Spreading the word or reducing the term spread? Assessing spillovers from euro area monetary policy

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Preliminary draft - comments welcome!

Abstract

Non-standard monetary policy measures, such as asset purchase programs aim to provide stimulus to the economy. In the euro area, these should bring down longer-term yields in general, or decrease spreads between euro area long-term yields. To assess spillovers from euro area monetary policy, we use a Bayesian variant of the global vector autoregressive (BGVAR) model that uses shrinkage priors coupled with stochastic volatility. For both shocks, we find positive and significant spillovers to industrial production in non-euro area EU member states in the short-run. These effects are transmitted via the financial channel (through interest rates and equity prices) and outweigh costs of euro area monetary policy through pressure on non-euro area EU member states' currencies. We do not find evidence of significant spillovers to consumer prices.

Keywords: Euro area monetary policy, quantitative easing, spillovers
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1 Introduction

Following the global financial crisis in 2007 and the failure of Lehman in 2008, major central banks have considerably lowered their policy rates to stimulate economic growth and consumer price inflation. Since the room for conventional monetary policy quickly eroded and against the background of deflationary pressures and weak economic growth, major central banks switched from traditional interest targeting to other forms of monetary policy. One of these non-conventional monetary policies works through an extension of the central banks' balance sheet by purchasing longer-term securities from the private sector , so-called *Quantitative Easing* (QE, see e.g., Fawley and Neely, 2013, for a detailed overview).

The main domestic transmission channels are the "portfolio balancing" channel and the "asset price channel" (see Joyce et al., 2012, for an excellent summary). In a nutshell, investors who sell bonds to the central bank, are likely to purchase other long-dated assets (e.g., corporate bonds) to restore the original duration of their overall portfolio. Ideally, this leads to an easing of financial conditions in a variety of market segments providing stimulus to the economy. Second, the reduction of bond yields should trigger a rise in asset prices ("asset price channel"), which in turn increases consumer wealth and overall aggregate demand. Regarding the transmission mechanism of QE, it seems obvious that the size of its boost to the economy is country-specific. The extent of financial deepening within the euro area differs. The same applies for long-term yields. This implies that to analyze spillovers from euro area monetary policy, it seems essential to use a coherent multi-country framework, that accounts for both heterogeneity of effects within the euro area and spillovers thereof.

Gambacorta et al. (2014) and Burriel and Galesi (2016) follow these lines of arguments and focus on within euro area spillovers. Gambacorta et al. (2014) estimate a structural panel VAR for eight advanced euro area countries to asses the effects of an exogenous increase in central banks' assets. These are pinned down by using a mixture of zero and sign restrictions. The findings in Gambacorta et al. (2014) suggest that an exogenous increase in central bank assets leads to a temporary rise in economic activity and – to a lesser degree - positive effects on prices. Also, these effects are rather homogeneous among euro area countries. Burriel and Galesi (2016) use a wider set of euro area countries, a global vector autoregressive framework that takes cross-country spillovers into account and a similar identification strategy. They find that an exogenous increase in ECBs total assets leads to a significant temporary rise in aggregate output and inflation, a depreciation of the effective exchange rate, an increase in real equity prices a fall in credit risk and a rise in new credit operations, while there are no significant effects on inflation expectations.

In this paper we assess spillovers from euro area monetary policy to non-euro area EU member states. Which economies are more strongly affected from euro area monetary policy, and which are more insulated? On the one hand, the increase in euro area demand is likely to boost economic activity in those countries that share strong trade links with the euro area member states that benefit most from downward pressure on their long-term yields. On the other hand, loose monetary policy in the euro area is expected to put appreciation pressure on other non-euro area EU member states that pursue a flexible exchange rate regime thereby putting a damper on economic growth.

Hitherto, there is a small but growing literature examining spillovers from euro area unconventional monetary policy. Bluwstein and Canova (2015) and Hálová and Horváth (2015) assess the effects of euro area unconventional monetary policy for non-euro area EU member states. Bluwstein and Canova (2015) use two-country Bayesian mixed frequency structural vector autoregressions to asses spillovers to non-euro area EU member states. Overall, they find positive but heterogeneous spillovers on output. In line with Burriel and Galesi (2016) the financial channel seems important in transmitting spillovers. Last, Hálová and Horváth (2015) use a panel vector autoregressive framework to either examine a shock to the shadow rate as a measure of unconventional policy (Wu and Xia, 2016) or to central banks' assets and the reaction of macroeconomic variables in CESEE economies. Corroborating results of Gambacorta et al. (2014) on within-euro area spillovers, they find strong effects on output, while spillovers to prices are rather weak.

We contribute to that young literature by investigating spillovers from euro area QE to non-euro area EU member states. In contrast to the former studies, we model effects of the ECB's asset purchase program by either assuming a compression of the yield curve or a narrowing of euro area cross-country long-term yields. More specifically, we compare results of the term spread shock to effects of a shock to the risk spread, which we define as the difference between between long-term yields of euro are member states and German long term yields. While the term spread shock captures changes in longer term yields (due to e.g., asset purchases), the risk spread should capture other forms of unconventional monetary policy such as forward guidance as a form to successfully commit to a loose monetary policy over a longer horizon and thereby convincing and reducing uncertainty in the markets. We use a multi-country framework that is able to fully take into account both, within euro area heterogeneity of monetary policy effects and resulting spillovers from these effects. More specifically, we use a variant of the Bayesian global vector autoregressive (BGVAR) framework put forth in Crespo Cuaresma et al. (2016), Feldkircher and Huber (2016b), Huber (2016) and Dovern et al. (2016). The proposed framework features shrinkage priors on the parameters of the model as well as time-varying error variances. Several studies (Sims and Zha, 2006; Primiceri, 2005) find rather limited evidence in favor of time-variation in the autoregressive parameters but recognize the importance to control for heteroscedasticity. For the present dataset, which is monthly and covers a rather limited time span, we use a stochastic volatility specification in order to capture dynamic properties commonly observed in macroeconomic and financial time series. These two features turn out to be important to produce accurate estimates and generate well behaved residuals.[1]

[1] Huber (2016) and Dovern et al. (2016) show that GVARs with shrinkage priors and stochastic volatility perform extraordinarily well in terms of forecasting.

Our main results for non-euro area EU member states are as follows: both shocks, namely a reduction in the term and the risk spread trigger a) an increase in industrial production, brought about by b) a rise in equity prices, driven by c) a reduction of longer-term yields and d) a temporarily appreciation of local exchange rates vis-á-vis the euro. Taken at face value, this implies that positive spillovers brought about by the euro area's economic expansion outweigh the dampening effect on output through an appreciation of local exchange rates. We do not find evidence for significant spillovers to consumer prices. Last, and comparing the two shocks we find in general very similar overall spillovers to non-euro area EU member states. Since the transmission within the euro area, however, differs considerably, country specific responses might as well vary significantly depending whether the term spread in the euro area decreases or longer-term yields narrow.

The paper is structured as follows. The next section introduces the econometric framework, while section 3 summarizes the data and model specification. section 4 provides a detailed examination of spillovers from euro area term spread and risk spread shocks and section 5 concludes.

2 Econometric framework

In this section we turn to the description of the econometric framework. Since most macroeconomic time series feature conditional heteroscedasticity we employ an extension of the traditional GVAR approach put forward by Pesaran et al. (2004) and recently proposed in Huber (2016) that effectively controls for heteroscedasticity by adopting flexible stochastic volatility specifications. The first subsection describes the global vector autoregressive model with stochastic volatility in fairly general terms. In the second subsection we briefly discuss the prior setup adopted and the Markov chain Monte Carlo (MCMC) algorithm.

2.1 The global vector autoregressive model with stochastic volatility

The GVAR model, originally proposed by Pesaran et al. (2004) builds on a sequence of $N+1$ country-specific VAR models that feature a set of weakly exogenous predictors constructed by taking weighted averages of other countries' endogenous variables,

$$x_{it}^* = \sum_{j=0}^{N} w_{ij} x_{jt}, \quad \text{for} \quad i \in \{0, \ldots, N\}, \tag{2.1}$$

with w_{ij} denoting a set of weights between countries i and j, normalized to sum up to unity. In the GVAR literature, these weights are typically assumed to be based on bilateral trade relationships or other measures of economic connectivity. The x_{it}^* variables are included to approximate the presence of observed or unobserved global factors and serve as a means to control for economic dependencies across countries.

We assume that the dynamics of a set of k_i endogenous variables in country i are described by the following VARX(p,q) model,

$$x_{it} = \sum_{j=1}^{p} A_{ij} x_{it-j} + \sum_{s=0}^{q} B_{is} x^*_{it-s} + \varepsilon_{it}, \tag{2.2}$$

with A_{ij} $(j = 1, \ldots, p)$ being $k_i \times k_i$-dimensional coefficient matrices, $B_{is},\ (s = 0, \ldots, q)$ are coefficient matrices of dimension $k_i \times k_i^*$ associated with the weakly-exogenous variables and ε_{it} is a normally distributed vector error term with a time-varying variance-covariance matrix Σ_{it}. Following Cogley and Sargent (2005) we can decompose Σ_{it} as follows

$$\Sigma_{it} = U_i H_{it} U_i', \tag{2.3}$$

where U_i is a $k_i \times k_i$-dimensional lower triangular matrix with unit diagonal and off-diagonal elements denoted by $u_{i,jn}$ $(j = 2, \ldots, k_i; n = 1, \ldots, k_i)$ and H_{it} is a diagonal matrix with $H_{it} = \text{diag}(e^{h_{i1,t}}, \ldots, e^{h_{ik_i,t}})$. Hereby we assume that the log-volatilities $h_{ij,t}$ follow an AR(1) process,

$$h_{ij,t} = \mu_{ij} + \rho_{ij}(h_{ij,t-1} - \mu_{ij}) + \kappa_{ij,t}, \tag{2.4}$$

where $\kappa_{ij,t}$ denotes a white noise error with variance ς^2_{ij}.

It is straightforward to show that the sequence of $N + 1$ can be combined to yield a global VAR model,

$$G x_t = \sum_{n=1}^{\max(p,q)} F_n x_{t-n} + \eta_t. \tag{2.5}$$

Hereby, we let $x_t = (x'_{0t}, \ldots, x'_{Nt})'$ denote a $k = \sum_{j=0}^{N} k_j$-dimensional vector that collects all endogenous variables in the system, G is a $k \times k$ matrix of contemporaneous coefficients that are a function of the B_{i0} matrices and the weights in w_{ij}. Moreover, F_n are $k \times k$ matrices of autoregressive coefficients that are driven by the weights and the estimates of A_{ij} for all countries and η_t is a k-dimensional vector white noise process with a block-diagonal matrix $\Sigma_t = \text{diag}(\Sigma_{0t}, \ldots, \Sigma_{Nt})$. Multiplying with G^{-1} from the left yields the reduced-form GVAR model that closely resembles a standard VAR model with parametric restrictions imposed through the weights w_{ij}.

2.2 Bayesian estimation and inference

While the GVAR modeling approach imposes parsimony by restricting the coefficients related to other countries' endogenous variables to be driven by trade weights (see Eq. (2.1)), the remaining number of parameters in Eq. (2.2) is still typically higher than the number of available observations. This calls for Bayesian shrinkage priors that effectively deal with this problem by shrinking the parameter space towards some stylized prior model.

Before proceeding to the actual prior implementation it is convenient to rewrite Eq. (2.2) into a standard regression model,

$$x_{it} = C_i z_{it} + \varepsilon_{it}, \tag{2.6}$$

with $z_{it} = (x'_{it-1}, \dots, x'_{it-p}, x^{*'}_{it}, \dots, x^{*'}_{it-q})'$ being a $K_i = k_i p + k^*_i q$-dimensional vector and $C_i = (A_{i1}, \dots, A_{ip}, B_{i0}, \dots, B_{iq})$ is a $k_i \times K_i = k_i p + k^*_i q$ matrix of stacked coefficients.

We follow Huber and Feldkircher (2016) and Feldkircher and Huber (2016a) and specify a global-local shrinkage prior in the spirit of Griffin and Brown (2010), labeled the Normal-Gamma (NG) prior, on each element of $c_i = \text{vec}(C_i)$,

$$c_{ij}|\tau^2_{ij} \sim \mathcal{N}(0, 2/\lambda^2_i \tau^2_{ij}),\ \lambda^2_i \sim \mathcal{G}(n_i, n_i),\ \tau^2_{ij} \sim \mathcal{G}(\vartheta_i, \vartheta_i). \tag{2.7}$$

Hereby we assume that the prior on c_{ij} depends on a local scaling parameter τ^2_{ij} and a global shrinkage parameter λ^2_i. For both hyperparameters we impose a set of gamma distributed priors with hyperparameters n_i and ϑ_i. The global shrinkage parameter pulls *all* elements of c_i towards zero whereas the local shrinkage parameter allows for non-zero signals in the presence of large λ^2_i. The crucial hyperparameter is ϑ_i that controls the excess kurtosis of the resulting marginal prior, implying that the smaller ϑ_i becomes, the thicker the tails of the marginal prior get.

Similarly to the prior on the regression coefficients we impose a NG prior on the off-diagonal elements of U_i,

$$u_{i,jn}|\kappa^2_{i,jn} \sim \mathcal{N}(0, 2/\zeta^2_i \kappa^2_{i,jn}),\ \zeta^2_i \sim \mathcal{G}(l_i, l_i),\ \kappa^2_{i,jn} \sim \mathcal{G}(\upsilon_i, \upsilon_i), \tag{2.8}$$

where $\kappa^2_{i,jn}$ is again a local shrinkage parameter, ζ^2_i denotes the global shrinkage parameter that pushes covariance parameters towards zero. The hyperparameters l_i and υ_i control the overall tightness of the prior and the excess kurtosis of the induced marginal prior.

We follow Kastner and Frühwirth-Schnatter (2014) and impose a normally distributed prior on $\mu_{ij} \sim \mathcal{N}(0, v_\mu)$, a Beta distributed prior on $\frac{\rho_{ij}+1}{2} \sim \mathcal{B}(a_0, b_0)$ and a Gamma prior on $\varsigma^2_{ij} \sim \mathcal{G}(1/2, 1/(2B_\varsigma)$. This prior setup has several convenient properties that are discussed in length in Kastner and Frühwirth-Schnatter (2014).

Posterior simulation is carried out by sampling from the $N+1$ country-specific posterior distributions in parallel. The MCMC algorithm is standard in the literature for VAR models. Specifically, we sample C_i on an equation-by-equation basis (for details, see Carriero et al., 2015) from an multivariate normal distribution. The free elements of U_i can be simulated by noting that the system can be rewritten as a set of k_i univariate regression models with standard normally distributed errors (see Cogley and Sargent, 2005). The log-volatilities and the parameters of the state equation Eq. (2.4) are simulated by means of the algorithm stipulated in Kastner and Frühwirth-Schnatter (2014) and implemented in the R package stochvol (Kastner, 2016). Finally, we follow Huber and Feldkircher (2016) and note that the conditional posterior distributions of τ^2_{ij} and $\kappa^2_{i,jn}$ are generalized inverse Gaussian (GIG). Moreover, λ^2_i and ζ^2_i can be simulated from an Gamma distribution.[2]

[2]For further information on the specific posterior moments, see Huber and Feldkircher (2016).

3 Data and model specification

We use monthly data spanning the period from 2000m1 to 2015m12. Our model focuses on QE effects from euro area member states to non-euro area EU member states. More specifically, the euro area countries covered consist of the EA-18 bar the Baltics, Cyprus and Malta due to their relative small role in the asset purchase program. Non-euro area EU countries include Denmark, Great Britain and Sweden on the one hand and Bulgaria, Czech Republic, Croatia, Hungary, Poland, and Romania on the other hand. We also include two non-EA member states that share close economic ties with both, the euro area and countries from Central- and Southeastern Europe (CESEE), namely Russia and Turkey. For completeness we also include data on the USA, China, Canada and Japan to control for global factors. That leaves us with a sample of good coverage of the euro area, non-euro area EU-member states and the G-8 industrialized advanced economies.

For the prior hyperparameters we specify $l_i = n_i = 0.01$ and $\vartheta_i = \upsilon_i = 0.6$. The first choice imposes heavy shrinkage on the model while the specific choice of $\vartheta_i = \upsilon_i = 0.6$ places significant prior mass on zero while at the same time maintaining heavy tails. For μ_j we set $v_\mu = 10^2$, leading to a rather uninformative prior on the level of the log-volatility. Finally, for the persistence parameter we set $a_0 = 25$ and $b_0 = 5$, placing significant mass on high persistence regions and $B_\varsigma = 1$. As noted previously we execute the MCMC algorithm for each country simultaneously and use 20,000 iterations with the first 5,000 being discarded as burn-in.[3]

In what follows we use two approaches to investigate spillovers from euro area quantitative easing. The first approach follows the framework of Baumeister and Benati (2013) and assumes that large scale purchases of longer-term securities result into a compression of the yield curve in the euro area. Fig. 1, top panel shows the dynamics of 10-year government bond yields for the euro area, Germany, euro area core (Austria, Belgium, Finland, France, Germany, and the Netherlands) and periphery countries (Portugal, Ireland, Italy, Greece and Spain).

[INSERT Fig. 1 HERE]

The figure shows how longer-term yields increased significantly in the aftermath of the global financial crisis and the euro area debt crisis, especially so for periphery countries. In July 2012, when Mario Draghi, President of the European Central Bank delivered his famous "whatever it takes speech" at the Global Investment Conference in London[4], however, yields started to decline strongly. Yields also decreased in January 2015 when the ECB announced to start its expanded asset purchase program in March

[3] To save computational time and due to storage limits we use a thinning interval to select 4,000 out of the 20,000 posterior draws. From these, we sort out unstable posterior draws which are characterized by large eigenvalues of the companion form of the global model which leads to approximately 500 posterior draws upon which the impulse response analysis in section 4 is based.

[4] See Acharya et al. (2015) for an empirical assessment of the macroeconomic effects of the "Whatever it takes" speech.

the same year, albeit by a considerably smaller amount probably also due to the fact that they have been on a downward trend for a prolonged period.

Hence we complement the term spread analysis by assessing the effect of a reduction in the risk spread, which we define as the spread of long-term rates in Germany (risk free) over domestic long-term rates. This should give an indication of how important "calming" the markets is compared to the actual purchase of longer-term securities. Fig. 1, bottom panel, illustrates that also a significant decrease in risk spreads was observable in July 2012.

The variable coverage in our modeling framework depends on the country block to which a country belongs and the shock to be assessed. Table 1 below provides a summary of the model specifications.

[INSERT Table 1 HERE]

Here, y denotes industrial production, p consumer prices, i_s and i_l short- and long-term interest rates (3-months and 10 year), sp either the term or the risk spread, eq stock prices and er the nominal exchange rate vis-á-vis the euro. All variables are in levels and data on industrial production is de-seasonalized.

The *domestic* variables are enlarged by a set of trade-weighted *foreign* variables denoted by asterisks. Recently, other weights based on e.g., financial flows have been proposed in the literature (see, e.g., Eickmeier and Ng, 2015). However, Feldkircher and Huber (2016b) present a sensitivity analysis with respect to the choice of weights in Bayesian GVAR specifications and show that trade weights yield a reasonable fit.

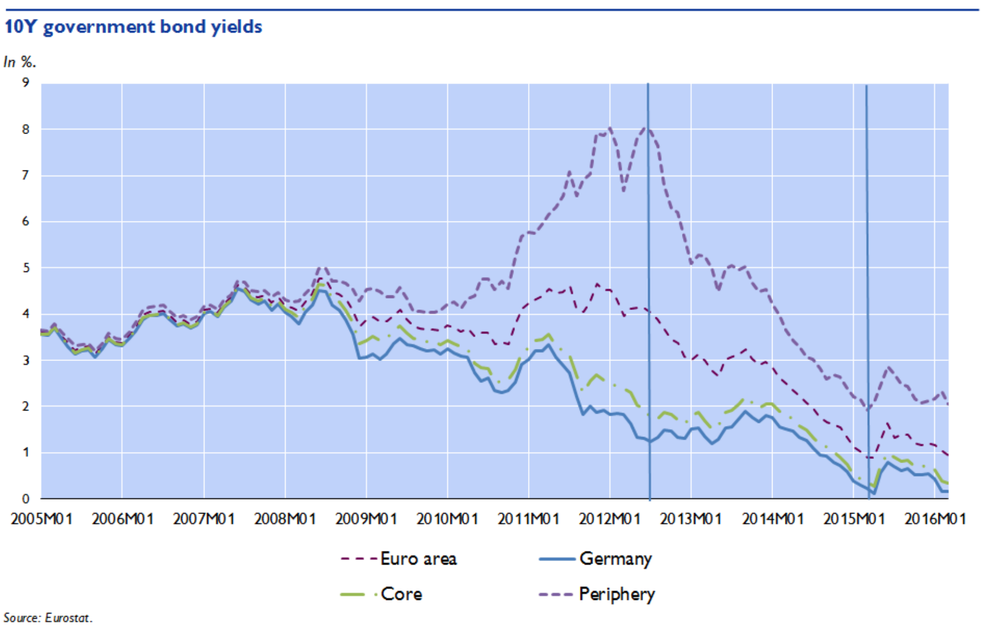
Looking at the term spread shock first, for euro area countries we include foreign counterparts of real activity, consumer prices, short-term interest rates, stock prices and the term spread. On top of that and to capture exchange rate dynamics, we include a trade-weighted average of the nominal exchange rate vis-á-vis the euro (e^*_{it}). In our analysis, Germany is the numeraire country and contains euro area short-term interest rates. In other words, and since short-term rates within the euro area are the same for all members (as approximated by the 3-months euribor), we make the assumption that euro area rates are mostly determined by German domestic variables and trade-weighted foreign factors from the perspective of Germany. Note that, this is rather a technical assumption since we cannot include the same endogeneous variable in more than one country model; short-term rates, however, are allowed to affect other euro area countries macrovariables, since they are still included in other euro area country models via i^*_t, which – due to strong economic within euro area integration – should resemble a time series that is close to the 3-months euribor. For *non-euro area* countries, we include the nominal exchange rate (er) vis-á-vis the euro directly as well as domestic short-term interest rates.

Considering the risk spread shock in the bottom panel of Table 1, a main difference to the term spread shock specification arises due to the inclusion of longer-term interest rates, either directly as a domestic variable, or indirectly as a foreign variable.[5] Also,

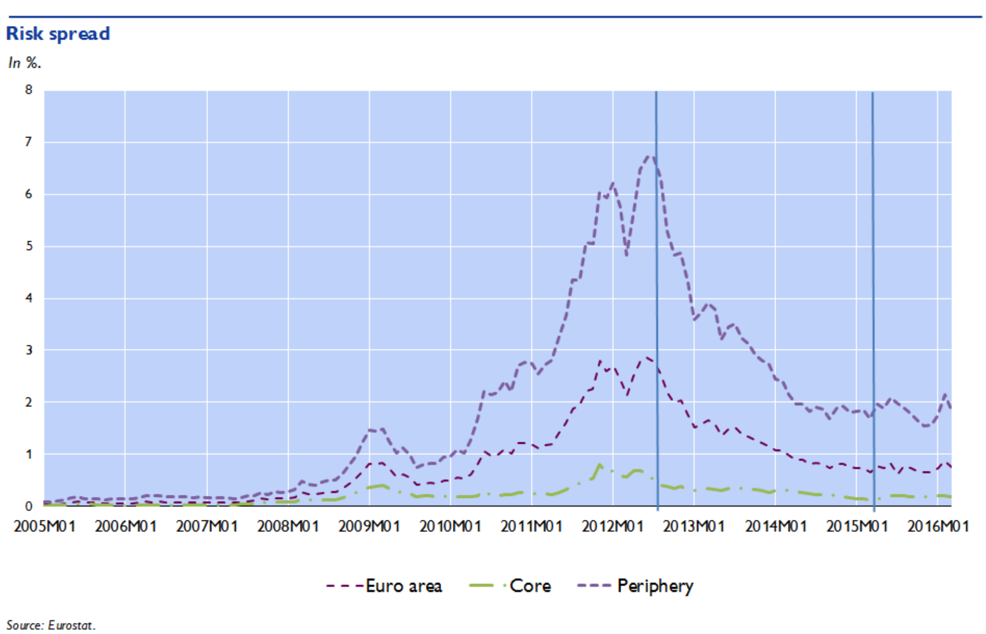
[5]Note that including long-term interest rates along with short-term rates and the term spread in the term spread model would not be meaningful.

Fig. 1: Evolution of 10-year government bond yields and the risk spread

(a) 10-year government bond yields



(b) Risk spread



Notes: The top panel of the plot shows the evolution of 10-year government bond yields, whereas the bottom panel shows movements in the risk spread. The risk spread is defined as the spread of 10-year government bond over German 10-year government bond yields. The core consists of Austria, Belgium, Finland, France, Germany, and the Netherlands, whereas the periphery is defined as Portugal, Ireland, Italy, Spain and Greece. Purchasing power parities used to calculate regional aggregates. The first vertical bar refers to the "whatever it takes speech" (July 2012), and the second vertical bar to the launch of the extended asset purchase program (March 2015).

Table 1: Summary of model specification

Term spread shock

Country	y	p	i_s	i_l	sp	er	eq	y^*	p^*	$i_s{}^*$	$i_l{}^*$	sp^*	er^*	eq^*
DE	√	√	√	–	√	–	√	√	√	√	–	√	√	√
EA (excl., DE)	√	√	–	–	√	–	√	√	√	√	–	√	√	√
Non-EA	√	√	√	–	√	√	√	√	√	√	–	√	–	√

Risk spread shock

Country	y	p	i_s	i_l	sp	er	eq	y^*	p^*	$i_s{}^*$	$i_l{}^*$	sp^*	er^*	eq^*
DE	√	√	√	√	–	–	√	√	√	√	√	√	√	√
EA (excl., DE)	√	√	–	–	√	–	√	√	√	√	√	√	√	√
Non-EA	√	√	√	√	–	√	√	√	√	√	√	√	–	√

Notes: In the upper panel, ”sp” denotes the term spread, while in the lower panel the risk spread.

the risk spread is only defined for euro area countries, excluding Germany for which the spread is by construction zero. As before, we include short-term interest rates for the euro area in the German country model and control for exchange rate movements in the euro area by allowing trade-weighted exchange rates to affect the euro area country models.

Last, note that not all variables are available for all countries covered in the analysis. This relates typically to long-term interest rates (but occasionally also to equity prices) for which coverage of Central, Eastern and Southeastern European (CESEE) countries is limited.

4 Empirical results

In this section we examine the domestic and international effects of a simultaneous compression of euro area single countries' term spreads as well as a simultaneous narrowing of longer-term yields in the euro area. In what follows we report structural impulse responses based on a recursive ordering of the variables in euro area countries. More specifically, we simultaneously shock the term spread (risk spread) in euro area countries with an ordering that assumes output and prices to be exogenous to the term spread (risk spread), while equity prices are allowed to react immediately. This identification is in the spirit of Walentin (2014) who examines the effect of QE on macroeconomic quantities through its impact on mortgage spreads in the USA, UK and Sweden.

As an alternative and for both shocks, we also report generalized impulse response functions (GIRF) as proposed in Pesaran and Shin (1998). GIRFs are appealing since they are insensitive to the ordering of the variables in the system, whereas the shocks in general remain (weakly) correlated (which strictly speaking prohibits a structural and economic interpretation). In practice, however, residual correlation is weak, especially when using a GVAR approach, since the weakly exogenous variables soak up a lot of the existing correlation.

4.1 Effects of a compression of the yield curve

Results for the term spread shock are depicted in Fig. 2.

[INSERT Fig. 2 HERE]

The figure shows the posterior median of generalized impulse responses (in blue) along with 25% and 75% percentiles of the posterior distribution (shaded area). The shock is calibrated to amount to a 100bp average reduction of the term spread over euro area countries. The corresponding quantities for the shock identified via a Cholesky decomposition are in orange (solid line posterior median, 50% credible set in dotted orange). For the sake of illustration, we have averaged responses for the euro area and the non-euro area EU member states by purchasing power parities. Note that we hold the response of short-term interest rates in the euro area (determined within the

German country model) constant at zero. This in the spirit of Baumeister and Benati (2013) and should mimic the current environment of low interest rates.[6]

The 100bp reduction of the term spread pushes down longer term yields in non-euro area EU member states. The direct spillover effect is about half of the size as in the euro area and in both regions significant according to the 50% credible sets up to about 30 months. The decline in longer-term yields drives up industrial production in the euro area up to four months after which the effect gradually peters out. However, responses are not precisely estimated and credible sets include the zero response. Spillovers to industrial production, by contrast, are positive and precisely estimated up to eight months. To investigate this further, it might be useful to consider responses for euro area core and periphery countries separately, provided in Fig. A.1. The reduction in the term spread triggers an immediate and significant increase (regarding the recursive identification) in industrial production in euro area core countries. By contrast, the effect on periphery countries is delayed and estimated are plagued by uncertainty. This results in overall insignificant results, while spillovers to non-euro are EU member states, which are more strongly integrated with the core relative to the periphery, are precisely estimated. Next, responses of consumer prices are close to zero and estimates accompanied by wide credible sets. In parallel with the reduction of the term spread, equity prices tick up in the euro area, and significantly so up to three months (recursive identification). Spillovers to none-euro EU member states show a similar pattern, namely a positive response in the short-run, followed by a significant negative rebound. Last, the economic expansion in the euro area leads to a depreciation of the euro against non-euro area EU member states with flexible exchange rates (reflected in a decrease of the exchange rate responses) and no or little movement of short-term interest rates. At the longer horizon, however, short-term rates in no-euro area EU member states start to decline and local exchange rates to weaken. For both, responses of short-term interest rates and exchange rates, however, credible sets are particularly wide throughout the forecasting horizon.

In Fig. 3 we assess in more detail the cross-country variation of spillovers. In other words, which non-euro area EU-member states are more strongly affected, which ones are more insulated from the shock. To that end we show peak effects of the spillovers (in absolute terms) with accompanying 50% credible sets to gauge uncertainty surrounding these effects.

[INSERT Fig. 3 HERE]

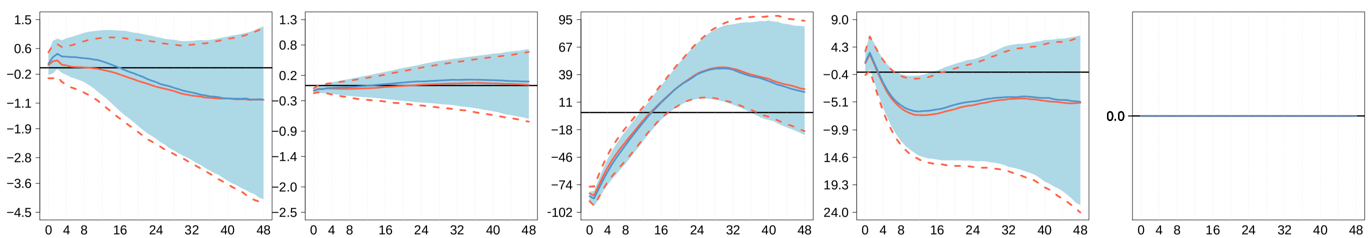
There are some salient features emerging from the data: While peak effects on industrial production are positive and significant throughout non-euro area EU member states, there is no significant effect on consumer prices. Hungary, Poland, Bulgaria, but also Turkey benefit most from the euro area economic expansion. With the exception

[6] Note that zeroing out the response of interest rates is not related to the identification of the shock. Rather, it relates to the estimation stage of the model, and is achieved by setting to zero the respective coefficients in the German country model.

Fig. 2: Responses to a 100bp reduction in the term spread.

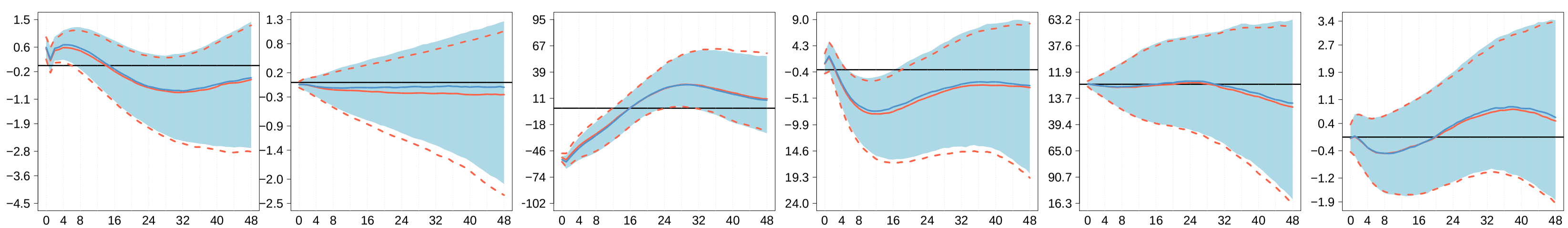
Euro area

(a) Industrial production **(b)** Consumer prices **(c)** Term spread **(d)** Equity prices **(e)** Short-term interest rate



Non-EA EU member states

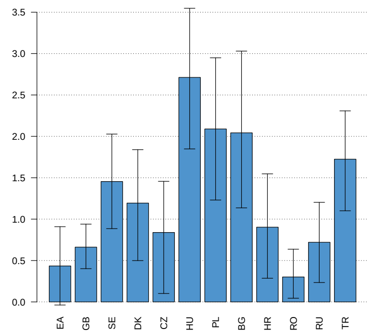
(f) Industrial production **(g)** Consumer prices **(h)** Term spread **(i)** Equity prices **(j)** Short-term interest rate **(k)** Exchange rate



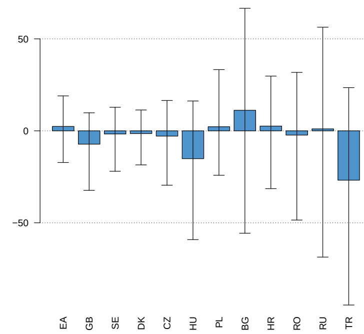
Notes: The figure shows impulse responses to a simultaneous 100bp reduction in the euro area term spread. Orange lines refer to the posterior median (solid) along with 50% credible set of generalized impulse response functions; blue solid line (median) and blue shaded area (50% credible set) show responses based on recursive identification. Regional averages based on PPP weights. Exchange rate refers to nominal exchange rates vis-á-vis the euro (decrease implying a depreciation of the euro).

Fig. 3: Peak effects of spillovers (term spread shock)

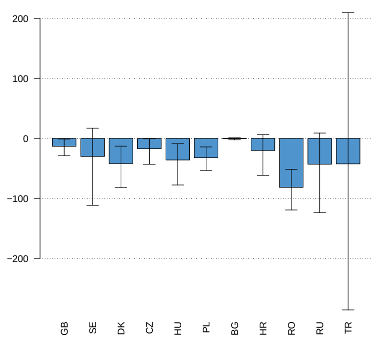
(a) Industrial production



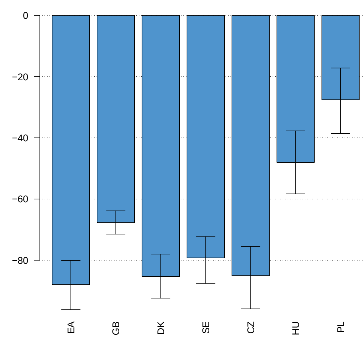
(b) Consumer prices



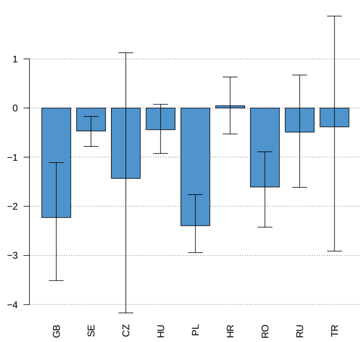
(c) Short-term interest rates



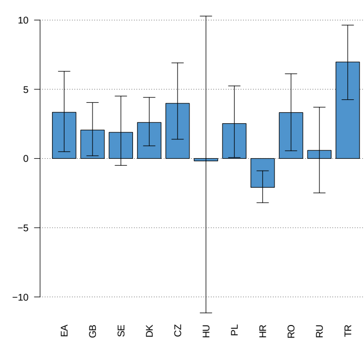
(d) Term spread



(e) Exchange rate



(f) Equity prices



Notes: The bar plots show peak effects in absolute terms with the whiskers denoting 50% credible intervals. A decrease of the exchange rate response implies an appreciation of the local currency against the euro.

of Croatia, which pursues a tightly managed floating exchange rate regime anchored on the euro, all non-euro area EU member states currencies strengthen against the euro. Peak effects are most pronounced for Poland, which also historically showed large swings in its exchange rate, Great Britain and Romania. To offset pressure on the local currency, non-euro area EU member states' short-term interest rates respond negatively to the term spread shock. For most economies, effects on short-term interest rates are precisely estimated. An exception to this is Turkey for which interest rates have been particularly volatile (and exceptionally high) during the beginning of the sample period. This might explain the large degree of uncertainty surrounding the estimates. Last, the term spread shock negatively affects term spreads in non-euro area EU member states. Peak effects are very homogeneous with only Hungarian and Polish spreads showing a smaller response compared to the other peers in the region. The decrease in term spreads triggers a significant increase in equity prices for most of the economies. Here, effects are most pronounced for Turkey, while there is a negative effect on the Croatian stock market.

Summing up, we find that a reduction in euro area term spreads positively affects industrial output, whereas effects on consumer prices are modest. This finding is in line with Hálová and Horváth (2015) and Gambacorta et al. (2014) for the euro area. Second, there is strong evidence for the financial channel transmitting spillovers to non-euro area EU member states (Bluwstein and Canova, 2015). In parallel with the reduction of the term spread, equity prices tick up and term spreads in non-euro area EU member states ease. Last, and in contrast to Bluwstein and Canova (2015) we find also evidence for the importance of the exchange rate channel with local currencies tending to appreciate against the euro in the short-run.

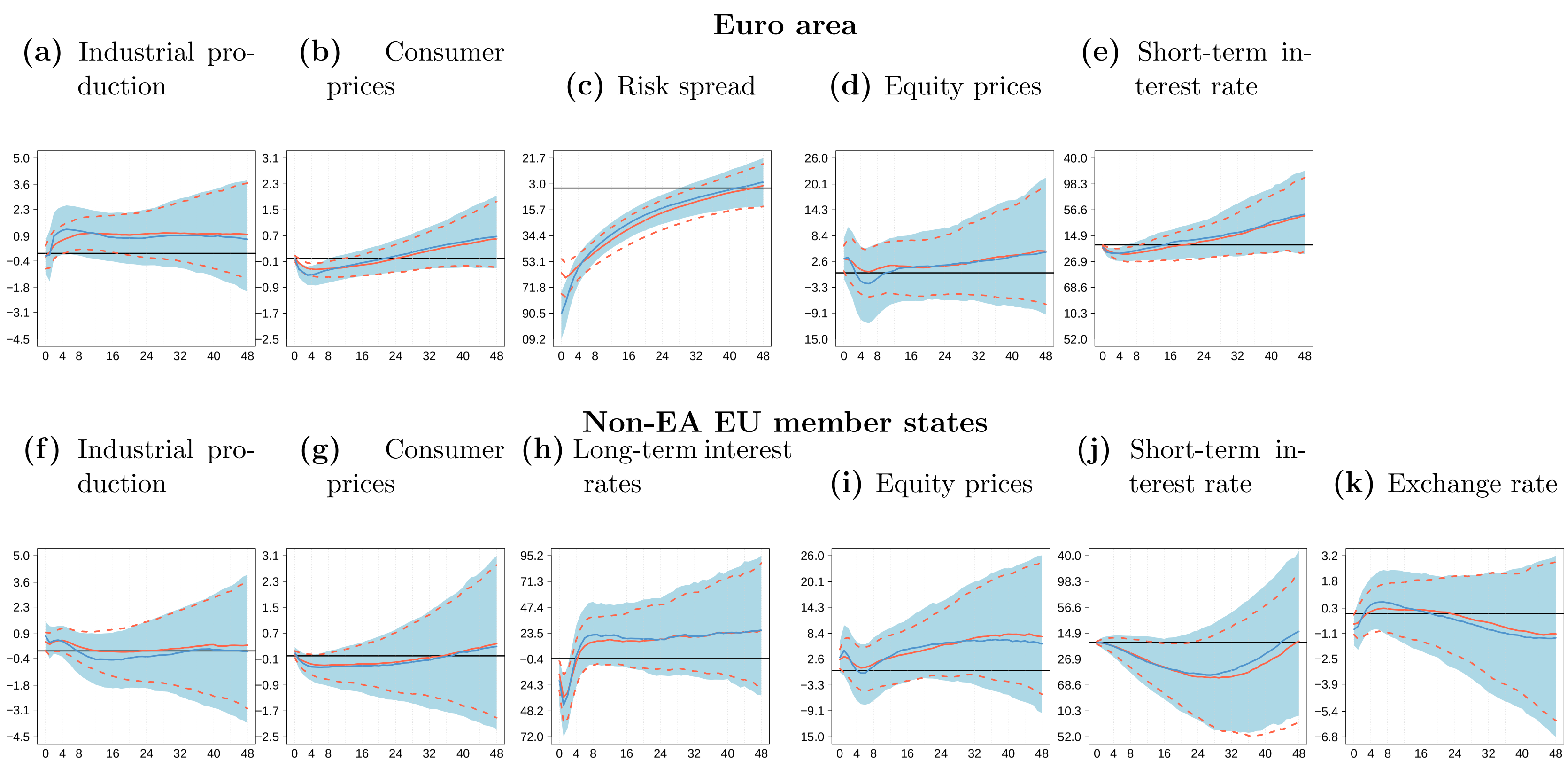
4.2 How far does "whatever it takes" take you?

In this section we contrast the results on the term spread shock with effects of a reduction in the risk spread. We define the risk spread as the difference between a euro area member states' long-term interest rate and long-term interest rates in Germany. A credible commitment to provide stimulus for an extended period of time might reduce cross-country long-term interest rate spreads. In the spirit of the term spread shock framework, we zero out the response of the German long-term interest rate. The results are depicted in Fig. 4.

[INSERT Fig. 4 HERE]

The overall effects of the risk spread shock on industrial production are positive but not significant. This holds true for both, euro area and non-euro area EU member states responses. Since the reduction in the risk spread is likely to benefit peripheral countries more it is worth looking at core and periphery responses separately (see Fig. A.2 in the appendix). This reveals that industrial production indeed increases and significantly so for periphery countries, while the effect for core countries is modest. Since most non-euro area EU member states trade heavily with core countries such as Germany, it

Fig. 4: Responses to a 100bp reduction in the risk spread.



Notes: The figure shows impulse responses to a simultaneous 100bp reduction in the euro area risk spread. Orange lines refer to the posterior median (solid) along with 50% credible set of generalized impulse response functions; blue solid line (median) and blue shaded area (50% credible set) show responses based on recursive identification. Regional averages based on PPP weights. Exchange rate refers to nominal exchange rates vis-á-vis the euro (decrease implying a depreciation of the euro).

is not surprising that overall spillovers are barely significant as well. In line with results on the reduction of the term spread, we do not find strong stimulus for consumer prices. In fact and in the short-term, consumer prices in the euro area tend to decrease. This effect, however, is very short-lived and consumer prices increase steadily afterwards, but effects are accompanied by large credible sets. By contrast, price spillovers are estimated throughout the forecast horizon with considerable uncertainty. Next, we observe that the reduction in the risk spread translates into a decrease in long-term yields in non-euro area EU member states. This implies that these countries can to a considerable degree also benefit from a reduction in uncertainty and risk in the euro area. That the financial channel is an important facet of the transmission channel is further revealed by looking at equity price responses. Responses in the euro area as well as spillovers are positive, and considering generalized impulse responses, significantly so on impact. Last and in parallel with a reduction in longer-term rates, short-term interest rates decline in both regions. Despite negative spillovers to domestic short-term rates in non-euro area EU member states, local currencies tend to strengthen against the euro in the short-run. After three to four months, however, exchange rates rebound.

Next, we examine in more detail cross-country variation of the spillovers provided in Fig. 5.

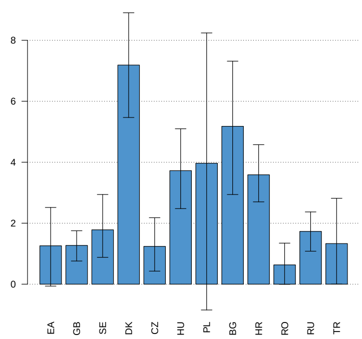
[INSERT Fig. 5 HERE]

Peak effects on industrial production are positive and significant for most economies covered in this study. Some of the countries that showed most pronounced peak effects in response to the term spread shock, also benefit strongly from the narrowing of long-term yields in the euro area (Bulgaria, Hungary and Poland). On top of that peak effects are pronounced for Denmark and Croatia. Effects on consumer prices are estimated with a high degree of uncertainty throughout the region. As with the term spread shock, most economies face appreciation pressure on their currencies (reflected by significant and negative responses), which causes an easing of short-term interest rates. The effects on short-term interest rates are most pronounced for Turkey, dwarfing maximum responses for the other countries. Also short-term rates in Russia and Hungary tend to respond considerably. Looking at long-term interest rates, reveals that responses are significantly negative throughout the region. Effects are more pronounced for advanced economies (Denmark, Great Britain, Sweden). Last, calming the markets results in equity prices ticking up and significantly so in Central Eastern European economies and Romania.

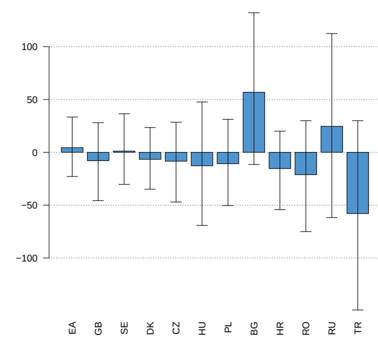
Summing up, we find positive and significant spillovers to output, appreciation pressures on the domestic currencies, resulting into an easing of short- and long-term interest rates and an increase in equity prices. There is no evidence for significant spillovers to consumer prices. While this overall pattern is very similar to what we have observed in response to the term spread shock, responses of single countries might differ considerably depending on the nature of the shock.

Fig. 5: Peak effects of spillovers (risk spread shock)

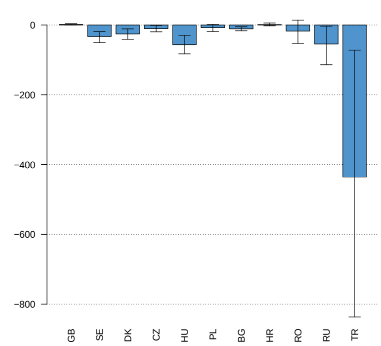
(a) Industrial production



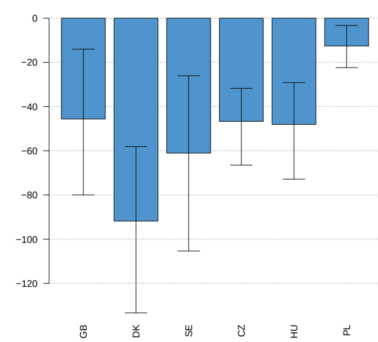
(b) Consumer prices



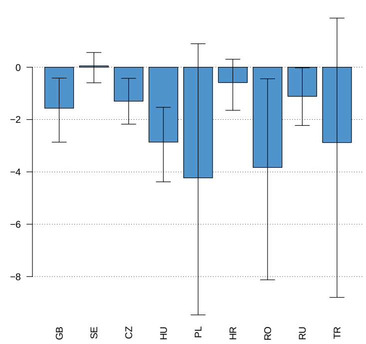
(c) Short-term interest rates



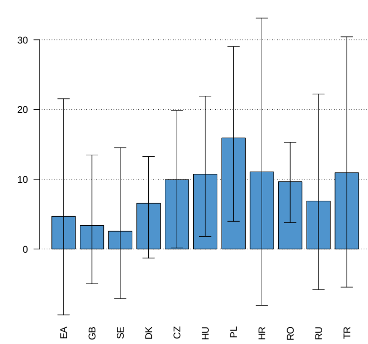
(d) Long-term interest rates



(e) Exchange rate



(f) Equity prices



Notes: The bar plots show peak effects in absolute terms with the whiskers denoting 50% credible intervals. A decrease of the exchange rate response implies an appreciation of the local currency against the euro.

5 Closing remarks

Since the global financial crisis, the ECB has implemented several non-standard measures.[7] The latest of these measures constitute buying large amounts of securities issued by euro area governments, agencies and EU institutions, asset-backed securities and covered bonds driving down longer-term yields. Not only the actual purchase of these securities can alter interest rates. Also the successful commitment of the ECB to follow a certain policy path can influence financial markets. In this paper we use a novel econometric approach that uses shrinkage priors coupled with stochastic volatility to assess spillovers from most recent euro area monetary policy actions. To that end, we examine the effects of a 100bp reduction in the euro area term spread as well as a reduction of the risk spread, that is defined by the spread of euro area member states' long-term government bond yield over German long term yields.

Our main results are as follows: First, we find positive and significant short-run effects on industrial production in non-euro area EU member states corroborating results of Bluwstein and Canova (2015) and Hálová and Horváth (2015). Second, we do not find evidence of positive effects on consumer prices. This finding is in line with results of Gambacorta et al. (2014) for the euro area and Bluwstein and Canova (2015) and Hálová and Horváth (2015) regarding spillovers to non-euro area EU member states. The link between asset prices and inflation in the context of quantitative easing has been recently analyzed by de Haan and Willem van den End (2016). They find that the transmission of financial developments to inflation can be quite long and that overall effects of quantitative easing on inflation can be quite uncertain, both in timing and direction. The weak relationship between asset prices and inflation in the euro area can hence account for the lack of evidence for spillovers we find in the data. Third, we find strong evidence for the financial channel. In response to both shocks, long-term interest rates decline as well as equity prices tick up. Taken at face value, this implies that policies to absorb foreign shocks have to account for the financial channel. Fourth, exchange rates tend to respond significantly with local currencies strengthening vis-á-vis the euro in the short-term. Appreciation pressure eases in the medium-term, also since non-euro area EU member states decrease short-term interest rates. That is, while the increase in financial integration has rendered the financial channel increasingly important, there is still evidence in the data for the more traditional exchange rate / trade channel. Last, and comparing the two shocks, at first sight we find very similar overall responses. Country-specific results, however, can differ substantially. As an explanation one might offer the distinct with-euro area effects of both shocks: while the term spread shock has a comparably stronger impact on euro area core countries, narrowing longer-term yields within the euro area has a stronger positive effect on euro area periphery countries. In terms of spillovers, this implies that countries that are more strongly integrated with euro area core economies, such as CESEE countries, tend to

[7] See, e.g., the studies by Giannone et al. (2012) and Lenza et al. (2010) that examine the early non-standard measures of the ECB that targeted liquidity provisioning and stability of the banking system. These studies find in general, that the ECB measures were quite effective.

benefit more from a reduction in the term spread, while for others a reduction in euro area cross-country long term spreads might be more important.

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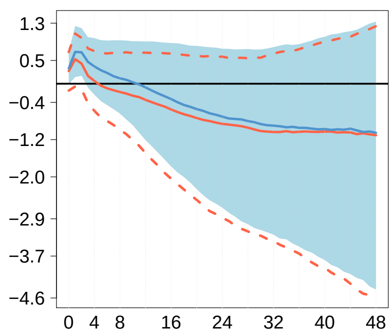
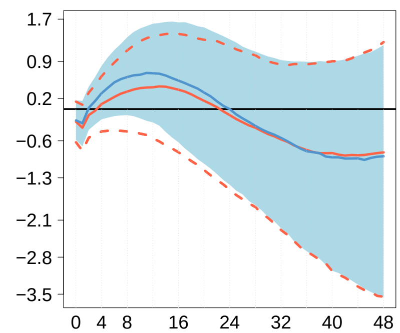
Appendix A Additional results

Fig. A.1: Term spread results - core vs. periphery

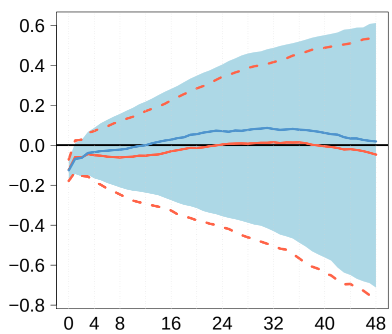
(a) Industrial production (core)



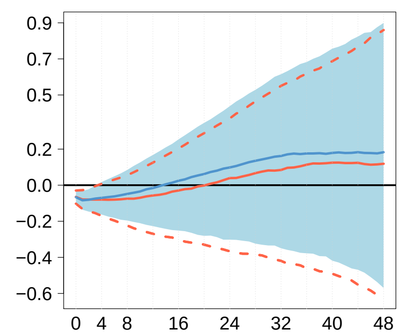
(b) Industrial production (periphery)



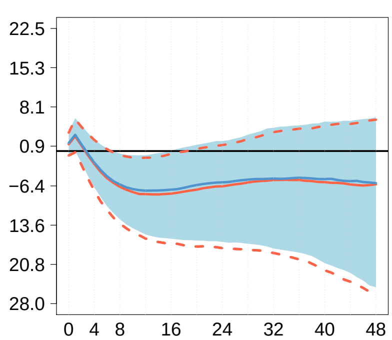
(c) Consumer prices (core)



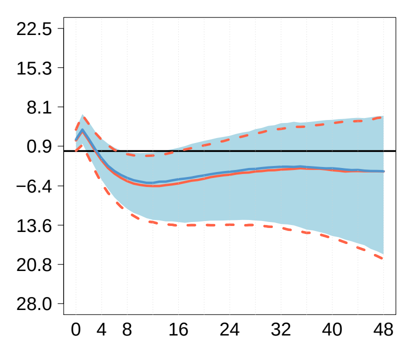
(d) Consumer prices (periphery)



(e) Equity prices (core)



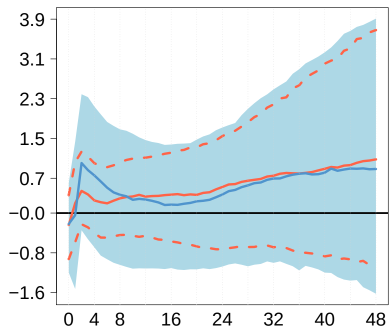
(f) Equity prices (periphery)



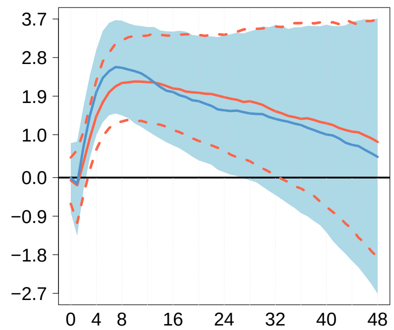
Notes: The figure shows impulse responses to a simultaneous 100bp reduction in the euro area risk spread. Orange lines refer to the posterior median (solid) along with 50% credible set of generalized impulse response functions; blue solid line (median) and blue shaded area (50% credible set) show responses based on recursive identification. Regional averages based on PPP weights. Exchange rate refers to nominal exchange rates vis-á-vis the euro (decrease implying a depreciation of the euro).

Fig. A.2: Risk spread results - core vs. periphery

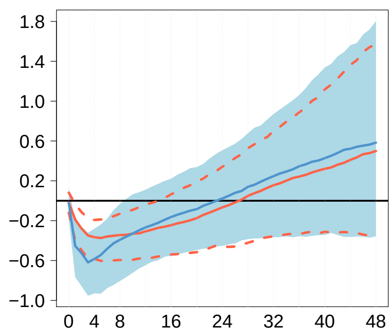
(a) Industrial production (core)



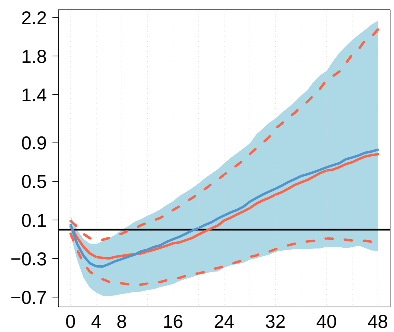
(b) Industrial production (periphery)



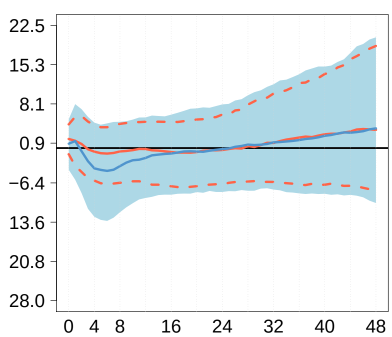
(c) Consumer prices (core)



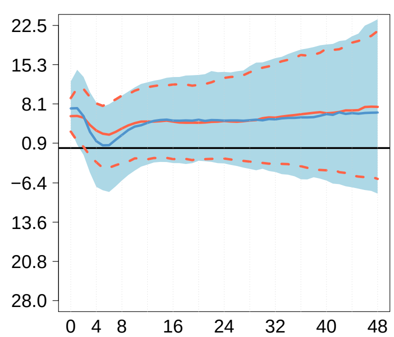
(d) Consumer prices (periphery)



(e) Equity prices (core)



(f) Equity prices (periphery)



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