Shock dependence of exchange rate pass-through: a comparative analysis of BVARs and DSGEs[1]

[This version is a R&R for *International Economics*]

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[1]This work is based and extends Section 5 of Ortega and Osbat (eds.) (2020, ECB OPS) and it was developed while the author was on secondment at the ECB. The conclusions expressed in the presentation are those of the author and do not necessarily represent the official views of the Bank of Lithuania, the ECB or the ESCB.

Motivation

- The idea behind the shock dependency of the pass through is relatively new in the literature and is founded on the concept that not every exchange rate movement is the same when it comes to evaluating its effect on prices and this depends on the shock to both.
- "*Using rules of thumb for exchange rate pass-through could be misleading*" (Forbes et al., 2016)
- Overall, while a simple reduced form estimate of ERPT may be informative for import prices, a more shock-dependent approach to assessing pass-through can be rather considered for HICP and its components.
- We cannot use the shock decomposition of single BVAR to "re-aggregate" the shock-dependent ERPT/PERR and go back to a rule of thumb, but use decompositions of many models to guide judgment.

Motivation

- In this paper we collected results from BVARs coming from several studies for the euro area, which apply the idea of a shock-dependent ERPT or *Price-to-Exchange Rate Ratio* (PERR) covering a period from the 1990s to the most recent quarter available (2019Q1 or Q2).
- The shock dependent ERPT is seen not as "transmission" of exchange rate changes, but as "co-movement" of prices and exchange rates given different shocks.
- We draw a comparison across models and also with respect to available DSGEs for the euro area as an aggregate and
- country-by-country making use of linear projections (similar to Lane and Stracca, 2018).

Summary of the presentation

1. Literature on shock dependent ERPTs/PERR and definitions
2. Our BVARs (compared to DSGEs)
3. What do we find from shock dependent ERPTs/PERR in BVARs and DSGEs?
4. Historical shock decomposition of FX: any robustness across models?
5. Shock dependent ERPTs/PERR in euro area member states by using linear projections: what can we learn from that?

Literature on shock dependent ERPTs/PERR

- **ERPTs are not constant over time and they may depend on a composition of economic shocks governing the exchange rate.**
- Already been challenged in some theoretical contributions (e.g. Corsetti and Dedola (2008))
- Shambaugh (2008): the ERPT ratios to consumer inflation do not react to all the shocks in the same way and that demand shocks are of limited importance for pass-through.
- Forbes et al. (2015, 2017): the domestic monetary policy shock is related with a large ERPT to consumer prices both in the UK and in a sample of advanced and emerging economies as well, with a much smaller pass-through found for domestic demand shocks.
- Lane and Stracca (2018): local projections and small VAR –> heterogeneity in the responses across the euro area!
- Ha et al. (2019) extends the sample, providing a structural factor-augmented vector-autoregressive model for 47 countries.
- **Main takeaways from the literature: different shocks can be associated with different pass-through measures + the main drivers are monetary policy and FX shock rather than domestic demand.**

4 BVARs are considered

1) ID a la Forbes et al. (2018)*; 2) Comunale and Kunovac (2017); 3) Leiva-Leon et al (2018, 2019) and 4) updated Conti et al. (2017). We use the same data.

- The common shocks across models: an exogenous exchange rate shock, a domestic demand and supply shocks and a monetary policy shock (similarly to Lane and Stracca, 2018).

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- As for monetary policy we can refer to a relative measure with respect to the US (Comunale and Kunovac (2017) and Leiva-Leon et al (2018)) or to euro area MP only (Forbes et al. (2018)) and euro area and US MPs separately (or Conti et al. (2017), while US is exogenous).

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Data description

- The data are up to the most recent quarter available (2019Q1 or Q2) for the BVARs.
- For this analysis we used this set of variables: real GDP (seasonally and working day adjusted), HICP (s. and work. day adjusted), country specific competitor export prices weighted by country's import shares, total import deflator: extra plus intra EA for goods and services and extra EA country specific broad Nominal Effective Exchange Rates (NEER) or bilateral EURUSD exchange rate.
- *As for the interest rates, we used the shadow rates for the euro area and the US coming from Krippner (2016).*
- For the local projections we also use the HICP components (core HICP, non-energy industrial goods price index, NEIG and services price index, SERV). These series are retrieved from ECB SDW or ECB internal sources (ECB projections database) and they are seasonally adjusted.

Data description

- We replaced the shadow rates from Wu and Xia (2016), if applied originally, with the ones taken from Krippner (2016), as proven to be more consistent and comparable across conventional and unconventional monetary policy environments and are less subject to variation with modelling choices (see Comunale and Striaukas, 2017).
- For comparability, here all shocks are inflationary and an increase means appreciation.
- Moreover we transformed all the variables, except the interest rates, in q-o-q log differences.

Main DSGE: NBB DSGE

- Structural DSGE models allow to study ERPT and PERR using the structural determinants of the pricing equations as well as the endogenous response of the economy in a general equilibrium context.
- **Main DSGE comparison is with De Walque et al. (2017) - updated "NBB DSGE"**
- 2 countries DSGE: US and EA
- Open economy block –> look at ERPT (incomplete to HICP)
- Estimated: Bayesian full-info ML approach (Smets and Wouters, 2007) + fix some parameters if poorly identified (priors)
- We look at shock dependent ERPT in the same fashion as for the BVARs, with the same set of shocks and where exo FX shock is the UIP shock.

The considered DSGEs

- Other DSGEs used as "median values" for the PERRs.
- Bank of Finland, Banca d'Italia, Deutsche Bundesbank, De Nederlandsche Bank, ECB, National Bank of Belgium, and National Bank of Romania provided their models of the EA = total of 7 DSGEs for the EA.
- We focus on NBB DSGE: rich in terms of features (LCP, distribution sector, intermediate goods in the production function).
- More details on DSGE models considered and comparison across DSGEs in Pisani (2019).

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- The identification schemes across the available BVARs are very much comparable and almost completely match those in the structural model (we take the NBB DSGE);
- The one that does not match is the impact of the domestic supply shock on inflation;
- In the BVARs there is a need to identify the supply from demand (a negative restriction is needed) but in the DSGE the effect is not different from zero and the opposite signs only appear and becomes reliable after 3-4 quarters.

How comparable are the IDs across BVARs and DSGEs?

- BVARs identifications #1 - common shock across models (original signs from the papers)

CK: Comunale and Kunovac (2017)

	GDP	HICP	Rel IR	FX (NEER)	IP
EA demand shock (AD)	1	1	1	app	*
EA monetary policy (MP) RELATIVE to US	1	1	-1	dep	*
Exogenous exchange rate shock (FX)	*	1	*	dep	1
EA supply shock (AS)	-1	1	*	*	*

BdE: Leiva et al. (2020)

	GDP	HICP	Rel IR	FX (EURUSD)	Rel GDP
EA demand Shock (AD)	1	1	1	*	1
EA monetary policy (MP) RELATIVE to US	-1	-1	1	*	-1
Exogenous exchange rate shock (FX)	1	-1	-1	app	*
EA supply shock (AS)	1	-1	-1	dep	1

How comparable are the IDs across BVARs and DSGEs?

- BVARs identifications #2 - common shock across models (original signs from the papers)

Forbes: Forbes et al. (2018)

	GDP	HICP	IR	FX (NEER)	IP
EA demand shock (AD)	1	1	1	dep	*
EA monetary policy (MP)	-1	-1	1	dep	*
Exogenous exchange rate shock (FX)	*	-1	-1	dep	1
EA supply shock (AS)	1	-1	*	*	*

BdI: Conti et al. (2017)[32]

	GDP	HICP	IR	FX (NEER or EURUSD)	Rel GDP
EA demand shock (AD)	1	1	1	app	1
EA monetary policy (MP)	1	1	-1	dep	1
Exogenous exchange rate shock (FX)	1	1	*	dep	0
EA supply shock (AS)	-1	1	*	*	-1

How comparable are the IDs across BVARs and DSGEs?

- DSGE identification: the NBB model - common shock across models (original signs from the papers)

DSGE

	GDP	HICP	IR	FX (EURUSD)	IP
EA demand shock (AD)	1	1	1	app	*
EA monetary policy (MP)	1	1	-1	dep	*
Exogenous exchange rate shock (FX)	1	1	1	dep	1
EA supply shock (AS)	1	-1**	-1	dep	*

App means appreciation and dep is depreciation. IR is interest rate, Rel IR is relative interest rates EA-US, FX is the exchange rate either NEER or EURUSD, HICP are consumer prices and IP are import prices. EA stands for euro area. Rel GDP in BdE is Real GDP EA-US. "1" denotes positive sign, "-1"denotes negative, "0" denotes zero restriction and "*" denotes unrestricted response. "**" means negative only after a few quarters

BVAR from CK (2017)

Comunale and Kunovac (2017) - Complete identification

Short run restrictions						
	GDP	HICP	IR	FX	IP	EXP
EA supply shock (AS)	-1	1	*	*	*	0
EA demand Shock (AD)	1	1	1	-1	*	0
Global demand shock (GD)	1	1	*	*	*	1
Exogenous exchange rate shock (FX)	*	1	*	1	1	*
Relative EA monetary policy (MP)	1	1	-1	1	*	*
Global supply shock (GS)	-1	1	*	*	*	1
Long run restrictions						
	GDP	HICP	IR	FX	IP	EXP
EA supply shock (AS)	*	*	*	*	*	*
EA demand Shock (AD)	0	*	*	*	*	*
Global demand shock (GD)	0	*	*	*	*	*
Exogenous exchange rate shock (FX)	0	*	*	*	*	*
Relative EA monetary policy (MP)	0	*	*	*	*	*
Global supply shock (GS)	*	*	*	*	*	*

Lag length: 2

Exogenous block: 1 (Foreign export prices for EA)

Re-normalised so that all inflationary, Impulses responses are "normalized" in a way that median response of fourth variable (exchange rate) to every shock is equal to 1 at the horizon zero.

What is a "shock-dependent" ERPTs"/PERR ?

- Following Corsetti and Dedola (2005), in recent (B)VARs more shocks are identified. They call "shock-dependent" or "conditional" ERPT the ratio of cumulative IRFs.
- This is *not* ERPT: it is a measure of co-movement of prices and exchange rates.
- We call the relative response of prices to that of the exchange rate after any shock z, the *Price-to-Exchange-Rate Ratio (PERR)*.

$$PERR^{z}_{j,h} = \frac{\sum_{t=1}^{h} IRF_j(\Delta p^z_t)}{\sum_{t=1}^{h} IRF_j(\Delta s^z_t)} \tag{1}$$

- This is the cumulative IRF of price changes (or inflation) over the cumulative IRF of FX changes (q-o-q).

Empirical estimates for shock-dependent ERPT/PERR to import prices

- Impact after Q1-Q12 of 1% depreciation in exchange rate (NEER or EURUSD), 4 BVARs and 7 DSGEs (BdI, BoFinland, DNB, BuBa, ECB, NBB, NBR).

Shocks	Horizons	Median DSGEs (extra-EA import prices)	Median BVARs (total import prices)	Forbes	CK
Exogenous exchange rate	Q1	0.40	0.30	0.16	0.44
	Q4	0.80	0.35	0.21	0.49
	Q8	0.80	0.35	0.22	0.48
	Q12	0.80	0.35	0.22	0.47
Domestic demand	Q1	0.30	0.10	0.22	-0.03
	Q4	0.60	0.11	0.25	-0.03
	Q8	0.60	0.12	0.26	-0.02
	Q12	0.60	0.13	0.26	0.01
Monetary policy	Q1	0.40	0.45	0.25	0.65
	Q4	0.80	0.48	0.25	0.70
	Q8	1.0	0.46	0.24	0.69
	Q12	1.0	0.46	0.24	0.68
Domestic supply	Q1	0.30	0.17	0.17	0.16
	Q4	0.60	0.24	0.25	0.23
	Q8	0.60	0.25	0.26	0.23
	Q12	0.70	0.25	0.26	0.23

Note: Impact after Q1-Q12 of 1% depreciation in exchange rate (NEER or EURUSD). Forbes refers to Forbes at el. (2018) identification, CK is Comunale and Kunovac (2017), BdE is Leiva et al. (2020) and BdI is Conti et al. (2017). Forbes, BdI and CK use NEER-38, BdE instead includes EURUSD. Monetary policy is taken in relative terms with respect to the US in CK and BdE. Data points until 2019 Q1 (or Q2). Other BVARs not reported because they do not have import prices in their models. Median of the DSGEs is obtained from the euro area models as in Ortega and Osbat (eds.) (2020). Import prices are total prices for BVARs and extra-EA prices in the DSGEs (the DSGE medians reported in this table exclude the model by the Bank of Finland, which applies total import prices).

Empirical estimates for shock-dependent ERPT/PERR to consumer prices

- Impact after Q1-Q12 of 1% depreciation in exchange rate (NEER or EURUSD)

Shocks	Horizons	Median DSGEs	Median BVARs	Forbes	CK	BdE	BdI	PAC*
Exogenous exchange rate	Q1	0.00	0.07	0.06	0.09	0.07	0.05	
	Q4	0.10	0.07	0.04	0.08	0.06	0.16	
	Q8	0.30	0.07	0.03	0.08	0.05	0.21	
	Q12	0.50	0.07	0.03	0.08	0.05	0.23	
Domestic demand	Q1	-0.10	-0.08	-0.08	-0.07	-0.04	-0.16	
	Q4	0.20	-0.11	-0.11	-0.11	-0.07	-0.22	
	Q8	0.40	-0.12	-0.12	-0.12	-0.07	-0.30	
	Q12	0.60	-0.12	-0.12	-0.12	-0.07	-0.40	
Monetary policy	Q1	0.10	0.07	0.08	0.15	0.02	0.06	
	Q4	0.30	0.09	0.10	0.13	0.01	0.08	
	Q8	0.60	0.10	0.10	0.13	0.01	0.10	
	Q12	0.80	0.12	0.10	0.13	0.00	0.13	
Domestic supply	Q1	-0.20	-0.05	-0.05	-0.02	-0.09	-0.05	
	Q4	-0.30	-0.05	-0.07	-0.03	-0.08	-0.03	
	Q8	-0.20	-0.04	-0.06	-0.02	-0.08	0.04	
	Q12	-0.10	-0.04	-0.06	-0.02	-0.07	0.20	

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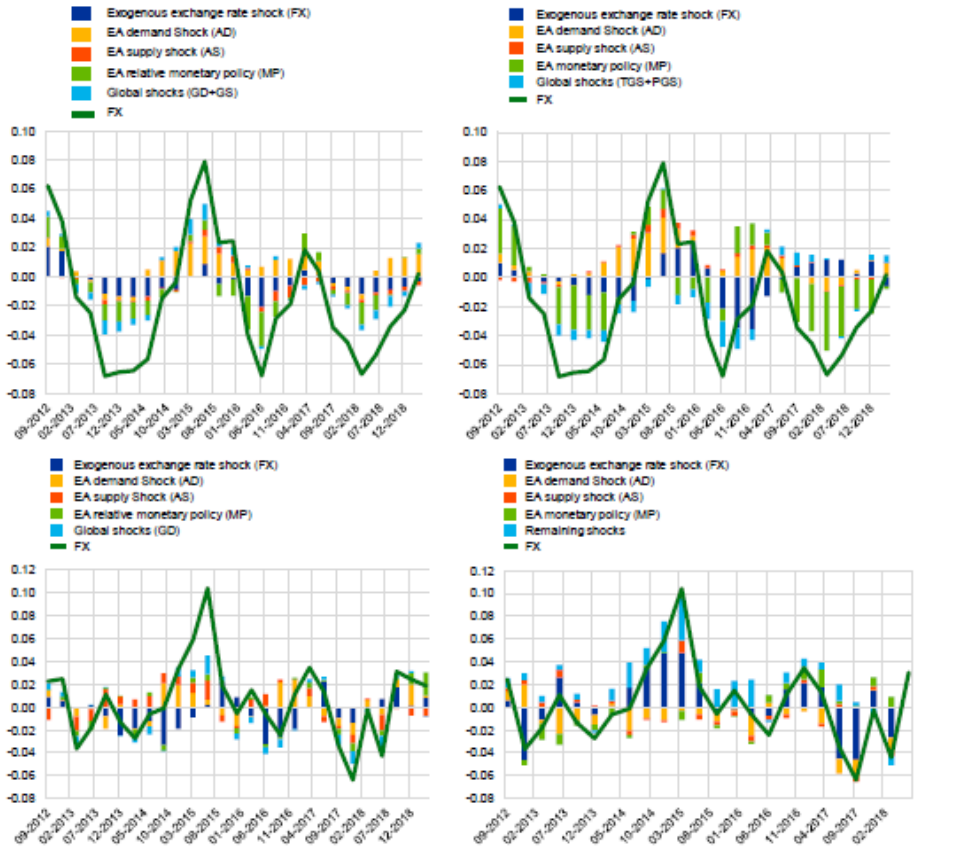
- DSGEs PERRs to the demand shock is positive in the medians, however there are differences across models, with some of them experiencing also negative values at later horizons (see Ortega and Osbat (eds.) (2020) and Pisani (2019)).

Complete FX decomposition

- Hard to find any coherent picture between BVARs and NBB DSGE: the decompositions are very different.

((Data from 2012Q3 to 2019Q1 – NEER-38 for 1) CK (LHS) and Forbes (RHS) then EURUSD for BdE (LHS below) and DSGE (RHS below))[33]



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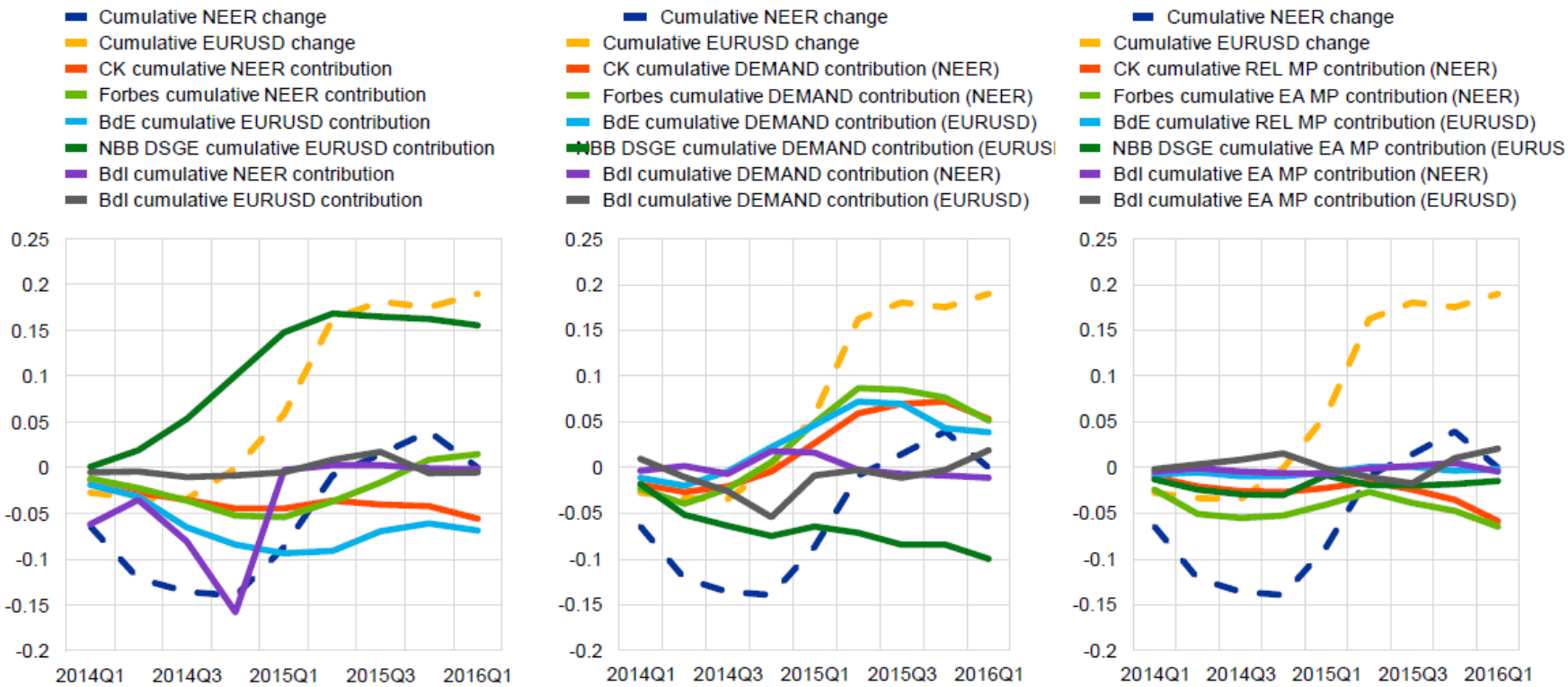
Historical shock decomposition of FX: any robustness across models?

- Looking at APP historical decomposition from 2014Q1 to 2016Q1 (EURUSD and NEER appreciate again q-o-q after)

(Cumulated historical decomposition from 2014Q1 to 2016Q1– LHS: exchange rate shock, in the middle: demand shock and RHS: monetary policy shocks)



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- In DSGEs: the UIP shocks can anticipate a depreciation one quarter ahead and this is partially dampened by the appreciation due to demand shocks.
- In BVARs: we can see a contribution of FX shocks especially in the case of NEER and the overall demand shocks explain a substantial part of change in the exchange rate. Much of the exchange rate change remains unexplained if MP –> to consider the systematic part.

How do we compare historical decompositions?

- **Updates 2020!**
- COVID19 outbreak: euro appreciations (EURUSD and NEER) after Q1
- Role of domestic demand for both FXs (positive after Q1) and global factors especially for NEER;
- FX shocks: flight to safety before in some models for both EURUSD and NEER;
- WIDE uncertainty bands.

Has there been time variation in PERR motivated by the different shocks?

Comunale and Kunovac (2017)

- This is *only* to show possible time variation in PERRs given a specific model (i.e. identification strategy and full set of shocks) among many, and it is *NOT* a way to provide an alternative measure of rule-of-thumb ERPT! There is not a single preferred baseline model –> different IDs, decompositions and PERRs.

- Time varying PERR for the EA (IT, DE, FR and ES also available): linear combination of individual pass-through ratios over all shocks, weighted by the relative importance of that shock in the historical decomposition of FX:

$$ERPT_t^j = \sum_{k=0}^{K} \theta_k(1) \widetilde{y_{j,t}^k} \tag{2}$$

$\theta_k(1)$ denoting the PERR ratios at 1-year horizon and $\widetilde{y_{j,t}^k}$ is the relative contribution of the kth structural shock to the jth variable at period t.

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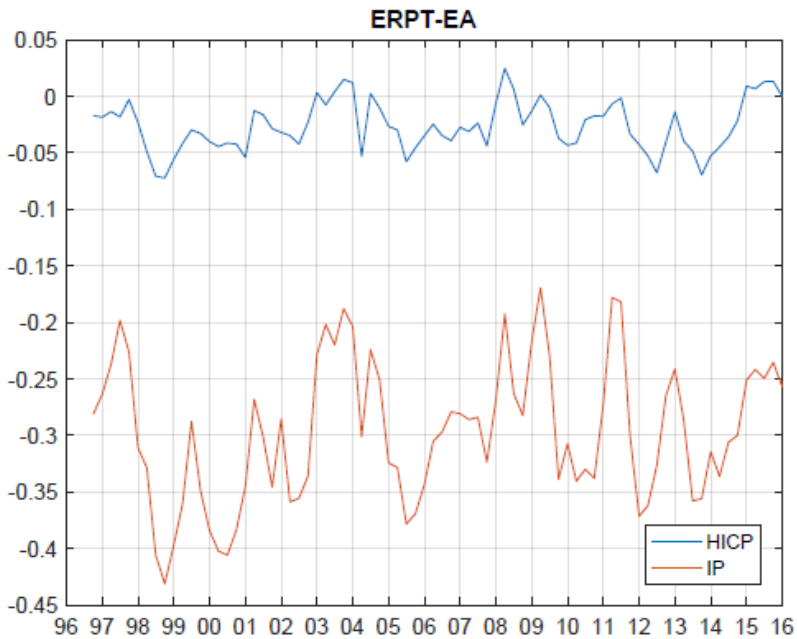
- Time varying PERR for the EA:



Linear projections

- We want to assess how HICP, its components (including HICPX, i.e. core HICP) and import prices react to EA common shocks identified via BVARs, i.e. exchange rate shock or monetary policy shock.
- Similar in spirit to Lane and Stracca (2018) –> euro area NEER movements independent of country determinants/characteristics.
- We make use of a simple local projection exercise a la Jorda (2005) –> 19EA MS, data until 2019Q1.

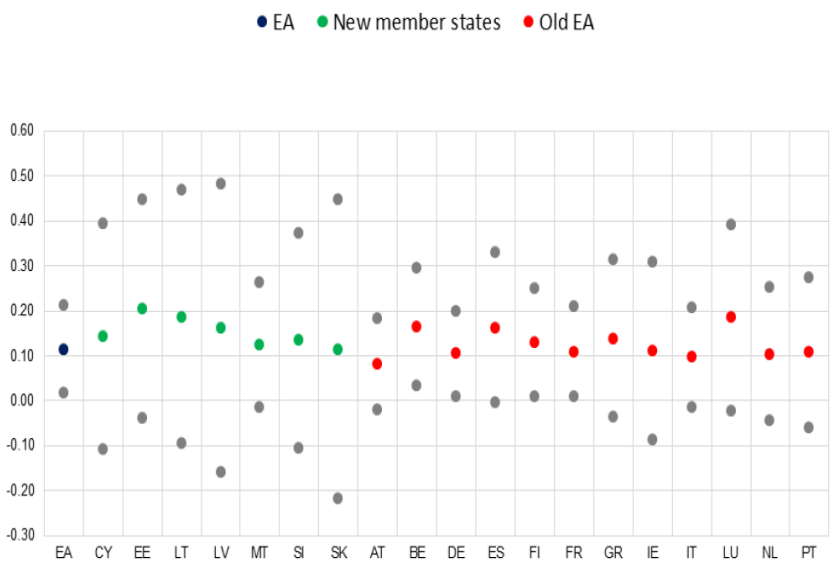
$$Y_t = \alpha + \phi_k \epsilon_{t,k} + \varepsilon_t \tag{3}$$

- We have different inflation measures for each country as dependent variable Y_t and the outcomes from common FX and monetary policy shocks $\epsilon_{t,k}$ as regressors. In the formula above, k refers to the shock (to exchange rate or monetary policy). The different ϕ_k coefficients will be therefore country-specific.

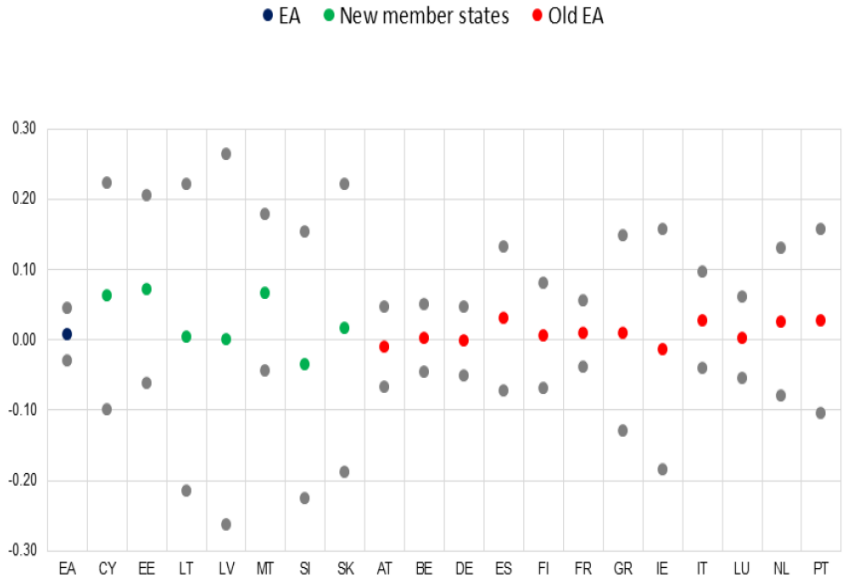
Linear projections: results

- **For exchange rate shocks**:

HICP



HICPx

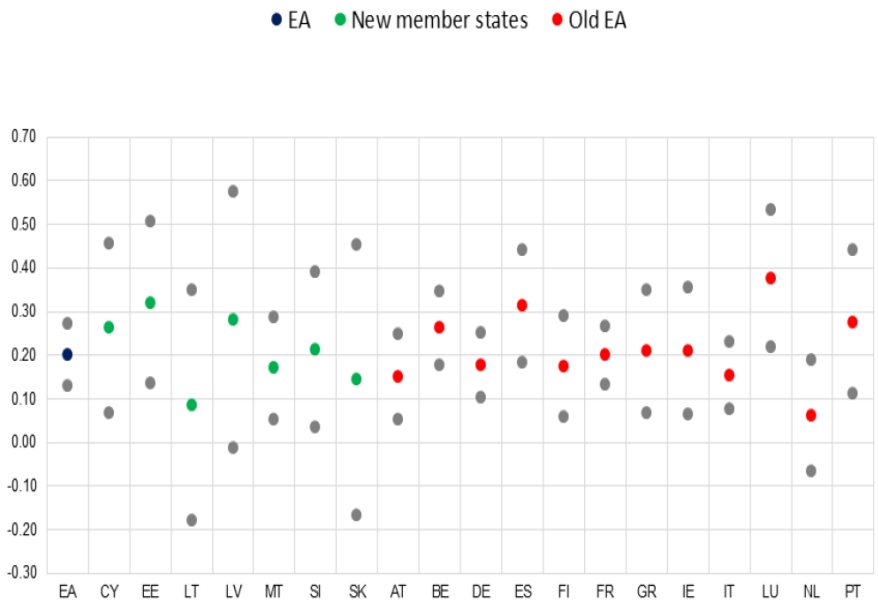


Local projections. Median values with 95% bands. Results across BVARs. Q1

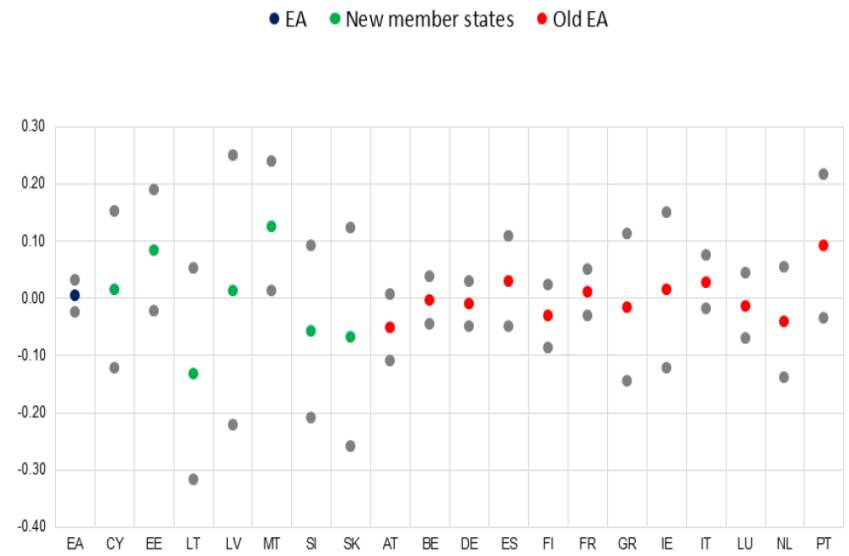
Linear projections: results

- **For relative MP shocks**:

HICP



HICPx



Local projections. Median values with 95% bands. Results across BVARs. Q1

Linear projections: results

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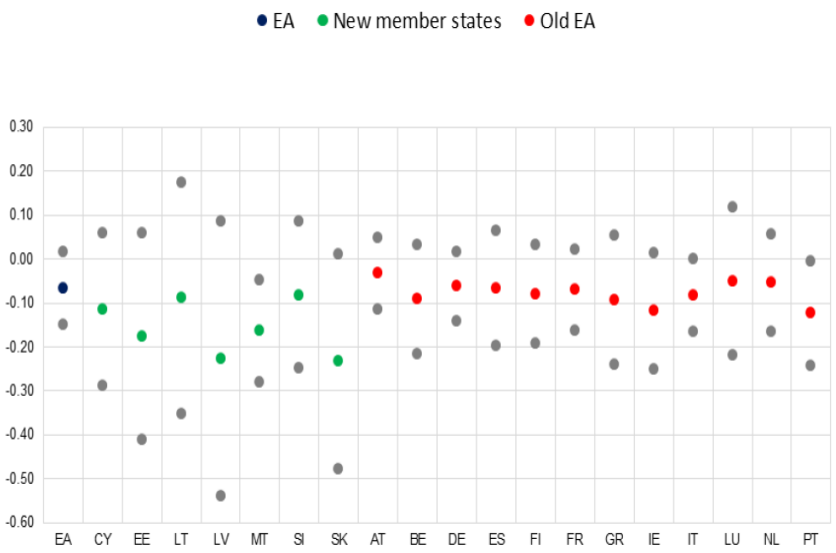
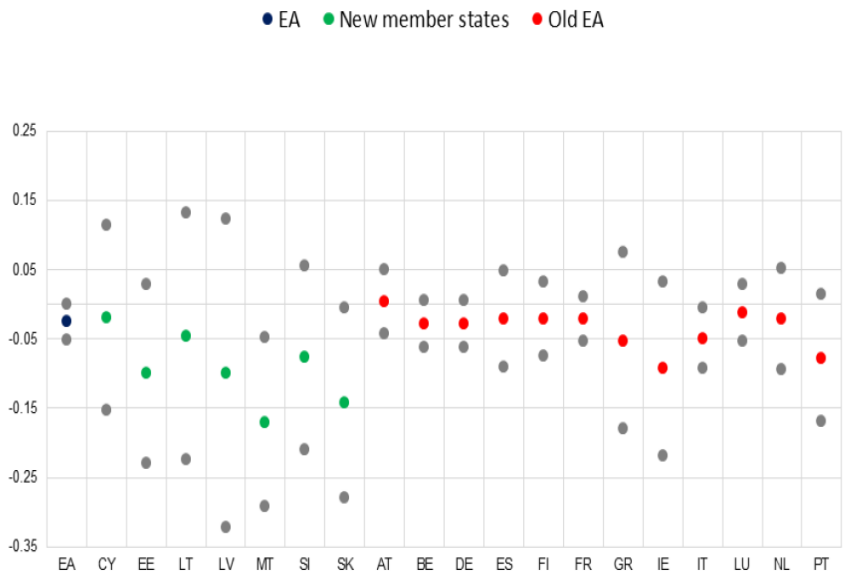


HICPx



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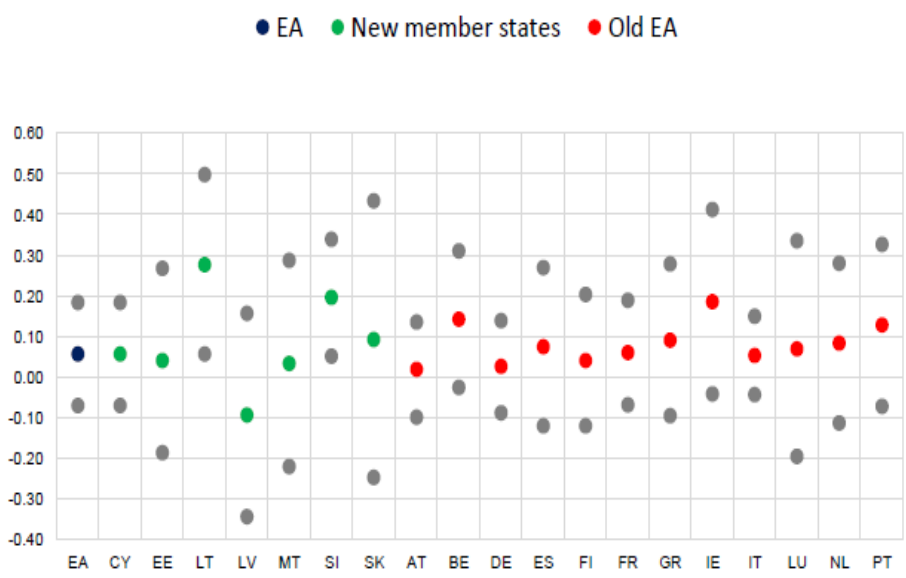
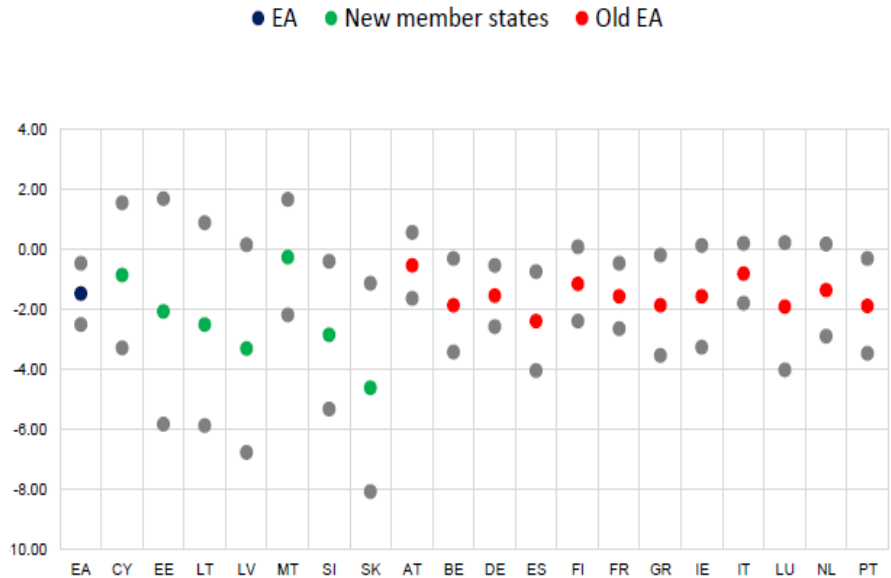
Linear projections: results

- **In the NBB DSGE**: HICP

UIP shock



EA MP shock



Local projections. Median values with 95% bands. Results for NBB DSGE. Q1

Linear projections: results

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- **As for relative monetary policy shocks:**
- larger impact mostly significant (confirmed in NBB DSGE) = *relative EA monetary policy shocks do play a role for HICP*;
- the very low values in core HICP can be mostly attributed to the price of services.
- (non-relative) EA monetary policy is also relevant for HICP.

Conclusions

- We analyse different BVARs and DSGEs covering shock-dependent (PERR) ERPT in euro area.
- Different shocks lead to different responses, but similarly across models. On impact PEER is similar across DSGEs and BVARs.
- **PERRs for import prices**: FX and MP shocks give larger PERRs $>$ **for HICP**: smaller in the case of FX shocks, MP still relevant.
- **Decomposition APP**: In DSGEs the UIP shocks can anticipate a depreciation one quarter ahead and this is partially dampened by the appreciation due to demand shocks. In BVARs, we can see a **contribution of FX shocks** especially in the case of NEER and the overall **demand shocks** explain a substantial part of change in the exchange rate, while the monetary policy shocks play a minor role.
- **LP**: for exchange rate shocks, their impact on HICP is the largest in some member states (but wide ranges). As for core HICP the coefficients are much smaller. The **relative EA MP** shocks do play a role for HICP in most of the countries and robust across models.

Thanks!

Thank you very much for your attention and looking forward to your comments!

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How comparable are the IDs across BVARs and DSGEs?

- BVARs identifications #3 - common shock across models (original signs from the papers)

PAC: Montes-Galdon et al. (2019)

	GDP	HICP	IR	FX (EURUSD)
EA demand shock (AD)	1	1	*	app
EA monetary policy (MP)	*	1	-1	dep
Exogenous exchange rate shock (FX)	*	1	1	dep
EA supply shock (AS)	-1	1	0	*

Note: App denotes appreciation and dep denotes depreciation. IR is interest rate, Rel IR is relative interest rates EA-US, FX is the exchange rate either NEER or EURUSD, HICP are consumer prices and IP are import prices. EA stands for euro area. Rel GDP in BdE and BdI is Real GDP EA-US. "1" denotes positive sign, "-1" denotes negative, "0" denotes zero restriction and "*" denotes unrestricted response. PAC also includes US monetary policy as an endogenous variable, while BdI treats it as exogenous.

BVAR from CK (2017)

2) Comunale and Kunovac (2017) - Complete identification

Short run restrictions						
	GDP	HICP	IR	FX	IP	EXP
EA supply shock (AS)	-1	1	*	*	*	0
EA demand Shock (AD)	1	1	1	-1	*	0
Global demand shock (GD)	1	1	*	*	*	1
Exogenous exchange rate shock (FX)	*	1	*	1	1	*
Relative EA monetary policy (MP)	1	1	-1	1	*	*
Global supply shock (GS)	-1	1	*	*	*	1
Long run restrictions						
	GDP	HICP	IR	FX	IP	EXP
EA supply shock (AS)	*	*	*	*	*	*
EA demand Shock (AD)	0	*	*	*	*	*
Global demand shock (GD)	0	*	*	*	*	*
Exogenous exchange rate shock (FX)	0	*	*	*	*	*
Relative EA monetary policy (MP)	0	*	*	*	*	*
Global supply shock (GS)	*	*	*	*	*	*

Lag length: 2

Exogenous block: 1 (Foreign export prices for EA)

Re-normalised so that all inflationary, Impulses responses are "normalized" in a way that median response of fourth variable (exchange rate) to every shock is equal to 1 at the horizon zero.

BVAR from CK (2017)

2) Comunale and Kunovac (2017) - ERPT ratios (or shock-dependent ERPT/PERRs)

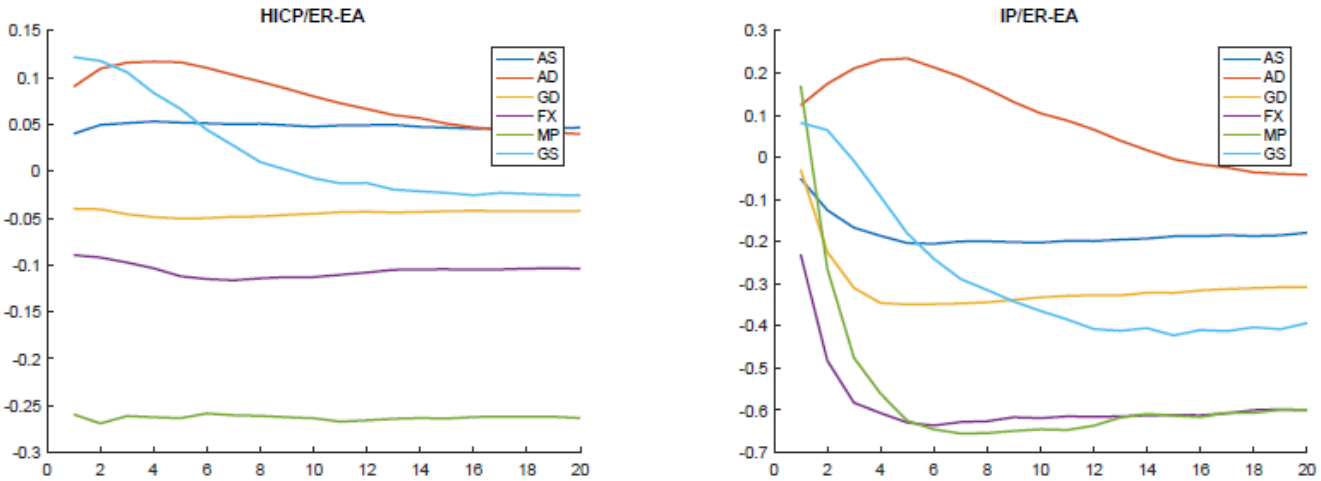

Figure 4: ERPT ratios for import deflator and HICP inflation in the euro area following each of the identified shocks - domestic aggregate demand (AD), aggregate supply (AS), global demand (GD), global supply (GS), exchange rate shock (FX), monetary policy (MP)

VAR ID in Lane and Stracca (2018)

Table 3. Sign restrictions imposed on a monthly VAR of the EA, estimated on the sample 1998: 1 to 2016: 12

Shock	*Demand*	*Supply*	*Monetary policy*	*FX*
Industrial production	+	+	+	
HICP	+	−	+	+
NEER	+		−	−
3-month interest rate	+	0	−	+

Note: All restrictions are imposed contemporaneously, with the exception of the HICP, where the restriction is imposed at $t+12$.

Overview of VAR specifications (original before making them comparable)

Variable block	Variable	Transformation	Specification BdE	CK	Forbes	PAC
Exchange rates	EURUSD	log-level				■
	EURUSD avg	log-diff	■			
	NEER	Q-o-Q			■	
	NEER-42	Q-o-Q		■		
Inflation measure	Headline domestic HICP	log-diff	■			
		Q-o-Q		■	■	■
Interest rates	Domestic shadow rate	level (detrended)			■	
		level; Wu-Xia				■
	Relative interest rate EA-US detren..	level; Wu-Xia		■		
	Relative shadow rate EA-US	difference EA-US; Krippner	■			
	US shadow rate	level; Wu-Xia				■
Other prices	Domestic import prices	Q-o-Q		■		
	Foreign export prices	Q-o-Q			■	
	Foreign export prices for EA	Q-o-Q		■		
	Import prices (goods and services)	Q-o-Q			■	
	Relative headline CPI EA-US	Q-o-Q				■
Real	Real GDP	log-diff	■			
		Q-o-Q		■	■	■
	Relative GDP EA-US	log-diff	■			
		Q-o-Q				■

Has there been time variation in PERR motivated by the different shocks?

- To identify potential changes in the response of EA inflation to exogenous exchange rate shocks, a time-varying parameter dynamic factor model, proposed in **Leiva-Leon et al. (2019)**, is applied.

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- The estimates indicate that the sensitivity of euro area headline inflation to exogenous exchange rate shocks has remained relatively steady over time. For core inflation: small and not significant.
- The sensitivity of the energy/food component of inflation to exogenous exchange rate shocks has significantly increased after the Great Recession.

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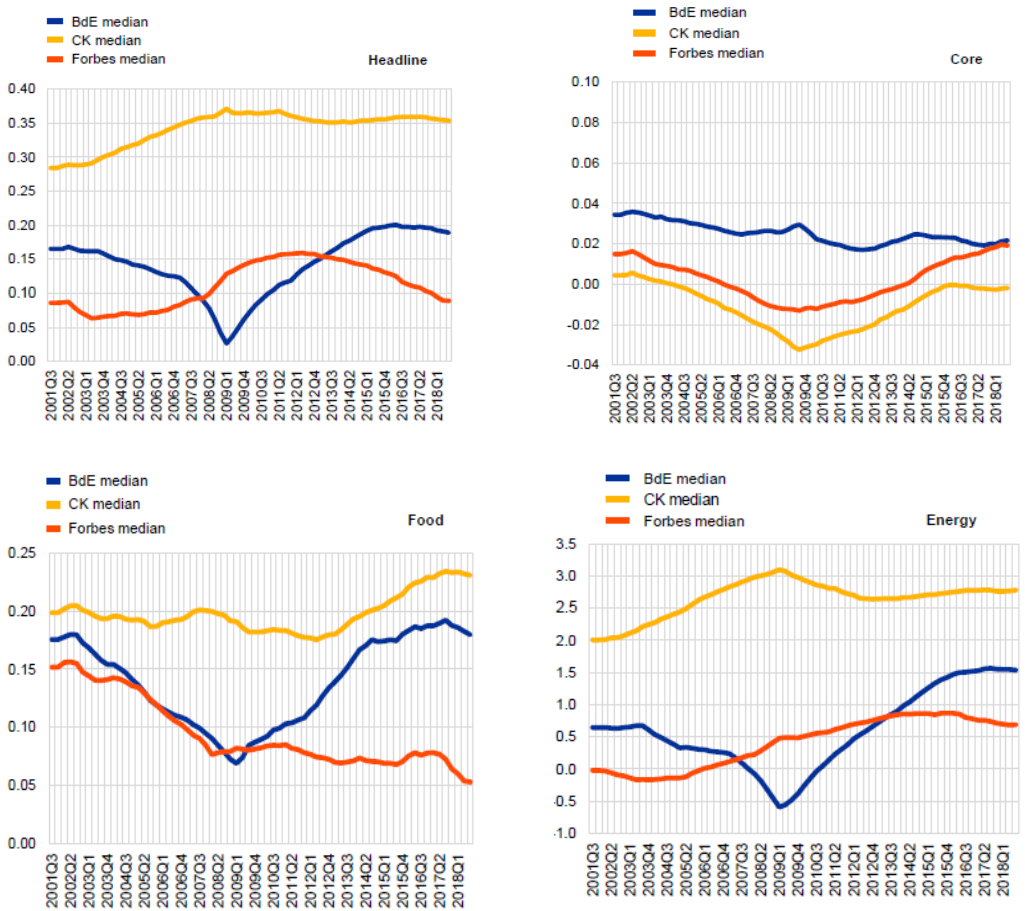

Source: Leiva-Leon et al. (2019)