ASYMMETRIC EFFECTS OF MONETARY POLICY IN DIFFERENT PHASES OF ARMENIA'S BUSINESS CYCLE

Central Bank of Armenia

Haykaz Igityan

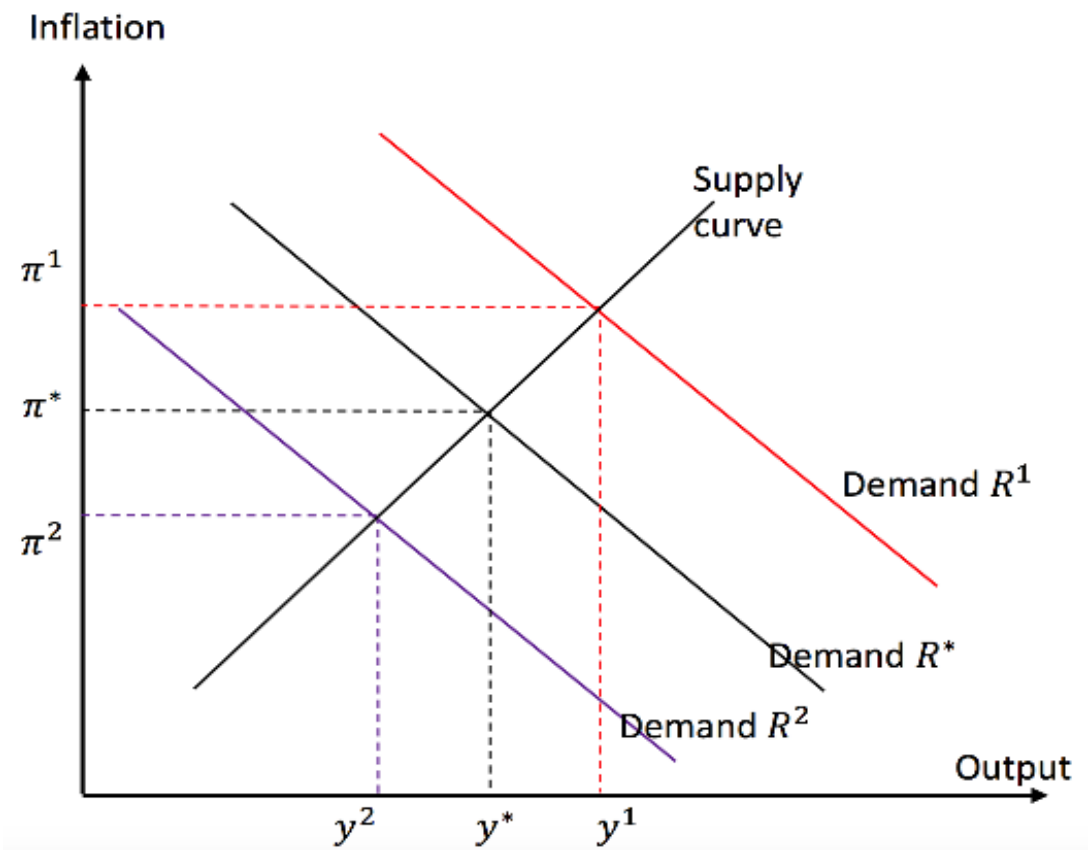
7th BSP International Research Conference

24-25 September, Manila, Philippines

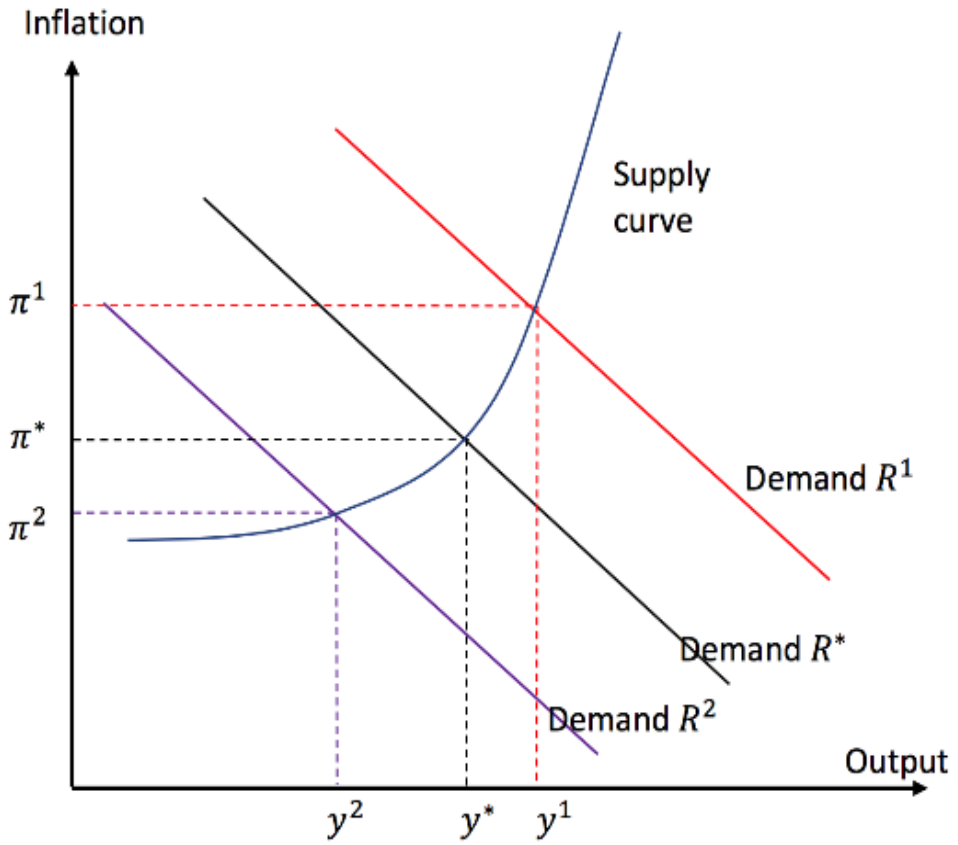
Outline

- Motivation
- Asymmetries in the Paper
- Empirical Evidence of Asymmetries
- Two Stage Estimation
- Nonlinear VAR
- Theoretical Model – Open Economy New Keynesian Model
- Sources of Asymmetries in the Model
- Curvature of the Model
- Asymmetries in the Transmission Mechanism of Monetary Policy
- The Efficiency of Monetary Policy through the Phases of Business Cycle
- Conclusions

Motivation



$$R^* \rightarrow R^1 = R^* \rightarrow R^2$$
$$y^* \rightarrow y^1 = y^* \rightarrow y^2$$
$$\pi^* \rightarrow \pi^1 = \pi^* \rightarrow \pi^2$$



$$R^* \rightarrow R^1 = R^* \rightarrow R^2$$
$$y^* \rightarrow y^1 < y^* \rightarrow y^2$$
$$\pi^* \rightarrow \pi^1 > \pi^* \rightarrow \pi^2$$

Motivation

- “The relation between unemployment and the rate of change of wage is therefore likely to be highly non-linear” A. W. Phillips, Economica, 1958
- “Monetary policy was a string. You could pull on it to stop inflation but you could not push on it to halt recession” M. Friedman, American Economic Review, 1968
- “The output costs of reducing inflation depend, in general, on the speed of the path chosen by the monetary authority, as well as on the functional form of the Phillips curve” D. Laxton, D. Rose and R. Tetlow, Bank of Canada, 1993

Asymmetries in the Paper

1. The response of the economy to the same size of positive and negative shocks at the steady state
2. The response of the economy to the same size of shock in expansions and recessions
3. The response of the economy to small and big shocks in expansions
4. The response of the economy to small and big shocks in recessions

Two Stage Estimation - Methodology

- Estimation of the interest rate equation
- Estimation of economic growth and inflation equations of following forms

$$\Delta y_t = a_0 + a_1 \Delta y_{t-1} + \sum_{i=1}^{4} a_{2,i} Policy_{t-i}^{+} + \sum_{i=1}^{4} a_{3,i} Policy_{t-i}^{-} + \varepsilon_t{}^{y}$$

$$\pi_t = b_0 + b_1 \pi_{t-1} + \sum_{i=1}^{4} b_{2,i} Policy_{t-i}^{+} + \sum_{i=1}^{4} b_{3,i} Policy_{t-i}^{-} + \varepsilon_t{}^{\pi}$$

Where $Policy_t^{+}$ is tight monetary policy, $Policy_t^{-}$ represents expansionary policy

Two Stage Estimation – Results

	Q/Q Output Growth	Q/Q Inflation
Q/Q Output Growth (-1)	0.206^{***} (0.057)	
Q/Q Inflation (-1)		0.337^{***} (0.022)
Constant	0.056 (0.182)	0.049^{***} (0.005)
$Sum(Policy^{+})^{1}$	$\mathbf{-0.907^{***}}$ **(0.186)**	$\mathbf{-0.619^{***}}$ **(0.075)**
$Sum(Policy^{-})^{2}$	**0.184** **(0.193)**	$\mathbf{0.843^{***}}$ **(0.154)**
$Sum(Policy^{+})$ + $Sum(Policy^{-})^{3}$	$\mathbf{-0.723^{***}}$ **(0.215)**	$\mathbf{0.224^{**}}$ **(0.104)**
$Policy^{+} = 0^{4}$	185.577^{***}	67.32^{***}
$Policy^{-} = 0^{5}$	0.902	29.869^{***}
$Policy^{+} + Policy^{-} = 0^{6}$	11.224^{***}	4.596^{**}

Nonlinear VAR Model

2 censored variables are added into the VAR system

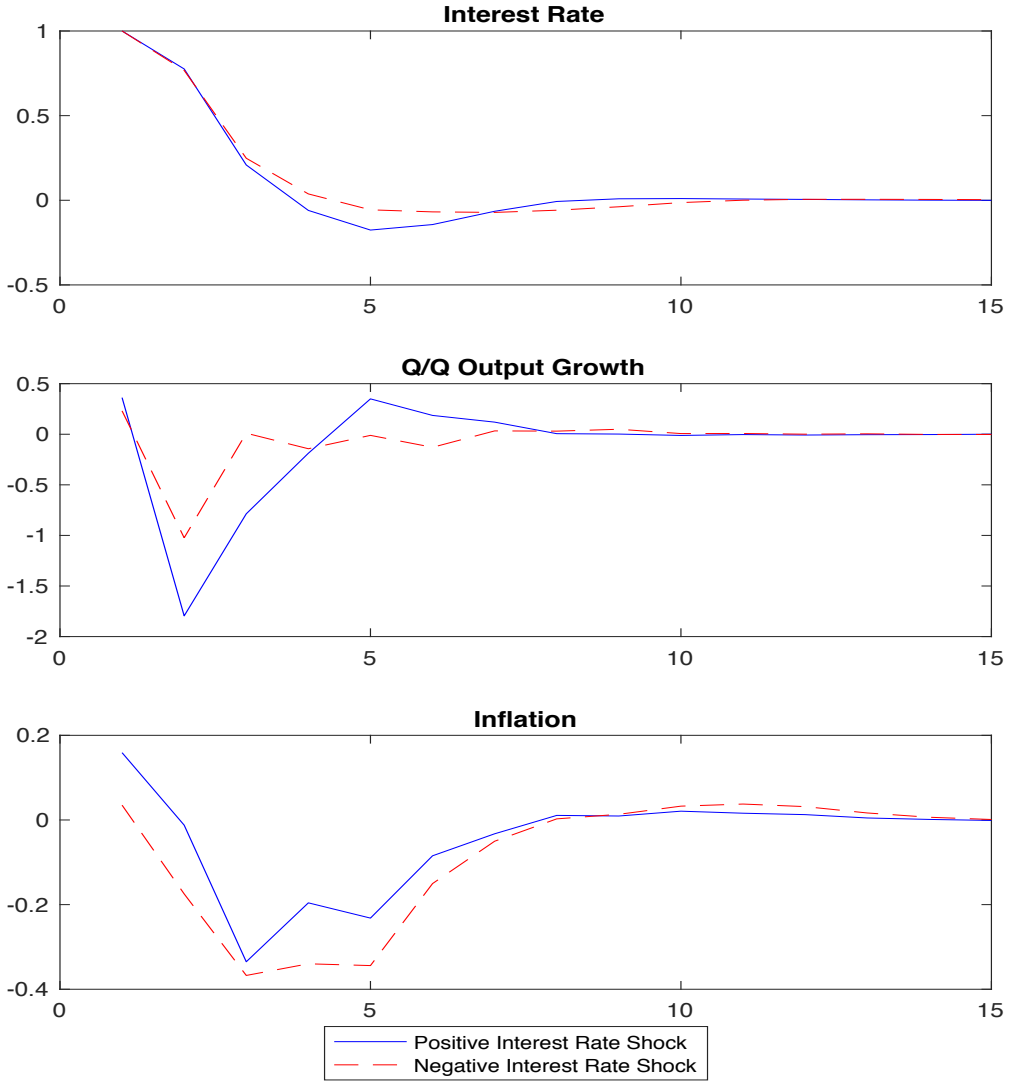
$$R_t = f_0 + \sum_{i=1}^{3} f_{1,i} R_{t-i} + \sum_{i=1}^{3} f_{2,i} \Delta y_{t-i} + \sum_{i=1}^{3} b_{3,i} \pi_{t-i} + {\varepsilon_t}^R$$

$$\Delta y_t = g_0 + \sum_{i=0}^{3} g_{1,i} R_{t-i} + \sum_{i=0}^{3} g_{2,i} R_{t-i}^{+} + \sum_{i=1}^{3} g_{3,i} \Delta y_{t-i} + \sum_{i=1}^{3} g_{4,i} \pi_{t-i} + {\varepsilon_t}^y$$

$$\pi_t = h_0 + \sum_{i=0}^{3} h_{1,i} R_{t-i} + \sum_{i=0}^{3} h_{2,i} R_{t-i}^{-} + \sum_{i=1}^{3} h_{3,i} \Delta y_{t-i} + \sum_{i=1}^{3} h_{4,i} \pi_{t-i} + {\varepsilon_t}^{\pi}$$

Where $R_t^+ = \begin{cases} R_t, if\ R_t > 0 \\ 0, if\ R_t \leq 0 \end{cases}$ and $R_t^- = \begin{cases} R_t, if\ R_t < 0 \\ 0, if\ R_t \geq 0 \end{cases}$

Response of the System to Interest Rate Shock



The responses to negative shock are shown as mirror images to facilitate the comparison

Theoretical Model - Open Economy New Keynesian Model

- Households: Consume domestically produced and imported goods, invest in capital, supply heterogeneous labor, hold capital, hold domestic and foreign bonds, choose utilization rate of capital
- Labor organization combines heterogeneous labor into homogeneous and supply to domestic firms
- Domestic good producer uses Cobb-Douglas production function by combining technology, capital and labor
- Importers import consumption goods, investment goods and goods used in export sector
- Final consumption and investment goods producers
- Exporters combine domestically produced and imported goods into export good
- Central Bank is doing inflation targeting

Sources of Asymmetries in the Model

- Domestic good producer's price setting frictions
- Exporter's price setting frictions
- Importers' price setting frictions
- Rigidities in labor market
- Investment adjustment costs in capital market

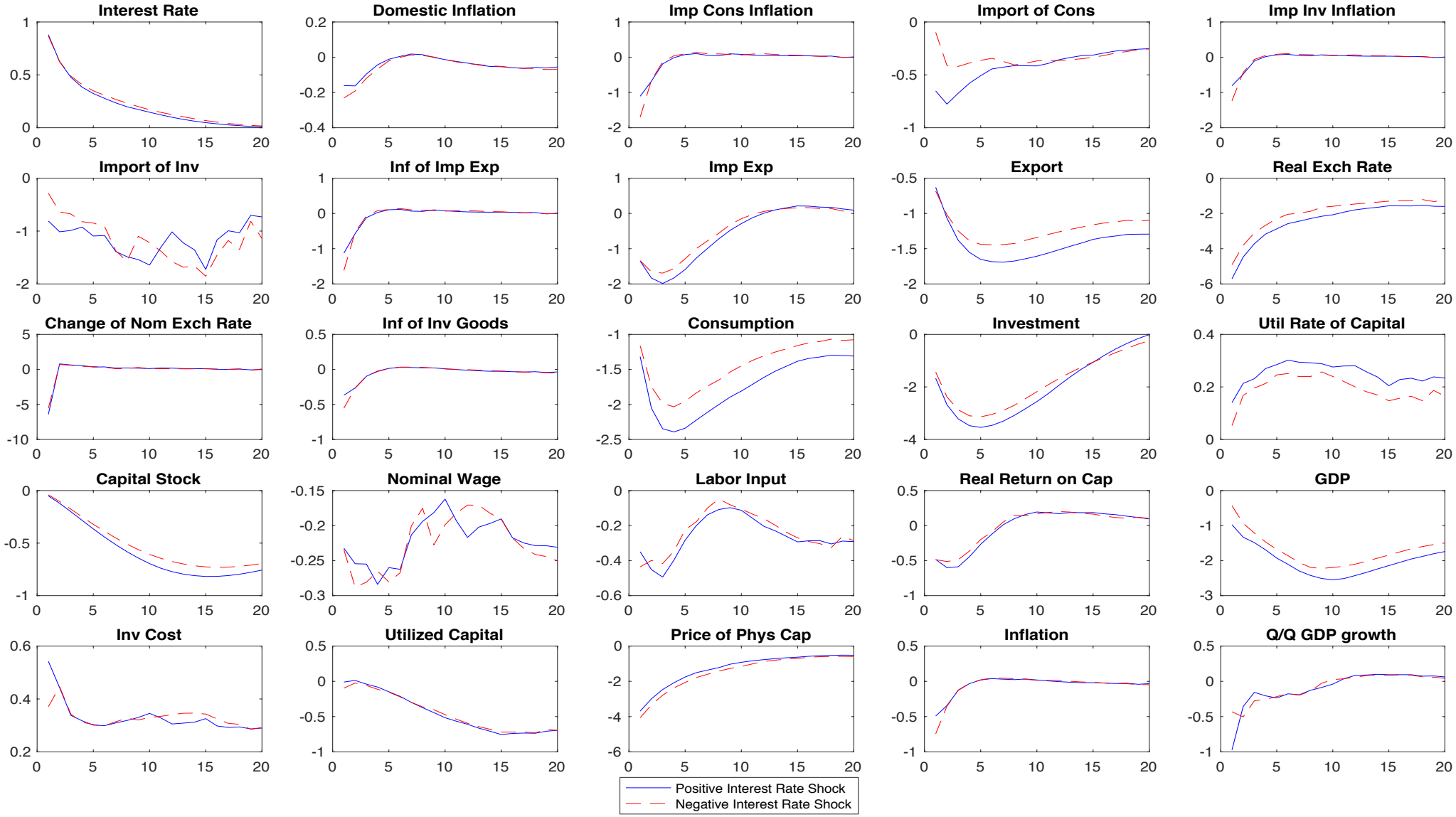
Curvature of the Model

	Description	Prior mean	Posterior mean	Support to the curvature
θ^{d}	Price stickiness coefficient of home produced goods	0.75	**0.90**	Less Convex
$\theta^{c,Imp}$	Price stickiness coefficient of imported consumption	0.75	**0.60**	More Convex
$\theta^{Inv,Imp}$	Price stickiness coefficient of imported investment goods	0.75	**0.58**	More Convex
$\theta^{Exp,Imp}$	Price stickiness coefficient of imported goods used in export sector	0.75	**0.49**	More Convex
θ^{Exp}	Price stickiness coefficient of exported goods	0.75	**0.73**	Convex
θ^{w}	Wage stickiness coefficient	0.75	**0.84**	Less Convex
S''	Investment adjustment costs parameter	9.0	**5.25**	Less Strict Convexity
$\lambda_w = \frac{\varepsilon_w}{\varepsilon_w - 1}$	Mark-up on wages	1.3	**1.16**	More Convex

Cases for Policy Experiment

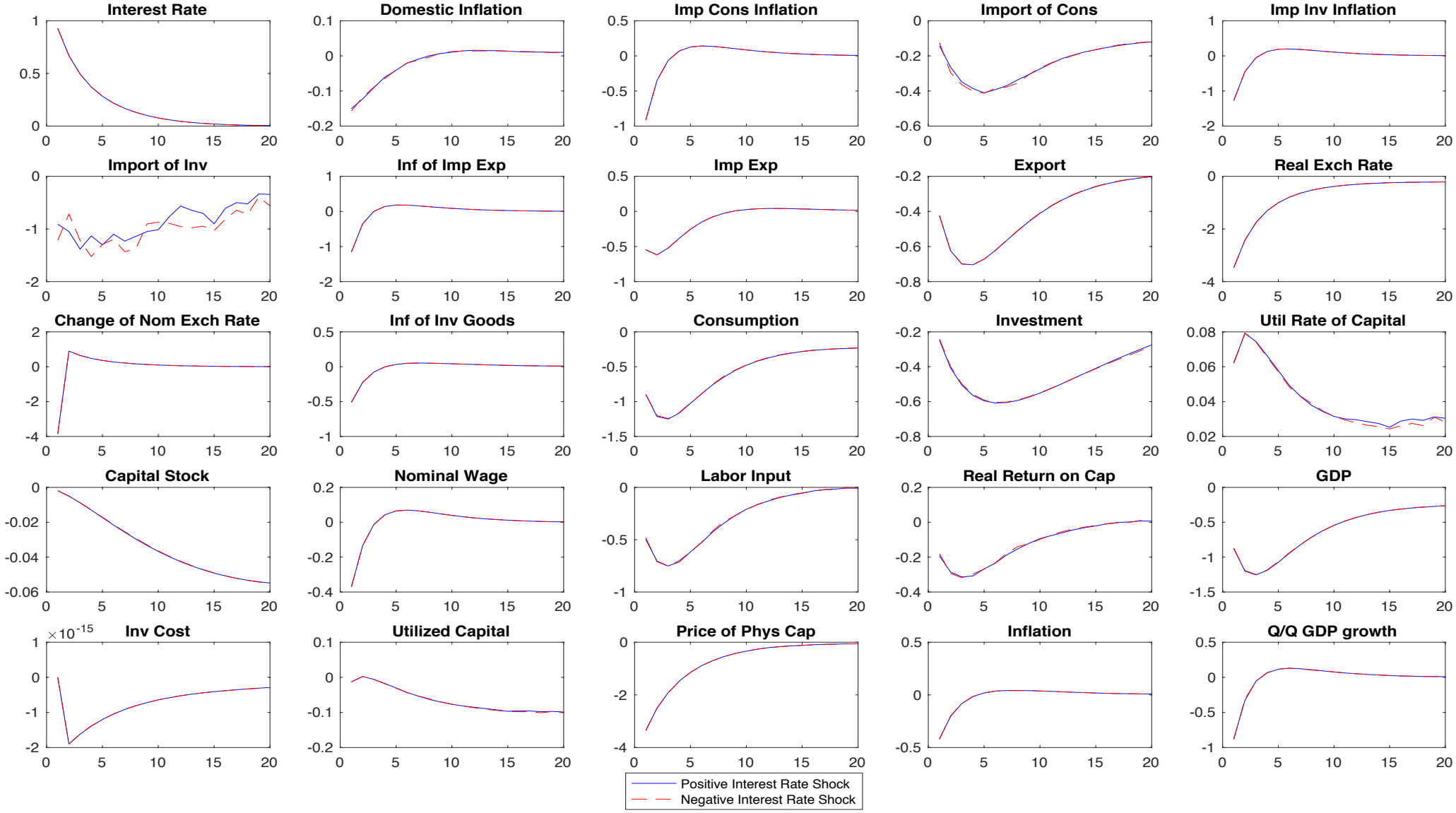
- Case 1. Nonlinear Economy
- Case 2. Model's frictions are log-linearized. Standard blocks are nonlinear
- Case 3. Capital market's frictions and standard blocks are nonlinear. All other frictions are log-linearized
- Case 4. Internal economy's price setting frictions and standard blocks are nonlinear. All other frictions are log-linearized
- Case 5. Labor market frictions and standard blocks are nonlinear. All other frictions are log-linearized
- Case 6. Nonlinear internal economy and standard blocks. Importers sector's frictions are log-linearized
- Case 7. Nonlinear imported sector. Internal economy's frictions are log-linearized

Asymmetries in the Transmission Mechanism of Monetary Policy: Case 1 (Nonlinear Economy)



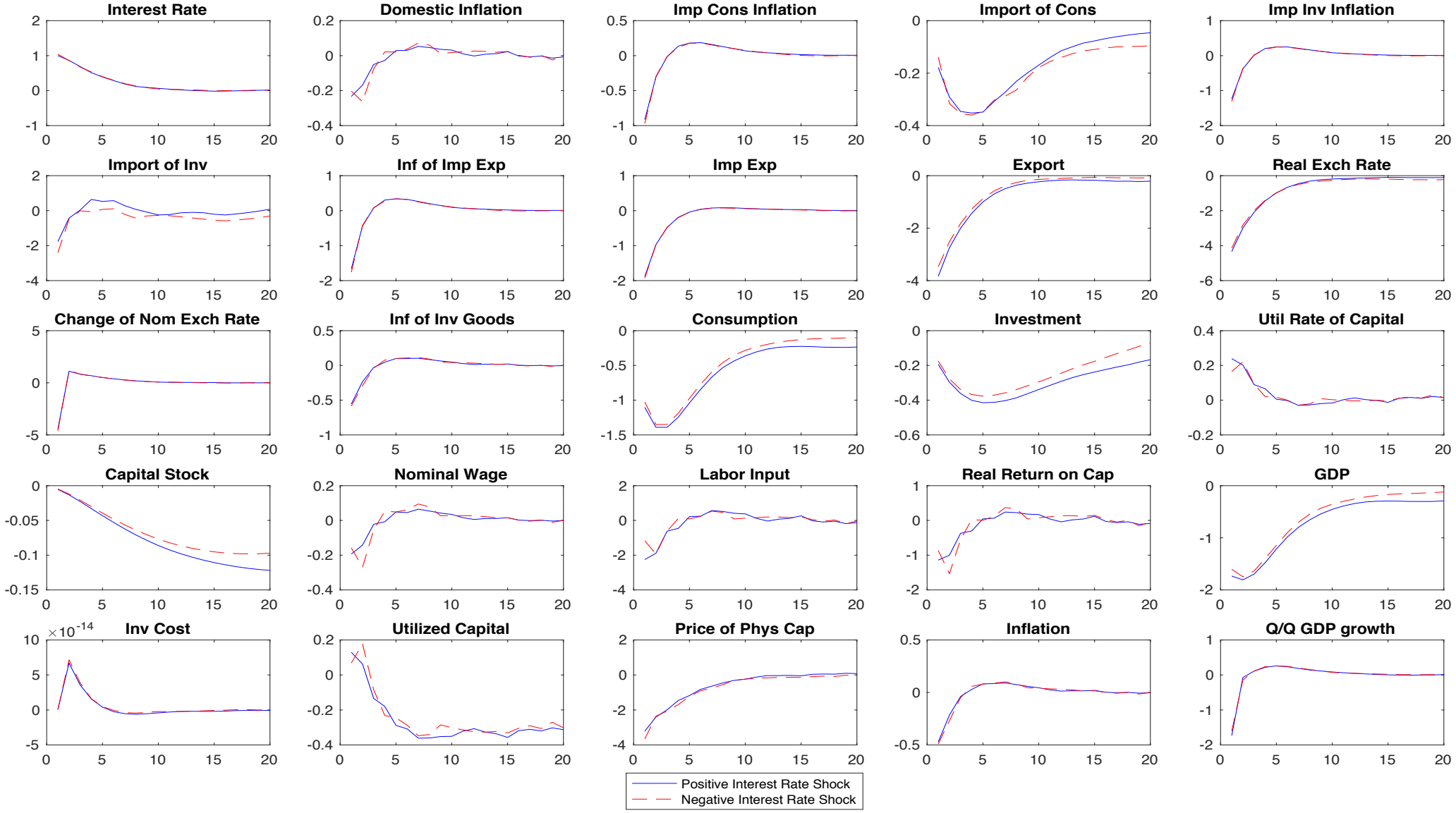
The responses to negative shock are shown as mirror images to facilitate the comparison

Asymmetries in the Transmission Mechanism of Monetary Policy: Case 2 (Model's frictions are log-linearized. Standard blocks are nonlinear)



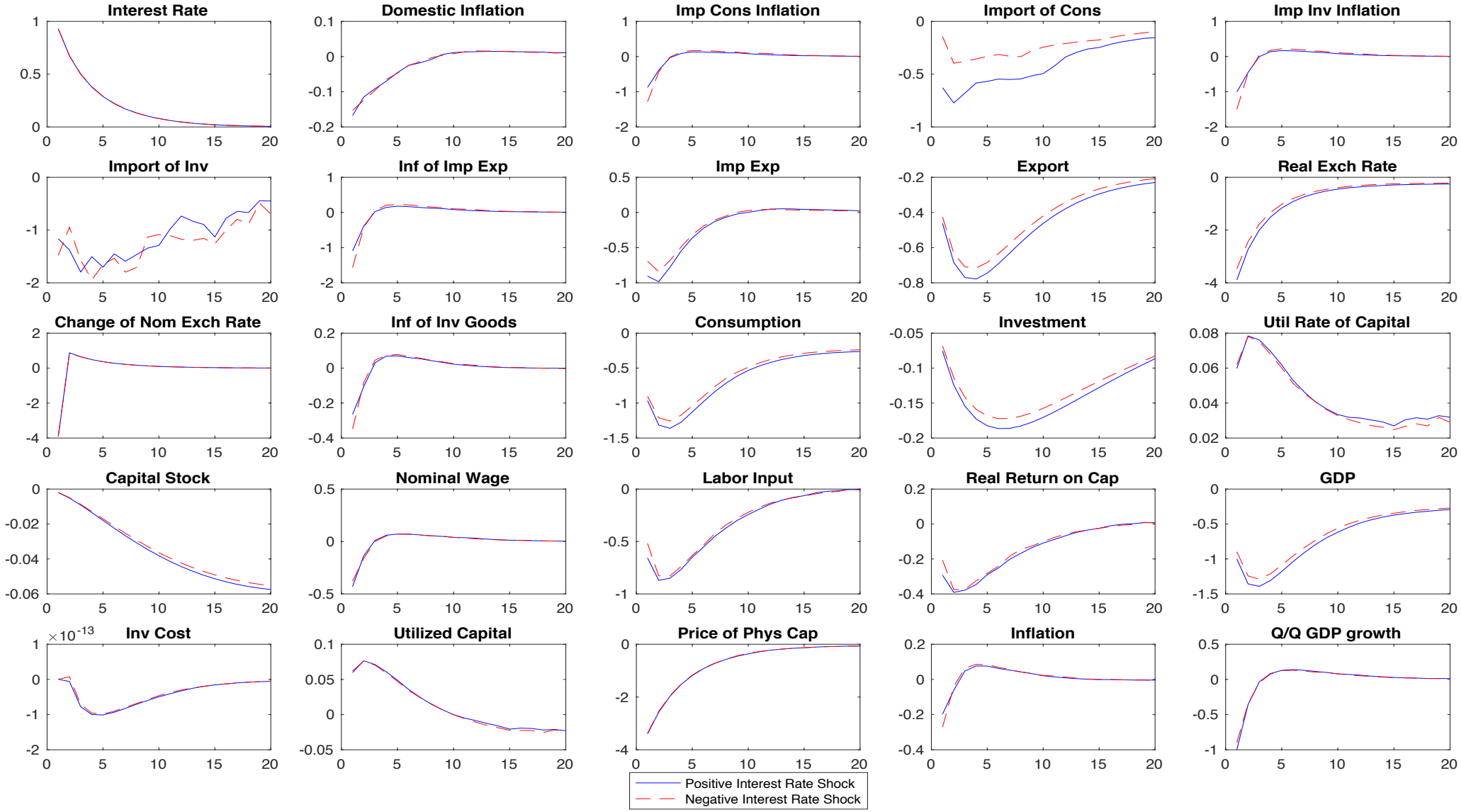
The responses to negative shock are shown as mirror images to facilitate the comparison

Asymmetries in the Transmission Mechanism of Monetary Policy: Case 5 (Labor market frictions and standard blocks are nonlinear. All other frictions are log-linearized)



The responses to negative shock are shown as mirror images to facilitate the comparison

Asymmetries in the Transmission Mechanism of Monetary Policy: Case 7 (Nonlinear imported sector. Internal economy's frictions are log-linearized)



The responses to negative shock are shown as mirror images to facilitate the comparison

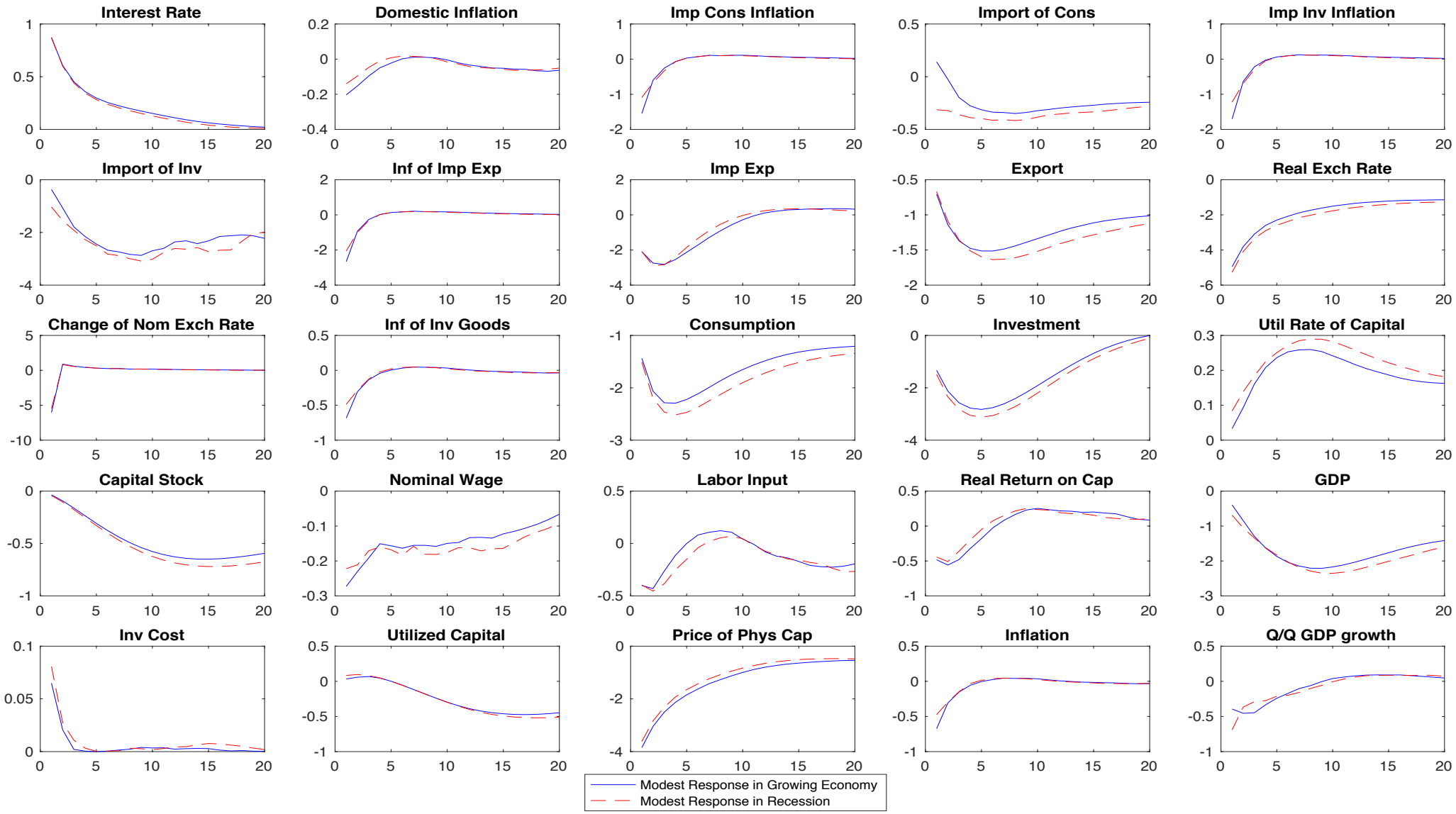
Third Order Empirical Moments (Skewness): Data and 7 Models

	Data	Case 1 (Nonlinear Economy)	Case 2 (Nonlinear standard blocks)	Case 3 (Nonlinear capital market)	Case 4 (Nonlinear internal economy's Phillips curves)	Case 5 (Nonlinear labor market)	Case 6 (Nonlinear internal economy)	Case 7 (Nonlinear external frictions)
Q/Q Inflation	**0.16**	**0.347**	**0.00**	0.024	0.122	0.265	0.285	0.204
Q/Q GDP Growth	**-1.26**	**-0.935**	**0.042**	-0.133	-0.335	-0.543	-0.636	-0.311
Interest Rate	**0.42**	**0.563**	**0.023**	0.091	0.181	0.331	0.388	0.135

Variance decomposition of inflation and economic growth

	Period 1		Period 5		Period 20		Period 100	
	Inflation	Economic Growth	Inflation	Economic Growth	Inflation	Economic Growth	Inflation	Economic Growth
Demand	51.94	**38.29**	46.16	**36.41**	46.20	**36.04**	46.10	**36.02**
Supply	46.72	**48.55**	52.7	**52.08**	52.69	**52.38**	52.79	**52.41**
Monetary	1.34	13.16	1.14	11.51	1.11	11.58	1.11	11.57

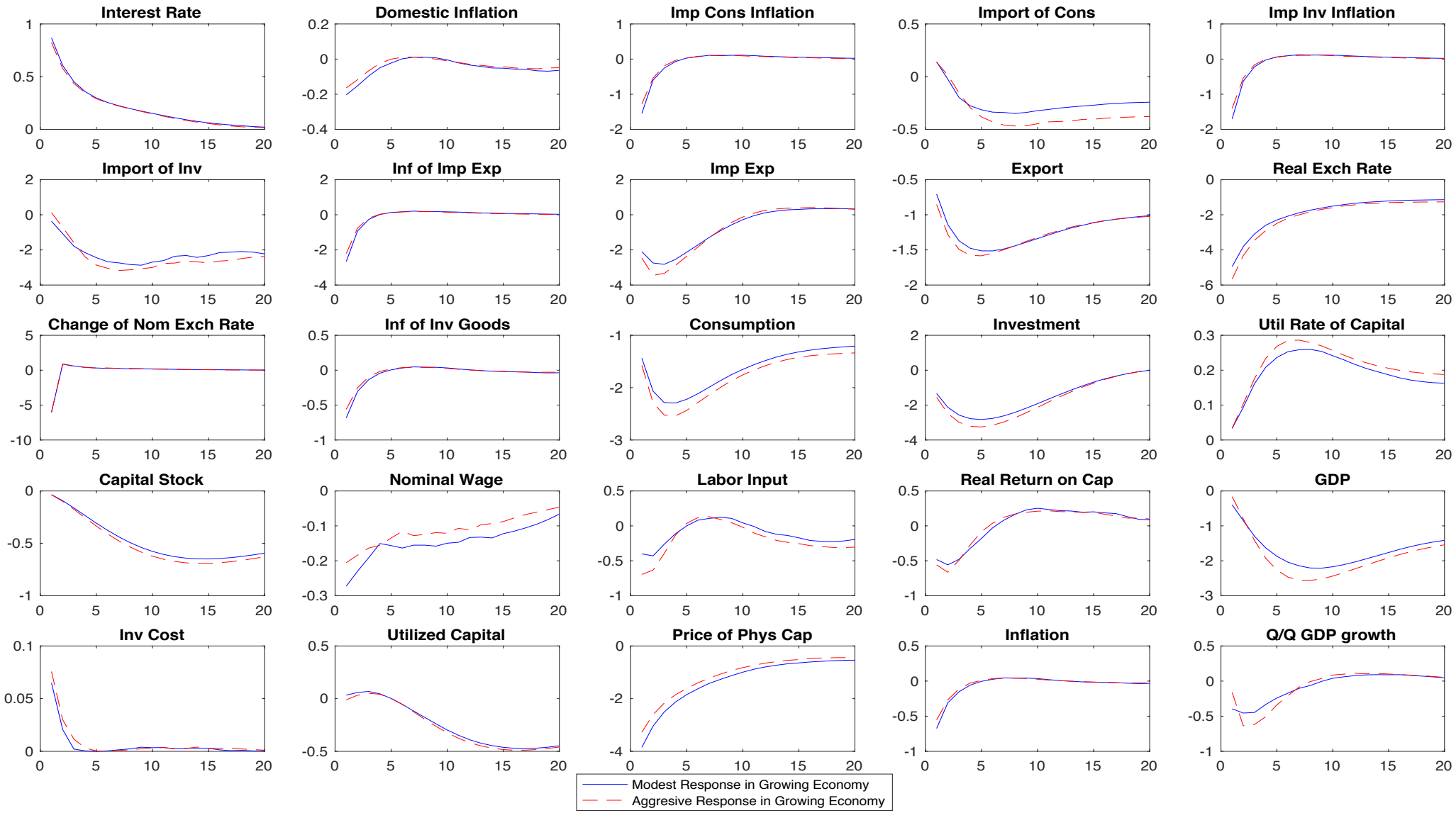
Monetary Policy in Demand Driven Expansion and Recession: 1% Shock



Expansion is defined as a 5% high output from steady state. Recession is defined as a 5% low output from steady state.

The recession graphs are shown as mirror images to facilitate the comparison

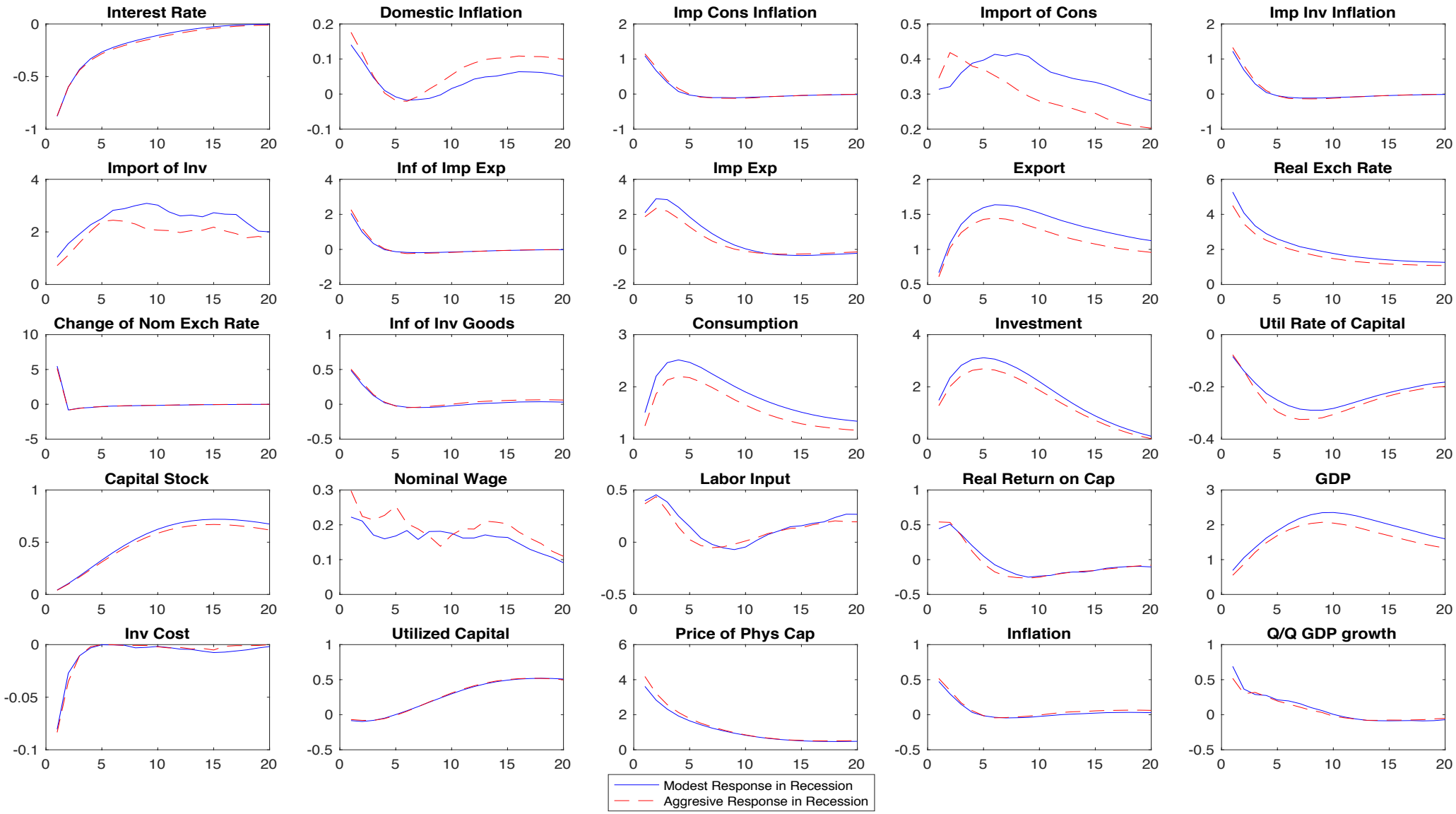
Monetary Policy in Demand Driven Expansion: 1% and 2% Shocks



Expansion is defined as a 5% high output from steady state.

The aggressive response is rescaled to facilitate the comparison

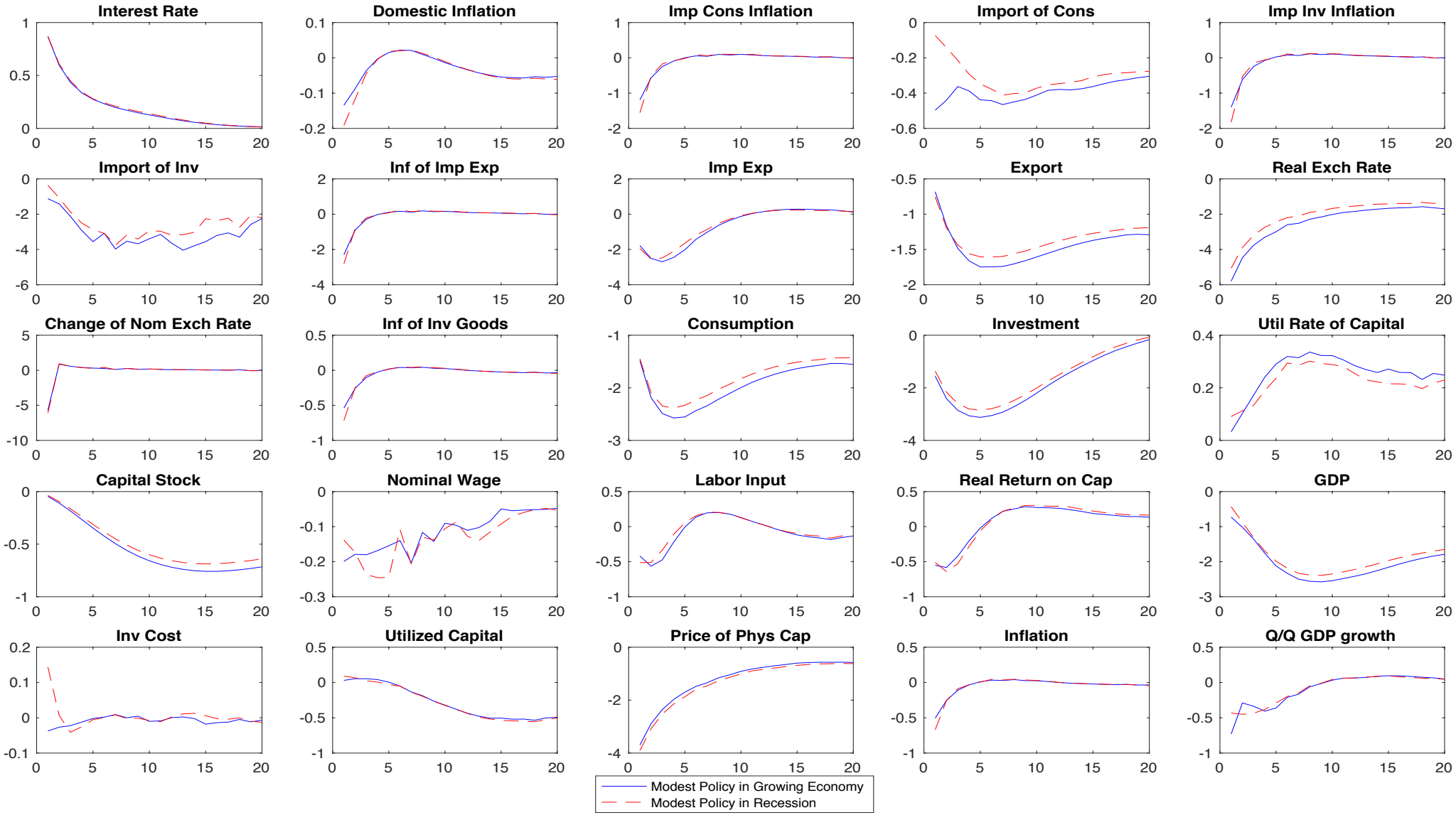
Monetary Policy in Demand Driven Recession: 1% and 2% Shocks



Recession is defined as a 5% low output from steady state.

The aggressive response is rescaled to facilitate the comparison

Monetary Policy in Supply Driven Expansion and Recession: 1% Shock



Expansion is defined as a 5% high output from steady state. Recession is defined as a 5% low output from steady state.

The recession graphs are shown as mirror images to facilitate the comparison

Conclusion - 1

- In equilibrium, contractionary monetary policy yields more reduction in output compared to the increase of output in a response to the same size of expansionary policy.
- In equilibrium, relatively more inflation is created by expansionary policy.
- Asymmetric response of inflation is mostly the result of importers' behavior.
- The other part of asymmetry in inflation is the result of domestic inflation's response to internal price setting frictions and rigidities of labor market.
- The asymmetric response of output is mostly the result of internal economy's frictions.
- By adding nonlinear behavior of importers, the asymmetric response of output increases through the channels of import and asymmetric change in real exchange rate.

Conclusion - 2

- In demand driven expansion, monetary policy is more effective to manage inflation than output
- In demand driven recession, monetary policy is more effective to stimulate output than create inflation
- But, being in demand driven expansion, aggressive contractionary policy diminishes the response of inflation and accelerates the response of output
- But, being in demand driven recession, aggressive expansionary policy increases the efficiency of creating inflation and decreases the response of output

Conclusion - 3

- In supply driven expansion, monetary policy is more effective to control output than inflation
- In supply driven recession, monetary policy is more effective to impact on inflation than output
- But, being in supply driven expansion, aggressive monetary policy accelerates the response of output with no significant relative reaction of inflation
- But, being in supply driven recession, aggressive monetary policy increases the efficiency of controlling output and diminishes the relative response of inflation

Thank You for Your Attention

APPENDIXES

Two Stage Estimation – First Stage

Table 2. OLS Estimation results of the interest rate equation

Interest Rate (-1)	$\mathbf{0.905}^{***}$ **(0.061)**
Q/Q Inflation	0.211^{*} (0.107)
Constant	0.014 (0.153)
$\boldsymbol{R^2}$	0.815

Two Stage Estimation – Second Stage, Results (2 Other Measures of Monetary Policy)

	Q/Q Output Growth (Gap Equation)	Q/Q Output Growth (Interest Rate Change)	Q/Q Inflation (Gap Equation)	Q/Q Inflation (Interest Rate Change)
Q/Q Output Growth (-1)	0.165^{***} (0.049)	0.134^{***} (0.053)		
Q/Q Inflation (-1)			0.203^{***} (0.067)	0.154^{***} (0.018)
Constant	0.107 (0.336)	0.044 (0.126)	0.013 (0.107)	0.068 (0.092)
$Sum(Policy^{+})^{1}$	$\mathbf{-1.297^{***}}$ **(0.096)**	$\mathbf{-1.267^{***}}$ **(0.197)**	$\mathbf{-0.621^{***}}$ **(0.186)**	$\mathbf{-0.640^{***}}$ **(0.091)**
$Sum(Policy^{-})^{2}$	$\mathbf{0.454^{**}}$ **(0.223)**	$\mathbf{0.438^{*}}$ **(0.220)**	$\mathbf{1.188^{***}}$ **(0.276)**	$\mathbf{0.998^{***}}$ **(0.072)**
$Sum(Policy^{+}) + Sum(Policy^{-})^{3}$	$\mathbf{-0.843^{***}}$ **(0.286)**	$\mathbf{-0.829^{***}}$ **(0.194)**	$\mathbf{0.567^{**}}$ **(0.258)**	$\mathbf{0.357^{***}}$ **(0.118)**
$Policy^{+} = 0^{4}$	179.098^{***}	41.311^{***}	11.131^{***}	49.615^{***}
$Policy^{-} = 0^{5}$	4.128^{**}	3.940^{*}	18.456^{***}	189.828^{***}
$Policy^{+} + Policy^{-} = 0^{6}$	8.660^{***}	18.186^{***}	2.197^{**}	3.007^{***}

Testing the Presence of Asymmetry in the VAR Model

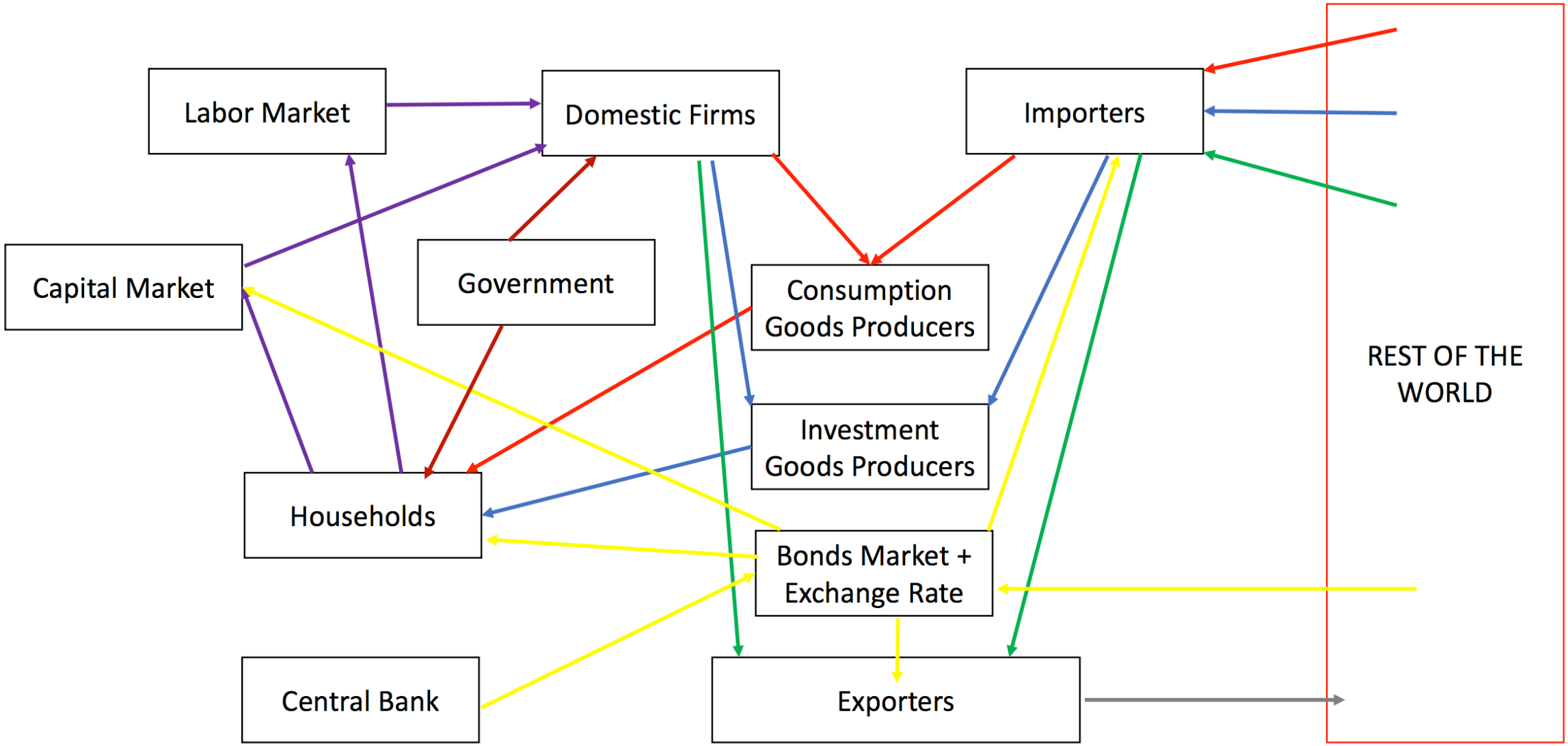
The following 2 hypotheses are tested:

$$H_0\colon g_{2,0} = \cdots = g_{2,3} = 0$$
$$H_0\colon h_{2,0} = \cdots = h_{2,3} = 0$$

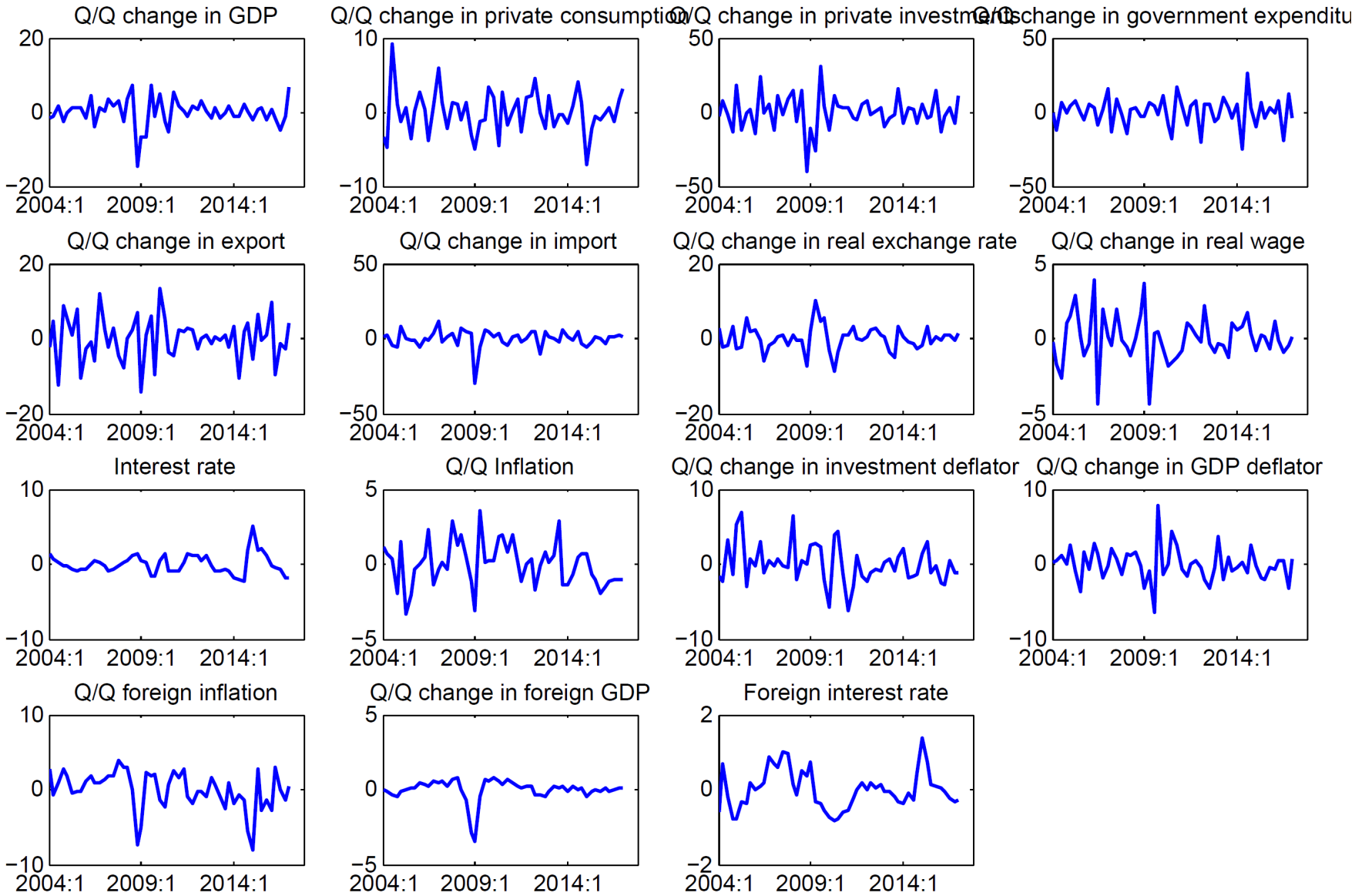
Table 5. Results of the slope-based tests

	F-statistic	p-Value
Economic Growth Equation	3.0046	0.0308
Inflation Equation	2.6419	0.0495

Theoretical Model - Open Economy New Keynesian Model

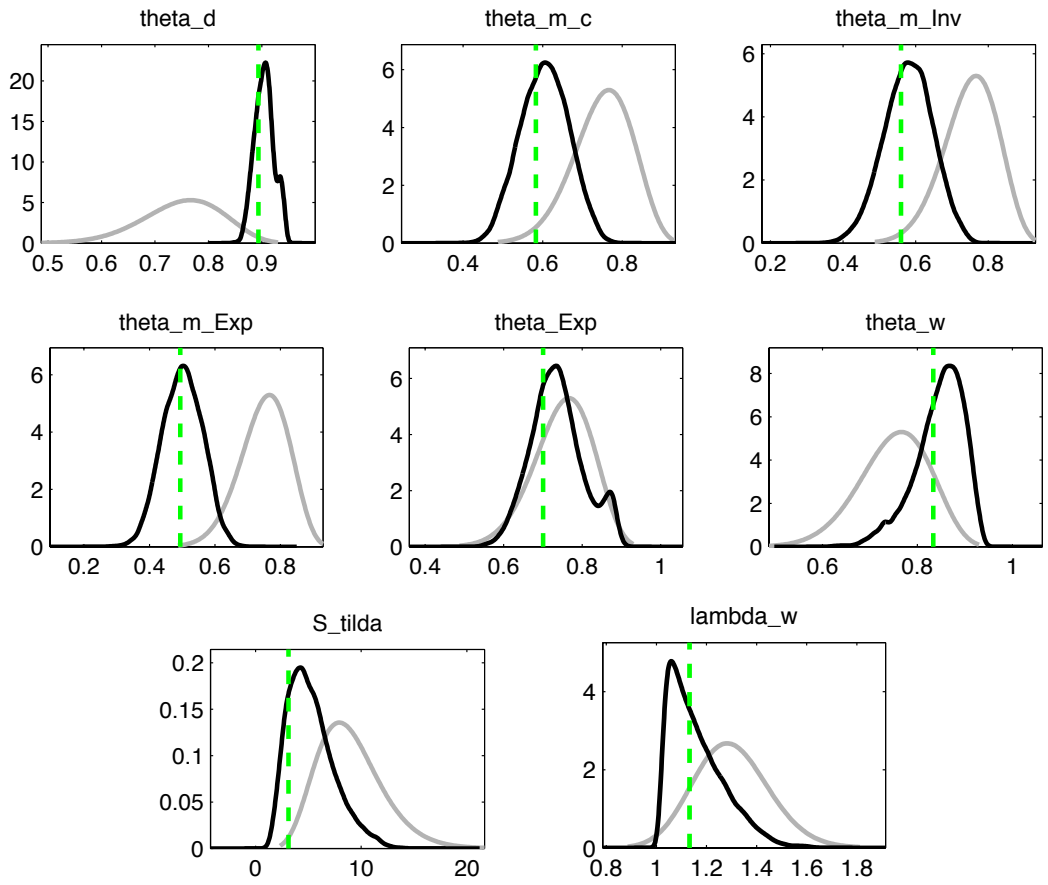


Data Used in the Estimation of Theoretical Model

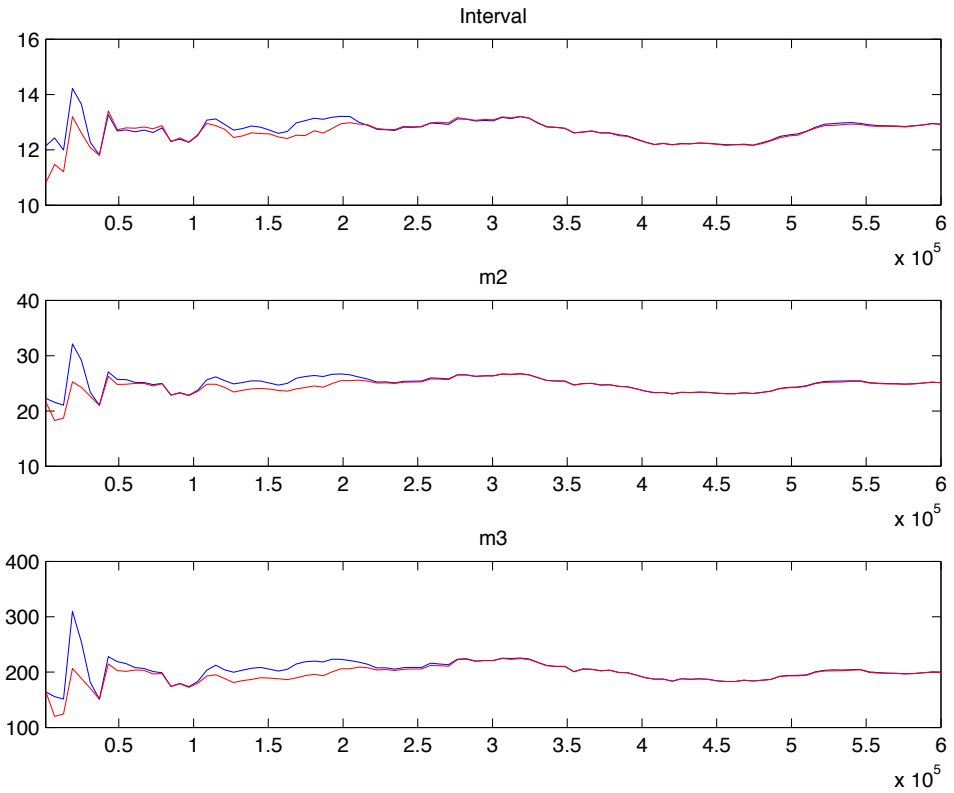


Estimation

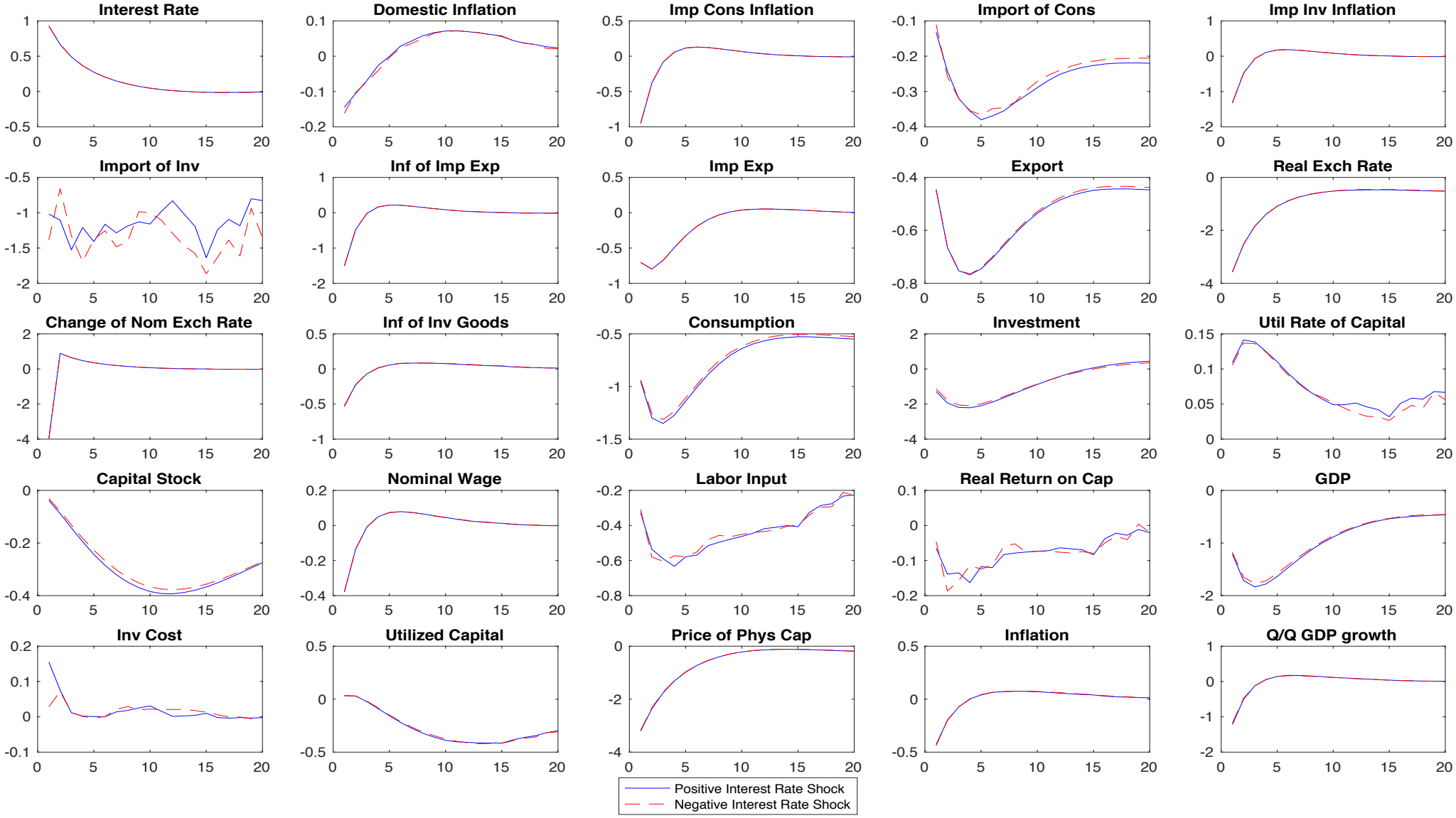
Prior and posterior densities



Multivariate convergence diagnostics

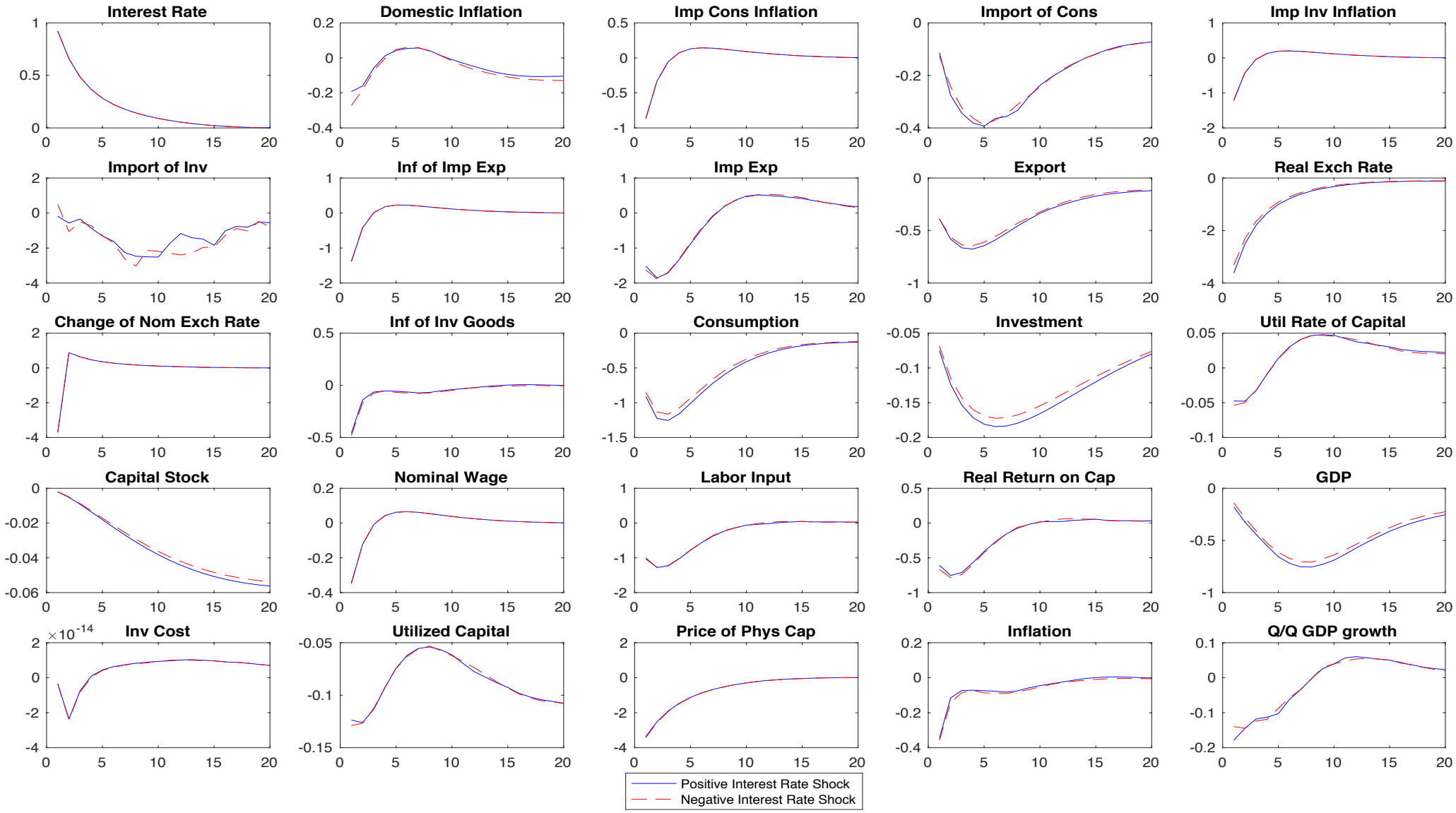


Asymmetries in the Transmission Mechanism of Monetary Policy: Case 3 (Capital market's frictions and standard blocks are nonlinear. All other frictions are log-linearized)



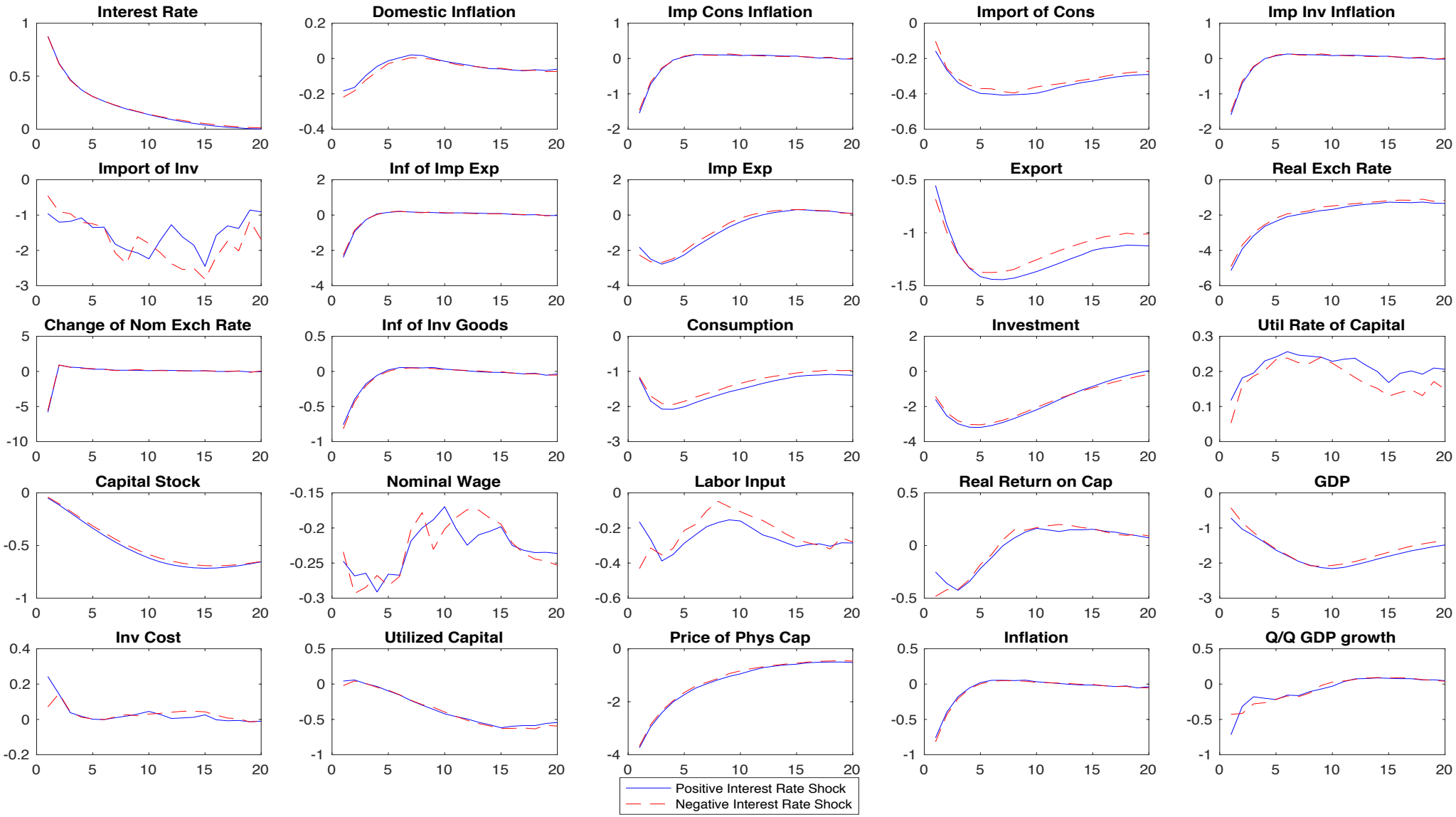
The responses to negative shock are shown as mirror images to facilitate the comparison

Asymmetries in the Transmission Mechanism of Monetary Policy: Case 4 (Internal economy's price setting frictions and standard blocks are nonlinear. All other frictions are log-linearized)



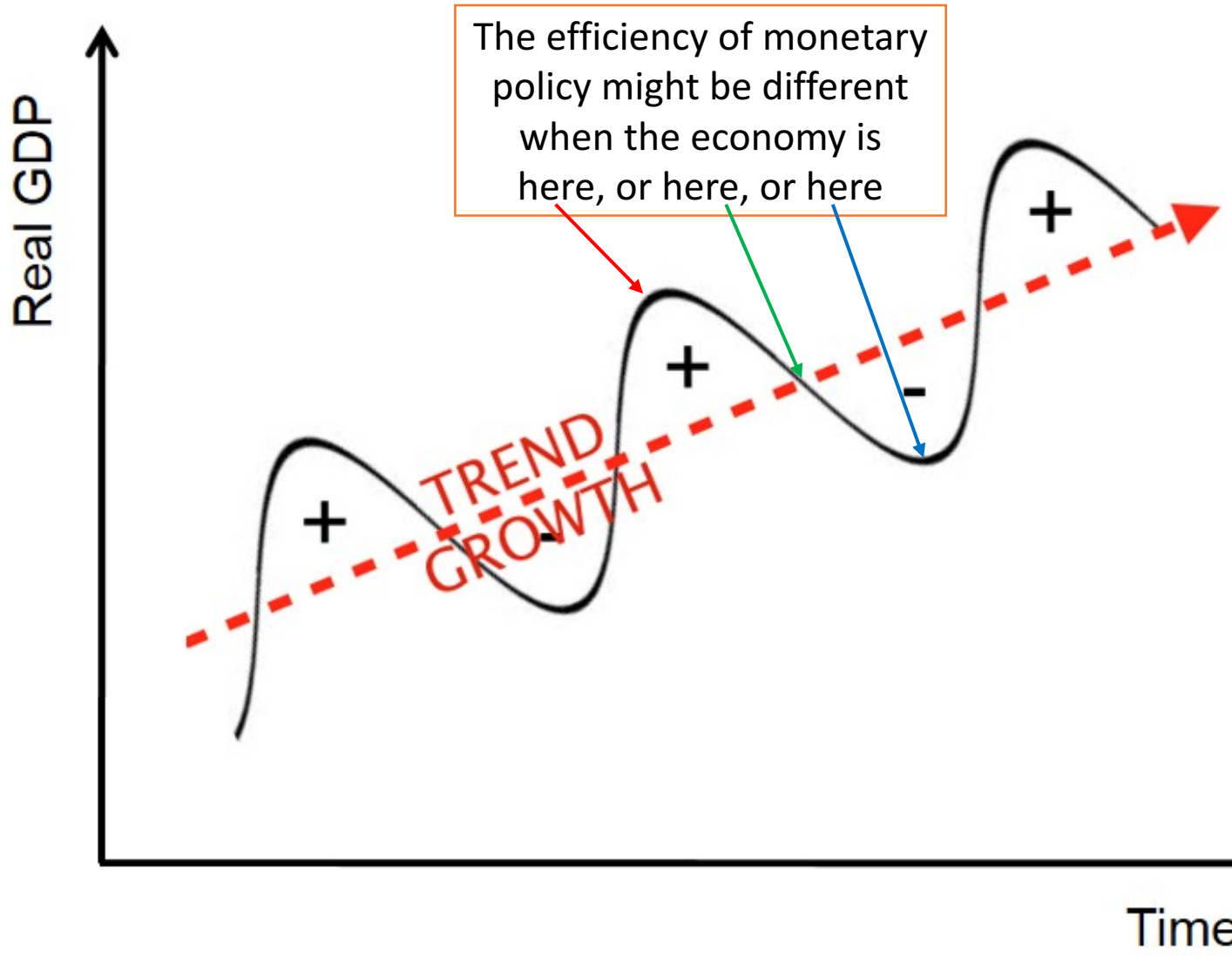
The responses to negative shock are shown as mirror images to facilitate the comparison

Asymmetries in the Transmission Mechanism of Monetary Policy: Case 6 (Nonlinear internal economy and standard blocks. Importers sector's frictions are log-linearized)

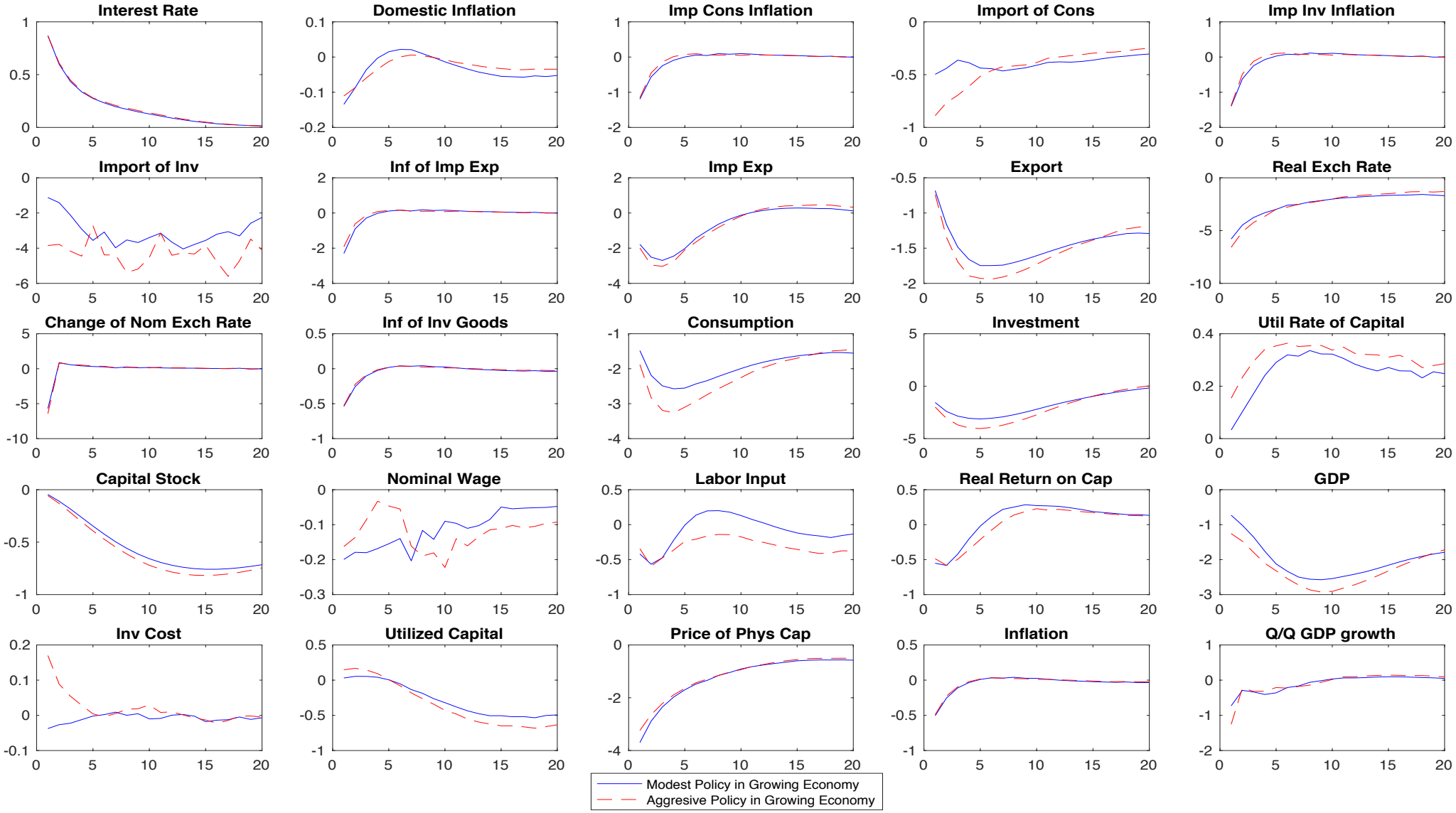


The responses to negative shock are shown as mirror images to facilitate the comparison

The Efficiency of Monetary Policy through the Phases of Business Cycle



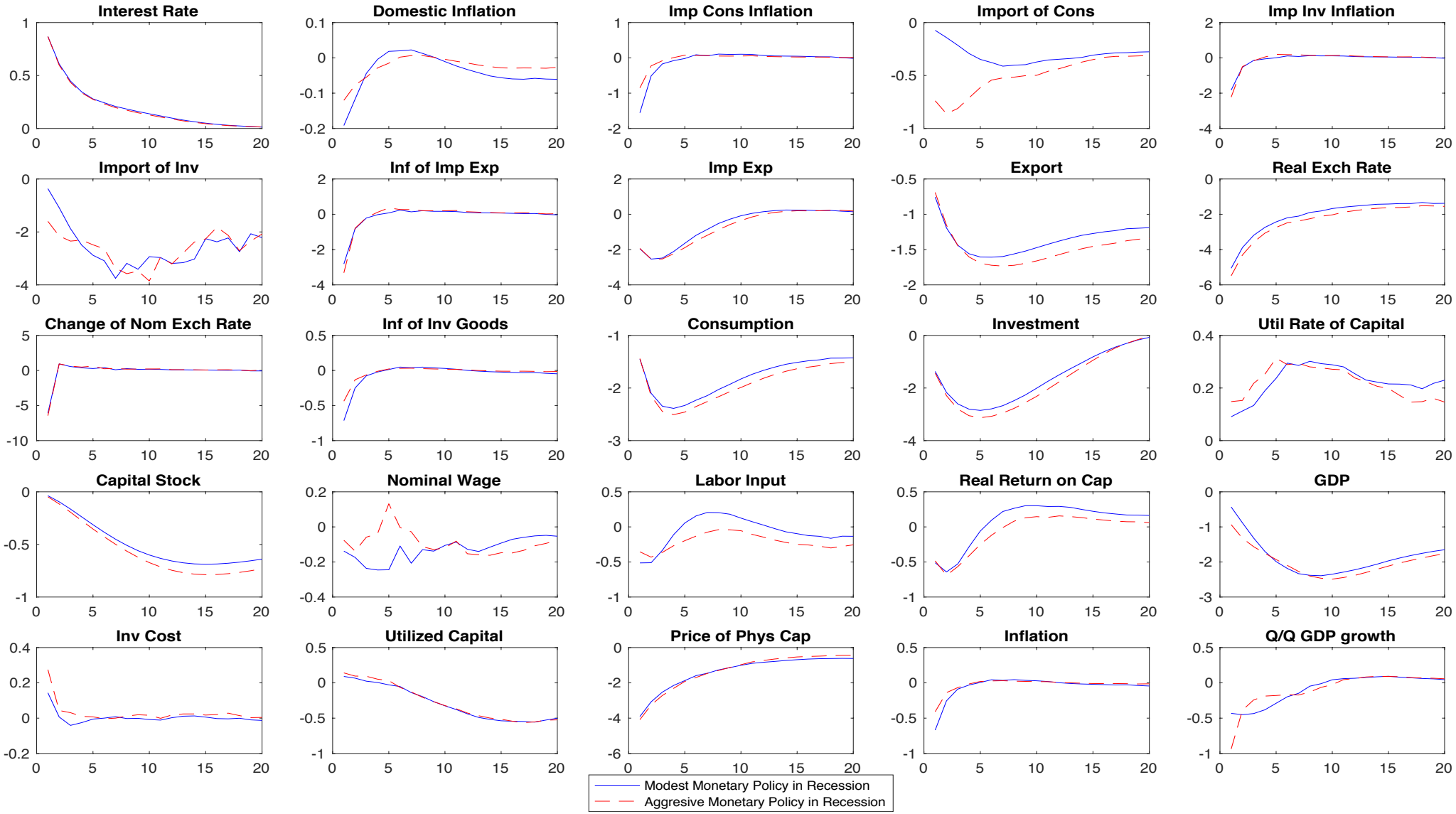
Monetary Policy in Supply Driven Expansion: 1% and 2% Shocks



Expansion is defined as a 5% high output from steady state.

The aggressive response is rescaled to facilitate the comparison

Monetary Policy in Demand Driven Recession: 1% and 2% Shocks



Recession is defined as a 5% low output from steady state.

The aggressive response is rescaled to facilitate the comparison