A PANEL VAR ANALYSIS OF MACRO-FINANCIAL IMBALANCES IN THE EU[1]

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[1] The conclusions expressed in the paper and presentation are those of the author and do not necessarily represent the official views of the Bank of Lithuania.

Introduction (1): why macro-financial imbalances are important?

- The real effective exchange rate (REER) assessment is becoming increasingly relevant for economic surveillance in the EU, together with the analysis of current account (CA) imbalances (MIP, IMF).
- It is key to build a proper measure of both misalignments, based to country-specific characteristics and equilibria, rather than ad-hoc thresholds, and to see how these interact and may influence each other.
- **Investigating if the REER and CA are close to the equilibrium values and how the misalignments interact can help one determine the future adjustment needs and possible trajectories of fundamentals.**

Introduction (2): What are the REER and the CA?

REER:

- We use nominal effective exchange rates (NEERs) deflated by the Consumer Price Index (CPI) in calculating the REER *vis-á-vis* the main 37 partners. This is a widely recognized way to proxy for price competitiveness. An increase in the REER means here a decrease in competitiveness.

$REER_{i,t} = \frac{NEER_{i,t} * CPI_{i,t}}{CPI^{f}_{i,t}}$

where the denominator $CPI^{f}_{i,t}$ is the geometrically weighted average of CPI indices of trading partners and $NEER_{i,t} = \prod_{j=1}^{J} w_{i,j,t}\ s_{i,j,t}$ where $s_{i,j,t}$ is the bilateral exchange rate between our country i and partner j.

- In order to assess the rate, we need a measure of medium-run equilibrium. Various ways −> here BEER method by IMG CGER based on fundamentals (including foreign capital flows).

Introduction (3): What are the REER and the CA?

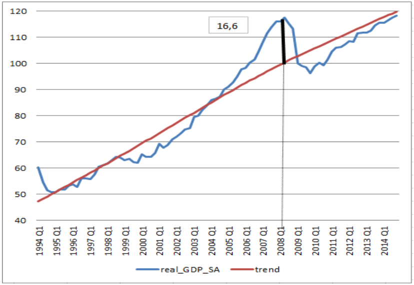
CA:

- We look at current account/GDP balance as part of the Balance of Payment. The CA is composed by the trade balance (X-M), net primary income or factor income (earnings on foreign investments minus payments made to foreign investors) and net cash transfers (f.i. remittances).
- It is a way to analyse the external balance between the country and the rest of the world.
- The CA imbalance may indeed contribute significantly to the emergence of bubbles and the cross-country transmission of financial crises (Ca' Zorzi et al., 2012), and it may also be a sign of serious macroeconomic and financial stress (Obstfeld, 2012).
- In order to assess the CA, we also need a measure of medium-run equilibrium. We apply the Macroeconomic Balance procedure by IMF CGER, based on country-specific CA fundamentals (including foreign capital flows).

Introduction (3): What is the output (or financial) gap?

Output gap: difference between (real) GDP and its trend - **short-term** (up to 8 years)
Financial gap: difference between (real) GDP or other financial variables and its trend - **medium-term** (up to 20 years) –> can be captured also by using a synthetic index (PCA) or other methods

Idea behind the gaps:



Research question

- In this paper, we investigate the interactions and asymmetries between current account (CA), Real Effective Exchange Rates (REER) misalignments and financial or output gaps in a EU perspective.
- We track the role of the financial gap in effecting the misalignments via foreign capital flows and change in production and the (possible) different direction of transmission between CA and REER.
- **The main aim of this paper is to identify the direction of transmissions and to analyze the impact of the gaps for EU and sub-groups, keeping the full heterogeneity in each step.**
- In order to do that, we make use of a panel with T=1994:2014 (2016) and N=27 (or sub-samples)

Topics presented here: steps

1. **REER misalignments** (based on REER determinants to build the equilibrium including foreign capital inflows) - Comunale (2017, 2018);

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3. Some **financial and output gap measures** from Comunale and Hessel (2014, DNB WP) and Comunale (2015, LP OP);

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2. **Current Account misalignments** (based on CA determinants to build the equilibrium including foreign capital inflows) - Comunale (2018);
3. Some **financial and output gap measures** from Comunale and Hessel (2014, DNB WP) and Comunale (2015, LP OP);
4. **Panel VAR in which all these imbalances interact**: financial cycle, REER misalignments and CA misalignments –> homogeneous panel VAR, Bayesian panel VAR and dynamic factor model. Analysis of impact on growth and of global variables.

Literature review - strands

- **Measures of "equilibrium" REER**: we present the resulting misalignments coming from the so-called BEER method. The BEER has been studied in Clark and MacDonald (1999) and Bénassy-Quéré et al. (2009, 2010); Comunale (2016a) −> paper above.
- **CA determinants**: IMF CGER (2006); Rahman (2008); Calderon et al. (2002); Chinn and Prasad (2003); Bussiére et al. (2010); Lee et al. (2008); Medina et al. (2010) and Ca'Zorzi et al. (2012). Recently in Darvas (2015). **CA misalignments**: based on IMF CGER (2006) "Macroeconomic Balance (MB)" approach. Comunale (2015) for CEE.
- **Financial gaps and real variables (mostly CA)**: Jordá et al. (2011); Mendoza and Terrones (2012); Lane and McQuade (2014); Comunale and Hessel (2014).

Literature review - strands (2)

- Recent work of Gnimassoun and Mignon (2013): analyse these **macro interactions** (output gap) for a sample of 22 industrialized countries by applying a homogeneous panel VAR. Positive output-gap shocks as well as currency overvaluation make CA deficits worse. Variations in CA imbalances mainly result from exchange-rate misalignments in the euro area, these are mostly explained by output gaps for non-eurozone members.
- Staehr and Vermeulen (2016) analyzed the relationships by individual VARs for 11 EA countries. An increase in REER is followed by a decline in GDP; the relationship is less clear for credit growth and current account balances.

- **Our contribution**: analysis is EU-focused (1994-2014); complete heterogeneity in the coefficients to build time-varying misalignments; different measures of gaps; Bayesian framework to count for heterogeneity and small sample and we include spillovers and global factors.

REER misalignments

Methodology (1b): REER misalignments

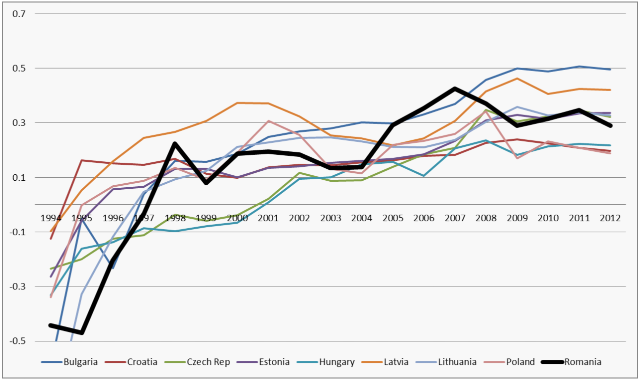
- Same setup/results as in Comunale (2017, 2018) –> huge foreign capital inflows in some EU countries –> shift to less productive sectors? (Dutch Disease)
- The theoretical background of this setup can be found in Lane and Milesi-Ferretti (2004) and in Corden (1994). The log-linearized model:

$$reer_{i,t} = f(flows_{i,t}; tot_{i,t}; bs_{i,t}) = \alpha_i + \beta_i X_{i,t} + \varepsilon_{i,t} \qquad *$$

- Misalignments as: $reer^{mis}_{i,t} = reer_{i,t} - \overline{reer}_{i,t} = reer_{i,t} - \widehat{\beta}'_{i,t} X^{HP}_{i,t}$
- *flows*: FDIs, portfolio or others (mainly banking loans); *tot*: terms of trade; *bs*: proxy for Balassa-Samuelson (real GDP per capita in relative terms)
- **Similar to the BEER approach by IMF CGER**.

* GM-FMOLS estimator (more in reserve slides)

Methodology (1b): REER misalignments



Results for Romania (from Comunale, 2017 JIMF)

CA misalignments

Methodology (2a): CA misalignments

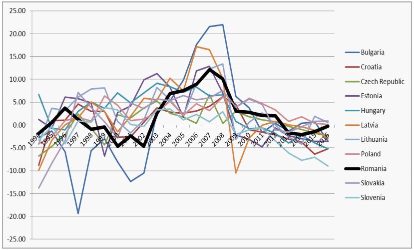
- This follows the IMF CGER (2006) and Lee et al.(2008): **Macroeconomic Balance approach (+new EBA lite (2016))**

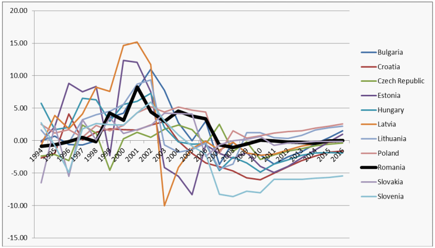
$$(CA/GDP)_{i,t} = \alpha_i + \beta_{i,t} X_{i,t} + \varepsilon_{i,t}$$
$$CAnorm_{i,t} = \widehat{\beta_t} \cdot X_{i,t+H}$$
$$\mathbf{CA\_mis}_{i,t} = \mathbf{CAunderlying}_{i,t+H} - \mathbf{CAnorm}_{i,t}$$
$$CA\_mis_{i,t} = CA_{i,t} - CAnorm_{i,t}$$

- **The considered variables** (IMF WEO, UNCTAD, UNDESA, WB WDI, EWN) are: the relative fiscal balance, relative old-age and young-age dependency ratio and relative population growth, the initial NFA, the oil balance, a relative income measure, the relative output growth, a crisis dummy (equal one after year 2008) and the net FDI flows/GDP (considered in Medina et al., 2010); portfolio net flows/GDP and other net flows/GDP.

For year 2012, the latest projections are for 2018 (as T+H), so we use for each year considered the projection for the 6th year ahead (H). Pooled OLS with Driscoll-Kraay

Methodology (2b): CA misalignments





Results for Romania with FDIs (from Comunale, 2018 ES). LHS with actual CA, RHS with underlying CA.

Financial and output gaps

Methodology (3a): Financial and output gaps

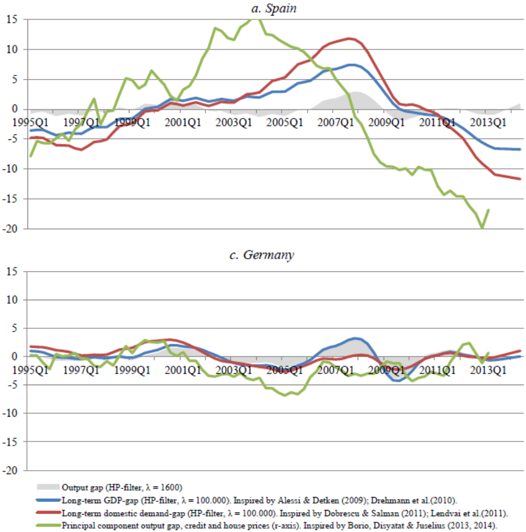
- **Financial gap measures**, following Comunale and Hessel (2014) and **Comunale (2015)*** –> Comunale et al. (2018): credit misalignments

1. **Based on HP series** = higher smoothing parameter (lambda = 100,000, for a cycle of 15-20 years Drehmann et al. (2011)) f*or: real GDP, credit to the private sector/GDP, or domestic demand (and house prices for Q)*
2. **A synthetic index** and is computed using the Principal Component Analysis (1st component) on *output gap, credit to the private sector/GDP growth and domestic demand growth (house price growth for Q; pca on levels also available).* The underlying series are stationary and can resemble something closer to an output gap.

- **Output gap** from HP filtered real GDP (lambda = 1,600).

*in Comunale (2015) application: ERPT in EA 19, checking if financial cycle may influence ERPT to HICP. We find that the ERPT can be higher in the presence of house price fluctuations at the frequency of the financial cycle (or index with it).

Methodology (3b): Spain v. Germany



Source: Comunale and Hessel (2014)

Panel VAR

This paper

Now...

- Given the gaps built as explained before: we look at the interactions.
- Check if the key misalignment is the REER or CA in different country groups and how the financial (and output gap) shocks are transmitted.
- Short and long-run effects.
- We use panels mainly because of data availability (N*T = increases the number of observations and degree of freedom) and to analyze (spillovers among) different groups within the EU, which is our main objective.

Methodology (4a): panel VAR

- **The main structure of our panel VAR** is as the following (Ciccarelli and Canova, 2013):

$$Y_{i,t} = A_{0i}(t) + A_i(l)Y_{i,t-1} + F_i(l)W_{t-1} + u_{i,t}$$

- Where $Y_{i,t}$ is the vector of our variables described in the preferred identification scheme as $Y_{i,t} = (gap_{it}, REER\_mis_{it}, CA\_mis_{it})$. W_{t-1} represent the vector of exogenous variables (if present, VARX).
- We have compacted into $A_{0i}(t)$ all the deterministic components of the data (constants, seasonal dummies and deterministic polynomial in time).
- $A_i(l)$ and $F_i(l)$ are polynomial in the lag operators (here assumed heterogeneous across units as in Ciccarelli and Canova, 2013; however we are also going to use homogeneous coefficients in our first panel VAR specification). u_{it} are the errors and they are identically and independently distributed $u_{it} \sim iid(0, \sum_u)$.

Methodology (4b): methods

1. An **homogeneous panel VAR** for the balanced panel 1994-2012 (ONLY we can make a comparison with Gnimassoun and Mignon, 2013);
2. **Bayesian panel VAR with partial pooling** (full interdependencies inside the panel (across variables in every unit) and heterogenous dynamics for small panels);

- *Robustness:*

- **Dynamic factor model** (cross-sectional dependence and slope heterogeneity).
- Possible spillovers inside the EU (and the EA) are likely to play a role in the full sample. Together with the dynamic factor model, abovementioned, we also include in our preferred Bayesian panel VAR setup, a variable to count for **possible spillovers** across the members.

Methodology (5): the homogeneous panel VAR

- We firstly use a **homogeneous panel VAR** for the balanced panel 1994-2012 (ONLY we can make a comparison with Gnimassoun and Mignon, 2013).
- Abrigo and Love (2015), which apply GMM-type estimators to the setup.
- GMM estimators: main assumption is that errors are serially uncorrelated (we do not count for possible cross-sectional dependence) and consistent if fixed T and large N;
- We control for global factors, here proxied by world GDP growth (*wgdpgr*), in order to weaken (the strong part of) possible cross-sectional dependence and we have added GDP growth (*gdpgr*) as the most endogenous variable in Choleski sense.

Methodology (6): the Bayesian panel VAR with partial pooling

- If we want to take into account the **full interdependencies inside the panel** and **heterogenous dynamics** –> **partial pooling method** - pooling in the units not in coefficients! **= if small T and small N** (Ciccarelli and Canova, 2013).
- Some spillovers (relative determinants) are indeed already present in our model.
- Bayesian shrinkage procedures (use both weighted mean of prior and (small) sample information).
- Choleski identification scheme with 1000 Montecarlo draws for standard errors and an horizon of 10 years for the IRFs;
- The pooling parameter is set small ($gam = 0.01$), which means almost perfect pooling;
- Steps for partial pooling Bayesian panel VAR (*code by Canova, modified for my setup - reserve slides*)

Methodology (7): Dynamic factor model

- Pesaran and Tosetti (2011) and Eberhardt and Teal (2010) −> slope heterogeneity and deals with cross-sectional dependence;
- Augmented Mean Group (AMG) estimator −> we also treat the unobserved common factors, not as a nuisance but as key factor

$$\mathbf{y}_{i,t} = \beta_i' \mathbf{x}_{i,t} + \gamma_i' \mathbf{f}_t + \mathbf{e}_{i,t}$$

where $\mathbf{x}_{i,t}$ is the vector of observed individual effects ($gap_{i,t}$, $REER\_mis_{i,t}$, $CA\_mis_{i,t}$) and $\mathbf{f}_t$ is a vector of m unobserved common factors (our spillovers or global factors), which affect all the individuals at different times and at different degrees allowing for heterogeneity in the slope represented by the vector $\gamma_i' = (\gamma_{i1,....}\gamma_{im})'$.

- A major drawback of this approach is that it does not take into account dynamic interdependencies across the variables.

Methodology (8): Spillovers in the VAR setup

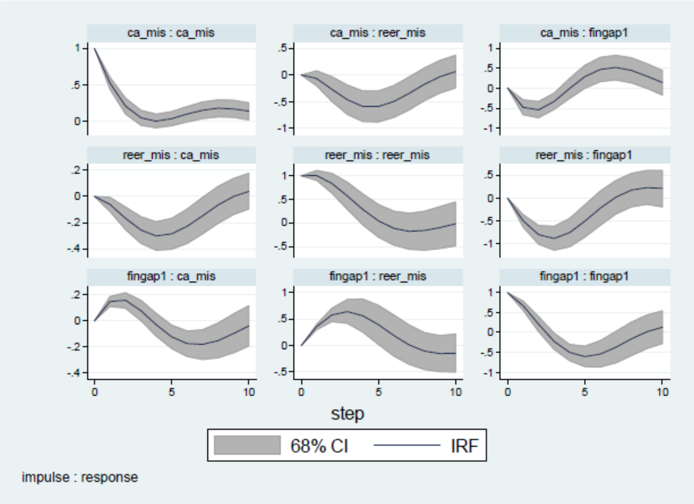
- We also include in our preferred Bayesian panel VAR setup, a variable to count for possible spillovers across the members.
- Adding either a weighted measure of GDP growth of the rest of the EU as in Comunale (2016a) or the weighted average of the financial cycles of the rest of the EU.

$$fgdpgr_{i,t} = \sum_{j=1}^{N-1} w_{i,j,t} \cdot gdpgr_{j,t}$$
$$ffcycle_{i,t} = \sum_{j=1}^{N-1} w_{i,j,t} \cdot fcycle_{j,t}$$

Results

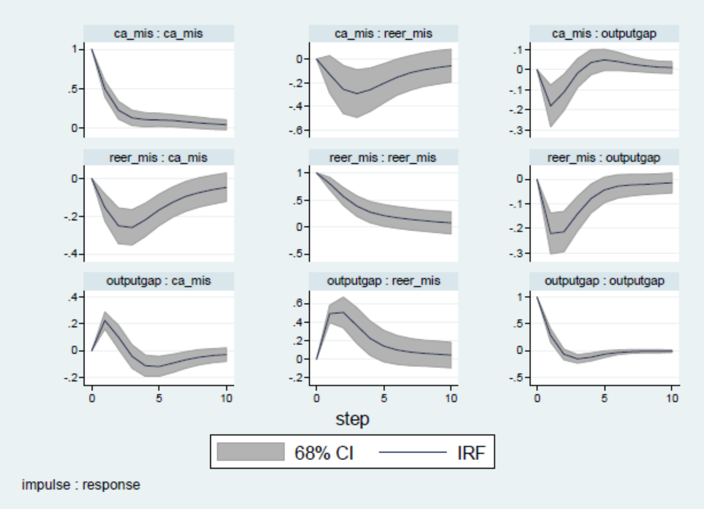
Results (1a): Homogeneous panel VAR for the EA (financial gap - real GDP)

Figure 5a: IRFs - euro area (EA19) with financial gap-



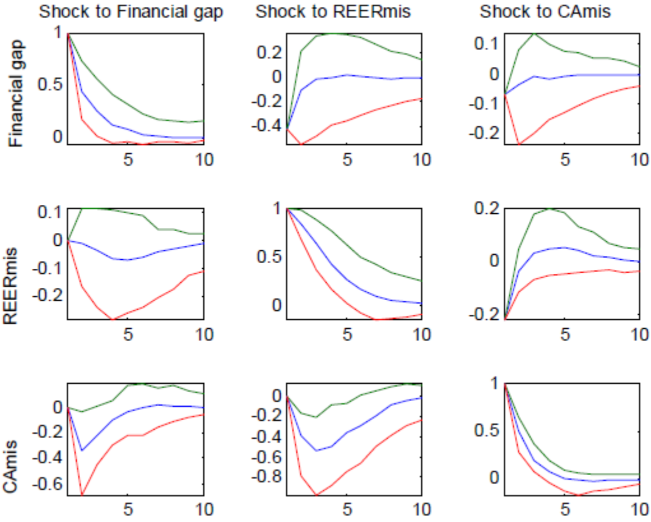
Results (1b): Homogeneous panel VAR for the EA (output gap)

Figure 5b: IRFs - euro area (EA19) with output gap-

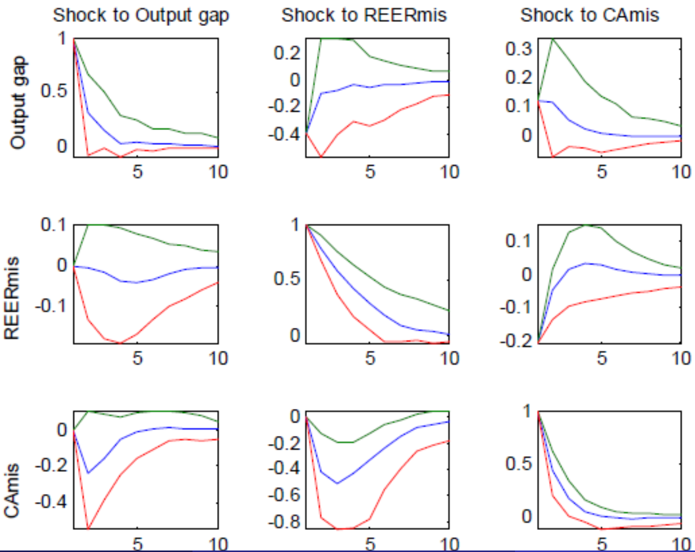


In the homogeneous panel VAR:
i) financial gap shocks are more persistent in affecting both CA and REER misalignments, in comparison with the regular output gap;
ii) the reaction of CA misalignments to a shock in REER misalignments is bigger than the one to a shock in the gap for EA (as in GM, 2013);
iii) REER misalignments and financial gap shocks are bad for growth and the latter are very persistent (*reserve slides*).

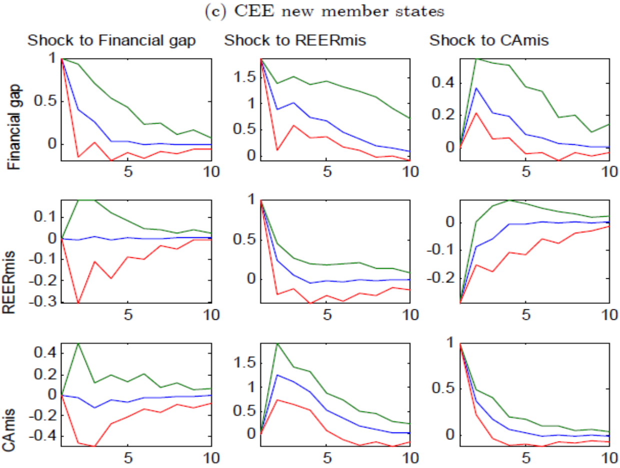
Results (2a): Bayesian panel VAR with partial pooling for the EA (financial gap - real GDP)



Results (2b): Bayesian panel VAR with partial pooling for the EA (output gap)

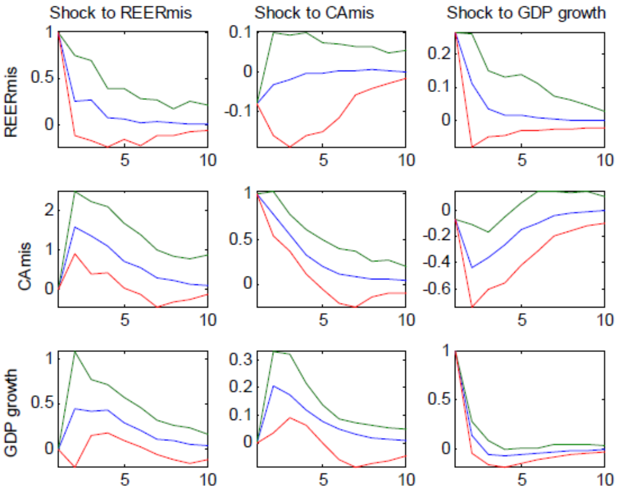


Results (2c): Bayesian panel VAR with partial pooling for the EU - CEE NMS



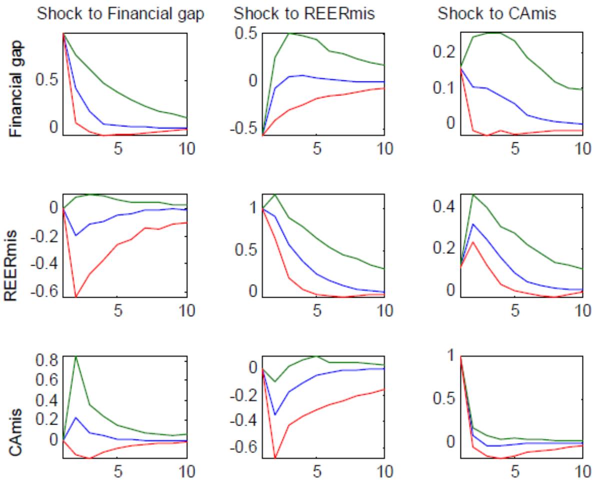
Results (2e): Bayesian panel VAR: CEE NMS with GDP growth

(c) CEE new member states



Results (2f): Bayesian panel VAR with partial pooling for the EU - DK,SE,UK

Figure 18a: IRFs by using partially pooling Bayesian panel VAR - Denmark, Sweden and UK -



Summing up

In the Bayesian VAR:
i) CA misalignments and REER misalignments are extremely closely related and affect each other;
ii) the financial and output gaps behave quite similarly (but output gap does not affect CA);
iii) the reaction of CA misalignments to a shock in REER misalignments is bigger than the one to a shock in the gap for EU, EA and EA core. The CA misalignments are key for Denmark, Sweden and UK, as in the periphery, and not in case of the EA core. For CEE: the direction is the opposite from REER misalignments to CA and the gaps.

Results (3a): Dynamic factor model EU

	EU27			EU27			EU27		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	ca_mis	reer_mis	pca2	ca_mis	reer_mis	pca2	ca_mis	reer_mis	pca2
ca_mis (-1)	0.201***	-0.146	0.00505	0.177***	-0.160	0.0288	0.124**	-0.177	-0.00967
	(0.0663)	(0.207)	(0.0242)	(0.0658)	(0.231)	(0.0241)	(0.0619)	(0.260)	(0.0383)
reer_mis	0.0100			0.0201			-0.00760		
	(0.0290)			(0.0297)			(0.0266)		
reer_mis (-1)		0.437***	-0.0144		0.441***	-0.0363***		0.404***	-0.0672***
		(0.0505)	(0.0118)		(0.0559)	(0.00805)		(0.0564)	(0.0144)
pca	0.227**	-0.966							
	(0.0962)	(0.748)							
pca (-1)			-0.0869*						
			(0.0494)						
fingap1							0.0415	-0.560*	
							(0.0433)	(0.318)	
fingap1 (-1)									0.396***
									(0.0594)
outputgap				0.113*	-0.373				
				(0.0586)	(0.350)				
outputgap (-1)						0.0298			
						(0.0470)			
UCFs	**0.795*****	**0.600*****	**0.968*****	**0.783*****	**0.651*****	**1.034*****	**0.818*****	**0.785*****	**0.980*****
	(0.126)	**(0.177)**	**(0.117)**	**(0.124)**	**(0.216)**	**(0.114)**	**(0.132)**	**(0.262)**	**(0.121)**
Constant	1.625***	2.412	-0.817***	1.619***	2.359	0.0860	4.018***	12.20***	-1.569***
	(0.476)	(1.522)	(0.104)	(0.460)	(1.469)	(0.0935)	(0.766)	(4.432)	(0.227)

Results (3b): Dynamic factor model sub-groups

	EA Core			Periphery			CEECs			CEECs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	ca_mis	reer_mis	fingap1	ca_mis	reer_mis	fingap1	ca_mis	reer_mis	fingap1	ca_mis	reer_mis	pca2
ca_mis (-1)	0.341**	0.110	-0.0938*	-0.0331	-0.0345	-0.0882	0.0566	-0.328*	-0.0230	0.112	-0.342**	-0.0305
	(0.156)	(0.324)	(0.0484)	(0.0787)	(0.0474)	(0.0803)	(0.0682)	(0.170)	(0.0710)	(0.0761)	(0.155)	(0.0342)
reer_mis	0.0645*			-0.0556			-0.0202			-0.0262		
	(0.0357)			(0.0500)			(0.0344)			(0.0365)		
reer_mis (-1)		0.475***	0.0125		0.237	-0.0842***		0.177*	-0.0263*		0.242**	0.0271***
		(0.0844)	(0.0282)		(0.151)	(0.0287)		(0.102)	(0.0141)		(0.0986)	(0.0102)
fingap1	0.191	-0.871**		-0.00704	-0.0837		0.0894***	-0.177				
	(0.159)	(0.368)		(0.113)	(0.134)		(0.0285)	(0.141)				
fingap1 (-1)			0.0414			0.431***			0.435***			
			(0.0525)			(0.103)			(0.0753)			
pca										0.328***	-0.0735	
										(0.104)	(0.261)	
pca (-1)												0.0300
												(0.0430)
UCFs	**0.841****	**0.837**	**0.959*****	**0.815*****	**0.702*****	**0.845*****	**0.760*****	**0.641*****	**1.031*****	**0.809*****	**0.579*****	**1.019*****
	(0.371)	**(0.533)**	**(0.152)**	**(0.146)**	**(0.139)**	**(0.162)**	**(0.0918)**	**(0.181)**	**(0.168)**	**(0.0915)**	**(0.148)**	**(0.164)**
Constant	-0.847	8.167	3.539***	6.210***	-2.189	-1.777***	3.428***	24.77***	-1.495***	3.366***	-1.903	-1.515***
	(0.891)	(8.094)	(0.604)	(1.025)	(1.757)	(0.610)	(0.674)	(5.053)	(0.345)	(0.735)	(3.190)	(0.272)

Conclusions

- **In the homogeneous panel VAR**: i) financial gap shocks are more persistent in affecting both CA and REER misalignments, in comparison with the regular output gap; ii) **the reaction of CA misalignments to a shock in REER misalignments is bigger than the one to a shock in the gap for EA (as in GM, 2013)**; iii) REER misalignments and financial gap shocks are bad for growth and the latter are very persistent.

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- **In the Bayesian VAR**: i) CA misalignments and REER misalignments are extremely closely related and affect each other; ii) the financial and output gaps behave quite similarly and iii) the reaction of CA misalignments to a shock in REER misalignments is bigger than the one to a shock in the gap for EU, EA and EA core (*as in the homogeneous panel VAR*); iv) **However, the CA misalignments are key for Denmark, Sweden and UK, as in the periphery, and not in case of the EA core. For CEE: the direction is the opposite from REER misalignments to CA and the gaps.**

Conclusions (2)

- *Robustness:*

- **Dynamic factor model** (cross-sectional dependence and slope heterogeneity). In the EU27 and CEE a positive shock in the financial gap may increase CA misalignments.
- **Possible spillovers** inside the EU (and the EA) are likely to play a role in the full sample. Together with the dynamic factor model, abovementioned, we also include in our preferred Bayesian panel VAR setup, a variable to count for possible spillovers across the members. Results are comparable with point 2.

To do: new ideas/projects related to this paper

- Comparison **underlying CA vs. actual CA-based** misalignments

To do: new ideas/projects related to this paper

- Comparison **underlying CA vs. actual CA-based** misalignments
- **New measures of financial cycles** from WGEM team (Christiano-Fitzgerald; Structural Time Series Models; VAR-based models)?

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- [Alternative to Canova and Ciccarelli (2013): the Zellner and Hong (1989) approach (pooling the coefficients)?]
- **Financial gaps as financial misalignments**: is it possible to create an equilibrium value for financial variables starting from determinants (for credit flows)? - *Comunale, Eller, Lahnsteiner (2018, 2019 OeNB)*

Thank you for your attention!

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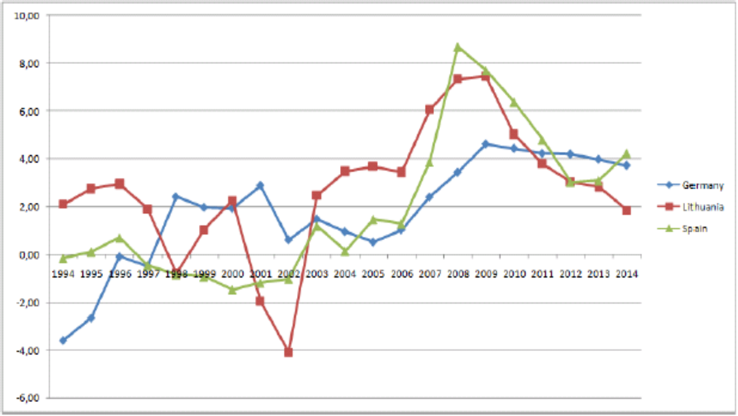
RESERVE SLIDES

Methodology (1c): REER misalignments

- non-stationary and cointegrated both in the full version with all the types of capital flows and the sub-samples;
- we want to keep the heterogeneity in the coefficients: **GM-FMOLS estimator**, which is built as the average of the within FMOLS estimator over the cross-sectional dimension (semi-parametric correction to the OLS estimator which eliminates the second order bias induced by the endogeneity of the regressors).

CA misalignments sub-groups

Figure 2: the evolution of CA misalignments for Germany, Lithuania and Spain



Dumitrescu and Hurlin (2012): Granger causality analysis

Ztild [pvalue]
With 1 lag

X--> Y	Y: REER_mis	CA_mis	Fingap1	outputgap	wgdp
X:					
REER_mis		3.1225	0.2518	-1.7476	-1.3002
		[0.0018]	[0.8012]	[0.0805]	[0.1935]
CA_mis	3.5253		10.0277	-0.9874	0.2872
	[0.0004]		[0.0000]	[0.3234]	[0.7739]
Fingap1	5.5177	10.5895		0.4509	1.9165
	[0.0000]	[0.0000]		[0.6520]	[0.0553]
outputgap	1.7263	0.4100	11.6192		10.5863
	[0.0843]	[0.6818]	[0.0000]		[0.0000]
wgdp	8.8622	4.9606	0.3134	-2.9425	
	[0.0000]	[0.0000]	[0.7540]	[0.0033]	

The null hypothesis is non-causality
Reject the null, i.e. Causality at 1%

Note: test statistic for heterogeneous panels based on the individual Wald statistics of Granger non causality averaged across the cross-section units.

Methodology (6): the Bayesian panel VAR with partial pooling

- We also impose (similar to Random Effects) from Ciccarelli and Canova (2013):

$$\alpha_i = \overline{\alpha} + \nu_i \quad \text{where } \alpha_i = [vec(A_i(l)), vec(A_{0i})]' \text{ and } \nu_i \sim iid(0, \textstyle\sum_\nu).$$

- The Bayesian way to treat this structure is using α_i as an exchangeable prior. The posterior mean of α_i is obtained by a combination of sample and prior information with weights given by the relative precision of the two types of information abovementioned and the posterior variance is a weighted average of the prior and of the sample variance.
- If $\overline{\alpha}$ and $\sum_\nu$ are unknown, the Gibbs sampler is applied as in here.

Methodology (6): the Bayesian panel VAR with partial pooling

- Steps for **partial pooling Bayesian panel VAR** (code by Canova, modified for my setup) - pooling in the units not in coefficients

1. de-mean the data;
2. initialize matrices storing the IRFs;
3. prior cross-sectional mean (*barBet*) pooling toward a random walk;
4. VAR unit by unit: *Bet* (from OLS) and *Bpost*:

$$Bpost = (X\prime * X + (1./gam) * eye(k,k)) \backslash$$
$$\backslash (X\prime * X * Bet + (1./gam) * barBet)$$

1. *res*, *sigma*, *varbet* (OLS residuals, covariance res and variance beta); *repost*, *sigmapost*,*varbetpost* (POST);
2. Gibbs sampling (MCMC) draws for *Bpost* and *sigmapost*;
3. companion form VAR & check roots and stability;
4. Choleski IRFs - store.

Methodology (7): Dynamic factor model

- Pesaran and Tosetti (2011) and Eberhardt and Teal (2010) –> slope heterogeneity and deals with cross-sectional dependence;
- Augmented Mean Group (AMG) estimator –> we also treat the unobserved common factors, not as a nuisance but as key factor

$\mathbf{y}_{i,t} = \beta_i' \mathbf{x}_{i,t} + \gamma_i' \mathbf{f}_t + \mathbf{e}_{i,t}$
where $\mathbf{x}_{i,t}$ is the vector of observed individual effects ($gap_{i,t}$, $REER\_mis_{i,t}$, $CA\_mis_{i,t}$) and $\mathbf{f}_t$ is a vector of m unobserved common factors (our spillovers or global factors), which affect all the individuals at different times and at different degrees allowing for heterogeneity in the slope represented by the vector $\gamma_i' = (\gamma_{i1,....}\gamma_{im})'$.

- A major drawback of this approach is that it does not take into account dynamic interdependencies across the variables.

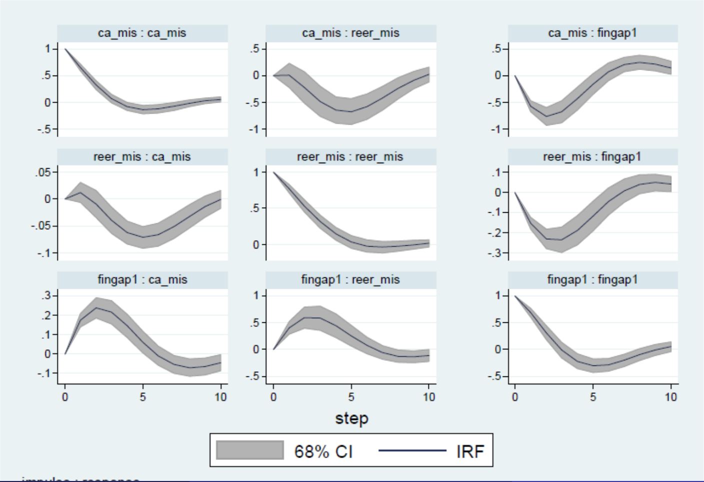
Methodology (8): Spillovers in the VAR setup

- We also include in our preferred Bayesian panel VAR setup, a variable to count for possible spillovers across the members.
- Adding either a weighted measure of GDP growth of the rest of the EU as in Comunale (2016a) or the weighted average of the financial cycles of the rest of the EU.

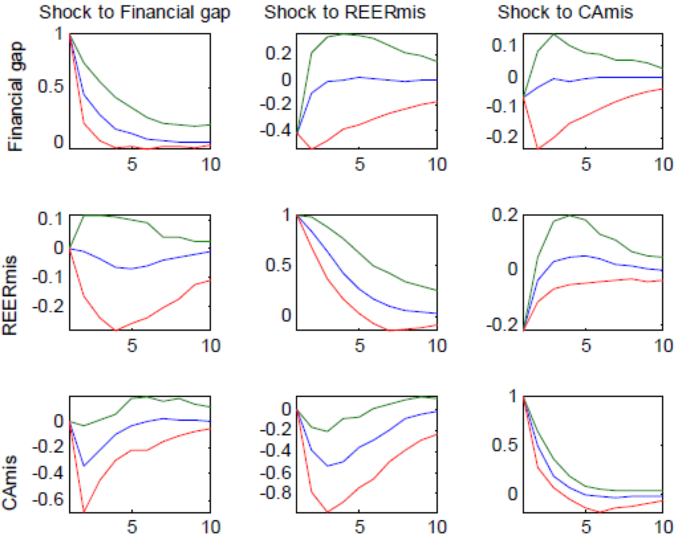
$$fgdpgr_{i,t} = \sum_{j=1}^{N-1} w_{i,j,t} \cdot gdpgr_{j,t}$$
$$ffcycle_{i,t} = \sum_{j=1}^{N-1} w_{i,j,t} \cdot fcycle_{j,t}$$

Results (1c): Homogeneous panel VAR for the EU (with exogenous world GDP growth)

Figure 3b: IRFs - with world GDP growth (exo) -

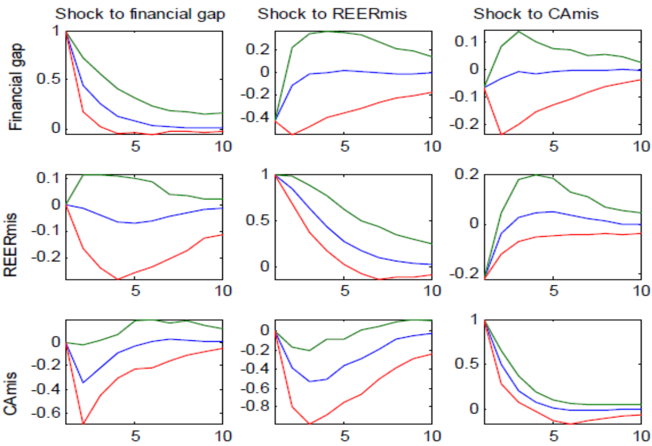


Results (2a): Bayesian panel VAR with partial pooling for the CORE



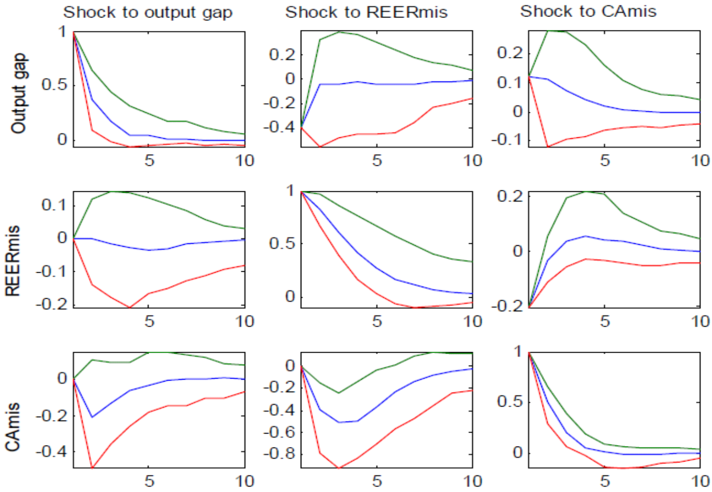
Results (2a): Bayesian panel VAR with partial pooling for the EU (financial gap - real GDP)

Figure 12a: IRFs by using partial pooling Bayesian panel VAR[67]



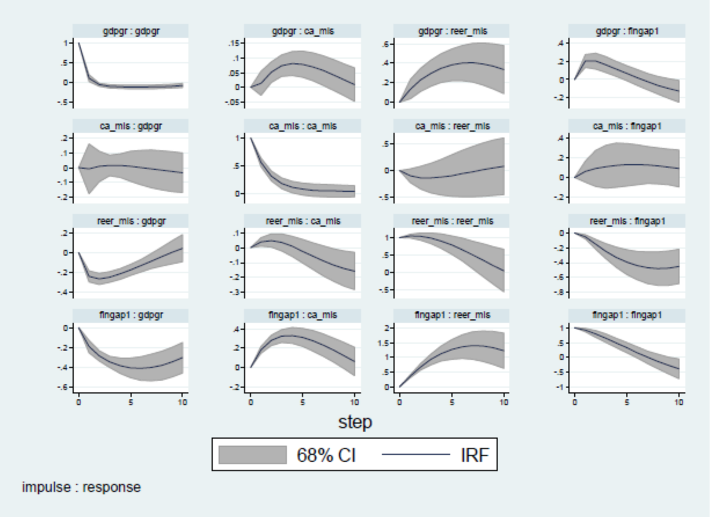
Results (2b): Bayesian panel VAR with partial pooling for the EU (output gap)

Figure 13: IRFs by using partial pooling Bayesian panel VAR - output gap -



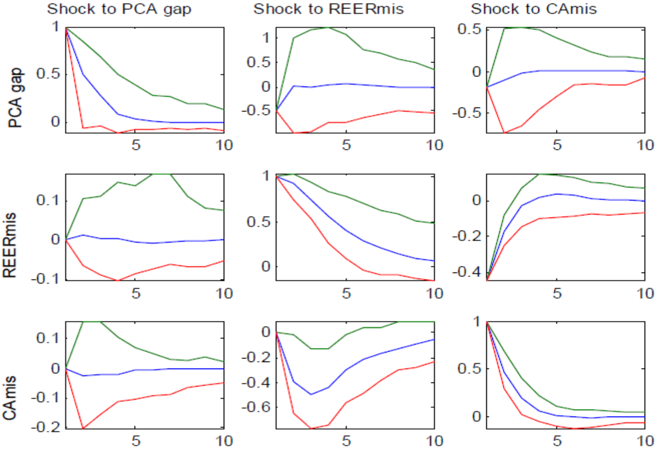
Results (1d): Homogeneous panel VAR for the EA (with GDP growth)

Figure 6: IRFs - only euro area with GDP growth -



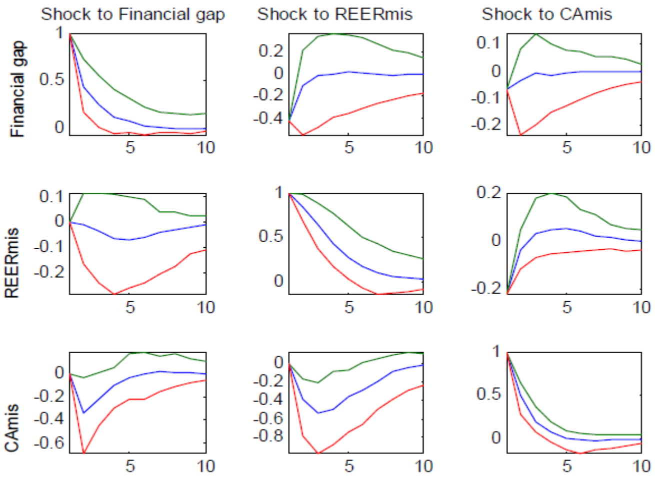
Results (2b): Bayesian panel VAR with partial pooling for the EU (financial gap - pca)

Figure 14: IRFs by using partial pooling Bayesian panel VAR - pca as financial gap -

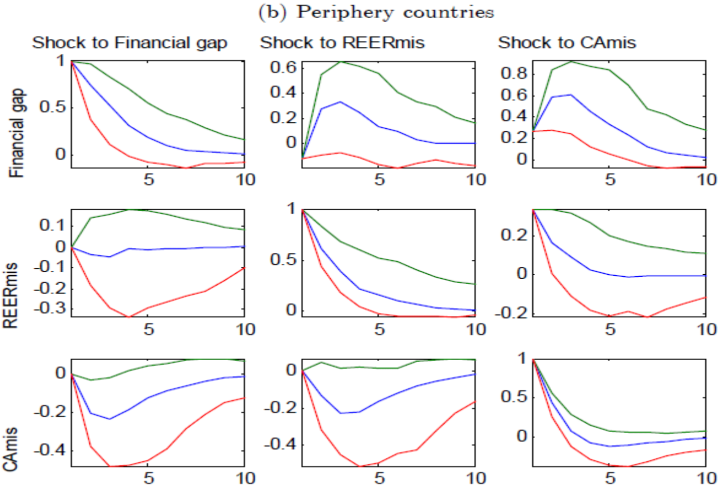


Results (2d): Bayesian panel VAR with partial pooling for the EU - EA CORE

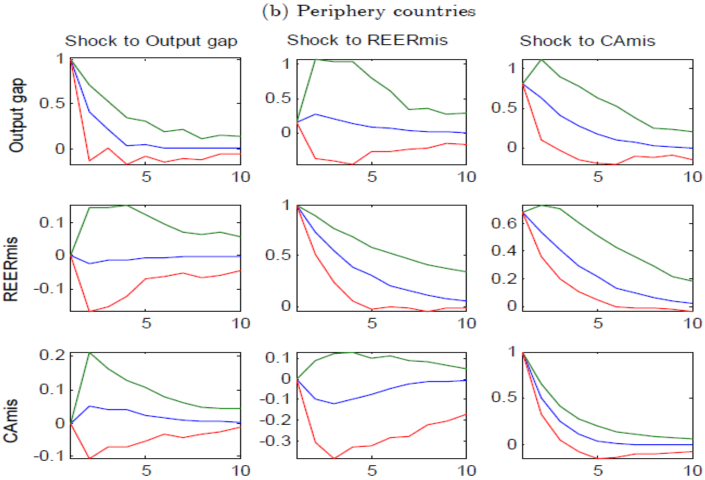
Figure 18b: IRFs by using partial pooling Bayesian panel VAR - euro area core -



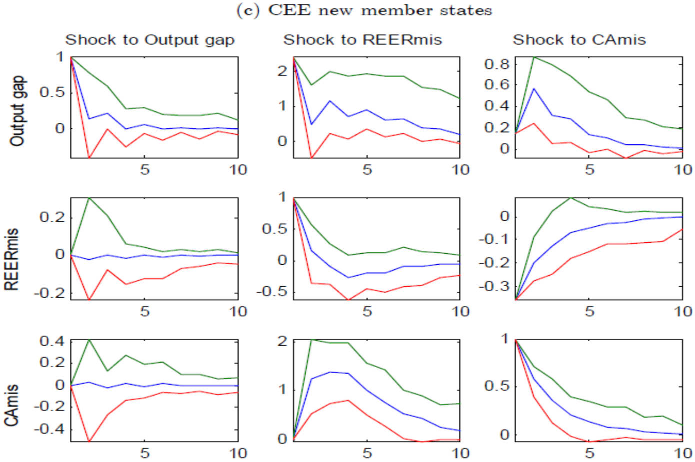
Results (2f): Bayesian panel VAR with partial pooling for the EU - PERIPHERY



Bayesian panel VAR: periphery with output gap



Bayesian panel VAR: CEE NMS with output gap



Results (3a): Dynamic factor model EU

	EU27			EU27			EU27		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	ca_mis	reer_mis	pca2	ca_mis	reer_mis	pca2	ca_mis	reer_mis	pca2
ca_mis (-1)	0.201***	-0.146	0.00505	0.177***	-0.160	0.0288	0.124**	-0.177	-0.00967
	(0.0663)	(0.207)	(0.0242)	(0.0658)	(0.231)	(0.0241)	(0.0619)	(0.260)	(0.0383)
reer_mis	0.0100			0.0201			-0.00760		
	(0.0290)			(0.0297)			(0.0266)		
reer_mis (-1)		0.437***	-0.0144		0.441***	-0.0363***		0.404***	-0.0672***
		(0.0505)	(0.0118)		(0.0559)	(0.00805)		(0.0564)	(0.0144)
pca	0.227**	-0.966							
	(0.0962)	(0.748)							
pca (-1)			-0.0869*						
			(0.0494)						
fingap1							0.0415	-0.560*	
							(0.0433)	(0.318)	
fingap1 (-1)									0.396***
									(0.0594)
outputgap				0.113*	-0.373				
				(0.0586)	(0.350)				
outputgap (-1)						0.0298			
						(0.0470)			
UCFs	**0.795*****	**0.600*** **	**0.968*** **	**0.783*** **	**0.651*** **	**1.034*** **	**0.818*** **	**0.785*** **	**0.980*** **
	(0.126)	**(0.177)**	**(0.117)**	**(0.124)**	**(0.216)**	**(0.114)**	**(0.132)**	**(0.262)**	**(0.121)**
Constant	1.625***	2.412	-0.817***	1.619***	2.359	0.0860	4.018***	12.20***	-1.569***
	(0.476)	(1.522)	(0.104)	(0.460)	(1.469)	(0.0935)	(0.766)	(4.432)	(0.227)

Results (3b): Dynamic factor model sub-groups

	EA Core			Periphery			CEECs			CEECs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	ca_mis	reer_mis	fingap1	ca_mis	reer_mis	fingap1	ca_mis	reer_mis	fingap1	ca_mis	reer_mis	pca2
ca_mis (-1)	0.341**	0.110	-0.0938*	-0.0331	-0.0345	-0.0882	0.0566	-0.328*	-0.0230	0.112	-0.342**	-0.0305
	(0.156)	(0.324)	(0.0484)	(0.0787)	(0.0474)	(0.0803)	(0.0682)	(0.170)	(0.0710)	(0.0761)	(0.155)	(0.0342)
reer_mis	0.0645*			-0.0556			-0.0202			-0.0262		
	(0.0357)			(0.0500)			(0.0344)			(0.0365)		
reer_mis (-1)		0.475***	0.0125		0.237	-0.0842***		0.177*	-0.0263*		0.242**	0.0271***
		(0.0844)	(0.0282)		(0.151)	(0.0287)		(0.102)	(0.0141)		(0.0986)	(0.0102)
fingap1	0.191	-0.871**		-0.00704	-0.0837		0.0894***	-0.177				
	(0.159)	(0.368)		(0.113)	(0.134)		(0.0285)	(0.141)				
fingap1 (-1)			0.0414			0.431***			0.435***			
			(0.0525)			(0.103)			(0.0753)			
pca										0.328***	-0.0735	
										(0.104)	(0.261)	
pca (-1)												0.0300
												(0.0430)
UCFs	**0.841****	**0.837**	**0.959*****	**0.815*****	**0.702*****	**0.845*****	**0.760*****	**0.641*****	**1.031*****	**0.809*****	**0.579*****	**1.019*****
	(0.371)	**(0.533)**	**(0.152)**	**(0.146)**	**(0.139)**	**(0.162)**	**(0.0918)**	**(0.181)**	**(0.168)**	**(0.0915)**	**(0.148)**	**(0.164)**
Constant	-0.847	8.167	3.539***	6.210***	-2.189	-1.777***	3.428***	24.77***	-1.495***	3.366***	-1.903	-1.515***
	(0.891)	(8.094)	(0.604)	(1.025)	(1.757)	(0.610)	(0.674)	(5.053)	(0.345)	(0.735)	(3.190)	(0.272)