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Financial conditions and monetary policy: the importance of non-linear effects

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Episodic nature of financial factors

"... a reason why statistically significant and macroeconomically important linkages have been elusive is because the importance of financial factors tends to be episodic in nature. In "normal times," firms make investment decisions on the basis of whether a project's expected rate of return exceeds the user cost of capital, and then having made that decision, seek the financing. In such times, the financing decision is, in some sense, subordinate to the real-side decisions of the firm; credit "doesn't matter." In other times, when the financial system is not operating normally, financial frictions become important as lending terms and standards tighten, making the interest rate a much less reliable metric of the cost of funds, broadly defined. During such times, which we will call stress events; credit can seem like it is the only thing that matters."

Kirstin Hubrich and Robert J. Tetlow (2015). **Financial stress and economic dynamics: The transmission of crises**. Journal of Monetary Economics, 70: 100 -115.

Financial conditions, economic activity and monetary policy

"To the extent that the decline in forward rates can be traced to a decline in the term premium*, …, the effect is financially stimulative and argues for greater monetary policy restraint, all else being equal. Specifically, if spending depends on long-term interest rates, special factors that lower the spread between short-term and long-term rates will stimulate aggregate demand. Thus, when the term premium declines, a higher short-term rate is required to obtain the long-term rate and the overall mix of financial conditions consistent with maximum sustainable employment and stable prices."

FRB Chairman Ben S. Bernanke, March 20, 2006, "***Reflections on the Yield Curve and Monetary Policy***."

***Term premium**: extra compensation required by investors for bearing interest rate risk associated with short-term yields not evolving as expected.

US GDP Growth, Federal Funds Rate and Term Premium

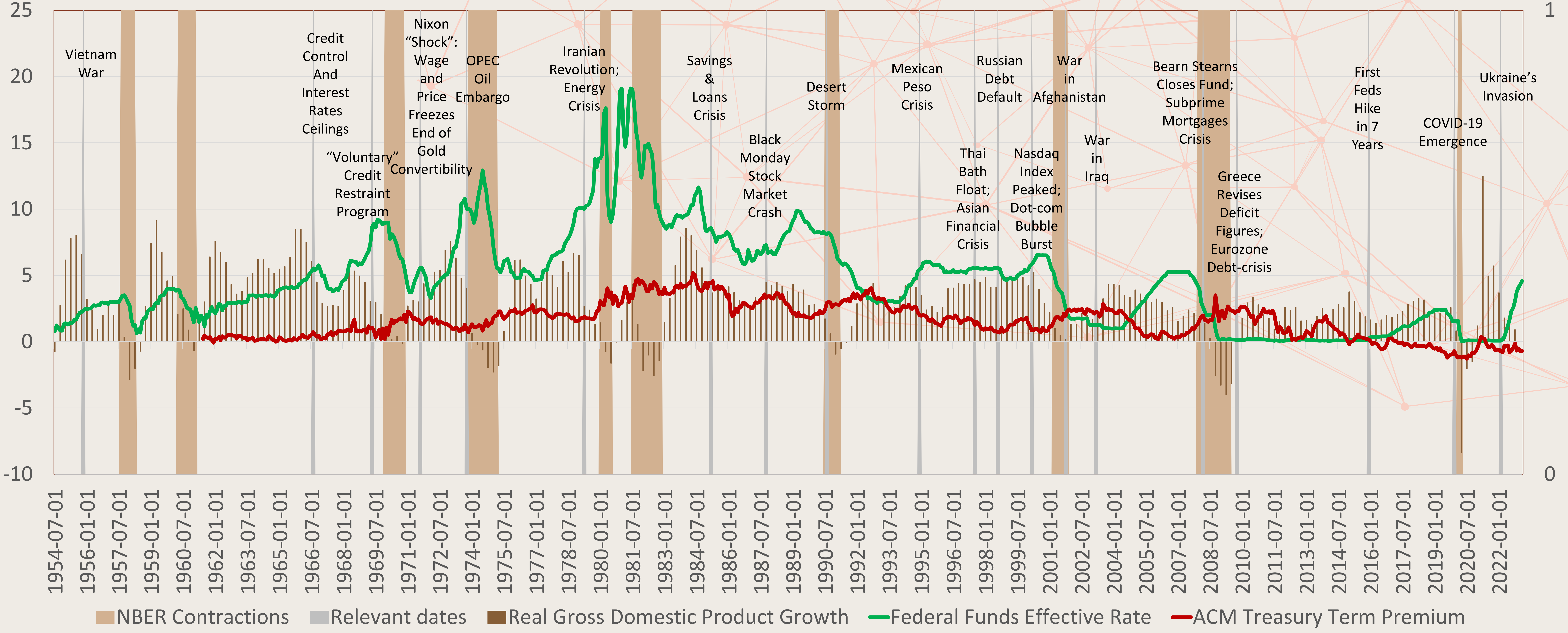


Figure 1: GDP is the growth rate of the real gross domestic product (GDPC1 in Fred Economic Data from the Federal Reserve Bank of St. Louis), federal funds rate is the effective federal funds rate (FEDFUNDS also in Fred Economic Data), term premium is the 10-year Treasury term premium computed following the methodology of Adrian, Crump and Moench (2013) and reported by the Federal Reserve Bank of New York (ACM10TP), and contractions are as dated by the NBER's Business Cycle Dating Committee.

This paper

- We estimate a Markov-switching Vector Autoregression (**MS-VAR**) and a Markov-switching Dynamic Stochastic General Equilibrium (**MS-DSGE**) macroeconomic model with financial frictions in long-term debt instruments developed by Carlstrom, Fuerst and Paustian (2017, AEJ: Macro) to provide evidence of the importance of allowing for switching parameters (non-linearities) and switching variance (heteroscedasticity) when analyzing macro-financial linkages in the US.
- Using a MS-DSGE specification with Markov Switching in parameters and variances we:
  - provide evidence on how financial conditions have evolved in the U.S. since 1962,
  - show how the Federal Reserve Bank has responded to the evolution of term premiums,
  - perform counterfactual analysis of the potential evolution of macroeconomic and financial variables under alternative financial conditions and monetary policy responses.

MS-VAR

- The specification adopts the spirit of smoothly time-varying parameters in VAR models presented by Primiceri (2005, RES), Cogley and Sargent (2005, RED) and Bianchi and Melosi (2017, AER). Following Hubrich and Tetlow (2015, JME) consider a nonlinear vector stochastic process of the following form:

$$\boldsymbol{y}_t'\boldsymbol{A}_0(\boldsymbol{s}_t^c) = \sum_{l=1}^{p} \boldsymbol{y}_{t-1}'\boldsymbol{A}_l(\boldsymbol{s}_t^c) + \boldsymbol{z}_t'\boldsymbol{C}(\boldsymbol{s}_t^c) + \boldsymbol{\varepsilon}_t'\boldsymbol{\Xi}^{-1}(\boldsymbol{s}_t^v)$$

  where $\boldsymbol{y}$ is a vector of endogenous variables, $\boldsymbol{z}$ is a matrix of exogenous variables and $\boldsymbol{\varepsilon}$ is a vector of innovations, while $\boldsymbol{A}_0(\boldsymbol{s}_t^c)$, $\boldsymbol{A}_l(\boldsymbol{s}_t^c)$ and $\boldsymbol{C}(\boldsymbol{s}_t^c)$ are matrices of Markov-switching parameters and $\boldsymbol{\Xi}^{-1}(\boldsymbol{s}_t^v)$ is a matrix of Markov-switching variances.

  $\boldsymbol{s}^m, \boldsymbol{m} = \{\boldsymbol{c}, \boldsymbol{v}\}$ are unobservable (latent) state variables, one for intercepts and coefficients, $\boldsymbol{c}$, and one for variances, $\boldsymbol{v}$. The values of $\boldsymbol{s}_t^m$ are elements of $\{\boldsymbol{1}, \boldsymbol{2}, \cdots, \boldsymbol{h}^m\}$ and evolve according to a first-order Markov process:

$$\mathbf{Pr}(\boldsymbol{s}_t^m = \boldsymbol{i} | \boldsymbol{s}_{t-1}^m = \boldsymbol{k}) = \boldsymbol{p}_{ik}^m, \qquad \boldsymbol{i}, \boldsymbol{k} = \boldsymbol{1}, \boldsymbol{2}, \cdots, \boldsymbol{h}^m$$

- Our set of endogenous variables is: $\boldsymbol{y}_t = [\boldsymbol{C}, \boldsymbol{P}, \boldsymbol{R}, \boldsymbol{M}, \boldsymbol{Tp}]'$, where $\boldsymbol{C}$ denotes the quarterly growth in personal consumption expenditures; $\boldsymbol{P}$ is CPI inflation; $\boldsymbol{R}$ is the nominal federal funds rate; $\boldsymbol{M}$ is growth in the nominal M2 monetary aggregate; and $\boldsymbol{Tp}$ represents the 10-year Treasury term premium from reported by the Federal Reserve Bank of New York (ACM10TP).

MS-VAR evidence of switching coefficients and/or switching variance

Model specification	Posterior density
$1c1v$	-2134.26
$2c1v$	-2116.98
$1c2v$	-2091.26
$2c2v$	-2087.19
$2cTPR3v$	-2074.19
$2cTPC3v$	-2071.41
$2cTPCP3v$	-2066.24
$3c3v$	-2052.12
$2cTP3v$	-2039.96
$1c3v$	-2014.16
$2cRMC3v$	-2008.31
$2cTPRM3v$	-1996.48
$2cRM3v$	-1986.39
$2c3v$	-1961.13*

Table 1: MS-VAR estimation results. Posterior modes are in logarithms for the estimated models

MS-VAR evidence of switching probabilities

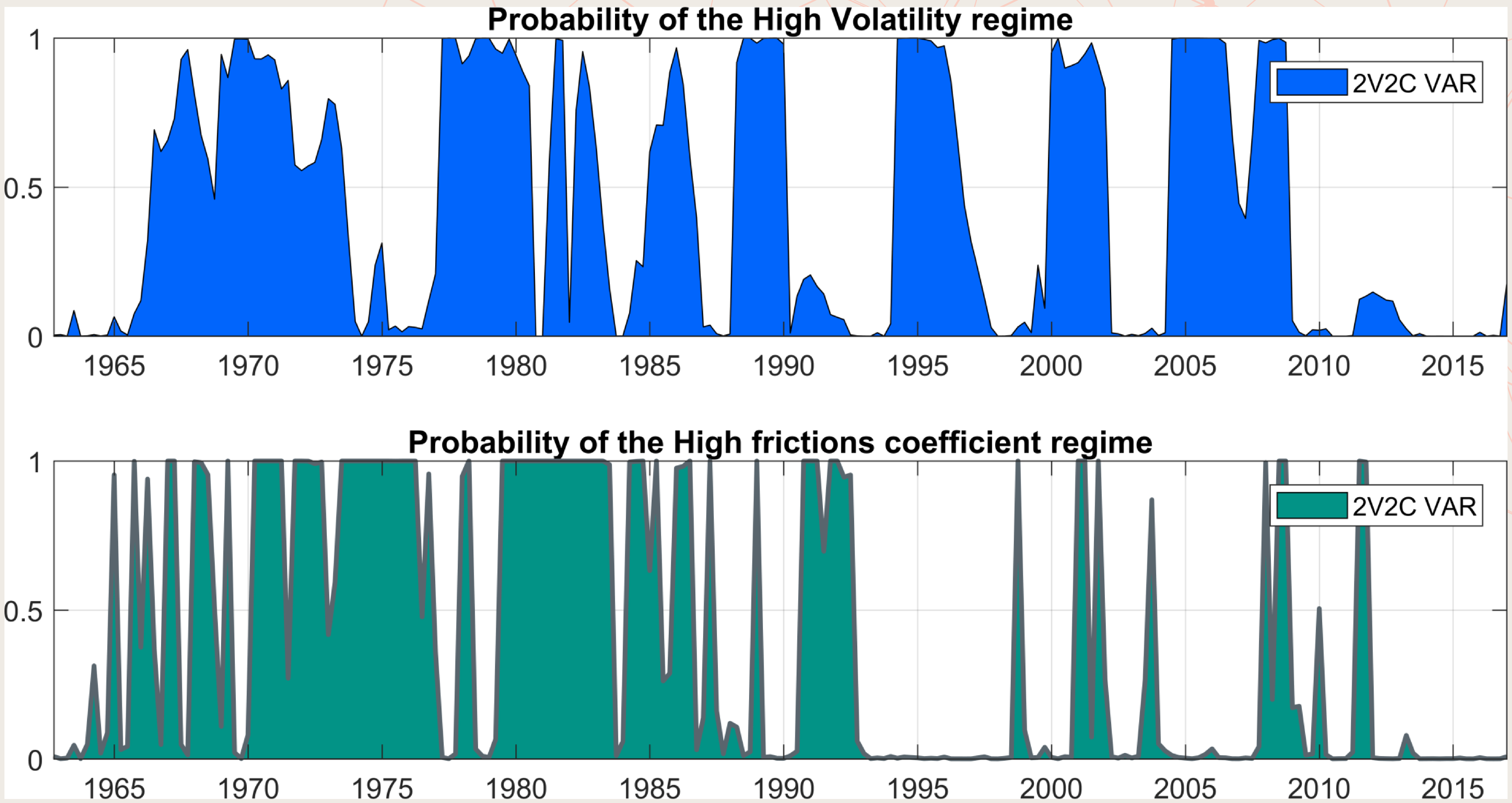


Figure 2: smoothed probabilities of MS-VAR coefficients and variances regimes. The top panel reports the probability of a High volatility regime. The second panel reports the probability for the High-stress regime.

MS-VAR evidence of important effects due to non-linearities and non-Gaussian shocks

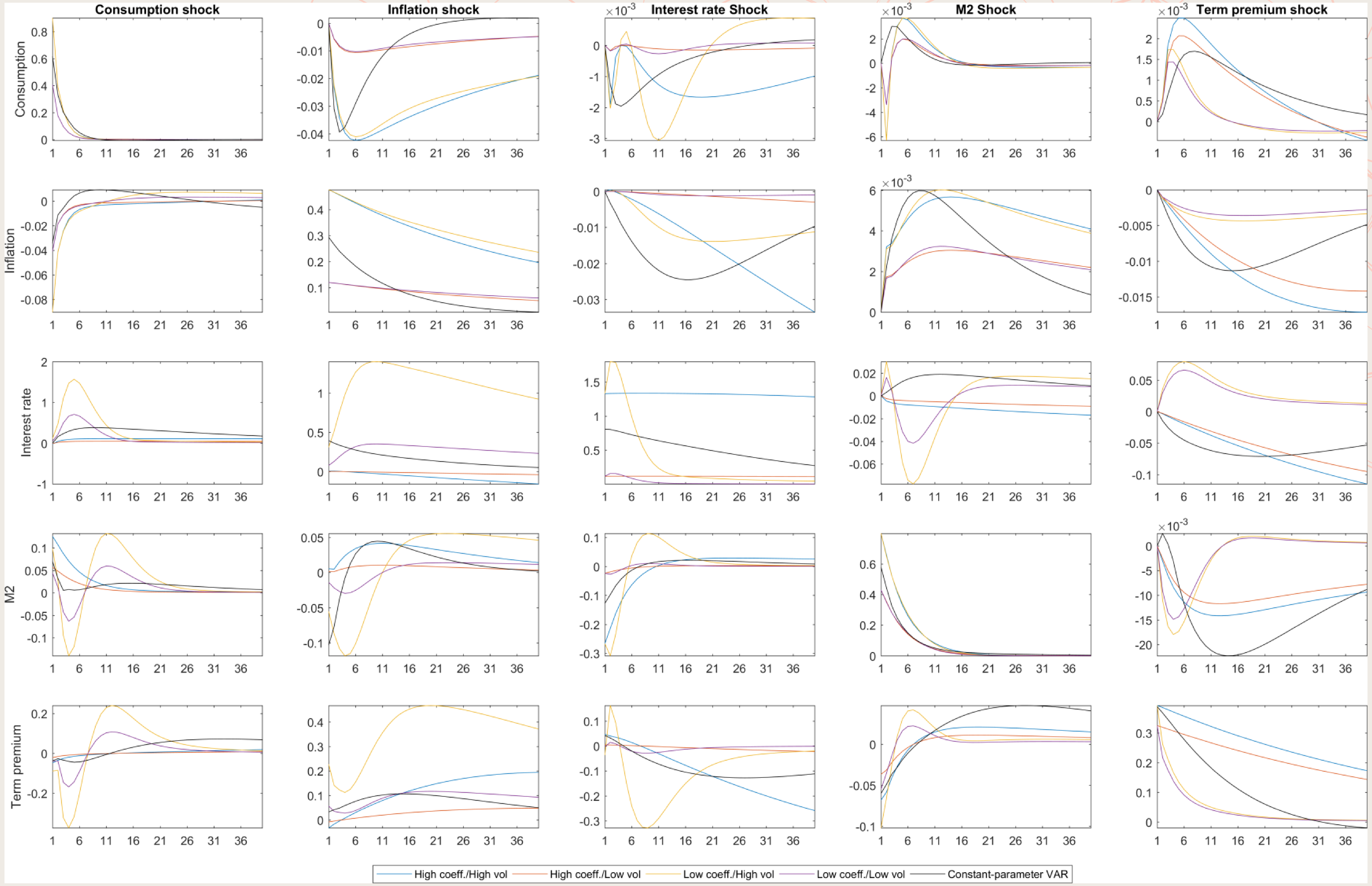


Figure 3: Impulse response functions for the 5 equations of the 2c2v MS-VAR and the 1c1v VAR.
High coefficient regimes are presented in blue/orange, while low coefficient regimes are shown in yellow/purple colors.

Why MS-DSGE?

- Give economic interpretation to changes in parameters and variances.
  - Parameters: financial frictions and monetary policy response to financial conditions.
  - Variances: volatility of credit market shocks.

- Analyze potential mechanisms.

- Perform counterfactual experiments.

Model: households

Each household chooses consumption, C_t, labor supply, H_t, short-term deposits in the financial intermediary (FI), D_t, investment bonds, F_t, investment, I_t, and next-period physical capital K_{t+1} to:

$$\max_{\{C_{t,}H_t,D_t,F_t,I_t,K_{t+1}\}_{t=0}^{\infty}} E_0\left\{\sum_{t=0}^{\infty}\beta^t e^{rn_t} ln(C_t - hC_{t-1}) - L\frac{H_t^{1+\eta}}{1+\eta}\right\} \quad (1)$$

subject to:

$$C_t + \frac{D_t}{P_t} + P_t^k I_t + \frac{F_{t-1}}{P_t} \leq W_t H_t + R_t^k K_t - T_t + \frac{D_{t-1}}{P_t} R_{t-1} + \frac{Q_t(F_t - \kappa F_{t-1})}{P_t} \quad (2)$$

$$K_{t+1} \leq (1-\delta)K_t + I_t \quad (3)$$

$$P_t^k I_t \leq \frac{Q_t(F_t - \kappa F_{t-1})}{P_t} \quad (4)$$

Households do not have access to long-term bonds, while FIs do, creating a market segmentation.

Equation (4) is a loan-in-advance constraint through which all investment purchases must be financed by issuing “investment bonds that are acquired by the FI. The endogenous behavior of the distortion related to Lagrange multiplier of the loan-in-advance constraint is fundamental for the real effects arising from market segmentation.

Model: financial intermediaries (1)

FIs choose net worth, N_t, and dividends, div_t, to maximize its value function, V_t, given by:

$$V_t \equiv \max_{\{N_t, div_t\}_{t=0}^{\infty}} E_0\{\sum_{t=0}^{\infty}(\beta\zeta)^t \Lambda_t div_t\} \quad (5)$$

subject to the resource constraint:

$$div_t + N_t[1 + f(N_t)] \leq \frac{P_{t-1}}{P_t}\left[\left(R_t^L - R_{t-1}^d\right)L_t + R_{t-1}^d\right]N_t \quad (6)$$

$$\text{where } f(N_t) \equiv \frac{\psi_{n,\varepsilon_t^{ff}}}{2}\left(\frac{N_t - N_{ss}}{N_{ss}}\right)^2$$

and the incentive compatibility constraint that ensures that the FI repays deposits, given that depositors can seize at most a fraction $(1 - \Psi_t)$ of the FI's assets:

$$E_t V_{t+1} \geq \Psi_t E_t\left\{R_{t+1}^L\left(\frac{D_t}{P_t} + N_t\right)\right\} \quad (7)$$

Model: financial intermediaries (2)

- Assuming that $\Psi_t \equiv \Phi_t \left[1 + \frac{1}{N_t}\left(\frac{E_t g_{t+1}}{E_t x_{t+1}}\right)\right]$, is a function of net worth in a symmetric manner with $f(N_t)$, the binding incentive constraint (7), which yields leverage as a function of aggregate variables but independent of each FI's net worth, is given by:

$$E_t \frac{P_t}{P_{t+1}} \Lambda_{t+1} \left[\left(\frac{R_{t+1}^L}{R_t^d} - 1\right) L_t + 1\right] = \Phi_t L_t E_t \frac{P_t}{P_{t+1}} \Lambda_{t+1} \frac{R_{t+1}^L}{R_t^d} \quad (8)$$

- Then, the FI's optimal accumulation decision is given by:

$$\Lambda_t [1 + N_t f'(N_t) + f(N_t)] = E_t \beta \zeta \Lambda_{t+1} \frac{P_t}{P_{t+1}} \left[\left(R_{t+1}^L - R_t^d\right) L_t + R_t^d\right] \quad (9)$$

- where $\Phi_t \equiv e^{\phi_t}$ is a credit shock that in logarithms follows an AR(1) process:

$$\phi_t = (1 - \rho_\phi)\phi_{ss} + \rho_\phi \phi_{t-1} + \boldsymbol{\sigma}_{\phi,\xi_t^{vol}} \varepsilon_{\phi,t} \quad (10)$$

where $\sigma_{\phi,\xi_t^{vol}}$ is the standard deviation of the stochastic volatility of the credit shock, $\varepsilon_{\phi,t} \sim i.i.d.\, N(0, \sigma_\phi^2)$, whose ξ_t^{vol} subscript denotes that it is allowed to change across regimes at time t. When we allow for regime switching in volatilities, regimes will be classified by the magnitude of this shock.

- Increases in ϕ_t will exacerbate the hold-up problem, and act as “credit shocks”, which will increase the spread and lower real activity.

Model: the effect of financial frictions

- To gain further intuition of the financial frictions, first log-linearize the FI incentive compatibility constraint (8) and the FI optimal net worth accumulation decision (9) to get:

$$E_t(r_{t+1}^L - r_t) = \frac{1}{L_{ss}-1} l_t + \left[\frac{1+L_{ss}(s-1)}{L_{ss}-1}\right] \phi_t \quad (11)$$

and

$$\psi_{n,\xi_t^{ff}} n_t = \left[\frac{sL_{ss}}{1+L_{ss}(s-1)}\right] E_t(r_{t+1}^L - r_t) + \left[\frac{(s-1)L_{ss}}{1+L_{ss}(s-1)}\right] l_t \quad (12)$$

Equation (11) is quantitatively identical to the corresponding relationship in the more complex costly state verification (CSV) environment of Bernanke, Gertler and Gilchrist (1999).

- Combining (11) and (12), we get the following expression:

$$E_t(r_{t+1}^L - r_t) = \frac{1}{L_{ss}} \boldsymbol{\psi_{n,\xi_t^{ff}}} n_t + (s-1)\phi_t \quad (13)$$

This expression shows the importance of $\psi_{n,\xi_t^{ff}}$ for the supply of credit. If $\psi_{n,\xi_t^{ff}} = 0$, the supply of credit is perfectly elastic, independent of the financial intermediaries net worth. As $\psi_{n,\xi_t^{ff}}$ becomes larger, the financial friction becomes more intense and the supply of credit depends positively on the financial intermediaries net worth.

Model: Central Bank Policy

- We assume that the central bank follows a term premium (tp_t) augmented Taylor rule over the short rate (T- bills and deposits):

$$ln(R_t) = \rho_{R,\xi_t^{mp}} ln(R_{t-1}) + \left(1 - \rho_{R,\xi_t^{mp}}\right)\left(\tau_{\pi,\xi_t^{mp}}\pi_t + \tau_{y,\xi_t^{mp}} y_t^{gap} + \boldsymbol{\tau_{tp,\xi_t^{mp}}} tp_t\right) + \sigma_{r,\xi_t^{vol}} \varepsilon_{r,t}$$

where $y_t^{gap} \equiv \frac{Y_t - Y_t^f}{Y_t^f}$ denotes the deviation of output from its flexible price counterpart, π_t t is CPI inflation rate, and $\varepsilon_{r,t}$ is an exogenous and auto-correlated policy shock with AR(1) coefficient ρ_m

- The term premium is defined as the difference between the observed yield on a ten-year bond and the corresponding yield implied by applying the expectation hypothesis (EH) of the term structure to the series of short rates.

Model summary

- Macroeconomic model with financial frictions in long-term debt instruments developed by Carlstrom, Fuerst and Paustian (2017, AEJ: Macro).
- **Financial intermediaries:**

By combining the Financial Intermediaries' incentive compatibility constraint and their optimal accumulation of net worth, we get the following financial accelerator type expression:

$$E_t(r_{t+1}^L - r_t) = \frac{1}{L_{ss}} \boldsymbol{\psi}_{\boldsymbol{n},\boldsymbol{\xi_t^{ff}}} n_t + (s-1)\phi_t \quad \text{(A)}$$

where ϕ_t is a credit shock that in logarithms follows an AR(1) process:

$$\phi_t = (1-\rho_\phi)\phi_{ss} + \rho_\phi \phi_{t-1} + \boldsymbol{\sigma}_{\boldsymbol{\phi},\boldsymbol{\xi_t^{vol}}} \varepsilon_{\phi,t} \quad \text{(B)}$$

Equation (A) shows the importance of $\psi_{n,\xi_t^{ff}}$ for the supply of credit.

Increases in ϕ_t will exacerbate the hold-up problem, and act as "credit shocks", which will increase the spread and lower real activity.

- **Central bank policy:**

We assume that the central bank follows a term premium (tp_t) augmented Taylor rule over the short rate (T- bills and deposits):

$$ln(R_t) = \rho_{R,\xi_t^{mp}} ln(R_{t-1}) + \left(1-\rho_{R,\xi_t^{mp}}\right)\left(\tau_{\pi,\xi_t^{mp}}\pi_t + \tau_{y,\xi_t^{mp}} y_t^{gap} + \boldsymbol{\tau}_{\boldsymbol{tp},\boldsymbol{\xi_t^{mp}}} tp_t\right) + \sigma_{r,\xi_t^{vol}}\varepsilon_{r,t}$$

where $y_t^{gap} \equiv \frac{Y_t - Y_t^f}{Y_t^f}$ denotes the deviation of output from its flexible price counterpart, π_t t is CPI inflation rate, and $\varepsilon_{r,t}$ is an exogenous and auto-correlated policy shock with AR(1) coefficient ρ_m.

MS-DSGE solution methods

- The Markov-Switching system can be cast in a state-space form by collecting all the endogenous variables in a vector X and all the exogenous variables in a vector Z:

$$B_1(\xi_t^{sp})X_t = E_t\{A_1(\xi_t^{sp},\xi_{t+1}^{sp})X_{t+1}\} + B_2(\xi_t^{sp})X_{t-1} + C_1(\xi_t^{sp})Z_t$$

$$Z_t = R(\xi_t^{sp})Z_{t-1} + \epsilon_t \qquad \text{with} \qquad \epsilon_t \sim N(0,\Sigma^{vo})$$

where ξ^{sp} and ξ^{vo} are Markov chains for the structural parameters and volatilities and the matrices $B_1(\xi_t^{sp})$, $A_1(\xi_t^{sp},\xi_{t+1}^{sp})$, $B_2(\xi_t^{sp})$, $C_1(\xi_t^{sp})$ and $R(\xi_t^{sp})$ are function of the model parameters.

- To solve the system we use the Newton methods developed in Maih (2015) which extend the one proposed by Farmer, Waggoner and Zha (2011) and concentrates in minimum state variable solutions of the form:

$$X_t = \Omega^*(\xi^{sp},\theta^{sp},H)X_{t-1} + \Gamma^*(\xi^{sp},\theta^{sp},H)Z_t(\xi^{vo},\theta^{vo})$$

- The presence of unobserved variables and unobserved Markov states of the Markov chains implies that the standard Kalman filter cannot be used to compute the likelihood, so we use the Kim and Nelson (1999) filter.

MS-DSGE estimation methods

- We use the Bayesian approach to estimate the model:
    1. We compute the solution of the system using an algorithm found in Maih (2015) and employ a modified version of the Kim and Nelson (1999) filter to compute the likelihood with prior distribution of the parameters.
    2. Construct the posterior kernel with the estimates from stochastic search optimization routines.
    3. We use the posterior mode as the initial value for the Metropolis Hastings algorithm with 50,000 iterations.
    4. Utilize mean and variance of the last 40,000 iterations from (3) to run the main Metropolis Hastings algorithm.
- Observables: US data from 1962q1 to 2017q3 of
    - Real GDP growth
    - Real gross private investment
    - Real wages: nominal compensation in the non-farm business sector divided by the consumption deflator
    - Annualized inflation
    - Labor input from non-farm business sector hours.
    - Interest rate
    - Treasury term premium from New York Fed web-site.

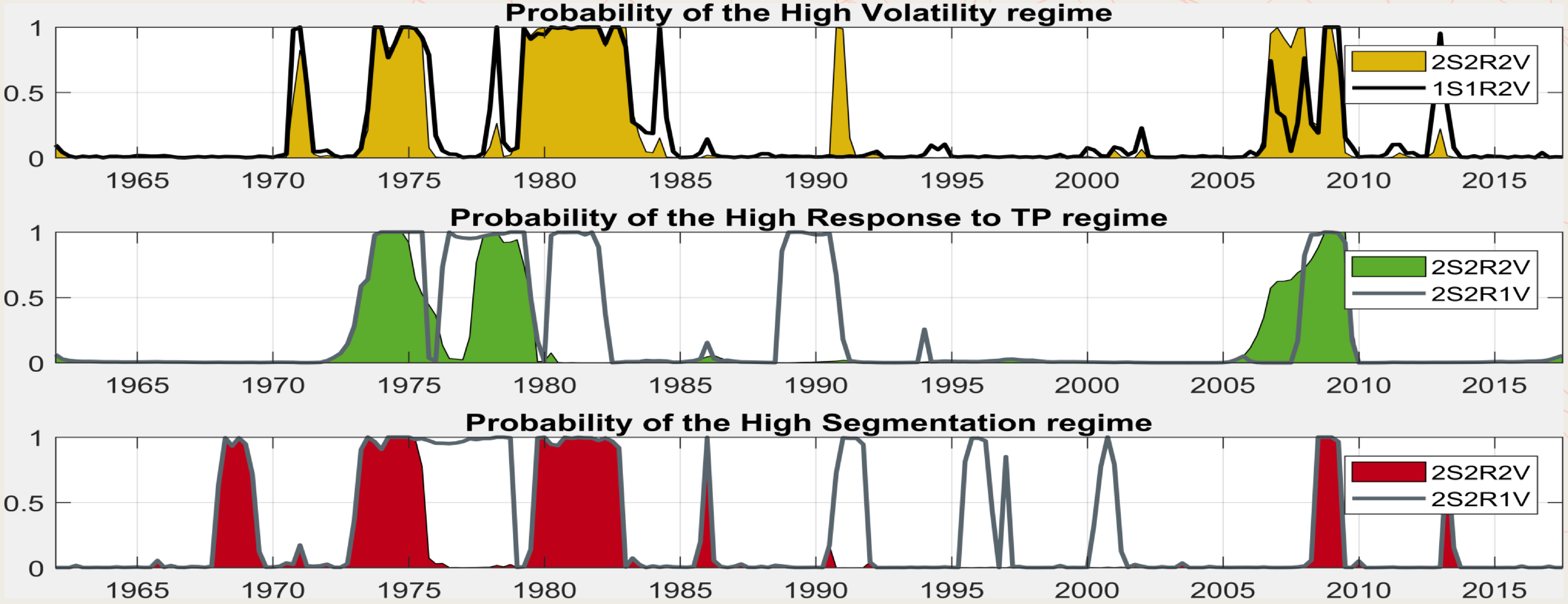
MS-DSGE evidence of switching coefficients and/o switching variance

# of Markov chains	# of States	Specification	Marginal likelihood	Market segmentation		Term premium response		Credit shock volatility		
				$\psi_{n,\xi_t^{ff}=1}$	$\psi_{n,\xi_t^{ff}=2}$	$\tau_{tp,\xi_t^{mp}=1}$	$\tau_{tp,\xi_t^{mp}=2}$	$\sigma_{\phi,\xi_t^{vol}=1}$	$\sigma_{\phi,\xi_t^{vol}=2}$	$\sigma_{\phi,\xi_t^{vol}=3}$
				Density: Uniform		*Density: Normal*		*Density: Inverse Gamma*		
1	1	$1S1R1V$	$-2,985.05$	0.89	-	-0.46	-	4.01	-	-
2	2	$1S1R2V$	$-2,601.51$	0.84	-	-0.49	-	2.99	7.01	-
2	3	$1S1R3V$	$-2,599.17$	0.59	-	-0.52	-	2.78	5.35	6.98
2	2	$2S1R1V$	$-2,714.86$	0.69	1.49	-0.84	-	6.04	-	-
3	4	$2S1R2V$	$-2,554.11$	0.36	0.97	-0.50	-	2.61	6.40	-
3	6	$2S1R3V$	$-2,548.58$	0.19	0.65	-0.50	-	3.09	5.31	6.72
2	2	$1S2R1V$	$-2,757.08$	0.81	-	-0.52	-0.97	6.29	-	-
3	4	$1S2R2V$	$-2,577.19$	0.68	-	-0.24	-0.82	3.05	6.53	-
3	6	$1S2R3V$	$-2,567.76$	0.66	-	-0.38	-0.96	2.69	5.33	6.56
3	4	$2S2R1V$	$-2,701.63$	0.63	1.39	-0.46	-1.10	5.74	-	-
4	8	$2S2R2V$	$-2,538.06$	0.25	0.91	-0.30	-0.90	3.19	6.27	-
4	12	$2S2R3V$	$-2,530.12$	0.22	0.90	-0.30	-0.86	3.01	6.13	6.87

Table 1: Marginal data density for the estimated models. In the colum Specification, S, R, and V correspond to segmentation, interest rate, and volatilities, respectively. The posterior mode is reported for all the parameters.

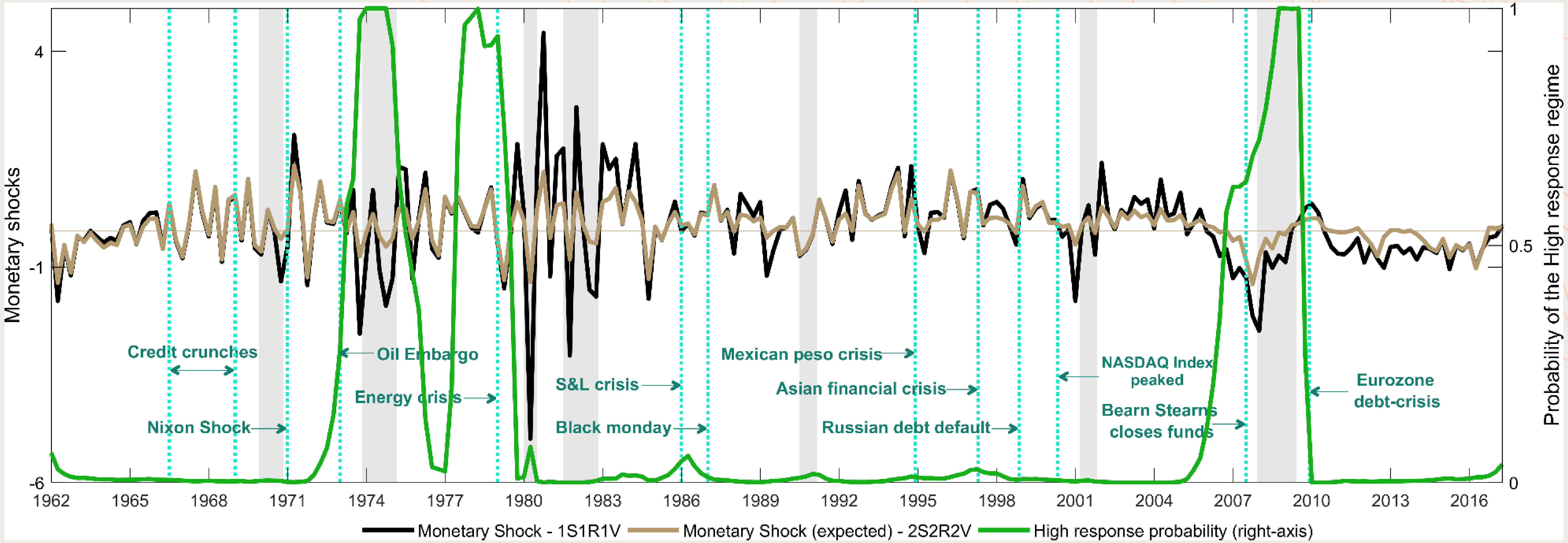
Comparison of estimated probabilities for parameters and volatilities baseline 2S2R2V

2S2R2V versus 1S1R2V versus 2S2R1V

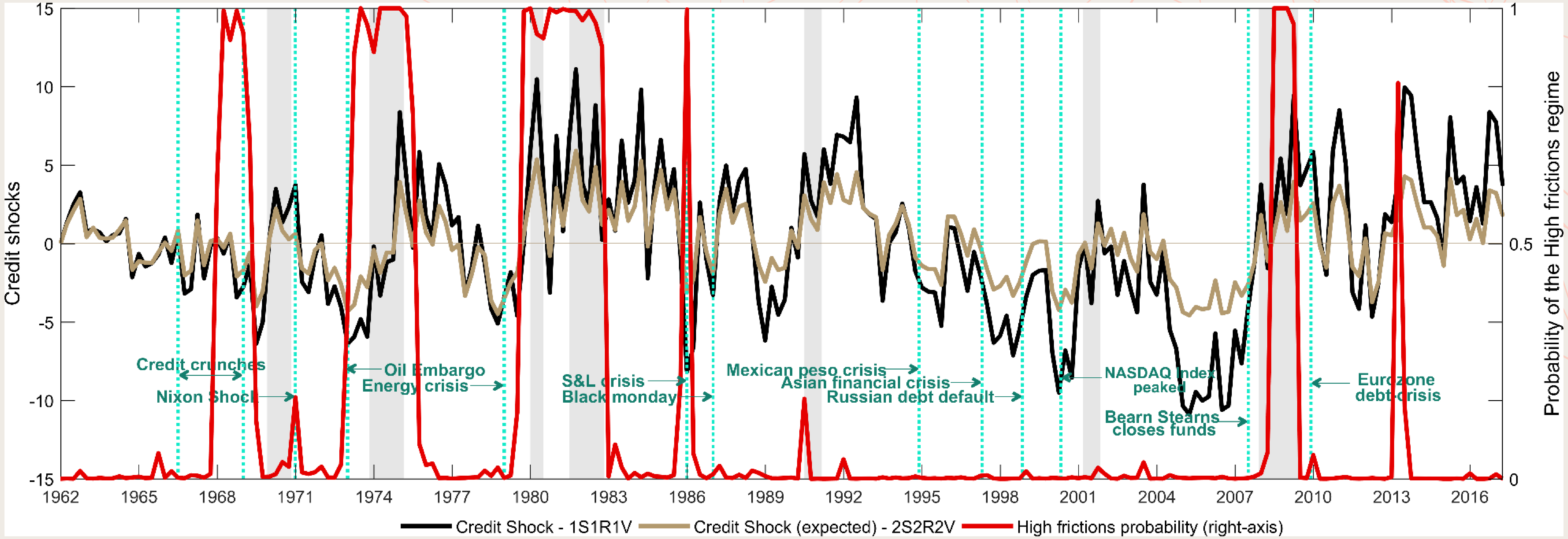


model:	222			112	221	
switching on:	S	R	V	V	S	R
# periods probability > 50%:	35	31	37	36	61	48
% of total sample	16%	14%	17%	16%	27%	22%
models to be compared:				222 vs 112	222 vs 221	
switching on:				V	S	R
# periods of periods when probability > 50% in both models:				31	35	26
% of 112 or 221:				86%	57%	54%

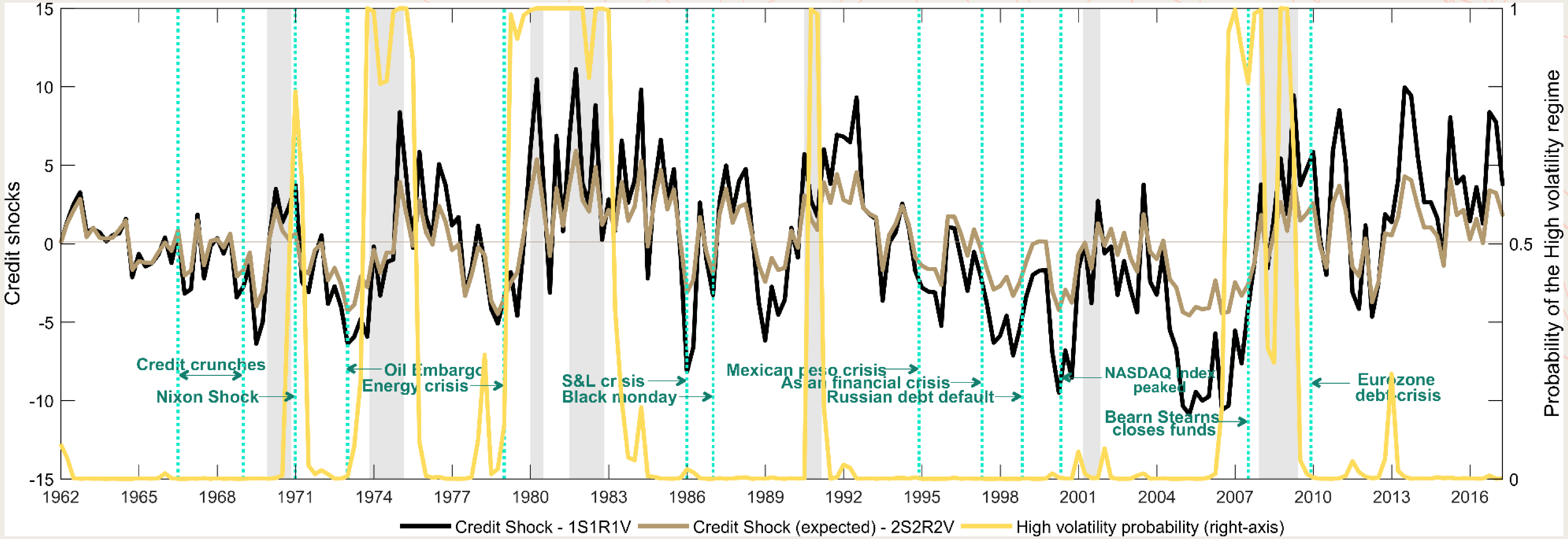
Monetary policy shocks with and without regime switching (2S2R2V vs 1S1R1V) and probability of high monetary policy response to the term premium



Credit shocks with and without regime switching (2S2R2V vs 1S1R1V) and probability of high credit frictions



Credit shocks with and without regime switching (2S2R2V vs 1S1R1V) and probability of high credit shocks



Impulse response functions to a Credit Shock

1S1R1V versus 2S2R2V

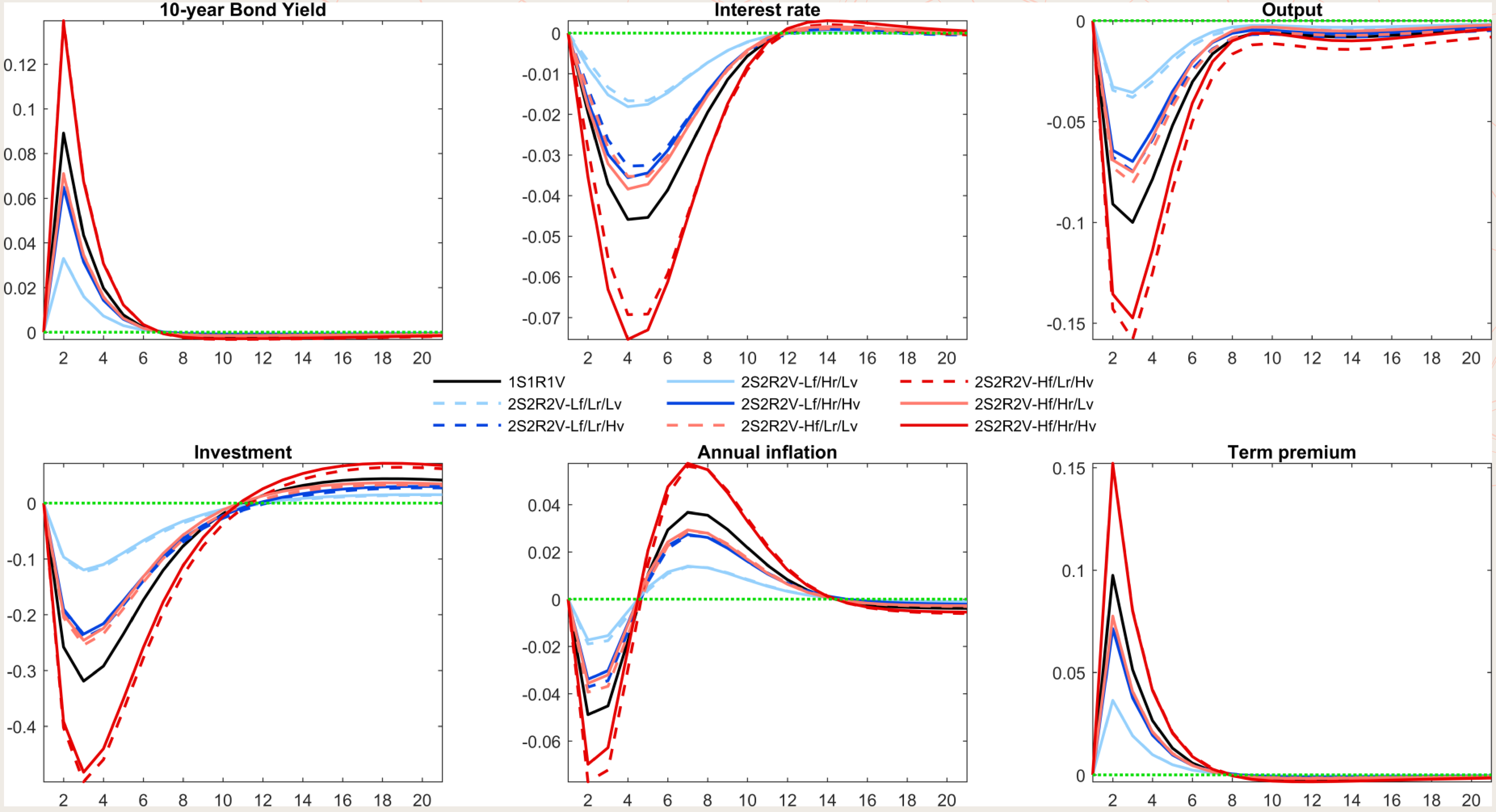


Figure: IRFs of the MS-DSGE model to a one standard deviation credit shock under alternative regimes for financial frictions, monetary policy and volatility. High financial frictions regimes are presented in red-like colors, while low ones are presented in blue-like colors. High monetary policy response regimes are presented in solid lines, while low ones are presented in dashed lines. High volatility regimes have dark colors, wile low ones are presented in light ones.

Impulse response functions to a Monetary Policy Shock

1S1R1V versus 2S2R2V

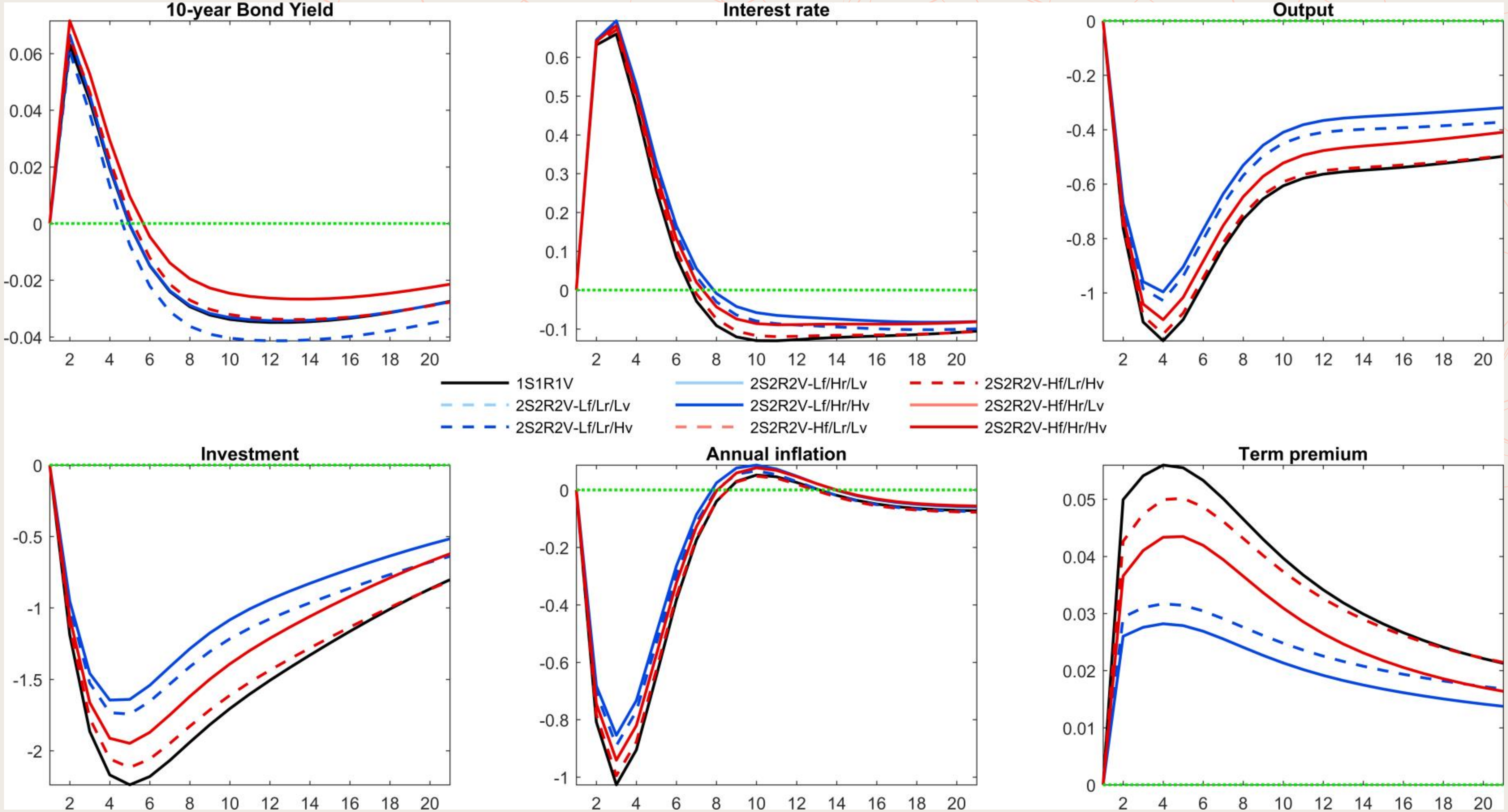
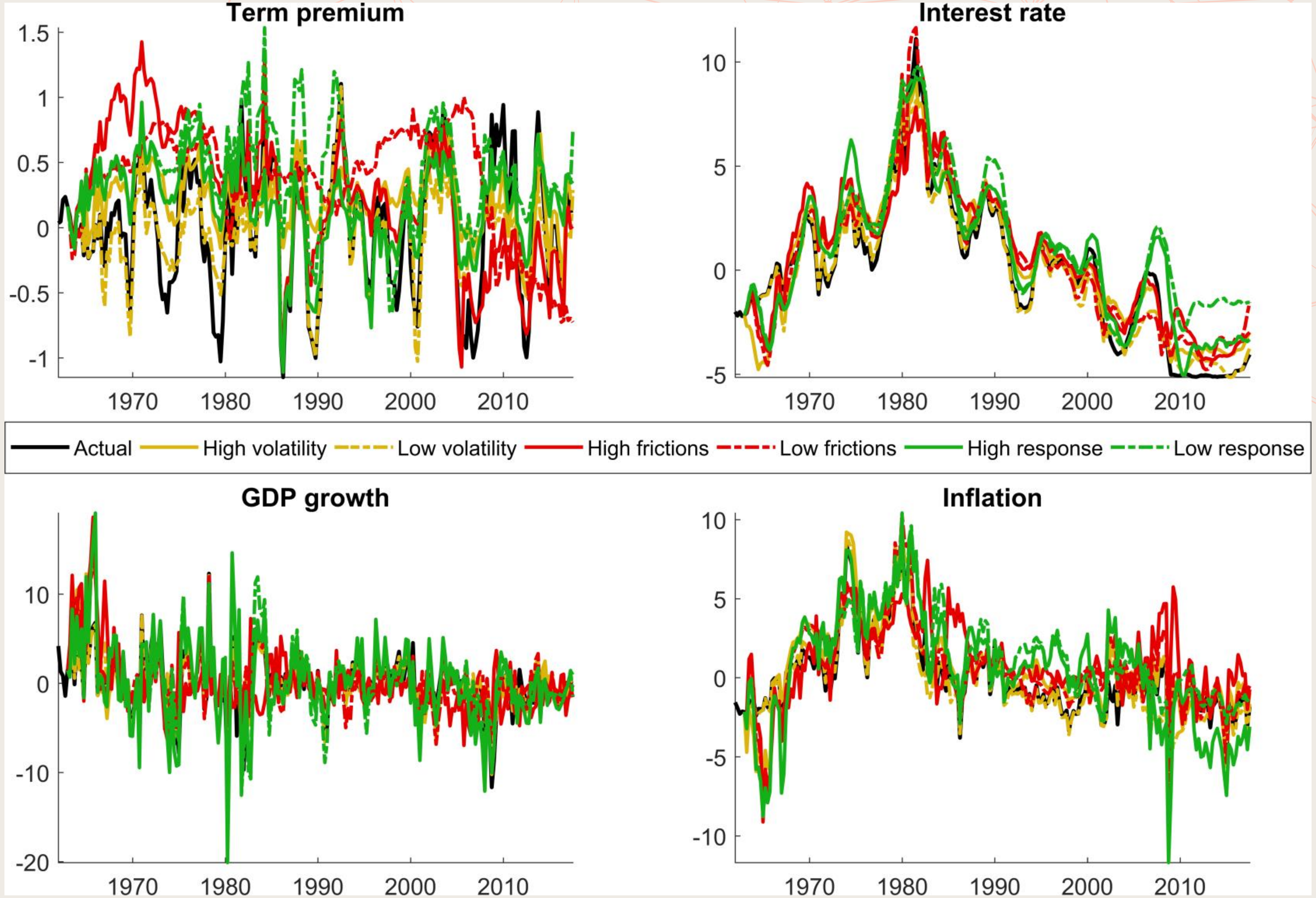
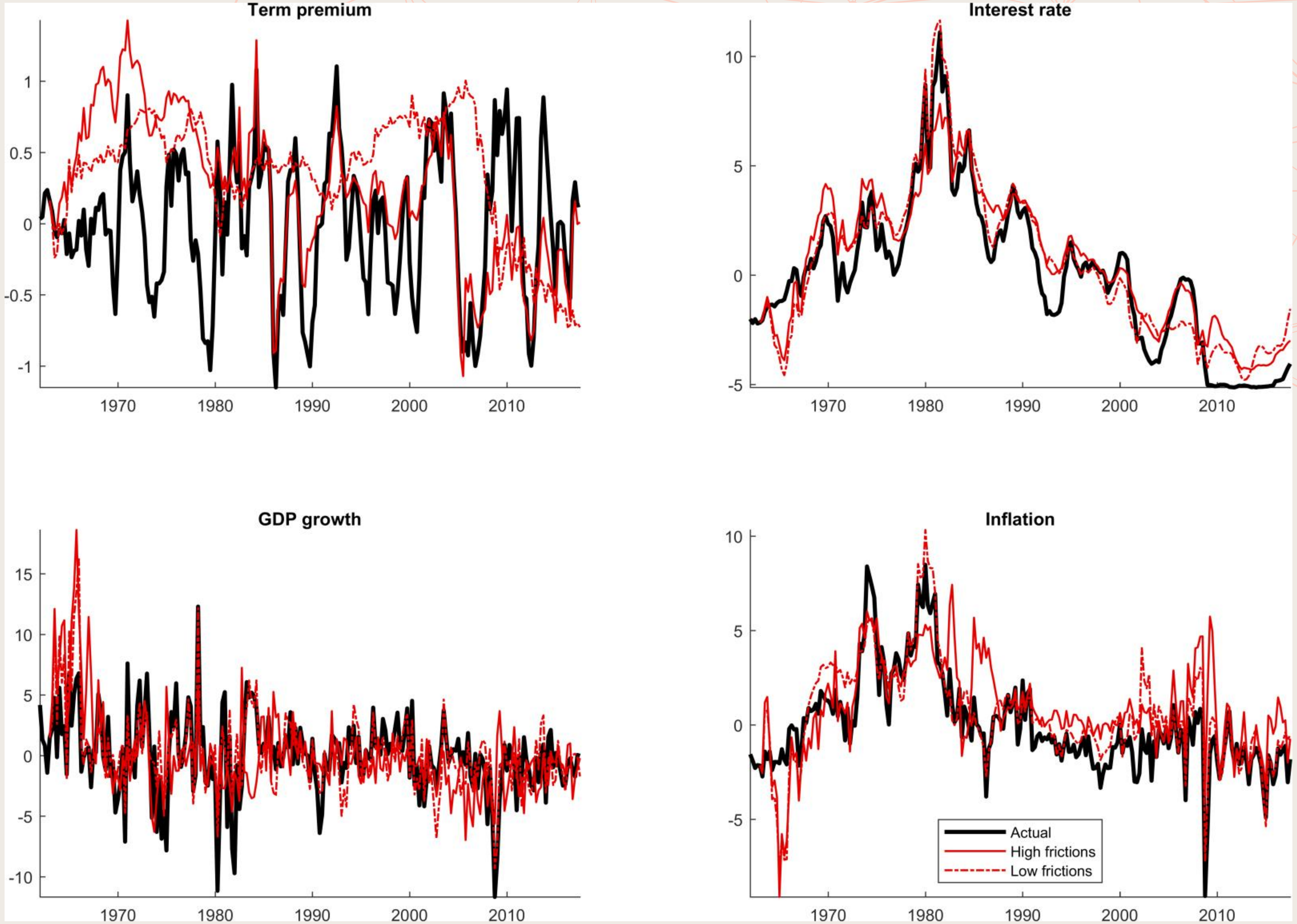


Figure : IRFs of the MS-DSGE model to a one standard deviation monetary policy shock under alternative regimes for financial frictions, monetary policy and volatility. High financial frictions regimes are presented in red-like colors, while low ones are presented in blue-like colors. High monetary policy response regimes are presented in solid lines, while low ones are presented in dashed lines. High volatility regimes have dark colors, wile low ones are presented in light ones.

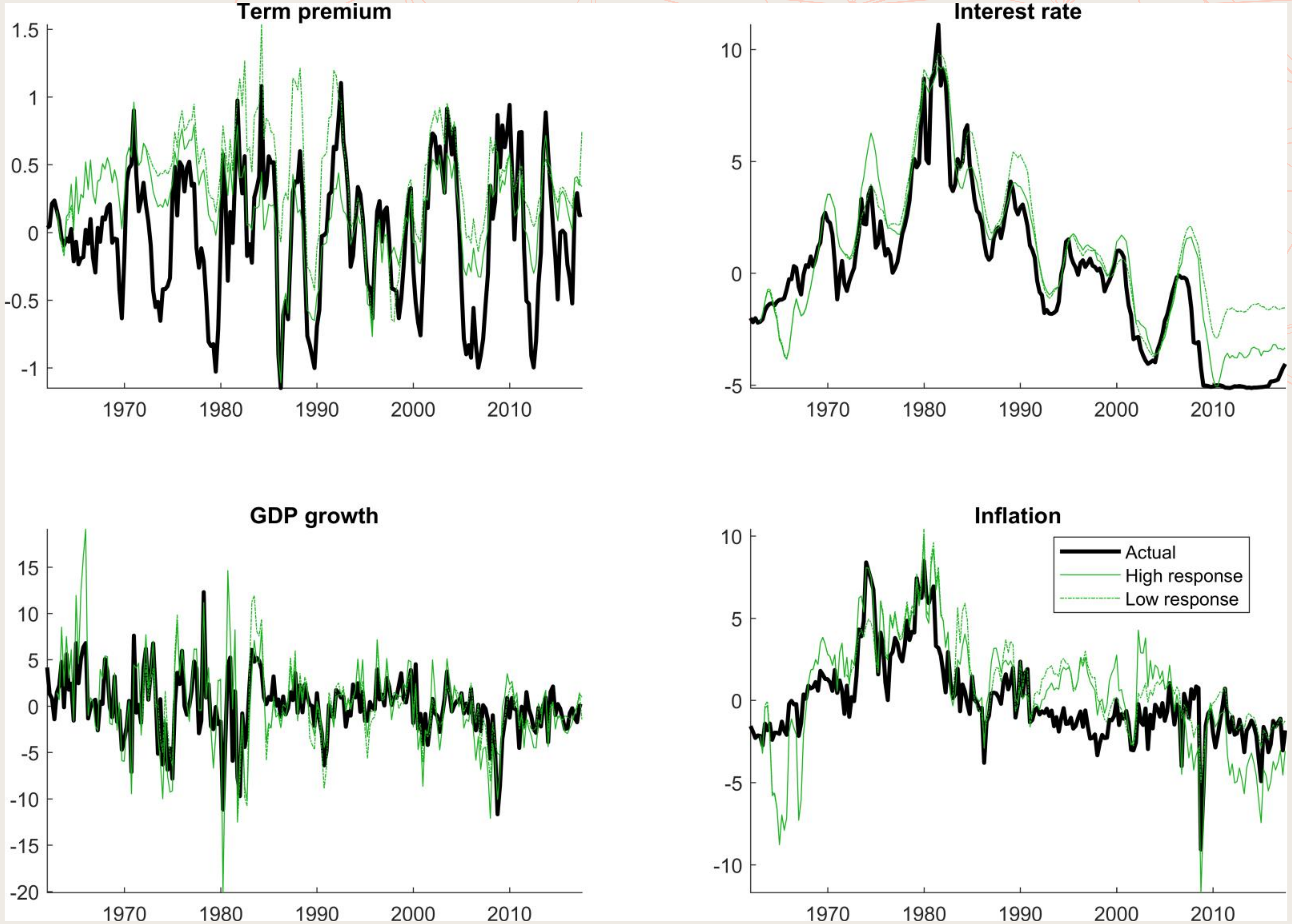
Counterfactuals



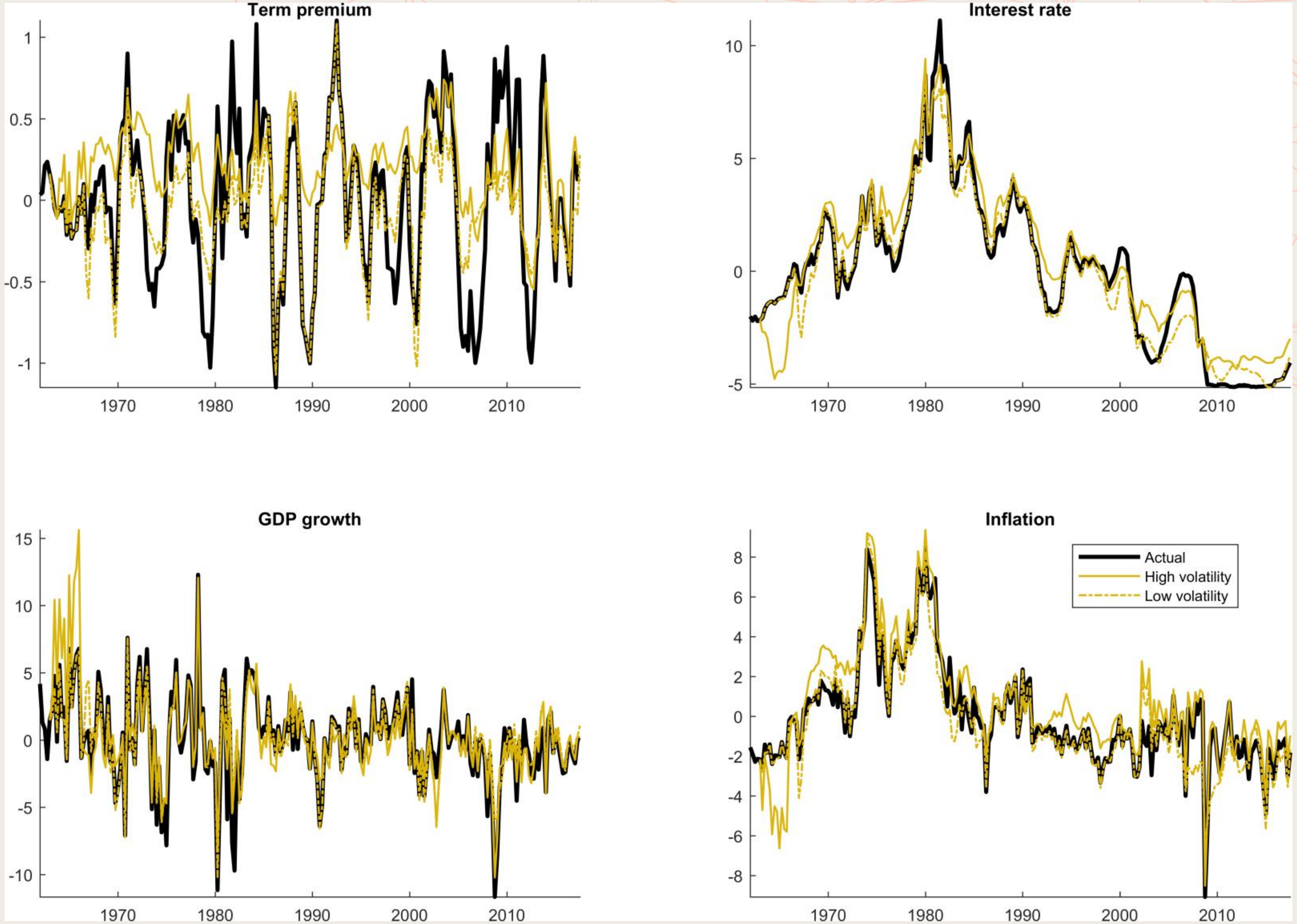
Counterfactuals: the role of credit market frictions



Counterfactuals:
the role of monetary policy response



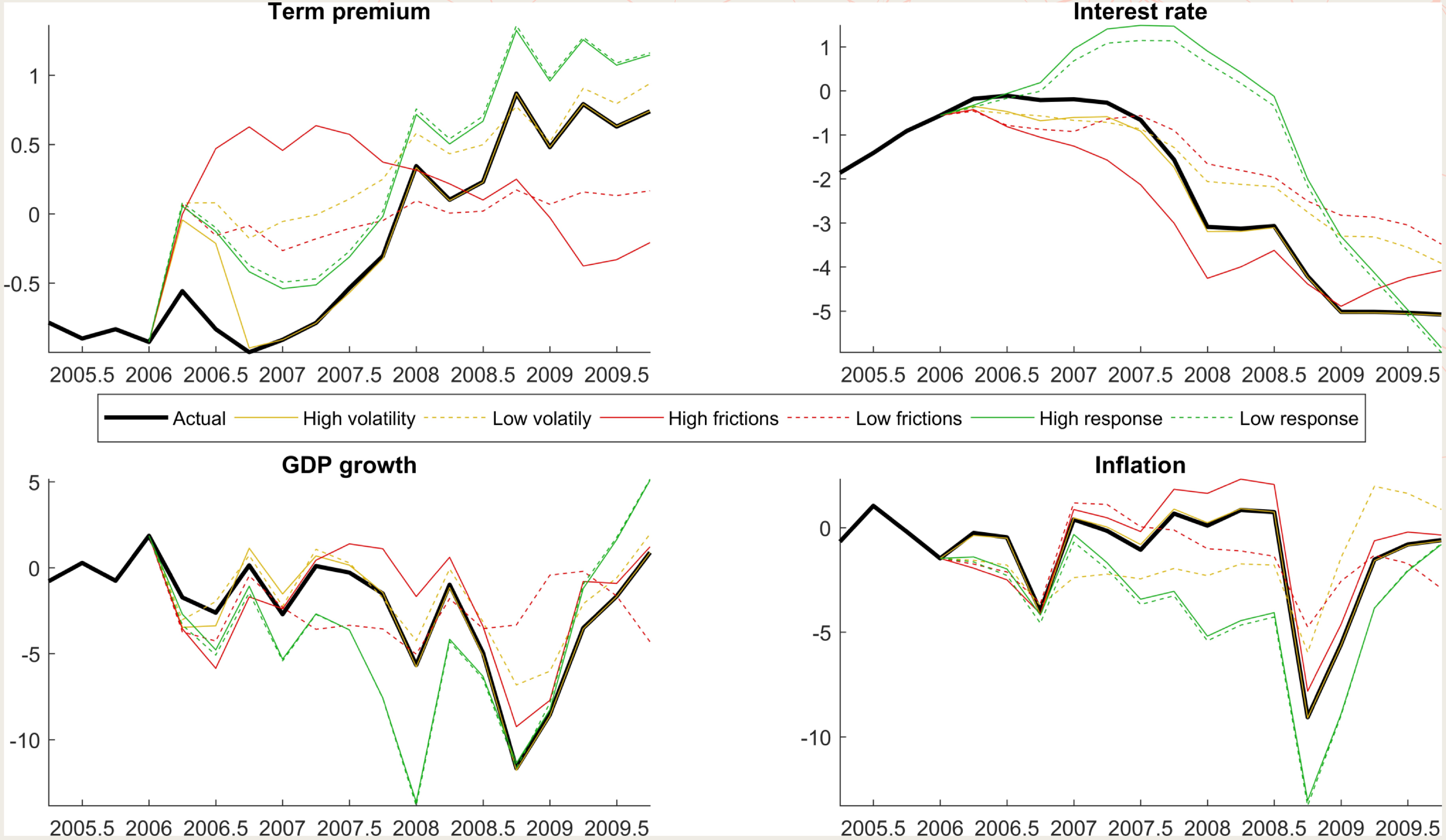
Counterfactuals: the role of credit shock volatilities



FED FUNDS: 1% in June 2003. ↑ cycle: 1.25% in June 2004, 2.25% end of 2004, 4.25% end of 2005, and 5.25% in June 2006.

↓ cycle: 4.75% in September 2007, 4.25% end of 2007, and [0% - 0.25%] end of 2008.

2006q1-2009q4 (16q): 12 HM (2006q4-2009q3), 4 HF (2008q3-2009q2), 9 HS (2006q4 – 2008q1 and 2008q4 – 2009q2).



The Real Effects of the Financial Crisis by Ben S. Bernanke in BPEA Fall 2018

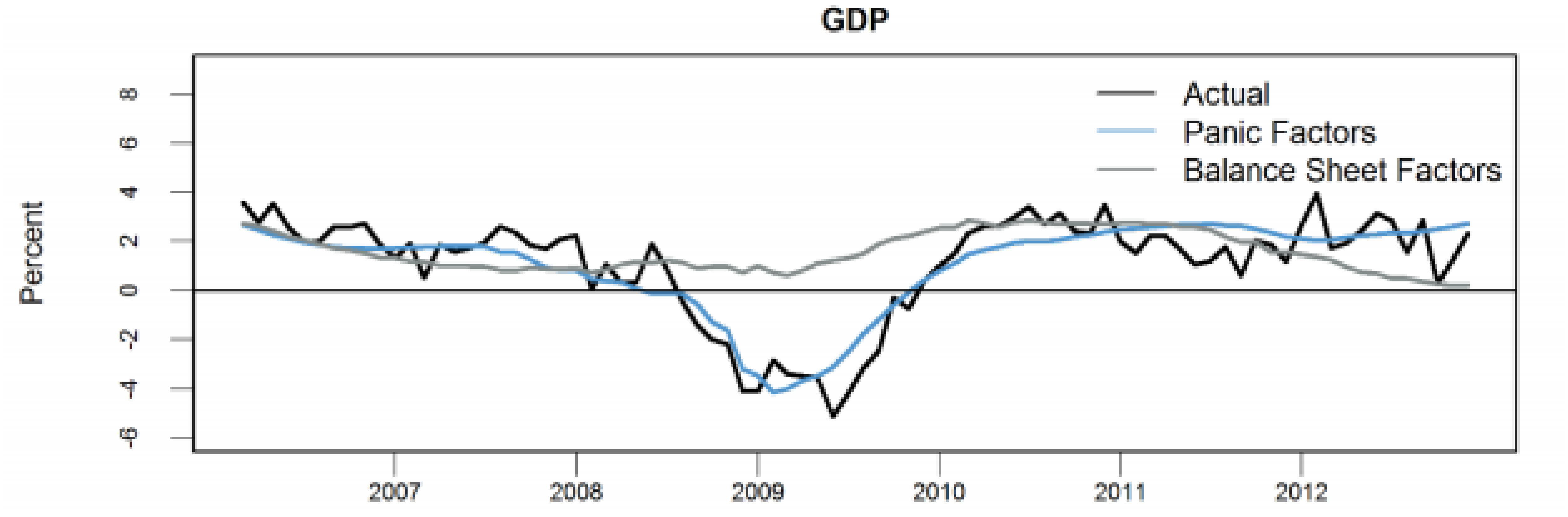
Table 2. F-Statistics for Inclusion of Each Factor in Prediction Equations[21]

Forecasted variable	Factor 1 (Housing)	Factor 2 (Credit)	Factor 3 (Funding)	Factor 4 (Banks)
GDP	0.06	4.89***	3.27**	0.63
Industrial Production	0.40	7.06***	4.87***	1.50
Employment Ex Construction	1.29	9.61***	2.52*	0.61
Unemployment	1.60	11.33***	2.56*	1.26
Real PCE	0.58	3.68**	3.76**	0.78
Real PCE (Durables)	0.33	3.51**	3.66**	0.44
Retail Sales	0.14	10.36***	4.59***	3.29**
Housing Starts	1.89	1.72	0.93	1.73
Capital Goods Orders	0.71	7.99***	2.96**	3.85**
ISM Manufacturing Index	2.40*	22.69***	13.00***	2.16*
Core PCE Inflation	0.88	1.55	0.85	0.42
df	(3;76)	(3;76)	(3;76)	(3;76)

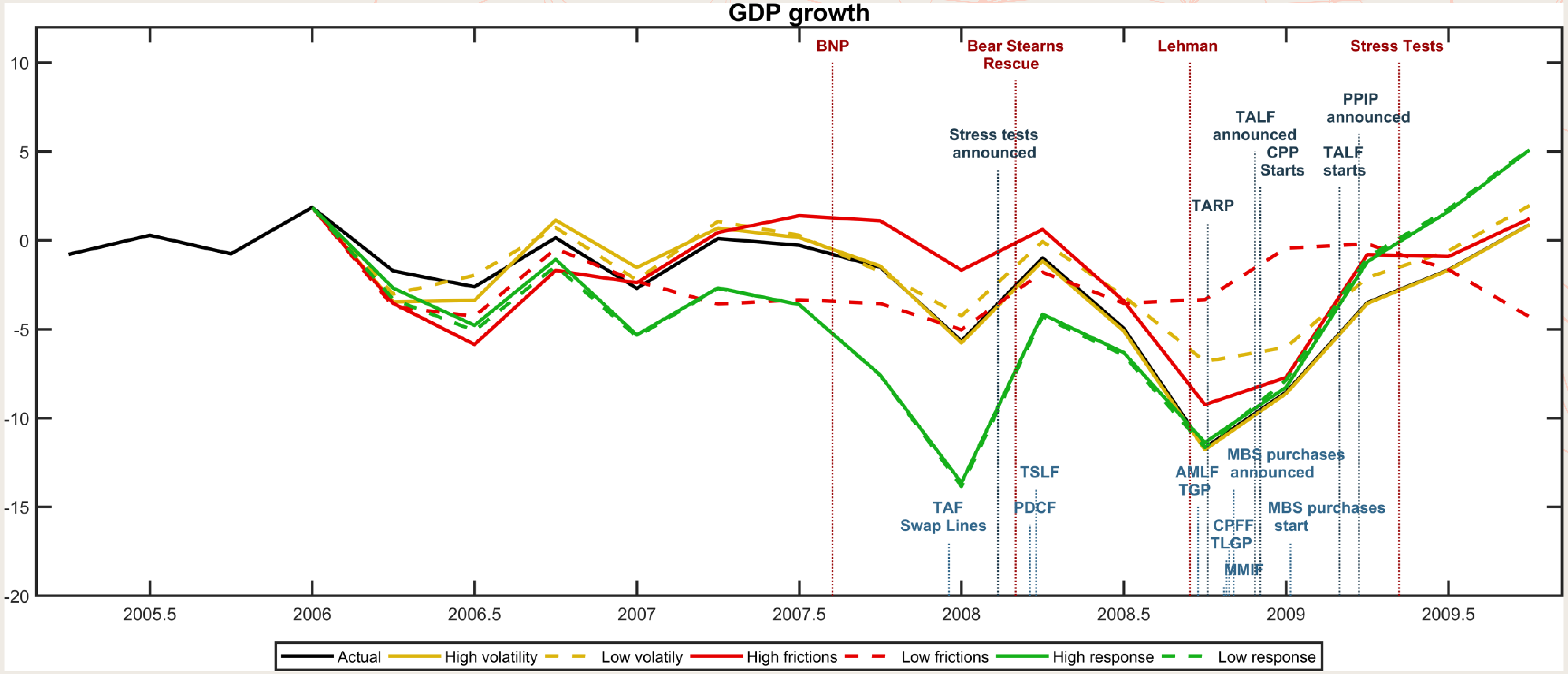
Table 4. F-Statistics for Inclusion of Pairs of Factors in Prediction Equations[23]

	Panic Factors (Factors 2 and 3)	Balance Sheet Factors (Factors 1 and 4)
GDP	3.57***	0.37
Industrial Production	5.29***	1.20
Employment Ex Construction	5.07***	1.46
Unemployment	8.09***	1.99*
Real PCE	3.75***	0.88
Real PCE (Durables)	6.00***	0.36
Retail Sales	8.50***	1.94*
Housing Starts	1.48	1.63
Capital Goods Orders	4.55***	2.46**
ISM Manufacturing Index	15.66***	2.05*
Core PCE Inflation	1.01	0.72
df	(6;73)	(6;73)

Figure 11. Dynamic Simulations: Panic and Balance Sheet Factors, 2006-2012



Counterfactual: the role of financial frictions, monetary policy and credit shocks



Counterfactuals generated with the estimated DSGE model results. Episodes and policies identified in Ben S. Bernanke (BPEA Fall 2018) The Real Effects of the Financial Crisis.

Conclusions

- Based on a model fit criteria, the introduction of Markov switching in parameters and variances improves the fit of a macroeconomic VAR model with financial variables, with the best fit in an unrestricted model with two switches in coefficients and three switches in variances (2c3v).

- The introduction of Markov switching in parameters and specially in variances, also greatly improves the fit of a DSGE macroeconomic model with financial frictions in long-term debt instruments developed by Carlstrom, Fuerst and Paustian (2S2R3V).

- In the used DSGE model, when allowing for switching in the parameters capturing financial frictions and monetary policy and switching in shocks volatilities there are different, well defined, regimes of high and low financial frictions, high and low monetary policy response to the term premium and high (, medium) and low credit shock volatilities regimes.

Conclusions cont.

- If Markov switching in variances is ignored, there is an overestimation of the high coefficient regimes.

- The DSGE without Markov switching requires larger shocks relative to a model with Markov switching in parameters. Events that otherwise might be interpreted as a structural regime switch are accommodated by large shocks.

- The IRFs are markedly different depending on the regime the economy is in.

- The presence of high financial frictions and high financial shocks explained why the Fed had to respond aggressively cutting interest rates and the severity of the 2008 GDP contraction.