MSc. DOFIN

Eastern Europe in the World Economy: A Global VAR Analysis

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1.Motivation

- Increased integration and interependence in the world economy
- The recent global economic crisis has emphasized the existence of a ***World Business Cycle***; co-movement of output, inflation, interest rates
- As a result, national economic issues should be considered from a global perspective

2.Objectives

- Explore the international transmission mechanism of global shocks to emerging countries from Eastern Europe: Romania, Poland, Hungary

- Analyze the magnitude of synchronization and co-movement between macroeconomic variables

- Identify possible asymmetric responses between developed and emerging economies

3.Literature review

- The details of most global models are unavailable and cannot be properly evaluated (cf. Granger and Jeon(2007));
- Pesaran *et al. (2004)* introduced the GVAR framework to study regional interdependencies;
- Using the GVAR framework, Dees *et al. (2007a)* studied the effect of shocks on the Euro Area (treated as a single economy);
- Dees *et al. (2007b)* used the model of Dees *et al. (2007a)* to test long-run macroeconomic relations (PPP, UIP, Fisher) in the global economy;
- Pesaran *et al. (2009a)* considered the problem of forecasting with the GVAR;
- Cesa-Bianchi *et al. (2012)* analyzed the effects of the emergence of China in the global economy on Latin America .

4.The GVAR Model- *Country Specific Models*

- Consider *N+1* countries in the global economy: $i=0,1,\ldots,N$
- Each country is treated as a small open economy: VARX*(1,1)

$$x_{it} = a_{i0} + a_{i1}t + \phi_i x_{i,t-1} + \psi_{i0} x^*_{it} + \psi_{i1} x^*_{i,t-1} + \varepsilon_{it}$$
$$t = 1,2,\ldots,T; i = 0,1,2,\ldots N \qquad (4.1)$$

where $x^*_{kit} = \sum_{j=0}^{N} w_{ij} x_{kjt}$, $w_{ij} = \frac{IM_i^j + EX_i^j}{IM_i + EX_i}$ are treated as weakly

exogenous ⇨ avoid the "***curse of dimensionality***"

4.The GVAR Model

Why Trade Based Weights?

4.The GVAR Model – *Building the Global Model(1)*

- Defining $z_{it} = \begin{pmatrix} x_{it} \\ x_{it}^{*} \end{pmatrix}$, the VARX* model (4.1) can be written as

$$A_i z_{it} = a_{i0} + a_{i1} t + B_i z_{i,t-1} + \varepsilon_{it} \;, \quad A_i = (I_{k_i}, -\psi_{i0}) \,, \quad B_i = (\phi_i, \psi_{i1})$$

- Stacking all the endogenous variables, from all countries in a global vector $g_t = (x_{0t}', x_{1t}', ..., x_{Nt}')$ and noting that $z_{it} = L_i g_t$, the country specific model becomes:

$$A_i L_i g_t = a_{i0} + a_{i1} t + B_i L_i g_{t-1} + \varepsilon_{it} \qquad (4.2)$$

- Stacking all the country specific VARX* models together, yields the global model:

4.The GVAR Model- *Building the Global Model (2)*

$$Gg_t = a_0 + a_1 t + Mg_{t-1} + \varepsilon_t \quad (4.3)$$

where

$$G = \begin{pmatrix} A_0 L_0 \\ A_1 L_1 \\ . \\ . \\ . \\ A_N L_N \end{pmatrix}, a_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ . \\ . \\ . \\ a_{N0} \end{pmatrix}, a_1 = \begin{pmatrix} a_{01} \\ a_{11} \\ . \\ . \\ . \\ a_{N1} \end{pmatrix}, M = \begin{pmatrix} B_0 L_0 \\ B_1 L_1 \\ . \\ . \\ . \\ B_N L_N \end{pmatrix}, \varepsilon_t = \begin{pmatrix} \varepsilon_{0t} \\ \varepsilon_{1t} \\ . \\ . \\ . \\ \varepsilon_{Nt} \end{pmatrix}.$$

Assuming G is of full rank:

$$g_t = G^{-1}a_0 + G^{-1}a_1 t + G^{-1}Mg_{t-1} + G^{-1}\varepsilon_t \quad (4.4)$$

- The GVAR is stable if the eigenvalues of $G^{-1}M$ ***lie on or inside the unit circle***

4.The GVAR Model- *Transmission of Shocks*

- The GVAR methodology allows global interactions through **three distinct but interrelated channels**:

I. global effects from the contemporaneous dependence of x_{it} on foreign specific variables x_{it}^{*} and its lagged values;

II. dependence of country domestic variables with **global variable** (oil price) ;

III. contemporaneous dependence of shocks in country $\boldsymbol{i}$ on the shocks of country $\boldsymbol{j}$:

$$\sum_{ij} = Cov(\varepsilon_{it}, \varepsilon_{jt}) \neq 0$$

4.The GVAR Model- *Error-Correction Properties*

- The error-correction form of the VARX*(1,1) model:

$$\Delta x_{it} = a_{i0} + a_{i1}t - (I_{k_i} - \phi_i)x_{i,t-1} + \psi_{i0}\Delta x_{it}^{*} + (\psi_{i0} + \psi_{i1})x_{i.t-1}^{*} + \varepsilon_{it} \qquad (4.5)$$

which can be rewritten as

$$\Delta x_{it} = a_{i0} + a_{i1}t - \Omega_i z_{i,t-1} + \psi_{i0}\Delta x_{it}^{*} + \varepsilon_{it}$$

- Under the assumption that $rank(\Omega_i) = r_i < k_i$ then $\Omega_i = \lambda_i \beta_i'$
- Restricting the trend coefficients to lie in the cointegration space:

$$a_{i1} = \Omega_i \nu_i$$

and taking into account the reduced rank assumption, (4.5) becomes:

$$\Delta x_{it} = a_{i0} + \Omega_i \nu_i - \lambda_i \beta_i' [z_{i,t-1} - \nu_i (t-1)] + \psi_{i0}\Delta x_{it}^{*} + \varepsilon_{it} \qquad (4.6)$$

5.Econometric Methodology

World Coverage of the GVAR-more than 90% of the global GDP

USA	**Euro Area**	**Latin America**
China	Germany	Argentina
Japan	France	Brazil
UK	Italy	Mexico
	Spain	Chile
Other developed economies	Netherlands	Peru
Canada	Belgium	
Australia	Austria	**Eastern Europe**
New Zealand	Finland	Romania
		Poland
Asia	**Western Europe**	Hungary
Korea	Sweden	
Indonesia	Switzerland	**Rest of the World**
Thailand	Norway	India
Philippines		South Africa
Malaysia		Turkey
Singapore		Saudi Arabia

- Euro Area treated a single economy- GDP-PPP (2008-2011) weights used at aggregation

5.Econometric Methodology-*Specification*

- Variables specification in country specific VARX* models

Non-US models		US model	
Domestic	Foreign	Domestic	Foreign
y_{it}	y_{it}^{*}	y_{US}	y_{US}^{*}
π_{it}	π_{it}^{*}	π_{US}	π_{US}^{*}
$\mathrm{Re}\,alEQ_{it}$	$\mathrm{Re}\,alEQ_{it}^{*}$	$\mathrm{Re}\,alEQ_{US}$	–
$\mathrm{Re}\,alEx_{it}$	–	–	$\mathrm{Re}\,alEx_{US}^{*}$
rs_{it}	rs_{it}^{*}	rs_{US}	–
rl_{it}	rl_{it}^{*}	rl_{US}	–
–	p_t^{o}	p_t^{o}	–

where

$$y_{it} = \ln(GDP_{it} / CPI_{it}), \qquad \pi_{it} = \ln(CPI_{it}) - \ln(CPI_{i,t-1}),$$

$$\mathrm{Re}\,alEQ = \ln(EQ_{it} / CPI_{it}), \qquad \mathrm{Re}\,alEx = \ln(E_{it}) - \ln(CPI_{it}),$$

$$rl = 0.25 * \ln(1 + R_{it}^{L} / 100), \qquad rs = 0.25 * \ln(1 + R_{it}^{S} / 100),$$

5.Econometric Methodology- *Trade Weights*

Trade Weights used in The GVAR Model (2008-2011)

Country	US	EURO	CHINA	HUNGARY	ROMANIA	POLAND	REST
US	0	0.147863	0.169692	0.001546	0.000741	0.002357	0.6778
EURO	0.136092	0	0.133851	0.032412	0.019789	0.068162	0.609694
CHINA	0.190765	0.173869	0	0.004205	0.00185	0.005688	0.623624
HUNGARY	0.022446	0.646832	0.063678	0	0.054646	0.055198	0.1572
ROMANIA	0.017804	0.63722	0.039966	0.091391	0	0.040801	0.172819
POLAND	0.019241	0.708813	0.041638	0.030966	0.013125	0	0.186217

Note: rows but not columns sum up to one

Source: author computation, IMF, Direction of Trade Statistics

- Since 2001 the trade share of E.A with U.S. halved while the trade share with China more than doubled
- Emerging markets have a bigger trade share with China than with US
- E.A is a key block in the transmission of shocks to Eastern Europe

5.Econometric Methodology- *Unit Root Tests*

- Weighted symmetric estimation of ADF regressions chosen to study the stationarity of the series;
- Test Results are available at pages 22 and 23 in the main paper
- **The test results supported the unit root hypothesis** with a few exceptions
- Inflation in some countries seems to be *I*(0)- *overdifferencing not a serious specification error*
- Real GDP in India appears to be *I*(2) - ***NOT PLAUSIBLE***

5.Econometric Methodology- *Estimation*

- Sample: 1998Q2-2011Q2
- Due to data limitations VARX*(1,1) chosen
- Data source: GVAR Data (2011 Vintage), IMF International Financial Statistics
- Determine the rank of Ω_i using the trace statistics
- Impose r_i^2 restrictions on the cointegration space:

$$\beta_i' = \left(I_{r_i} \vdots W_i\right)$$

- the coefficients from W_i estimated with reduced rank regression
- Other parameters consistently estimated using OLS regressions:

$$\Delta x_{it} = d_i + \lambda_i ECM_{i,t-1} + \psi_{i0}\Delta x_{it}^* + \varepsilon_{it} \qquad (5.1)$$

- 133 from 149 regressions pass the serial correlation test at 5% significance level

5.Econometric Methodology- *Cointegration Tests*

Number of Cointegration Relations in individual VARX(1,1) models (**Trace Statistics**)*

Country	CR	Country	CR
ARGENTINA	**3**	NORWAY	**5**
AUSTRALIA	**2**	NEW ZEELAND	**3**
BRAZIL	**3**	PERU	**3**
CANADA	**2**	PHILIPPINES	**3**
CHILE	**3**	POLAND	**3**
CHINA	**2**	ROMANIA	**2**
EURO	**3**	SOUTH AFRICA	**4**
HUNGARY	**2**	SAUDI ARABIA	**2**
INDIA	**2**	SINGAPORE	**3**
INDONESIA	**3**	SWEEDEN	**2**
JAPAN	**1**	SWITZERLAND	**1**
KOREA	**2**	THAILAND	**3**
MALAYSIA	**3**	TURKEY	**3**
MEXICO	**2**	UK	**4**
		US	**2**

5.Econometric Methodology- *Persistence Profiles (1)*

- Refer to the time profiles of the effect of shocks on the cointegration relations
- Unity at impact; should tend to zero if the vector is a ***" true cointegration relation":***

$$PP(\beta_{ji}' z_{it}; \zeta_t; n) = \frac{\beta_{ji}' L_i F^n \sum_\zeta F^{n\prime} L_i' \beta_{ji}}{\beta_{ji}' L_i \sum_\zeta L_i' \beta_{ji}} \quad (5.2)$$

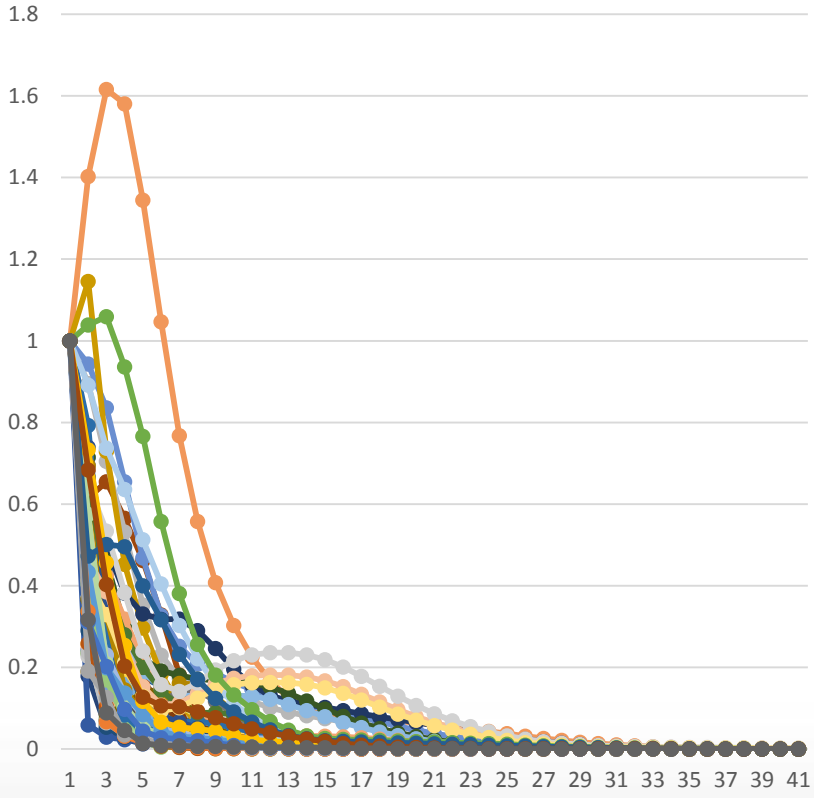
effect on the cointegration relation at time *n*

initial effect on the cointegration relation

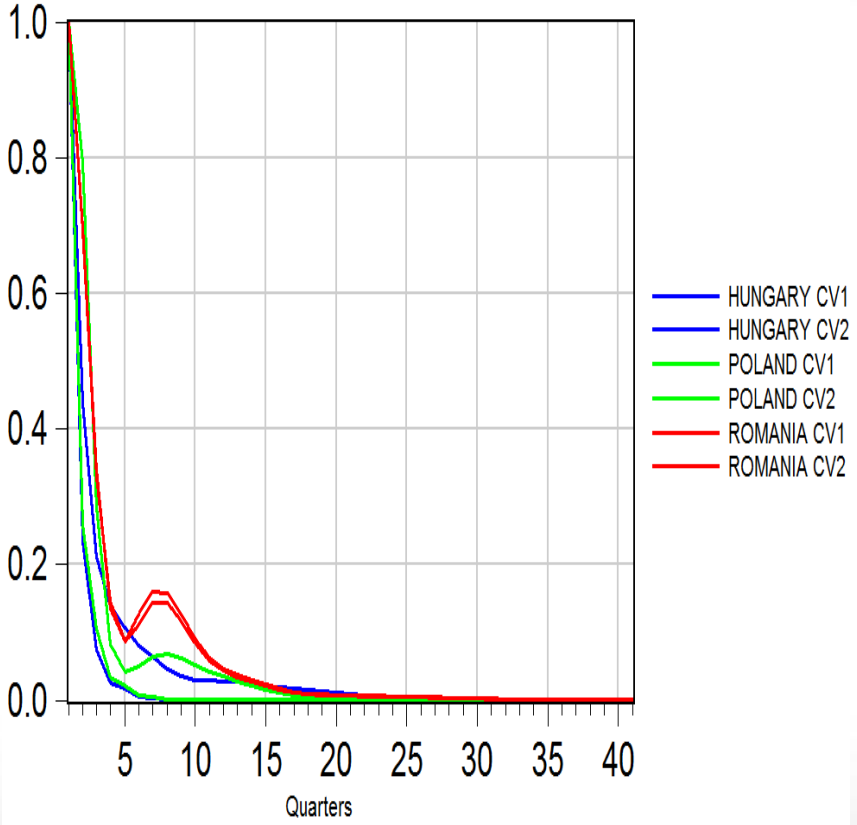
- The number of cointegration relations was reduced in some cases based on an preliminary analysis of PPs and stability of the model
- ***29 long-run macroeconomic relations in the Global Economy***

5.Econometric Methodology- *Persistence Profiles(2)*

PPs for ALL the cointegration vectors



PPs for Eastern Europe



- Satisfactory speed of convergence to equilibrium

5.Econometric Methodology- *Weak Exogeneity*

- Test the joint significance of the estimated ECM in the following auxiliary regressions:

$$\Delta x^{*}_{it,l} = a_{il} + \sum_{j=0}^{r_i} \rho_{ij,l} ECM^{j}_{i,t-1} + \gamma_{il} \Delta x_{i,t-1} + \chi_{il} \Delta \tilde{x}^{*}_{i,t-1} + \varepsilon_{il,t}$$

- Evaluate $\rho_{ij,l} = 0,\ j = 1, 2, ..., r_i$ using standard *F* tests

Table 4.4 1: *F statistics for the weak exogeneity tests*

Country	F test	Fcrit_5%	y^{*}	π^{*}	Re $alEQ^{*}$	Re $alEx^{*}$	rs^{*}	rl^{*}	p^{o}
CHINA	F(1,37)	4.105456	3.574678	3.938403	3.389909	NA	0.750883	3.910219	0.340867
EURO	F(3,33)	2.891564	0.468523	0.389718	0.952721	NA	0.947668	1.97932	0.1129
HUNGARY	F(2,35)	3.267424	0.779912	0.340454	1.09468	NA	1.31176	0.860159	0.324466
POLAND	F(2,35)	3.267424	0.050982	0.875299	0.479059	NA	1.437683	0.650128	0.29864
ROMANIA	F(2,35)	3.267424	0.258939	0.132282	1.638794	NA	0.281566	1.011246	0.944686
US	F(1,39)	4.091279	0.764995	0.140963	NA	0.772443	NA	NA	NA

- the weak exogeneity assumption was ***rejected only for 2*** out of 171

5.Econometric Methodology- *Impact Elasticities*

$$\Delta x_{it} = d_i + \lambda_i ECM_{i,t-1} + \psi_{i0}\Delta x_{it}^{*} + \varepsilon_{it}$$

Contemporaneous effects of foreign variables on their domestic counterparts

	Domestic Variables				
Country	y	π	$RealEQ$	rs	rl
CHINA	0.888355*	0.116537	NA	0.607115*	NA
	(0.51)	(0.29)		(0.28)	
EURO	0.679534*	0.510953*	1.15647*	0.322104*	1.033555*
	(0.16)	(0.06)	(0.04)	(0.07)	(0.09)
HUNGARY	1.129229*	1.524596*	1.333934*	1.034662*	NA
	(0.28)	(0.51)	(0.16)	(0.40)	
POLAND	-0.28127	1.891795*	1.202576*	0.372391*	NA
	(0.47)	(0.44)	(0.10)	(0.25)	
ROMANIA	0.625334	1.373937*	0.808609*	1.179451*	NA
	(0.72)	(0.36)	(0.39)	(0.48)	
US	0.675353*	0.977974*	NA	NA	NA
	(0.00)	(0.04)			

*Note: * denotes significance at the 5% level. White's heteroscedastic-robust standard errors are given in parentheses.*

- Equity markets overreact to foreign equity price changes
- Monetary policy reactions are more synchronized than they were 30 years ago

5.Econometric Methodology- *Average Cross-Section Correlations of Residuals*

Variable	Country	VECMX* Residuals	Variable	Country	VECMX* Residuals
y	CHINA	-0.10455	$RealEx$	CHINA	0.084154
y	EURO	0.033751	$RealEx$	EURO	0.238359
y	HUNGARY	0.062995	$RealEx$	HUNGARY	0.139532
y	POLAND	0.025149	$RealEx$	POLAND	0.268836
y	ROMANIA	-0.0174	$RealEx$	ROMANIA	0.270369
y	US	-0.00627	$RealEx$	US	NA
π	CHINA	-0.05221	rs	CHINA	-0.01727
π	EURO	-0.02466	rs	EURO	0.027271
π	HUNGARY	0.04536	rs	HUNGARY	-0.00145
π	POLAND	0.022733	rs	POLAND	-0.0595
π	ROMANIA	0.034735	rs	ROMANIA	0.015978
π	US	-0.05487	rs	US	-0.01201
$RealEQ$	CHINA	NA	rl	CHINA	NA
$RealEQ$	EURO	-0.0447	rl	EURO	-0.02672
$RealEQ$	HUNGARY	-0.04598	rl	HUNGARY	NA
$RealEQ$	POLAND	-0.03531	rl	POLAND	NA
$RealEQ$	ROMANIA	0.013462	rl	ROMANIA	NA
$RealEQ$	US	-0.03117	rl	US	-0.03609

- ***Small correlations of residuals***; do not depend on the choice of variable or country

5.Econometric Methodology- *Impulse Response Analysis*

- The shocks between countries are weakly correlated:

$$\sum_{ij} = Cov(\varepsilon_{it}, \varepsilon_{jt}) \neq 0$$ ⇨ Spillover effects

- **Generalized Impulse Response Functions** (*Pesaran & Shin (1998)*):

$$GI_{g:\varepsilon_{lt}}(n, \sqrt{\sigma_{ll}}, I_{t-1}) = E(g_{t+n} / \varepsilon_{lt} = \sqrt{\sigma_{ll}}, I_{t-1}) - E(g_{t+n} / I_{t-1}) \qquad (5.1)$$

$$GIRF(g_t, \varepsilon_{lt}, n) = \frac{\theta_j' F^n G^{-1} \sum_{\varepsilon} \theta_l}{\sqrt{\sigma_{ll}}} \qquad (5.2)$$

- GIRFs – invariant to the ordering of the variables
  – capture historical correlation between shocks

5.Econometric Methodology- *Stability*

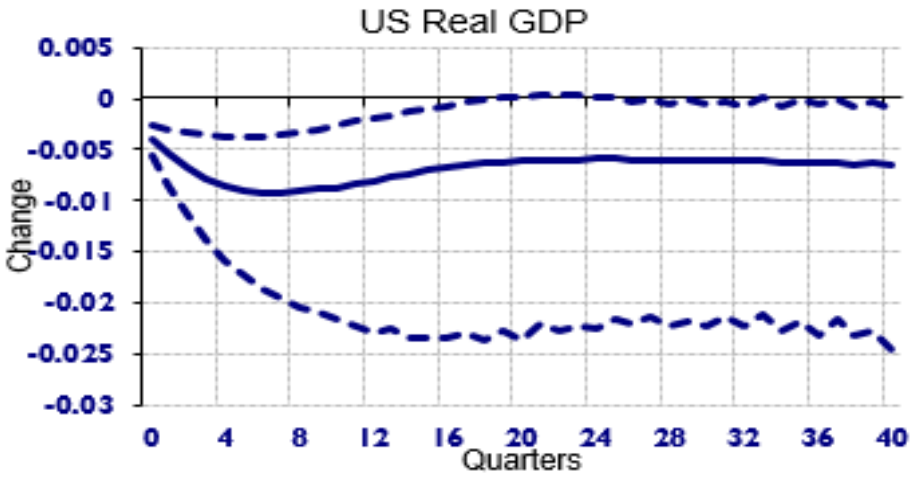
- From 149 eigenvalues 86 lie **on** the unit circle ⇨ **permanent effects of the shocks**
- The other have moduli less than one; the three largest: 0.9 ,0.9 ,0.86
- Some are complex ⇨ **cyclical behavior in the GIRFs**

6.Shock Scenarios

- A one standard error negative shock to US GDP
- A one standard error negative shock to US Equity Prices
- A one standard error positive shock to US long-term interest rates
- A one standard error negative shock to Euro Area GDP
- A one standard error negative shock to Euro Area Equity Prices

6.Shock Scenarios: A Shock to US GDP

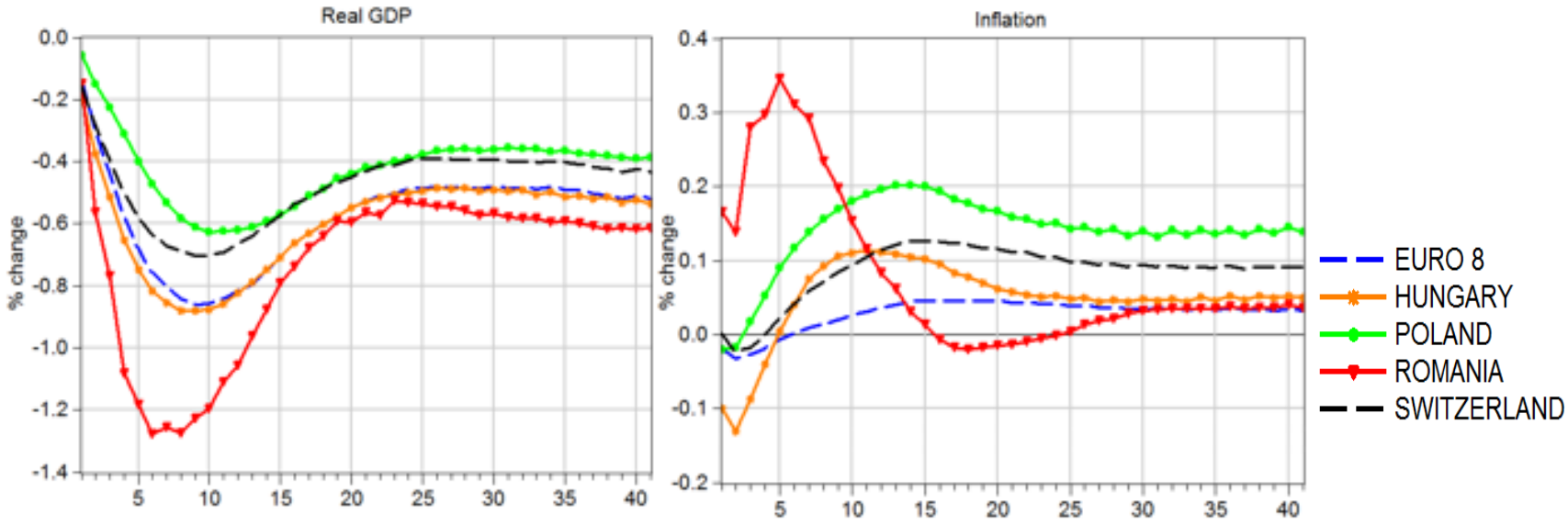
GIRFs from a Negative Unit (- 1 σ) Shock to US Real Output
(bootstrapped median estimates with 90% confidence bands)



- The shock is associated with a decrease in inflation, interest rates and equity prices ⇨ given the signs of the responses, the shock can be interpreted as a **demand shock**

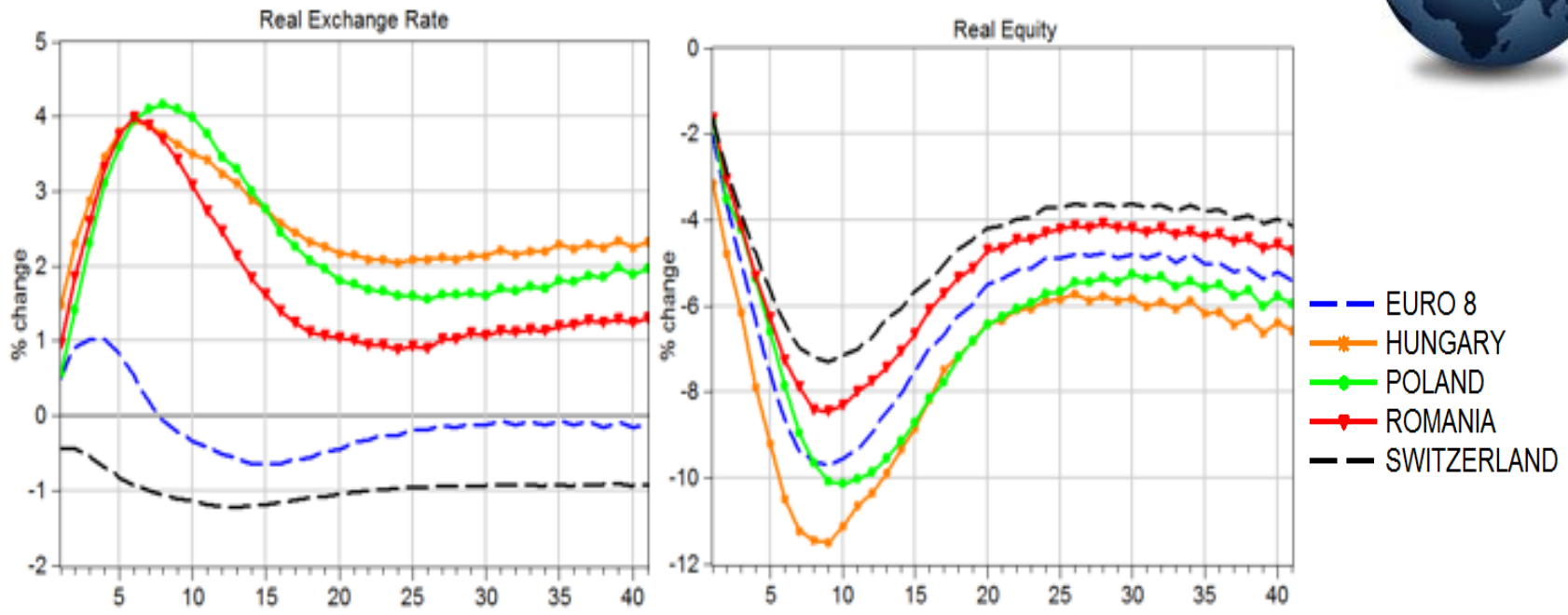
6.Shock Scenarios: A Shock to US GDP

GIRFs from a Negative Unit (- 1 σ) Shock to U.S. Real Output
(bootstrapped median estimates)



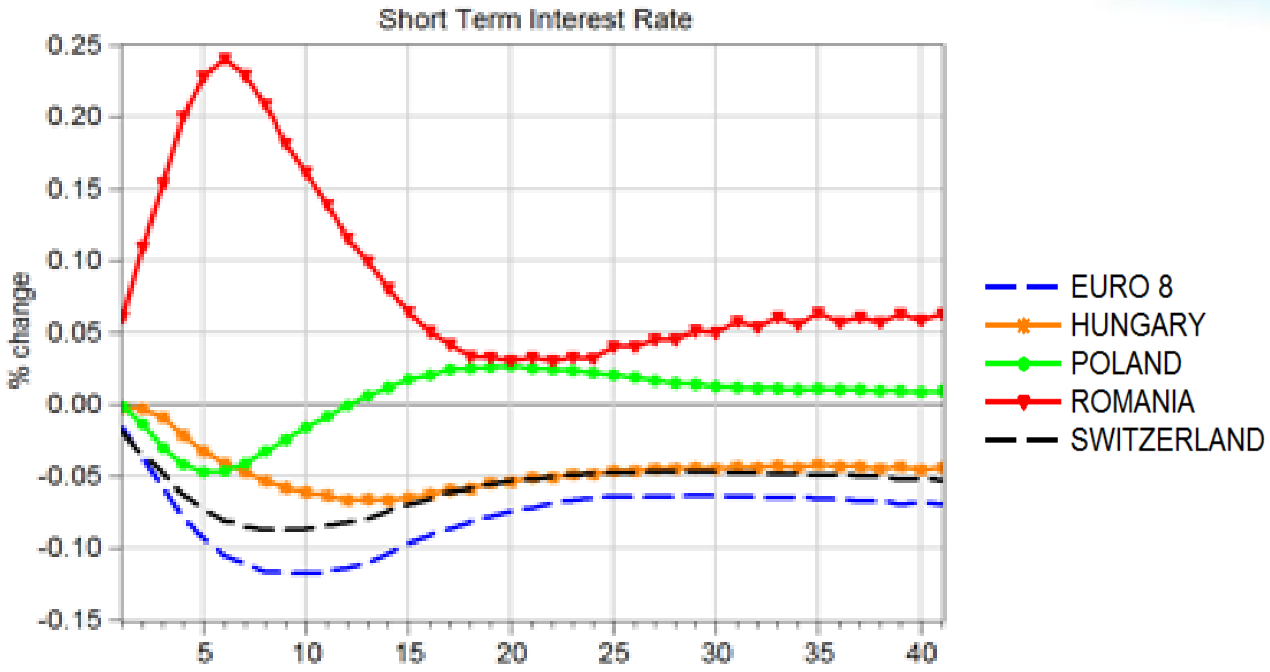
- Romania has the fastest and largest drop in real output
- Poland seems to be less affected than the other countries
- The transmission of the shock seems to be relatively slow
- Over time the shock propagation increases

6.Shock Scenarios: A Shock to US GDP



- Asymmetric responses of exchange rates ⇨ "***flight to quality***"
- Larger volatility of exchange rates in emerging countries
- Financial linkages - important channel in transmission of shocks
- Equity markets react strongly- 7-12% decrease in the first 2 years- double compared to US equity prices

6.Shock Scenarios: A Shock to US GDP

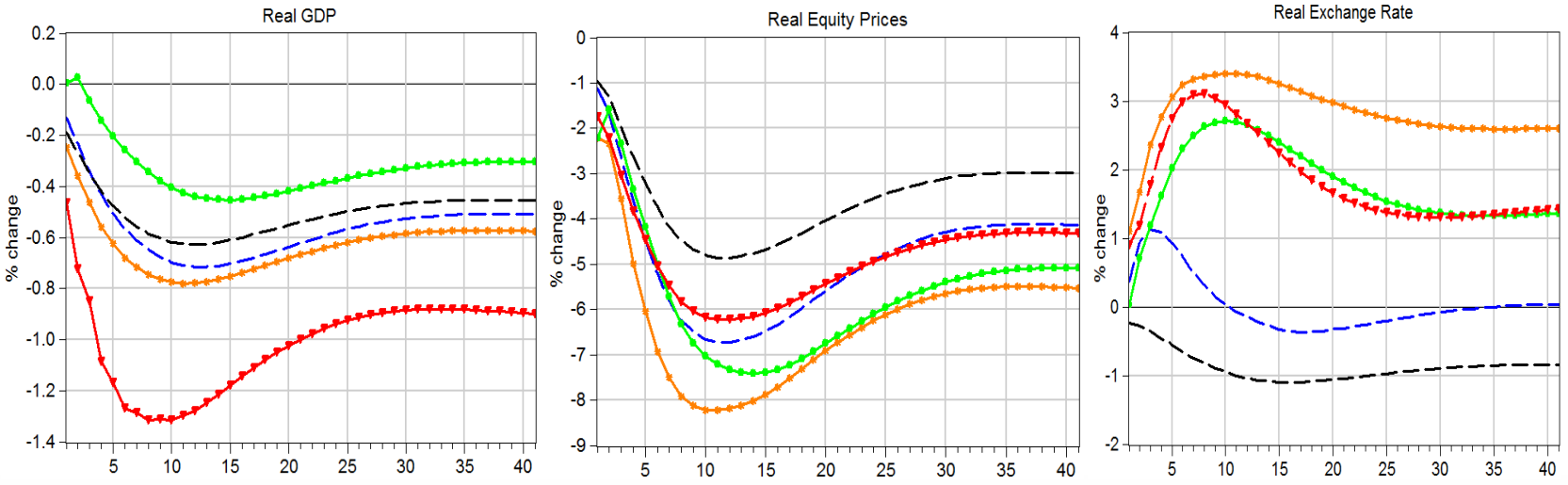


- Monetary authorities seem *to accommodate the negative US GDP shock by lowering interest rates*
- The response of the interest rate in Romania mimics the response of the monetary policy in Romania at the beginning of the global *recession-* ***procyclical monetary policy-*** could explain the large drop in Real GDP
- Hypothesis proposed- mix of "***fear of floating***" and "***fear of loosing reserves***"

6.Shock Scenarios: *Structural US GDP Shock- Aggregate Demand Shock*

- Cholesky decomposition of the covariance matrix of US errors
- Monetary policy cannot react contemporaneously to output deviations:

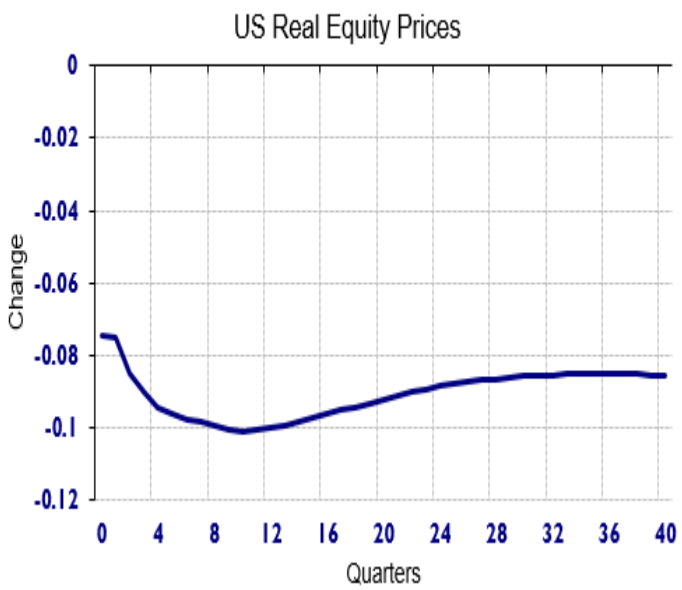
$$x_{USt} = (oil, \textit{short-term interest rate}, \textit{long-term interest rate}, \textit{equity prices}, \textit{inflation and output}).$$

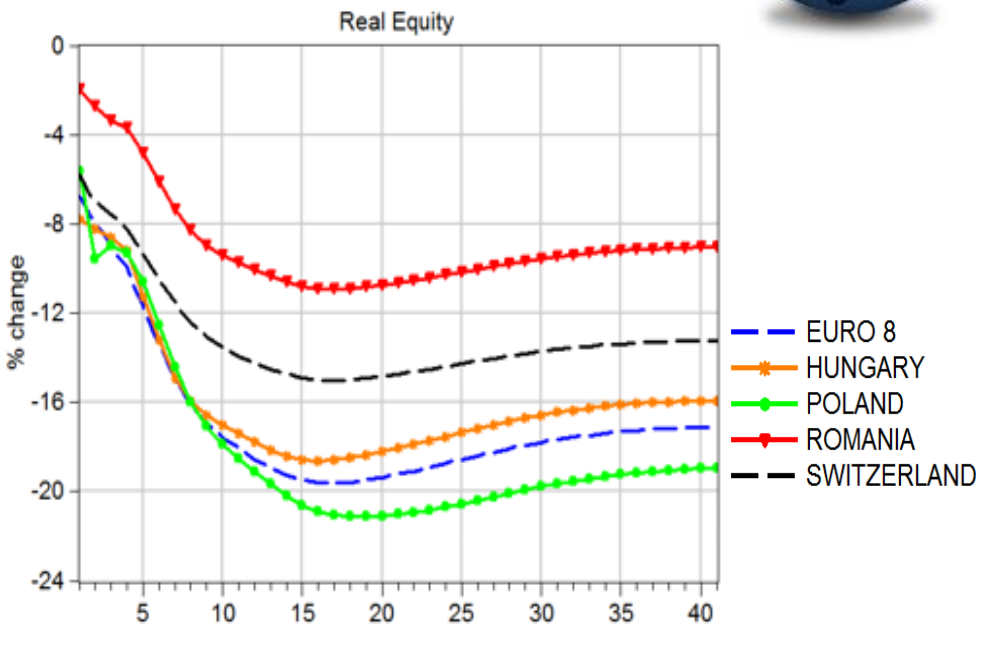


- ***The results are almost identical to the unidentified case*** ⇨ modest correlation in the residuals

6.Shock Scenarios: A Shock to US Equity Prices

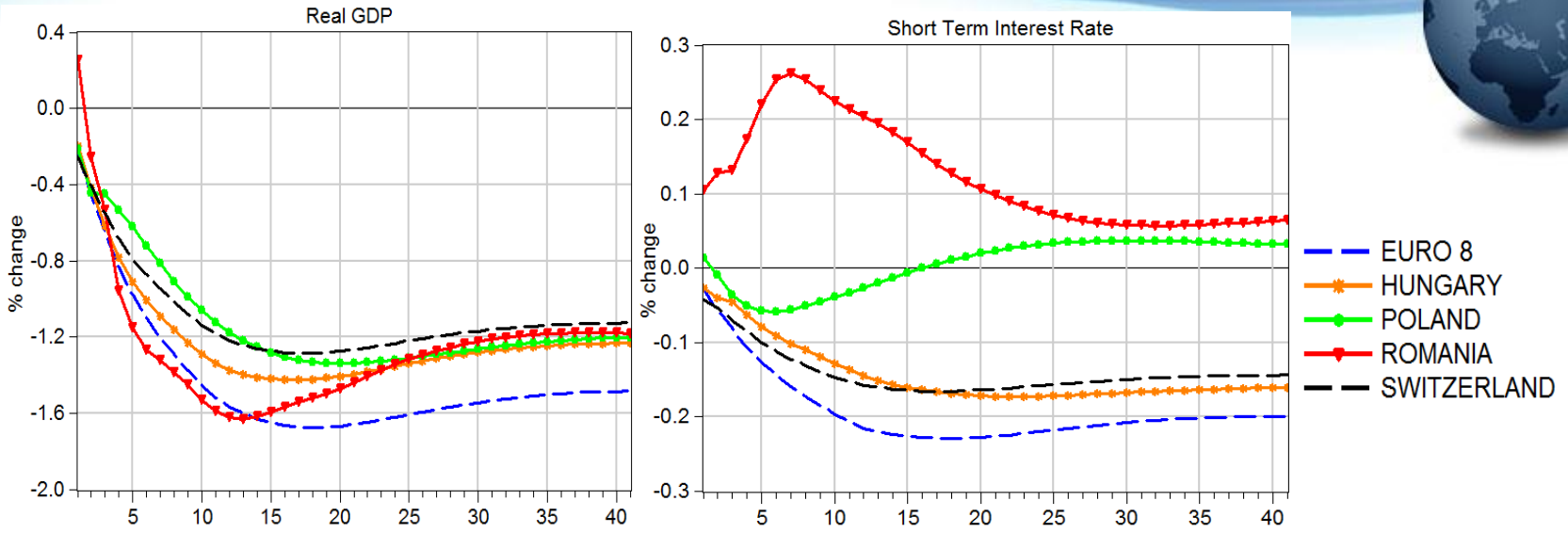
GIRF of U.S. Real Equity from a Negative Shock (-1 σ) to U.S. Real Equity (point estimates)

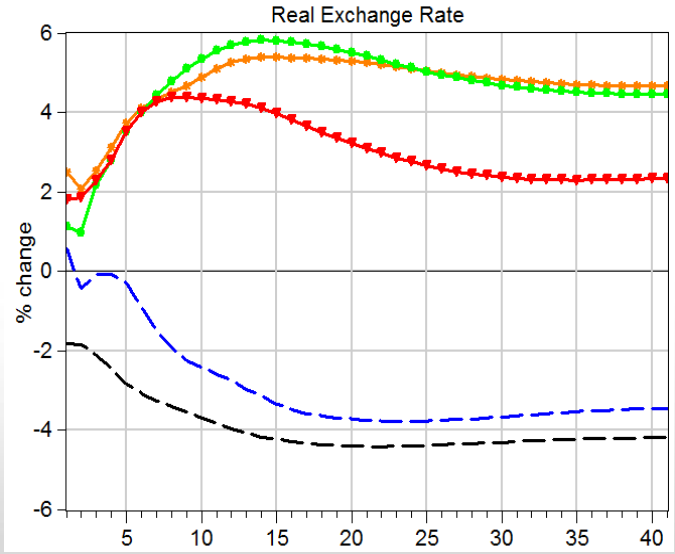




- the ***transmission mechanism*** to other equity markets is ***fast*** and significant
- In the case of Poland and Hungary, the overall impact is 2 times greater than the decrease in US equity prices and ***3 times compared to the initial shock***
- Equity markets tend to ***overshoot*** the US response

6.Shock Scenarios: A Shock to US Equity Prices

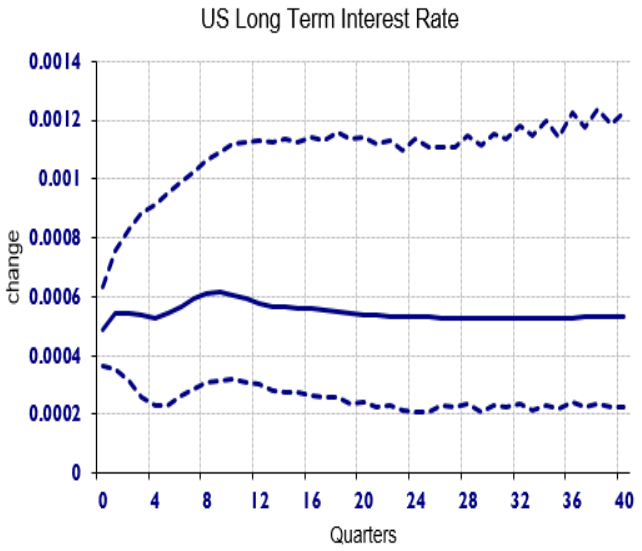


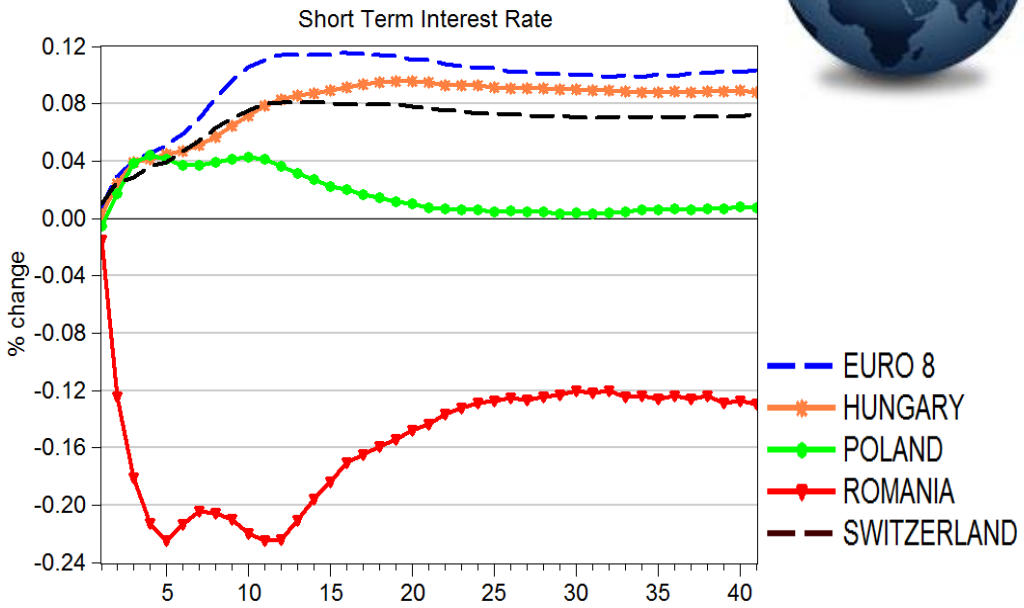


- The same asymmetric response of exchange rates as in the case of the US GDP Shock
- GDP is less affected on impact but continues to decrease over time
- Interest rates tend to decrease

6.Shock Scenarios: A Shock to US Long-Term Interest Rates

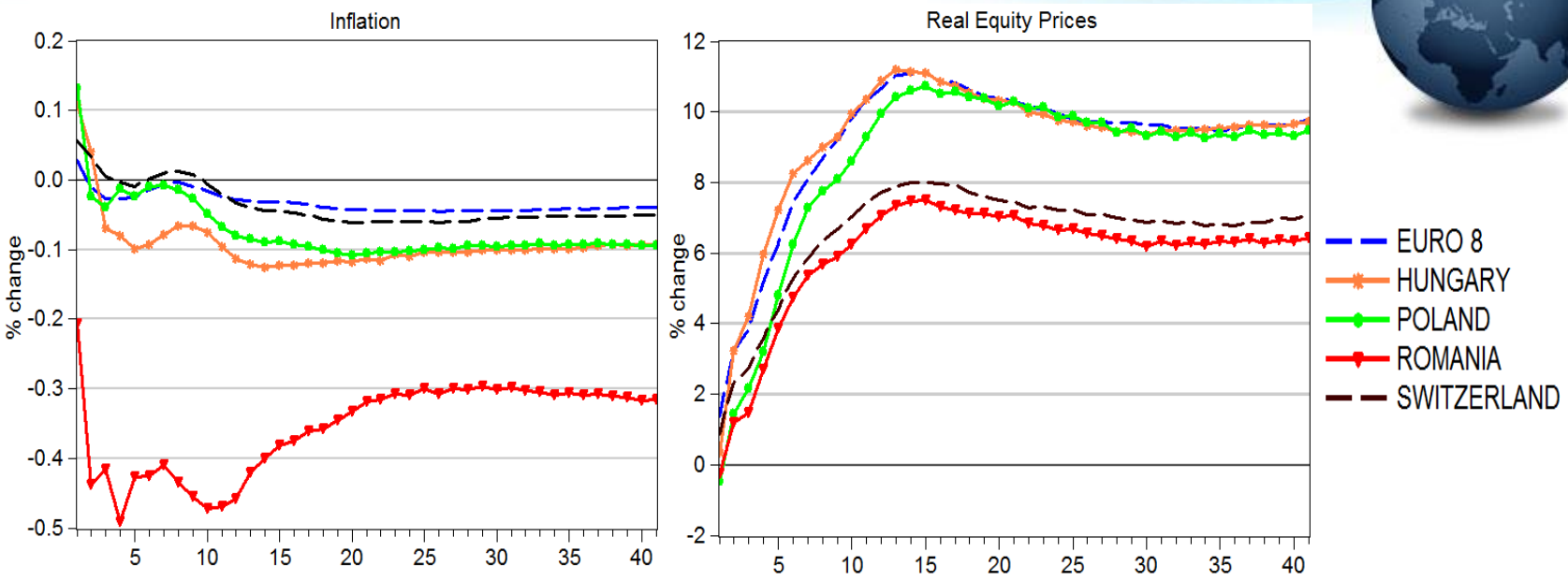
*GIRF of U.S LTIR from a **Positive Shock** ($+1\sigma$) to U.S. Long Term Interest Rates*
(bootstrapped median estimates with 90% confidence bands)





- The shock can be viewed as a ***reduction to QE by reducing bond purchases***
- Corresponds to a 20 basis points increase at an annual basis
- Interest rates tend to rise in the focus countries with the exception of Romania

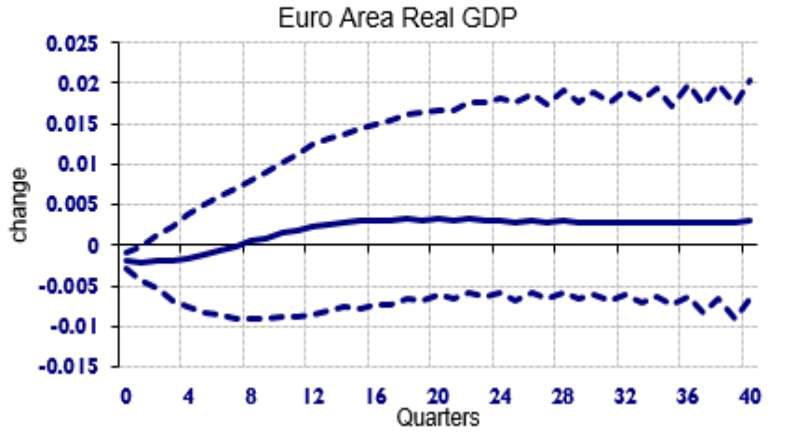
6.Shock Scenarios: A Shock to US Long-Term Interest Rates

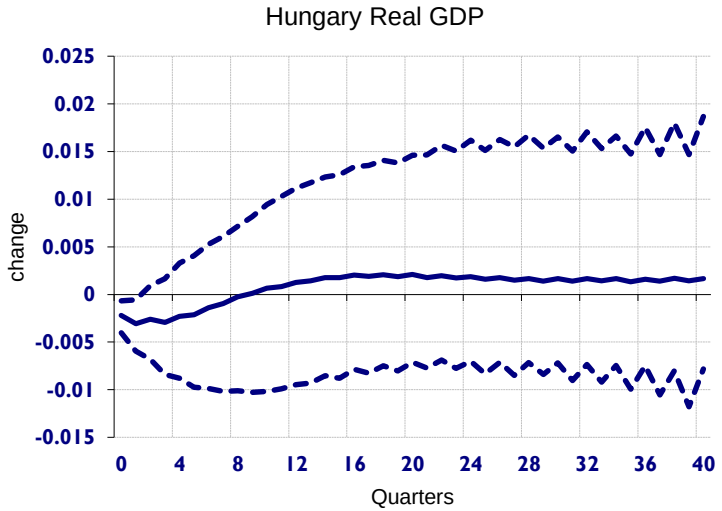


- Inflation tends to rise initially- "***Price puzzle***"
- Decrease of inflation in Romania could explain the fall in interest rates- ***Fisher Effect***
- Equity markets tend to rise although the responses are ***not statistically significant at 10%***

6.Shock Scenarios: A Shock to Euro Area GDP

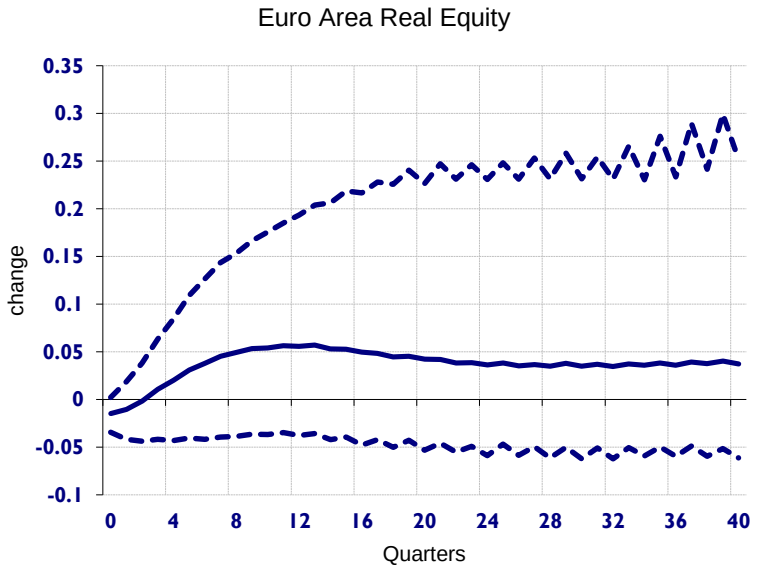
GIRFs from a Negative Shock (-1 σ) to Euro Area Real GDP
(bootstrapped median estimates with 90% confidence bands)

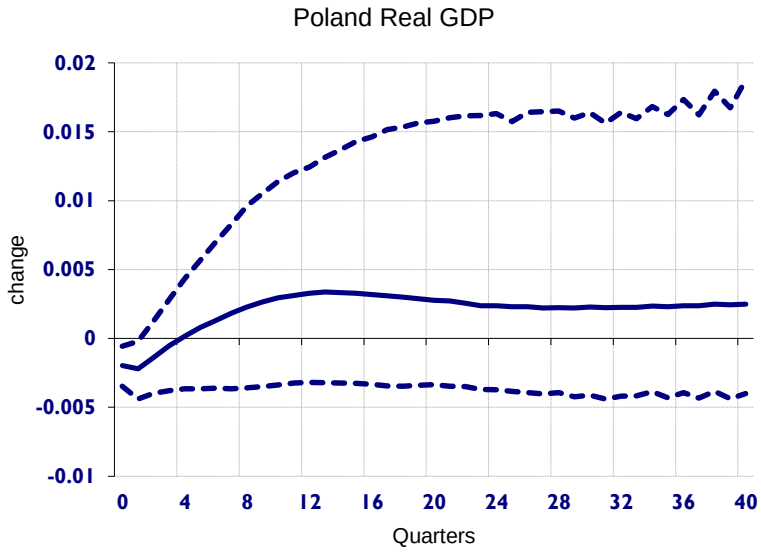




- The shock corresponds to 0.2% decrease in real output in the first year
- Euro Area ***seems to recover rather fast*** from the shock; the ***shock is not amplified over time***, as was the case of US GDP shock
- **The effects of the shock could be compensated between the members of the region**
- Real GDP in Hungary seems to follow the same response as the Euro Area
- ***The impact on other variables is very limited and not statistically significant***

6.Shock Scenarios: A Shock to Euro Area Equity Prices





- The shock corresponds to a fall of 1.4% in the E.A equity market
- Real GDP in Poland appears to be affected although the effect is small
- ***The impact on other variables is very limited and not statistically significant***

7. Conclusions

- Shocks originating from US have the largest impact worldwide - ***second and even third round effects***
- The transmission of shocks from US to real variables is slow while the **response of financial variables is rather quick and significant**
- Equity markets **overshoot** the US response
- **Asymmetric responses in exchange rates** between emerging and developed economies - ”*flight to quality*”
- **Shocks originating from the E.A appear not to be amplified** over time and do not have significant effects on other variables

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THANK YOU!