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DO THE ECB'S MONETARY POLICIES BENEFIT EMERGING MARKET ECONOMIES? A GVAR ANALYSIS ON THE CRISIS AND POST-CRISIS PERIOD

by Andrea Colabella*

Abstract

This paper studies the spillover effects of the ECB's monetary policies on non-euro area countries over the period 2004-2016, using the GVAR methodology, applied to a large sample of countries and a broad set of variables. Monetary policies are proxied by short-term interest rates and Wu and Xia's (2016) shadow rates in the euro area, the US and the UK. Identification is performed via a Cholesky decomposition for the euro area only. An increase in the euro area's shadow interest rate triggers a broad-based and persistent output decline abroad, especially in central eastern and south-eastern European economies. A euro-area shadow rate increase is also transmitted to the short-term interest rates of a number of countries, although such increases are short-lived and not as widespread as the GDP spillovers. There is evidence that differences in countries' responses to euro area monetary shock depends on their characteristics. The spillover effects are transmitted mainly through the trade channel, but the short-term interest rate channel, although to a lesser extent, plays a role.

JEL Classification: C32, E32, E52, E58, F41, O52.
Keywords: Global VAR, spillover, euro area monetary policy, Europe, CESEE.

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* Bank of Italy, Directorate General for Economics, Statistics and Research.

1. Introduction[1]

In recent years, central banks in advanced economies have implemented standard and non-standard monetary policies to counter the effects of the crises that hit the global economy over the last decade. A substantial strand of the economic literature has focused on international spillover effects of the Fed's unconventional monetary measures on financial markets and the real economy (e.g., Fratzscher *et al.*, 2016; Bauer and Neely, 2014; Chen *et al.* 2016). Analyses of the international effects of ECB's non-standard monetary policy have been mostly centred on financial markets (Ciarlone and Colabella, 2016; Fratzscher *et al.,* 2014; Georgiadis and Gräb, 2015; Falagiarda *et al.*, 2015; Falagiarda and Reitz, 2015, just to mention a few), while studies on the real economy have come to the fore only recently (Bluwstein and Canova, 2016; Feldkircher *et al.*, 2017; Hájek and Horváth, 2017; Potjagailo, 2017; Benecká *et al.,* 2018).

This study aims to contribute to this latter and growing stream of literature, focusing mostly (but not exclusively) on the effects of the ECB's non-standard monetary policies on Central-Eastern and South-Eastern European (CESEE) economies, in consideration of their high degree of trade and financial integration with the euro area. In view of the ongoing recalibration of the ECB's Extended Asset Purchase Programme (EAPP), and with markets expecting the prospective end of EAPP and the beginning of a tightening cycle by the ECB, the analysis of spillover effects is of crucial importance at this juncture.

In accomplishing our task, we opted to use a Global Vectorial Autoregressive (GVAR) model covering major advanced and emerging market countries, in addition to CESEE economies. This allows us to account for complex interlinkages between different countries and regions in the world avoiding the "curse of dimensionality" problems that usually mark multi-country models. We built a new dataset for the 31 countries included in the model, mostly drawing from the IMF International Financial Statistics database on GDP, inflation, short-term interest rates and exchange rates (*vis-à-vis* the euro). The ECB's monetary policy measures are approximated by the Wu and Xia's (2016) shadow policy rate, specifically designed to take into account conventional and unconventional monetary policies, while not being constrained by the zero lower bound (ZLB).

So far, the main objective of the great majority of GVAR studies has been to analyze the global propagation of shocks from the country where they originated; in general, the issue of shock identification in the originating country is not tackled. This lack of identification could raise the question of the nature of the shock that is being transmitted to all the other economies in the model (i.e., whether it is in fact the shock of interest – in our case a monetary policy shock – or something else), which limits the possibility to use the results for the purpose of policy simulation (Galesi and Sgherri, 2009). To overcome this issue, we deem it crucial to adopt an identification strategy, even though a very basic one. Hence, we follow a simple Cholesky decomposition, applied to the euro area only, with a view to striking a balance between the need for clear-cut identification of the shock and

[1] I would like to thank participants to a Banca d'Italia lunch seminar, those to the 12th South-Eastern European Economic Research Workshop (Tirana, 6-7 December 2018), an anonymous referee as well as Ambrogio Cesa-Bianchi, Emidio Cocozza, Pietro Catte, Marco Flaccadoro, Giorgio Merlonghi, Carlo Pizzinelli and Vanessa L. Smith for their helpful comments and suggestions. Part of this work was undertaken when I was visiting the Department of Economics at the University of Oxford, whose kind hospitality is gratefully acknowledged. The views expressed in this paper are those of the author and not necessarily reflect those of the Bank of Italy. All the remaining errors are exclusively mine. E-mail: andrea.colabella@bancaditalia.it.

the desire to keep things as simple as possible and not imposing an implausible structure on the model itself.

Our main results show that a contractionary monetary policy shock in the euro area brings about a broad-based and persistent output decline abroad, especially in CESEE economies and, to a lesser extent, in other euro area neighbouring countries. At the same time, the increase in the euro area shadow interest rate is transmitted also to the short-term interest rates of a number of other countries, although such increases are short-lived and not as widespread as the GDP spillovers.

Against this background, we checked whether the transmission of the spillover effects can be seen as occurring through a trade and/or a short-term interest rate channel, an exercise that is seldom performed in the GVAR literature. We focus on CESEE economies for the reasons explained above and our findings underscore that country characteristics could have a significant bearing on the prevalence of one channel or the other.

We classified countries according to the degree of trade and financial openness (high and low) and to the type of the exchange rate regime (*vis-à-vis* the euro) in place, i.e. countries with some form of peg to the euro and those without, and checked whether the relative importance of the two channels varied along these dimensions.

First, we find that, in CESEE economies with high trade openness, there seems to be working the external demand effect of the trade channel - which implies a positive co-movement between GDP in the euro area and those in its neighboring countries -, a likely consequence of the weaker external demand reflecting the larger export share of such countries.

Second, we also find the existence of a consumption switching effect, i.e. the negative co-movement between the euro area GDP and that of its neighbors, which is triggered by the depreciation of the domestic currency *vis-à-vis* the euro or the limited transmission of the euro area short-term interest rate increase. Such an effect partly offsets the demand absorption channel, and appears to be on the table in the case of countries with flexible exchange rate regime *vis-à-vis* the euro or with low financial openness.

Third, differences in the degree of financial integration point to the role of the short-term interest rate channel in CESEE economies: in fact, such a channel operates only for those countries that are highly financially integrated (most likely with the euro area given the set of country at stake). It could reflect the higher degree of cross-border leverage, the stronger responsiveness to foreign lending conditions in these economies, the policy reactions of domestic central banks to contain the emergence of rate spreads and the resulting capital movements. In countries with low financial openness, there appear to be two mechanisms at play: the weak link with global interest rates (and through them to euro area interest rates), which softens the effects of the increase in the euro area short-term interest rates; and the consumption switching effect.

Finally, both the trade channel and the short-term interest rate channel could matter in explaining the difference in spillovers between countries that have some form of peg to the euro and those that don't. The fact that the sharper GDP contraction occurred in countries 'pegged' to the euro, - which are in general small and open - can be due to the working of the external demand channel, which is not offset by exchange rate depreciation and the associated expenditure switching effect. In addition, such a GDP reduction could also stem from the larger increase in short-term domestic interest rates and thus from larger monetary policy spillovers.

In terms of policy implications, our results suggest that when designing and implementing policies, authorities in CESEE countries should factor in spillovers originating from the prospective normalization of the ECB's monetary policy.

This piece of research contributes to the literature on the spillover effects of the ECB monetary measures in four dimensions. First, it analyses a broad set of countries – accounting for more than 80% of world GDP - while maintaining its attention on the CESEE economies, which are analyzed in greater detail throughout the paper. It also focus on a time span that takes into account the unfolding of the different ECB's non-standard monetary policy measure. Differently from the majority of papers in the field so far, which do not use any identification strategy, rather we chose to identify the shock we are interested in by a very simple approach (i.e. a Cholesky decomposition). Finally, we disentangle the working of the ECB's monetary policy spillovers through the lens of different transmission channels.

The remainder of this paper is organized as follows. Section 2 contains a brief review of the literature. Section 3 sketches the transmission channels. Section 4 describes the general set-up of a GVAR model, whereas Section 5 provides details of the construction of the model used in the paper. In Section 6 the identification strategy is presented. Section 7 holds the results of the exercise, while some robustness tests are reported in Section 8. Section 9 concludes.

2. Review of the literature

The issue of international spillovers of the ECB's non-standard monetary policy has recently been the subject of a number of studies.[2] Bluwstein and Canova (2016) implement a Bayesian mixed-frequency structural vector autoregressive model to study such spillovers on nine European (EU and non-EU) countries between December 2008 and May 2014.[3] As a proxy for the ECB's unconventional monetary policy, they add up the amounts of long-term refinancing operation programmes, the Securities Markets Programme, and the first and second Covered Bond Purchase Programmes. They also use a dummy variable that takes into account the news stemming from the announcement of non-standard monetary policies. They find that the size of international spillovers on output and, to a lesser extent, inflation positively depends on the size of the financial market and the fraction of domestic banks in the banking system. They also note that the exchange rate regime plays no role.

Horváth and Voslarova (2017) implement a panel VAR model to study the external effects of the ECB's non-standard monetary policy on output growth and inflation in the Czech Republic, Hungary and Poland. They use three proxies to measure the ECB's unconventional monetary policy: Wu and Xia's (2016) and Krippner's (2013) shadow rates and asset stocks in the Eurosystem's balance sheet between 2008 and 2014. Their evidence shows that economic activity reacts more strongly than prices to the ECB's unconventional policy. Using variance decompositions, they also find that the ECB's unconventional policy explains more than 10% of economic activity fluctuations but only approximately 2% of price fluctuations.

Babecká Kucharčuková *et al.* (2016), using data from January 1999 to July 2014, build a monetary conditions index (MCI) for the ECB policy, which provides a synthetic measure of euro area monetary

[2] See Dedola *et al.* (2013) for the theoretical underpinnings of the unconventional monetary policy spillovers. Some papers focus only on the external effects of the ECB's conventional monetary policy. See Hájek and Horváth (2017) for a survey.

[3] They convert both low-frequency macroeconomic data (reported on a monthly basis) and high-frequency financial market data (daily data) to a common weekly frequency.

conditions based on a dynamic factor model of 14 monetary policy indicators, including interest rates, monetary aggregates, selected ECB's balance sheet items and the exchange rate. To analyze the effects on inflation and output of the ECB's monetary policies in the Czech Republic, Denmark, Hungary, Poland, Sweden and the United Kingdom, they use two subcomponents of the MCI, one tracking the conventional and the other the unconventional policy. The results point to a marked heterogeneity as to the relevance of international spillovers of the ECB's measures: while conventional monetary policy spillovers impact on all countries (especially in terms of output), the external spillover effects from unconventional policy are typically weak, and their size varies across countries.

Hájek and Horváth (2017) compare the international spillover of the euro area and US monetary policy stances, along with international spillovers of price shocks, on industrial production and prices in non-euro area EU countries (both advanced and emerging economies) using monthly data spanning from January 2001 to December 2016 in a GVAR model set-up. To take into account the ECB and the Fed's monetary policy stance they use three types of shadow policy rates, proposed, respectively, by Wu and Xia (2016), Krippner (2013) and Chen *et al.* (2017). Against this background, they find that an increase in the ECB's shadow rate decreases economic activity and, to a lesser extent, prices; moreover, the authors illustrate that for non-euro area EU countries shocks stemming from changes in the Fed's monetary policy stance matter less than those originating in the euro area, while euro area price shocks do not appear to have a bearing on non-euro area EU economies.

In a Bayesian version of GVAR (BGVAR) models, Feldkircher *et al.* (2017) use a 28-country monthly dataset from October 2000 to June 2016 to assess the existence of spillovers related to the ECB's asset purchases programmes. They use longer-term yields in the euro area economies and spreads between euro area countries longer-term yields as a proxy of such programmes, and identify the shock with sign and zero restrictions. Feldkircher *et al.* (2017) show that shocks originating from both proxies generate positive spillovers on industrial production of non-euro area countries, underlying that the effects are mostly transmitted via financial channels, and strong enough to outweigh the effects of appreciation pressures on local currencies *vis-à-vis* the euro.

Through a GVAR model run on monthly data spanning from October 2008 to June 2014 Chen *et al.* (2017) study the domestic and international propagation of the Fed and the ECB's unconventional monetary policies on 24 major advanced and emerging market economies. They measure unconventional monetary policies with a shadow interest rate developed by Lombardi and Zhu (2014), and identify monetary policy shocks via sign restrictions. They find that the Fed's unconventional policies have stronger domestic and international impacts than the euro area's non-standard measures, especially in terms of output dynamics and inflation. At the same time, they show that responses are rather heterogeneous across emerging market economies.

IMF (2016) analyzes the cross-border impact of the ECB's early non-standard monetary policies on six non-euro area EU countries (i.e., two Nordic and four CESEE economies). The analysis, which is run on monthly data between 2008 and 2014, applies a large-scale GVAR model that covers the major euro area economies, Brazil, China, India, Russia, Switzerland, the United Kingdom, and the United States. The ECB's unconventional monetary policies are proxied by the Wu and Xia's (2016) shadow rate and the term spread. In contrast to the findings of Feldkircher *et al.* (2017), the IMF's study finds no statistically significant effect on non-euro area economies' output and inflation.

Potjagailo (2017) studies spillover effects from a euro area monetary policy shock, including those stemming from the implementation of non-standard measures, on fourteen European countries outside the euro area. The analysis is based on a factor-augmented vector autoregressive (FAVAR) model with two blocks. After an expansion in the euro area monetary policy, production increases in most of non-euro area countries, whereas short-term interest rates and financial uncertainty decline. Nevertheless, spillover effects vary according to country characteristics: they are larger in non-euro area economies with a higher degree of trade openness and financial integration.

Moder (2017) analyses the impact of the euro area's non-standard monetary policy measures on South-Eastern Europe, by using bilateral BVAR models and data spanning from 2008 to 2015. Adopting Eurosystem balance sheet assets as the main proxy for the ECB's non-standard monetary policies, she finds widespread and significant spillover effects on prices, but only limited effects, in just half of the sample countries, on output. She also stresses that exports appear to be the most relevant transmission channel for many countries, while the financial channel plays only a limited role.

Benecká *et al.* (2018) investigate the international effects of a euro area monetary policy shock through a GVAR model in the period 2001Q1 2016Q4 for 37 countries, including some CESEE economies. They use shadow rates as a proxy for the monetary policy stance and impose zero and sign restrictions. In particular, they introduce euro area common variables (i.e., the euro area policy rate and the exchange rate *vis-à-vis* the US dollar) which respond only to euro-area country-specific variables. Against this background, they find that in response to a euro area monetary tightening output falls and price adjust in most CESEE countries, although with a significant degree of heterogeneity.

3. Transmission channels

Euro area monetary policy shocks can propagate to non-euro area economies through different transmission channels, some of which operate only in the case of unconventional monetary policies (Bluwstein and Canova, 2016). While the transmission of such a shock is potentially spreadable to the rest of the world, an important region to focus on is the one made up by CESEE countries as the latter are very commercially and financially integrated with the euro area. In this context, the main transmission channels are being analyzed are the trade and the financial (short-term interest rate) one (Potjagailo, 2017).[4]

Trade channel. A tightening of euro area monetary policy decreases demand for non-euro area economies' exports of goods and services. This tends to depress those economies' output (*income absorption effect*). However, as a consequence of the euro area monetary tightening, those economies' exchange rates (*vis-à-vis* the euro) will tend to depreciate, if they are allowed to move freely, with the amplitude of the exchange rate response being determined *inter alia* by the non-euro area countries' monetary policy response to the external monetary shock. In this context, the exchange rate depreciation will be likely to improve these countries' trade balances and to raise their output via the *expenditure switching effect*. Hence, the latter tends to offset the income absorption effect, and the net spillover effect is potentially ambiguous. Under a flexible exchange regime (*vis-à-vis* the euro), whether the income absorption effect dominates the expenditure switching effect (or *vice-versa*) depends, in addition to the size of the exchange rate movement, on the structural features of the non-euro area economy, including its degree of openness, the elasticity of substitution between domestic and foreign goods and the intertemporal elasticity of substitution. On the contrary, for countries with fixed

[4] For the sake of simplicity and in view of the very stylized model used herein, we will simply refer to the financial channel in terms of a short-term interest rate channel, bearing in mind that it encompasses different transmission mechanisms.

exchange rates (*vis-à-vis* the euro), there is no offset, and the trade channel points unambiguously to a co-movement between their output and that of the euro area.

Short-term interest rate channel.[5] In light of the strong financial integration between the euro area and CESEE economies, euro area monetary policy impulses can also influence such countries via the short-term interest rate channel, irrespective of the depth in trade integration and the exchange rate regime. The short-term interest rate channel can operate in different ways: a) indirectly, through a rise in CESEE domestic interest rates triggered by an increase in euro area interest rate via higher world interest rates (Galí and Monacelli, 2005); b) through the global banking sector and by cross-border leverage (Potjagailo, 2017). A rise in the euro area interest rate increases the cost of euro-denominated loans, depressing their demand. In parallel, the depreciation of CESEE currencies (*vis-à-vis* the euro) caused by the euro area monetary tightening tends to increase the burden of existing foreign currency loans, which in turn generates negative wealth effects and deteriorates the creditworthiness of borrowers (Bruno and Shin, 2015). As euro area resident banks face a higher cost of funding at home, they curtail credit supply to CESEE economies (Cetorelli and Goldberg, 2012, Ciarlone and Colabella, 2016). Hence, euro area monetary policy can depress CESEE credit growth and cross-border banking and international capital inflows through deteriorated funding conditions. This, in turn, can dampen domestic investment and bring about international co-movements in output (Devereux and Yetman, 2010).

4. GVAR model

GVAR models are an econometric technique that purports to describe multi-country relationships, both in the short- and in the long-term. They intuitively capture important features of a comprehensive economic system, while maintaining a simple structure that allows for easy estimation (Canova and Ciccarelli, 2013). First introduced by Pesaran *et al.* (2004), these models, by exploiting the existence of long- and short-term relationships, aim to examine the propagation of shocks through various macroeconomic linkages between countries and regions, while addressing some of the common problems of large scale, reduced-form models.[6] In addition, GVAR models take into account higher-order spillover effects (Becké *et al.*, 2013), whose absence could lead to a large and systematic underestimation of the effects of cross-country interlinkages (Georgiadis, 2017).

Constructing a GVAR model involves two steps. In the first step a vector error correction model (VECM) is estimated separately for each country. In this modelling strategy, each economy (apart from the US) is (individually) estimated as a small open economy in which domestic variables are related to country-specific foreign variables and global variables. While the latter are common across all countries (i.e., the price of oil, or a global volatility index), the foreign variables are country-specific and provide the link between the evolution of the domestic economy and the rest of the world; they are taken as (weakly) exogenous when the country-specific models are estimated. In economic terms, the weak exogeneity assumption allows us to treat each country as a small open economy with respect to the rest of the world.

[5] This channel resembles the confidence, the wealth, and the portfolio rebalancing channels, which have a bearing first on financial markets – by changing liquidity, risk, and asset prices – and then hit the macroeconomy, through movements in investment and consumption (Bluwstein and Canova, 2016).

[6] GVAR models are closely related to Factor Augmented Vector Autoregression (FAVAR) models, which however also involve the need to give an economic interpretation to the common factors (Dees *et al.*, 2007).

In the second step, a global model is constructed combining all the estimated country-specific models and linking them through a matrix of predetermined cross-country linkages. In this way, each country is potentially affected by developments in all other countries.[7] Then, the model is solved.

First step. Country VECM build-up

Assume that in the global economy there are N+1 countries, indexed by i = 0, 1, 2,…, N. With the exception of country "0", which is supposed to be large (the United States), the remaining N countries are modelled as small open economies, in which a set of domestic variables ($\boldsymbol{x_{it}}$) is related to a set of country-specific foreign variables ($\boldsymbol{x^*_{it}}$), using an augmented vector autoregressive model (VARX*) specification.[8] Specifically, for each country i, a VARX*(p_i, q_i) model is considered; in this model the $k_i x\ 1$ vector $\boldsymbol{x_{it}}$ of domestic variables is related to the $k^*_i x\ 1$ vector of country-specific foreign variables ($\boldsymbol{x^*_{it}}$), and the $m_d x\ 1$ global variables ($\boldsymbol{d_t}$) plus a constant and a deterministic time trend.

$$\boldsymbol{\Phi_i}(L, p_i)\, \boldsymbol{x_{it}} = \boldsymbol{a}_{i0} + \boldsymbol{a}_{i1} t + \boldsymbol{\Upsilon}_i(L, q_i)\boldsymbol{d_t} + \boldsymbol{\Lambda}_i(L, q_i)\boldsymbol{x}^*_{it} + \boldsymbol{u_{it}} \qquad (1)$$

with t = *1, 2,…,*T. Here $\boldsymbol{\Phi_i}(L, p_i) = I - \sum_{i=1}^{p_i} \boldsymbol{\Phi_i} L^i$ is the matrix lag polynomial of order p_i of the coefficients associated with $\boldsymbol{x_{it}}$; $\boldsymbol{a}_{i0}$ is a $k_i x\ 1$ vector of fixed intercepts; $\boldsymbol{a}_{i1}$ is the $k_i x\ 1$ vector of coefficients on the deterministic time trends; $\boldsymbol{\Upsilon}_i(L, q_i) = \sum_{i=1}^{q_i} \boldsymbol{\Upsilon_i} L^i$ is the matrix lag polynomial of order q_i of the coefficients associated with $\boldsymbol{d}_t$; $\boldsymbol{\Lambda}_i(L, q_i) = \sum_{i=1}^{q_i} \boldsymbol{\Lambda_i} L^i$ is the matrix lag polynomial of the coefficients associated with $\boldsymbol{x}^*_{it}$; $\boldsymbol{u_{it}}$ is a $k_i x\ 1$ vector of country-specific shocks, which we assume to be serially uncorrelated, with zero mean and a non-singular covariance matrix ($\boldsymbol{\Sigma_{ii}}$), namely $\boldsymbol{u_{it}} \sim i.i.d.(\boldsymbol{0}, \boldsymbol{\Sigma_{ii}})$.[9]

For each country i at each time t, the vector $\boldsymbol{x^*_{it}}$ is constructed as the weighted average across all countries j of the corresponding variables in the model ($\boldsymbol{x_{jt}}\ j \neq i$). As a way of dealing with the "curse of dimensionality" when N is relatively large, the weights used in the construction of $\boldsymbol{x^*_{it}}$ are not estimated but specified *a-priori*, based on information that measures the strength of bilateral linkages in the global economy.

In line with the practice followed by the great majority of the existing GVAR literature (Dees *et al.*, 2007; Cesa-Bianchi *et al.*, 2011; IMF, 2016 and Hájek and Horváth, 2017 – just to mention a few authors) trade weights, obtained by the IMF's Direction of Trade Statistics (DoTS), will be used. The trade weight of country *j* in the foreign variables of country *i* (ω_{ij}) is given by the share of country *j* in the total trade of country *i*.[10] Hence, $\boldsymbol{x}^*_{it}$ is constructed as follows:

$$\boldsymbol{x}^*_{it} = \sum_{j=0}^{N} \omega_{ij}\, \boldsymbol{x_{jt}} \qquad (2)$$

in addition $\omega_{ii} = 0$ and $\sum_{j=0}^{N} \omega_{ij} = 1$.

Dees *et al.* (2007) show that country specific models Eq. (1) can be written in error correction (ECM) form representation, tested for cointegration and estimated.[11]

[7] These subsections follow rather closely Sgherri and Galesi (2009) and Metelli and Natoli (2018).

[8] VARX* are vector autoregressive models which use exogenous variables, in addition to endogenous ones.

[9] $\Phi_i(L, p_i)$, $\Upsilon_i(L, q_i)$, and $\Lambda_i(L, q_i)$ can differ across countries; the lag orders of order p_i and q_i are also chosen on a country-by-country basis.

[10] Trade statistics for the relevant countries and time periods include only trade in goods, thus omitting trade in services.

[11] To estimate country-specific VARX* models in ECM form (VECMX*) the Johansen's (1992) reduced-rank procedure is applied, modified to take into account the presence of exogenous variables (Harbo, 1998).

For the purpose of estimating the parameters of country-specific models, foreign variables are assumed to be weakly exogenous and this assumption can be tested (see below). Following Johansen (1992) and Granger and Lin (1995), the weak exogeneity assumption in the context of cointegrating models implies no long-run feedback from $\boldsymbol{x}_{it}$ to $\boldsymbol{x}^*_{it}$ without necessarily ruling out lagged short-run feedback between the two sets of variables. In this case $\boldsymbol{x}^*_{it}$ is said to be "long-run forcing" for $\boldsymbol{x}_{it}$, and implies that the error correction terms of the individual country VECMs do not enter in the marginal model of $\boldsymbol{x}^*_{it}$. As mentioned above, this allows us to treat each country as a small open economy with respect to the rest of the world. In other words, each country's domestic macroeconomic developments cannot affect the whole set of the rest of the world countries, at least in the long-run, though allowing for short-run feedbacks.

Second Step. Constructing and solving the GVAR model

After the estimation of the single VARX* models, they can be combined. Without loss of generality, we focus on the analysis of a first-order VARX*(1,1) specification. For the sake of simplicity and conciseness we also drop the vector of global variables, $(\boldsymbol{d}_t)$. Hence, Eq. (1) can be rewritten as

$$\boldsymbol{x}_{it} = \boldsymbol{a}_{i0} + \boldsymbol{a}_{i1}t + \boldsymbol{\Phi}_i\boldsymbol{x}_{i,t-1} + \boldsymbol{\Lambda}_{i0}\boldsymbol{x}^*_{it} + \boldsymbol{\Lambda}_{i1}\boldsymbol{x}^*_{it-1} + \boldsymbol{u}_{it} \tag{3}$$

for *i = 0,1,2,...,N.*

We define a new variable, $(\boldsymbol{z}_{i,t})$, which puts together domestic and foreign variables in $\boldsymbol{z}_{i,t} = (\boldsymbol{x}'_{it}, \boldsymbol{x}^{*\prime}_{it})'$, and plug it in Eq. (3).

$$\boldsymbol{A}_i\boldsymbol{z}_{it} = \boldsymbol{a}_{i0} + \boldsymbol{a}_{i1}t + \boldsymbol{B}_i\boldsymbol{z}_{it-1} + \boldsymbol{u}_{it} \tag{4}$$

where $\boldsymbol{A}_i = \left(\boldsymbol{I}_{k_i}, -\boldsymbol{\Lambda}_{i0}\right)$, $\boldsymbol{B}_i = (\boldsymbol{\Phi}_i, \boldsymbol{\Lambda}_{i1})$

We then define a global vector $\boldsymbol{x}_t$that collects all domestic variables for all the countries,

$$\boldsymbol{x}_t = (\boldsymbol{x}'_{1t}, \boldsymbol{x}'_{2t} \dots \boldsymbol{x}'_{Nt})' \tag{5}$$

which is a $kx1$ vector containing all the endogenous variables, with $k = \sum_{i=1}^{N} k_i$.

Hence, using Eq.(2), we can obtain the identity

$$\boldsymbol{z}_{it} = \boldsymbol{W}_i\boldsymbol{x}_t \tag{6}$$

for *i = 0,1,2,...,N,* where $\boldsymbol{W}_i$ is a country-specific link matrix of dimensions $(k_i + k^*_i)$ x k. This allows us to rewrite each country model in terms of the global vector specified above. By substituting Eq.(6) in Eq.(4), it yields

$$\boldsymbol{A}_i\boldsymbol{W}_i\boldsymbol{x}_{it} = \boldsymbol{a}_{i0} + \boldsymbol{a}_{i1}t + \boldsymbol{B}_i\boldsymbol{W}_i\boldsymbol{x}_{it-1} + \boldsymbol{u}_{it} \tag{7}$$

for *i = 0,1,2,...,N,* with $\boldsymbol{A}_i\boldsymbol{W}_i$ being a k_ix k matrix. The GVAR model is therefore constructed by stacking up all the individual country models.

$$\boldsymbol{G}\boldsymbol{x}_t = \boldsymbol{a}_0 + \boldsymbol{a}_1t + \boldsymbol{H}\boldsymbol{x}_{t-1} + \boldsymbol{u}_t \tag{8}$$

where

$$\boldsymbol{G} = \begin{pmatrix} \boldsymbol{A}_0\boldsymbol{W}_0 \\ \boldsymbol{A}_1\boldsymbol{W}_1 \\ \vdots \\ \boldsymbol{A}_N\boldsymbol{W}_N \end{pmatrix}, \qquad \boldsymbol{H} = \begin{pmatrix} \boldsymbol{B}_0\boldsymbol{W}_0 \\ \boldsymbol{B}_1\boldsymbol{W}_1 \\ \vdots \\ \boldsymbol{B}_N\boldsymbol{W}_N \end{pmatrix},$$

$$\boldsymbol{a_0} = \begin{pmatrix} \boldsymbol{a_{00}} \\ \boldsymbol{a_{10}} \\ \vdots \\ \boldsymbol{a_{N0}} \end{pmatrix}, \boldsymbol{a_1} = \begin{pmatrix} \boldsymbol{a_{01}} \\ \boldsymbol{a_{11}} \\ \vdots \\ \boldsymbol{a_{N1}} \end{pmatrix}, \boldsymbol{u_t} = \begin{pmatrix} \boldsymbol{u_{0t}} \\ \boldsymbol{u_{1t}} \\ \vdots \\ \boldsymbol{u_{Nt}} \end{pmatrix}$$

As **G** is a non-singular matrix that depends on trade weights and estimated parameters, we can invert it to obtain the GVAR model in its reduced form

$$\boldsymbol{x_t} = \boldsymbol{b_0} + \boldsymbol{b_1 t} + \boldsymbol{F x_{t-1}} + \boldsymbol{v_t} \tag{9}$$

where

$$\boldsymbol{b_0} = \boldsymbol{G^{-1} a_0}, \qquad \boldsymbol{b_1} = \boldsymbol{G^{-1} a_1}, \qquad \boldsymbol{F} = \boldsymbol{G^{-1} H}, \qquad \boldsymbol{v_t} = \boldsymbol{G^{-1} u_t}$$

Eq.(9) can be solved recursively. The variance - covariance matrix of the GVAR is retrieved from the country-specific reduced-form residuals v_{it} and is given by the following

$$\Sigma^v = \begin{bmatrix} \Sigma_0^v & \dots & \Sigma_{0,N}^v \\ \dots & \dots & \dots \\ \Sigma_{N,0}^v & \dots & \Sigma_N^v \end{bmatrix} \tag{10}$$

with $\Sigma_{i,j}^v$ and Σ_i^v being, respectively, the sample covariance matrix between country *i* and country *j*, and the sample covariance matrix of country *i*.

5. Model set-up

On the basis of the variables selected in IMF (2016), we build a new database extracted from IMF International Financial Statistics that include monthly data for a wide set of countries, both advanced and emerging market economies, from January 2004 to December 2016. The choice made in terms of the starting date reflects mainly data availability, while allowing us to focus on the global financial crisis, sovereign debt crisis and post-crises periods.

With a view to analyzing spillovers stemming from the ECB's non-standard monetary policies especially on the euro area's closest Central and Eastern neighbours, we include a large number of countries from the CESEE area. At the same time, we also would like to take into account interactions with other important players in the world economy. Thus, we take on board in the GVAR model: a) the euro area, made up of 12 countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain), which account for more than 95% of total GDP (at 2016 PPP) of the area;[12] b) advanced non-euro area European Union (EU) economies (Denmark, Sweden and the United Kingdom); c) other non-EU advanced economies (Japan, Norway, Switzerland and the United States); d) major emerging market economies, (Brazil, China, India, Russia – BRICs - and Turkey); e) CESEE economies (Bulgaria, Croatia, the Czech Republic, FYR Macedonia, Hungary, Poland, and Serbia). These 31 economies account for slightly more than 80% of the world GDP at 2016 PPP.

To strike a balance between country- and data-coverage we decide to use only four domestic variables to limit the dimension of the model: real GDP index, CPI inflation, nominal exchange rate *vis-à-vis* the euro and a monetary policy proxy.[13] We also add two global variables: oil prices and a

[12] As it is customary in the literature on GVAR models, we picked up single euro area economies and built up the euro area by aggregating country models through the use of the respective GDP PPP weights.

[13] For the euro area, the nominal effective exchange rate is used.

measure of global volatility index (Gambacorta *et al.*, 2014; Georgiadis, 2015 and Conti *et al.,* 2015), which helps take into account the impact of financial tensions on the world economy.[14]

As regards the endogenous variables, we opt to transform into logarithms the real GDP index, so as to better align the variable choice to that of a great deal of the literature (Dees *et al.*, 2007; Cesa-Bianchi *et al.*, 2011). Real GDP is converted to monthly frequency via the Chow-Lin procedure, using industrial production as reference (IMF, 2016; Ganelli and Twak, 2016). We also use the shadow policy rates from Wu and Xia (2016) as short-term interest rates in the euro area, the United Kingdom and the United States, and short-term interest rates for the remaining countries.[15] Wu and Xia's (2016) shadow rate coincides with the policy rate in normal times and can move to negative territory when the policy rate hits the ZLB. It is the shortest maturity rates extracted from term structure models (for the euro area, the United Kingdom and the United States, respectively) that would generate the observed yield curves. In general, the inclusion of shadow rates in the model is particularly important since they reflect both conventional and unconventional monetary policy tools.[16] As such, and unlike conventional monetary policy rates, they can approximate the monetary policy stance once the economy hits the ZLB and unconventional monetary policy is in place (Hájek and Horváth, 2017; Damjanovic' and Masten, 2016), while incorporating both the effect of monetary policy measures on current economic conditions as well as market expectations of future policy actions. On top of this, the use of the entire yield curve to calculate the shadow rate allows to take into account of all the measures on intermediate and longer maturity rates (Mouabbi and Sahuc, 2018). To give an illustration of how important non-standard monetary measures have been in recent years **Figure 1** depicts the evolution of the ECB's policy rate (green line), that of the EONIA (red line) and, finally, that of the Wu and Xia's shadow rate (blue line). As long as the policy rate is far above the ZLB, the three lines overlap each other. However, as soon as the ECB started implementing non-standard policy measures, a gap opens up between the shadow rate (which appears to reflect such a more accommodative policy stance) and the policy and EONIA rates. The gap widens further in correspondence of the launch of the EAPP. Notwithstanding this anecdotal evidence, a proper identification of unconventional monetary policy shocks remains far from easy (Conti *et al.,* 2015).

Foreign variables are modeled as a weighted average of the corresponding domestic variables. Hence, we have foreign real activity, CPI inflation, short-term interest rates and nominal exchange rates.

[14] Given their focus on the euro area, Boeckx *et al.* (2017) include among their variables a Composite Indicator of Systemic Stress (CISS) in the financial system for the euro area. In light of the different geographical scope of this paper, we use the VIX, despite the latter captures tensions related to equity market only.

[15] Another widely-used shadow rate used in the literature has been proposed by Krippner (2013). Assessing pros and cons of different measures for shadow rates is beyond the scope of this paper, but the main difference between the Wu and Xia's (2016) and Krippner's (2013) shadow rates concerns the way they are respectively estimated. In particular, the Wu and Xia's measure has one fewer constraint on the empirical specification than Krippner's, which, according to Elbourne *et al.* (2018) gives rise to a trade-off between letting the data speak and the risk of overfitting the data. However, those authors argue that in the euro area the Wu and Xia's (2016) shadow rate better tracks a priori beliefs about significant monetary events than Krippner's (2013) one. They underline in particular key episodes such as the announcement and implementation of the EAPP in January 2015 (announcement) and March 2015 (first purchases). In the months following those events, the Krippner's shadow rate indicates an almost 200 basis points tightening of monetary policy, which Elbourne *et al.* (2018) consider as implausible. In contrast, the Wu and Xia's rate indicates a significant easing of monetary conditions in the same period. For a recent and thorough review see also Comunale and Striaukas (2017)

[16] Claus *et al.* (2014), Francis *et al.*, (2014) and Van Zandweghe (2015) show that in general the shadow rate captures the stance of monetary policy during ZLB episodes in the same way the policy rate does in normal times, thus preserving the dynamic relationships in place in the economy.

The country-model for the United States is built bearing in mind the relative size and importance of this economy in the world (Pesaran *et al.,* 2004; Dees *et al.* 2007). To this end, we include oil prices (Feldkircher, 2015) and the volatility index as endogenous variables (Chen *et al*. 2017), while excluding the exchange rate (Pesaran *et al.,* 2004). In addition, in light of the size and role of the financial market in the United States, we exclude foreign short-term rates from the United States model (Dees *et al.*, 2007). **Table 1** presents descriptive statistics with data definitions.[17]

For the construction of the trade weights needed to build the foreign variables, we use IMF-DoTS bilateral data regarding the exports and imports of merchandise goods covering 2014 – 2016, so as to better reflect the global economy evolution in the post-crises period. **Table 2** reports such weights. One can note that the euro area, China and the United States are the main trade partners of all the other countries of the model. In addition, the trade share of the euro area for the neighbouring countries is generally around 50%, while trade inter-linkages among CESEE individual countries appear to be very low, with just few exceptions. Other countries trade only marginally with CESEE economies, too. It is worth noticing that the weights are sufficiently "granular",[18] so as to satisfy one of the sufficient conditions to estimate a GVAR model (Dees *et al.*, 2007; Galesi and Sgherri, 2009).[19]

We perform an Augmented Dickey-Fuller and a Weighted Symmetric estimation of ADF regressions tests on the levels, first and second differences of all variables.[20] Apart from CPI inflation, which is integrated of order 2 – I(2) – most of the time series for real activity, short-term interest rates and exchange rates are I(1), in line with the findings of the literature (Hájek and Horváth, 2017).[21] This does not pose restrictions on the estimating procedure as long as the GVAR model passes the stability test of Dees *et al.* (2007),[22] i.e. that the moduli of all the 82 eigenvalues of the matrix F above are on or within the unit circle.[23] To keep things as simple as possible, we assume that the deterministic components of the individual vector correction models allow for an unrestricted intercept term and a restricted (to the cointegration space) trend term. We also apply the lags suggested by the Schwartz-Bayesian Information Criteria because they tend to be more accurate for small samples (Ivanov and Kilian, 2005). On top of this, we also run the F-test for weak exogeneity and that for residual serial correlation (Dees *et. al.,* 2007, Galesi and Sgherri, 2009). Test results are in **Tables 3** and **4**, and point to the presence of weak exogeneity in the data and very limited residual correlation.[24]

[17] Data appendix provide greater detail on data sources and transformation.

[18] According to Galesi and Sgherri (2009) granularity means that $\sum_{j=1}^{N} \omega_{i,j}^2 \to 0 \; as \; N \to \infty, \; for \; i = 1,2, \dots N$. As there are just a few relatively high weights (the highest one being 64%, which is the share of trade of the Czech Republic with the euro area), this condition is met.

[19] Two more conditions must be met: the first one relates to the dynamic stability of the model; the second one refers to the need for a weak correlation of idiosyncratic shocks. See below for greater detail.

[20] Data tests and estimations are run through the use of the GVAR Toolbox. See Smith, L.V. and A. Galesi (2014), GVAR Toolbox 2.0 https://sites.google.com/site/gvarmodelling/gvar-toolbox.

[21] Appendix B reports detailed results for ADF and WS tests.

[22] For the sake of brevity, we do not report country-specific models and related model-selection tests, including the number of cointegrating vectors for each country. Results are available upon request.

[23] To address the issue of possible overestimation of the number of cointegration relationships based on asymptotic critical values, and to assure the stability of the global model, we reduced the number of cointegration relations for a number of countries, along the lines suggested by Dees *et al.* (2007) and Cesa-Bianchi *et al.* (2011). More specifically, we reduced the cointegration rank of Bulgaria from four to three, that of the Czech Republic from three to one and, finally, that of the US from three to two.

[24] In particular, the test for the weak exogeneity hypothesis is rejected in around 7% of the cases, while the residual correlation emerges in a very limited way (again 7% of the sample), and only in exchange rate equations.

6. Identification strategy

Historically, the identification issue in GVAR models is taken up in terms of a particular strategy that uses generalized impulse response functions (GIRFs). In the context of GVAR frameworks GIRFs, originally proposed in Koop, Pesaran and Potter (1996) and further developed in Pesaran and Shin (1998), seem to be more appealing than Sims's (1980) traditional Orthogonalized Impulse Response Functions (Galesi and Lombardi, 2009): in fact, since GIRFs use the historical variance-covariance matrix, they do not orthogonalize the system residuals, while taking into account the historical correlations among the variables. As a consequence, GIRFs do not require the existence of an *a-priori* variable ordering in all the countries of the model. They are indeed invariant to the ordering of variables, and of the country models in the GVAR framework. Moreover, the use of GIRFs reflects the typical GVAR analysis that aims to investigate the geographical transmission of (country-specific or global) shocks. As such, the lack of identification is in general not perceived as a major obstacle to study the propagation of a (unidentified) shock among the countries in the model (Galesi and Sgherri, 2009).

At the same time, such a lack of identification impairs the GIRFs ability to provide information about the causal relationships among variables, therefore limiting the potential application of the GIRFs, especially for purposes of policy simulation (Galesi and Sgherri, 2009). Nevertheless, Dees *et al.* (2007) show that, if an ordering is assumed for only a country in the model (the US in their case), the Impulse Response Functions (IRFs) resulting from a simulation where such an ordering is imposed and those stemming from GIRFs are qualitatively similar.[25] Hence, the overwhelming majority of the literature has opted to utilize the GIRFs even for the analysis of a monetary policy shock.[26]

Only very recently the economic literature in the field has tried to identify monetary policy shocks in the context of the GVAR framework, resorting to zero and sign restriction assumptions (Feldkircher *et al.,* 2017; Giorgiadis, 2015; Benecká *et al.*, 2018 and Burriel and Galesi, 2018) or Cholesky ordering (IMF, 2016).[27] In what follows, we try to strike a balance between the need for identifying causal relationships among the variables of the system and the necessity to avoid imposing *a-priori* restrictions on too many countries. In order to keep things as simple as possible, we broadly follow IMF (2016) and enact a Cholesky decomposition for the euro area only.

In more analytical terms, to identify shocks in a GVAR model one needs to specify a matrix $\mathbf{P_0}$ that pre-multiplies Eq. (8). This yield to

$$\boldsymbol{P_0 x_t} = \boldsymbol{P_0 b_0} + \boldsymbol{P_0 b_1 t} + \boldsymbol{P_0 F x_{t-1}} + \boldsymbol{\epsilon_t} \quad (11)$$

where

[25] Dees *et al.* (2007) use an identification of a US monetary policy shock under two different orderings of the variables in the US model; they first test the Sims and Zha's (2006) type of ordering: oil, short-term interest rate, long-term interest rate, equity prices, inflation, output; then they use the alternative ordering: oil, long-term interest rate, equity prices, inflation, output, short-term interest rate, where the monetary policy variable is placed last, after inflation and output.

[26] In addition to Dees *et al.* (2007), both Felkircher (2015), who analyses the transmission of a euro area interest rate shock to non-euro area countries and other regions, and the above-mentioned piece of research by Hájek and Horváth (2017) employ GIRFs in this context.

[27] It is worth noticing that apart from Burriel and Galesi (2018), both Feldkircher *et al.* (2017) and Georgiadis (2015) focus on time windows which only partly overlap, to different degrees, to the one analyzed herein. At the same time, the exercise performed by Burriel and Galesi (2018) is rather different from the one presented in the following section, since they focus on euro area countries only.

$$\boldsymbol{P_0} = \begin{bmatrix} P_{0,0} & \cdots & P_{0,N} \\ \cdots & \cdots & \cdots \\ P_{N,0} & \cdots & P_{N,N} \end{bmatrix} \qquad (12)$$

with $P_{i,j}$ being matrices and

$$\boldsymbol{\epsilon_t} = \boldsymbol{P_0 v_t}$$

is the vector of identified structural shocks, with covariance matrix Σ_ε:

$$\Sigma_\varepsilon = \begin{bmatrix} \Sigma_{0,0} & \cdots & \Sigma_{0,N} \\ \cdots & \cdots & \cdots \\ \Sigma_{N,0} & \cdots & \Sigma_{N,N} \end{bmatrix} \qquad (13)$$

Identification of all the different shocks related to the total number of endogenous variables that are usually at stake in a GVAR model can be a "formidable undertaking"; however, this articulated identification strategy would not need to be put in place, as in practice monetary policy, demand and supply shocks are likely to be highly correlated across countries (Dees *et al.*, 2007). Here we limit our attention to the identification of the monetary policy shock in the euro area economy and consider the time profiles of its effects on other countries. To do so, we rank the euro area economy first, i.e., it will be represented by the matrix $P_{0,0}$.

As mentioned above, to identify a monetary policy shock in the euro area model we rely on a Cholesky decomposition, assuming an ordering in line with that proposed by IMF (2016), Dees *et al.* (2007) – or, in the context of the FAVAR literature, Bernanke *et al.* (2005).[28] In other words, in our ordering we assume shadow interest rates first, followed by exchange rate, output and inflation. In doing so, we will use the "Structural Generalized Impulse Response Function" (SGIRF), which ortogonalizes the system's residuals. By making such an assumption, we impose that the matrix $\boldsymbol{P_{0,0}}$ is lower triangular. At this stage, we also have to impose restrictions on the other elements of $\boldsymbol{P_0}$. In this regard, as we are not interested in identifying shocks in other countries, we can assume that all the other matrices on the diagonal of $\boldsymbol{P_0}$ are identities, and, along the lines of Dees *et al.* (2007), we set off-diagonal elements of $\boldsymbol{P_0}$ in Eq. (12) to be zero:

$$\boldsymbol{P_0} = \begin{bmatrix} P_{0,0} & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & I \end{bmatrix} \qquad (14)$$

7. Results and transmission channels

We start by analyzing the domestic and cross-country effects of an unexpected increase in the ECB's shadow policy rate of 20 basis points, equal to one standard error shock. As the impulse response analysis is based on the level of data and parameter estimation is run in the VECM representation, shocks will typically have a permanent effect (Feldkircher, 2015). Impulse response functions, with 2000 bootstrap replications, are shown in **Figures 2, 3** and **4**, for output, inflation and short-term interest rates, respectively.[29]

[28] While being the simplest identification scheme, the recursive identification scheme *à la* Cholesky is still probably the most diffused one. At the same time, it could impose at times very binding restrictions (Barigozzi *et al.*, 2014).

[29] IRFs for the nominal exchange rate are available upon request.

Output response

When an unexpected shock hits the euro area shadow policy rates, domestic activity decreases by about 0.4% on the policy horizon (Figure 2). While this impulse appears to have a bigger effect on activity than that obtained in the context of ECB's "conventional" monetary policies (Feldkircher, 2015 and Hájek and Horváth, 2017),[30] it is substantially in line with results obtained when the ECB's non-standard monetary measures are taken into account (Feldkircher *et al.,* 2017, Benecká *et al.*, 2018).

In terms of external spillovers, Figure 1 shows a widespread effect among countries and regions. In general, major advanced and emerging market economies outside the EU are hit by the euro area monetary policy shock, which triggers a permanent reduction in their GDP. However, the size of the effect is differentiated among countries. In the US and Japan is rather contained, a likely consequences of weaker trade links with the euro area (than the one in place between the euro area and non-euro area EU countries), along with other factors.[31] On the contrary, in China, Russia and Turkey there seems to be a very strong response to the euro area monetary policy shock, likely reflecting the working of indirect spillover effects, and, in the case of Russia and Turkey, the relatively high share in cross-trade, too.

Other advanced EU economies and Switzerland appear to react somewhat less than the euro area itself, ranging from -0.2% (the United Kingdom) to -0.4% (Sweden), while Central Eastern European (CEE) economies generally show a response in activity much closer to that of the euro area, especially in the case of the Czech Republic. In the context of South-Eastern European (SEE) economies, the response is differentiated. While that of Romania and Bulgaria is rather strong (-0.6 and -0.8%, respectively) - though the effect in the latter country fades away after 18 months - Croatia's activity contraction (-0.4%) is in line with that of Macedonia and Serbia, at around -0.3 %. In general, such rather homogeneous pattern can be likely traced back to the high degree of trade integration between the euro area and CEE, SEE economies, and, to a lesser extent, other EU advanced economies, which can help explain the similarity in the response to the monetary policy shock, confirming the results obtained by Georgiadis (2015).

Inflation response

Figure 3 shows the SGIRFs for inflation. In general, they appear to be not significant. In particular, the effect of the monetary policy shock on inflation in the euro area is mostly frontloaded and not significant. While this result might appear odd, it is common to models having a specification similar to the one used here, such as Chen *et al.* (2017) or IMF (2016).[32]

Comparing our results with other contributions in the literature is far from easy, since there is basically no other study that identifies a monetary policy shock in a GVAR setting over the period 2008-2016 through a Cholesky decomposition with the set of variables and countries adopted herein. In this context, but with a different estimation methodology, the lack of significance of the inflation response to a monetary policy shock can be found also in Potjgailo (2017) and Feldkircher *et al.* (2017), who find a frontloaded, very limited and often not significant effect of monetary policy shock

[30] Feldkircher (2015) found that an increase of 50 b.p. in the euro area short term interest rate triggers a decrease in domestic real activity of about 0.3%, a result similar to that found by Hájek and Horváth (2017). Bartocci *et al.* (2017) show that the corporate sector purchase programme (CSPP), one of the last non-standard measures implemented by the ECB, brought about an increase in GDP of about 0.3%.

[31] For instance in the case of the United States, the assumption of a lack of feedback of domestic financial markets to developments in financial markets abroad.

[32] See section 2 for greater detail.

on inflation.[33] At the same time, Burriel and Galesi (2018) analyze the propagation of an unconventional monetary policy shock in a euro area wide GVAR model, with sign and zero restrictions, and find that there are heterogeneous effects on inflation, varying from significant to not significant.

As regards the possible interpretations, we highlight that this exercise is done on a very specific sample period, which includes the two major recent crises, their ensuing consequences, and a protracted period of very low oil prices, which hit multi-year lows. On top of this, the limited impact of a monetary policy shock on inflation has been already detected by the literature (Conti *et al.*, 2015) and could also be driven by the link between asset prices and inflation, which has been recently analyzed by de Haan and van den End (2016). In particular, they find that the transmission lag of financial developments to inflation can be quite long and that the overall effects of quantitative easing on inflation can be uncertain, both in timing and direction. All of these could have contributed to watering down the effects of the monetary policy shocks on the euro area inflation evolution.[34]

Short-term interest rates response

In Figure 4 SGIRFs for short-term interest rates and shadow rates are reported. At a first glance, one can note that, unlike GDP SGIRFs, transmission of the shock is less widespread across countries; in addition, relatively soon (in less than one year) the effects become not significant, in line with the findings of Potjgailo (2017). The size of the spillovers to other countries' short-term interest rates is generally smaller than the magnitude of the shock in the euro area (shadow) interest rate.

Even in the euro area, the shadow rate shock is not very persistent: its significance dies out after around 8 months, and it appears to last even less in the rest of the world. In this respect, it is worth noting that the major advanced, and to a lesser extent, emerging market countries are not affected by the contractionary monetary policy shock in the euro area, with the exception of Japan and the UK. The effect on the latter country, along with the lack thereof on the US, confirms the results obtained by Chen *et al.* (2017). In contrast, CESEE countries experience smaller (but still significant) shocks than the euro area, which are in general very short-lived. However, the SGIRFs significance peters out more quickly in those countries whose SGIRFs mirror the pattern of the euro area's SGIRF more closely.

Transmission channels

The observed, significant spillover effects can stem from different transmission channels. For example, the contraction in GDP after a euro area monetary tightening could potentially reflect the decrease of foreign demand through the trade channel, interest rate co-movements and the operating of the short-term interest rate channel through cross-border leverage; at the same time, in countries with flexible exchange rates the expenditure switching effect could be at work, as a consequence of the depreciation in the exchange rate (*vis-à-vis* the euro).

[33] Feldkircher *et al.* (2017) analyze different sets of countries, including euro area core and periphery economies, CESEE countries and other advanced European economies. When they use the euro area longer term yields as a proxy of the monetary policy, and analyze the effect of monetary policy shocks on inflation in different country groups, they find that this is barely significant for a very limited amount of time both for euro area core economies and for other advanced European economies, while being not significant for the remaining groups. In addition, when the monetary proxy is the spread between longer term yields of euro area countries, consumer prices reaction throughout the region exists, but not in a statistically significant manner.

[34] In different settings, Peersman and Smets (2001) and Peersman (2004) find that a monetary policy shock in the euro area does not have a significant impact on prices.

Identifying the transmission channels involved is important in terms of policy design. However, different transmission channels are often jointly at play and likely intermingling with each other, thus making it difficult to disentangle the importance of each of them. Be as it may, in what follows we try to sketch the relevant transmission channels for CESEE countries. To do so, we compare SGIRFs across three country dimensions: exchange rate regime, trade openness and financial openness. In particular, we split CESEE economies into two groups according to the exchange rate regime in place: countries with a sort of peg *vis-à-vis* the euro (fixers) and countries without such a peg (floaters), to take into account the role of different exchange rate regime in the interpretation of the results. We then use the share of trade to GDP as a measure of trade openness, and the share of gross foreign assets and liabilities to GDP as a measure of financial integration. While financial integration *per se* does not mean financial integration with the euro area, for CESEE economies this approximation could hold as these countries are integrated with the euro area through strong financial linkages. Indeed, the euro area is the source of large capital flows to the CESEE economies and their domestic banking systems are largely dominated by euro area banking groups (Ciarlone and Colabella, 2016).

Through using a measure of trade and one of financial integration, we can compare SGIRFs across the two country dimensions that are likely to be connected to the underlying transmission channels. While trade openness is probably a crucial feature for the transmission of foreign monetary policy shocks via foreign demand and expenditure switching effects, the measure of financial integration might turn up to be of particular importance for the transmission via the short-term interest rate channel. Against this background, countries can be divided into two sub-groups with respect of each of the above-mentioned measures: countries whose mean of the trade openness (or financial integration) over the sample period is above the cross-country median, and countries where this mean value lies below the median (**Table 5**). As expected, countries from central Europe (namely, Hungary and the Czech Republic) rank higher along the trade and financial integration dimensions, while economies from the Balkan region lag somewhat behind.[35]

As said above, GDP decreases significantly after a euro area monetary policy shock in CESEE countries (Figure 1). However, the reactions appear to be more marked in CESEE countries with a high degree of trade openness (Hungary, the Czech Republic) and/or a peg of their currency to the euro (e.g., Bulgaria). By the same token, countries that are less financially integrated or that let their currency float *vis-à-vis* the euro seem to be relatively less affected by the euro area monetary policy shock (for instance, Poland and Serbia).

The role of the exchange rate regime for the monetary policy spillover appears clear-cut, especially in terms of duration of the shock (Figure 3): in fact, countries with pegged exchange rates display IRFs that are significant for longer periods. At the same time, the degree of financial integration seems to be at stake, too: short-term interest rates react strongly (to the ECB's monetary policy shock) in highly financially integrated countries (e.g., Hungary), whereas the response is much smaller, when significant, for countries with low financial integration.

Comparing the effects of spillovers on GDP and the interest rate in CESEE economies, the following observations emerge. First, the different impact of the shock on GDP in countries with different degree

[35] Annual data are used for the two measures. Data for trade openness (i.e. the share of the sum of exports and imports to GDP) and financial integration (i.e. the share of the sum of gross foreign assets and liabilities relative to GDP) are from IMF IFS, as well as GDP data. Fixers and floaters are classified according to the 2016 IMF Annual Report on Exchange Arrangements and Exchange Restriction. However, the Czech Republic's koruna was classified as floating currency as in the majority of the period between 2004 and 2016 it was floating.

of trade openness is likely to be due to the working of the trade channel, rather than of the short-term interest rate channel. In greater detail, the more pronounced GDP contraction in countries having a higher degree of trade openness seems to mirror the impact of a larger demand contraction (reflecting, in turn, the larger export share of these countries). In contrast, in countries having a low degree of financial integration, two mechanisms appear to be at work. On the one hand, a weak indirect link with the euro area interest rate market via the global interest rate seems to exist, contributing to smoothing out the effects of interest rate increases in the euro area; on the other hand, the expenditure switching mechanism partly offsets the demand absorption channel. This mechanism appears to be on the table also in countries with low trade openness, which are probably less affected by the drop in the euro area GDP.

Secondly, both the trade channel and the short-term interest rate channel could contribute to explaining the generally more marked dip in GDP recorded in 'fixers' than that of 'floaters'. To start up with, the deeper GDP contraction in countries with fixed exchange rates can be traced back to the trade channel. In fact, such economies are generally small and open, and operate in a context where spillovers are not offset by the exchange rate depreciation and the associated expenditure switching effects, whilst this likely being the case for 'floaters'. Moreover, such a GDP reduction could also stem from the larger increase in domestic interest rates and thus from larger short-term interest rate spillovers to countries with exchange rate pegs. In this regard, such findings support the 'trilemma hypothesis'.[36] At the same time, spillovers to output in countries with flexible exchange rate regimes are also significant and sizable, indicating that any offset through the expenditure switching effect is at most a partial one.

Thirdly, differences in the degree of financial integration highlight the role of the short-term interest rate channel. The spillover effects on the short-term interest rates in countries with more integrated financial markets are in line with previous empirical results by Aizenman *et al.* (2016) and Bluwstein and Canova (2016). However, the finding that the degree of financial integration matters, although to a lesser extent, for the size of spillover effects to the real economy positions our results between those by Potjagailo (2017), who instead underscores the lack of difference in industrial production response between financially integrated and less-integrated economies, and those by Bluwstein and Canova (2016), who observe that euro area unconventional monetary policy has stronger effects on more financially developed economies in terms of both financial variables and output effects.

8. Robustness tests

To check for the soundness of the results, we run a wide set of multi-pronged robustness tests, which include a) a different Cholesky ordering; b) the use of GIRFs rather than the SGIRFs; c) a simulation of the main model on (slightly) different time periods; d) using different measures for the shadow rates (Krippner, 2013; Pericoli and Taboga, 2018) and e) substituting the euro area shadow rate with the 3-month EONIA; f) setting up a regional model (e.g., running the model without non-European economies, including the US); g) using quarterly data starting from 2000; h) limiting the Wu and Xia's shadow rate to the euro area only. In all the robustness tests we replicate the main model, including the size of the shock to the monetary policy proxy, while implementing once at a time the

[36] According to the 'trilemma hypothesis' (Obstfeld *et al*., 2005), countries with more stable exchange rates should face a stronger interest-rate transmission of foreign monetary policy shocks in presence of free capital movements.

changes suggested above. In general, the results of Section 7 tend to be confirmed, especially in terms of GDP impact. For the sake of brevity, we will focus mainly on the latter variable.[37]

a) Different Cholesky ordering

As for the different Cholesky ordering, we first followed Dees *et al.* (2007) and moved the shadow rate last in the euro area model. Hence, the ordering for the decomposition becomes: GDP, inflation, exchange rate and shadow rate. Furthermore, we also implemented the Cholesky decomposition along the lines of Peersman and Smets (2001), according to which we rank GDP first, inflation second, shadow rate third and exchange rate last. The outcome of either permutation does not change the GDP and interest rate patterns, both in the euro area and abroad, confirming that results do not depend on permutation of the elements of the Cholesky ordering (Dees *et al.*, 2007; IMF, 2016; Peersman and Smets, 2001).

b) GIRFs

A second test we run was to use GIRFs to analyze the extra-euro area diffusion of the monetary policy shock instead of SGIRF. Results from using a GIRF propagation scheme qualitatively confirm, although to a lesser extent, the findings obtained by the Cholesky decomposition. In particular, while the monetary policy shock hits euro area GDP, and that of a couple of CESEE's economies, in a significant manner, its propagation to other countries' GDP appears to be less broad-based, although similar in qualitative terms to the results obtained under the SGIRFs scenario.

c) Different time periods

We changed the time period over which the model is fitted and simulated. In this context, we decided to start the time sample at end-2007, so as to focus only on the global financial crisis and sovereign debt crisis period, and the following years. Results appear to be generally robust to this specification change. At the same time, it is worth stressing that while the SGIRFs patterns are similar to those of the main model, confidence bands seem to be less stable, likely reflecting the significantly reduced amount of data used to do bootstrapping simulations. When setting the end date to June 2016 rather than December 2016, results appear to be qualitatively consistent again. Nonetheless, the effects of euro area monetary policy shock on the euro area GDP – and consequently on other countries - fades away sooner than before, likely suggesting that the outer months of the sample (when the ECB decided to prop up its asset purchases to €80 billion monthly and extended the set of eligible assets) are key in keeping the euro area response significant.

d) Different shadow rates

We replicated the exercise, changing twice the shadow rates for the euro area. To start up with we ran the model with the shadow rate proposed by Krippner (2013), then we used that proposed by Pericoli and Taboga, 2018).[38] In both cases it turns up that the dynamics of the GDP's IRFs appear to be consistent with those of the main model, but are significant in a fewer number of cases, confirming the findings of Hájek and Horváth, (2017). At the same time, inflation IRFs are smoother and significant. Such a result could be likely due to the different way of calculating shadow rates: in fact, as **Figure 5** shows

[37] Simulations regarding other variables and graphs related to the exercise commented herein are available from the author upon request.

[38] While Krippner's (2013) shadow rates are available for all of the major economic areas, Pericoli and Taboga's (2018) are for the euro area only. Hence, in the latter experiment, we substituted only the euro area shadow rate with the new one.

there are wide gaps between different shadow rates, depending on the underlying procedures and assumptions used to build them.[39]

e) EONIA interest rate

In order to control whether and how much the results depend on the use of shadow rates, instead of using the latter, we replicated the GVAR regression with a market-based interest rate in the euro area, namely the 3-month EONIA, as the latter reflects the functioning of a deep market while not being constrained by the ZLB (and so, it takes into account, at least in part, non-standard monetary policies of the ECB). Against this background, GDP IRFs are comparable, broadly speaking, to those obtained in the main model, in terms of size of the impact and overall effects. At the same time, inflation dynamics is again mostly frontloaded and in many countries, including the euro area, significant. However, the effects of the interest rate shock are less pronounced and very short-lived, especially in the euro area, likely reflecting the fact that, differently from the shadow rate, the interest rate used in this set of simulations mirrors only in part the ECB's non-standard monetary measures.

f) Regional model

With a view to determining how much results hinge on the presence of non-European countries, we also considered a model without such economies.[40] The exclusion of the latter has a bearing on the significance of the GDP IRFs, which became in general not significant while remaining qualitatively consistent with the findings of the model of Section 7. Again, inflation's effects occur especially in the first periods, but in general are confirmed to be insignificant. As in case *e)* and apart from the euro area – where the interest rate shock originates - short-term interest rate IRFs are again very brief. In general, the inclusion of non-European economies, which takes into account the complex interactions between different areas of the global economy, seems to reinforce, in terms of significance, the dynamics triggered in the euro area, in the latter region as well as more globally.

g) Use of quarterly data

We also lengthened data coverage back in time (until the second quarter of 2000), using quarterly data. Nevertheless, this exercise was made at the expenses of data availability along two dimensions: in fact, not only some data series for certain countries were not existing (e.g., exchange rate for Macedonia and Serbia), but also the total number of observations for a given complete series is much lower. The latter issue is also reflected in the evolution of confidence bands in all the IRFs: while the median estimates for GDP, inflation and the short-term interest rate in the simulations evolve according to the corresponding variables in the main model, their confidence bands drift widely apart.

h) Wu and Xia's shadow rate in the euro area only.

Finally, we wondered how the impact and time effects of the euro area shadow rate shock, domestically and abroad, was connected to the use of other shadow rates in major advanced economies. In order to do so, we substituted the 3-month government bill rate of the US and the UK for the respective shadow rates. Overall, results of such a simulation bring about a more contained effect of the euro area monetary policy shock on GDP IRFs,[41] along with limited loss of significance, especially for the US and the UK. Regarding short-term interest rates, the effects of the euro area monetary policy measure appears to be more short-lived in CEESE economies and, in particular, in the UK.

[39] See footnote 15 for greater detail.

[40] In practical terms we excluded from the model the US, China, Brazil, India, Japan, Russia and Turkey.

[41] The average GDP IRFs after 40 periods is around 80% of that obtained in the main model.

9. Concluding remarks

Since the outbreak of the global financial crisis, central banks in advanced countries have resorted to non-standard monetary policies to tackle looming risks. In the case of the ECB, such risks have evolved in nature over time, and, to cope with them, the ECB has accordingly implemented a wide set of non-standard monetary policies, which have influenced financial markets both at home and abroad, in particular in CESEE economies (Falagiarda *et al.*; 2015, Ciarlone and Colabella; 2016). At the same time, spillover effects of such non-standard monetary policy on the real economy of these countries have received only limited attention, so far. In this paper, we have contributed to addressing this gap, bringing to the fore new evidence on the spillover effects on CESEE economies' GDP and, to a lesser extent, on short-term interest rates: a tightening in the monetary policy stance in the euro area would have a negative impact on CESEE economies' GDP, via both the trade and the financial channels, and on short-term interest rates.

Going forward, the presence of monetary policy spillovers may pose challenges to CESEE countries' fiscal and monetary policy authorities as they implement their own policies. It is therefore crucial that these spillover effects are duly factored in by CESEE authorities, so as to avoid unintended consequences on domestic economies while realizing political economy measures.

References

Aizenman, J., M. D. Chinn, and H. Ito, (2016), "Monetary policy spillovers and the trilemma in the new normal: periphery country sensitivity to core country conditions", *Journal of International Money and Finance*, Volume 68: 298–330.

Babecka Kucharcukova, O., P. Claeys, and B. Vasıcek, (2016), "Spillover of the ECB's monetary policy outside the euro area: How different is conventional from unconventional policy*?", Journal of Policy Modeling*, 38(2): 199–225.

Barigozzi, M., Conti A. M., and M. Luciani, (2014), "Do Euro Area Countries Respond Asymmetrically to the Common Monetary Policy?", *Oxford Bulletin of Economics and Statistics*, Volume 76(5): 693-714.

Bartocci, A., L. Burlon, A. Notarpietro, and M. Pisani, (2017), "Macroeconomic effects of non-standard monetary policy measures in the euro area: the role of corporate bond purchases", *Banca d'Italia, Temi di Discussione*, No 1136.

Bauer, M. D., and C. J. Neely, (2014), "International Channels of the Fed's Unconventional Monetary Policy", *Journal of International Money and Finance*, Volume 44 (C): 24–46, doi: 10.1016/j.jimonfin.2013.12.007.

Benecká, S., L. Fadejeva, and M. Feldkircher, (2018), "Spillovers from euro area Monetary Policy: A Focus on Emerging Europe", *Czech National Bank Working Paper No. 2.*

Bernanke, B., J. Boivin, and P. Eliasz, (2005), "Measuring monetary policy: a factor augmented vector autoregressive (FAVAR) approach", *Quarterly Journal of Economics*, Volume 120: 387–422.

Bluwstein, K., and F. Canova, (2016), "Beggar-Thy-Neighbor? The International Effects of ECB Unconventional Monetary Policy Measures", *International Journal of Central Banking*, Volume 12(3), Special Issue: 21-128.

Boeckx, J., M. Dossche, and G. Peersman, (2017), "Effectiveness and Transmission of the ECB's Balance Sheet Policies", *International Journal of Central Banking,* Volume 13: 297-333.

Bruno, V., and H. S. Shin, (2015), "Cross-border banking and global liquidity", *Review of Economic Studies,* Volume 82 (2): 535–564.

Burriel, P., and A. Galesi, (2018), "Uncovering the heterogeneous effects of ECB unconventional monetary policies across euro area countries", *European Economic Review,* Volume 101: 210-229.

Canova, F., and M. Ciccarelli, (2013), "Panel vector autoregressive models: a survey", *ECB Working Paper Series*, No 1507.

Cesa-Bianchi, A., M. H. Pesaran, A. Rebucci, and T. Xu, (2011), "China's emergence in the world economy and business cycles in Latin America", *IDB Working paper series*, No-IDB-266.

Cetorelli, N., and L. S. Goldberg, (2012), "Banking globalization and monetary transmission", *Journal of Finance*, Volume 67 (5): 1811–1843.

Chen, Q., A. Filardo, D. He, and F. Zhu, (2016), "Financial Crisis, US Unconventional Monetary Policy and International Spillovers", *Journal of International Money and Finance,* Volume 67: 62–81, doi:10.1016/j.jimonfin.2015.06.011.

Chen, Q., M. Lombardi, A. Ross, and F. Zhu, (2017), "Global impact of US and euro area unconventional monetary policies: a comparison.", Technical report, *BIS Working Papers No. 610.*

Claus, E., I. Claus, and L. Krippner (2014) "Asset markets and monetary policy shocks at the zero lower bound". *Reserve Bank of New Zealand Discussion Paper Series DP2014/03*, Reserve Bank of New Zealand.

Ciarlone, A., and A. Colabella, (2016), "Spillovers of the ECB's non-standard monetary policy into CESEE economies," *Ensayos sobre política económica,* Volume 34 (81): 175–190.

Comunale, M., and J. Striaukas, (2017), "Unconventional monetary policy: interest rates and low inflation. A review of literature and methods," *CORE Discussion Papers* 2017026, Université catholique de Louvain, Center for Operations Research and Econometrics (CORE).

Conti, A. M., S. Neri, and A. Nobili, (2015), "Why is inflation so low in the euro area?", *Banca d'Italia, Temi di Discussione*, No 1019.

Damjanovic´, M., and I. Masten, (2016), "Shadow short rate and monetary policy in the Euro area", *Empirica,* Volume 43: 279–298.

Dedola, L., P. Karadi, and G. Lombardo, (2013), "Global Implications of National Unconventional Policies", *Journal of Monetary Economics,* Volume 60 (1): 66–85. doi: 10.1016/j.jmoneco.2012.12.001.

de Haan, L., and J. W. van den End (2016), "The signalling content of asset prices for inflation: Implications for Quantitative Easing", *DNB Working Paper 516*, DeNederlandsche Bank.

Dees, S., F. di Mauro, M. H. Pesaran, and L. V. Smith, (2007), "Exploring the international linkages of the Euro area: a global VAR analysis", *Journal of Applied Econometrics*, Volume 22: 1–38.

Devereux, M. B., and J. Yetman, (2010), "Leverage constraints and the international transmission of shocks", *Journal of Money, Credit, and Banking*, Volume 42 (s1): 71–105.

Elbourne, A., J. Kan and S. Duijndam, (2018);"The effects of unconventional monetary policy in the euro area, *CBP Discussion Paper 371.*

Falagiarda, M., P. McQuade, and M. Tirpák, (2015), "Spillovers from the ECB's non-standard monetary policies on non-euro area EU countries: Evidence from an event-study analysis", *ECB Working Paper* No. 1869.

Falagiarda, M., and S. Reitz, (2015), "Announcements of ECB unconventional programs: Implications for the sovereign spreads of stressed euro area countries", *Journal of International Money and Finance*, Volume 53: 276–295.

Feldkircher, M., T. Gruber, and F. Huber, (2017), "Spreading the word or reducing the term spread? Assessing spillovers from euro area monetary policy", *Department of Economics Working Paper Series 5554*, WU Vienna University of Economics and Business.

Feldkircher, M., (2015), "A global macro model for emerging Europe", *Journal of Comparative Economics,* Volume 43: 706–726

Francis N., L. E. Jackson, and M. T. Owyang, (2014), "How has empirical monetary policy analysis changed after the financial crisis?" *Working Papers 2014-19,* Federal Reserve Bank of St. Louis.

Fratzscher, M., M. Lo Duca, and R. Straub, (2014), "ECB unconventional monetary policy actions: Market impact, international spillovers and transmission channels", in papers presented at the 15th Jacques Polak Annual Research Conference, 13–14 November 2014.

Fratzscher, M., M. Lo Duca, and R. Straub, (2016), "On the International Spillovers of US Quantitative Easing", *Economic Journal,* Volume 128: 330-377, https://doi.org/10.1111/ecoj.12435.

Galesi, A., and M. J. Lombardi, (2009) "External Shocks and international inflation: linkages a global VAR analysis", *ECB Working Paper Series*, No 91.

Galesi, A., and S. Sgherri, (2009), "Regional financial spillovers across Europe: A global VAR analysis", *IMF Working Paper, WP/09/23*.

Galí, J., and T. Monacelli, (2005), “Monetary policy and exchange rate volatility in a small open economy”, *Review of Economic Studies*, Volume 72 (3): 707–734.

Gambacorta, L., B. Hofmann, and G. Peersman, (2014), “The effectiveness of unconventional monetary policy at the zero lower bound: a cross-country analysis”, *Journal of Money, Credit and Banking*, Volume 46(4): 615-642.

Ganelli, G., and N. Tawk, (2016), “Spillovers from Japan’s Unconventional Monetary Policy to Emerging Asia: a Global VAR approach”, *IMF Working Paper*, WP/16/99.

Georgiadis, G., (2015), “Examining asymmetries in the transmission of monetary policy in the euro area: Evidence from a mixed cross-section global {VAR} model”, *European Economic Review*, Volume 75: 195 – 215.

Georgiadis, G., (2017), “To bi, or not to bi? Differences between spillover estimates from bilateral and multilateral multi-country model”, *Journal of International Economics*, Volume 107: 1-18.

Georgiadis, G., and J. Gräb, (2015), “Global financial market impact of the announcement of the ECB’s extended asset purchase programme”, *Working Paper* No. 232, Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute.

Granger, C. W. J., and J. L. Lin, (1995), “Causality in the Long Run”, *Econometric Theory*, Volume 11: 530-536.

Harbo, I., S. Johansen, B. Nielsen, and A. Rahbek, (1998), ‘Asymptotic Inference on Cointegrating Rank in Partial Systems’, *Journal of Business and Economic Statistics*, Volume 16: 388-399.

Hájek, J., and R. Horváth, (2017), “International Spillovers of (Un)Conventional Monetary Policy: The Effect of the ECB and US Fed on Non-Euro EU Countries”, *Czech National Bank Working Paper No. 5.*

Horváth, R., and K. Voslarova, (2017), “International Spillovers of ECB’s Unconventional Monetary Policy: The Effect on Central Europe”, *Applied Economics*, Volume 49(24): 2352–2364.

Ivanov, V., and L. Kilian, (2005), “A Practitioner’s Guide to Lag Order Selection for VAR Impulse Response Analysis”, *Studies in Nonlinear Dynamics and Econometrics*, Volume 9(1): 1–36.

IMF, (2016), “Cross-Country Report On Spillovers”, *IMF Country Report No. 16/212*.

Johansen, S., (1992), “Cointegration in Partial Systems and the Efficiency of Single-Equation Analysis”, *Journal of Econometrics*, Volume 52: 231-254.

Krippner, L., (2013), “A Tractable Framework for Zero Lower Bound Gaussian Term Structure Models”, *Reserve Bank of New Zealand Discussion Paper Series*, DP2013/02.

Koop, G., M. H. Pesaran, and S. M. Potter, (1996), “Impulse Response Analysis in Nonlinear Multivariate Models”, *Journal of Econometrics*, Volume 74: 119-147.

Lombardi, M. J., and F. Zhu, (2014), “A Shadow Policy Rate to Calibrate US Monetary Policy at the Zero Lower Bound”, *BIS Working Papers 452*.

Metelli, L., and F. Natoli, (2018), “The international transmission of US fiscal shocks”, *mimeo*, Banca d’Italia.

Moder, I., (2017), “Spillovers from the ECB's non-standard monetary policy measures on south-eastern Europe”, *ECB Working Paper Series*, No 2095.

Mouabbi, S., and J.-C., Sahuc, (2018), “Evaluating the Macroeconomic Effects of the ECB's Unconventional Monetary Policies”. Available at SSRN: https://ssrn.com/abstract=2909856 or http://dx.doi.org/10.2139/ssrn.2909856

Obstfeld, M., J. C. Shambaugh, and A. M. Taylor, (2005), “The trilemma in history: tradeoffs among exchange rates, monetary policies, and capital mobility”, *Review of Economics and Statistics*, Volume 87 (3): 423–438.

Peersman, G., (2004), “The Transmission of Monetary Policy in the Euro Area: Are the Effects Different Across Countries?”, *Oxford Bulletin of Economics and Statistics,* Volume 66(3): 285-308.

Peersman, G., and F. Smets, (2001), “The monetary transmission mechanism in the Euro area: more evidence from VAR analysis”, *ECB Working Paper Series*, No 91.

Pericoli, M., and M. Taboga, (2018), “Nearly exact Bayesian estimation of non-linear no-arbitrage term structure models” *Banca d'Italia,* forthcoming.

Pesaran, M. H., and Y. Shin, (1998), “Generalized impulse response analysis in linear multivariate models”, *Economic Letters*, Volume 58: 17-29.

Pesaran, M. H., T. Schuermann, and S. Weiner, (2004), “Modeling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model”, *Journal of Business and Economic Statistics*, Volume 22: 129–162.

Potjagailo, G., (2017), “Spillover effects from Euro area monetary policy across Europe: A factor-augmented VAR approach.” *Journal of International Money and Finance*, Volume 72: 127–147.

Sims, C., (1980), “ Macroeconomics and Reality”, *Econometrica*, Volume 48: 1-48.

Sims, C., and T. Zha, (2006), “Does monetary policy generate recessions?”, *Macroeconomic Dynamics*, Volume 10: 231–272.

Smith, L.V., and A. Galesi (2014), GVAR Toolbox 2.0 https://sites.google.com/site/gvarmodelling/gvar-toolbox.

Van Zandweghe, W., (2015), “Monetary Policy Shocks and Aggregate Supply”, *Economic Review* : volume 3: 31–56.

Wu, J. C., and F. D. Xia, (2016), “Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound”, *Journal of Money, Credit and Banking,* Volume 48(2–3): 253–291, doi: 10.1111/jmcb.2016.48.issue-2-3.

Tables and Figures

Table 1. Descriptive statistics.

Variable	Mean	Maximum	Minimum	Std. dev.
Real GDP Index, Chow-Lin transformation, SA, logs	4.54	5.06	3.77	0.10
CPI inflation, SA, logs	0.00	0.02	-0.01	0.00
Nominal exchange rate (*vis-à-vis* the euro), logs	2.55	2.55	2.76	2.37
Wu-Xia shadow rates/ 3-month rates	0.03	0.03	0.03	0.03
Poil, ASPS, Index, SA, logs	4.87	5.52	4.03	0.38
VIX, logs	2.88	4.23	2.33	0.36

Source: Thompson Reuters Datastream. Authors' elaborations.

Table 2. Weight Matrix (based on fixed weights) - average 2014-2016.

Country	BR	BG	CN	HR	CZ	DK	EURO	HU	IN	JP	MK	NO	PL	RO	RU	RS	SE	CH	TR	GB	US
BR	0.00	0.00	0.04	0.00	0.00	0.01	0.02	0.00	0.03	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.04
BG	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.06	0.00	0.00	0.04	0.01	0.03	0.00	0.00	0.02	0.00	0.00
CN	**0.30**	0.04	0.00	0.03	0.05	0.06	**0.14**	0.04	**0.25**	**0.41**	0.05	0.07	0.05	0.03	**0.18**	0.06	0.05	0.08	0.12	0.10	**0.34**
HR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
CZ	0.00	0.02	0.01	0.03	0.00	0.01	0.05	0.05	0.00	0.00	0.01	0.01	0.06	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.00
DK	0.00	0.01	0.01	0.01	0.01	0.00	0.03	0.01	0.00	0.00	0.00	0.05	0.02	0.01	0.01	0.01	0.08	0.00	0.01	0.01	0.01
EURO	**0.27**	**0.51**	**0.25**	**0.62**	**0.64**	**0.47**	0.00	**0.60**	**0.25**	**0.16**	**0.52**	**0.45**	**0.60**	**0.59**	**0.45**	**0.47**	**0.49**	**0.53**	**0.43**	**0.53**	**0.31**
HU	0.00	0.03	0.01	0.08	0.03	0.01	0.03	0.00	0.00	0.00	0.01	0.00	0.03	0.08	0.01	0.05	0.01	0.01	0.01	0.01	0.00
IN	0.04	0.00	0.04	0.01	0.00	0.01	0.02	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.02	0.01	0.01	0.05	0.03	0.02	0.04
JP	0.04	0.00	**0.17**	0.00	0.01	0.01	0.03	0.01	0.05	0.00	0.01	0.02	0.01	0.00	0.06	0.01	0.01	0.02	0.02	0.02	**0.11**
MK	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
NO	0.01	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.10	0.00	0.01	0.03	0.01
PL	0.00	0.03	0.01	0.03	0.09	0.04	0.07	0.05	0.01	0.00	0.01	0.03	0.00	0.04	0.04	0.04	0.04	0.01	0.02	0.02	0.01
RO	0.00	0.09	0.00	0.01	0.01	0.00	0.02	0.05	0.00	0.00	0.03	0.00	0.01	0.00	0.01	0.05	0.00	0.00	0.02	0.00	0.00
RU	0.02	0.09	0.05	0.04	0.03	0.01	0.06	0.04	0.02	0.03	0.02	0.01	0.06	0.03	0.00	**0.10**	0.03	0.01	**0.10**	0.01	0.02
RS	0.00	0.02	0.00	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE	0.01	0.01	0.01	0.01	0.01	**0.14**	0.04	0.01	0.01	0.01	0.00	0.10	0.03	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.01
CH	0.02	0.01	0.02	0.01	0.01	0.01	0.08	0.01	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.03	0.05	0.03
TR	0.01	0.08	0.01	0.02	0.01	0.01	0.04	0.01	0.02	0.00	0.04	0.01	0.01	0.04	0.06	0.03	0.01	0.02	0.00	0.02	0.01
GB	0.03	0.03	0.05	0.02	0.05	0.07	**0.16**	0.03	0.05	0.03	0.08	**0.17**	0.05	0.04	0.03	0.02	0.07	**0.11**	0.07	0.00	0.06
US	**0.24**	0.01	**0.32**	0.02	0.02	0.06	**0.17**	0.03	**0.22**	**0.29**	0.02	0.06	0.02	0.02	0.06	0.02	0.06	**0.13**	0.08	**0.14**	0.00

Note: the entry (*i,j*) represents country *j* trade with country *i* as a share of the trade of country *j* with the rest of the world. In **bold** shares greater or equal to 0.1.
Source: IMF DoTS.

Table 3. Test for Weak Exogeneity at the 5% Significance Level

Country	F test	Fcrit_0.05	ys	dps	es	srs	poil	vix
BR	F(2,140)	3.10	0.94	**5.09**		0.69	0.46	0.34
BG	F(4,138)	2.70	0.94	0.58		1.83	0.12	0.98
CN	F(1,142)	3.94	0.04	1.18		0.17	0.81	3.66
HR	F(3,139)	2.70	**4.63**	1.15		0.60	2.04	0.16
CZ	F(1,141)	3.94	0.00	0.09		0.25	0.72	0.41
DK	F(2,140)	3.10	0.20	0.38		**3.56**	0.53	1.54
EURO	F(2,140)	3.10	3.05	1.32		2.45	1.43	0.71
HU	F(3,139)	2.70	1.44	0.39		1.26	0.86	2.24
IN	F(1,142)	3.94	0.01	0.06		1.32	0.09	1.76
JP	F(1,141)	3.94	0.01	0.01		0.01	2.10	0.72
MK	F(2,140)	3.10	0.22	0.01		1.01	1.60	0.47
NO	F(3,139)	2.70	**3.84**	1.11		1.40	0.58	**4.26**
PL	F(1,141)	3.94	**3.98**	0.10		0.68	0.13	0.42
RO	F(2,140)	3.10	0.23	0.30		0.86	0.03	2.99
RU	F(2,140)	3.10	0.48	1.07		0.43	0.24	1.52
RS	F(1,142)	3.94	**7.64**	0.03		1.21	0.60	2.07
SE	F(1,141)	3.94	2.44	0.05		0.00	0.13	0.02
CH	F(2,140)	3.10	0.13	0.04		2.70	0.53	1.82
TR	F(1,141)	3.94	1.89	0.19		0.12	0.00	0.24
GB	F(1,141)	3.94	0.00	0.39		0.62	0.51	0.05
US	F(2,142)	3.09	1.70	1.21	0.26			

Note. F-Test for weak exogeneity of foreign variables: 'ys' stands for foreign GDP; 'dps' stands for foreign inflation; 'es' stands for foreign exchange rate; 'srs' stands for foreign short-term rate; 'poil' stands for oil price index and 'vix' for VIX index. 'F-crit.' refers to the critical value at the 5% level and 'F-test' indicates the associated degrees of freedom. Significant values in bold.
Source: Authors' elaborations.

Table 4. Average Pairwise Cross-Section Correlations: Variables and Residuals

	y			dp			e			sr		
Country	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals
BR	0.72	0.17	0.04	-0.03	0.06	0.02	0.18	0.19	0.19	0.16	0.03	-0.01
BG	0.83	0.21	0.01	0.22	0.06	-0.01	0.00	-0.07	-0.04	0.55	0.09	-0.01
CN	0.79	0.03	-0.13				-0.26	0.15	0.17	0.22	0.12	-0.01
HR	0.04	0.27	0.03	0.27	0.14	0.02	0.17	0.07	0.02	0.36	0.01	0.01
CZ	0.84	0.24	0.00	0.24	0.11	0.01	-0.04	0.07	0.03	-0.58	-0.05	-0.07
DK	0.73	0.22	0.02	0.29	0.12	-0.03	-0.02	-0.01	0.03	0.57	0.13	0.00
EURO	0.73	0.32	-0.03	0.34	0.19	-0.09	0.03	0.21	0.22	0.51	0.11	-0.03
HU	0.65	0.21	-0.01	0.20	0.06	-0.03	0.21	0.06	0.05	0.45	0.05	0.02
IN	0.80	0.05	0.02	0.03	0.04	-0.01	0.22	0.19	0.21			
JP	0.67	0.19	0.02	0.09	0.08	-0.02	-0.06	0.07	0.14	0.40	0.15	0.01
MK	0.82	0.12	0.05	0.21	0.06	0.01	0.01	-0.01	-0.02	0.24	-0.09	-0.01
NO	0.82	0.06	0.00	0.11	0.08	0.00	0.21	0.17	0.15	0.49	0.15	0.05
PL	0.82	0.15	0.00	0.27	0.16	0.00	0.15	0.15	0.11	0.45	0.09	0.01
RO	0.83	0.20	0.00	0.20	0.09	0.02	0.18	0.09	0.06	0.42	0.03	0.03
RU	0.71	0.21	0.04	0.05	-0.02	-0.01	0.24	0.17	0.17	-0.34	-0.03	-0.04
RS	0.76	0.16	0.05	0.22	0.10	0.04	0.17	0.00	-0.03			
SE	0.83	0.27	0.08	0.24	0.10	-0.02	0.04	0.13	0.11	0.49	0.01	-0.02
CH	0.84	0.23	0.05	0.27	0.16	0.03	-0.26	0.06	0.11	0.46	-0.02	-0.02
TR	0.81	0.10	0.00	0.21	0.09	-0.01	0.24	0.18	0.16	0.51	0.09	0.05
GB	0.82	0.27	0.05	0.27	0.16	0.00	0.08	0.18	0.15	0.51	0.10	-0.03
US	0.82	0.14	-0.02	0.25	0.15	-0.07				0.43	0.02	-0.01

Note: The first three columns show, respectively, the cross-country correlation for GDP in levels (1st column), the corresponding correlations for the first differences (2nd column) and the according correlations for the residuals of equations across the countries (3rd column) . Columns 4-6, 7-9, and 10-12 show results of the same exercise for inflation, exchange rates and short-term interest rates, respectively.

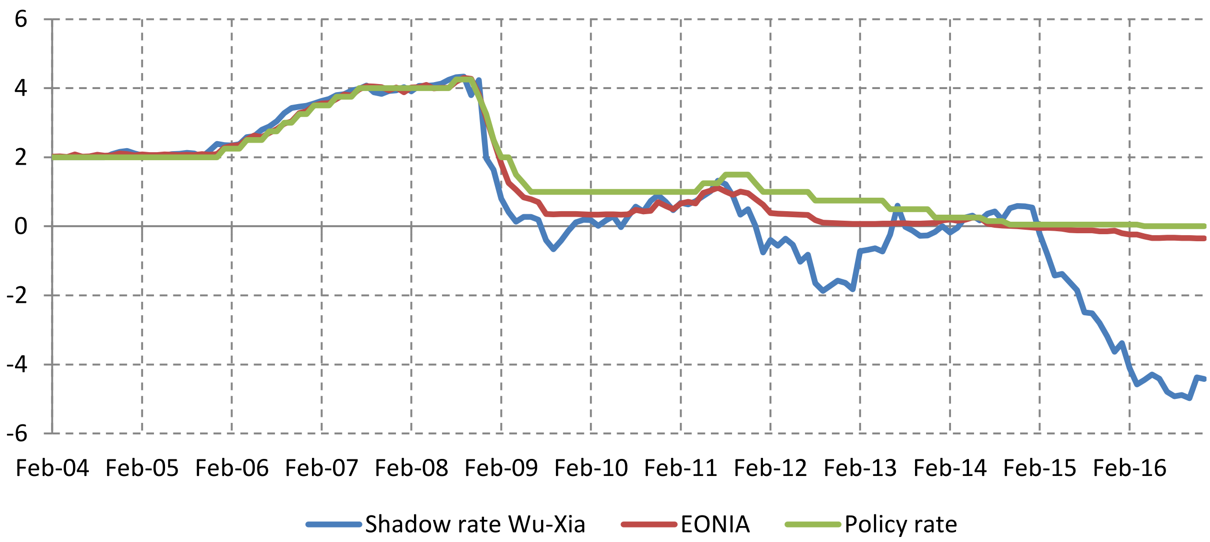
Source: Authors' elaborations.

Table 5. Countries' sub-groups.

	Trade openness	Financial integration	Exchange rate regime
BL	**99**	**197**	Fix
CT	60	171	Fix
CZ	**126**	**177**	Flo
HN	**135**	**411**	Flo
MC	**94**	142	Fix
PO	68	127	Flo
RO	69	111	Flo
SB	48	**190**	Flo
Median	81	174	-

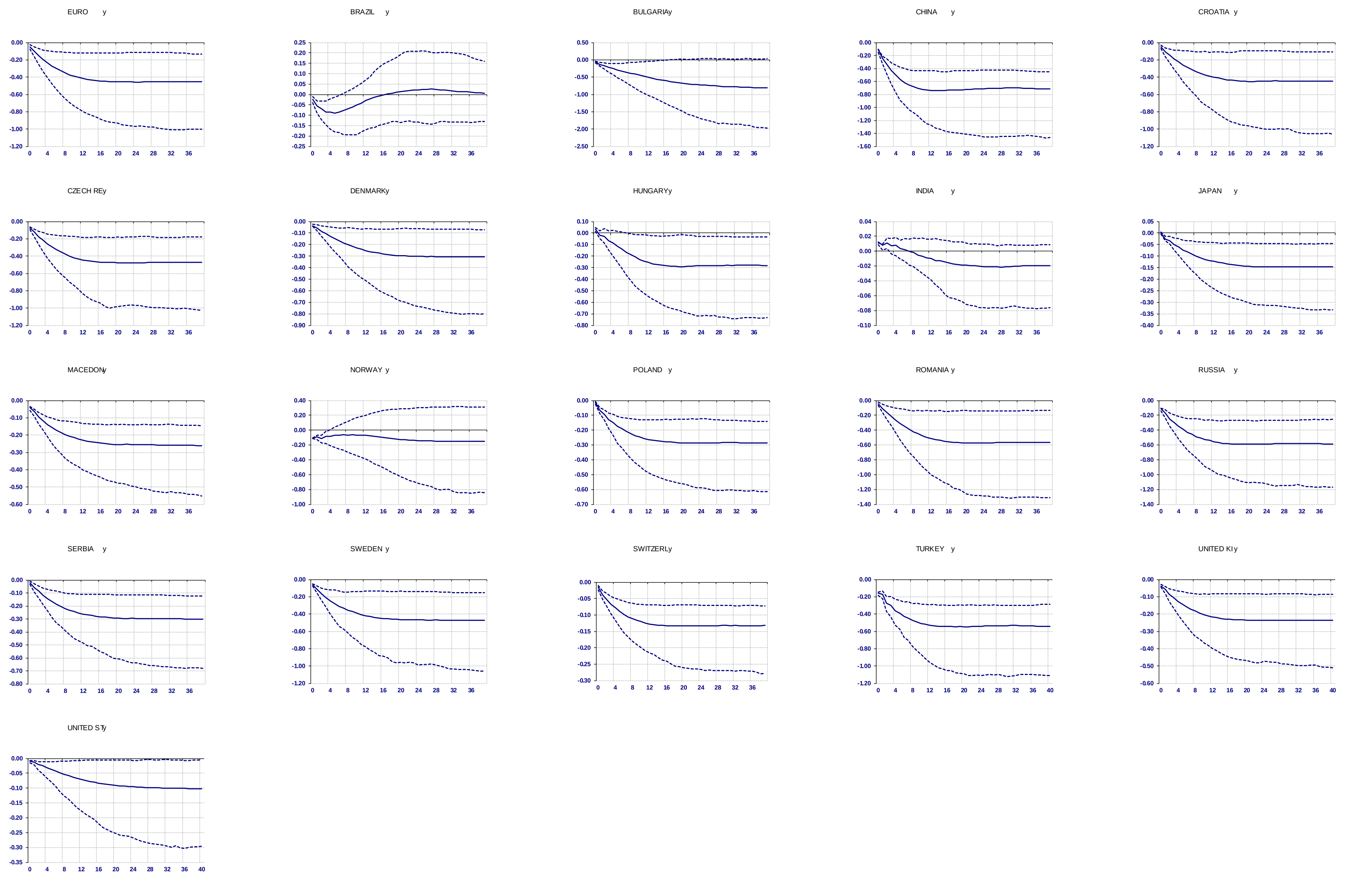
Note. Each country's trade openness (financial integration) indicator is the average over the period 2004 – 2016 of the share of the sum of import and export (foreign assets and liabilities) to GDP. Bold figures are values above the median. Exchange rate regime are classified into two broad categories: fixers (Fix) and floaters (Flo), which respectively correspond to hard and soft pegs, and float and free float in the IMF 2016 AREAER. The Czech Republic is classified as a floater for reasons explained in the main text.
Source: IMF IFS, IMF 2016 AREAER.

Figure 1. ECB's policy rate, EONIA and Wu and Xia's shadow rate, 2004-2016



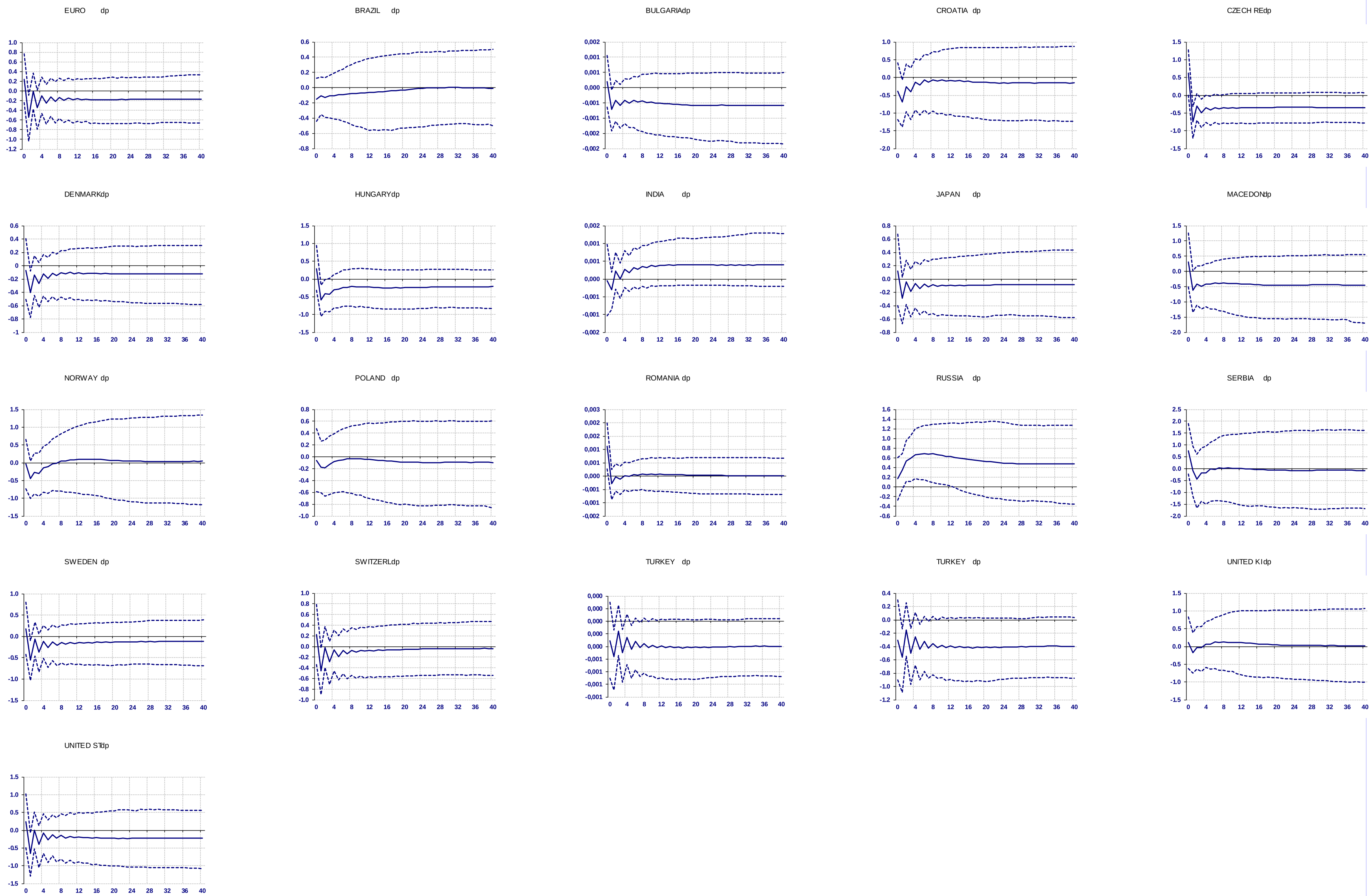
Source: Eikon Datastream.

Figure 2. Output response to a 20 basis point shock in the euro area shadow rate.



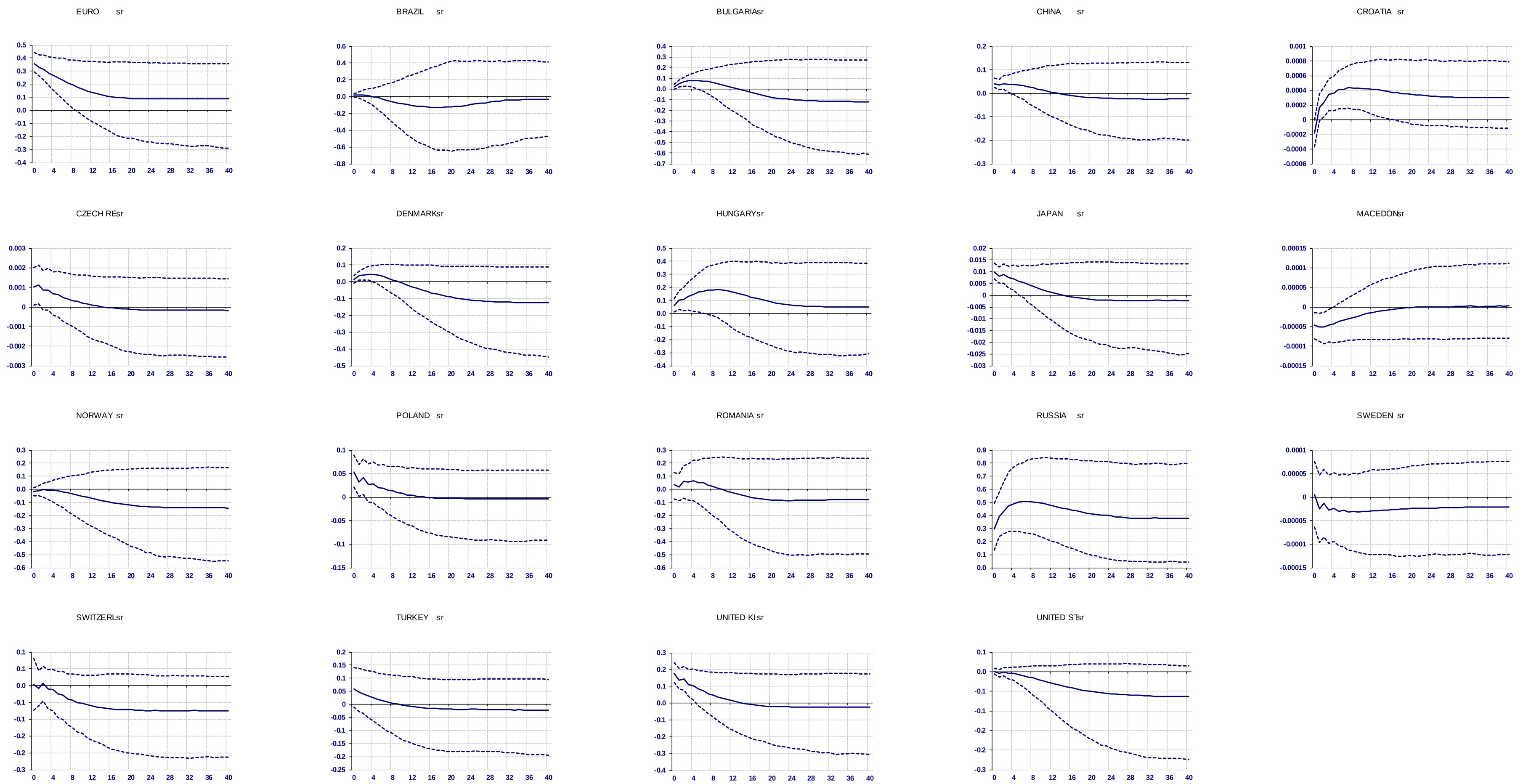
Source: Authors' elaboration.

Figure 3. Inflation response to a 20 basis point shock in the euro area shadow rate.



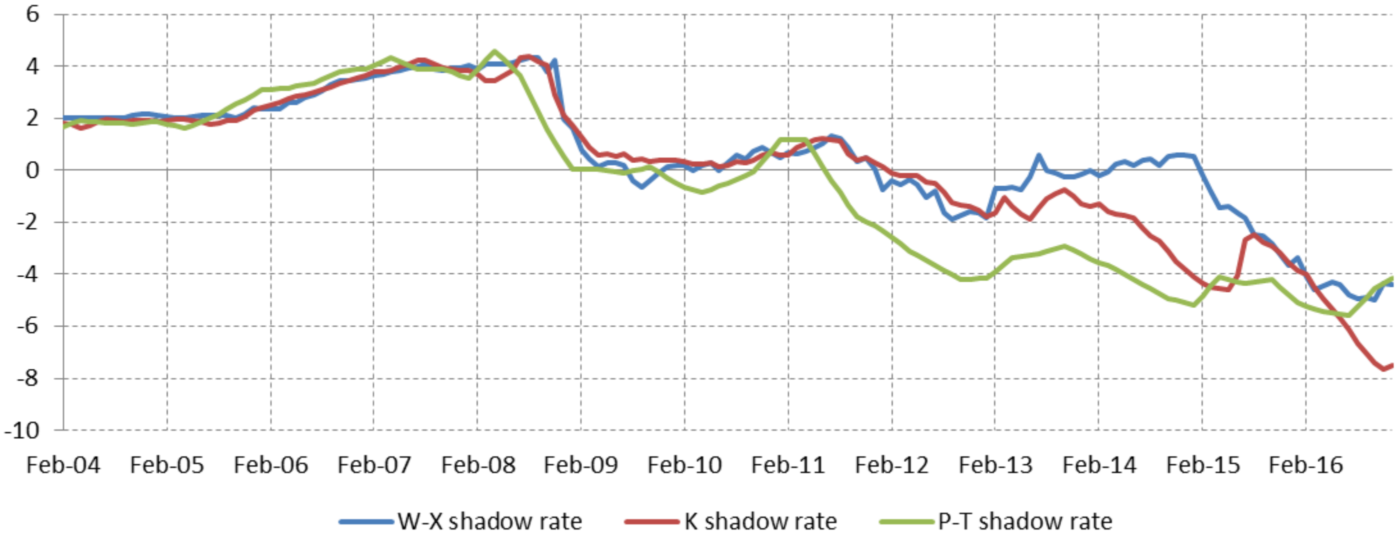
Source: Authors' elaboration.

Figure 4. Short-term interest rates response to a 20 basis point shock in the euro area shadow rate.



Source: Authors' elaborations.

Figure 5.Shadow rates, 2004-2016



Note: W-X stands for Wu and Xia, K stands for Krippner and P-T for Pericoli and Taboga.

Source: Data from Wu and Xia (2016), Krippner (2013) and Pericoli and Taboga (2018)

Appendices

APPENDIX A. Data description.

Table A1. Data description

Variable	Description	Source	Notes
y	Log of Real GDP Index Base 2010 = 100	IMF IFS	Monthly time series obtained using the Chow-Lin method with the Industrial Production Index used as a reference (seasonally adjusted using Eviews X12).
dp	Log difference of CPI - Index Base 2010 = 100	IMF IFS	Monthly time series seasonally adjusted using Eviews X12).
e	Log of nominal exchange rate	IMF IFS	Nomial exchange rates vis-à-vis the euro; for the euro its NEER is used.
sr	sr=1/12*ln(1+R/100)	IMF IFS	R is the 3-month rate. Wu and Xia's (2016) shadow policy rate is used for the euro area, the UK and the US.
poil	Log of Average selling prices, US dollar per barrel	IMF IFS	
vix	Log of the VIX	IMF IFS	
Foreign assets&Liabilities	Billion of US dollar	IMF IFS	
Import&Export	Millions of US dollar	IMF DoTS	

APPENDIX B. ADF and WS tables.

Tables B1, B2, and B3 include ADF and WS tests for domestic, foreign and global variables, respectively. Tests are run for model in levels, (with and without trend), in first differences and in second differences.

Table B1. Unit Root Tests for Domestic Variables at the 5% Significance Level

Domestic Variables	Statistic	Critical Value	BRAZIL	BULGARIA	CHINA	CROATIA	CZECH REPUBLIC	DENMARK	EURO	HUNGARY	INDIA	JAPAN	MACEDONIA	NORWAY	POLAND	ROMANIA	RUSSIA	SERBIA	SWEDEN	SWITZERLAND	TURKEY	UNITED KINGDOM	UNITED STATES
y (with trend)	ADF	-3.45	-1.48	-1.34	-1.25	-1.81	-2.85	-4.37	-3.79	-3.08	-2.30	-3.86	-3.42	-3.84	-1.41	-1.76	-0.91	-2.78	-3.84	-5.61	-4.75	-5.62	-5.07
y (with trend)	WS	-3.24	-1.15	0.54	-1.07	0.14	-2.09	-1.29	-2.29	0.51	-2.38	-1.73	-3.62	-3.25	-1.34	0.02	-1.06	-2.08	-2.40	-4.36	0.89	-2.08	-2.36
y (no trend)	ADF	-2.89	-5.20	0.77	-1.91	-2.62	-0.76	0.10	-0.95	0.33	-0.04	-1.01	0.37	-0.18	1.37	1.06	-1.07	-1.67	-0.11	-1.66	-2.55	-0.19	0.26
y (no trend)	WS	-2.55	-0.87	0.13	2.39	-0.74	-1.17	-0.29	-1.98	0.10	3.45	-1.31	0.92	-0.39	2.60	0.38	-1.44	-1.75	-0.56	0.99	-2.06	-0.67	0.07
Dy	ADF	-2.89	-1.82	-3.78	-10.39	-3.14	-3.51	-4.96	-5.51	-4.04	-9.69	-4.79	-7.74	-7.62	-7.62	-6.70	-5.32	-6.80	-3.27	-6.34	-5.22	-3.21	-5.68
Dy	WS	-2.55	-2.19	-3.97	-10.58	-0.73	-3.67	-5.13	-2.57	-4.23	-9.84	-4.93	-7.66	-7.41	-7.57	-6.72	-5.49	-6.92	-3.48	-5.19	-3.82	-3.00	-3.44
DDy	ADF	-2.89	-4.04	-6.56	-8.53	-7.14	-15.17	-11.60	-11.06	-10.56	-9.03	-8.26	-7.19	-5.04	-8.33	-10.32	-12.09	-9.15	-16.21	-4.48	-16.06	-8.18	-4.94
DDy	WS	-2.55	-4.42	-6.89	-8.90	-6.94	-15.41	-11.79	-11.22	-10.78	-9.24	-8.47	-7.07	-4.77	-8.74	-10.49	-12.29	-9.48	-15.61	-3.82	-16.32	-8.35	-4.67
dp (with trend)	ADF	-3.45	-4.45	-5.46		-6.86	-7.24	-6.96	-4.33	-5.21	-7.54	-4.83	-6.54	-7.05	-4.09	-6.73	-4.84	-6.55	-2.69	-3.12	-6.17	-4.72	-4.38
dp (with trend)	WS	-3.24	-4.65	-5.39		-6.96	-5.67	-6.87	-4.33	-5.36	-7.61	-4.64	-5.10	-7.19	-4.32	-6.90	-5.00	-6.71	-2.78	-3.36	-6.31	-4.91	-4.36
dp (no trend)	ADF	-2.89	-4.30	-4.95		-6.29	-7.28	-4.07	-4.37	-4.80	-6.64	-5.87	-6.49	-7.03	-3.60	-5.41	-4.81	-3.79	-2.50	-2.88	-5.50	-3.81	-4.41
dp (no trend)	WS	-2.55	-4.35	-4.56		-6.45	-5.42	-3.81	-4.22	-4.78	-6.80	-6.02	-4.71	-7.13	-3.58	-5.50	-4.95	-3.86	-2.67	-3.10	-5.47	-3.78	-4.32
Ddp	ADF	-2.89	-10.50	-9.82		-8.12	-13.17	-13.31	-7.16	-10.78	-9.15	-8.81	-9.60	-6.62	-10.34	-8.55	-8.22	-10.86	-7.81	-7.50	-8.65	-10.74	-13.55
Ddp	WS	-2.55	-10.69	-10.06		-8.11	-11.14	-13.18	-7.41	-10.97	-9.34	-8.78	-8.86	-7.10	-10.48	-8.91	-8.34	-11.09	-3.82	-7.18	-8.86	-10.89	-13.75
DDdp	ADF	-2.89	-10.22	-8.40		-6.84	-7.95	-7.89	-8.70	-10.53	-12.42	-7.91	-8.24	-9.88	-10.15	-8.48	-8.45	-5.20	-6.58	-7.02	-8.21	-10.37	-7.40
DDdp	WS	-2.55	-10.01	-8.57		-6.18	-6.73	-7.95	-8.72	-11.01	-12.72	-7.56	-6.54	-9.80	-10.35	-9.01	-8.95	-5.57	-6.96	-5.96	-7.66	-10.62	-7.35
e (with trend)	ADF	-3.45	-1.76	-4.08	-2.97	-2.76	-2.55	-2.43	-2.71	-5.15	-1.94	-2.22	-7.11	-1.49	-6.31	-2.51	-2.78	-1.87	-1.36	-2.09	-2.82	-2.83	
e (with trend)	WS	-3.24	-1.75	-3.82	-3.00	-2.98	-2.14	-2.65	-2.92	-4.88	-2.11	-1.69	-7.26	-1.82	-3.73	-1.72	-2.94	-1.44	-1.63	-2.27	-2.97	-1.84	
e (no trend)	ADF	-2.89	-0.97	-4.21	-1.86	-1.83	-1.01	-2.50	-2.12	-2.04	-1.89	-2.29	-7.08	-1.24	-3.14	-1.89	-1.09	-1.80	-1.39	-1.30	0.36	-2.33	
e (no trend)	WS	-2.55	-1.30	-3.79	-0.70	-1.49	-1.49	-2.71	-2.20	-1.84	-1.35	-1.61	-7.25	-1.52	-2.47	0.39	-1.08	0.81	-1.74	0.11	0.60	-2.14	
De	ADF	-2.89	-7.13	-6.77	-7.65	-7.36	-3.80	-6.76	-7.57	-5.44	-6.99	-6.81	-11.04	-7.70	-6.14	-5.28	-7.18	-4.77	-6.68	-7.98	-8.44	-8.96	
De	WS	-2.55	-7.21	-5.94	-7.68	-7.50	-3.88	-6.91	-7.61	-5.02	-6.75	-6.98	-11.31	-7.88	-6.25	-3.91	-7.35	-4.30	-6.84	-8.13	-7.08	-8.88	
DDe	ADF	-2.89	-14.00	-7.26	-4.39	-7.64	-7.41	-9.53	-13.21	-6.35	-8.41	-12.95	-6.29	-4.79	-11.80	-6.52	-8.24	-5.25	-3.98	-8.91	-10.02	-4.29	
DDe	WS	-2.55	-14.20	-7.46	-4.74	-7.82	-5.33	-9.76	-13.39	-5.46	-8.52	-13.16	-6.65	-4.96	-12.02	-4.50	-8.37	-5.59	-4.21	-9.18	-9.11	-4.61	
sr (with trend)	ADF	-3.45	-3.15	-14.81	-2.08	-4.57	1.87	-7.93	-1.45	-2.30		-2.31	-2.29	-3.14	-1.82	-4.08	-2.65		-0.81	-3.92	-2.39	-3.77	-1.35
sr (with trend)	WS	-3.24	-3.30	-2.33	-2.49	-2.55	2.50	-1.91	-1.50	-2.60		-1.88	-1.87	-2.54	-2.09	-2.65	-2.58		-0.86	-2.30	-2.39	-3.82	0.69
sr (no trend)	ADF	-2.89	-2.98	-6.58	-0.91	-5.42	-4.38	-3.72	-0.64	-0.58		-1.10	-1.38	-0.83	-1.38	-4.23	-1.41		-1.87	-3.22	-2.22	-2.88	-2.31
sr (no trend)	WS	-2.55	-3.19	-1.12	-1.64	-1.49	-1.14	-0.25	0.71	-0.29		0.07	-1.76	-0.40	-0.87	-0.80	-1.73		-1.51	-1.15	-1.59	-0.54	1.21
Dsr	ADF	-2.89	-3.55	-6.40	-3.26	-5.66	0.14	-5.58	-6.05	-3.44		-6.71	-4.57	-7.70	-5.83	-5.16	-2.71		-0.57	-3.23	-3.72	-4.61	-5.83
Dsr	WS	-2.55	-3.76	-4.47	-2.69	-3.54	-0.34	-5.73	-6.18	-3.63		-2.96	-4.70	-3.57	-5.62	-3.50	-3.02		-0.98	-3.55	-3.77	-3.63	-4.59
DDsr	ADF	-2.89	-7.83	-3.88	-3.91	-3.82	-4.50	-5.33	-5.61	-3.78		-4.17	-11.47	-4.70	-10.19	-5.48	-4.99		-1.81	-12.89	-5.94	-6.35	-3.57
DDsr	WS	-2.55	-7.95	-2.09	-4.24	-3.96	-4.52	-4.25	-4.85	-3.95		-4.58	-11.67	-4.55	-10.21	-5.38	-5.20		-2.16	-12.70	-4.45	-4.48	-3.21

Source: authors' elaboration.

Table B2. Unit Root Tests for Foreign Variables at the 5% Significance Level

Foreign Variables	Statistic	Critical Value	BRAZIL	BULGARIA	CHINA	CROATIA	CZECH REPUBLIC	DENMARK	EURO	HUNGARY	INDIA	JAPAN	MACEDONIA	NORWAY	POLAND	ROMANIA	RUSSIA	SERBIA	SWEDEN	SWITZERLAND	TURKEY	UNITED KINGDOM	UNITED STATES
ys (with trend)	ADF	-3.45	-1.82	-3.33	-3.75	-4.71	-2.46	-5.41	-4.38	-2.01	-2.54	-1.50	-3.83	-5.58	-2.82	-2.38	-3.34	-3.14	-5.57	-3.09	-4.71	-4.66	-1.58
ys (with trend)	WS	-3.24	-1.90	-3.10	-3.02	-3.02	-3.12	-3.88	-3.40	-2.80	-2.49	-1.83	-1.89	-4.07	-3.05	-3.02	-2.65	-3.16	-3.77	-3.28	-3.85	-3.54	-1.86
ys (no trend)	ADF	-2.89	-0.06	-1.18	-2.03	-0.63	-0.81	-0.89	-0.05	-0.63	0.02	-0.69	-0.36	-0.93	-1.08	-0.77	0.01	-1.10	-0.59	-1.13	-1.98	-1.34	-0.39
ys (no trend)	WS	-2.55	1.82	-0.71	-0.58	-0.66	-0.40	0.04	0.06	-0.42	1.49	2.02	-0.31	-0.09	-0.43	-0.65	0.11	-0.52	0.21	-0.07	-0.21	-0.22	1.77
Dys	ADF	-2.89	-4.72	-6.98	-8.32	-6.09	-5.88	-3.05	-2.94	-6.34	-4.27	-9.15	-6.46	-6.07	-6.27	-6.04	-3.59	-6.30	-6.36	-6.64	-2.79	-6.06	-4.85
Dys	WS	-2.55	-4.92	-2.40	-2.85	-2.68	-2.70	-3.25	-3.15	-2.69	-4.45	-9.34	-2.69	-3.65	-2.97	-2.48	-3.70	-2.58	-3.68	-3.06	-3.01	-2.81	-5.04
DDys	ADF	-2.89	-16.79	-3.02	-3.53	-2.38	-2.26	-6.88	-16.43	-2.38	-16.47	-9.31	-6.39	-6.69	-6.15	-2.30	-15.54	-13.43	-7.08	-13.81	-15.50	-14.42	-16.76
DDys	WS	-2.55	-17.06	-3.19	-3.46	-2.61	-2.49	-6.98	-16.69	-2.60	-16.74	-9.59	-6.55	-6.83	-6.28	-2.55	-15.80	-13.63	-7.10	-14.04	-15.75	-14.66	-17.03
dps (with trend)	ADF	-3.45	-5.28	-4.91	-5.43	-4.63	-4.19	-4.49	-4.96	-4.50	-4.89	-5.56	-4.83	-4.10	-4.53	-4.30	-4.33	-4.73	-4.78	-4.59	-4.78	-4.63	-4.99
dps (with trend)	WS	-3.24	-5.39	-4.90	-5.55	-4.63	-4.24	-4.58	-5.04	-4.47	-4.97	-5.67	-4.92	-4.18	-4.42	-4.26	-4.39	-4.64	-4.83	-4.68	-4.80	-4.68	-4.67
dps (no trend)	ADF	-2.89	-5.11	-4.40	-5.33	-4.39	-4.07	-4.40	-4.33	-4.30	-4.82	-4.36	-4.32	-3.95	-4.42	-4.15	-4.21	-4.37	-4.61	-4.37	-4.42	-4.58	-4.93
dps (no trend)	WS	-2.55	-5.11	-4.05	-5.39	-4.11	-3.84	-4.34	-4.11	-3.96	-4.78	-4.06	-4.14	-3.79	-4.01	-3.79	-4.04	-3.91	-4.46	-4.27	-4.18	-4.47	-4.19
Ddps	ADF	-2.89	-8.95	-7.65	-6.21	-6.94	-7.09	-5.66	-8.68	-7.39	-5.93	-12.34	-9.27	-6.83	-6.98	-6.74	-6.87	-7.19	-5.68	-7.10	-7.26	-6.83	-5.58
Ddps	WS	-2.55	-9.07	-7.89	-4.89	-7.19	-7.32	-3.50	-8.81	-7.64	-4.39	-12.52	-9.37	-7.05	-7.23	-6.99	-7.10	-7.43	-5.14	-7.34	-7.43	-7.06	-4.34
DDdps	ADF	-2.89	-8.84	-7.48	-6.35	-6.24	-6.19	-6.69	-6.59	-6.05	-6.30	-6.46	-6.13	-6.58	-6.25	-6.51	-6.44	-6.16	-6.64	-8.65	-6.21	-6.44	-6.29
DDdps	WS	-2.55	-8.99	-6.51	-6.53	-5.65	-5.04	-5.83	-5.62	-5.24	-5.48	-6.22	-5.78	-5.64	-5.48	-5.80	-5.94	-5.44	-5.58	-8.78	-5.99	-5.84	-6.50
es (with trend)	ADF	-3.45	-2.78	-2.97	-1.98	-2.93	-2.90	-2.27	-2.87	-2.89	-2.60	-2.97	-3.01	-3.02	-2.73	-2.84	-2.55	-2.97	-2.51	-2.71	-2.85	-2.48	-2.62
es (with trend)	WS	-3.24	-2.92	-3.17	-2.03	-3.13	-3.07	-2.49	-3.11	-3.09	-2.72	-3.08	-3.13	-3.44	-2.95	-3.04	-2.76	-3.18	-2.73	-2.90	-3.07	-2.71	-2.70
es (no trend)	ADF	-2.89	-2.15	-2.34	-1.82	-2.95	-2.69	-2.11	-3.07	-2.84	-2.18	-2.11	-3.01	-2.17	-2.73	-2.85	-2.40	-2.71	-2.46	-2.41	-2.86	-2.16	-2.26
es (no trend)	WS	-2.55	-1.61	-2.24	-2.04	-3.14	-2.91	-2.33	-3.13	-3.05	-1.59	-1.42	-3.08	-2.40	-2.95	-3.04	-2.39	-2.83	-2.69	-2.60	-3.06	-2.11	-1.65
Des	ADF	-2.89	-7.56	-7.31	-7.74	-7.28	-7.41	-7.55	-8.13	-7.52	-7.89	-7.82	-7.50	-7.84	-7.54	-7.28	-7.49	-7.28	-7.79	-7.68	-7.62	-7.42	-7.89
Des	WS	-2.55	-7.56	-7.24	-7.81	-7.32	-7.46	-7.61	-8.16	-7.58	-7.89	-7.81	-7.41	-7.82	-7.58	-7.26	-7.41	-7.33	-7.83	-7.60	-7.67	-7.45	-7.90
DDes	ADF	-2.89	-4.12	-5.54	-4.57	-5.09	-4.78	-4.02	-5.88	-4.18	-4.25	-4.11	-4.17	-3.95	-4.27	-5.04	-4.38	-5.45	-4.11	-3.88	-4.18	-3.93	-4.24
DDes	WS	-2.55	-4.46	-5.20	-4.93	-4.92	-4.68	-4.40	-5.25	-4.50	-4.59	-4.45	-4.49	-4.34	-4.65	-4.87	-4.64	-5.12	-4.51	-4.24	-4.57	-4.31	-4.59
srs (with trend)	ADF	-3.45	-3.19	-2.15	-4.32	-2.41	-2.47	-3.47	-2.44	-2.46	-3.96	-3.45	-2.70	-3.58	-2.30	-2.46	-2.56	-2.49	-2.73	-2.81	-2.57	-3.01	-2.75
srs (with trend)	WS	-3.24	-2.87	-2.50	-1.73	-2.85	-2.92	-3.34	-1.77	-2.79	-2.98	-2.66	-2.81	-3.50	-2.87	-2.80	-2.88	-2.69	-2.87	-3.12	-2.81	-3.09	-3.19
srs (no trend)	ADF	-2.89	-0.91	-0.52	-3.01	-0.56	-0.95	-1.62	-2.74	-1.01	-1.72	-1.48	-0.85	-1.32	-1.50	-0.69	-0.69	-0.79	-0.76	-1.57	-0.93	-1.00	-0.68
srs (no trend)	WS	-2.55	-0.13	-0.04	-0.08	-0.21	0.86	-1.46	-1.52	0.72	-0.76	-0.42	-0.08	-1.19	-0.12	-0.18	-0.24	-0.23	-0.06	0.93	-0.66	-0.42	-1.14
Dsrs	ADF	-2.89	-3.99	-2.86	-3.18	-2.82	-2.93	-3.80	-2.90	-2.94	-3.72	-4.61	-2.91	-3.39	-3.12	-2.82	-3.14	-2.75	-3.20	-3.20	-3.09	-3.14	-3.58
Dsrs	WS	-2.55	-2.58	-2.97	-2.37	-3.04	-3.04	-3.66	-2.66	-3.10	-2.48	-2.27	-3.04	-2.94	-2.92	-3.03	-3.05	-2.89	-3.16	-2.89	-2.89	-2.97	-3.06
DDsrs	ADF	-2.89	-7.40	-5.50	-6.27	-5.56	-5.76	-5.78	-4.41	-5.60	-7.07	-8.08	-5.58	-6.32	-5.68	-5.53	-6.05	-5.27	-5.68	-6.30	-5.24	-6.07	-6.77
DDsrs	WS	-2.55	-5.27	-4.40	-5.53	-4.85	-4.81	-4.12	-3.08	-4.82	-5.00	-5.32	-4.88	-4.48	-4.90	-4.88	-4.90	-4.46	-4.61	-4.98	-4.30	-5.03	-4.29

Source: authors' elaboration.

Table B3. Unit Root Tests for Global Variables at the 5% Significance Level

Global Variables	Test	Critical Value	Statistic
poil (with trend)	ADF	-3.45	-2.37
poil (with trend)	WS	-3.24	-2.60
poil (no trend)	ADF	-2.89	-2.19
poil (no trend)	WS	-2.55	-2.39
Dpoil	ADF	-2.89	-4.98
Dpoil	WS	-2.55	-5.08
DDpoil	ADF	-2.89	-8.49
Dpoil	WS	-2.55	-8.66
vix (with trend)	ADF	-3.45	-4.39
vix (with trend)	WS	-3.24	-4.42
vix (no trend)	ADF	-2.89	-2.92
vix (no trend)	WS	-2.55	-3.09
Dvix	ADF	-2.89	-9.28
Dvix	WS	-2.55	-9.44
DDvix	ADF	-2.89	-7.18
Dvix	WS	-2.55	-7.23

Source: authors' elaboration.

APPENDIX C
Country Codes.

Country	Code
BRAZIL	BR
BULGARIA	BG
CHINA	CN
CROATIA	HR
CZECH REPUBLIC	CZ
DENMARK	DK
EURO	EURO
HUNGARY	HU
INDIA	IN
JAPAN	JP
MACEDONIA	MK
NORWAY	NO
POLAND	PL
ROMANIA	RO
RUSSIA	RU
SERBIA	RS
SWEDEN	SE
SWITZERLAND	CH
TURKEY	TR
UNITED KINGDOM	GB
UNITED STATES	US

Source: ISO 3166-1 country codes, apart from the euro area.

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2018

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CECCHETTI S., F. NATOLI and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, v. 14, 1, pp. 35-71, **WP 1025 (July 2015).**

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DE BLASIO G, S. DE MITRI, S. D'IGNAZIO, P. FINALDI RUSSO and L. STOPPANI, *Public guarantees to SME borrowing. A RDD evaluation,* Journal of Banking & Finance, v. 96, pp. 73-86, **WP 1111 (April 2017).**

GERALI A., A. LOCARNO, A. NOTARPIETRO and M. PISANI, *The sovereign crisis and Italy's potential output,* Journal of Policy Modeling, v. 40, 2, pp. 418-433, **WP 1010 (June 2015).**

LIBERATI D., *An estimated DSGE model with search and matching frictions in the credit market,* International Journal of Monetary Economics and Finance (IJMEF), v. 11, 6, pp. 567-617, **WP 986 (November 2014).**

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NUCCI F. and M. RIGGI, *Labor force participation, wage rigidities, and inflation,* Journal of Macroeconomics, v. 55, 3 pp. 274-292, **WP 1054 (March 2016).**

RIGON M. and F. ZANETTI, *Optimal monetary policy and fiscal policy interaction in a non_ricardian economy,* International Journal of Central Banking, v. 14 3, pp. 389-436, **WP 1155 (December 2017).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, v. 22, 2, pp. 661-697, **WP 1100 (February 2017).**

2019

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