

One Money, Many Markets¹

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¹The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.

Motivation

- ▶ Monetary policy in the euro area has long been challenged by financial, economic and institutional heterogeneity among member countries.
- ▶ Some convergence process in financial markets, but little in other important markets (for monetary transmission) such as labor and housing.
- ▶ Two questions emerge:
 - ▶ To what extent do differences in institutional backgrounds imply a heterogeneous transmission of the European Central Bank's (ECB) common monetary policy?
 - ▶ Which specific institutional characteristics drive the observed heterogeneity?

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In this paper...

- ▶ We investigate heterogeneity in the transmission of monetary policy across the euro area (EA) using a dynamic factor model (DFM).
 - ▶ We assemble a large dataset including economic and financial time series for the EA as a block and for the 11 original member countries, spanning the years from 1999 to 2016.
 - ▶ We identify the common monetary policy shock with a high-frequency approach.
 - ▶ For each set of impulse responses (e.g. GDP across member countries), we calculate the coefficient of variation statistic and we propose to use it as a way to statistically test for differences in the degree of heterogeneity between variables.
- ▶ We use heterogeneity across EA to investigate how institutional characteristics affect monetary transmission.

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Findings

- ▶ At the aggregate EA level, the factor model results are in line with theory (including no price puzzle).
- ▶ Country-level effects are significantly heterogeneous in private consumption, prices and variables related to labour and housing markets. At the same time, we find small heterogeneity of transmission to output and financial variables.
- ▶ Correlating institutional characteristics with responses in key variables shows clear patterns. Transmission of monetary shocks is stronger in countries:
 - ▶ that classified as Periphery
 - ▶ with higher homeownership rate
 - ▶ with higher share of adjustable rate mortgage contracts
 - ▶ with higher share of (wealthy) hand-to-mouth consumers
 - ▶ with higher wage rigidity
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Related Literature

- ▶ EURO AREA HETEROGENEOUS MONETARY TRANSMISSION
Calza et al.(2013), Ciccarelli et al. (2013), Barigozzi et al.
(2014).
- ▶ DYNAMIC FACTOR MODEL (DFM)
Bernanke, Boivin and Elias (2005), Stock and Watson (2012).
- ▶ HIGH-FREQUENCY IDENTIFICATION
Gertler and Karadi (2015), Jarocinski and Karadi(2018).

Empirical Strategy: The Dynamic Factor Model

- ▶ A small number of factors summarise the macroeconomy
- ▶ The ECB follows not only euro-wide data but also individual country data
- ▶ Overcomes a number of problems common in traditional VARs
 - ▶ Curse of dimensionality
 - ▶ Omitted variable bias
 - ▶ Measurement error

The Dynamic Factor Model

Macroeconomic time series...

$$X_t = (X_{1t}, \dots, X_{nt})' \quad (1)$$

...are modeled as a combination of factors and an idiosyncratic disturbance

$$X_t = \Lambda F_t + e_{it} \quad (2)$$

Evolution of factors

$$\Phi(L)F_t = \eta_t \quad (3)$$

Factors and factor loadings are estimated using principal component analysis.

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External Instrument Identification

- ▶ Find series that is correlated with monetary policy shocks, but uncorrelated with other shocks to the system.
- ▶ Technically, when regressing an external instrument on the VAR innovations, the fitted value of the regression identifies the structural shock (up to scale and sign).
- ▶ Intuitively, the variation in policy identified with the external instrument is true policy "surprise".

Algebra for external instrument

High Frequency Instrument

- ▶ The Instrument: Change in EONIA 1Y Swap rate during policy announcement.
- ▶ Assumption that all observed changes in swap rate are due to policy surprise.
- ▶ Endogenous policy changes do not move swap rate as they are priced in.
- ▶ How large should the window be?
 - ▶ 13:00 - 19:00 CET

“Scripta Volant, Verba Manent” - 1Y EONIA swap rate 5 Jun 2008

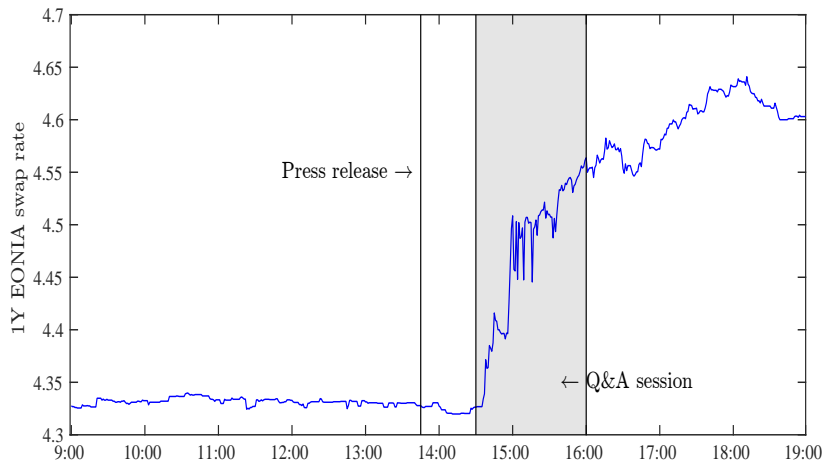


Figure: 1-year EONIA swap rate on 5 June 2008. Horizontal axis shows Central European Time (CET). Source: Bloomberg, authors' calculations.

1Y EONIA swap rate 6 Oct 2011

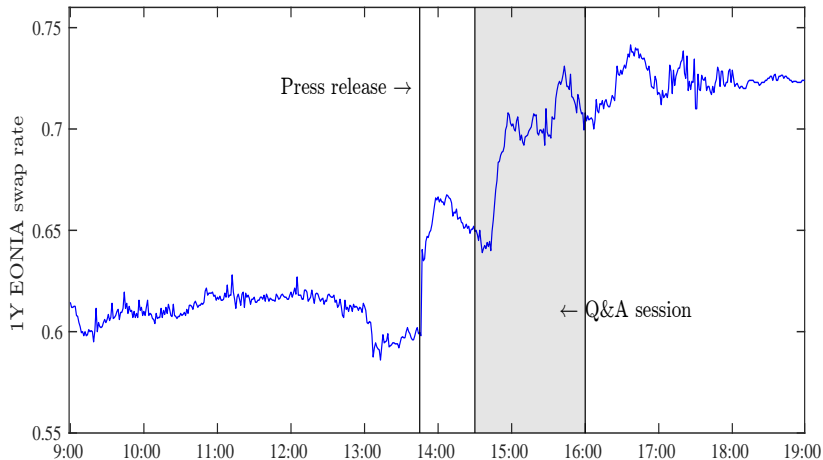


Figure: 1-year EONIA swap rate on 6 October 2011. Horizontal axis shows Central European Time (CET). Source: Bloomberg, authors' calculations.

<https://www.ecb.europa.eu/press/pressconf/2011/html/is111006.en.html>

Instrument Series

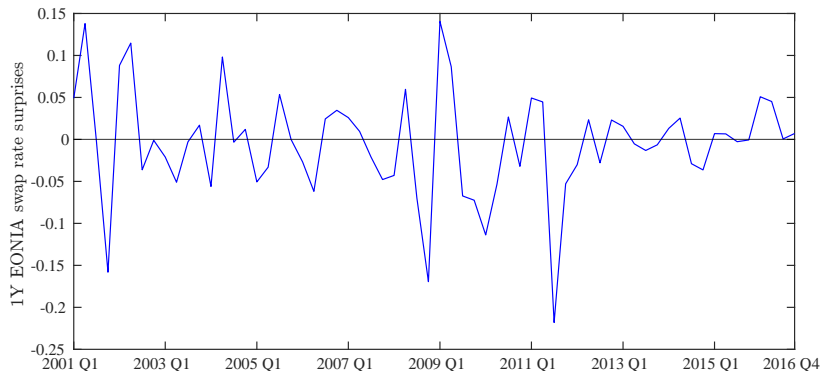


Figure: Instrument - Quarterly 1-year EONIA swap rate surprises from 2001Q1 to 2016Q4

Data

- ▶ Quarterly time series from 1999:Q4 to 2016:Q4 for 90 area-wide measures such as prices, output, investment, employment and housing...
- ▶ ...as well as 342 individual country time series on measures of output, prices and housing.
- ▶ 179 series are used to extract factors.
 - ▶ Beware of double-counting!
- ▶ All data series are transformed to induce stationarity. Depending on the nature of the data, this was done either by taking the first difference in logs or levels.

Empirical Model Set Up

- ▶ We select 5 factors using a battery of tests: Onatski (2009), Onatski (2010), Bai and Ng (2002), qne Owen and Wang (2015).
- ▶ On the basis of Akaike and Bayes Information Criteria we include one lag for the baseline of the DFM.

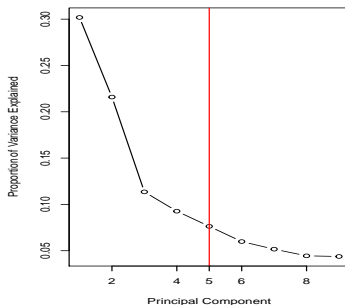
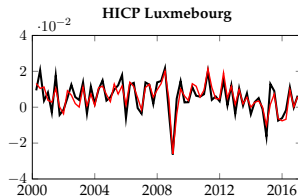
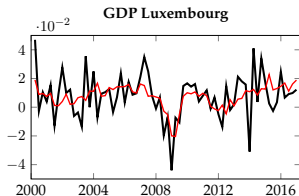
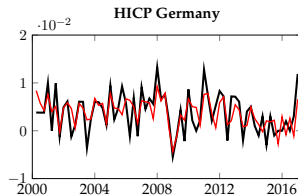
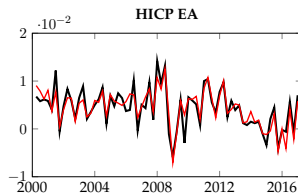


Figure: Data variance explained by each additional factor

How Well Do Factors Capture the Euro Economy?

	EA aggregate	Average across individual country series	Average across large* countries	Average across small** countries
Gross Domestic Product	0.85	0.56	0.70	0.45
Harmonised Index of Consumer Prices	0.81	0.64	0.71	0.59
House Prices	0.71	0.46	0.52	0.40
Exports	0.76	0.54	0.49	0.58
Imports	0.75	0.58	0.45	0.69
Government Spending	0.18	0.68	0.77	0.59
Gross Fixed Capital Formation	0.76	0.33	0.51	0.19
Consumption	0.61	0.30	0.34	0.27
Unemployment	0.72	0.51	0.68	0.36
Long-term Rates	0.99	0.98	0.98	0.98
Rents	0.41	0.35	0.32	0.38
Share Prices	0.65	0.58	0.59	0.57
Producer Prices in Industry	0.87	-	-	-
Wages	0.75	-	-	-
Employment	0.74	-	-	-
GER 2Y yield	0.98	-	-	-
Cost of Borrowing indicator	0.91	-	-	-
EONIA	0.99	-	-	-
Nominal Effective Exchange Rate	0.12	-	-	-

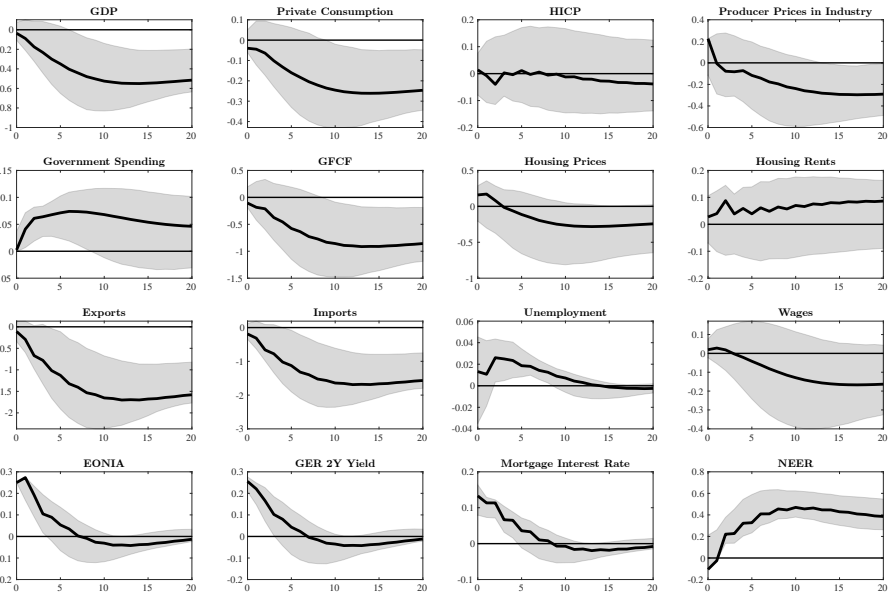
Fitted Factors Examples



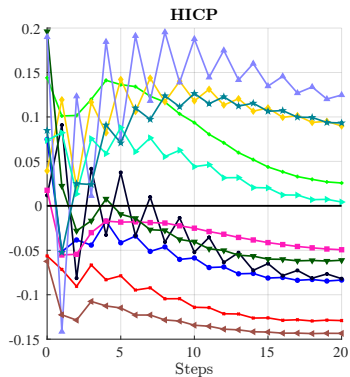
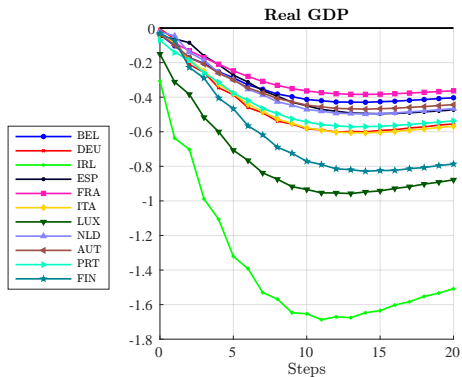
Tentative Factor Interpretation

	Series	R-squared
Factor 1	Producer Prices in Industry	0.67
	Harmonised Index of Consumer Prices	0.56
	Industrial Turnover Index, Manufacturing	0.53
	Compensation of Employees	0.49
	Gross Fixed Capital Formation Price Index	0.48
Factor 2	Cost of Borrowing for Households for House Purchase	0.49
	6-month Euribor	0.45
	1-year Euribor	0.45
	3-month Euribor	0.44
	Long-term Interest Rate Belgium	0.43
Factor 3	Government Spending Italy	0.61
	Unit Labour Cost Germany	0.61
	Government Spending Finland	0.61
	Unit Labour Cost Luxembourg	0.60
	Unit Labour Cost Italy	0.60
Factor 4	Unemployment Italy	0.63
	Unemployment Netherlands	0.49
	Real House Prices Ireland	0.44
	Unemployment Finland	0.43
	Real House Prices France	0.43
Factor 5	Real House Prices Netherlands	0.46
	GDP Spain	0.40
	Private Consumption Spain	0.33
	House Prices Netherlands	0.32
	Gross Fixed Capital Formation in Construction	0.32

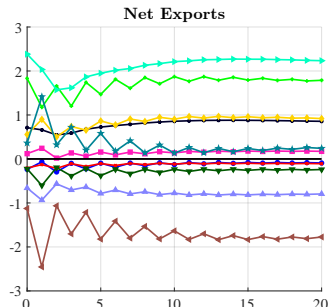
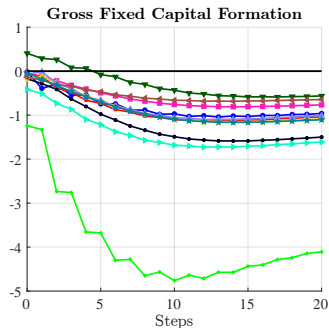
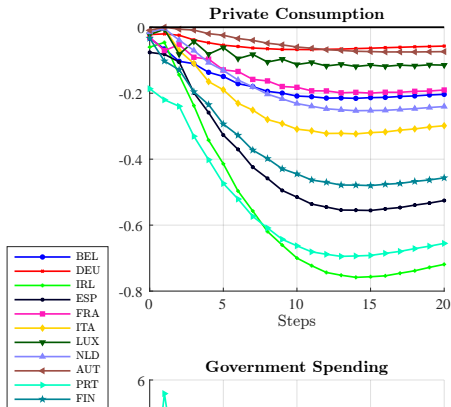
Euro-wide Results



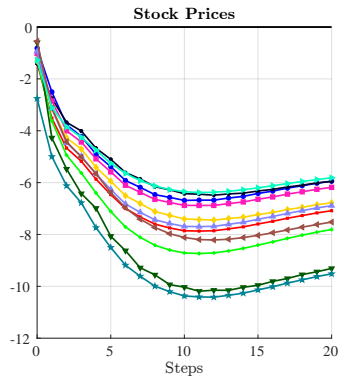
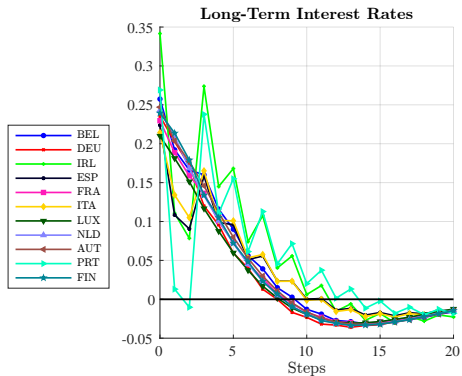
Cross-Country Results



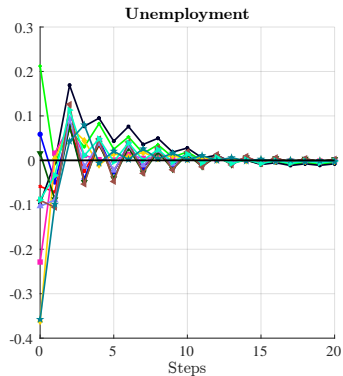
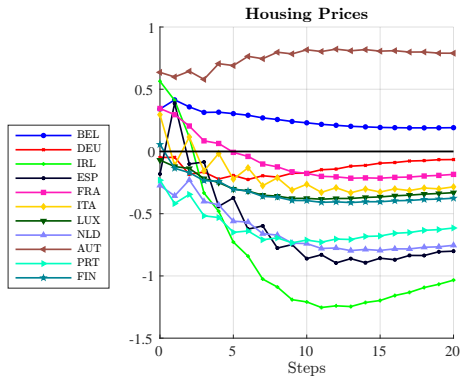
Cross-Country Results - Breaking Down GDP



Cross-Country Results - Financial Markets



Cross-Country Results - Housing Markets



Measuring Heterogeneity of IRFs - Coefficient of Variation

Variable	Coefficient of Variation	Lower Bound	Upper Bound
On Impact			
GDP	1.45	0.70	4.00
Private Consumption	1.19	1.01	2.52
Unemployment Rates	7.16	2.83	25.02
Housing Prices	2.03	1.51	4.57
Housing Rents	3.81	3.15	6.96
HICP	3.24	0.99	13.25
Long-term Interest Rates	0.21	0.14	0.53
Stock Prices	0.37	0.21	0.65
At the 20th Step			
GDP	0.64	0.47	0.95
Private Consumption	1.02	0.99	1.11
Unemployment Rates	1.24	0.94	4.22
Housing Prices	1.08	0.84	2.02
Housing Rents	2.41	1.13	8.20
HICP	1.25	0.62	4.05
Long-term Interest Rates	0.46	0.17	1.87
Stock Prices	0.21	0.19	0.26

Pair-wise Degree of Heterogeneity Testing

	GDP	HICP	LTINT	SP	PCON	U	RHPI	RREN
On Impact								
GDP	0	-0.99	1.20*	1.06*	0.16	-5.42*	-0.84	-2.15
HICP	0.99	0	3.02*	2.85*	1.69	-3.81	0.66	-0.41
LTINT	-1.20*	-3.02*	0	-0.13	-0.90*	-6.66*	-1.79*	-3.43*
SP	-1.06*	-2.85*	0.13	0	-0.84*	-6.84*	-1.60*	-3.32*
PCON	-0.16	-1.69	0.90*	0.84*	0	-5.20*	-0.75	-2.48*
U	5.42*	3.81	6.66*	6.84*	5.20*	0	5.02	3.46
RHPI	0.84	-0.66	1.79*	1.60*	0.75	-5.02	0	-1.51
RREN	2.15	0.41	3.43*	3.32*	2.48*	-3.46	1.51	0
At the 20th Step								
GDP	0	-0.55	0.21	0.45*	-0.39*	-0.59*	-0.43*	-1.74*
HICP	0.55	0	0.64	1.02*	0.19	-0.18	-0.16	-0.93*
LTINT	-0.21	-0.64	0	0.24	-0.60	-0.99*	-0.62	-1.65*
SP	-0.45*	-1.02*	-0.24	0	-0.80*	-1.04*	-0.85*	-2.17*
PCON	0.39*	-0.19	0.60	0.80*	0	-0.20	0.00	-1.38*
U	0.59*	0.18	0.99	1.04*	0.20	0	0.20	-0.84
RHPI	0.43*	0.16	0.62	0.85*	0.00	-0.20	0	-0.66
RREN	1.74*	0.93*	1.65*	2.17*	1.38*	0.84	0.66	0

Patterns of Transmission in the Euro Area

- ▶ Large diversity of institutional characteristics turns EA into prime laboratory to empirically study how characteristics affect monetary transmission.
- ▶ Consumption, gross fixed capital formation, unemployment, house prices and long-term interest rates in periphery countries respond to a shock more strongly than in core countries.
- ▶ Share of adjustable mortgage contracts and homeownership rate correlate positively with the strength of monetary transmission.
- ▶ Liquidity matters: Both the share of hand-to-mouth and wealthy hand-to-mouth consumers correlate significantly with the strength of monetary transmission.

Patterns of Transmission in the Euro Area

Table: Selected institutional characteristics of EA member countries.

Country	Core country	LTV ratio (%)	AMR share (%)	Homeownership rate (%)	Wage rigidity (%)	Price rigidity (months)	Share of HtM (%)	Share of WHtM (%)	Employment protection (index)	Total Leverage (%)
BEL	Yes	83	20	72.2	40	18.9	19.1	10.7	1.8	180
DEU	Yes	70	15	53.3	59	17.0	23.6	12.1	2.5	100
IRL	No	74	100	78.2	84	12.2	35.4	19.6	1.2	275
ESP	No	70	90	80.6	51	13.7	25.7	18.0	2.2	150
FRA	Yes	75	15	61.8	27	8.3	19.5	9.5	2.5	145
ITA	No	50	70	73.2	72	15.8	23.1	13.7	2.8	115
LUX	Yes	80	60	61.8	33	10.8	18.0	12.2	2.1	325
NLD	Yes	90	10	63.9	41	8.4	17.9	9.2	3.3	225
AUT	Yes	60	50	59.2	15	11.0	12.7	4.2	2.3	125
PRT	No	85	98	80.6	72	6.1	26.6	17.2	3.9	175
FIN	Yes	75	98	71.8	49	6.5	24.3	13.2	2.0	151

Notes: The third column reports the loan-to-value ratio for housing financing Calza et al. (2013). The fourth column reports the share of adjustable mortgage contracts Albertazzi et al. (2019). The sixth column reports the share of firms that adjusted wages less than once a year. The seventh column reports the average duration in months until prices are changed Alvarez et al. (2006). The eighth and ninth columns report the share of households that are classified as hand-to-mouth and wealthy hand-to-mouth, respectively (authors' calculations following the classification procedure by Slacalek and Violante (2020) and using data from the ECB's Household Finance and Consumption Network). The second to last column reports the employment protection index (OECD indicators of employment protection). The last column reports the ratio of total leverage to GDP (Eurostat).

Patterns of Transmission in the Euro Area

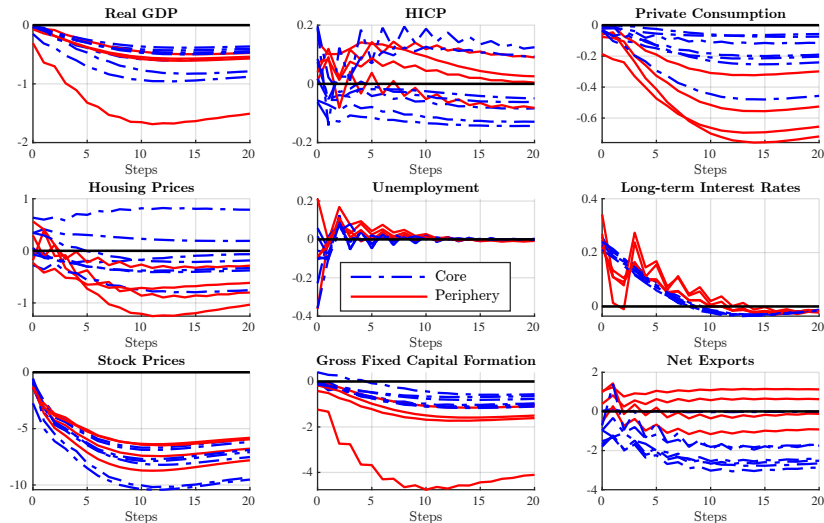


Figure: Percentage responses of selected variables to a 25bp contractionary policy shock across euro-area member countries grouped by core vs. periphery.

Patterns of Transmission in the Euro Area

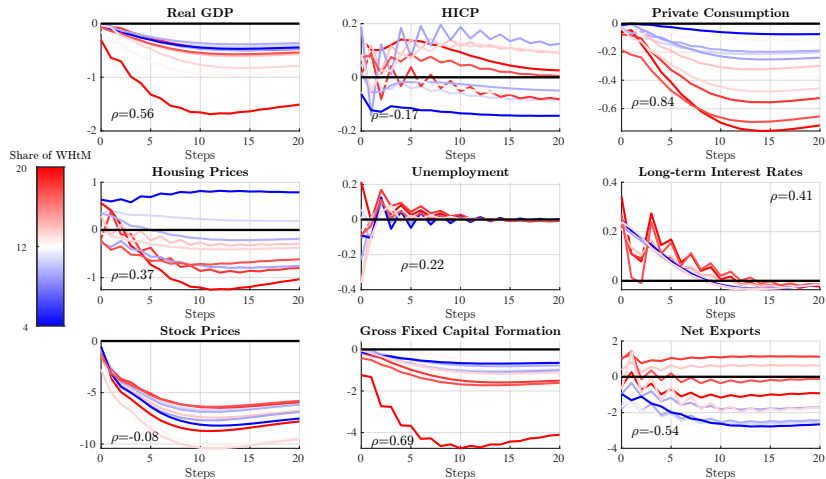


Figure: Percentage responses of selected variables to a 25bp contractionary policy shock across euro-area member countries with colour intensity as a function of the share of wealthy hand-to-mouth consumers.

Conclusion

- ▶ We document the degree of heterogeneity in monetary policy effects across the euro area, systematically analyzing the impulse response of a large number of macroeconomic and financial variables
- ▶ We propose the coefficient of variation (CV) as a quantitative measure of the degree of heterogeneity of impulse responses functions. This measure can be useful not only for empirical applications, but also theoretical ones (ability to quantify + statistically test level of heterogeneity)
- ▶ We find that differences in housing (share of adjustable mortgage contracts and homeownership rates), liquidity (share of (wealthy) hand-to-mouth hand-to-mouth consumers), and wage rigidity explain a large proportion of the EA cross-country heterogeneity of responses to monetary policy shocks

Appendix

External Instrument Identification

When regressing an external instrument Z_t on the VAR innovations η_t , the fitted value of the regression identifies the structural shock.

Innovations η_t are assumed to be linear combinations of structural shocks ϵ_t .

$$\eta_t = H\epsilon_t = [H_1 \dots H_r](\epsilon_{1t} \dots \epsilon_{rt})' \quad (4)$$

$$\Sigma_{\eta\eta} = H\Sigma_{\epsilon\epsilon}H' \quad (5)$$

$$\epsilon_t = H^{-1}\eta_t \quad (6)$$

External Instrument Identification

Combining $X_t = \Lambda F_t + e_{it}$ and $F_t = \Phi(L)^{-1} H \epsilon_t$, we get

$$X_t = \Lambda \Phi(L)^{-1} H \epsilon_t + e_t \quad (7)$$

Conditions for instrument:

1. $E(\epsilon_{1t} Z_t) = \alpha \neq 0$ (relevance);
2. $E(\epsilon_{jt} Z_t) = 0, j = 2, \dots, r$ (exogeneity);
3. $\Sigma_{\epsilon\epsilon} = D = \text{diag}(\sigma_{\epsilon_1}^2, \dots, \sigma_{\epsilon_r}^2)$ (uncorrelated shocks)

Back

External Instrument Identification

Covariance between innovations and instrument:

$$E(\eta_t Z_t) = E(H\epsilon_t Z_t) = (H_1 \dots H_r)(E(\epsilon_{1t} Z_t) \dots E(\epsilon_{rt} Z_t))' = H_1 \alpha \quad (8)$$

Denoting by Π the matrix of coefficients from the population regression of Z_t on η_t , we can write

$$\begin{aligned}\Pi\eta_t &= E(Z_t\eta_t')\Sigma_{\eta\eta}^{-1}\eta_t \\ &= \alpha H_1'(HDH')^{-1}\eta_t \\ &= \alpha(H_1'H'^{-1})D^{-1}(H^{-1}\eta_t) \\ &= (\alpha/\sigma_{\epsilon_1}^2)\epsilon_{1t}\end{aligned}$$

\Rightarrow The shock identified using the instruments Z_t is the predicted value from the population regression of Z_t on the innovations η_t