On the Empirical (Ir)Relevance of the Zero Lower Bound Constraint

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Overview

The *ZLB Irrelevance Hypothesis*

The economy's performance has not been affected by the ZLB contraint

- **Focus on two dimensions:**
  1. No increase in volatility of macro variables
  2. No changes in response of macro variables to shocks

- ... this is indeed what we find

- **Interpretation:** Unconventional policies effective at getting around the ZLB constraint

Related Literature

- **Papers estimating effects of forward guidance and QE**
  [Krishnamurthy and Vissing-Jorgensen (2011), Hamilton and Wu (2012), D'Amico and King (2013, 2017), Andrade et al. (2016), Swanson (2017), Greenlaw et. al. (2018), etc., etc...]

- **Papers assessing "irrelevance hypothesis"**

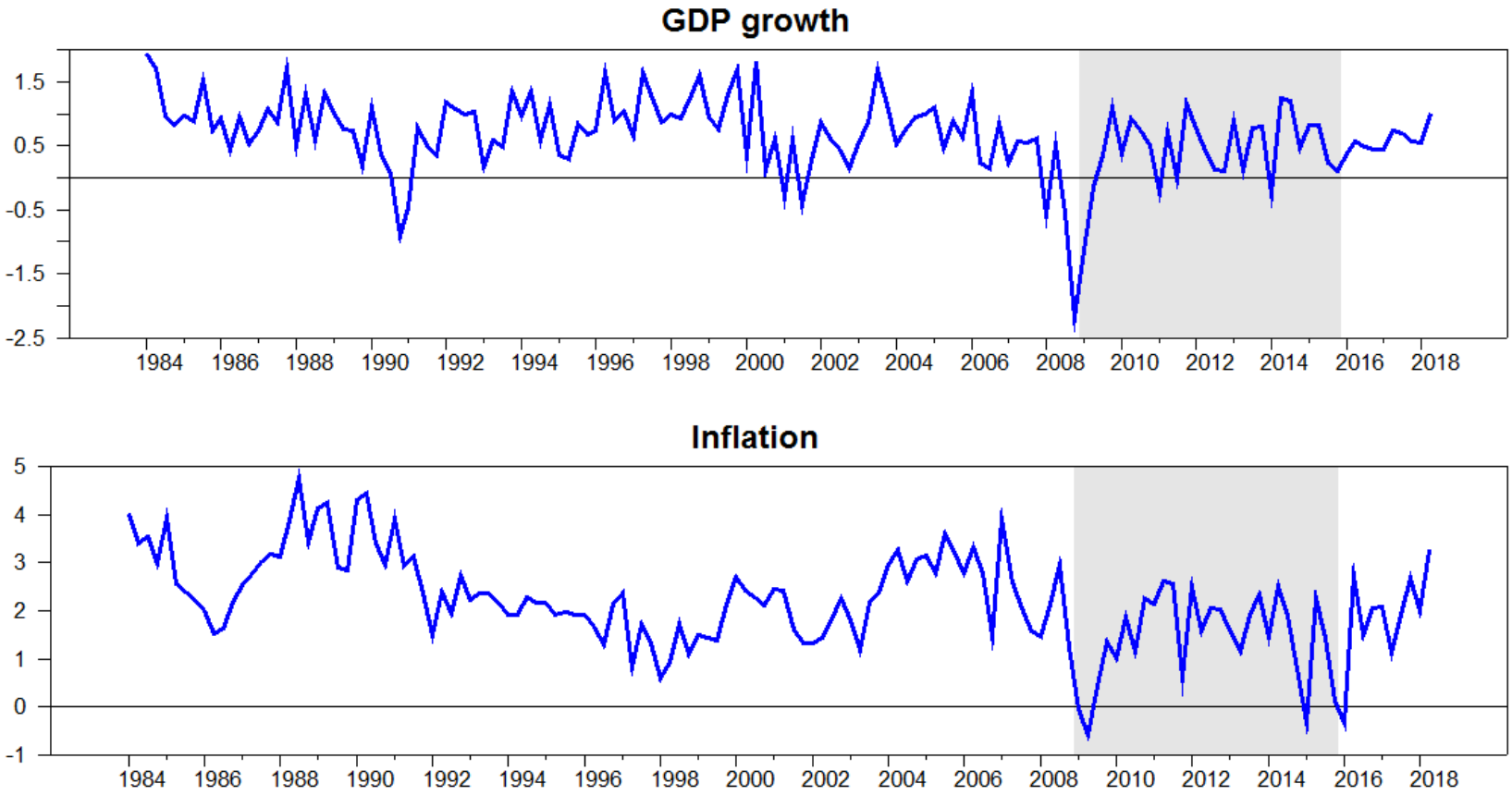
  - **Model-based evidence**
    [Christiano et. al. (2015), Gust et al. (2017)]

  - **Indirect evidence**
    response of yields to news [e.g. Swanson and Williams (2014)]
    shadow rate approach [Wu and Xia (2016), Wu and Zhang (2017)]

1. Did the ZLB increase Macro Volatility? Some Evidence

Macroeconomic Volatility and the ZLB

U.S. data 1984:Q1-2018:Q2



No Significant Change during ZLB (1)

Table 1
Relative Volatility: $std\,(x)^{ZLB}\,/\,std\,(x)^{NO-ZLB}$

	ZLB		*Pre-84*
GDP	0.92	0.89	2.19
Hours	1.32	0.74	1.60
GDP Deflator	1.02	0.88	3.11
Great Recession?	*yes*	*no*	*no*

Standard deviations are computed relative to the NO-ZLB period given by 1984Q1-2008Q4 and 2016Q1-2018Q2. The ZLB period is 2009Q1-2015Q4. When the Great Recession is excluded the pre-ZLB sample period ends in 2007Q4 and the ZLB period starts in 2009Q3. The pre-84 period starts in 1960Q1 and ends in 1983Q4.

No Significant Change during ZLB (2)

Table 2

Volatility Regressions: $|x_t - \bar{x}_t| = CONST + \alpha ZLB_t + \beta GR_t$

	CONST	*ZLB*	*GR*
GDP	0.41*	0.01	
	(0.04)	(0.05)	
	0.37*	−0.01	0.94*
	(0.03)	(0.05)	(0.19)
Hours	0.47*	0.05	
	(0.05)	(0.16)	
	0.42*	−0.00	1.39*
	(0.04)	(0.09)	(0.42)
GDP Deflator	0.70*	0.03	
	(0.07)	(0.12)	
	0.69*	0.02	0.37
	(0.07)	(0.11)	(0.26)

The Table reports the estimated coefficients from an OLS regression of the absolute value of the deviation of each variable's growth rate from its mean, on a constant and a dummy for the ZLB period (2009Q1-2015Q4), with and without a control dummy for the Great Recession period (2008Q1-2009Q2). The sample period is 1984Q1-2018Q2. Standard errors obtained using the Newey-West estimator (4 lags).

Macroeconomic Volatility and the ZLB? Predictions from a Benchmark Model

Standard New-Keynesian Model

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - (i_t - \mathbb{E}_t\{\pi_{t+1}\} - z_t) \qquad \text{(DynamicIS)}$$

$$\widehat{\pi}_t = \beta \mathbb{E}_t\{\widehat{\pi}_{t+1}\} + \kappa \widehat{y}_t \qquad \text{(NKPC)}$$

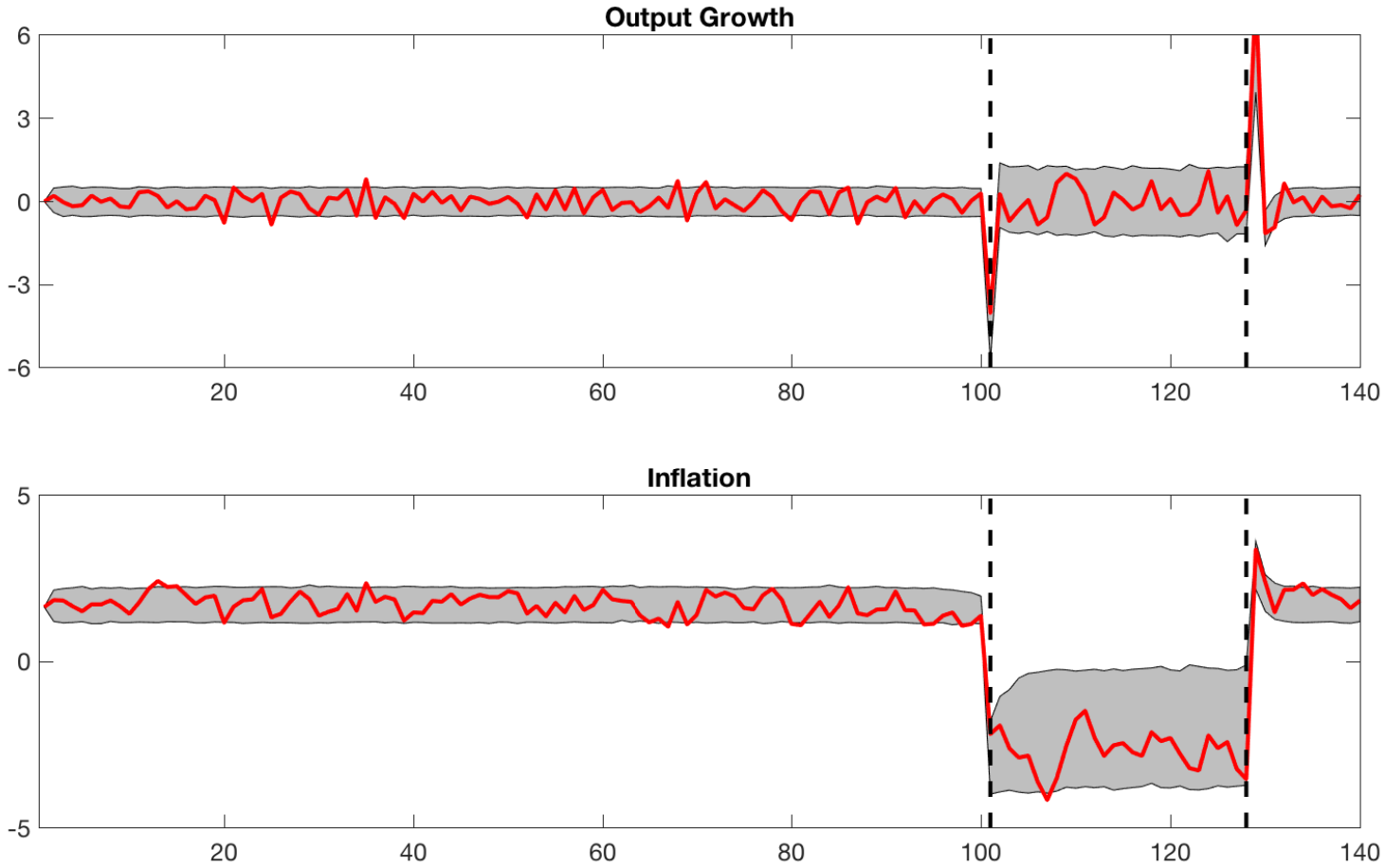
$$i_t = \max\left[0,\ \phi_i i_{t-1} + (1-\phi_i)(\rho + \pi + \phi_\pi \widehat{\pi}_t + \phi_y \Delta \widehat{y}_t)\right] \qquad \text{(TaylorRule)}$$

$$i_t^L = (1-\beta\gamma) i_t + \beta\gamma E_t\{i_{t+1}^L\} \qquad \text{(LongTermRate)}$$

- **Discount rate shock:** $z_t = \eta_t + \rho_t$
  - "recurrent" component: $\eta_t = \rho_\eta \eta_{t-1} + \epsilon_t^\eta$
  - two-state component: $\rho_t \in \{\rho > 0; \rho_L < 0\}$
- **Calibration of shock process**
  $\Rightarrow$ ZLB episode every 140 quarters, last 3 quarters (on average)
  $\Rightarrow$ ~4% decline in GDP when large shock hits
- **Monte-Carlo exercise:** 1000 simulations with ZLB binding for 28 quarters

Macroeconomic Volatility and the ZLB

Benchmark model, sample simulation



Large Increase in Volatility in Benchmark Model (1)

Table 3
Relative Volatility: Simulations
Baseline Interest Rate Rule

Output	1.49 [0.86,2.37]	2.29 [1.69,2.95]
Inflation	1.94 [0.91,3.38]	2.39 [1.02,3.86]
Markov transitions?	yes	no

For each variable the Table reports the mean of the standard deviation in the ZLB period relative to the no-ZLB period over 1000 model simulations under the baseline interest rate rule. The no-ZLB period is given by the first 100 observations and the last 8 observations in the simulation. The ZLB period corresponds to the intermediate 28 observations. 95% confidence intervals reported in brackets.

Large Increase in Volatility in Benchmark Model (2)

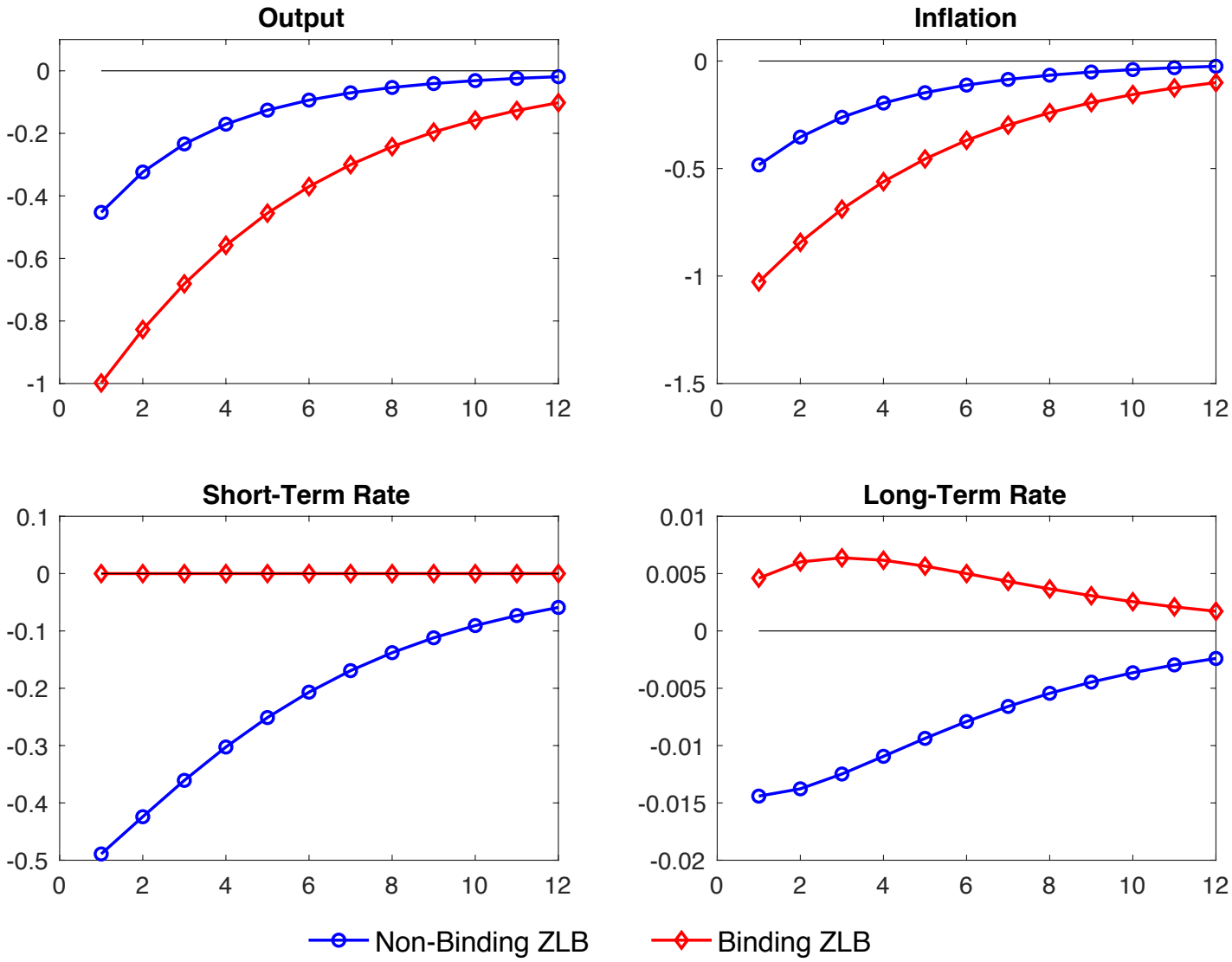
Table 4
Volatility Regressions: Simulations
Baseline Interest Rate Rule

	CONST	*ZLB*	*MT*	*%REJ*
Output	0.32* [0.27,0.36]	0.35* (0.16,0.56)		86%
	0.26* [0.23,0.3]	0.34* [0.19,0.50]	4.15* [3.34,4.92]	98%
Inflation	0.27* [0.23,0.32]	0.47* [0.21,0.79]		98%
	0.26* [0.22,0.30]	0.47* [0.22,0.79]	0.61* [0.02,1.31]	98%

For each variable the Table reports the mean, over 1000 model simulations under the baseline interest rate rule, of the estimated coefficients from an OLS regression of the absolute value of the demeaned growth rate of each variable on a constant, a dummy indicating the ZLB period and, when it applies, a dummy for the two periods when a Markov transition occurs (*MT*). 95% confidence bands reported in brackets. *%REJ* is the fraction of simulations for which the estimated coefficient on the ZLB dummy is positive and statistically significant using the Newey-West estimate of the standard error (4 lags).

Dynamic Responses to a Demand Shock

Baseline Taylor Rule



2. Did the ZLB Affect the Response to Shocks? A Time-Varying VAR Approach

Empirical Framework

Based on Primiceri (2005)

Vector autoregression with **time-varying coefficients** and **stochastic volatility**

$$\mathbf{x}_t = \mathbf{A}_{0,t} + \mathbf{A}_{1,t}\mathbf{x}_{t-1} + \mathbf{A}_{2,t}\mathbf{x}_{t-2} + ... + \mathbf{A}_{p,t}\mathbf{x}_{t-p} + \mathbf{u}_t$$

where

- $\mathbf{x}_t \equiv [\Delta productivity_t,\ hours_t,\ inflation_t,\ 10yr - yield_t]$
- $\mathbf{A}_{j,t}$: matrices of time-varying coefficients (random walk)
- $\mathbf{u}_t \sim N(\mathbf{0}, \mathbf{\Sigma}_t)$: linear combination of "structural" shocks

Sample: 1953:Q1 to 2015:Q4, quarterly frequency

Identification

Mix of long run and sign restrictions

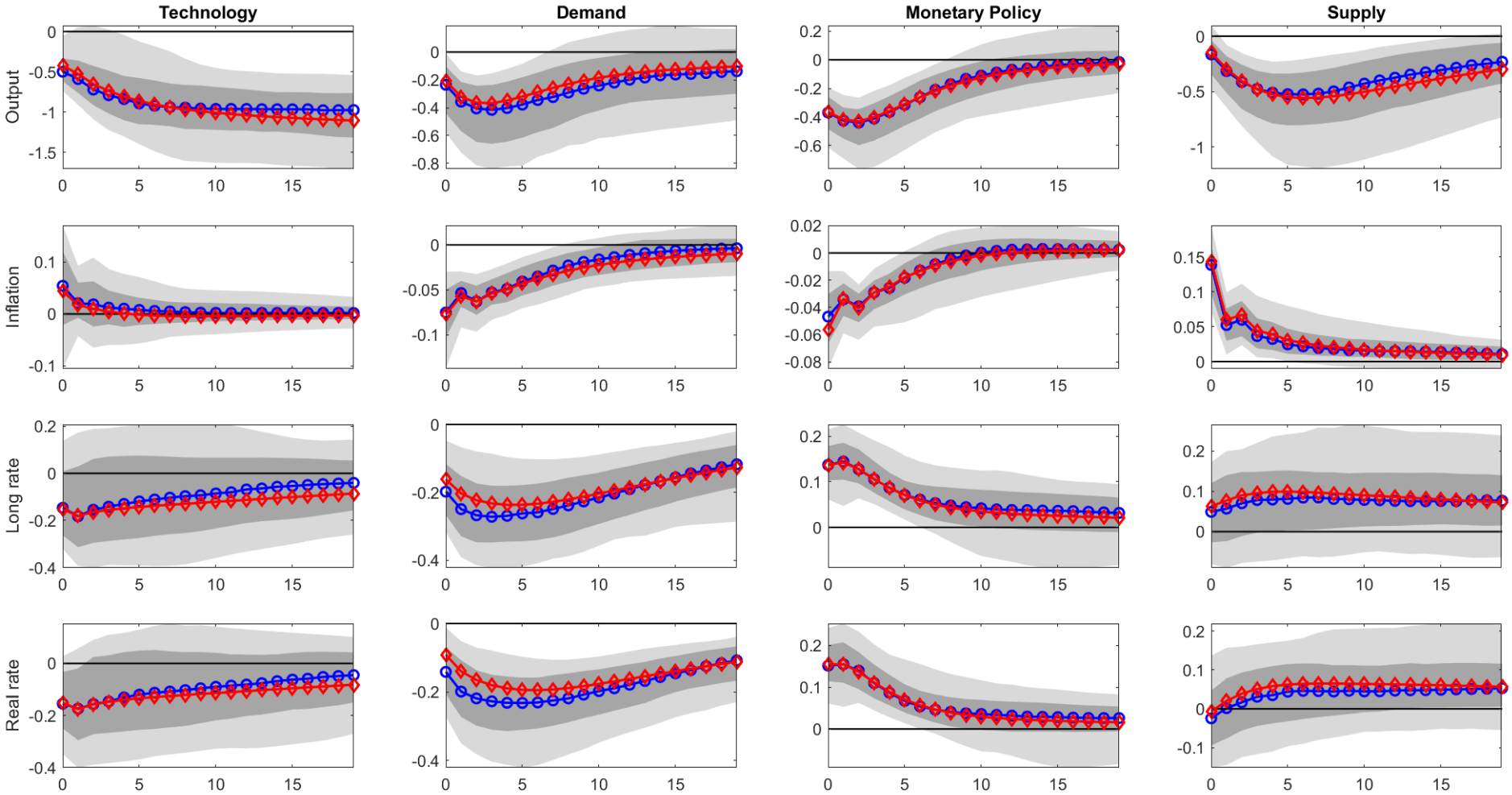
- **Long Run Restriction**
  $\Rightarrow$**"Technology":** only source of unit root in labor productivity

- **Sign Restrictions** (sign of comovements at one-year horizon)

	output, *inflation*	*output*, 10*yr* − *yield*	*inflation*,10*yr* − *yield*
"Demand"	positive	positive	positive
"Monetary"	positive	negative	negative
"Transitory Supply"	negative	any	any

Dynamic Responses: The Impact of the Binding ZLB

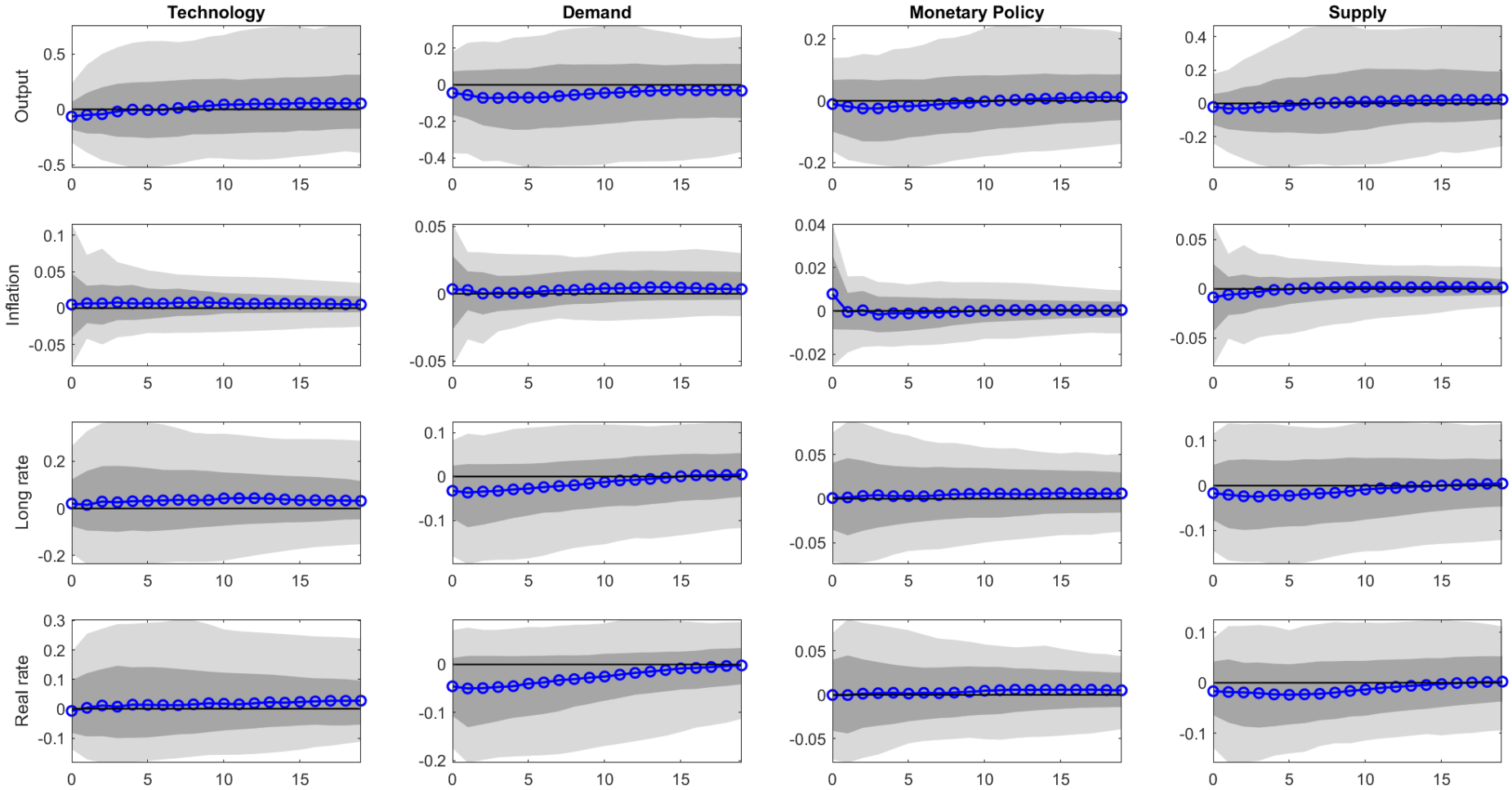
Average impulse responses (with 68% and 95% confidence bands)



Pre-ZLB period (2002:Q1-2008:Q4) ZLB period (2009:Q1-2015:Q4)

Dynamic Responses Differentials

Average differences (with 68% and 95% confidence bands)



Did the ZLB affect the Response of Long-Term Rates?

An Estimated Long-Term Interest Rate Rule

$$i_t^L = \phi_0 + \phi_i i_{t-1}^L + (1-\phi_i)[\phi_\pi \pi_t + \phi_y \Delta y_t] + \varepsilon_t^m$$

Multiplicative dummies for binding ZLB period

Instruments: estimated non-monetary components from TVC-SVAR

Table 5: Estimated Long-Term Interest Rate Rule

π_t	2.42*	2.82*	2.26*	2.61*
	(0.61)	(0.82)	(0.23)	(0.32)
$\pi_t * ZLB_t$	−0.08	−0.01	−0.17*	−0.45
	(0.08)	(0.06)	(0.06)	(0.50)
Δy_t			3.52*	4.43*
			(0.42)	(0.58)
$\Delta y_t * ZLB_t$			−0.16	−0.60
			(0.08)	(0.89)
ϕ_0 and ϕ_i dummies?	Yes	No	Yes	No

4. Reconciling Theory with Evidence? An Attempt

New-Keynesian Model with Shadow Rate Taylor Rule

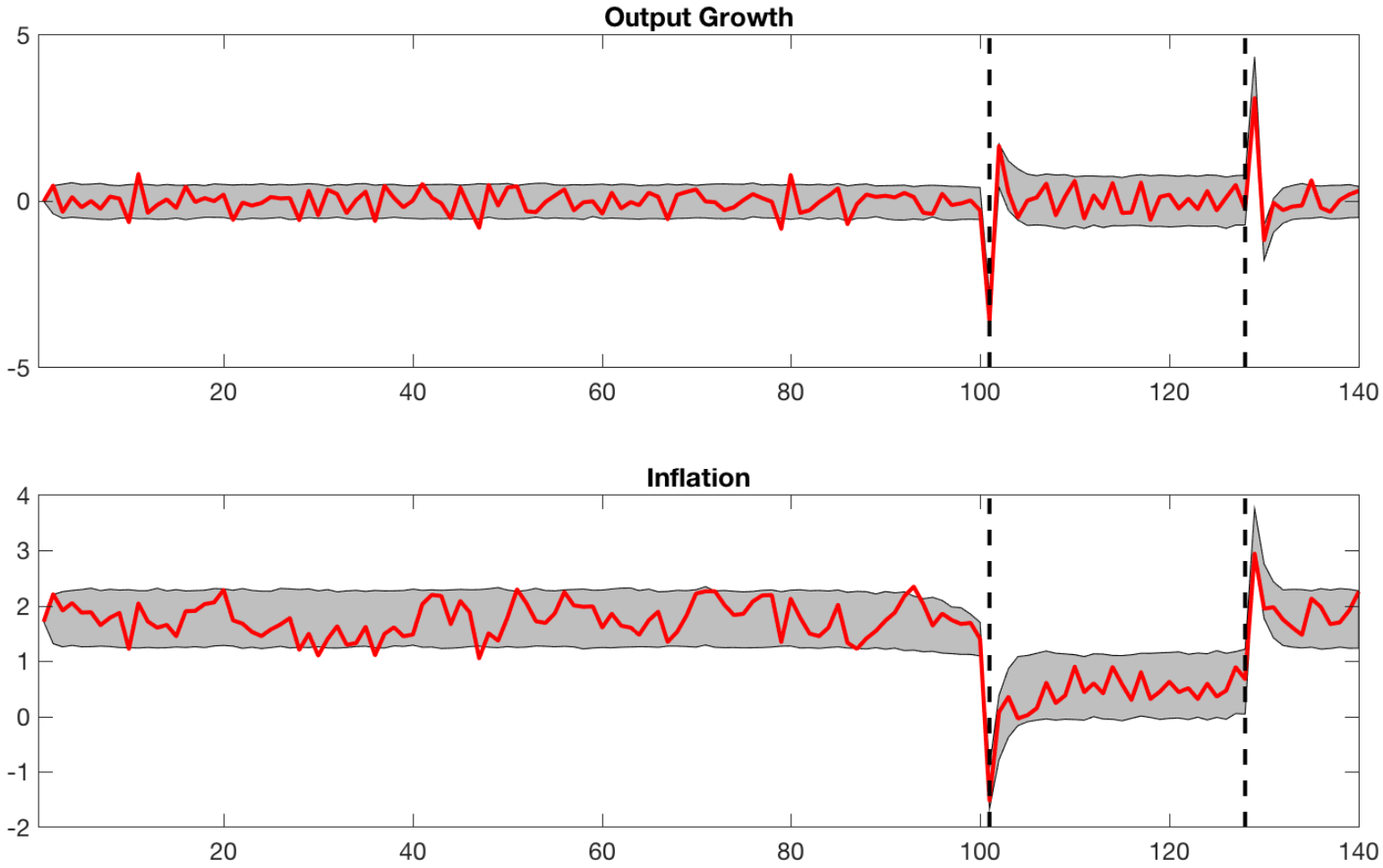
- **A shadow rate rule**

$$i_t = max[0, i_t^s]$$

$$i_t^s = \phi_i i_{t-1}^s + (1 - \phi_i)(\rho + \pi + \phi_\pi \hat{\pi}_t + \phi_y \Delta \hat{y}_t)$$

- **Simulations:**
  - relative standard deviations
  - volatility regressions

Macro Volatility with Shadow Rate Rule



Dynamic Responses to a Demand Shock

Shadow Rate Rule

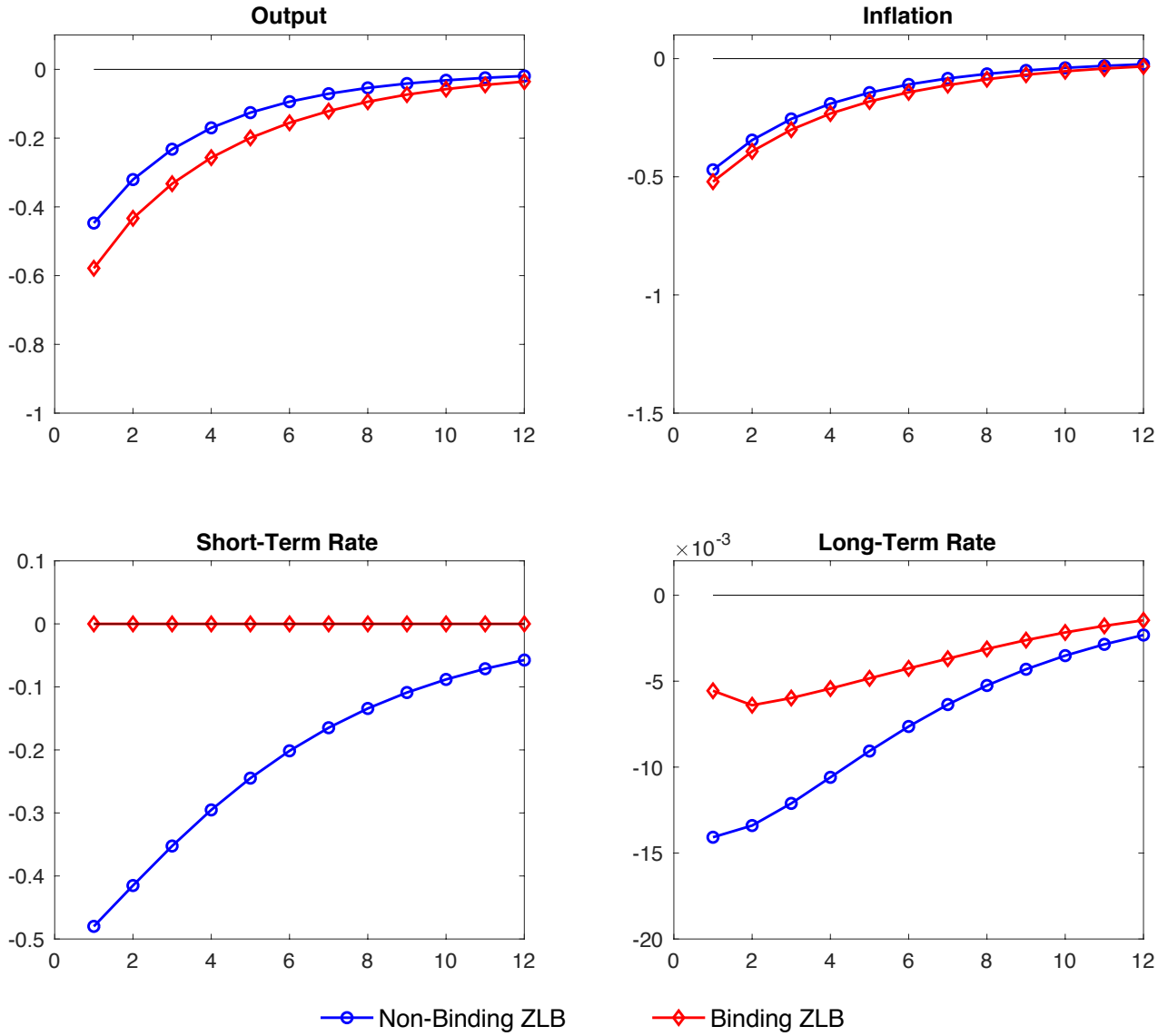


Table 6
Relative Volatility: Simulations
Shadow Rate Rule

Output	1.01 [0.65,1.9]	1.50* [1.03,1.94]
Inflation	0.82 [0.50,1.38]	1.0 [0.59,1.41]
Markov transitions?	yes	no

For each variable the Table reports the mean of the standard deviation in the ZLB period relative to the no-ZLB period over 1000 model simulations under the shadwo rte interest rate rule. The no-ZLB period is given by the first 100 observations and the last 8 observations in the simulation. The ZLB period corresponds to the intermediate 28 observations. 95% confidence intervals reported in brackets.

Table 7
Volatility Regressions: Simulations
Shadow Rate Rule

	CONST	*ZLB*	*MT*	*%REJ*
Output	0.31* [0.28,0.35]	0.1 (−0.03,0.27)		15%
	0.26* [0.23,0.3]	0.14* [0.02,0.26]	3.11* [2.66,3.6]	49%
Inflation	0.28* [0.24,0.32]	0.03 [−0.06,0.14]		7%
	0.26* [0.22,0.29]	0.05 [−0.04,0.14]	1.37* [1.07,1.69]	16%

For each variable the Table reports the mean, over 1000 model simulations under the shadow rate interest rate rule, of the estimated coefficients from an OLS regression of the absolute value of the demeaned growth rate of each variable on a constant, a dummy indicating the ZLB period and, when it applies, a dummy for the two periods when a Markov transition occurs (*MT*). 95% confidence bands reported in brackets. *%REJ* is the fraction of simulations for which the estimated coefficient on the ZLB dummy is positive and statistically significant using the Newey-West estimate of the standard error (4 lags).

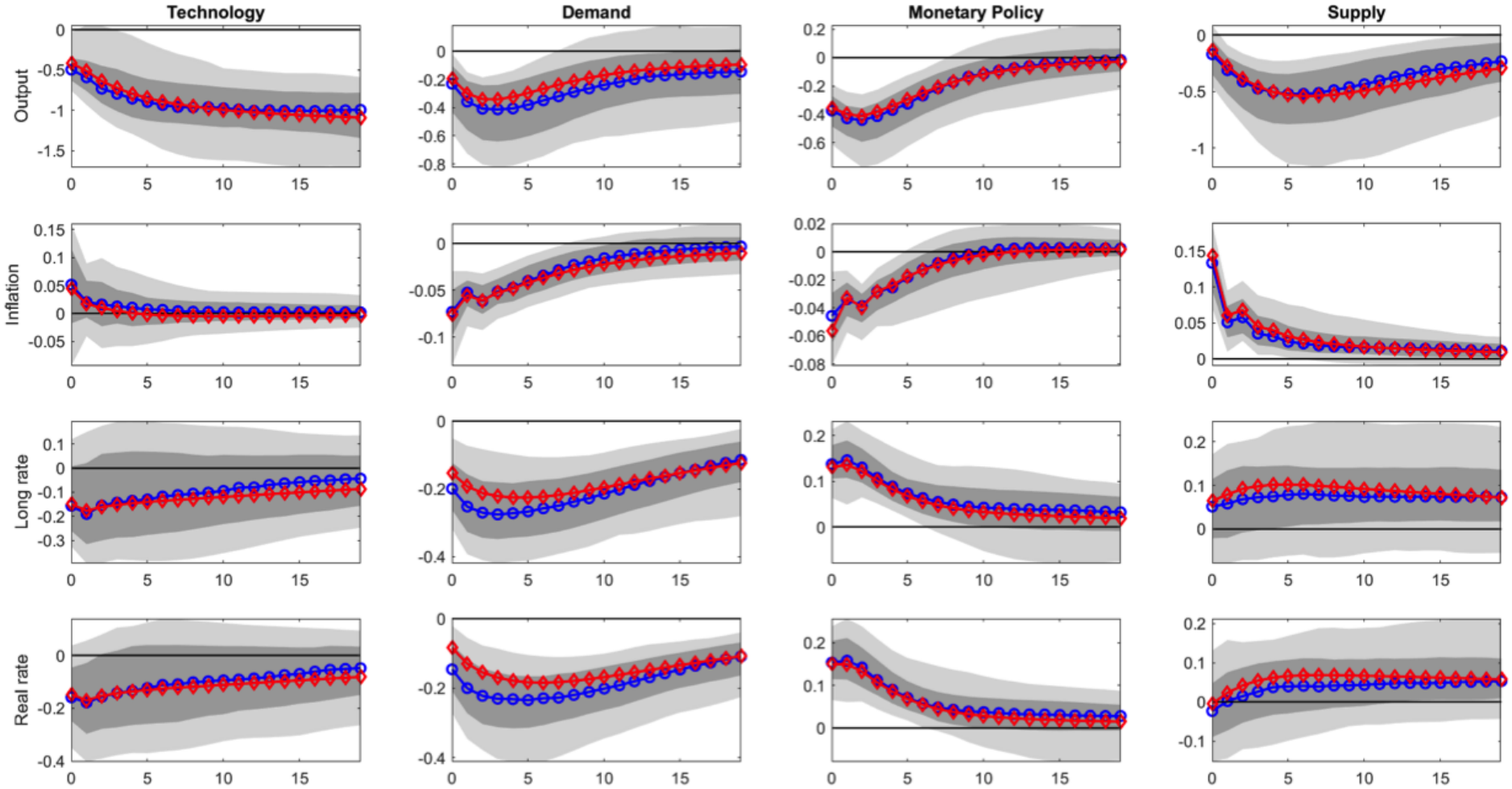
Concluding Comments

- **Little evidence against the "ZLB irrelevance hypothesis"**
  - increase in volatility
  - change in response of macro variables to shocks
  - change in response of long rate to macro developments
- **Possible Interpretation**
  - Unconventional policies effective at getting around the ZLB

Appendix

Dynamic Responses: The Impact of the Binding ZLB

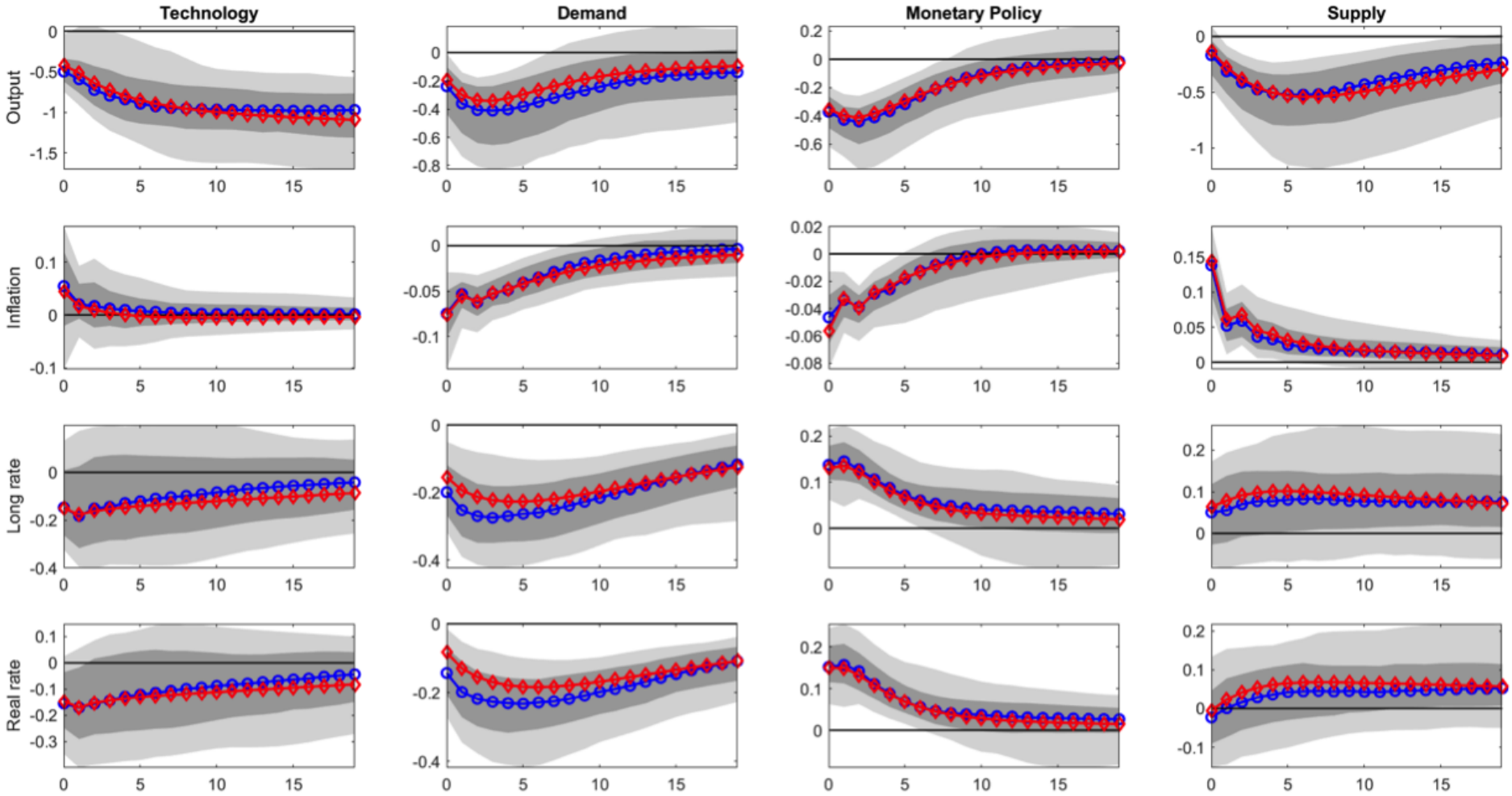
Excluding the Great Recession



Pre-ZLB period (2002:Q1-2007:Q4) ZLB period (2010:Q1-2015:Q4)

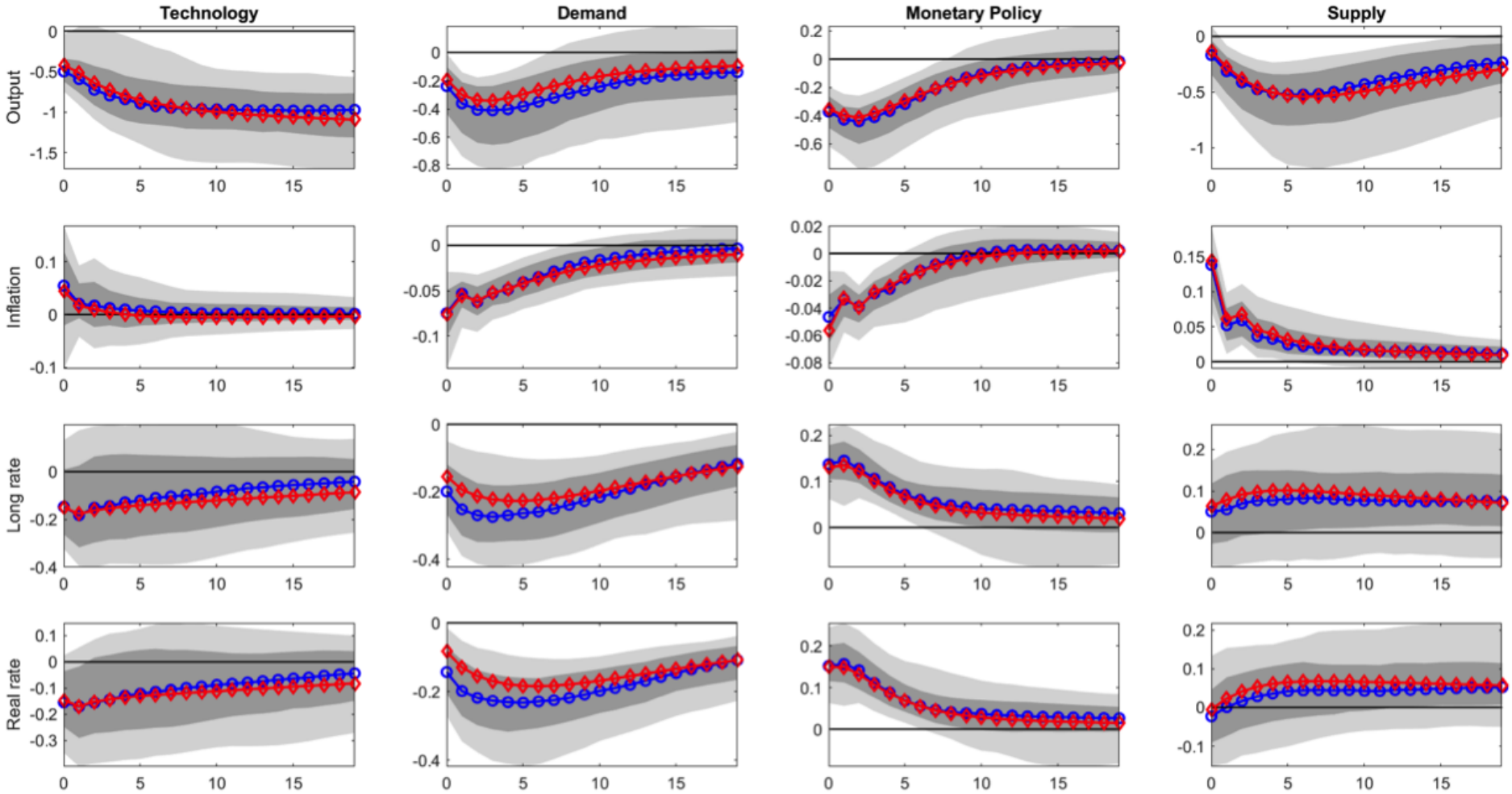
Dynamic Responses: The Impact of the Binding ZLB

Extended pre-ZLB sample



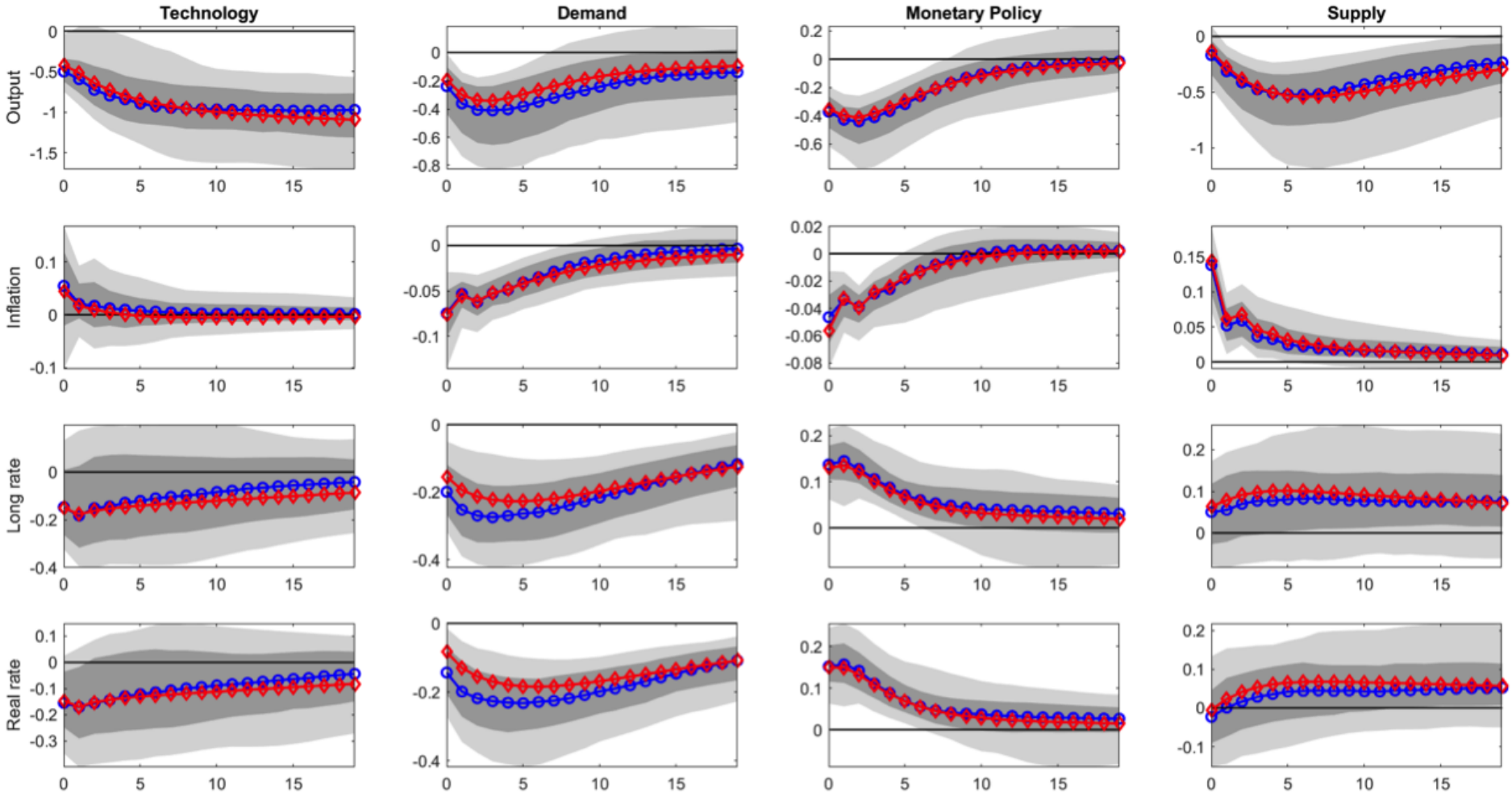
Pre-ZLB period (1984:Q1-2008:Q4) ZLB period (2009:Q1-2015:Q4)

Dynamic Responses: Pre-Volcker vs. Pre-ZLB



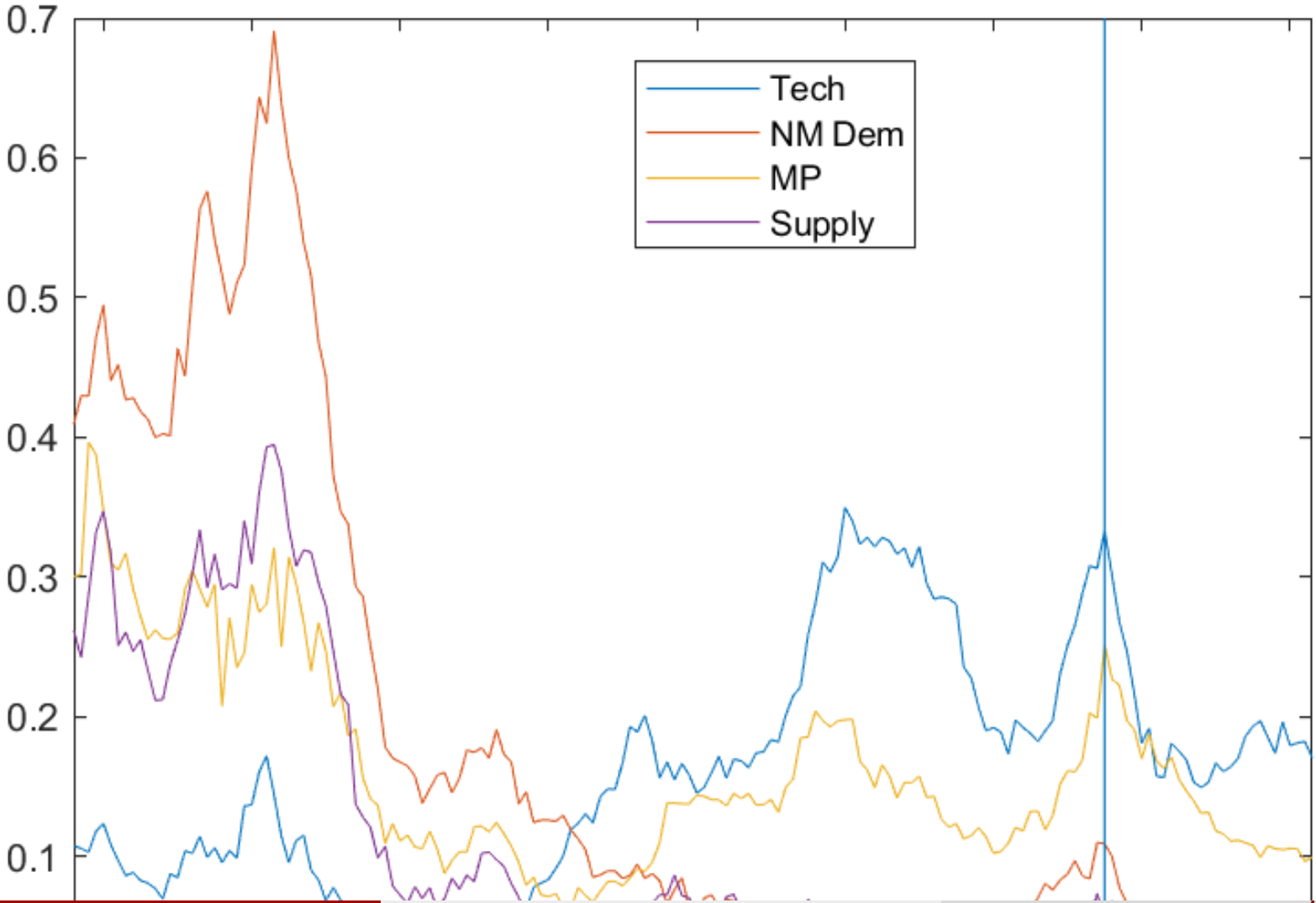
Pre-ZLB period (1984:Q1-2008:Q4) Pre-Volcker (1972:Q1-1978:Q4)

Dynamic Responses: Pre-Volcker vs. Post-Volcker

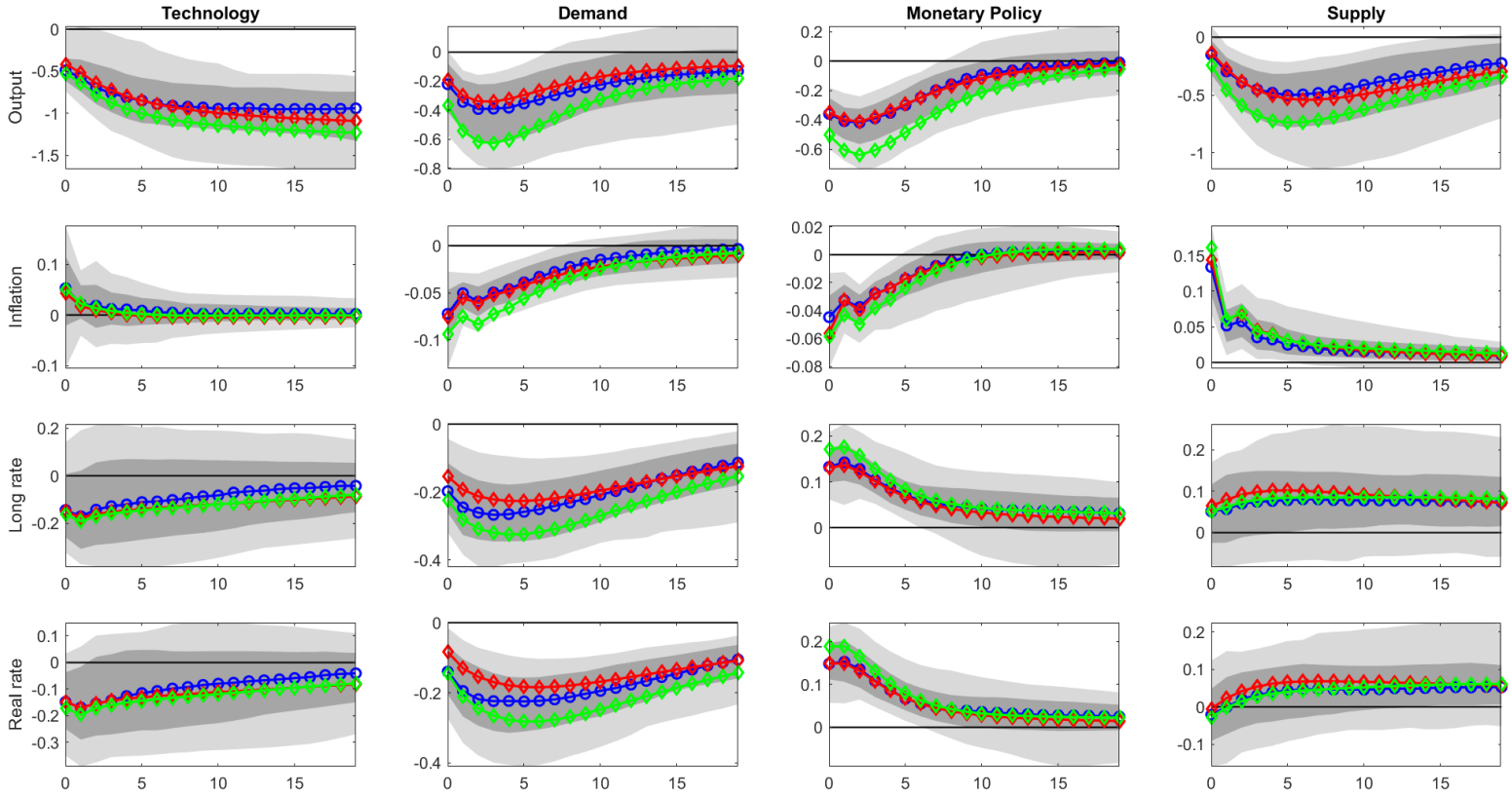


Pre-Volcker period (1973:Q2-1979:Q2) Post-Volcker (1979:Q3-1985:Q3)

Shocks Decomposition



Dynamic Responses (with 2008:Q4)



Pre-ZLB period (2002:Q1-2008:Q4) ZLB period (2009:Q1-2015:Q4