BUCHAREST ACADEMY OF ECONOMIC STUDIES
DOCTORAL SCHOOL OF FINANCE AND BANKING

Structural Changes in the Transmission Mechanism of Monetary Policy in Romania – a Markov Switching Vector Autoregression Analysis

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- Motivation of the theme
- Analysis of the series involved in the model
- Detection of structural breaks
- Estimation of the MSVAR model
- Regime-dependent impulse-response functions and variance decomposition
- Concluding remarks and further research

Key References

- Hamilton (1989)
- Krolzig (1997)
- Krolzig & Toro (2001)
- Ehrmann, Ellison & Valla (2003)
- Paolillo & Petragallo (2004)
- Sims & Zha (2006)
- Gaytan Gonzalez & Gonzalez Garcia (2006)
- Bordon & Weber (2010)

The macroeconomic framework in Romania

The introduction of inflation targeting in 2005, together with important economic developments, marked the beginning of a new macroeconomic framework in Romania, which is likely to have changed the effectiveness of monetary policy.

This paper is an attempt to analyze whether the transmission mechanism in Romania has been subject to structural breaks by employing a Markov-Switching VAR model.

Questions: Which were the causes in the process of inflation reduction in Romanian economy?
What changes appear in the dynamic relationship between macroeconomic variables?

Markov Switching Vector Autoregression

A general form of the model:

$$X_t = \begin{cases} v_1 + B_{11}X_{t-1} + \ldots + B_{p1}X_{t-p} + A_1 u_t & s_t = 1 \\ \vdots & \\ v_m + B_{1m}X_{t-1} + \ldots + B_{pm}X_{t-p} + A_m u_t & s_t = m \end{cases} \quad (1)$$

$$u_t \sim N(0; I_K)$$

$$\boldsymbol{\Sigma}_i = E(A_i u_t u_t' A_i') = A_i E(u_t u_t') A_i' = A_i I_K A_i' = A_i A_i' \quad (2)$$

$\Pr(s_{t+1} = j \,|\, s_t = i) = \rho_{ij}$ - hidden Markov chain

$$P = \begin{bmatrix} \rho_{11} & \rho_{12} & \cdots & \rho_{1m} \\ \rho_{21} & \rho_{22} & \cdots & \rho_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{m1} & \rho_{m2} & \cdots & \rho_{mm} \end{bmatrix}$$ - transition probabilities matrix (3)

Markov Switching Vector Autoregression

Response vectors:

$$\left.\frac{\partial E_t X_{t+h}}{\partial u_{k,t}}\right|_{s_t=\ldots=s_{t+h}=i} = \theta_{ki,h} \qquad h \geq 0 \tag{4}$$

Initial disturbance vector $u_0 = (0 \ldots 0, 1, 0 \ldots 0)$

$$\hat{\theta}_{ki,0} = \hat{A}_i u_0 \tag{5}$$

$$\hat{\theta}_{ki,h} = \sum_{j=1}^{\min(h,p)} \hat{B}_{ji}^{h-j+1} \hat{A}_i u_0 \text{ for } h > 0 \tag{6}$$

Empirical results

- Stationarity of the series involved in the model: industrial production, inflation, interest rate and exchange rate

Table 1: Unit Root Tests		
Variable	ADF	Lags
OUTPUT	-13.95***	12
INFLATION	-6.90***	12
INTEREST	-8.66***	12
EXCHANGE	-8.72***	12
*** denotes 1 percent significance		

- Evidence from a standard VAR analysis

Table 2: VAR Lag Order Selection Criteria			
Lag	AIC	SC	HQ
0	-28.04794	-27.96766	-28.01532
1	-28.81016*	-28.40874*	-28.64708*
2	-28.72267	-28.00012	-28.42912
3	-28.65978	-27.61609	-28.23576
4	-28.59785	-27.23302	-28.04336
5	-28.54697	-26.86101	-27.86202
6	-28.60663	-26.59954	-27.79121

Empirical results

- Preliminary evidence on the causal links between interest rate, economic activity and inflation rate

Table 3: Granger Causality Tests

Effect on OUTPUT	p-values
INFLATION	0.15
INTEREST	0.39
EXCHANGE	0.04**
Block	0.13
Effect on INFLATION	
OUTPUT	0.83
INTEREST	0.14
EXCHANGE	0.01***
Block	0.04**
Effect on INTEREST	
OUTPUT	0.35
INFLATION	0.03**
EXCHANGE	0.02**
Block	0.02**
Effect on EXCHANGE	
OUTPUT	0.38
INFLATION	0.00***
INTEREST	0.01***
Block	0.00***
*** and *** denote rejection of the null hypothesis at 5 and 1 percent significance levels, respectively*	

Empirical results

Table 4: Diagnosis tests

	Statistic	p-value
OUTPUT Eq.		
Jarque-Bera	3682.77	0.00
White Heteroskedasticity Test	0.18	0.99
INFLATION Eq.		
Jarque-Bera	58.07	0.00
White Heteroskedasticity Test	1.09	0.36
INTEREST Eq.		
Jarque-Bera	332.46	0.00
White Heteroskedasticity Test	4.82	0.00
EXCHANGE Eq.		
Jarque-Bera	2.62	0.27
White Heteroskedasticity Test	0.83	0.63

- Standard specification tests applied to each equation;

- Analysis of the stability over time of VAR parameters;

- Looking for evidence suggesting structural changes.

Empirical results

Fig. 1: OUTPUT Eq., CUSUM Test

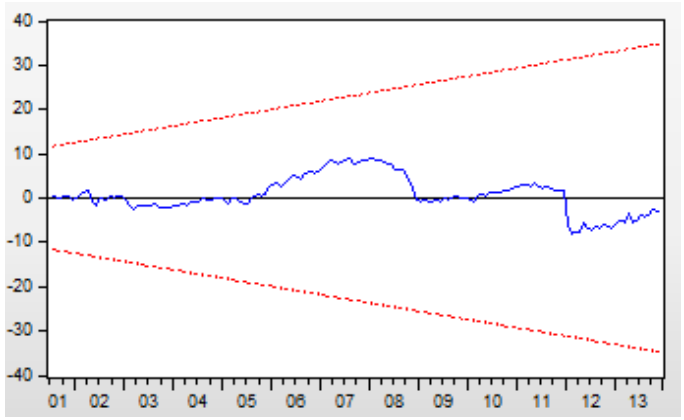


Fig. 2: OUTPUT Eq., CUSUM-Q Test

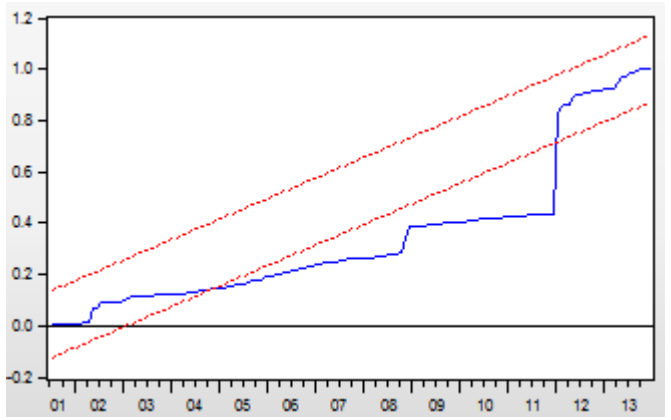


Fig. 3: INFLATION Eq., CUSUM Test

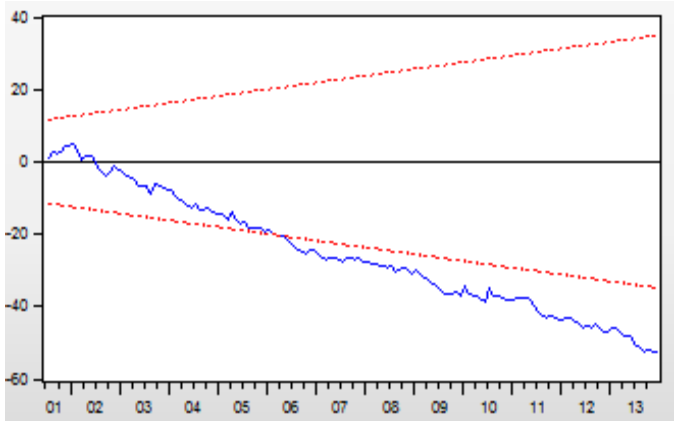
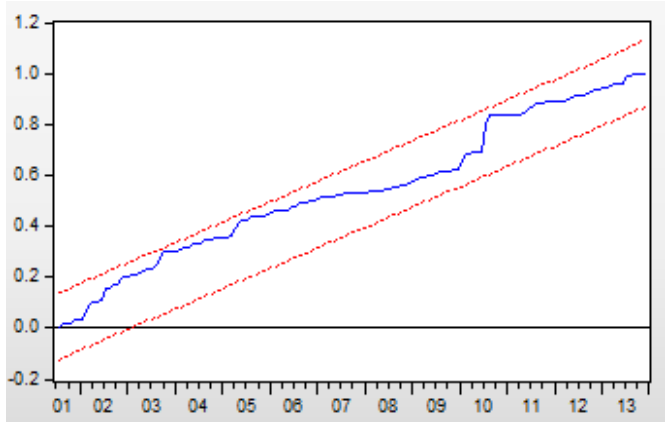


Fig. 4: INFLATION Eq., CUSUM-Q Test



Tests that reveal model instability of general form:

- CUSUM Test does not require an a-priori selection of the breakpoint and detects instability in the intercept;
- CUSUM-Q detects instability in the variance of the regression error.

Empirical results

Fig. 5: INTEREST Eq., CUSUM Test

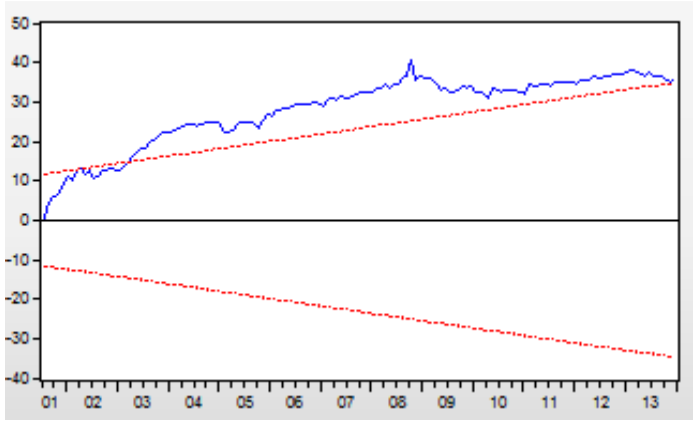


Fig. 6: : INTEREST Eq., CUSUM-Q Test

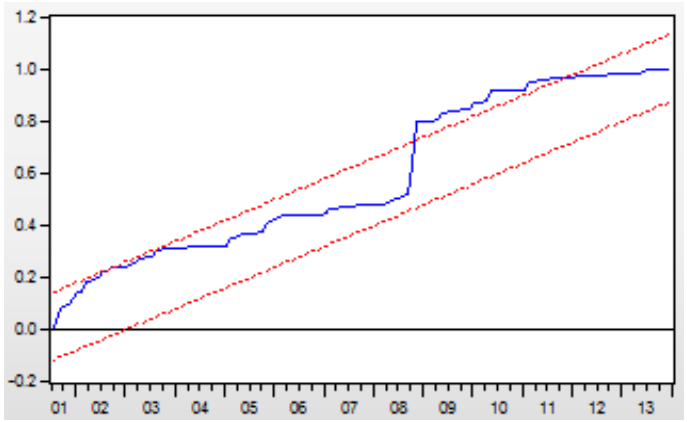


Fig. 7: EXCHANGE Eq., CUSUM Test

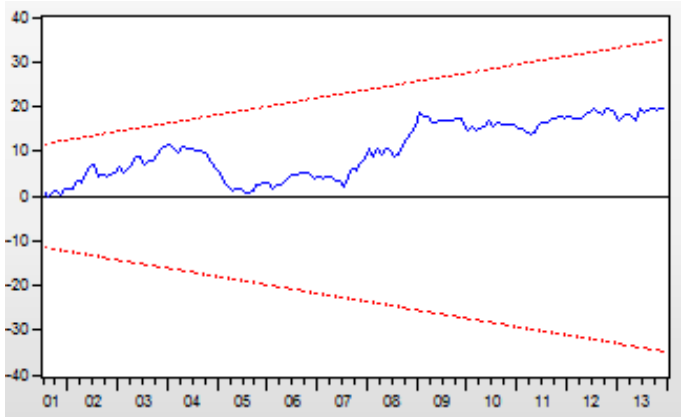
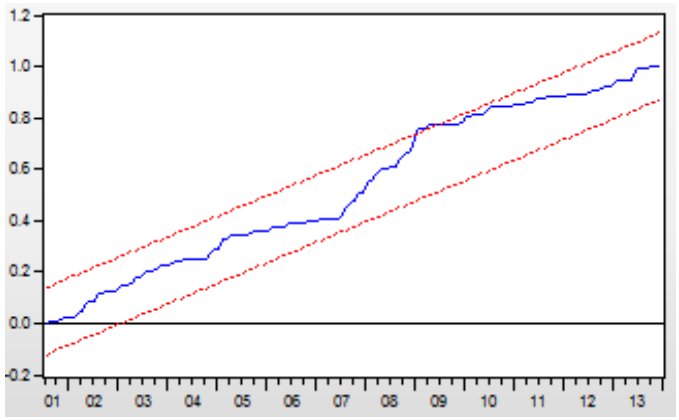


Fig. 8: EXCHANGE Eq., CUSUM-Q Test



Empirical results

Tabel 5: Bai & Perron structural break dates

	Coefficients` significance	Number of structural breaks	Date
H0: There are x structural breaks			
Ha: There are x+1 structural breaks (x=0,1,2,3,4)			
OUTPUT Eq.			
Coefficients of lags of OUTPUT	-0.1231	1	2005M08
Coefficients of lags of INFLATION	-0.4222*		
Coefficients of lags of INTEREST	-0.0006		
Coefficients of lags of EXCHANGE	0.2382**		
Constant	0.0012		
INFLATION Eq.			
Coefficients of lags of OUTPUT	0.0035	2	2005M05 2011M02
Coefficients of lags of INFLATION	0.5448***		
Coefficients of lags of INTEREST	0.0002		
Coefficients of lags of EXCHANGE	0.0623**		
Constant	0.0011***		
INTEREST Eq.			
Coefficients of lags of OUTPUT	7.7879	3	2003M02 2008M11 2011M02
Coefficients of lags of INFLATION	-0.6434*		
Coefficients of lags of INTEREST	0.3058**		
Coefficients of lags of EXCHANGE	0.2751**		
Constant	-0.6670		
EXCHANGE Eq.			
Coefficients of lags of OUTPUT	-0.0441	1	2008M12
Coefficients of lags of INFLATION	0.5242***		
Coefficients of lags of INTEREST	-0.0011**		
Coefficients of lags of EXCHANGE	0.3357***		
Constant	-0.0008		

- Supplementary evidence about the instability of the coefficients of the equations of the linear VAR

, ** and * denote 10, 5 and 1 percent significance levels, respectively*

Empirical results

Table 6: MSVAR(2,1) estimation

	OUTPUT	INFLATION	INTEREST	EXCHANGE
Regime 1				
OUTPUT(-1)	-0.39***	-0.00	-0.01	-0.07
INFLATION(-1)	-0.52***	0.56***	-0.32	0.53***
INTEREST(-1)	-0.05	0.01	0.43***	-0.07
EXCHANGE(-1)	0.26***	0.05**	0.16*	0.25***
Intercept	0.00***	0.00***	-0.00	-0.00
Regime 2				
OUTPUT(-1)	0.39	0.01	-0.45	-0.04
INFLATION(-1)	-0.32	0.57	1.87	0.10
INTEREST(-1)	-0.03	-0.05***	-0.54*	-0.10
EXCHANGE(-1)	0.35	0.13**	-0.44	0.70
Intercept	-0.01	0.00	0.00	0.00

, ** and * denote 10, 5 and 1 percent significance levels, respectively*

The transition probabilities matrix:

$$P = \begin{bmatrix} 0.96 & 0.50 \\ 0.04 & 0.50 \end{bmatrix}$$

Empirical results

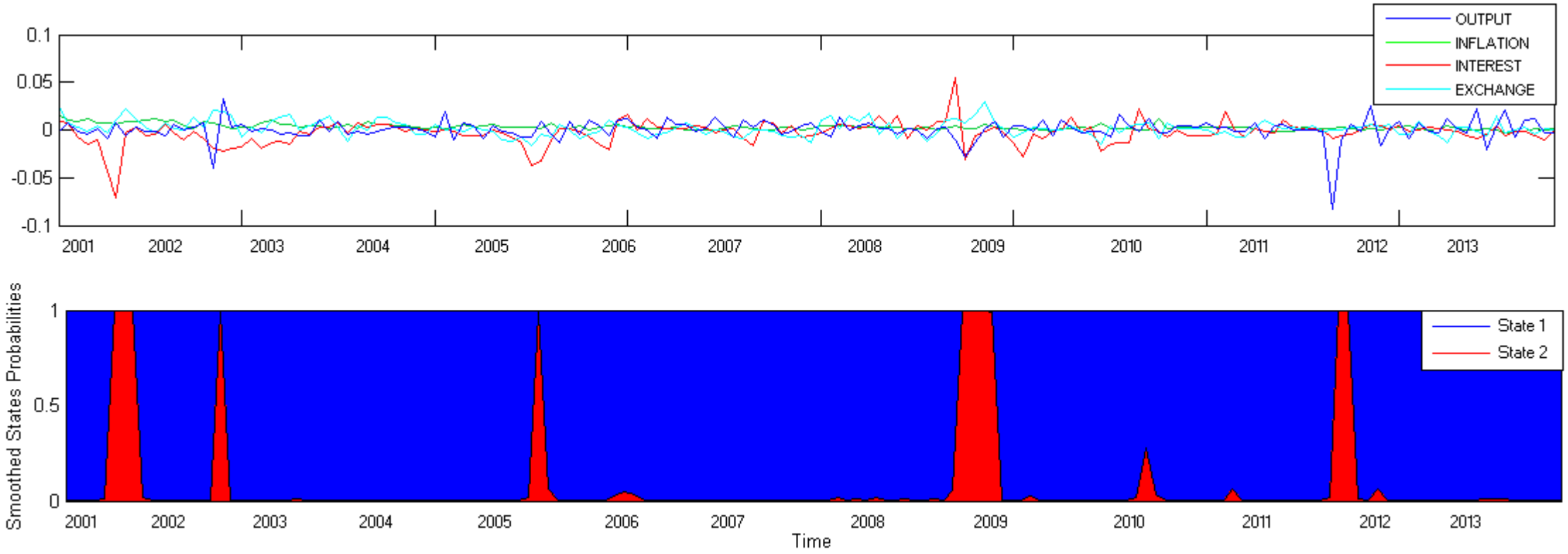
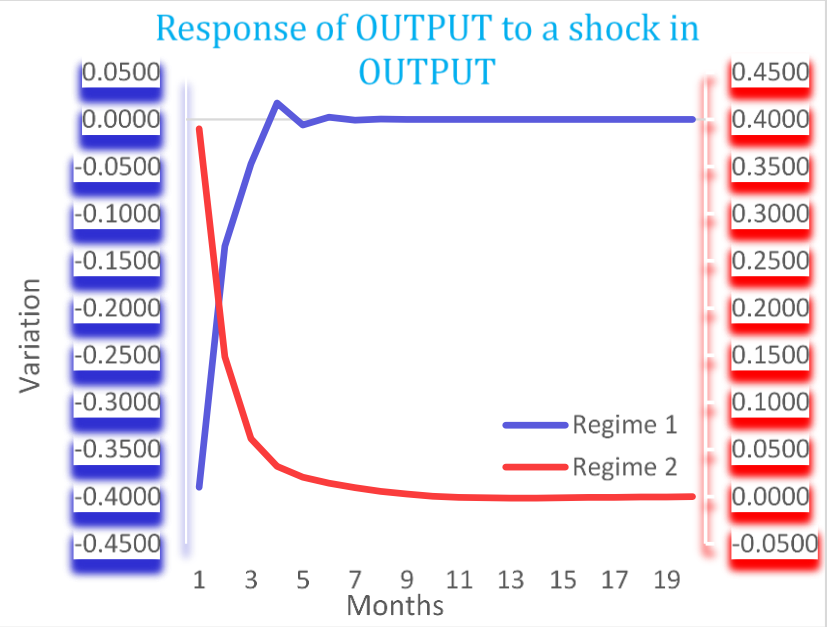
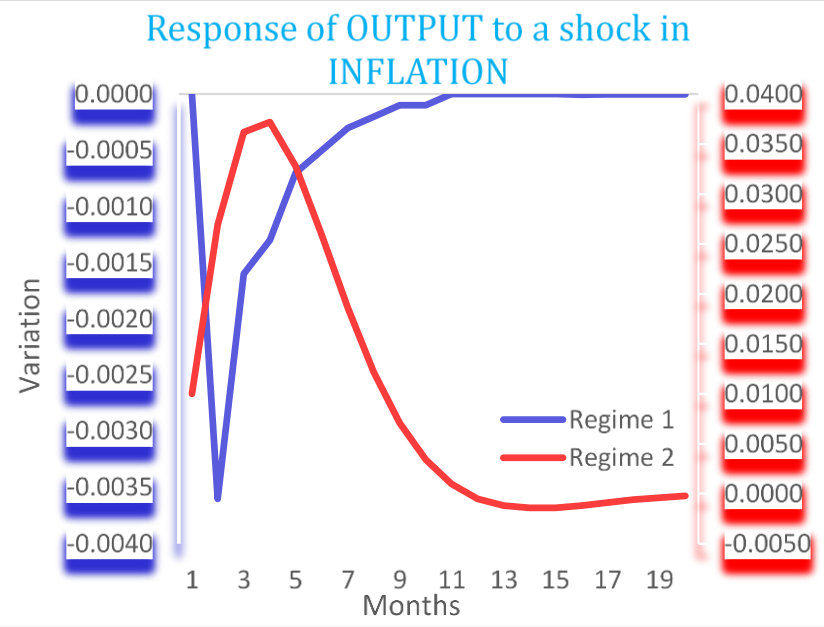
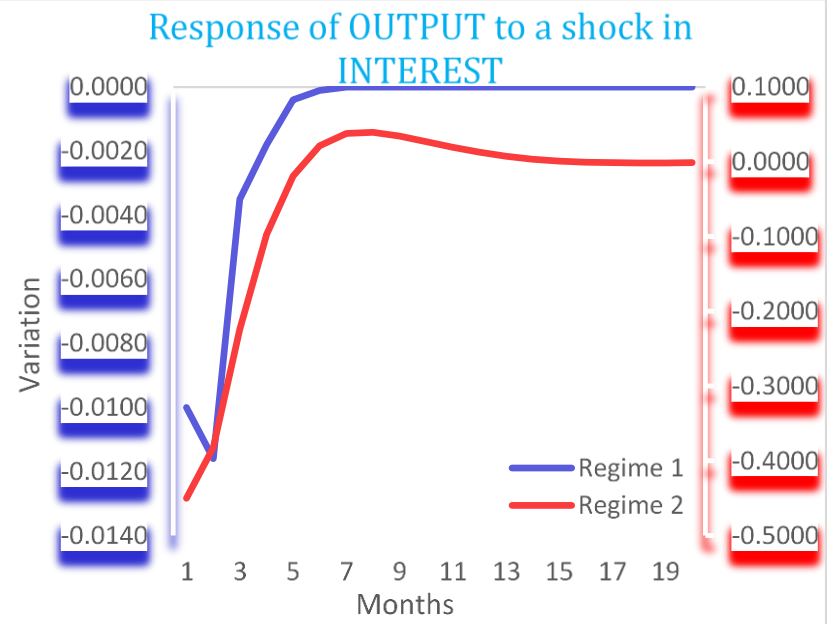


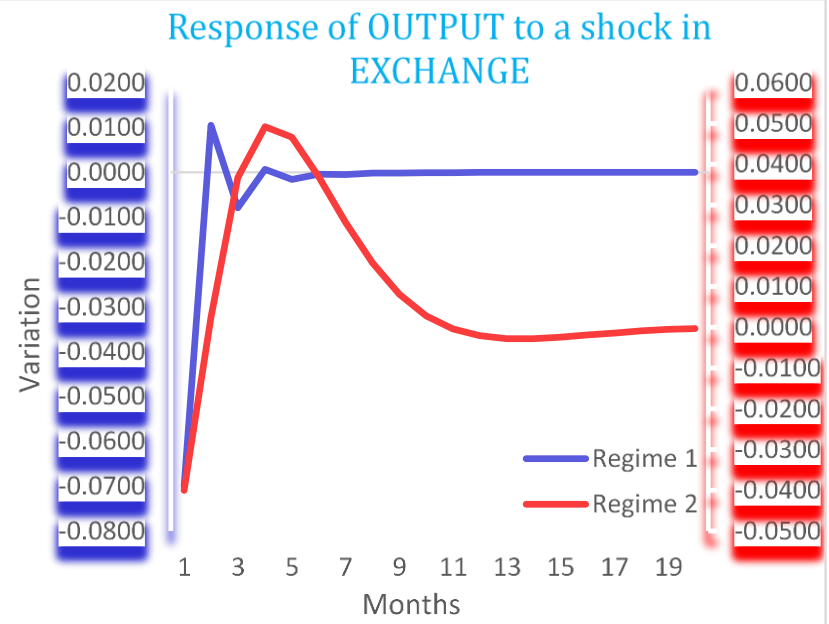
Fig. 10: Smoothed States Probabilities

Empirical results – IRF analysis









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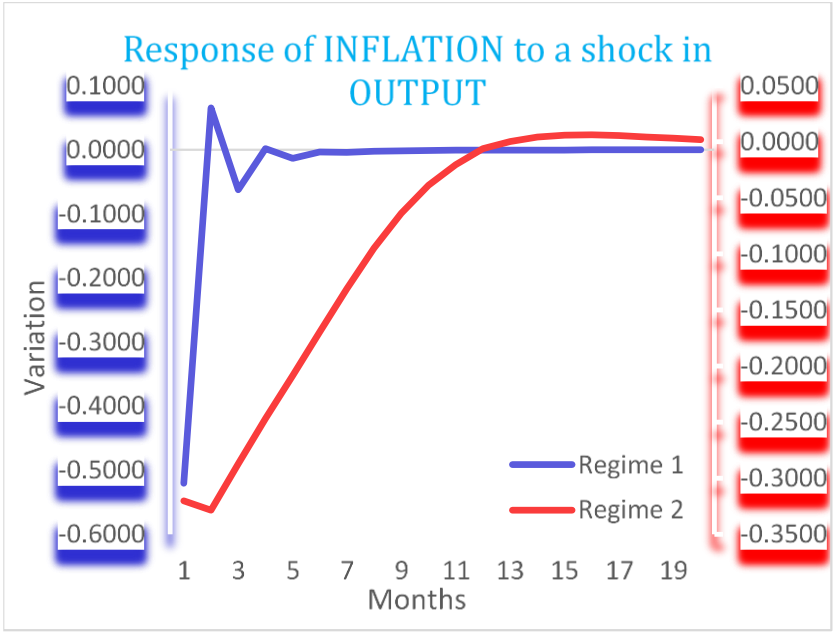

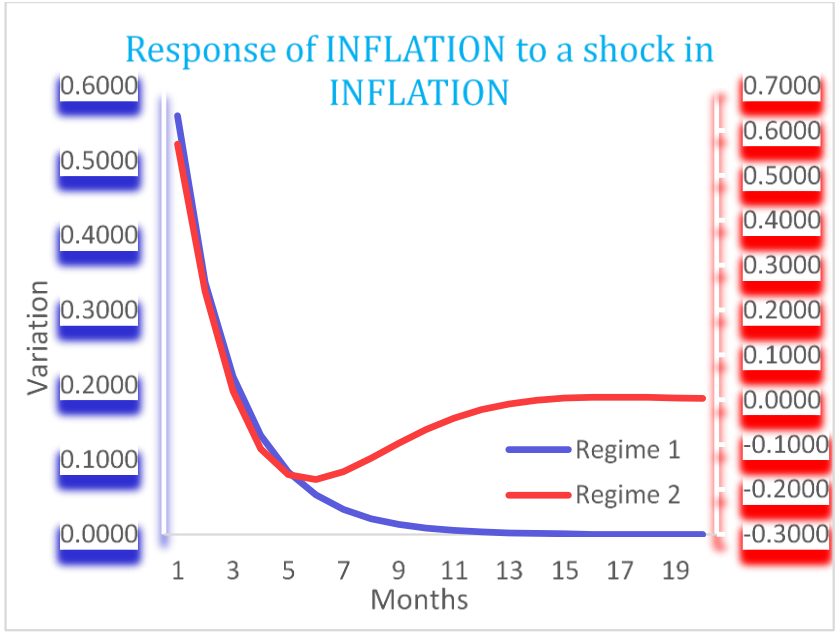

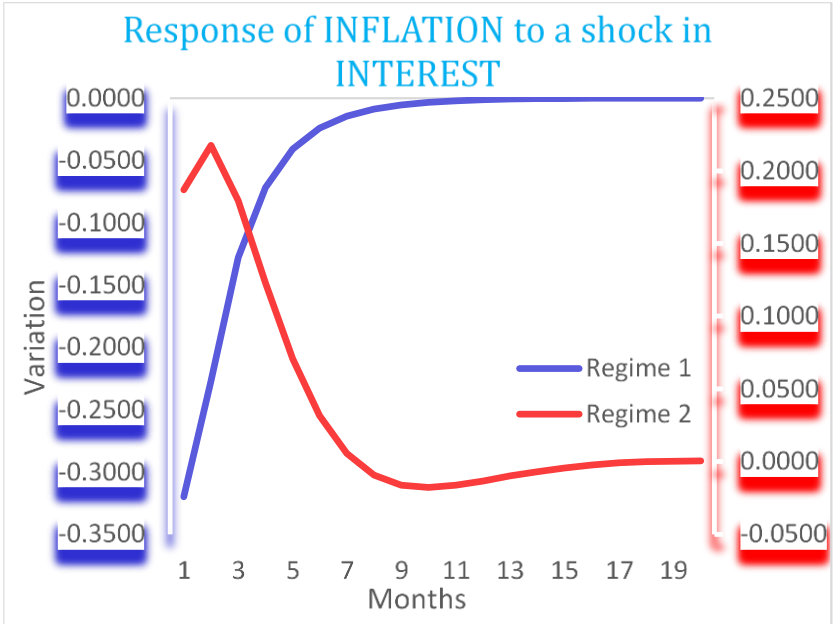

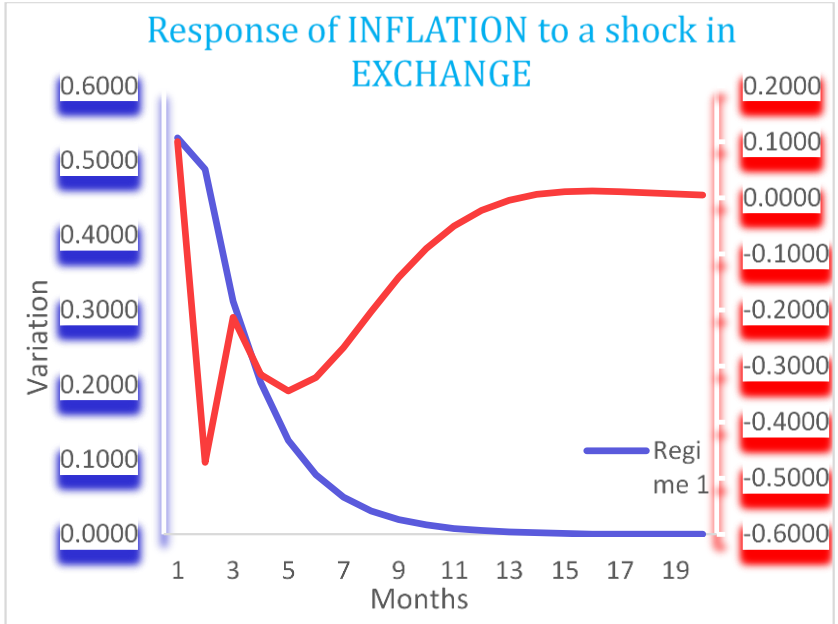

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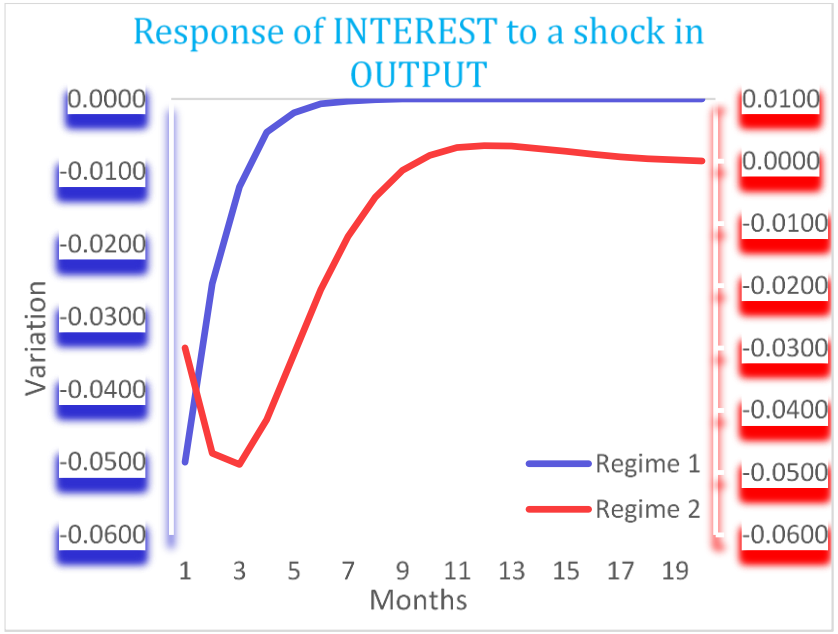

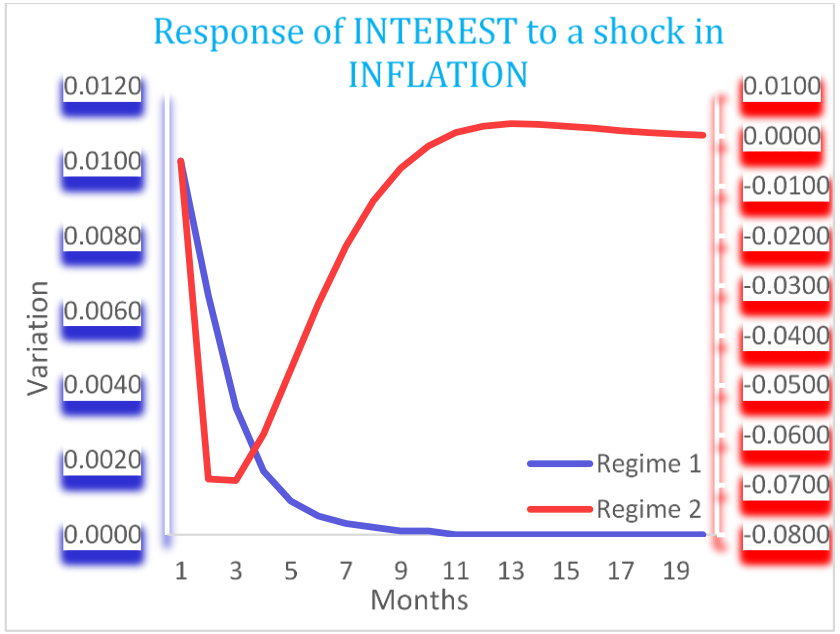

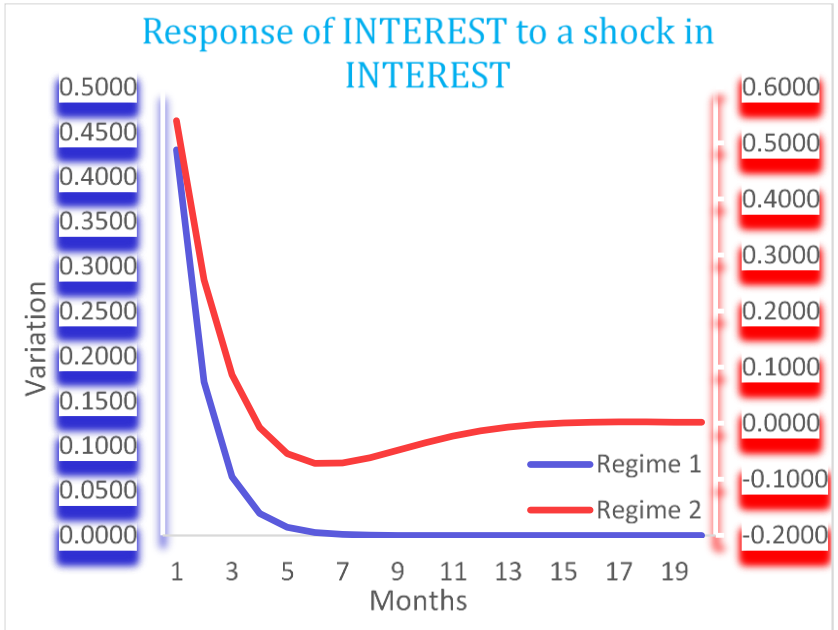

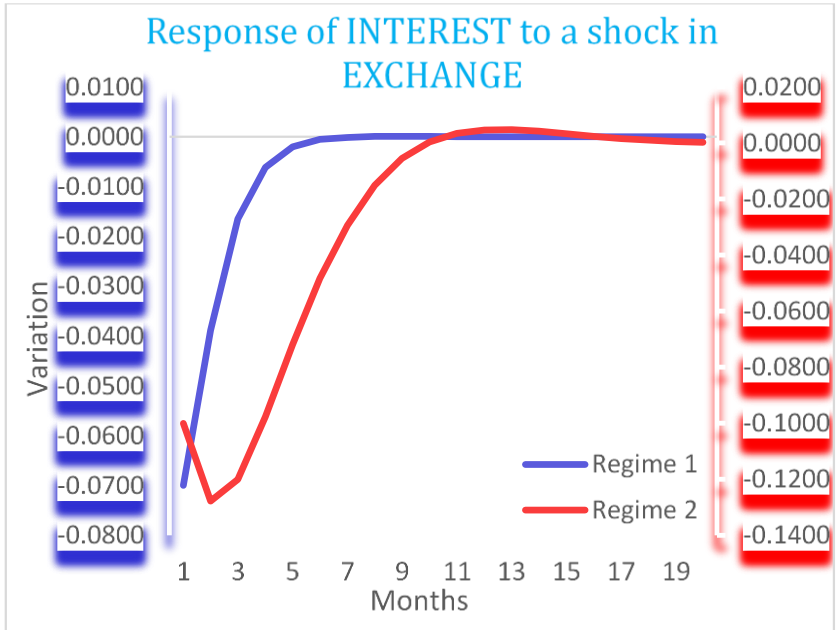

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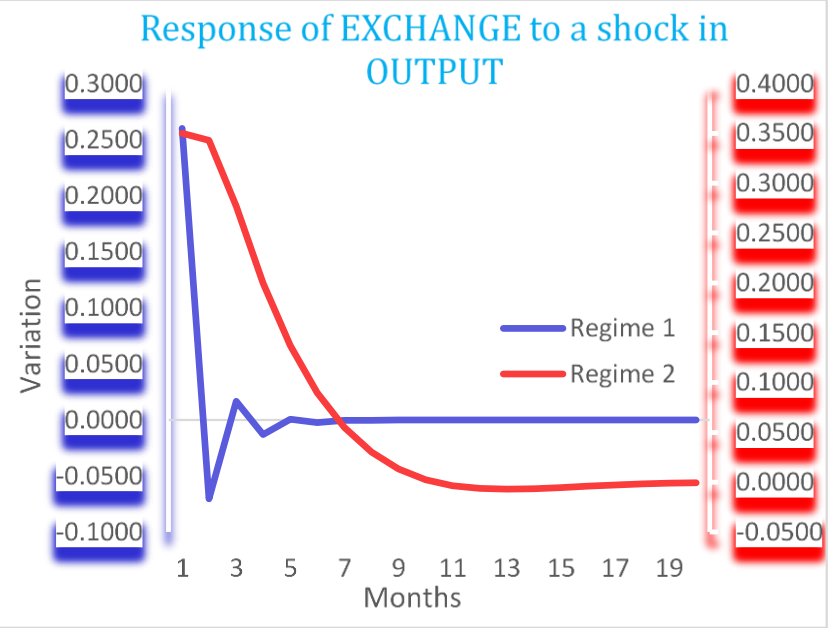
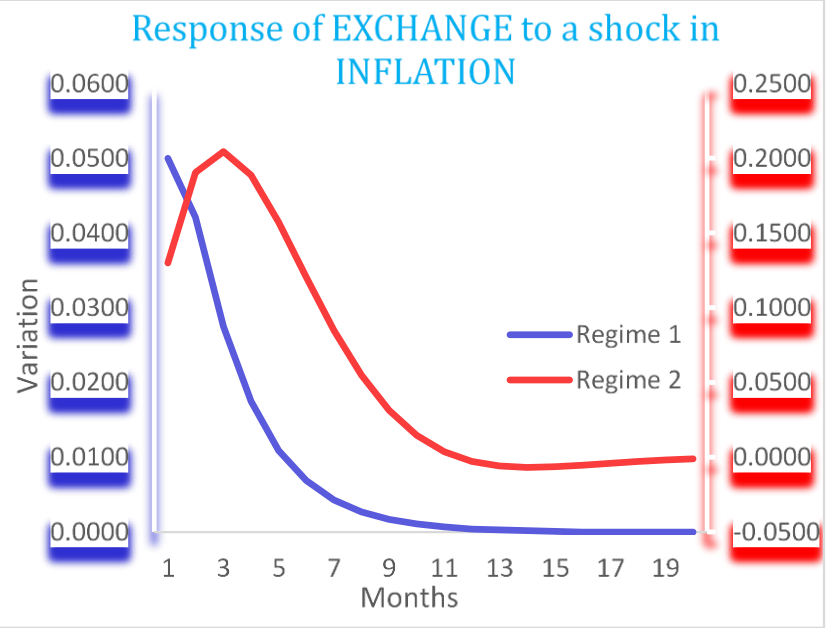
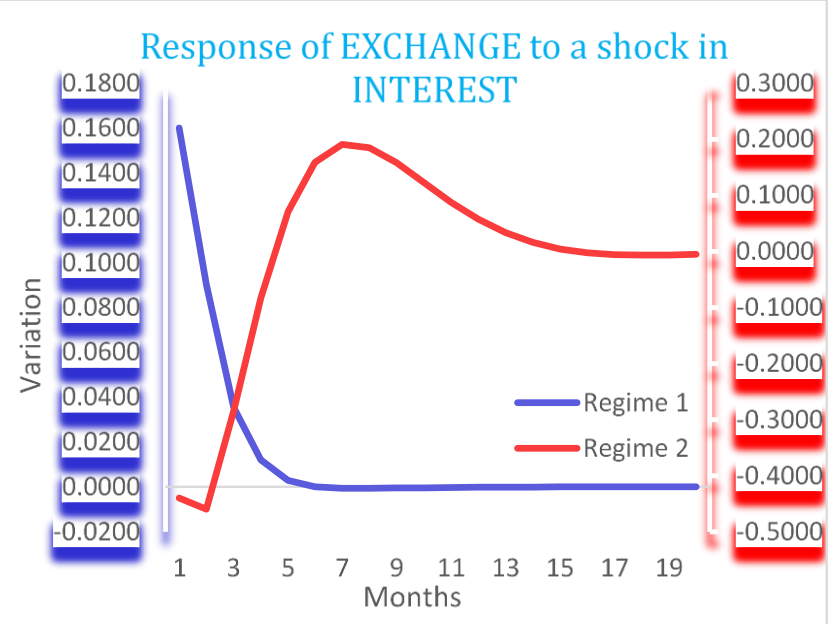
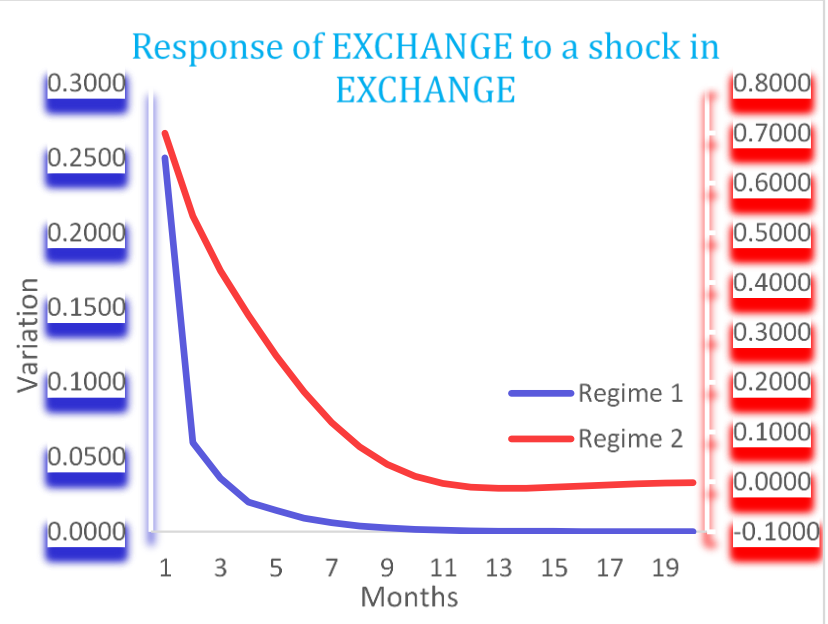






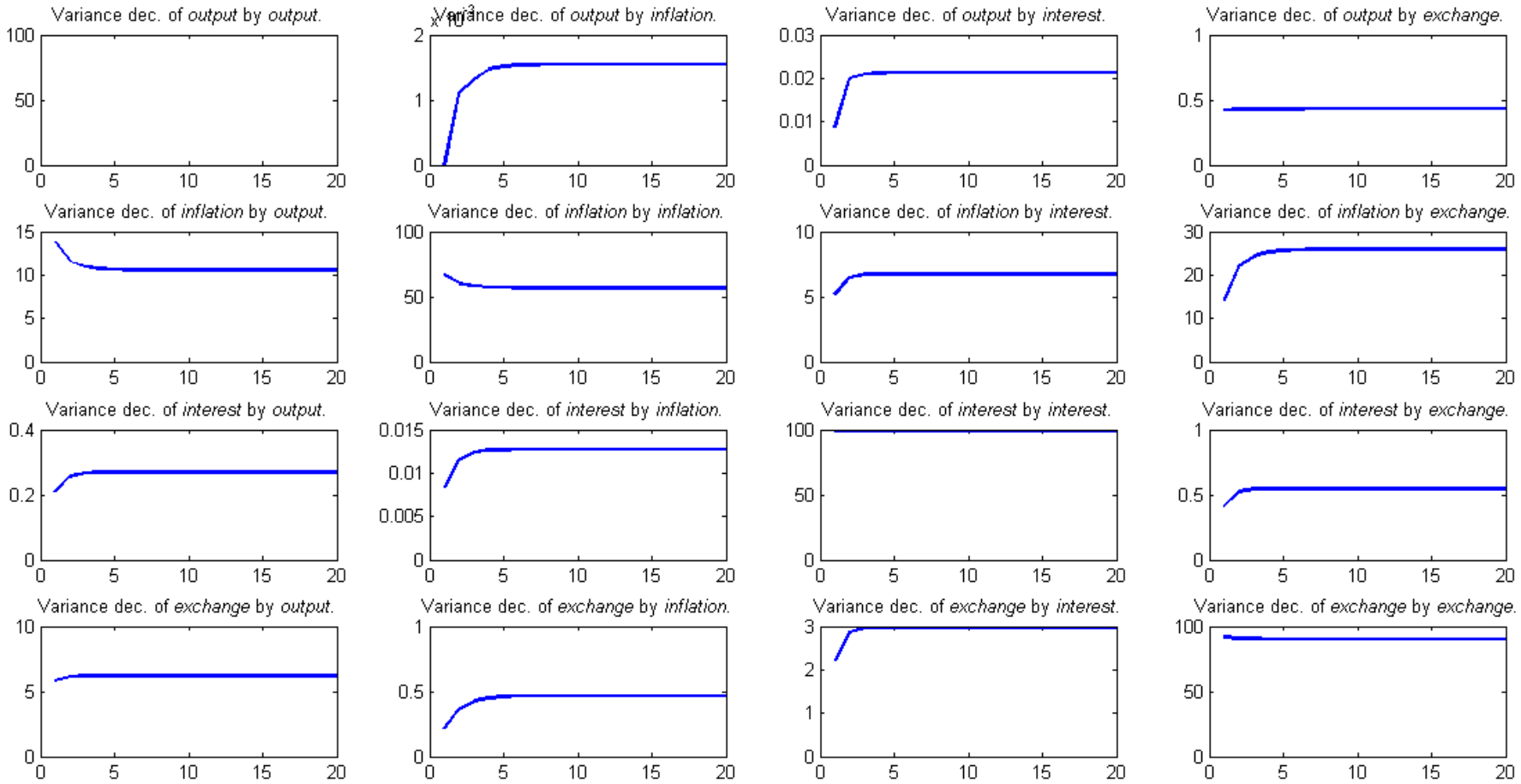


Empirical results – Variance decomposition

Table 7: Variance Decomposition (percent of total variance)				
Forecast horizon : 1 year				
Regime 1 (relative stability)				
	OUTPUT	INFLATION	INTEREST	EXCHANGE
OUTPUT	99.54	0.01	0.02	0.43
INFLATION	10.56	56.82	6.74	25.89
INTEREST	0.27	0.01	99.17	0.55
EXCHANGE	6.18	0.47	2.97	90.38
Regime 2 (crisis)				
	OUTPUT	INFLATION	INTEREST	EXCHANGE
OUTPUT	73.28	0.36	25.74	0.61
INFLATION	2.83	9.36	84.57	3.23
INTEREST	0.6	1.33	94.07	4
EXCHANGE	11.59	5.33	18.97	64.12

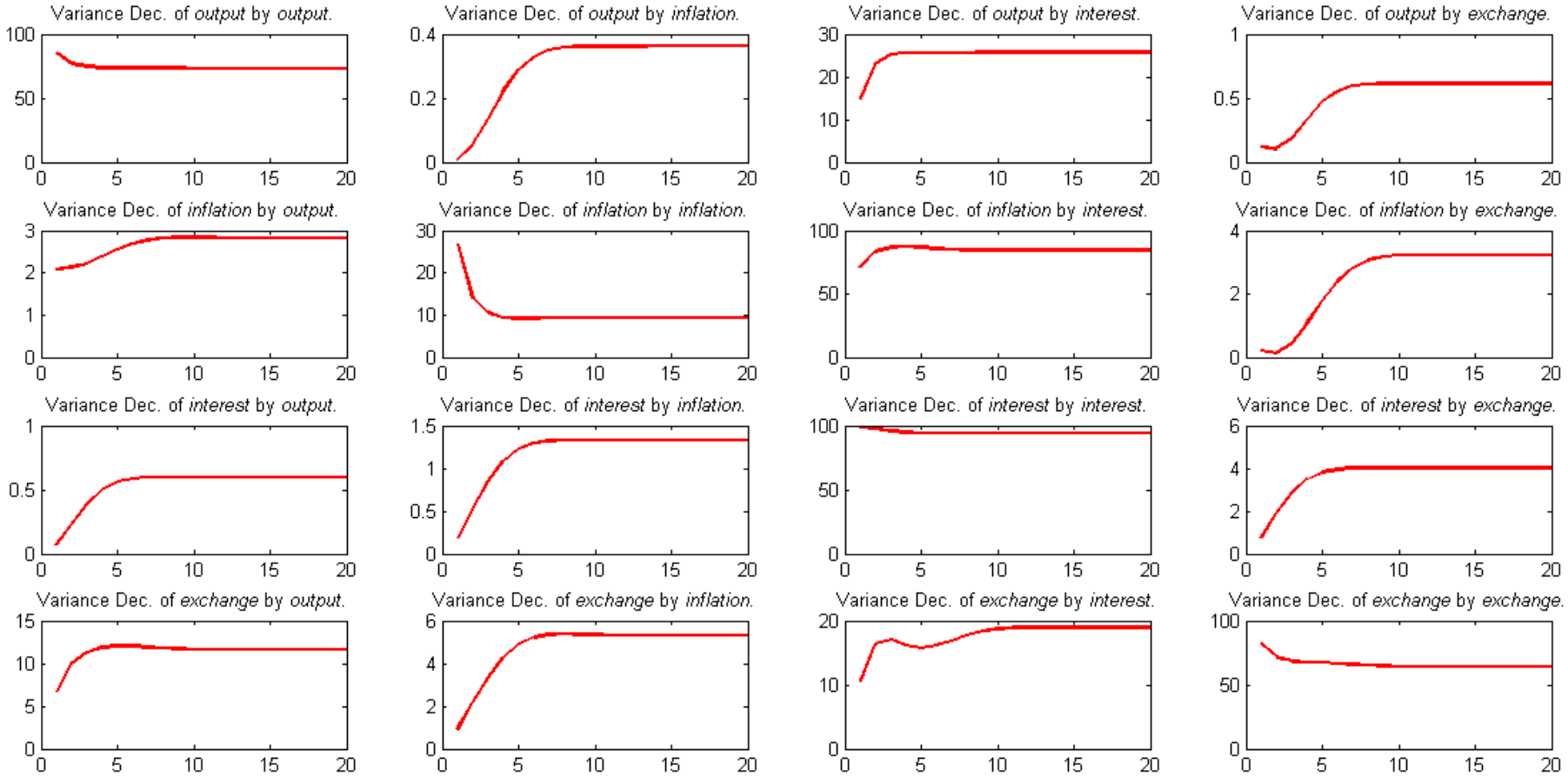
Empirical results – Variance decomposition

Variance Decomposition – Regime 1



Empirical results – Variance decomposition

Variance Decomposition – Regime 2



Concluding remarks and further research

- Major structural changes in the transmission mechanism of monetary policy in Romania;
- Greater amplitudes in the responses to shocks during the crisis regime --> the existence of an asymmetry in the transmission mechanism;
- Responses to disturbances within the crisis regime tend to be more persistent than the ones under the stable regime;
- Responses to disturbances within the stable regime are less expansive and more faster in their attenuation.

Further improvements and analysis:

- Markov Switching VAR with Time Varying Transition Probabilities;

- Markov Switching VAR with a Threshold variable.

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Thank you for your attention!