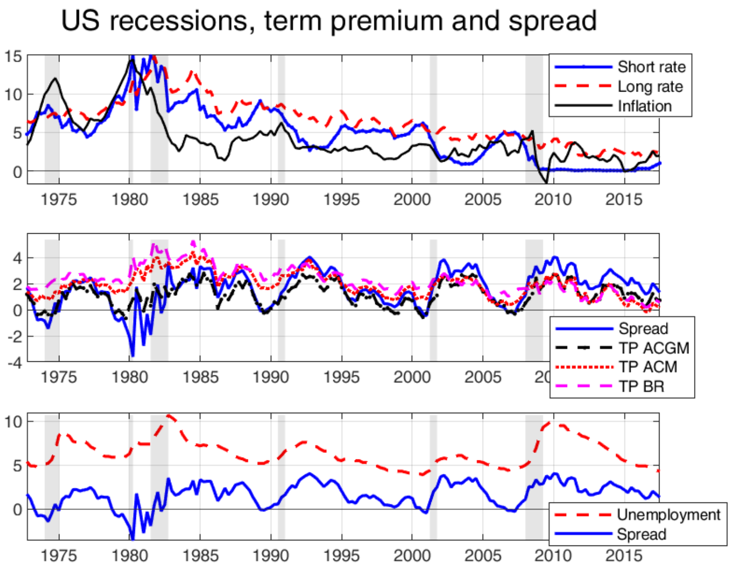
$TP_t = R_t^{(10)} - R_t^{(EH)}$ => Term Premium

$R_t^{EH} = \frac{1}{10} E_t \sum_{i=0}^{9} R_{t+i}^{(1)}$ => Risk Neutral Rate (EH)

SP_t and TP_t key indicators of financial conditions, targeted by recent monetary policy

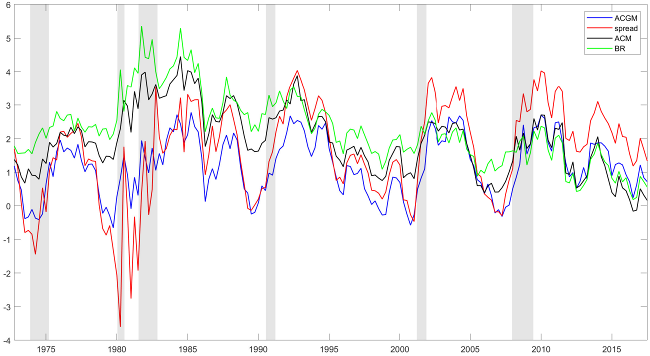
Key Focus of the paper: Explain cyclicality of SP_t and TP_t

Term Spread and Term Premium Cyclicality



Term Premium(s) and Term Spread

US recessions, term premium and spread

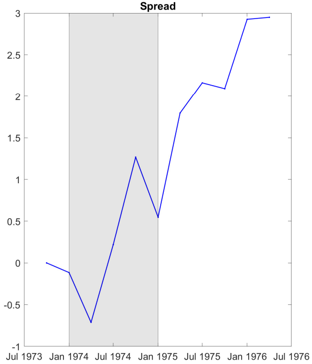


Two term structure stylized facts

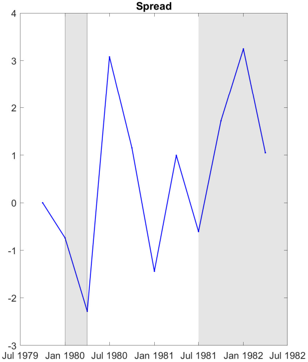
- The term spread and term premium are counter-cyclical

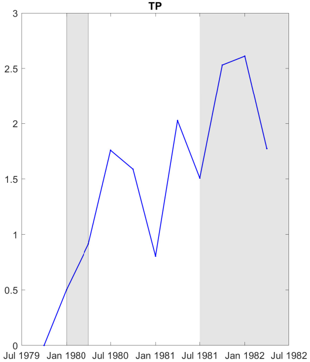
- High positive correlation between the term spread (and the term premium) with the unemployment rate.

1974 recession

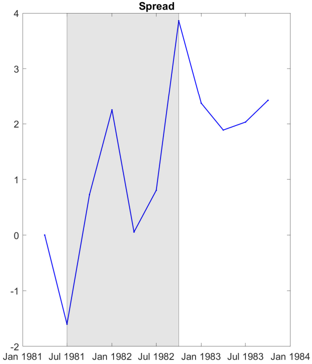


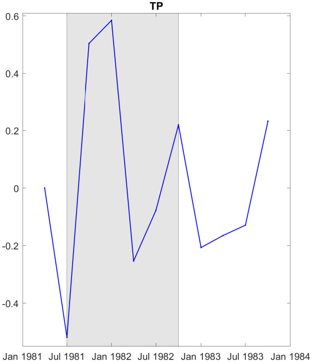
1980 recession



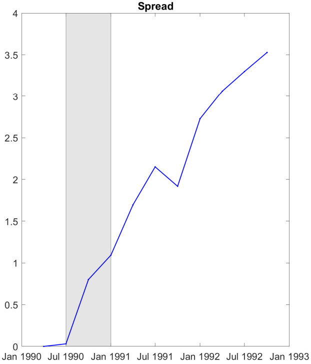


1981 recession

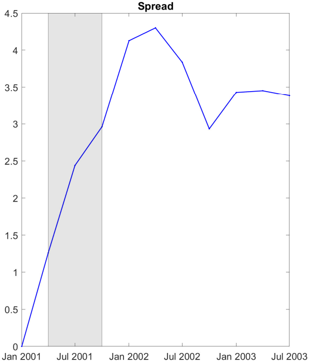




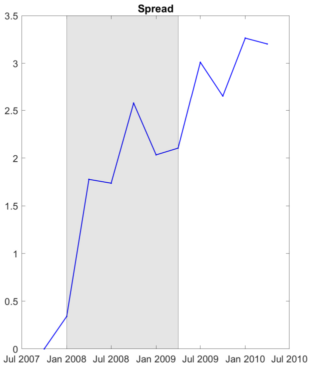
1990 recession



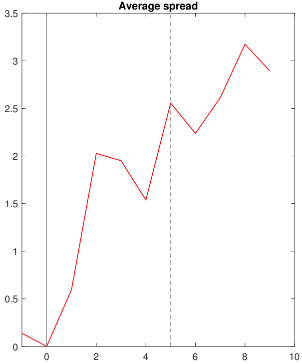
2001 recession

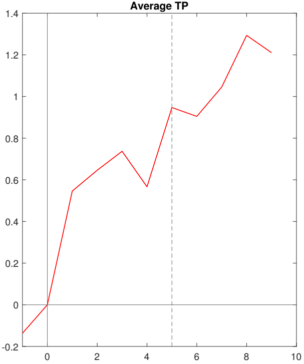


2008 recession



Average across recessions

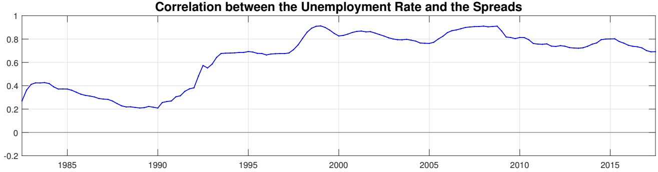


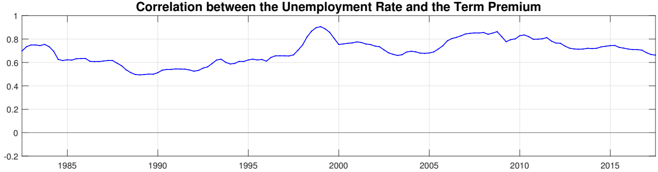


Two term structure stylized facts

- The term spread and term premium are counter-cyclical
- High positive correlation between the term spread (and the term premium) and the unemployment rate.

Unemployment and TS / TP





Literature Focus: Negative Supply Shock drives up TP

- Mainstream macro-finance models with complete markets explain the positive term premiums with negative supply shocks.
- The mechanism is that inflation causes the bond to be a bad asset in the very state of the world when consumer's marginal utility of consumption is high, so they demand a positive premium.
- Somewhat silent about effects on the yield slope

Negative Supply Shock
Counterfactual Effect on SP

Take the following stylized model:

$$\pi_t = a\pi_{t-1} + u_t$$

$$R_t = b\pi_t$$

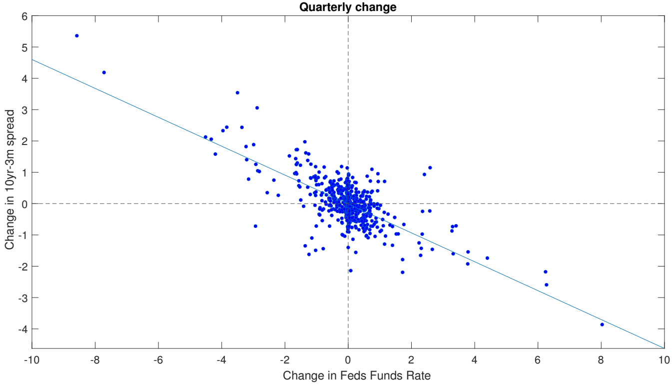
$$R_t^L = \frac{1}{2}[R_t + E_t R_{t+1}]$$

A recessionary supply shock $\uparrow u_t$ => $\uparrow R_t$ => $\uparrow R_t^L$

Importantly $\uparrow R_t$ > $\uparrow R_t^L$ (given that $a < 1$)

Therefore $\uparrow u_t$ => $\downarrow SP_t$, counterfactual in recessions

Another Way to Look at SP Counter-cyclicality



Punchline and Paper Motivation

- Data moves between the NW and SE quadrants.
- Recessionary dynamics of mainstream model points to the SE quadrant, mostly.
- But data in recent recessions point otherwise => NW.

=> We present a structural DSGE that fits the observed patterns in the data.

Demand shocks

- Demand shocks have mostly been omitted in the literature because they imply an overall negative term premium.
- With complete financial markets: a negative demand shock reduces inflation, increasing the real price of bonds and decreasing yields.
- The increase in prices means that bonds are a good hedge against bad times, so consumers do not demand a positive premium => counterfactual
- The decrease in yields also means a decrease in TP in recessions => counterfactual

Literature

- Models with complete financial markets.
  - Rudebusch and Swanson (2012) and Kung (2015) have models with complete financial markets. They seek to explain the positive slope of the yield curve.
  - Emphasis is on macro-to-finance channel.
- Models with incomplete financial markets
  - Gertler and Karadi (2013), Carlstrom et al. (2017) Sims and Wu (2021) have models with segmented markets. Their goal is to examine the effects of QE policies.
  - Emphasis is on finance-to-macro channel.
- We introduce a new focus: the cyclicality of the term structure

Outline

- Motivation
- Model
- Results
- Robustness
- Conclusions

A NK Model With Segmented Financial Markets and Unemployment

- **Financial intermediaries**
  - The short-term bond market is segmented from the long-term bond market: only financial intermediaries can purchase long term private and public bonds
  - Costly enforcement problem on financial intermediaries leads to an endogenous leverage constraint that results in excess returns
  - Loan in advance constraint on investment: firms must issue long term bonds to finance part of their investment
- **Labor market**: search and matching frictions; wages are set by Nash bargaining
- **Central bank**: Standard Taylor rule with interest rate smoothing
- **Shocks**: technology shock, monetary policy shock, credit shock

Model: Financial Intermediaries

The balance sheet of a financial intermediary (FI) is given by

$$Q_t F_{fi,t} + Q_{B,t} B_{fi,t} = D_{fi,t} + N_{fi,t}$$

FIs maximize the discounted stream of payouts to the households:

$$\mathcal{V}_{fi,t} = \max \left(1 - \sigma\right) E_t \sum_{k=1}^{\infty} \sigma^{k-1} \Lambda_{t,t+k} n_{fi,t+k}.$$

Subject to Incentive Constraint

$$\mathcal{V}_{fi,t} \geq \theta_t \left(Q_t f_{fi,t} + \omega Q_{B,t} b_{fi,t}\right)$$

θ_t is a credit shock: When θ_t increases, depositors are less willing to deposit funds in the FIs because these can take a larger fraction of assets in the event of default.

Model: Financial Intermediaries

Market segmentation allows FIs to take arbitrage opportunities. Their FOCs are

$$E_t \Lambda_{t,t+1} \frac{1}{\pi_{t+1}} \left(R^F_{t+1} - R^d_t \right) \Omega_{fi,t+1} = \frac{\mu_{fi,t}}{(1 + \mu_{fi,t})} \theta_t, \tag{1}$$

$$E_t \Lambda_{t,t+1} \frac{1}{\pi_{t+1}} \left(R^B_{t+1} - R^d_t \right) \Omega_{fi,t+1} = \frac{\mu_{fi,t}}{(1 + \mu_{fi,t})} \theta_t \omega, \tag{2}$$

Leverage constraint:

$$\phi_{fi,t} = \frac{Q_t f_{fi,t} + \omega Q_{B,t} b_{fi,t}}{n_{fi,t}} \leq \bar{\phi}_{fi,t}$$

$\mu_{fi,t}$ is the incentive constraint multiplier.
If constraint binds => $\mu_{fi,t} > 0$, spreads > 0

Model: Households

$$U_t = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log \left(C_t - hC_{t-1} \right) \right\},$$

Subject to budget constraint and:

- Standard law of motion of capital:
  $k_{t+1} = \left(1 - \delta_K \left(z_t\right)\right) k_t + \hat{I}_t$
- Law of motion of labor: $L_t = (1 - \rho) L_{t-1} + m_t$
- Loan in advance constraint: $\psi P_t^k \hat{I}_t \leq Q_t \left(F_{w,t} - \kappa F_{w,t-1} \right)$

Model: Households

The FOCs are

$$\lambda_t = \frac{1}{C_t - hC_{t-1}} - \beta \mathbb{E}_t \left(\frac{h}{C_{t+1} - hC_t} \right)$$

$$1 = R_t^D \mathbb{E}_t \frac{\Lambda_{t,t+1}}{\pi_{t+1}}$$

$$r_{Kt} = p_t^k M_{2,t} \delta_K' (z_t)$$

$$p_t^k M_{2,t} = \mathbb{E}_t \Lambda_{t,t+1} \left(r_{Kt+1} z_{t+1} + (1 - \delta_K (z_{t+1})) p_{t+1}^k M_{2,t+1} \right)$$

$$Q_t M_{1,t} = \mathbb{E}_t \Lambda_{t,t+1} \pi_{t+1}^{-1} \left\{ 1 + M_{1,t+1} \kappa Q_{t+1} \right\}$$

Model: Labor Market

The labor market has a standard matching function

$$m_t = \bar{m} u_t^{\zeta} v_t^{1-\zeta},$$

Each period, there is a fixed probability of each job being destroyed. Destroyed jobs are replaced by new ones. The law of motion of employment is given by

$$L_t = (1-\rho) L_{t-1} + m_t.$$

Wages are determined by Nash bargaining

$$w_t = \eta \left[(1-\alpha) p_{S,t} \frac{X_t}{L_t} + CV_t^F \right] + (1-\eta) \left[ub_t - CV_t^H \right],$$

Model: Supply side

- Retail sector
  - Linear production function $Y_t = X_t$ and nominal price rigidities á la Calvo
- Intermediate production sector
  - The production function is a Cobb-Douglas

$$X_t = A_t \left(\gamma^t L_t\right)^{1-\alpha} (K_t)^{\alpha}$$

  - Firms are subject to hiring costs

$$hc_t = \varphi_t v_t$$

  - The FOCs are standard
    - $r_{K,t} = \alpha p_{S,t} \frac{X_t}{K_t}$
    - $J_t = (1-\alpha) p_{S,t} \frac{X_t}{L_t} - w_t + \mathbb{E}_t \Lambda_{t,t+1} J_{t+1}$
    - $\varphi_t = J_t \mu_{V,t}$

Model: Monetary and Fiscal authorities

The Central Bank sets the nominal short-term interest rate according to a standard Taylor Rule

$$R_t^d = \left(R_{t-1}^d\right)^{\varphi_i} \left[R^d \left(\frac{\pi_t}{\pi^*}\right)^{\varphi_\pi} \left(\frac{\hat{Y}_t}{\gamma \hat{Y}_{t-1}}\right)^{\varphi_y} \right]^{1-\varphi_i} \varepsilon_t^m$$

The government consumes and exogenous amount of output, collects taxes and finances its deficit issuing long-term debt according to the following budget constraint

$$T_t = G_t + ub_t(1 - L_t) + (1 + \kappa Q_{B,t}) \frac{B_{G,t-1}}{P_t} - Q_{B,t} \frac{B_{G,t}}{P_t}.$$

Term Premium and Term Spread: Closed-Form

$$\widehat{TP}_t \approx \Theta \sum_{j=0}^{\infty} \left(\frac{\kappa}{R^d}\right)^j \mathbb{E}_t \left\{ (1-\Delta)\,\hat{\phi}_{t+j} - \frac{\sigma\theta\phi}{\Omega}\hat{\phi}_{t+j+1} + \left(1 - \rho_\theta \frac{\sigma\theta\phi}{\Omega}\right)\hat{\theta}_{t+j} \right\}$$

$$\widehat{TS}_t = \left\{ \underbrace{\frac{R^d - \kappa}{R^d} \sum_{j=0}^{\infty} \left(\frac{\kappa}{R^d}\right)^j \hat{R}^d_{t+j} - \hat{R}^d_t}_{\widehat{NS}_t} \right\} + \widehat{TP}_t$$

Inspecting the Mechanism: Credit Shock

1. Tightening Credit Shock Makes FIs more likely to Default
2. Deposits decline => Less Funding for Banks
3. Less purchases of long-term bonds => Long-term Rates Increase
4. Firms cannot invest as much => economic activity declines
5. Short-term Rate declines through monetary policy reaction function
6. Both the Term Spread and the Term Premium increase

Outline

- Motivation
- Model
- Results
- Robustness
- Conclusions

Results: Calibration

Table: Baseline parameter values

Parameter	Description	Value
κ	Bond duration	0.975
ψ	Debt-financed investment	0.81
σ	Financial intermediary survival reate	0.95
θ	Recoveravility parameter/credit shock	0.5792
X	Leverage	4
ω	Government bond recoverability	0.5028
π	Steady state inflation	3%
γ	Growth rate	1.5%
θ_p	Calvo probability of not changing prices	0.63
ρ_θ	AR credit shock	0.95
ρ_A	AR technology shock	0.95

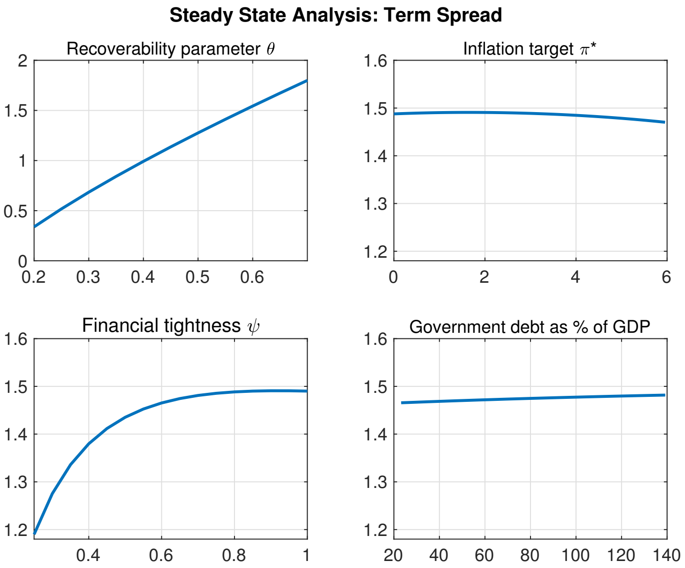
Results: Matching of moments

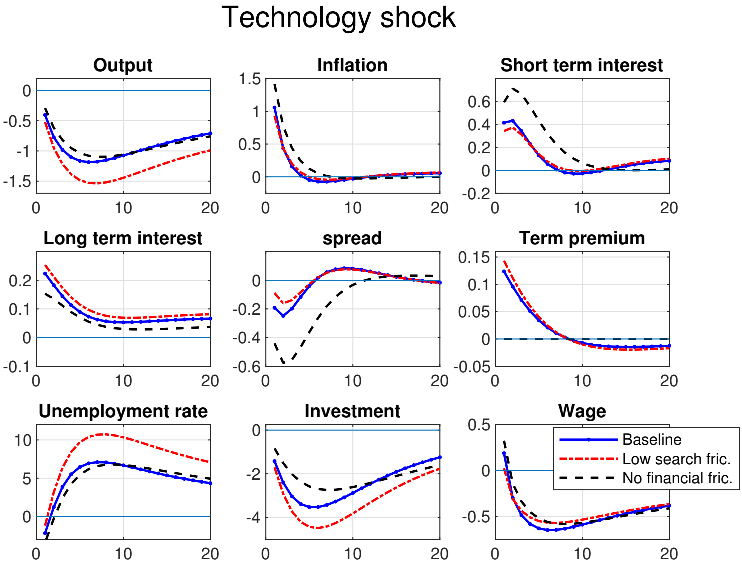
Moment matching	$\sigma(x)/\sigma(y)$				$\rho(x,y)$			
	Data	Baseline	Low S&M	No FF	Data	Baseline	Low S&M	No FF
Inflation	0.35	0.27	0.20	0.32	0.36	0.26	0.22	0.02
Unemployment	7.92	7.61	8.77	8.17	-0.87	-0.76	-0.77	-0.72
Employment	0.58	0.48	0.67	0.49	0.87	0.79	0.86	0.74
Wages	0.64	0.68	0.44	0.68	0.10	0.86	0.83	0.81
Investment	3.84	3.84	3.91	2.57	0.93	0.95	0.94	0.99
Consumption	0.59	0.52	0.50	0.52	0.83	0.45	0.63	0.99
Short rate	0.22	0.22	0.16	0.23	0.33	0.11	0.10	-0.42
Long rate	0.13	0.05	0.04	0.04	0.02	-0.15	-0.21	-0.32
Spread	0.18	0.19	0.13	0.19	-0.41	-0.17	-0.18	0.44
Term premium	0.09	0.05	0.04	-	-0.41	-0.37	-0.34	-
$\sigma(y)$	1.43	1.43	1.81	1.21				

Term Structure Steady-State

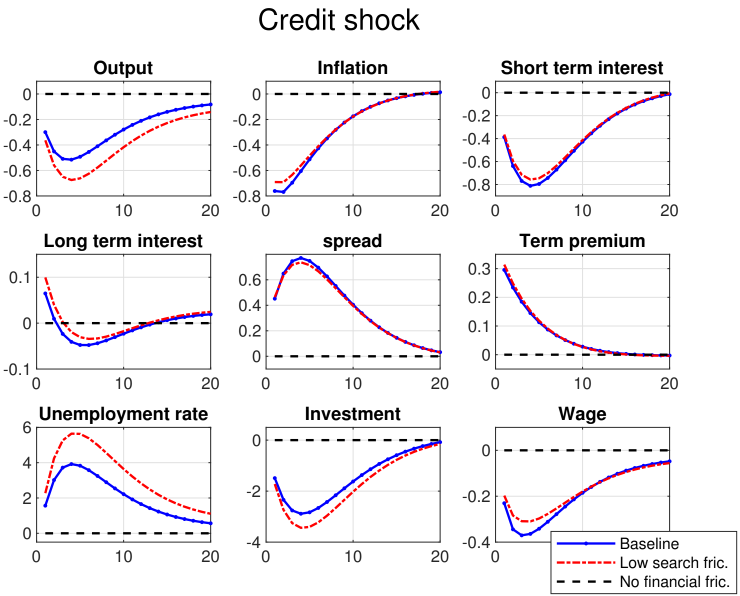
- Conventional Models: *TP* is a function of model covariances. Same thing for *TS*
- Segmented Market Model: $TS = 1 + \omega\left(\frac{\theta}{(1-\sigma)+\sigma\phi\theta} - \frac{1}{\phi}\right)$

Results: Steady-state Analysis




Technology shock
Output
Inflation
Short term interest
Long term interest
spread
Term premium
Unemployment rate
Investment
Wage
Baseline
Low search fric.
No financial fric.

Results: IRFs, Credit shock



Cross-correlations

Variable	Data	Baseline	Technology shock	Mon. Policy shock	Credit Shock
			$\rho(x, y)$		
Spread	-0.41	-0.17	0.11	0.61	-0.98
Term Premium	-0.41	-0.36	-0.31	-0.88	-0.70
			$\rho(x, ur)$		
Spread	0.57	0.47	0.44	-0.77	0.98
Term Premium	0.54	0.11	-0.27	0.95	0.53

Outline

- Motivation
- Model
- Results
- Robustness
- Conclusions

Cross-correlations, Alternative Shocks

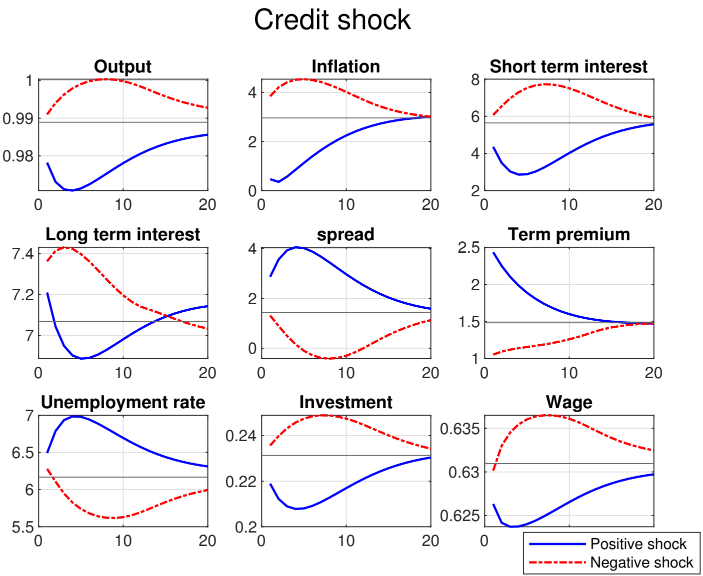
			$\rho(x,y)$			
Variable	Data	Preference shock	Inv.-specific shock	Mark-up shock	Gov. spending shock	Infl. target shock
Spread	-0.41	0.83	-0.60	0.50	-0.94	0.87
Term Premium	-0.41	0.79	0.54	-0.43	0.94	-0.51
			$\rho(x,ur)$			
Spread	0.57	-0.66	0.85	-0.54	0.97	-0.41
Term Premium	0.54	-0.62	-0.19	0.47	-0.96	-0.78

Asymmetric Effects of Credit Shocks

$$\mathcal{V}_{fi,t} \geq \theta_t \left(Q_t f_{fi,t} + \omega Q_{B,t} b_{fi,t} \right)$$

- ‘Booming’ Credit Shock, Large Reduction in θ_t
  - Endogenous Financial Constraint is not binding
  - Lots of liquidity, Excess Returns Arbitraged Away
  - Long-Bond rates go down until reaching the short-rate
  - Standard Expansionary effect on the economy
- ‘Tightening’ Credit Shock, Large Increase in θ_t
  - Endogenous Financial Constraint binding
  - Reduces Funding for Firms
  - Cost of long-term borrowing increases, so does spread and term premium
  - Reduces Investment and Productive Capacity for Firms
  - Amplified Contractionary Effects

Robustness: Asymmetric Effects of Credit Shocks



Cross-correlations: OBC v/s ABC

Moment matching	$\sigma(x)/\sigma(y)$			$\rho(x,y)$		
	Data	OBC	ABC	Data	OBC	ABC
Inflation	0.35	0.27	0.26	0.36	0.26	0.35
Unemployment	7.92	7.61	7.77	-0.87	-0.76	-0.81
Employment	0.58	0.48	0.47	0.87	0.79	0.84
Wages	0.64	0.68	0.69	0.10	0.86	0.89
Investment	3.84	3.84	3.96	0.93	0.95	0.95
Consumption	0.59	0.52	0.42	0.83	0.45	0.32
Short rate	0.22	0.22	0.22	0.33	0.11	0.31
Long rate	0.13	0.05	0.05	0.02	-0.15	-0.25
Spread	0.18	0.19	0.20	-0.41	-0.17	-0.40
Term premium	0.09	0.05	0.07	-0.41	-0.37	-0.42
$\sigma(y)$	1.43	1.43	1.57			

Outline

- Motivation
- Model
- Results
- Robustness
- Conclusions

Conclusions

This paper first highlights two stylized facts

- The term spread and the term premium are highly counter-cyclical.
- There is a high positive correlation between unemployment and these term structure variables.

We build a DSGE to rationalize these facts:

- A technology shock in a complete markets model –the standard in the literature– is insufficient to capture term structure cyclical dynamics.
- A credit shock in an incomplete, segmented markets model fits term spread patterns better during most recessions.

=> Credit risk key to understand Term Premium, Term Spread