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

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# Cyclical movements of US GDP, Federal Funds Rate and Term premium*, 1961q1 – 2017q4

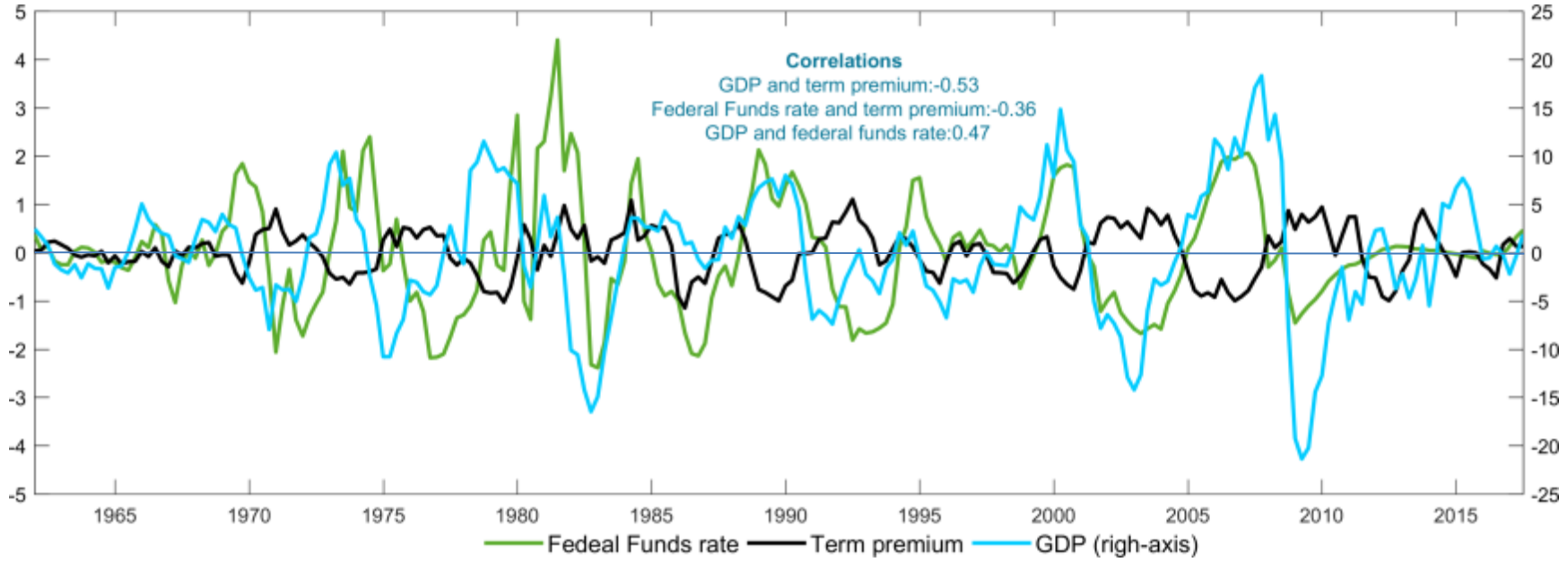



Figure 1: shows the deviation of each original series from its HP filter. GDP is the real gross domestic product (GDPC1 in Fred Economic Data from the Federal Reserve Bank of St. Louis), federal funds rate is the effective federal funds rate (FEDFUNDS also in Fred Economic Data), and term premium is 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).

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

# Financial conditions, economic activity and monetary policy

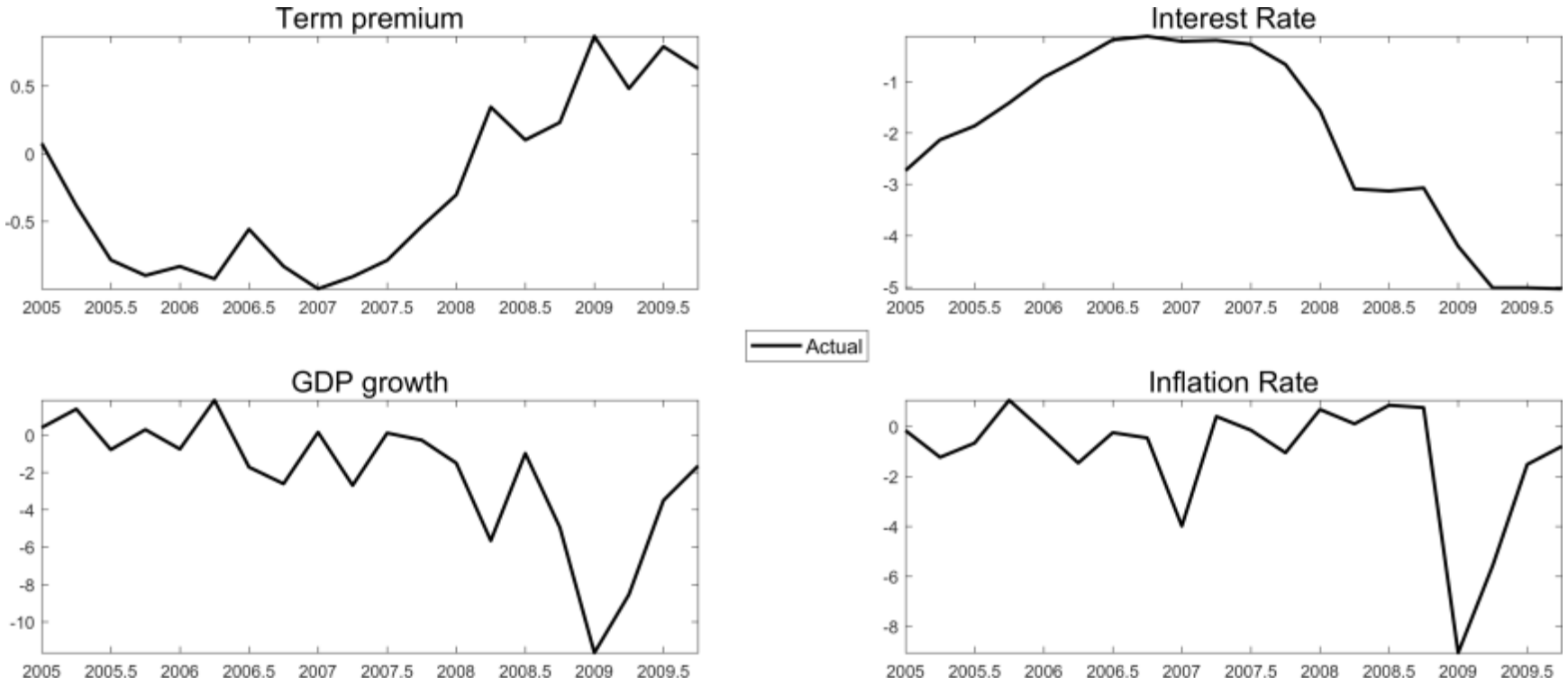
"To the extent that the decline in forward rates can be traced to a decline in the term premium*, …, the effect is financially stimulative and argues for greater monetary policy restraint, all else being equal. Specifically, if spending depends on long-term interest rates, special factors that lower 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***."

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): 0q HM.



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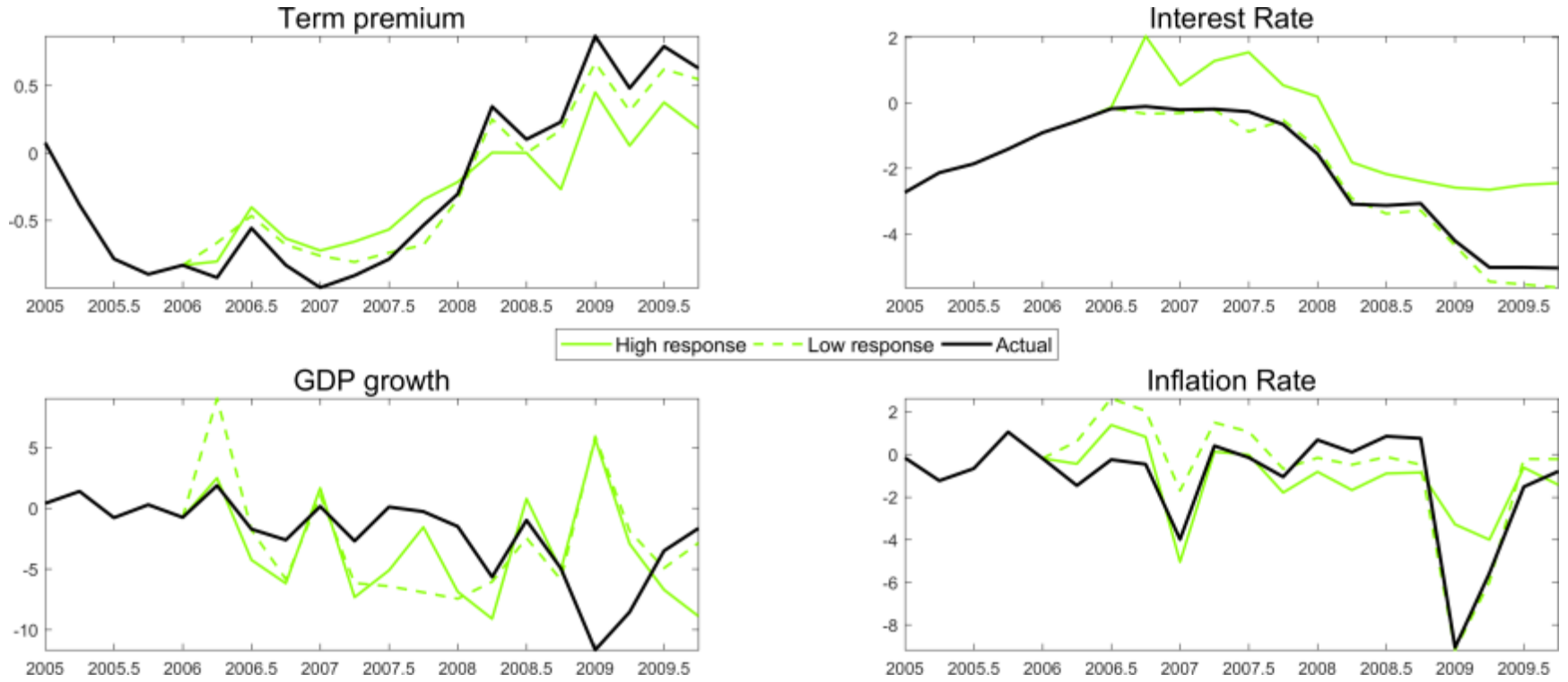


| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| | | | | |
| | | | | |
| If LM _ _ _ | Faster rise | Closer to data | Boom and bust | Higher |
| If HM ____ | Steeper increase | Increase + 2% | Strong contraction | Lower |

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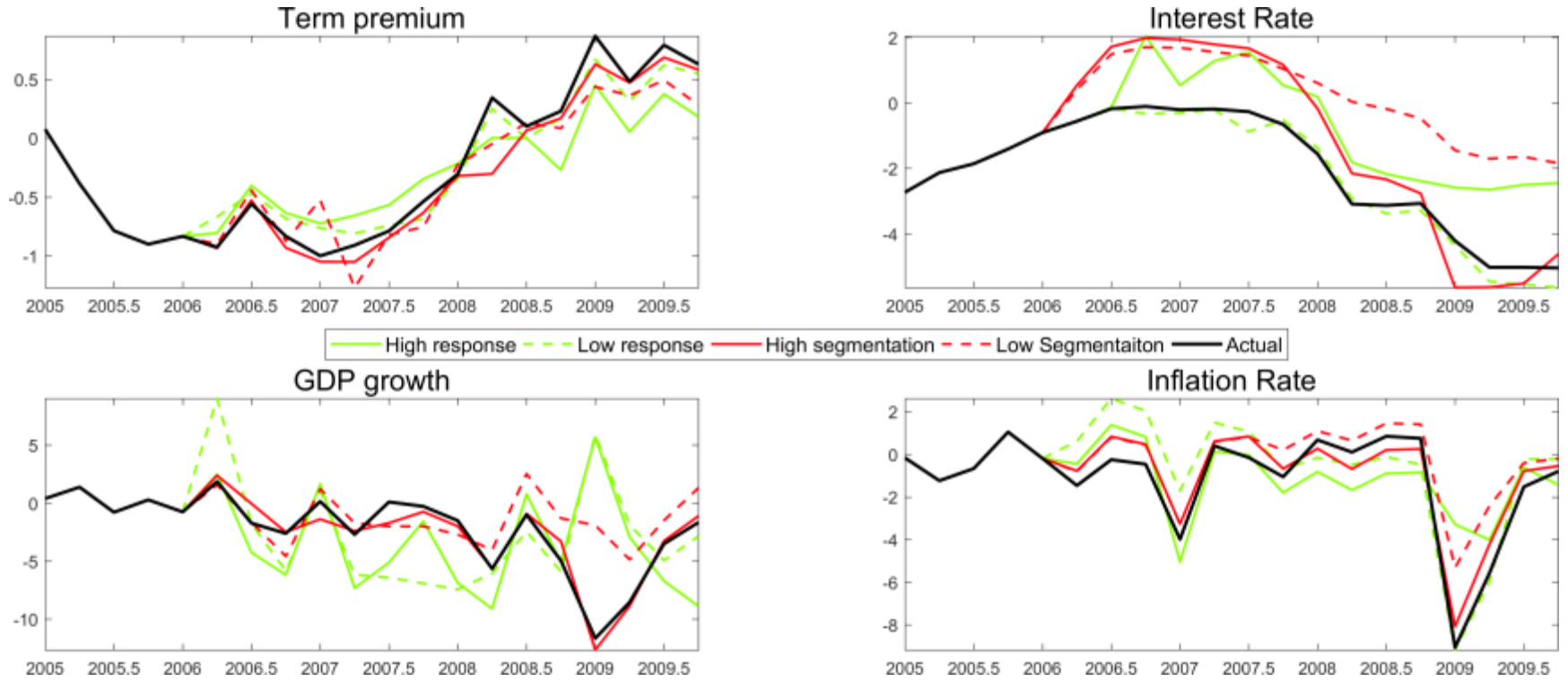
2006q1-2009q4 (16q): 0q HM, 13q HF (2006q1-2008q1 & 2009q2-2010q1).




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| | | | | |
| If LF _ _ _ | | Smaller cut in 2008 - 2009 | Mild contraction | Higher |
| If LM _ _ _ | Faster rise | Closer to data | Boom and bust | Higher |
| If HM ____ | Steeper increase | Increase + 2% | Strong contraction | Lower |

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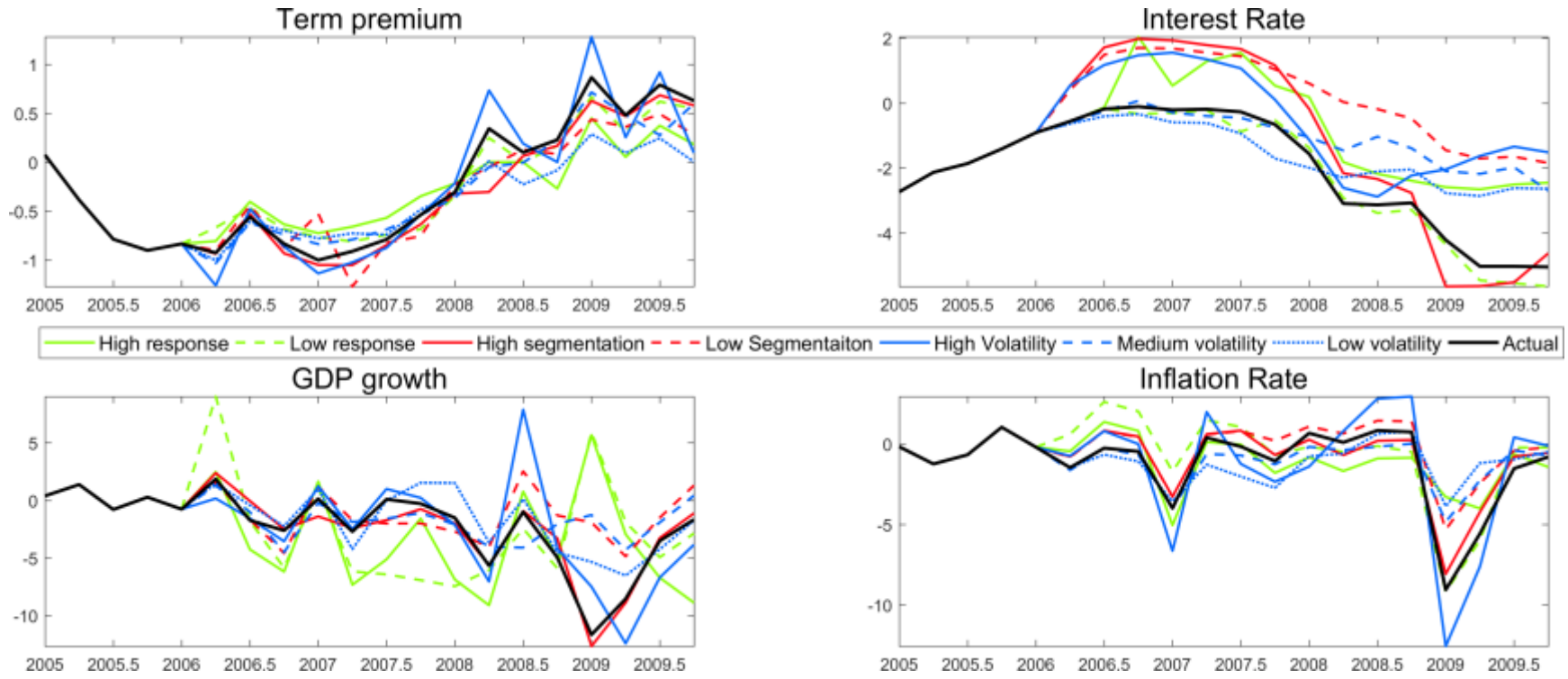
2006q1-2009q4 (16q): 0 HM, 13 HF (2006q1-2008q1 & 2009q2-2010q1), 1 HS (2008q4) and 3 MS (2006q3, 2008q2-q3).




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If HS ___ | First lower and then higher | Higher | Deeper contraction in 2009q1 & q2 | Prolonged deflation |
| If LF _ _ _ | | Smaller cut in 2008 - 2009 | Mild contraction | Higher |
| If LM _ _ _ | Faster rise | Closer to data | Boom and bust | Higher |
| If HM ____ | Steeper increase | Increase + 2% | Strong contraction | Lower |

# In this paper

- We estimate a Markov-switching Vector Autoregression (**MS-VAR**) model finding evidence of the importance of allowing for switching parameters (non-linearities) and switching variance (non-Gaussian) when analyzing macro-financial linkages in the US.

- Guided by the MS-VAR findings (2c3v), we estimate 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 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 |
|---|---|
| $2c3v$ | -1961.13* |
| $2cRM3v$ | -1986.39 |
| $2cTPRM3v$ | -1996.48 |
| $2cRMC3v$ | -2008.31 |
| $1c3v$ | -2014.16 |
| $2cTP3v$ | -2039.96 |
| $3c3v$ | -2052.12 |
| $2cTPCP3v$ | -2066.24 |
| $2cTPC3v$ | -2071.41 |
| $2cTPR3v$ | -2074.19 |
| $2c2v$ | -2087.19 |
| $1c2v$ | -2091.26 |
| $2c1v$ | -2116.98 |
| $1c1v$ | -2134.26 |

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

# 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:

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

subject to the resource constraint:

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

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

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:

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

# 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:

$$E_t \frac{P_t}{P_{t+1}} \Lambda_{t+1} \left[\left(\frac{R^L_{t+1}}{R^d_t} - 1\right) L_t + 1\right] = \Phi_t L_t E_t \frac{P_t}{P_{t+1}} \Lambda_{t+1} \frac{R^L_{t+1}}{R^d_t} \quad (8)$$

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

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

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

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

where $\sigma_{\phi,\xi_t^{vol}}$ is the standard deviation of the stochastic volatility of the credit shock, $\varepsilon_{\phi,t} \sim i.i.d.N\left(0, \sigma_\phi^2\right)$, whose $\xi_t^{vol}$ 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 $\phi_t$ 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:

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

and

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

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:

$$E_t(r^L_{t+1} - r_t) = \frac{1}{L_{ss}} \boldsymbol{\psi_{n,\xi^{ff}_t}} n_t + (s-1)\phi_t \qquad (13)$$

This expression shows the importance of $\psi_{n,\xi^{ff}_t}$ for the supply of credit. If $\psi_{n,\xi^{ff}_t} = 0$ , the supply of credit is perfectly elastic, independent of the financial intermediaries net worth. As $\psi_{n,\xi^{ff}_t}$ 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, $\pi_t$ t is CPI inflation rate, and $\varepsilon_{r,t}$ is an exogenous and auto-correlated policy shock with AR(1) coefficient $\rho_m$

- 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.

# 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 $Z$:

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

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

  where $\xi^{sp}$ and $\xi^{vo}$ 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.

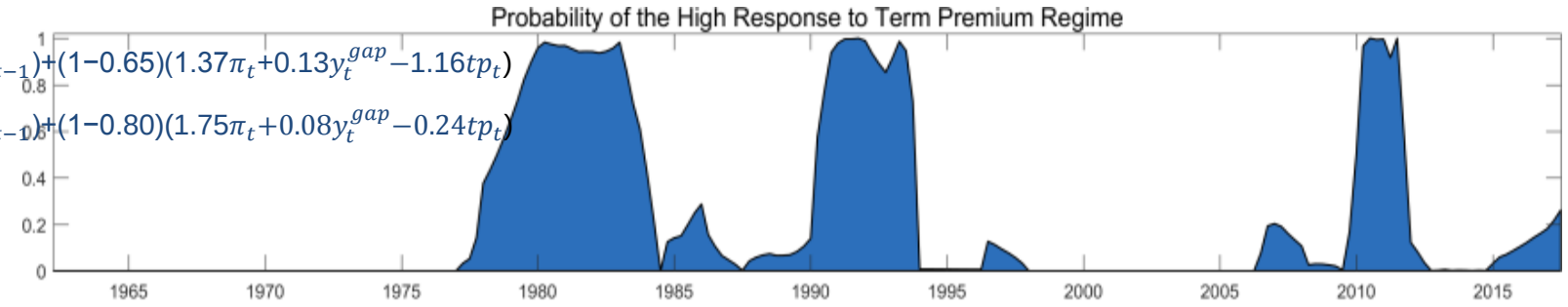
# Regime probabilities of the MS-DSGE model

$\ln(R_t)=0.65\ln(R_{t-1})+(1-0.65)(1.37\pi_t+0.13y_t^{gap}-1.16tp_t)$

$\ln(R_t)=0.80\ln(R_{t-1})+(1-0.80)(1.75\pi_t+0.08y_t^{gap}-0.24tp_t)$

$H_{h,l}^{mp}=0.09$

$H_{l,h}^{mp}=0.04$

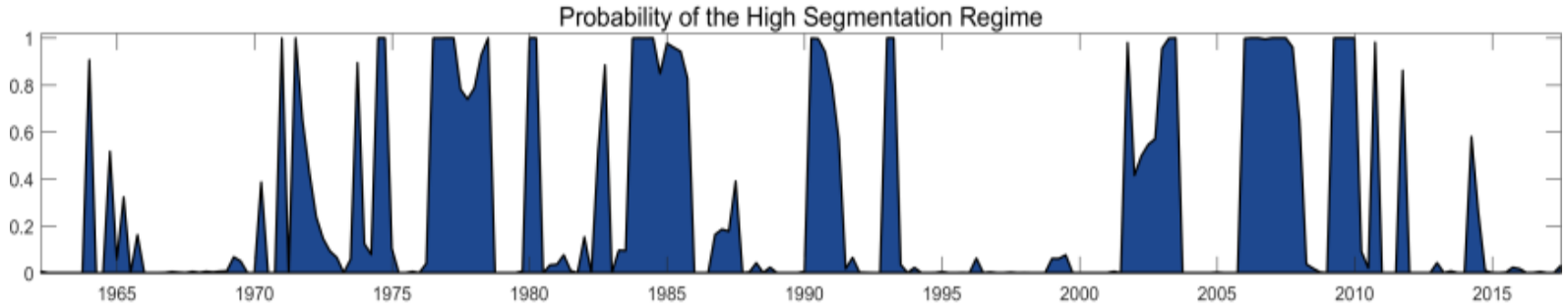



$\psi^{h}_{n,\xi_t^{ff}}=1.98$

$\psi^{l}_{n,\xi_t^{ff}}=0.11$

$H_{h,l}^{ff}=0.21$

$H_{l,h}^{ff}=0.20$




$\sigma_{\phi}^{h}=7.57$

$\sigma_{\phi}^{m}=4.01$

$\sigma_{\phi}^{l}=3.83$

$H_{h,m}^{vol}=0.01$

$H_{h,l}^{vol}=0.07$

$H_{m,h}^{vol}=0.17$

$H_{m,l}^{vol}=0.19$

$H_{l,h}^{vol}=0.17$

$H_{l,m}^{vol}=0.18$

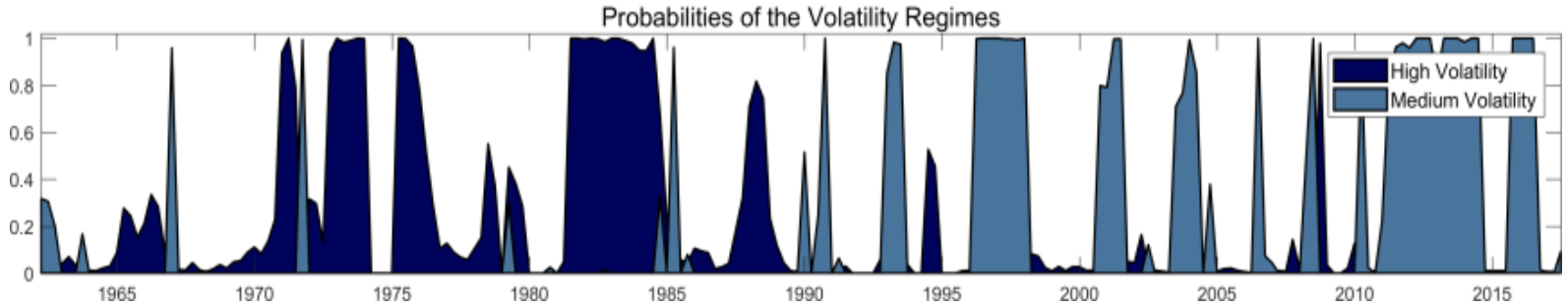



Figure 6: Probabilities at the posterior mode. Top panel: Probability of the High response to term premium regime. Middle panel: Probabilities of the High segmentation regime. Lower panel: Probabilities of the High and Medium volatility regimes.

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# Credit shock

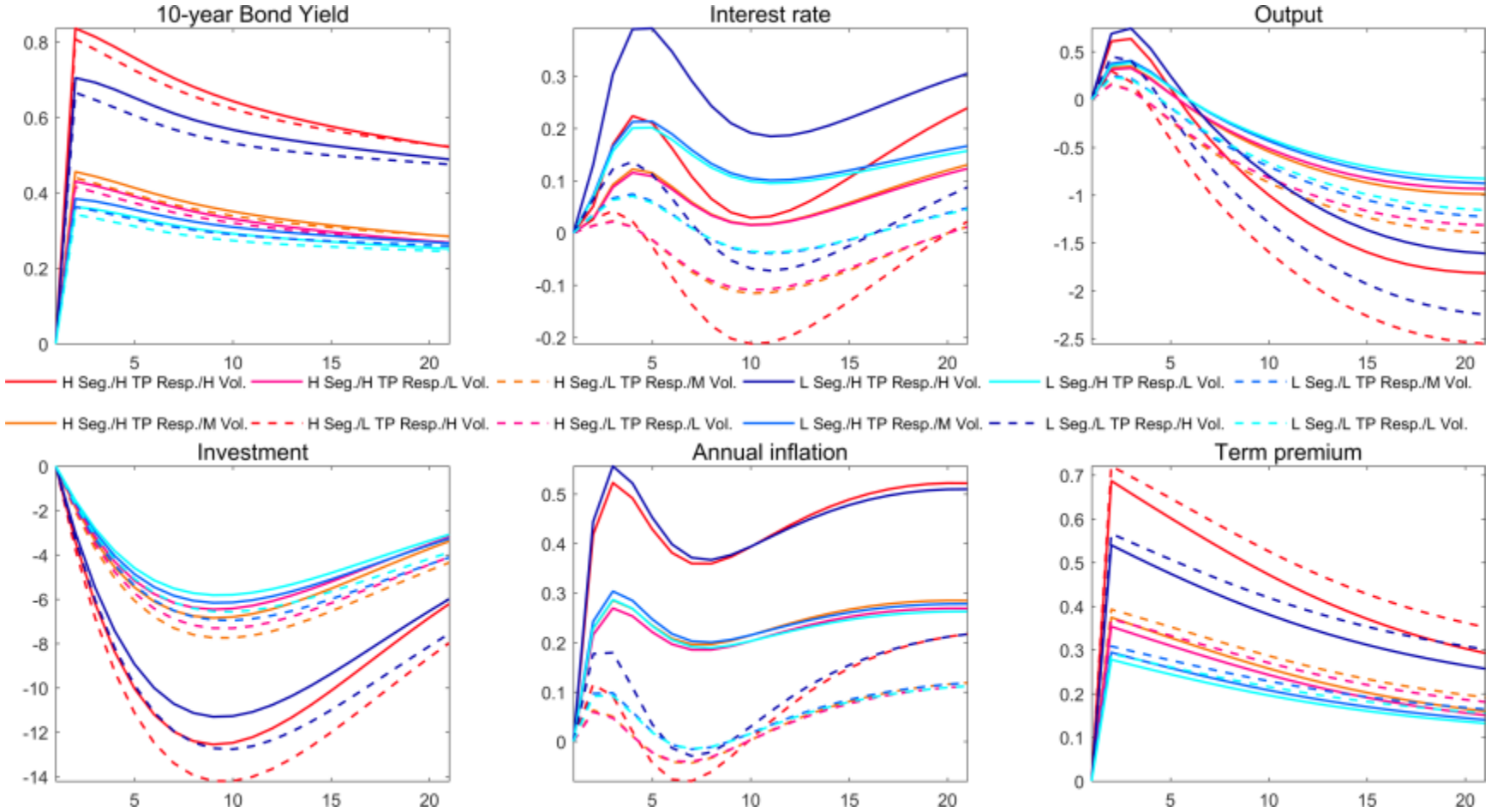



Figure 4: IRFs of the MS-DSGE model to a one standard deviation credit shock under alternative regimes for financial frictions, monetary policy and volatility. High financial frictions regimes are presented in red-like colors, while low ones are presented in blue-like colors. High monetary policy response regimes are presented in solid lines, while low ones are presented in dashed lines. High volatility regimes have the darkest colors, medium mild tones, and low ones are in the lightest tones.

# Monetary policy shock

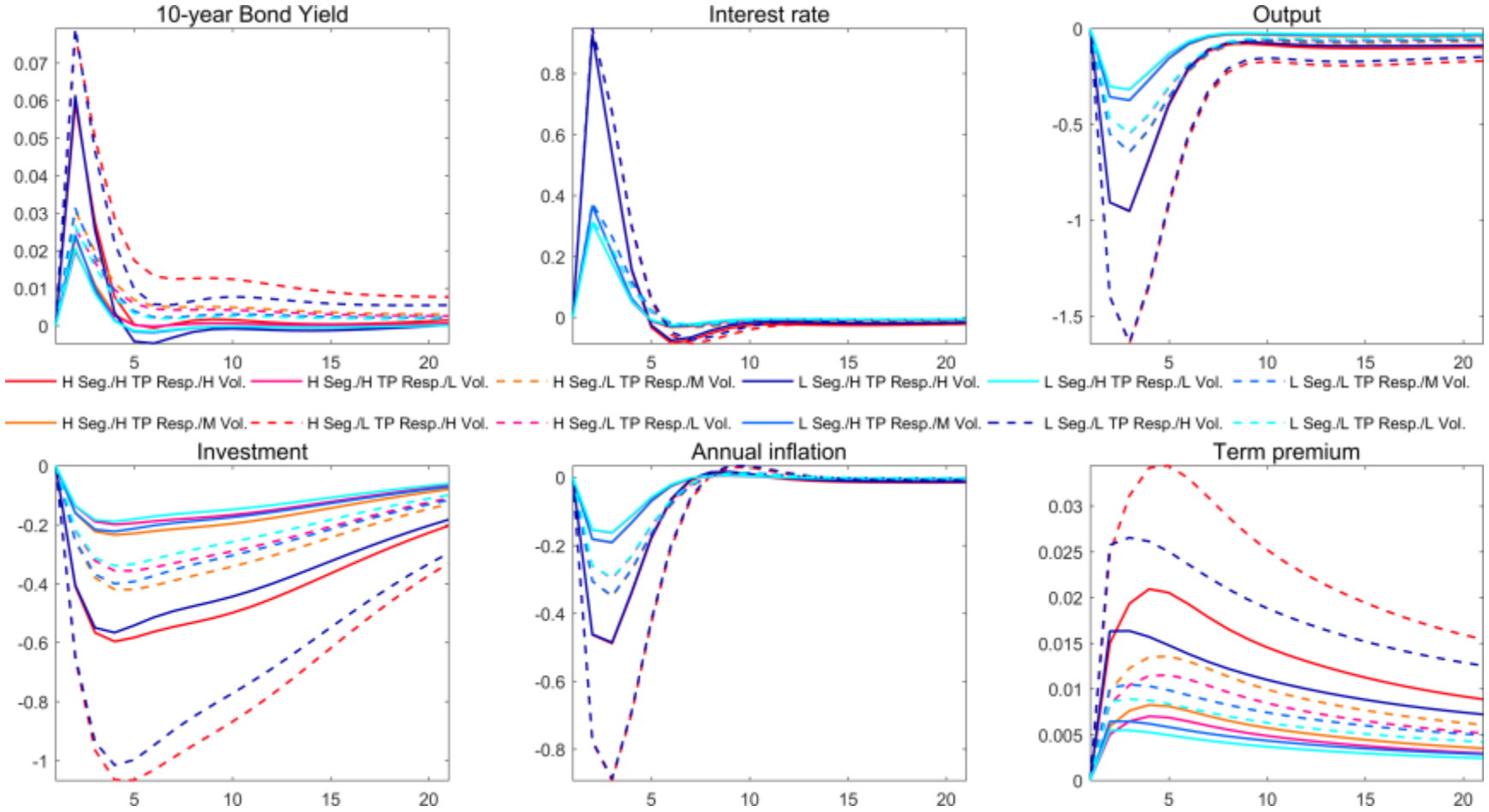



Figure 5: IRFs of the MS-DSGE model to a one standard deviation monetary policy shock under alternative regimes for financial frictions, monetary policy and volatility. High financial frictions regimes are presented in red-like colors, while low ones are presented in blue-like colors. High monetary policy response regimes are presented in solid lines, while low ones are presented in dashed lines. High volatility regimes have the darkest colors, medium mild tones, and low ones are in the lightest tones

# Counterfactuals

- To further explore the effects of financial conditions and monetary policy, we run six counterfactual exercises:

| Episode | High financial frictions | High or medium credit shocks variance | High monetary policy response to term premium |
|---|---|---|---|
| 1971q1 – 1978q3 (31q) | 15 | 14 | 0 |
| 1978q4 – 1983q4 (21q) | 5 | 10 | 21 |
| 1990q2 – 1993q4 (15q) | 7 | 4 | 15 |
| 2000q4 – 2004q2 (15q) | 5 | 8 | 0 |
| 2006q1 – 2009q4 (16q) | 13 | 4 | 0 |
| 2010q1 – 2011q4 (8q) | 2 | 4 | 8 |

- We suppose what could have happened if:
  - Financial frictions: high (solid) or low (dashed).
  - Credit shock volatility: high (solid), medium (dashed) or low (dotted).
  - Monetary policy: high (solid) or low (dashed).

# 1962q1 – 1970q4

- Since the start of our sample in 1962q2 and until 1970q4, the estimation assigns a high probability to a low credit market segmentation and low credit shock volatility regime[1].

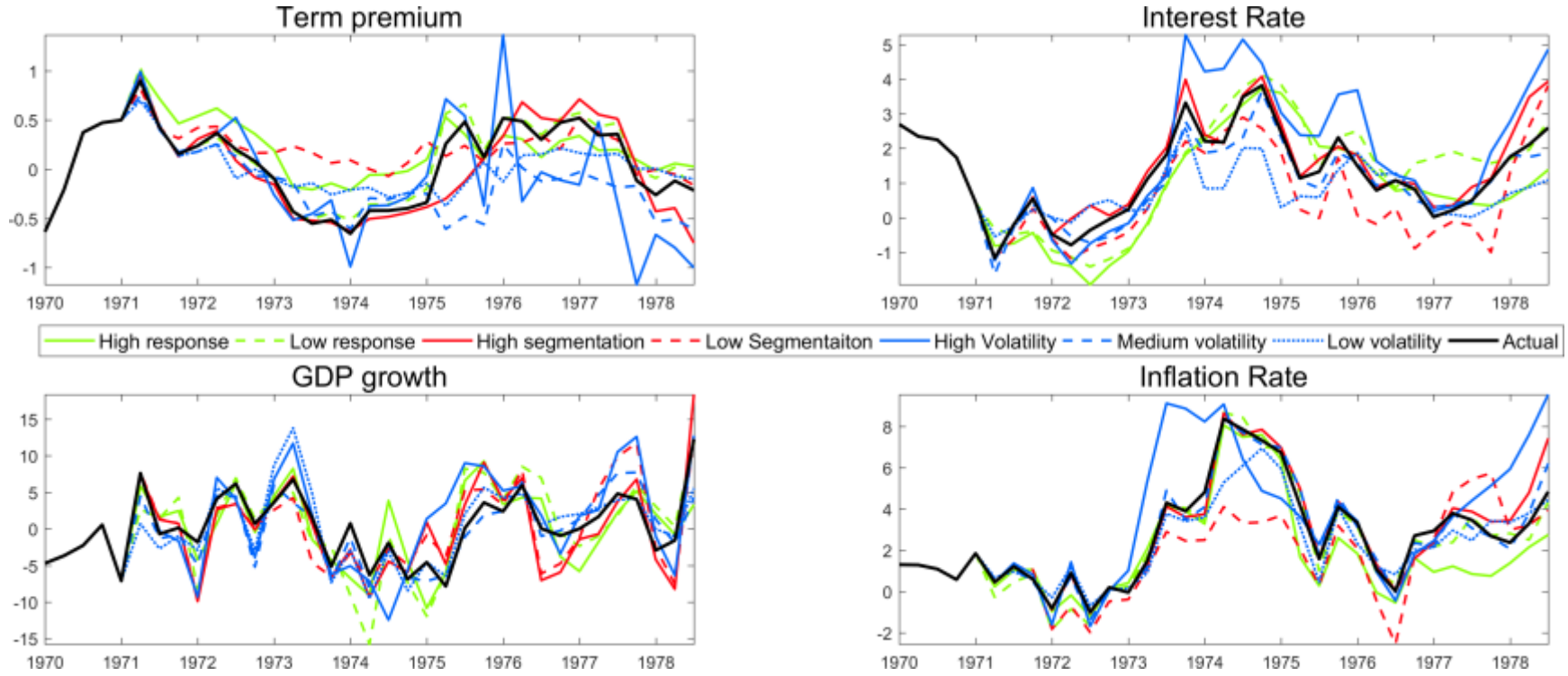
- This despite the 1966 “Credit Crunch” and the Vietnam War expenses run by the government, the tighter monetary policy in 1967q3 and 1968q3, and that according to the NBER's Business Cycles Dating Committee there was an economic contraction from 1969q4 to 1970q4.

- Given that there is scant evidence of regime switching of either financial frictions, financial shocks or monetary policy response during this 1962q2 - 1971q1 period, we do not perform a counterfactual exercise for it.

[1]The only exceptions are 1964q1 and 1964q4 when there is a high probability of high credit market segmentation and 1967q1 when there is a high probability of a medium credit shock variance.

# 1971q1 – 1978q3 (31q): 15 HF, 14 HS, 0 HM

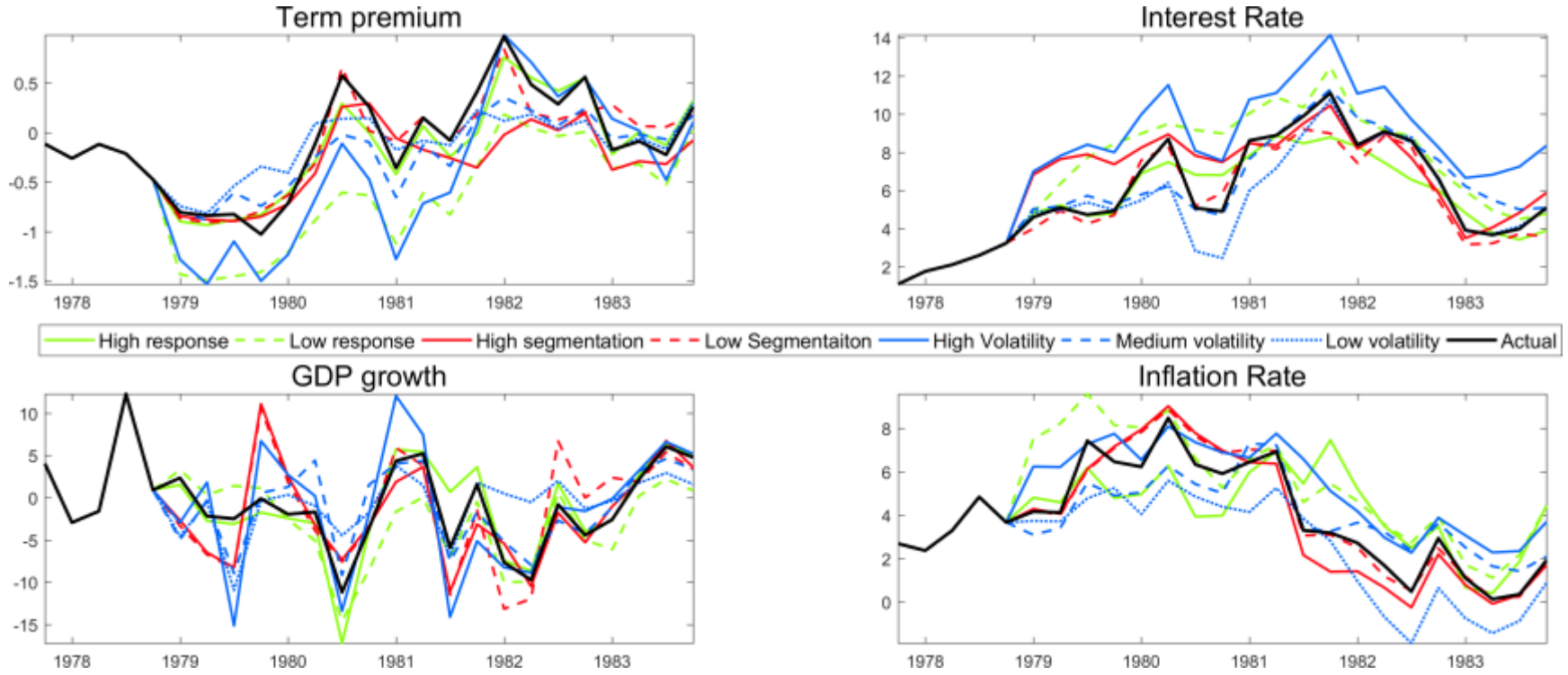
The FED raised rates in 1971q3 and 1972q1 to fight inflation. Richard Nixon's unilaterally cancelled the international convertibility of the USD to gold in 1971q3, the world economy faced the 1973q3 OPEC embargo oil shock, and the US government ran deficits to pay for the Vietnam war and President Lyndon Johnson's Great Society Programs. Also, according to the NBER's Committee there was an economic contraction from 1973q4 to 1975q1.




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If LF _ _ _ | Closer to SS | Increase less | Larger | More moderate |
| If LS . . . | Closer to SS | Lower and less volatile | Higher and less volatile | Lower and less volatile |
| If HM ____ | Closer to SS | Lower | Lower | Lower |

# 1978q4 – 1983q4 (21q): 5 HF, 10 HS, 21 HM

With inflation and interests rates rising during the late 1970s and early 1980s savings and loan institutions with regulation on maximum payable interest rates, saw their funding base eroded, while the fixed-rate interest that they earned in their mortgages represented large valuation losses in their assets. Despite the Depository Institutions Deregulation and Monetary Control Act of 1980, but turned out insufficient which prompted industry deregulation and eventually taxpayers bailout. In 1979q4 there was a negative oil supply shock related to the Irag and Iran war. The NBER's committee identifies two recessions from 1980q1 to 1980q3 and from 1981q3 to 1982q4.




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If LF _ _ _ | Higher | Increase less | | |
| If LS . . . | Higher closer to SS | Lower | Less volatile | Lower |
| If LM _ _ _ | Lower below SS | Higher | Higher | Higher |

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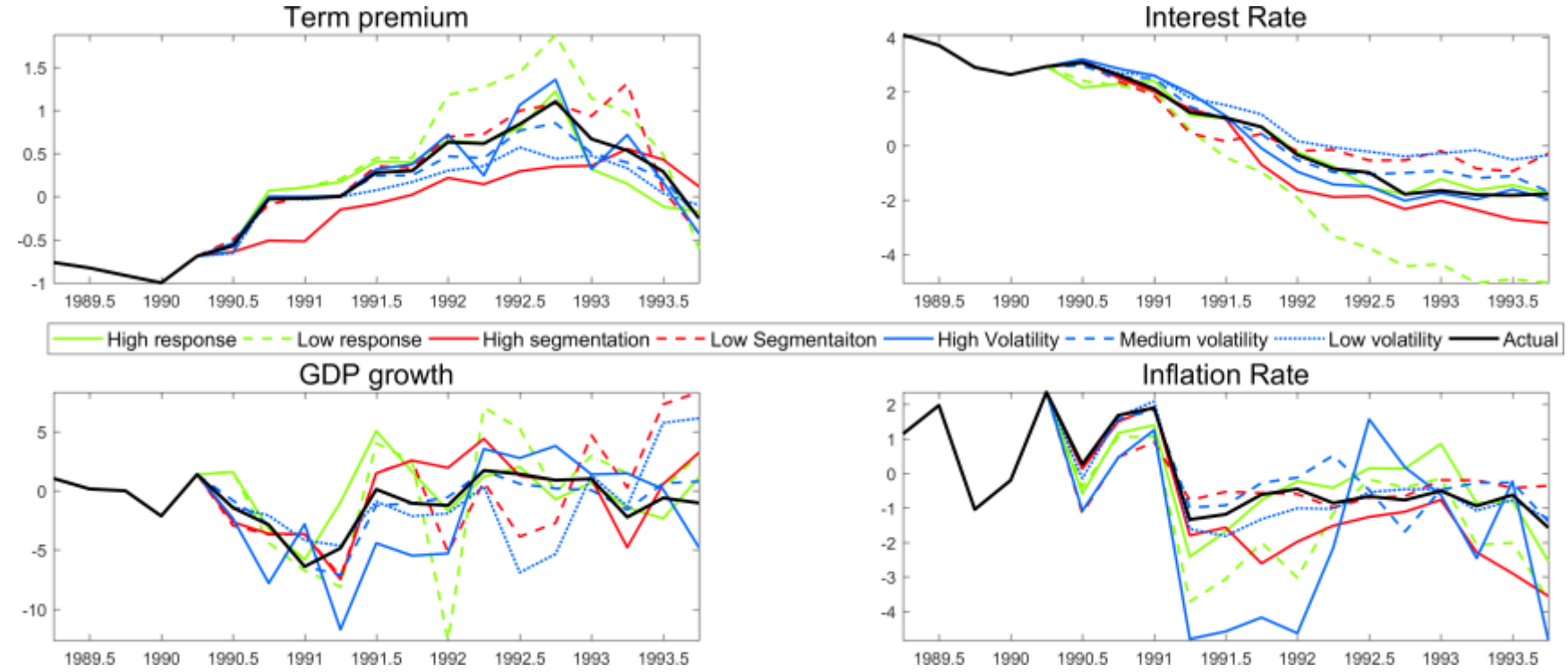
# 1990q2 – 1993q4 (15q): 7 HF, 4 MS, 15 HM

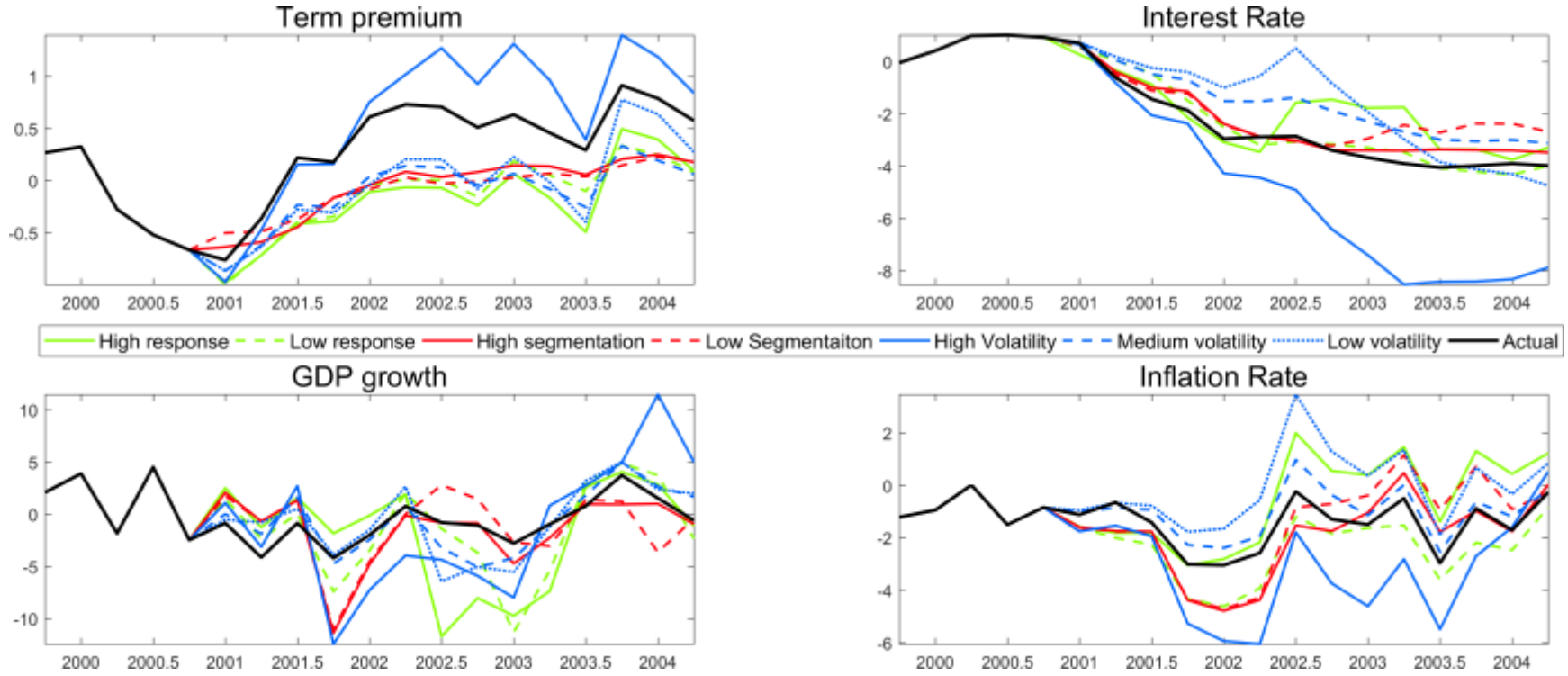
Starting in 1990q3, the FOMC lowered interest rates from 8.25% to 4% by the end of 1991 and to 3% by 1992q3. Meanwhile, the NBER' Committee dates a contraction from 1990q3 to 1991q1. The Federal Deposits and Insurance Corporation (FDIC) experienced an improvement after president George H.W. Bush responded to the problems in the banking and thrift industries which have their origins two decades before. By the end of 1991, nearly 1,300 commercial banks either failed or required failing assistance from the FDIC causing its severe undercapitalization. The main overarching provisions of the FDICIA, which was implemented in 1994, include “prompt corrective action” and “least cost resolution. This process was followed by the Riegle-Neal Act of September 1994 that allowed banks to branch at intra- and interstate levels.




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If HF ___ | Increase less | Decrease more | Stronger recovery | Lower |
| If HS ___ | Higher | Decrease more | Higher contraction | Deep deflation |
| If LS . . . | Lower | Decrease less | Smaller contraction | Closer to data |
| If HM ___ | Lower | Earlier but smaller decrease | Mitigate contraction | Closer to data |
| If LM _ _ _ | Higher | Sharper decrease | Longer and deeper contraction | Deep deflation |

# 2000q4 – 2004q2 (15q): 5 HF, 8 MS, 0 HM

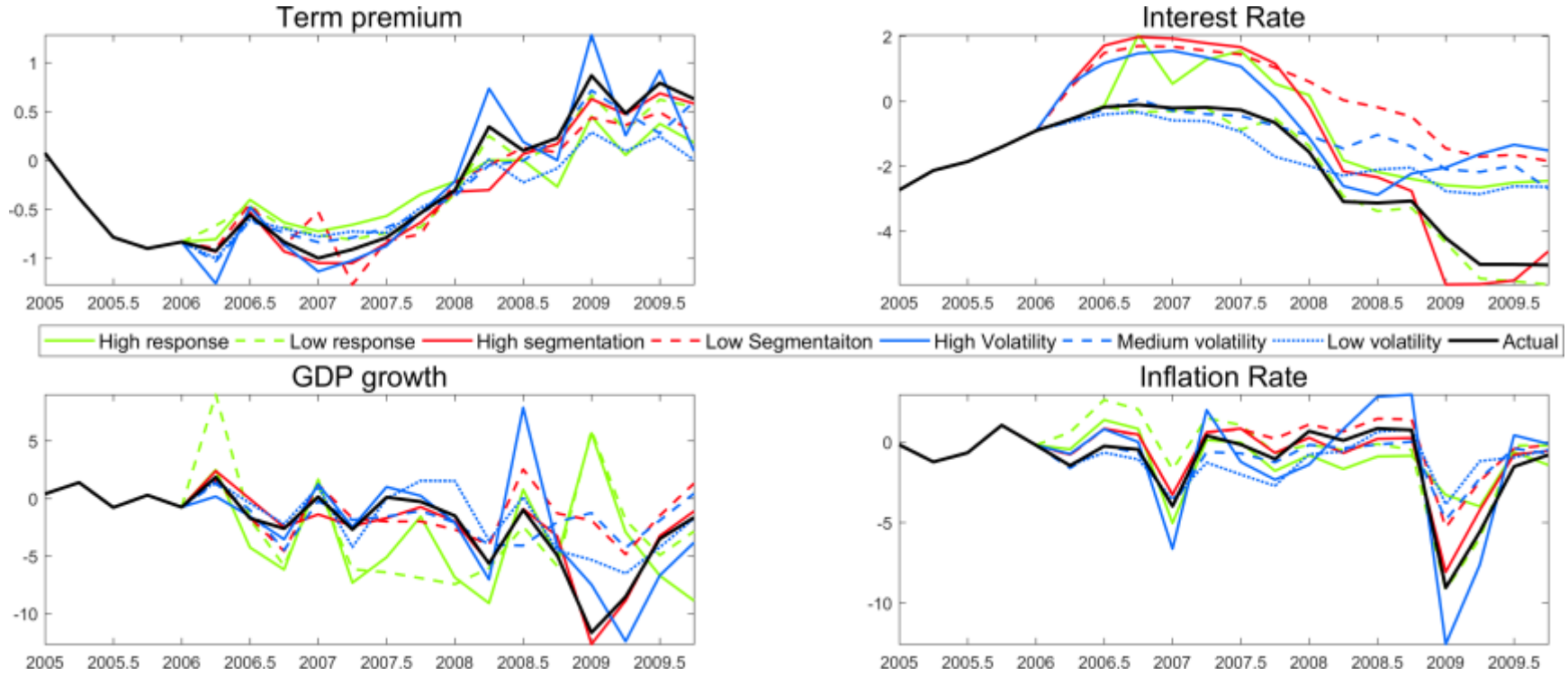
In 1999q4, president Bill Clinton signed into law the Financial Services Modernization Act, commonly called Gramm-Leach Bliley Act that repealed the Glass-Steagall Act giving the Fed new supervisory powers aimed to promote the benefits of financial integration for consumers and investors while safeguarding the soundness of the banking and financial systems. Now the commercial and investment banking, separated since 1933, wouldn't have restrictions of integration between them leading to the creation of the financial holding groups. In this period the FED also played an active role as a supervisor of the Financial Holding Companies (FHC). The Fed supervises the consolidated organization, while primarily relying on the reports and supervision of the appropriate state and federal authorities for the FHC subsidiaries, taking the role of an "umbrella" supervisor. This necessity surge because these large FHC had risk spread across their subsidiaries, but managed it as a consolidated entity. In this episode there is low probability of a high monetary policy response to the term premium. The NBER's Committee dates a contraction from 2001q1 to 2001q4 and starting in January 2001, the FOMC cut interest rates 11 times that year from 6.5% to 1.75%. September 11, 2001 attack. 2003 Iraq invasion.




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If LF _ _ _ | | | | |
| If HS ___ | Much larger | Much lower | Deeper and longer contraction | Prolonged deflation |
| If HM ____ | Lower | Earlier decrease | Delayed contraction to 2002q3 but deeper | Higher |

# 2006q1 – 2009q4 (16q): 13 HF, 1 HS 3 MS, 0 HM

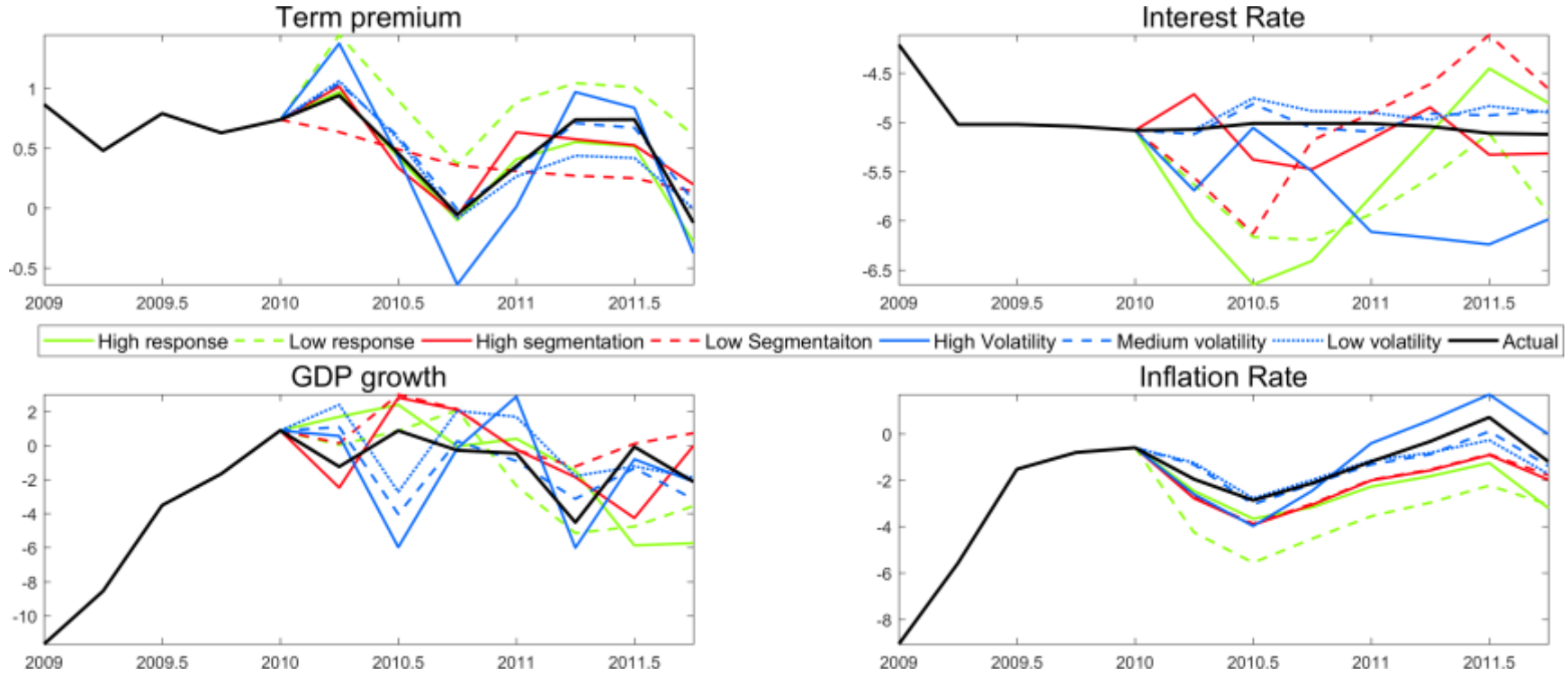
This episode is preceded by a Feds Funds target that in June 30, 2004 started an upward trend from the 1% prevailing since June 25, 2003 to 2.25% by the end of 2004 and 4.25% by the end of 2005. During the first half of the year the FOMC added other four 0.25% increments to 5.25% by June 2006. The presence of high financial frictions also allows us to understand why the FED needed to be so aggressive lowering interest rates during the recession lowering them to 4.25% by the end of 2007 and to [0% - 0.25%] in December 16, 2008. This period includes the most critical events of the subprime crisis.




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If LF _ _ _ | | Smaller cut in 2008 - 2009 | Mild contraction | Higher |
| If HS ___ | First lower and then higher | Higher | Deeper contraction in 2009q1 & q2 | Prolonged deflation |
| If LM _ _ _ | | Closer to data | Boom and bust | Higher |
| If HM ____ | | Increase + 2% | Strong contraction | Lower |

# 2010q1 – 2011q4 (8q): 2 HF, 4 MS, 8 HM

In 2010 President Obama signed the ‘‘Dodd-Frank Wall Street Reform and Consumer Protection Act’’ which consolidated regulatory agencies and created a new oversight council to evaluate systemic risk. It included comprehensive regulation of financial markets including increased transparency of derivatives. It also considered consumer protection reforms and tools for financial crisis resolution complementing the FDIC authority and a proposal that the Fed receive authorization from the Treasury for extensions of credit in "unusual or exigent circumstances“ and the Volcker rule banning trading on proprietary trading by commercial banks.




| | Term premium | Interest rate | GDP growth | Inflation rate |
|---|---|---|---|---|
| If LF _ _ _ | Steady reduction | First lower, then higher | Faster recovery | |
| If HS ___ | More volatile | Lower | More volatile | First lower, then higher |
| If LM _ _ _ | Higher | Low in line with Wu and Xia shadow | Slower recovery | Lower |

# Counterfactuals: summary of results

| Episode | High financial frictions | High or medium credit shocks variance | High monetary policy response to term premium | Counterfactual highly responsive monetary policy stance |
|---|---|---|---|---|
| 1971q1 – 1978q3 (31q) | 15 | 14 | 0 | It could have attained lower inflation at the cost of lower GDP. |
| 1978q4 – 1983q4 (21q) | 5 | 10 | **21** | Helped to mitigate inflation at the cost of economic activity. |
| 1990q2 – 1993q4 (15q) | 7 | 4 | **15** | Mitigate economic contraction. |
| 2000q4 – 2004q2 (15q) | 5 | 8 | 0 | It could have delayed the GDP contraction to 2002q3, but this would have been deeper and inflation larger. |
| 2006q1 – 2009q4 (16q) | 13 | 4 | 0 | It might have precipitated the GDP contraction. |
| 2010q1 – 2011q4 (8q) | 2 | 4 | **8** | Mitigate economic contraction. |

The presence of high financial frictions and high shock volatility makes recessions deeper and recoveries more sluggish showing the importance of the financial-macroeconomic nexus.

# Conclusions (1)

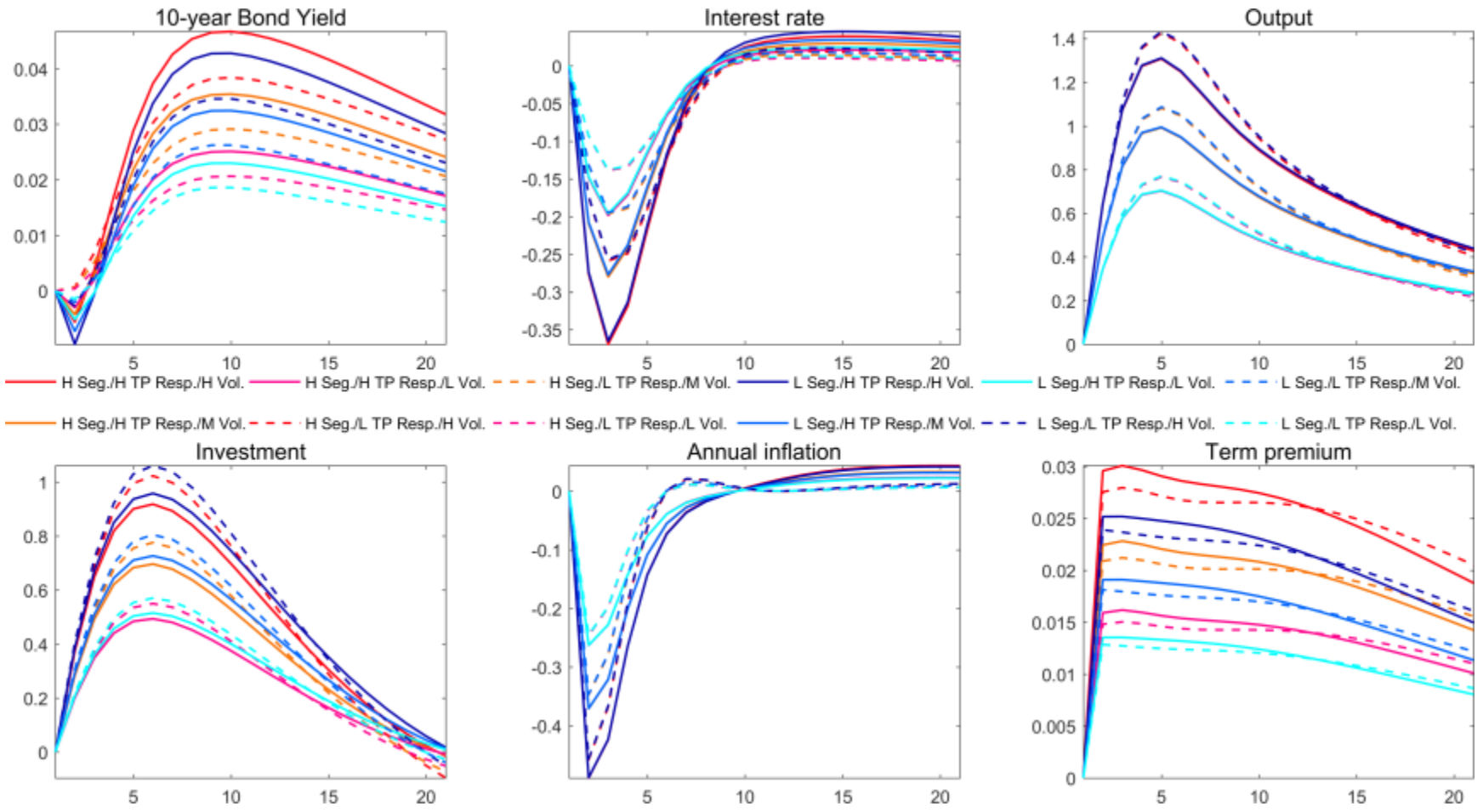
- We use a MS-VAR to provide evidence of the importance of allowing for switching parameters (non-linearities) and switching variance (non-Gaussian) when analyzing macro-financial linkages in the US.
- Using the preferred specification of two regimes in coefficients and three regimes in volatilities, we modify the DSGE model in Carlstrom, Fuerst and Paustian (AEJ: Macro 2017) by allowing Markov-switching in the parameters that capture financial frictions, monetary policy responses and stochastic volatility.
- Classifying regimes as high and low financial frictions, high and low interest rate response to term premium and high, medium and low credit shock volatility; we perform a Bayesian estimation of the model to identify those regimes.
- The Bayesian Maximum Likelihood estimation of the MS-DGSE model identifies:
  - 59 quarters (27% of the sample that runs from 1962q1 to 2017q4) of high financial frictions:1971q1 – 1971q4, 1976q3 – 1978q3, 1983q4 – 1985q4, 1990q2 – 1991q2, 2002q3 – 2003q3, 2006q1 – 2008q1 and 2009q2 – 2010q1.
  - 43 quarters (19.3%) when the interest rate response to the term premium is estimated high: 1978q4 – 1983q4, 1990q2 – 1993q4 and 2010q1 – 2011q4. I
  - 34 quarters (15.2%) of large probability of high credit shock volatility, 46 quarters (20.6%) with large probability of medium credit shock volatility and 142 quarters (63.7%) with large probability of low credit shock volatility.

# Conclusions (2)

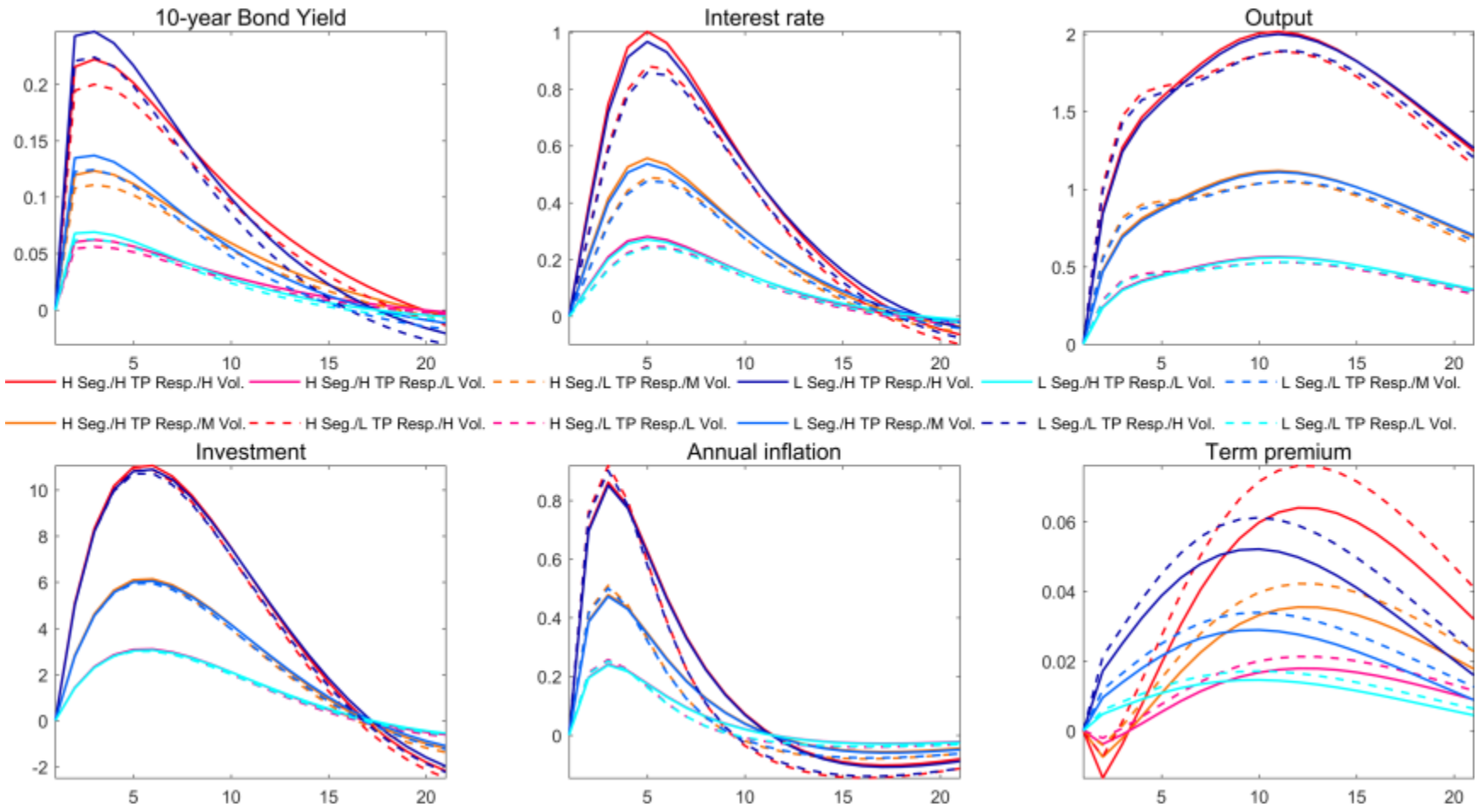
- Using the estimated model we perform counterfactual analysis of the potential evolution of macroeconomic and financial variables under alternative financial conditions and monetary policy responses.
- We analyze six episodes with presence of high financial frictions and/or medium and high shocks volatility.
- In three of them there was a high monetary policy response to financial factors: 1978q4 - 1983q4 which helped to mitigate inflation at the cost of economic activity, and the 1990q2 - 1993q4 and 2010q1 - 2011q4 episodes in which the high response served to mitigate economic contractions.
- Meanwhile, in the three episodes where low response to financial factors is observed, if the monetary authority had responded more aggressively, from 1971q1 - 1978q3 it could have attained lower inflation at the cost of lower GDP, from 2000q4 - 2004q4 it could have delayed the GDP contraction to 2002q3, but this would have been deeper and inflation larger, and in 2006q1 -2009q4 it might had precipitated the GDP contraction.
- The presence of high financial frictions and high shock volatility makes recessions deeper and recoveries more sluggish showing the importance of the financial-macroeconomic nexus.

# ANNEX

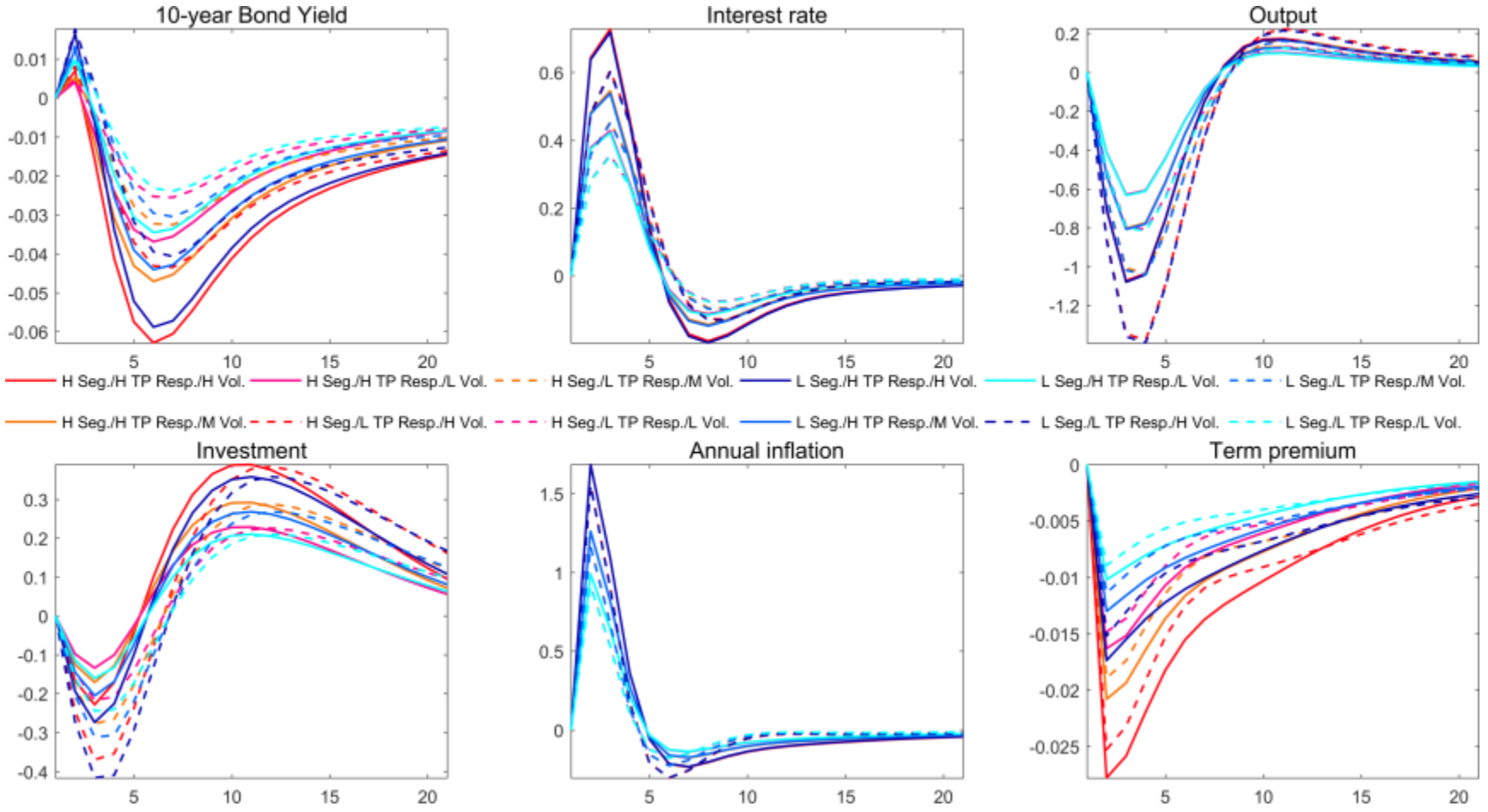
# Technology


10-year Bond Yield
Interest rate
Output
Investment
Annual inflation
Term premium
H Seg./H TP Resp./H Vol.
H Seg./H TP Resp./L Vol.
H Seg./L TP Resp./M Vol.
L Seg./H TP Resp./H Vol.
L Seg./H TP Resp./L Vol.
L Seg./L TP Resp./M Vol.
H Seg./H TP Resp./M Vol.
H Seg./L TP Resp./H Vol.
H Seg./L TP Resp./L Vol.
L Seg./H TP Resp./M Vol.
L Seg./L TP Resp./H Vol.
L Seg./L TP Resp./L Vol.

# Investment-specific



# Price mark-up

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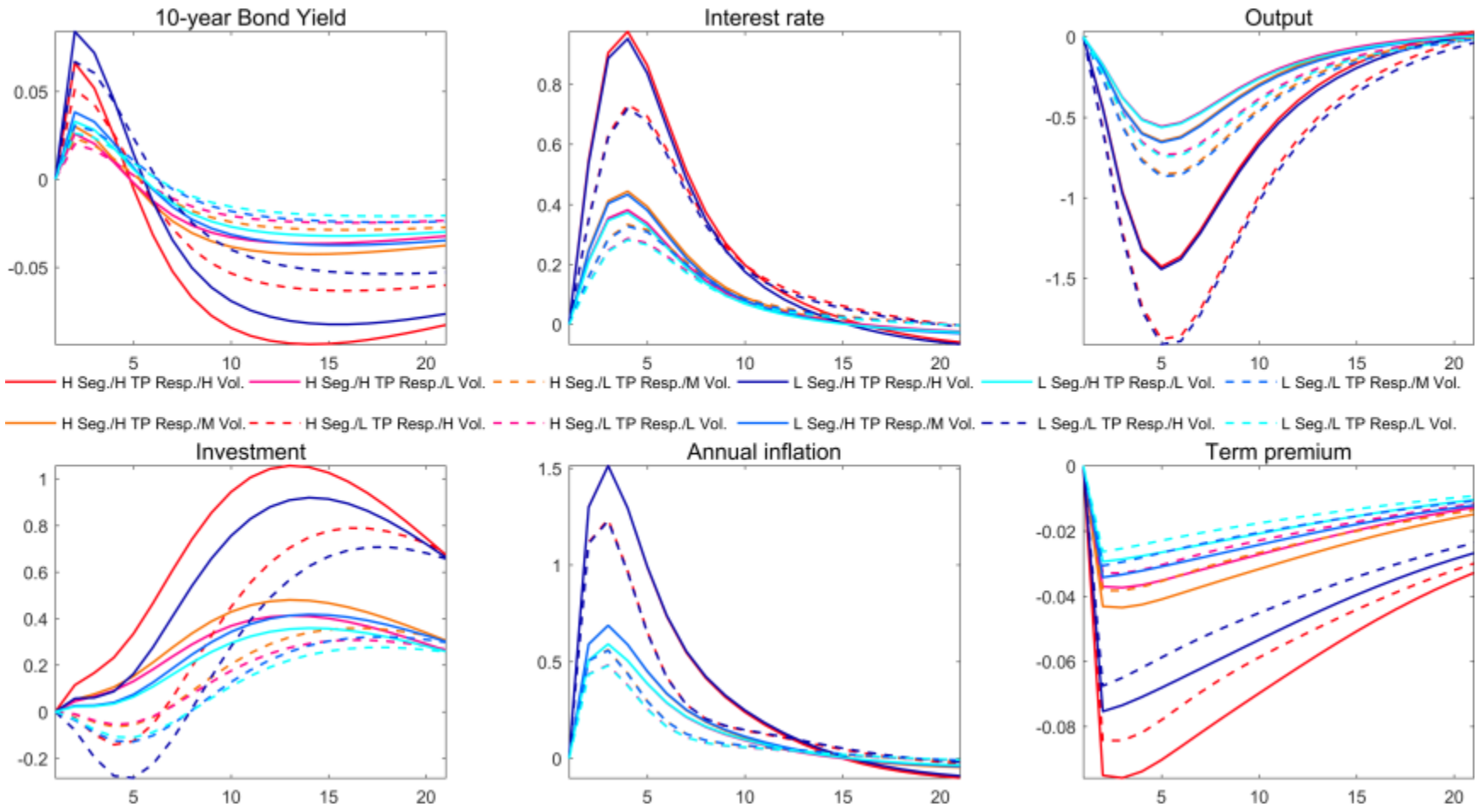
# Wage mark-up


10-year Bond Yield
Interest rate
Output
H Seg./H TP Resp./H Vol.
H Seg./H TP Resp./L Vol.
H Seg./L TP Resp./M Vol.
L Seg./H TP Resp./H Vol.
L Seg./H TP Resp./L Vol.
L Seg./L TP Resp./M Vol.
H Seg./H TP Resp./M Vol.
H Seg./L TP Resp./H Vol.
H Seg./L TP Resp./L Vol.
L Seg./H TP Resp./M Vol.
L Seg./L TP Resp./H Vol.
L Seg./L TP Resp./L Vol.
Investment
Annual inflation
Term premium

# Discount rate